Canadian Environmental Assessment Agency
Agence canadienne d'évaluation environnementale

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March 18, 2016

Mr. Mike Lambert
Head, Environment and Regulatory Affairs
Pacific NorthWest LNG Ltd.
Oceanic Plaza, Suite 1900
1066 West Hastings Street
Vancouver BC V6E 3X1

Dear Mr. Lambert:

Thank you for the comments and information submitted by Pacific NorthWest LNG Ltd. (PNW LNG) to the Canadian Environmental Assessment Agency (the Agency) on March 4, 2016. The effort undertaken by PNW LNG to review the draft Environmental Assessment Report and potential conditions for the Pacific NorthWest LNG Project (the Project) and provide detailed comments is appreciated.

The Agency has carefully considered PNW LNG's submission, in consultation with expert federal departments including Fisheries and Oceans Canada, Natural Resources Canada, Environment and Climate Change Canada, and Health Canada. The Agency also considered comments from Aboriginal groups and the public regarding the ecological value and importance of the marine environment and fish habitat including Flora Bank in the project area. The Skeena River watershed is one of the largest and most diverse wild salmon watersheds in the world, and is second only to the Fraser River in its capacity to produce sockeye salmon. All available science and information is being taken into account in the environmental assessment, recognizing the importance of understanding what is required to protect this ecologically and biologically significant habitat.

The Agency is of the view that a number of PNW LNG's suggestions, such as adjusting the timing limitations for tree clearing on Lelu Island while avoiding impacts to bats, can be addressed in the finalization of the Environmental Assessment Report and potential conditions.

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PNW LNG has indicated that some of the key mitigations and potential conditions that the Agency has proposed to avoid or reduce significant adverse environmental effects to fish and fish habitat and marine mammals are not feasible.

The new and more detailed information you provided related to construction activities in the marine environment and on Lelu Island has given rise to several new areas of uncertainty which need to be taken into account in determining the Project's effects on fish and fish habitat, marine mammals, human health, and current Aboriginal use of lands and resources for traditional purposes.

Consequently, the Agency is requesting information from PNW LNG, as outlined below, to address the identified areas of uncertainty including how it intends to mitigate any adverse effects. Further background and details are provided in the attached March 15, 2015 correspondence from Fisheries and Oceans Canada and from Natural Resources Canada.

Effects of marine construction activities on fish and fish habitat and marine mammals

PNW LNG states in the March 4, 2016 submission to the Agency that in-water construction must generally be able to proceed on a continuous basis, night and day. This differs from the Agency's previous understanding based on PNW LNG's earlier submissions with regard to the continuous nature of construction, the scale of light and noise, and the methods and mitigations associated with construction of the marine jetty. PNW LNG has also suggested changes to the proposed conditions commenting that some are not technically or economically feasible and others should be applied on a more discretionary basis. With these proposed changes, there is uncertainty regarding the effects of light, noise, and sediment erosion and deposition resulting from in-water construction to fish and fish habitat and marine mammals.

The Agency requests that PNW LNG provide an assessment of the effects of light and noise to fish and marine mammals arising from all in-water marine construction activities. Further, the Agency requests an assessment of the effects of the marine vessel fleet and the coffer dams during marine construction, on sediment erosion and deposition and associated effects to fish and fish habitat, and how PNW LNG plans to mitigate those effects.

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This assessment must include:

- A detailed work plan and schedule for construction of the marine jetty (suspension bridge, trestle and berths):
    - List of in-water construction activities and locations, the months and number of hours in a 24-hour day that such activities are proposed, and whether they would be sequential or simultaneous.
    - Description of the types and number of construction vessels involved in marine construction activities, and any differences between night and day time vessel activities. Include scows, derricks, barges, marine dredgers, utility tugs (specify propulsion type), and small craft vessels.
    - Information about the duration of use and methods of construction and removal of the coffer dams.
- A description of circumstances and frequency that vibratory pile driving would not be technically feasible other than for pile seating, and the resulting impacts on underwater noise levels.
- A description of circumstances where bubble curtains and/or isolation casings will be applied as a mitigation measure, and their effectiveness at mitigating underwater noise effects.
- A description of mitigation measures to be used where bubble curtains and/or isolation casings are not technically or economically feasible, for what activities, and the effectiveness of these other methods at mitigating underwater noise effects.
- A description of alternatives to marine mammal observers to enable detection of marine mammals near the work area, and the effectiveness of such methods.
- The frequency and duration of in-water construction activities on a daily, monthly and seasonal basis. Considering the expectation that marine mammals will not enter the safety zone for as long as construction noise continues, include stops and recommencements.
- If scour protection will not be used around the coffer dams, include high-resolution modelling of the scour expected, and how it relates to the erosion rates predicted in PNW LNG's November 2015 report.
- A discussion of the mitigation measures to manage potential effects of marine construction vessels on water quality and sediment erosion/deposition.
- An assessment of the combined effects from construction activities (light, noise and potential changes to water quality and sediment erosion/deposition) to fish and fish habitat and marine mammals.

PNW LNG states in the March 4, 2016 submission that the requirement for in-water timing windows would constrain construction activities to a point where marine construction would become unfeasible.

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PNW LNG suggests a more flexible condition which would allow construction to proceed year-round with mitigation measures that may include timing windows, subject to Fisheries and Oceans Canada's approval.

Based on PNW LNG's updated fish and marine mammal field data (2015 survey results), describe potential circumstances outside of anticipated least risk timing windows when approval for in-water construction with additional mitigation measures might be sought. Include in your response:

- Additional mitigation measures that would be proposed to avoid adverse effects during important life stages of fish and marine mammals (e.g. herring spawning and salmon rearing on Flora Bank, eulachon and marine mammal migrations).
- Based on the updated data, any times when in-water construction activities might not be acceptable, regardless of mitigation applied.

Effects of marine structures on fish habitat including Flora Bank

Concerns raised during the public comment period reference the December 2015 comments from Aboriginal groups suggesting that observed currents over the shallow part of Flora Bank could be greater than the currents simulated in PNW LNG's Delft-3D modelling. These concerns relate to both the accuracy of modelled current speeds over Flora Bank, and the model's omission of rocky outcrops and LNG carriers at the marine berths given their potential effects on waves and tidal currents over Flora Bank.

As a result, the Agency requests that PNW LNG provide information to address these concerns. Federal experts have provided recommendations in the attached comments regarding comprehensive modelling and systematic observations of currents to address these concerns (see Annexes 1 and 2).

Effects of construction noise and light on human health

PNW LNG states in the March 4, 2016 submission that construction is expected to take place during both day and night, and that measures to restrict these activities to minimize noise and light emissions during nighttime hours may not be possible. This is a deviation from earlier submissions that stated that nighttime light emissions would be limited, and that nighttime construction would be limited to low noise activities.

- The Agency requests that PNW LNG perform a quantitative assessment of nighttime construction noise and associated effects to human health (e.g., sleep disturbance), or advise as to whether daytime acoustic modelling results for construction noise submitted previously would be applicable to nighttime noise levels and associated effects.
- The Agency requests that PNW LNG indicate how nighttime construction noise and light emissions would be mitigated to ensure no significant adverse effects to human health including the public and Aboriginal peoples.

Effects on current Aboriginal use of lands and resources for traditional purposes

As stated above, PNW LNG has presented information in its March 4, 2016 submission regarding changes to the construction schedule and methods that could affect fish and fish habitat, including marine mammals, and that would increase the amount of light and noise emitted at night. This new information needs to be taken into consideration in the Agency's assessment of the effects of the Project on the preferred location, means and timing of traditional uses, and on Aboriginal perspectives on the importance, uniqueness and overall cultural value of the Project area.

The Agency requests the following information:

- A description of how the responses to the requests related to fish and fish habitat and marine mammals affect the current use of lands and resources for traditional purposes by Aboriginal peoples.
- How nighttime construction noise and light emissions would be mitigated to ensure significant adverse effects to current use of lands and resources for traditional purposes are avoided.

In accordance with subsection 27(6) of the *Canadian Environmental Assessment Act, 2012* the federal timeline within which the Minister of Environment and Climate Change's decisions must be made is paused as of March 18, 2016 and will resume once the Agency determines that the information provided satisfies this information request. Consistent with the Agency's policy on information requests, the Agency may take up to 15 days to determine whether the information request has been satisfied, which does not count against the federal timeline for the environmental assessment.

The Agency is committed to continue working with PNW LNG to complete the environmental assessment in an efficient and effective manner. We will contact you to arrange a follow-up meeting with the Agency and relevant federal experts at your earliest convenience to discuss this information request.

Sincerely,

<Original signed by>

Lisa Walls
Regional Director
Pacific and Yukon Region
Canadian Environmental Assessment Agency

Attachments: Annex 1: Letter from Fisheries and Oceans Canada to the Agency, March 15, 2016
Annex 2: Letter from Natural Resources Canada to the Agency, March 15, 2016

c.c.: Pacific NorthWest LNG Technical Working Group Members

Annex 1 **Letter from Fisheries and Oceans Canada to the Agency, March 15, 2016**

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Fisheries and Oceans Canada | Pêches et Océans Canada

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Vancouver, British Columbia
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March 15, 2016

Your file *Votre référence*
CEAA: 80032

Our file *Notre référence*
13-HPAC-PA6-00004

Catherine Ponsford
Project Manager
Canadian Environmental Assessment Agency
Pacific and Yukon Regional Office
410-701 Georgia Street West
Vancouver, BC V7Y 1C6

Dear Ms. Ponsford:

Subject: DFO Comments on the Agencies March 2nd and 7th, 2016 Information Requests for the Pacific Northwest LNG Project.

Please refer to your March 2nd and March 7th e-mails to Fisheries and Oceans Canada (DFO) requesting advice on the draft environmental assessment report. Specifically, the March 2nd e-mail requested a DFO response on three specific issues of concern and the March 7th e-mail requested feedback on the Proponent's comments and recommended amendments to the draft EA report conditions. DFO has completed its review of these issues with detailed responses provided as an attachment to this letter (Appendix 1).

In undertaking the review of the Proponent's information, DFO Science was requested to provide specialist advice on the comments relating to the 3D Model and marine mammals. Conclusions of the Science advice are provided in Appendix 1. The full text of the science advice, including the context and analysis for: issues relating to the 3 D model is provided in Appendix 2; issues relating to marine mammals and the new information provided by the Proponent and Prince Rupert Port Authority is provided in Appendix 3; and issues relating to CEAA EA Draft Condition 6.12.4 is provided in Appendix 4.

Background:

DFO's comments in this letter and Appendix 1 are predicated on the importance and significance of fish habitat features found within and adjacent to the project site. The importance of this habitat was reiterated in the Department's May 29th, 2015 submission to the Agency in refuting the Proponent's low value characterization of the available

habitat at the project site. The Skeena watershed is one of the largest and most diverse wild salmon watersheds in the world, and is of great importance to commercial, recreational, and Aboriginal fisheries. All five Pacific salmon species (Chinook, chum, coho, pink and sockeye) are found in the Skeena, with the Skeena being second only to the Fraser River in its capacity to produce sockeye salmon.

The project area is not only important for fish, but is highly utilized by marine mammals. Harbour Porpoises, Dalls Porpoises, Harbour Seals, Stellar Sea Lions and Northern Killer Whales are observed feeding within the Project Area year round. Marine mammal abundance substantially increases within the area during eulachon and herring migrations. These migrations also draw additional species such as Humpback whales into the area.

Federal and Provincial biological inventory and mapping initiatives, Pacific North Coast Integrated Management Area Atlas (PNCIMA) and British Columbia Marine Conservation Analysis (BCMCA), have determined that the Local Assessment Area (LAA) (Chatham Sound) is an ecologically and biologically significant area, one of 14 identified within PNCIMA and one of the 3 identified along the PNCIMA mainland coast. The BCMCA specifically details the PNW Project Development Area (PDA) as highly important for marine estuarine plants with only the Fraser River estuary comparing to its biological importance along the BC coast. Inventory and mapping initiatives have also indicated that the LAA and PDA are of high importance to critical life stages of Pacific salmon, eulachon, herring, smelt, sand lance, Dungeness crab, flat fish, invertebrates (prawn, shrimp, krill) and marine mammals.

Harbour Porpoise Risk Categorization:

DFO Science was requested to review and comment on the updated information on Harbour Porpoises as provided by the Proponent and the Prince Rupert Port Authority (PRPA). Based on the review of this information, it remains DFO's position that the displacement of individuals from concentrated areas adjacent to the proposed pile driving activities could have significant consequences for Harbour Porpoises at the population level. It is thus reasonable to conclude that the proposed pile driving works pose a high risk of significant adverse residual effects to Harbour Porpoise.

Hydrodynamic Modeling:

DFO Science was requested to undertake a review of the information provided by the Tsimshian Environmental Stewardship Authority and by Lax Kw'alaams on the Proponent's 3D hydrodynamic modelling. DFO's full analysis and conclusions of this review can be found in Appendix 2. The following provides a summary of some of the key observations and recommendations arising from the DFO Science review.

- Recent data shows evidence that the currents from the Delft-3D simulations are much smaller than observed over the shallow part of Flora Bank, representing a

30%-50% margin of error. This is larger than the uncertainty of 20-40% estimated in DFO (2016).

- The advice that DFO previously provided on the potential impacts of the SW Tower and SW Anchor Block with respect to scour, total suspended solids, and changes in currents in the vicinity of the structures, does not need to be revised in light of this new information as uncertainties in the currents were taken into account in developing this advice. However, should background tidal currents speeds be shown to be 40 or 50 cm/s, then the advice would need to be revised.
- DFO recommends that the Proponent undertake a systematic observation program of the currents in the vicinity of the proposed structures and over the shallow part of the bank to address concerns about whether the modeling system is simulating the currents over Flora Bank correctly.
- Given the high likelihood that the vessels at berth will impact the waves and the currents between the berth and Flora Bank, DFO recommends that a comprehensive modelling effort be undertaken to quantitatively assess the magnitude of the changes. This will enable an assessment of whether the vessels at berth could materially affect the model predictions of sediment movement on and off of Flora Bank.
- DFO recommends that the Proponent provide additional details on the marine terminal, in particular the berths, and their piling structure, to determine whether a different value of the porous plate loss coefficient would be more appropriate.
- Should the modeling assessment of the potential impacts of the LNG carriers at berth be shown to have a significant impact on the waves and currents in the vicinity of the rocky outcrops, DFO recommends that the rock outcrops be assessed as part of the hydrodynamic model.

Uncertainties in Relation to In-water Works:

The Proponent's comments on the draft conditions, has resulted in the identification of several new areas of uncertainty which should be taken into consideration when determining the potential adverse effects on fish and marine mammals. These areas of uncertainty include: the duration of the in-water works; the hours of operation of in-water works; intensity of construction activities, including the types and number of vessels operating; and the absence of information on potential effects of lights during night time operations.

Regarding the length of time in-water works will be undertaken, the Proponent has provided a number of schedules over the course of the EA which are not consistent. The December 2014 EIS Addendum – Appendix G 20, provides a construction schedule with the number of support vessels required for each task. This schedule identifies the length of in water works lasting 47 months (3 years – 11 months). This schedule does recognize that some of the in water works may be undertaken simultaneously rather than sequentially which would reduce the overall length of time. The August 19th, 2015 letter from the Proponent to DFO indicates that in water works associated with the marine structure would last 21 months and in-water works for the Materials Off-Loading Facility

would last 7 months (28 months). No information is provided on whether these activities will be undertaken simultaneously or sequentially.

In relation to the hours of operation of in-water works, DFO's recommended wording for Condition 6.12.4 provided in January 2016, assumed that in-water works would only occur during the day time. In reviewing the Proponent's response to Condition 6.12.4, this assumption no longer appears to be valid as they have requested to amend this condition to allow for night time construction. Assuming a marine construction schedule of 28 months, it remains unclear at this time if night time works will be required for this entire period. Should the Proponent be working at night for the entire 28 months, this would significantly increase the intensity of the underwater noise and light which would be reflected in an increased risk to marine fish and mammals.

In considering the intensity of the works, an understanding of the types and numbers of vessels that will be operating in the marine environment at any one time is necessary. Based on Table 2.4 of Appendix G-20, should the in water works be undertaken simultaneously, there could be up to 10 scows, 10 derricks, 13 barges and 3 marine dredgers at any one time. These vessels and equipment would then be supported by a number of additional utility tugs and small craft vessels. It is uncertain if these numbers remain applicable, time of day each vessel will operate, how much light each vessel will emit, the noise generated by each vessel and potential effects each vessel will have on the environment (e.g. tug propeller wash on the shallow sand/mud environment).

As it relates to the operation of lights, the only lighting mitigation measures provided by the Proponent were for those lights which would be placed on bridge and pile supported trestle post construction. DFO is not aware of the Proponent having undertaken an analysis of the number of lighted vessels that will be operating at night, the duration of these activities and the potential interaction that may occur with between fish and the increase in light broadcasted to the marine environment (e.g. increased fish attraction to the vessels with lights and potential effects on behaviour and habitat use).

Based on the sensitivities of the site (CRA fish and marine mammals), timing and duration of the works, the combined uncertainty of the number and types of vessels and derricks operating, the effect of the lights used during operation and the cumulative increase in underwater noise, these construction activities have the potential to result in increased risk to fish and marine mammals. Due to the uncertainty and lack of information on these issues, DFO is unable at this time to quantify this increased risk.

The following recommendations would provide assistance in quantifying the risk of the construction related activities on fish and marine mammals:

- Completion of a detailed work plan identifying the duration of all in water works, and clearly identifying if the works will be completed sequentially or simultaneously.

- Clear identification of what works and activities will be undertaken at night, and the duration of night time activities in association with the overall work plan requested above.
- Identification of the type and number of vessels that will be operating on a daily and nightly basis, including scows, derricks, barges, marine dredgers, utility tugs and small craft vessels.
- A description of the noise and light propagation from these vessels operating during the day and night and potential impacts on the marine substrate.
- Impact assessment of the effects (including cumulative effects) of noise and light on the marine environment (fish, habitat and marine mammals) and physical disturbance (e.g. propeller wash in shallow areas), based on the number of vessels operating during construction, the duration of construction and the intensity of the works (e.g. 24hrs/7 days a week for 28 months).

Should you have any questions or concerns regarding the contents of this letter or attached comment, please contact Mr. Alain Magnan at alain.magnan@dfo-mpo.gc.ca or by phone at 250-756-7021.

Yours sincerely,

<Original signed by>

Cheryl Webb
Regional Director
Ecosystem Management Branch
Fisheries and Oceans Canada

Attach:
Appendix 1: DFO response to CEAA's March 2nd and 7th questions from CEAA
Appendix 2: Centre for Science Advice: Updated hydrodynamics information and questions from external participants regarding inadequacies in the modeling on the Hydrodynamics model
Appendix 3: Centre for Science Advice: Rational for FPP's evaluation of moderate to high magnitude of impact to Harbour Porpoise from the development of the new PNW LNG terminal provided by the Proponent and Prince Rupert Port Authority
Appendix 4: Centre for Science Advice: PNW LNG's proposed wording to condition 6.12.4 of the draft EA conditions

Cc: Alain (Al) Magnan, FPP, Nanaimo
Jessica Coulson, NRCan

Appendix #1

DFO response to CEAA's March 2nd and 7th 2016 Requests for Information

APPENDIX 1

DFO Response to the March 2nd and 7th Questions from CEAA:

The Canadian Environmental Assessment Agency (Agency) provided written requests to DFO on March 2nd and March 7th, 2016 to provide additional clarification on information received from the Proponent, First Nations and the Public on the draft environmental assessment (EA) report. On March 2nd the Agency requested that DFO respond to specific questions on the hydrodynamic model, loss of terrestrial insects and impacts to marine mammals. On March 7th, the request was for DFO to review and comment on the Proponent's recommended amendments to the draft EA conditions.

The following provides DFO's response to these two Agency requests. Information provided in these responses is supported by the following DFO Centre for Science Advice Pacific documents attached as follows:

- Appendix 2: Centre for Science Advice: Updated hydrodynamics information and questions from external participants regarding inadequacies in the modeling on the Hydrodynamics model
- Appendix 3: Centre for Science Advice: Rational for FPP's evaluation of moderate to high magnitude of impact to Harbour Porpoise from the development of the new PNW LNG terminal provided by the Proponent and Prince Rupert Port Authority
- Appendix 4: Centre for Science Advice: PNW LNG's proposed wording to condition 6.12.4 of the draft EA conditions

DFO Response to the March 2nd Questions from CEAA:

1) *The Agency is seeking your advice on comments submitted by the Tsimshian Environmental Stewardship Authority and by Lax Kw'alaams in December 2015 on the proponent's 3D modelling efforts described in their November 10, 2015 submission. These Aboriginal comments were sent to you on December 18, 2015, in an email from me. This request is further to my email to you of January 19, 2016 and our telephone discussions of January 12 and January 20, 2016. Does DFO have any updates to your advice of January 13, 2016, arising from consideration of these Aboriginal comments? Please include the following in your considerations:*

A. *How the presence of one or two LNG carriers at the marine berths could materially affect the model predictions of sediment movement on and off of Flora Bank.*

DFO Response to Question 1-A:

Please find attached the results of DFO's analysis on this question. The complete analysis and results are found in Appendix 2.

- Given the high likelihood that the vessels at berth will impact the waves and the currents between the berth and Flora Bank, it is recommended that there be a comprehensive modelling effort to

quantitatively assess the magnitude of the changes so that there can be an assessment of whether the vessels at berth could materially affect the model predictions of sediment movement on and off of Flora Bank.

- It is recommended that the Proponent provide additional details on the cross-sectional area blocked by the pilings of the Northern and Southern Loading Platforms and the Central Berth Platform to determine whether a different value of the porous plate loss coefficient would be required for these structures as compared to the trestle.
- DFO anticipates that it has the expertise to review the modelling approaches and results for the waves and the currents.

B. *Concerns raised by McLaren and Davies regarding the inability of the model to explain observable sand grain sizes and bedforms on Flora Bank, as well as concerns regarding the accuracy of current speeds.*

DFO Response to Question 1-B:

Please find attached the results of DFO's analysis on this question. The complete analysis and results are found in Appendix 2.

- The new ADCP data provide clear evidence that the currents from the Delft-3D simulations have appreciably smaller speeds than observed currents over the shallow part of Flora Bank.
- Roughly, the model is underestimating a 30 cm/s signal by 10-15 cm/s: a 30-50% error. This is larger than the uncertainty of 20-40% estimated in DFO (2016).
- The advice that DFO provided on the potential impacts of the SW Tower and SW Anchor Block with respect to scour, total suspended solids, and changes in currents in the vicinity of the structures, does not need to be revised in light of this new information as uncertainties in the currents were taken into account in developing this advice. However, should background tidal currents speeds be shown to be 40 or 50 cm/s, then the advice would need to be revised.
- A systematic observational program of currents in the vicinity of the proposed structures (SW Tower, Anchor Block, trestle, berthing jetties) and over the shallow part of the bank would be required to address concerns over whether the modelling system is properly simulating currents over Flora Bank. This could be accomplished with a systematic observational program of ADCP transects that captures the range of conditions encountered over the bank.
- The Delft-3D simulations were central to the long term simulations related to sediment transport and the underestimation of the currents may be important for that application. DFO does not have the expertise to comment on this issue.

APPENDIX 1

C. Concerns raised regarding the exclusion of the rock outcrops from the modelling efforts

DFO Response to Question 1-C:

Please find attached the results of DFO's analysis on this question. The complete analysis and results are found in Appendix 2.

- To support an evaluation of the likely impacts of the proposed project overall, and of the potential impacts associated with rocky outcrops, correction for the underestimate in currents (Question #1) and modelling of the impact of vessels at berth (Question #4) need to be addressed first.
- The new results can then be examined by a competent expert to assess whether the changes in the hydrodynamics in the vicinity of the rocky outcrops are sufficiently large to require an assessment of the potential changes in the sediment transport in the vicinity of the rocky outcrops.
- DFO has the capacity to review the hydrodynamics modelling and evaluate the adequacy of the modelling to describe potential impacts of the project on the hydrodynamics.

D. Concerns regarding effects of the proposed Project infrastructure (construction and operations) on Flora Bank's stability

DFO Response to Question 1-D:

Please find attached the results of DFO's analysis on this question. The complete analysis and results are found in Appendix 2.

- As noted by the numerous reviewers, careful calibration and validation of the models is required to support the use of the models for application to sediment transport problems.
- CEAA Questions #1 (magnitude of the currents) and Question #4 (vessels at berth) need to be addressed in order to improve the calibration and validation of the hydrodynamic models and to improve the representation of the potential impacts of the marine structures on the hydrodynamics of Flora Bank.
- The modelling tools used by the proponent are suitable for assessing the potential impact of the marine structures on the hydrodynamics (waves and currents), and the results can be used by NRCan and others to assess potential changes to sediment transport about Flora Bank.

2) From DFO, the Agency is seeking your advice on concerns raised by Lax Kw'alaams (see page 10 of "Lax Kw'alaams' Comments on Pacific NorthWest LNG's Response to CEAA's June 2, 2015 Letter," December 2015), T.Buck Suzuki and members of the public during the ongoing comment period regarding the removal of terrestrial insect habitat on Lelu Island and associated effects on fish on Flora Bank.
How would DFO characterize the risk to marine fish from the destruction of terrestrial habitat near Flora Bank from which terrestrial insects originate given the proponent's reported preliminary

findings of fish stomach contents? The 30m vegetation buffer around the edge of the island may be a factor in your considerations.

DFO Response to Question 2:

Recent studies undertaken by the Proponent has determined that certain species of juvenile salmonids (e.g. chum and coho) were found to have ingested a large number of terrestrial l insects. Research to date hasn't provided any information on the species of insects, where these insects originated from, or where they were ingested by the fish. There are numerous sources of terrestrial insects in the Skeena River estuary including those carried onto the marine environment from off-shore winds, insects originating from marine riparian vegetation, small tributary streams and those conveyed down the Skeena River.

The removal of terrestrial habitat from Lelu Island will result in the destruction of wetlands, small streams and patches of marine riparian that supply and transport insects and nutrients into the marine environment around Lelu Island. It is therefore anticipated that development of Lelu Island will reduce fish prey production in the immediate area. To mitigate impacts associated with the land clearing activities, the Proponent proposes to retain a 30m riparian vegetation buffer around the perimeter of Lelu Island in areas not required for access onto, or off of, the island. It is anticipated that 30 meters of unaltered vegetation will maintain riparian functions on the sections of Lelu Island adjacent to Flora Bank.

Studies provide evidence that salt marsh and upland riparian vegetation are vital ecosystem components providing detritus and habitat for salmonid food organisms (insects). The retention of 30 meters of unaltered vegetation will provide direct inputs of insects through insect drop as well as provide beach wrack (organic/plant material deposited in the upper intertidal) which will provide habitat for detritus-based insects that become available to fish during tidal events. Shorelines and terrestrial habitats surrounding Lelu Island contain several of small streams and functioning riparian areas that supply additional terrestrial prey into the habitats surrounding Flora Bank. In addition to terrestrial prey, marine fish within the area feed on a variety of food items including marine prey species that are not directly dependent on Lelu Islands terrestrial habitats and therefore are not anticipated to be impacted by terrestrial habitat removal.

The availability of terrestrial prey from the 30m vegetated buffer surrounding Lelu Island combined with terrestrial prey from surrounding shorelines, small streams, marine prey and the Skeena River will reduce the risk of marine fish being impacted by the reduction of prey production associated with the removal of terrestrial habitats from Lelu Island.

3) *The Agency is seeking your advice regarding conclusions of effects to harbour porpoise. To date, the Agency has received the following preliminary comment from PRPA:*

> *"Following review by an external expert in the evaluation of cetaceans in environmental assessments, PRPA is of the view that the significance conclusion does not meet the Agency's own criteria as defined section's 11.2 and 11.3 of the EA Report and as defined within the respective CEAAgency Operational Policy Statement. Specifically, the scientific rationale for the Agency's prediction of a moderate to high magnitude of effect to Harbour Porpoise is not justified. In consideration of the overall population and habitat abundance of the pacific population of the Harbour Porpoise1, the Agency's conclusion regarding the magnitude of the effect and its significance is questionable. If the CEAAgency cannot clearly substantiate its opinion on the magnitude of the project effects to harbor porpoise abundance and habitat availability, the significance evaluation should be re-evaluated."*

The Agency expect to receive this external review from PRPA on March 4, as well as new information from the proponent, both questioning the Agency's conclusions regarding significant adverse effects to harbour porpoise. We will send those reports to you upon receipt.

A. *Does DFO still advise that given the susceptibility of harbour porpoises to underwater noise, the extensive use of the Project development area by harbour porpoises, and the uncertainty regarding availability of suitable alternative habitats, the proposed pile driving works pose a high risk of significant adverse residual effects to harbour porpoise?*

DFO Response to Question 3-A:

Please find attached the conclusions of DFO's analysis on this question. The complete analysis and conclusions are found in Appendix 3.

Given the evidence that Harbour Porpoises respond to pile driving noise at lower received sound levels and thus at greater distances than estimated in Stantec (2014), plus the uncertainty in the effectiveness of bubble curtain mitigation, it is probable that the zones of potential disturbance could encompass the majority of areas of highest porpoise densities observed and modelled in Stantec (2016). These areas also include the locations where large aggregations of Harbour Porpoises form in winter and spring (BCCSN). Disturbance caused by pile driving noise levels in this zone may well result in the displacement of Harbour Porpoises from this important habitat. Although Harbour Porpoises can be found in other areas within Chatham Sound, densities tend to be low compared to the waters south of Digby Island and surrounding Ridley and Lelu islands. This suggests these areas are lower quality or marginal habitat and would be unlikely to support a large influx of animals should pile driving cause displacement from high density habitat. Evidence suggests that Harbour Porpoises can show strong site fidelity and tend not to undertake large scale movements, at least in northeast Pacific coastal waters. Thus, it is uncertain whether coastal areas beyond Chatham Sound would be occupied by displaced animals or if sufficient suitable habitat exists in such areas. Although Harbour Porpoises displaced from habitats by noise for

periods of relatively short periods of hours or days have been documented to return after noise cessation, reoccupation can be fairly slow (e.g. Brandt et al. 2013; Thompson et al. 2013). Pile driving activity in the proposed development area is likely to be continuous for at least 21 months (EIS Addendum, December 2014, Appendix G.20 and Chapter 2, Project Description), thus potential displacement from important habitat could be as long as two years, which could have a significant detrimental effect on the viability of the Harbour Porpoise population in the area. If and when Harbour Porpoises would return to these areas following such a prolonged displacement is uncertain.

In summary, displacement of animals from concentration areas adjacent to the proposed pile driving activities could have significant consequences for Harbour Porpoises at the population level. It is thus reasonable to conclude that the proposed pile driving works pose a high risk of significant adverse residual effects to Harbour Porpoise.

B. *Does DFO agree with the characterization in the Agency's draft Environmental Assessment Report (see pages 78, 170, 178) of the magnitude of residual effects to harbour porpoise as "a measurable change in marine mammal abundance outside the range of natural variability, major changes to habitat quality or quantity or behaviour change that effects important life processes" and that such an effect would be significant given the listing under SARA of harbour porpoise as a species of special concern?*

DFO Response to Question 3-B:

Based on the information provided in the response to the question above, the Canadian Environmental Assessment Agency's (CEAA) characterization of the magnitude of resident effects to Harbour Porpoise appears to be accurate. Further, their conclusion in the EA report on page 78, that "the Project is likely to cause significant adverse environmental effects to harbour porpoise, given its susceptibility to behavioural effects from underwater noise, its current at risk status, its extensive use of the Project area year-round, and the uncertainty of suitable alternative habitat" is consistent with the information provided above and is thus reasonable.

DFO Response on the Proponent's Comments to the Draft EA Conditions:

Condition 6.1:

PNW LNG's Suggested Revision:

> *The Proponent shall **i)** identify, prior to the start of in-water construction activities, to the satisfaction of Fisheries and Oceans Canada and following consultation with Aboriginal groups and other relevant federal authorities, **the mitigation measures, which may include** timing windows of least risk for in-water construction activities to protect marine fish, including marine mammals, during sensitive life stages, **that will be implemented during in water construction** and **ii)** notify the Agency and Aboriginal groups of the **identified mitigation measures that meet specified thresholds** ~~timing windows of least risk identified and the results of the pre-construction surveys supporting the identification of these mitigation techniques and timing~~*

~~windows~~ once Fisheries and Ocean Canada has indicated it is satisfied and before in-water construction activities start. In doing so, the Proponent shall:

DFO Comments and Recommendations:

Least risk timing windows are considered as one of many mitigation measures that can be applied when undertaking in water construction activities. The advantage of using timing windows is that it is a simple mitigation measure to implement which ensures protection of fish and fish habitat during sensitive life stages such as spawning and incubation periods. However, in some situations, it has been shown that with implementation of additional and more robust mitigation measures, works can proceed outside of the timing windows with a reduced risk to fish and fish habitat.

DFO concurs with the proponent's comments that the purpose of this condition was not to limit all in water works to the least risk timing windows. DFO proposes the following edits (in red) to Condition 6.1 as previously edited by the Proponent:

> 6.1 The Proponent shall ***i)*** identify, prior to the start of in-water construction activities, to the satisfaction of Fisheries and Oceans Canada and following consultation with Aboriginal groups and other relevant federal authorities, ***the mitigation measures, which may include*** timing windows of least risk for in-water construction activities to protect marine fish, including marine mammals, ~~during sensitive life stages~~, ***that will be implemented during in water construction*** and ***ii)*** notify the Agency and Aboriginal groups of the ***identified mitigation measures that meet specified thresholds*** ~~timing windows of least risk identified and the results of the pre-construction surveys supporting the identification of these mitigation techniques and timing windows~~ once Fisheries and Ocean Canada has indicated it is satisfied and before in-water construction activities start. In doing so, the Proponent shall:

DFO Rational for recommended change: Mitigation measures are required to protect all life stages of fish and marine mammals, not just sensitive life stages.

Condition 6.6:

PNW LNG's Suggested Revision:

> *The Proponent shall use coffer dams to isolate the south-west tower block and anchor block work areas during in-water construction activities and* ***scour protection around the coffer dams may be incorporated as required when monitoring reveals the potential for unacceptable scour.*** *The coffer dams shall be shaped in a manner that minimizes scour and turbulence around the south-west tower block and anchor block of the suspension bridge.*

DFO Comments and Recommendations:

DFO's advice on this recommended condition was based on the results of the 3D model which indicated that without any type of scour protection, erosion at the base of the SW Tower and Anchor Block could be significant. Page 148 of the Hatch report predicts that erosion, over a 28 day freshet condition, without scour protection, would be approximately 2.6 m at the SW Anchor Block and 0.6 m at the SW Tower. With scour protection, this erosion would be significantly reduced to 0.05 m for the SW Anchor

Block and 0.13 m for the SW Tower. These predictions were based on a rectangular design for both the SW Anchor and SW Tower. Additional modeling indicated that with the use of a round structure, erosion around these two structures was considerably reduced.

At this time it is unknown if the coffer dams will be round or square in nature. In addition, it is unknown how large the coffer dams will be and what affect this structure will have on erosion. With a potential erosion rate of 2.6 m over a 28 day period, DFO is of the opinion that this represents an unacceptable risk to Flora Bank and Flora Bank eelgrass and as such, an adaptive management approach as recommended by the proponent's rewording of this condition is not appropriate.

However, as there remains uncertainty with erosion associated with a round structure, and the actual size of the coffer dam, DFO would be supportive of the proponent undertaking additional high resolution modeling as a basis for determination if scour protection was required. Should the modeling confirm that installation of the coffer dam, without scour protection, would not exceed the erosion rate of 0.05 m for the SW Anchor Block and 0.13 m for the SW Tower, DFO would support the Proponent's recommendation that scour protection not be required during construction. Based on this recommendation, DFO provides the following edits (in red) to Condition 6.6:

> 6.6 The Proponent shall use coffer dams to isolate the south-west tower block and anchor block work areas during in-water construction activities. The coffer dams shall be shaped in a manner that minimizes scour and turbulence on the substrate. In order to protect Flora Bank from increased turbidity and sediment deposits during the construction phase, the Proponent shall undertake the following mitigation measures to minimize erosion of the substrate:
>
> a) Scour protection shall be placed around the coffer dams extending a minimum of 10 m from the edge of the SW Anchor and 15 m from the SW Tower; or
>
> b) The Proponent can undertake additional high resolution modeling substituting the exact shape and size of the coffer dams with the rectangular structures previously used. Should the high resolution modeling indicate that the coffer dams structure result in erosion rates of 0.05 m or less for the SW Anchor Block and 0.13 m or less for the SW Tower, then the use of scour protection would not be required. Should the modeling indicate that scour protection is not required for the construction phase of the project, monitoring of erosion and total suspended solids would still be required.

Condition 6.8:

PNW LNG's Suggested Revision:

> *The Proponent shall use impact installation methods only when seating piles into bedrock* ***or when the use of vibratory hammers is not otherwise technically and economically feasible.*** ~~*and*~~ *Impact hammers shall be* ~~*constructed of*~~ ***shrouded in*** *sound absorbent material.*

APPENDIX 1

DFO Comments and Recommendations:

The recommendation for the use of vibratory hammers is to reduce potential impacts to fish and marine mammals in the project area. DFO has no objections to the use of impact hammers when the use of vibratory hammers is not technically feasible. However, DFO has concerns with the recommended wording of not using vibratory hammers if it is not economically feasible. Rational being that there are no clear guidelines provided as to what constitutes "economically feasible". Based on the habitat value of project area, the high use of the area by marine mammals, the potential for significant effects to a SARA listed species, working year round, it is DFO's opinion that the Proponent must undertake robust and significant mitigation measures which would cost more than if this project were to occur in less sensitive habitats. Consequently, until such time as a definition is provided for "economically feasible", DFO does not support the recommended changes to Condition 6.8.

Shrouding the impact hammer with sound absorbent material could potential have benefits in reducing noise generated in the ambient air. However, this mitigation measure would likely have very limited effect on reducing underwater noise as the noise in the marine environment is transmitted via the steel pilings. As such, DFO has no objections with the Proponent's recommended wording on shrouding of the impact hammers.

Based on the above noted comments, DFO proposes the edits (in red) to Condition 6.8 as previously edited by the Proponent:

> 6.8 The Proponent shall use impact installation methods only when seating piles into bedrock ***or when the use of vibratory hammers is not otherwise technically*** ~~***and economically***~~ ***feasible.*** ~~and~~ Impact hammers shall be ~~*constructed of*~~ ***shrouded in*** sound absorbent material.

Condition 6.9

PNW LNGs Suggested Revision:

> *The Proponent shall,* ***where technically and economically feasible,*** *use bubble curtains and isolation casings when conducting impact pile driving activities and sub-tidal blasting* ***where underwater pressure levels have the potential to exceed 30 kilopascals during impact pile driving or 100 kilopascals during sub-tidal blasting.***

DFO Comments and Recommendations:

The proponent's recommended wording does not take into consideration the fact that the pile driving will be undertaken in a location of high fish and marine mammal usage and as such requires the highest level of mitigation to be employed. With DFO's significance determination on Harbour Porpoises it will be necessary to apply significant effort on mitigation measures for all aspects of this project. As the effect of bubble curtains is significantly reduced in high current areas, it will be necessary to ensure that additional mitigation measures are in place at all times. Based on the above noted information, DFO does not support the Proponent's recommended wording and would request that the original wording as defined by CEAA in Condition 6.9 be maintained.

APPENDIX 1

Condition 6.12.4
PNW LNG's Suggested Revision:

> *6.12.4. ~~conducting~~ **commencing** in-water construction activities identified in 6.12.1 only after marine mammal observers are able to conduct the observations referred to in 6.12.3.*

DFO Comments and Recommendations:
The following provides DFO's conclusions on the Proponent's recommended wording for Condition 6.12.4. The complete Science analysis and conclusions are found in Appendix 4.

Behavioural avoidance responses by Harbour Porpoises to pile driving noise leading to displacement from habitat adjacent to construction operations may occur at received sound levels as low as of 130–140 dB re 1 µPa (rms). It is thus unlikely that animals would remain in or enter an area ensonified by pile driving noise to received levels of 160 dB 1 µPa (rms) or higher. However, it would be precautionary to maintain mitigation as described in draft conditions 6.12 to avoid the risk of injury should individuals become exposed to high sound pressure levels. However, given the low probability of individuals being present in or entering an exclusion zone based on a 160 dB 1 µPa (rms) isopleth after pile driving has commenced, continuation of pile driving in situations where the exclusion zone is not visible to the marine mammal observer (e.g., at night or in fog) would pose a relatively low risk. As a result, protection of individual Harbour Porpoises and other marine mammals from injury with the suggested changes to 6.12.4 would likely be adequate.

There is considerable uncertainty in the effectiveness of pile driving noise mitigation and the cumulative noise levels from multiple pile drivers operating concurrently. Underwater noise monitoring once pile driving operations commence would determine source noise levels and the effectiveness of proposed bubble curtain mitigation, as well as sound pressure levels over the ensonified area. Alternative methods of reducing the noise generated by vibratory or impact hammer pile driving could be explored and utilized especially if the proposed bubble curtain mitigation proves ineffective at attenuating noise to expected levels. Acoustic monitoring before and during pile driving operations could determine if Harbour Porpoises are present within the exclusion zone or at greater ranges from the pile driving site. Monitoring systems could be used to detect Harbour Porpoises during pile driving operations and mitigate the risk of physical injury should individual porpoises enter the area of high intensity noise. The deployment of arrays of acoustic systems that can detect and record the high-frequency echolocation clicks from Harbour Porpoises could be used to determine, with an appropriate signal processing algorithm of proven performance, the presence or absence, range and direction of Harbour Porpoises at various distance from pile driving activities. The use of this mitigation measure is recommended.

Based on the above noted comments, DFO proposes the edits (in red) to Condition 6.12.4 as previously edited by the Proponent:

> *6.12.4. ~~conducting~~ **commencing** in-water construction activities identified in 6.12.1 only after marine mammal observers are able to conduct the observations referred to in 6.12.3. In order to*

confirm the absence of Harbour Porpoises within the marine mammal exclusion zones during night time and low visibility conditions, the Proponent shall deploy and monitor arrays of acoustic systems that can detect and record the high-frequency echolocation clicks from Harbour Porpoises, with an appropriate signal processing algorithm of proven performance.

Condition 6.12.5

PNW LNG's Suggested Revision:

Stopping or not starting the in-water construction activities identified in condition 6.12.1 ***if a cetacean (of any species or status) or a member of another species of marine mammal (if listed under SARA)*** *is observed in the safety radius by the marine mammal observers referred to in condition 6.12.3 and not re-starting the in-water construction activities identified in condition 6.12.1 until the animal has moved out of the safety radius* ~~***and***~~ ***or no cetacean (of any species or status) or other marine mammal species (if listed under SARA)*** *have been observed in the safety radius for a period of at least 30 minutes; and*

DFO Comments and Recommendations:

The intent of this condition is to ensure that the Proponent implements appropriate mitigation measures for the protection of all marine mammals including cetaceans (whales, porpoises and dolphins) and pinnipeds (seals and sea lions). Specifically, the condition as written was to ensure that the Proponent did not contravene Section 7 of the Marine Mammal Regulations which states: "*No person shall disturb a marine mammal except when fishing for marine mammals under the authority of these Regulations*." (Marine Mammal Regulations, 2015).

The Proponent's recommended wording would limit protection of marine mammals to cetacean's and SARA listed species. As the Marine Mammal Regulations do not specify that the prohibition only applies to cetacean's and SARA listed species, amending the wording as recommended by the Proponent would place them in non-compliance with these regulations. Consequently, DFO does not support the Proponent's recommended wording and recommends that the original wording as proposed by the Agency remains unchanged.

Condition 6.12.6

PNW LNG's Suggested Revision:

Implementing mitigation measures, including ***but not limited to*** *sound dampening technology and soft-start procedures to reduce underwater noise levels in the safety radius referred to in condition 6.12.2.*

DFO Comments and Recommendations:

DFO has no objections to the Proponent's suggested wording for Condition 6.12.6 as it allows for additional mitigation measures, including the use of sound dampening technology and soft-start procedures.

APPENDIX 1

Condition 6.16

PNW LNG's Suggested Revision:

The Proponent shall use tugs that produce the least possible scour volumes from propeller action ***during operations.***

DFO Comments and Recommendations:

DFO concurs that the use of Voith-Schneider propulsion system was intended as a mitigation measure for operation of the facility and not for construction. However, the use of regular tugs on or near Flora Bank during construction has the potential of creating increased erosion, elevated levels of turbidity and disturbance to eelgrass beds. It is anticipated that potential mitigation measures associated with the use of tugs during construction can be identified within a Construction Environmental Management Plan (CEMP) prior to commencement of construction. Mitigation measures would include avoidance of any tug travel directly over Flora Bank below certain tide levels, monitoring of effects of tugs, water quality sampling, etc. Development of a CEMP will be a requirement of a *Fisheries Act* Authorization. Based on the above noted information, DFO does not have any objections to the Proponent's recommended wording.

APPENDIX 2

DFO Centre for Science Advice Pacific

Science response to CEAA request re: updated hydrodynamics information and questions from external participants regarding inadequacies in the modeling

Centre for Science Advice Pacific

Non-CSAS Rapid Science Response

Request Information

Request Contact:	**Al Magnan**	Project Type/Fishery:	**LNG**
Requesting Branch	**EMB**	Requesting Program	**FPP**
Advice Title	Science response to CEAA request re: updated hydrodynamics information and questions from external participants regarding inadequacies in the modelling		
Date of request:	**March 3, 2016**	Project footprint:	
Region of proposed impact:	**Skeena Estuary**	Habitat Type:	**Estuarine/Shallow Marine**
Relevant species:			
Date required:	**March 14, 2016**	Request #:	**RSR2016-05FPP_PNW**

Overview

Pacific NorthWest Liquid Natural Gas (PNW LNG) is proposing to construct a large scale liquefied natural gas (LNG) export terminal within the Skeena River estuary, which will require dredging, blasting and pile driving to construct a suspended trestle and terminal berths. On April 8, 2013 the Canadian Environmental Assessment Agency (the Agency) issued a Notice of Commencement for the environmental assessment of the PNW LNG project located on Lelu Island, BC.

The Environmental Impact Statement (EIS) and Addendum submitted by PNW LNG to the Canadian Environmental Assessment Agency (CEAA) on 28 Feb 2014 and 12 Dec 2014, respectively, provided information with regard to potential effects of marine operations and marine structures upon the sea bed and habitat at Agnew and Flora Banks. The Addendum also provided detailed responses to Information Requests posed by the Government of Canada in regard to sediment deposition; including a report that provides a sediment transport and deposition analysis that utilized 2D models (e.g., USCGA CMS and PTM) conducted by PNW LNG's marine engineering consultant, Hatch.

Two CSAS Science Responses have been developed in support of DFO's participation and input to CEAA during the Environmental Assessment for Pacific NorthWest (PNW) liquefied natural gas (LNG) project proposed near Lelu Island, in the Skeena Estuary, British Columbia. The first Science Response outlined key deficiencies in the draft hydrodynamics modelling provided by PNW LNG, and the second Science Response provided advice regarding whether or not the deficiencies had been adequately addressed, it also identified outstanding uncertainties, evaluated PNWLNG conclusions, and provided recommendations to FPP regarding potential monitoring and mitigation options.

CEAA subsequently received feedback through the EA consultation process that prompted a further request for DFO expert advice to assist in finalizing the environmental assessment report and potential conditions.

To prepare this response, Science experts in DFO reviewed the following documents:

- Hatch. 2015b. Pacific Northwest LNG Supplemental Modelling Report for 3D Modelling Update, H345670-0000-12-124-0013, Rev.0, November 10, 2015.
- McLaren, P, Dec 3, 2015. An assessment of the "Supplemental Report for 3D Modelling Update" prepared by Hatch for PNWLNG November 10, 2015
- McLaren, P., 2016. The Environmental Implications of Sediment Transport in the Waters of Prince Rupert, British Columbia, Canada: A Comparison Between Kinematic and Dynamic Approaches. *Journal of Coastal Research.*

- Townend, I. Dec 1, 2015. Review of Hatch report entitled: "Pacific Northwest LNG, 3D modelling Update, Supplemental Modelling Report 16/9/15, Rev C"
- PGL Environmental Consultants Ltd. Dec 15, 2015. Expert Review – Pacific NorthWest LNG (PNWLNG) Supplemental Modelling Report

1ST QUESTION

Context:

Based on comments CEAA received through consultation with Aboriginal groups and the current public comment period, DFOs advice was requested to assist CEAA in finalizing the environmental assessment report and potential conditions.

Question:

Does DFO have any updates to your advice of January 13, 2016, arising from consideration of concerns raised by McLaren and Davies regarding the inability of the model to explain observable sand grain sizes and bedforms on Flora Bank, as well as concerns regarding the accuracy of current speeds?

Importance: ☐ Essential ☐ Important ☐ Desirable

SCIENCE RESPONSE

Background

Documents considered:

- PGL Environmental Consultants Ltd (2015) – in particular the appendix by Dr. Davies dated 11 December 2015
- Notes from the Tsimshian Environmental Stewardship Association (TESA) / Hatch Meeting on Dec 04, 2015 (file name: TESA-Hatch-PNWLNG-follow-up-Rev0.docx), including ocean currents data collected by STANTEC over Flora Bank.
- Tsimshian Environmental Stewardship Association (TESA) presentation provided to CEAA meeting on 4 March, 2016
- Hatch. 2015a. 3D Modelling of Potential Effects of Marine Structures on Site Hydrodynamics and Sedimentation. H345670-0000-12-124-0012, Rev. 0, May 5, 2015.
- Hatch2015b
- Hatch, 2014a. Appendix of the Addendum to the Environmental Impact Statement for PNW LNG: Potential Impacts of the Marine Terminal Structures on the Hydrodynamics and Sedimentation Patterns Project Memo H345670. November 25, 2014. H345670-0000-12-220-0028, Rev. A
- DFO. 2016. Technical review of final 3D modelling - potential effects of marine structures on site hydrodynamics and sedimentation from the construction of the Pacific Northwest liquefied natural gas terminal. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/007.

Additional information:

- Ocean currents data collected by STANTEC over Flora Bank were not included in the Hatch 2015b document which formed the basis of DFO's review of the Proponent's final 3D modelling (DFO 2016).
- The data shown in the TESA presentation were acquired from a single Acoustic Doppler Current Profiler (ADCP) transect over Flora Bank conducted on 23 February 2015, during a flood tide. There is also a histogram of current magnitudes which shows that the speeds are less than 30 cm/s for 65% of the time (and thus > 30 cm/s 35% of the time).
- In the PGL report, the following observations are made:
    - Based on interpretation of the histogram only (Dr. Davies notes that he did not have access to the actual data), currents over the top of the bank are greater than 30 cm/s and thus the proponent's claim that the currents over the bank are 25-30cm/s underestimates the real currents.

- Fig 5-20 (Hatch 2015b) shows that the simulated currents from the Delft3D model at a location to the east of the large marine structures are systematically less than 25 cm/s.
- Currents over Flora Bank were larger in the modelling report in Hatch (2014a) based on the Coastal Modelling System (CMS).

- Slide 16 of the TESA presentation of 4 March 2016, shows HATCH results comparing the observed currents and model currents on the top of the Flora Bank. The observed currents are about 30 cm/s on the top of the bank (range of roughly 25-35 cm/s; between distances 0 to 1500 m), however the model simulations for those locations and time period show currents in the range 10-20 cm/s.
- The observed currents then decrease between 1500 m to 2000 m and then increase to 60 cm/s from 2200 m to 2500 m. This large increase occurs as the transect proceeds off the top of the bank to the east of Kitson Island.
- Slide 15 of the TESA presentation of 4 March 2016 shows the results of a LIDAR survey that indicates the water depths used in the modeling may be too shallow in some places (up to 3 m near Kitson Island).

Slide 16 from the TESA presentation is presented here.

B. Water current data are presently insufficient to confirm current velocities over Flora Bank. A small set of ADCP data collected by Stantec, but not used in calibration/verification, suggests that currents over Flora Bank are higher than those used to calibrate the model. Critically, the currents observed from the Stantec data set suggest that currents exceed 0.3 m/s (identified by the red line added to the power point slide in Figure 2). This velocity is the general threshold above which currents are able to transport sediment. This suggests that the model may under-estimate sediment movement (accretion/erosion) which may, in turn, lead to an underestimation of effects.

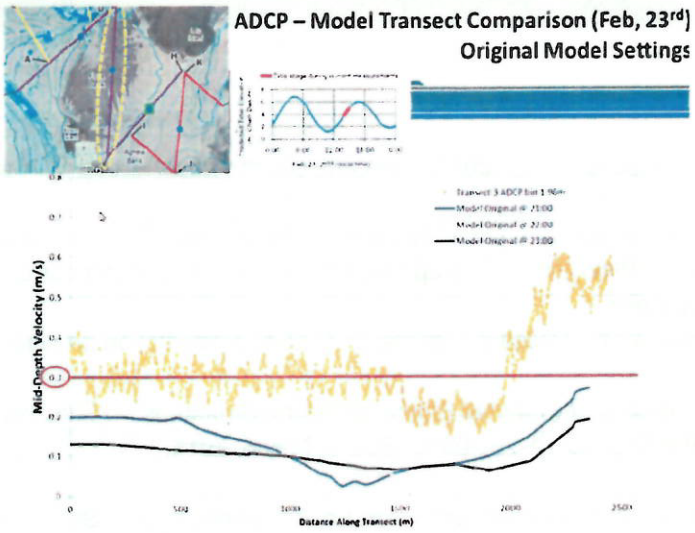


Figure 2 - comparison of model predictions for current velocity (black, grey, and blue lines) with ADCP data (yellow points). Source: PowerPoint presentation, Feb. 10, 2016). Note: the red line has been added by PGL for reference.

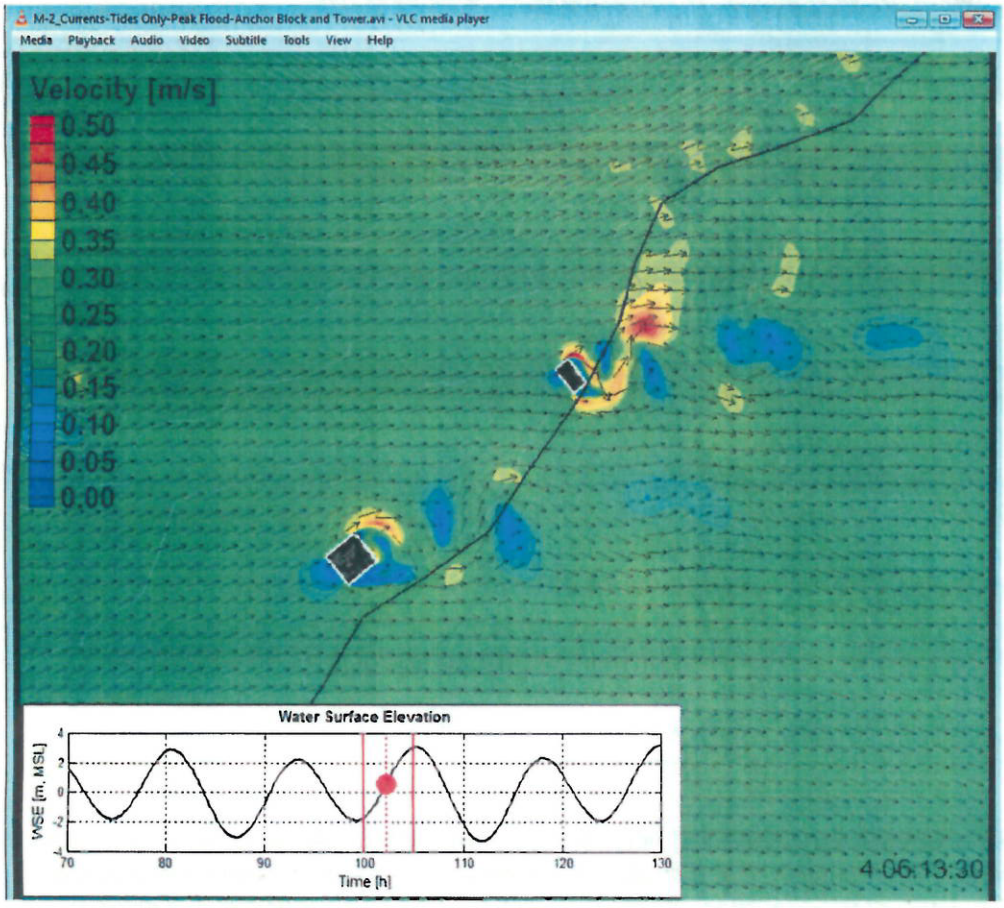
Analysis

- From TESA slide 16, we conclude that the observed flood tide currents on top of Flora Bank were about 25-35 cm/s on February 23, 2015 and that the simulations (10-20 cm/s) underestimate the currents at this time and place.
- Error estimates for the currents would allow an assessment of whether the significant amount of small scale variability in the observed data was a product of sampling error or an actual environmental signal.
- The winds measured at Holland Rock were very weak, 1-4 km/hr, at the time the observations were made (between 1 pm and 4 pm local time). Based on a rule of thumb that wind-driven currents are about 3% of the winds speed, wind-driven currents are estimated to be 1-3 cm/s. This is insufficient to account for the difference between the simulated and observed currents.
- A key consideration is whether this single observation is sufficiently representative to conclude that the model is systematically underestimating the currents over Flora Bank.
- Appendix K (Hatch 2015b) provides time series of depth-average speeds at 9 locations on Flora Bank

(Figures K-2 to K-10). These can be broadly characterized as having daily maxima in the range 15- 25 cm/s with occasional peaks up to 35-40 cm/s. Tidal current magnitudes show a strong variation over the 29 dayspring/neap cycle).

- Figures K-24 and K-26 from the Hatch (2015b) show a comparison of current speeds from a Delft3D simulation and a MORPHO simulation over 30 day period from 11 May to 10 June. These results also indicate daily maximum tidal currents in the range 10-25 cm/s, with occasional larger values.
- Overall these modelled current speeds are broadly consistent with the model results shown in TESA slide 16 above.
- Accordingly, the results from TESA slide 16 appear to provide a reasonable estimate of the differences between the observed and modelled currents over Flora Bank during a period dominated by tidal currents.
- The figure in TESA slide 15 shows that the older bathymetry is about 1 m shallower than the new LIDAR result. The 3 m discrepancy occurs in a small area near Kitson Island. This could affect bottom friction and current speeds over the bank in the model. Simulations with the new bathymetry would provide an indication of how sensitive the model results are to uncertainties in water depth in this area where the water is generally quite shallow.

The advice that DFO provided on the potential impacts of the SW Tower and SW Anchor Block (DFO 2016), was largely based on the high resolution simulations using the MORPHO model. A snapshot of the simulated current field during flood tide with the SW Tower and SW Anchor Block in place is provided below.



The figure shows tidal currents of 20-30 cm/s (green) over much of Flora Bank. One can also see eddies being shed from the two marine structures (the blues and the yellow/red).

Levels of total suspended solids and current magnitudes near the structures will increase if the background currents increase. However the advice respected the fact that there is uncertainty in the modelling.

Advice

- The new ADCP data provide clear evidence that the currents from the Delft-3D simulations have appreciably smaller speeds than observed currents over the shallow part of Flora Bank.
- Roughly, the model is underestimating a 30 cm/s signal by 10-15 cm/s: a 30-50% error. This is larger than the uncertainty of 20-40% estimated in DFO (2016).
- The advice that DFO provided on the potential impacts of the SW Tower and SW Anchor Block with respect to scour, total suspended solids, and changes in currents in the vicinity of the structures, does not need to be revised in light of this new information as uncertainties in the currents were taken into account in developing this advice. However, should background tidal currents speeds be shown to be 40 or 50 cm/s, then the advice would need to be revised.
- A systematic observational program of currents in the vicinity of the proposed structures (SW Tower, Anchor Block, trestle, berthing jetties) and over the shallow part of the bank would be required to address concerns over whether the modelling system is properly simulating currents over Flora Bank. This could be accomplished with a systematic observational program of ADCP transects that captures the range of conditions encountered over the bank.
- The Delft-3D simulations were central to the long term simulations related to sediment transport and the underestimation of the currents may be important for that application. DFO does not have the expertise to comment on this issue.

Responder: Charles Hannah Responder: Patrick Cummins

2ND QUESTION

Question:

Does DFO have any updates to your advice of January 13, 2016, arising from consideration of concerns raised regarding effects of the proposed Project infrastructure (construction and operations) on Flora Bank's stability?

Importance: ☐ Essential ☐ Important ☐ Desirable

SCIENCE RESPONSE

Background

Document considered:

- McLaren (2016). The Environmental Implications of Sediment Transport in the Waters of Prince Rupert, British Columbia, Canada: A Comparison Between Kinematic and Dynamic Approaches. *Journal of Coastal Research*.
- PGL Environmental Consultants Ltd (2015) – in particular the appendix by Dr. Davies dated 11 December 2015
- Tsimshian Environmental Stewardship Association (TESA) presentation provided to CEAA meeting on 4 March, 2016

Additional Information:

- McLaren (2016) describes a conceptual model of the proposed trestle and berthing jetties in order to assess their potential impacts on sediment transport. In this model, all of the pilings supporting these structures are assumed to be arranged in a linear fashion such that their combined width produces a barrier that extends for 547 metres. Such a barrier would create a shadow zone shielding a substantial fraction of Flora Bank (nearly 75% of the length of the low water line defining the bank).
- McLaren (2016) acknowledges that this model ignores the actual arrangement of the pilings.

- McLaren (2016) states that DFO reviews have assumed that numerical (dynamic) modelling is an approach that is suitable for assessing the potential impacts of the proposed structures.
- DFO notes that the review of PGL (2015) affirmed that the proponent is using appropriate numerical modelling tools to assess the potential impact of the structures.

Analysis

- DFO's comments are limited to the validity of model predictions of perturbations to waves and currents in the vicinity of Flora Bank.
- Were the pilings to be arranged in a linear fashion as described in McLaren (2016), substantial impacts on the hydrodynamics at the site would be expected. However, when considering the impact of the marine structures on the hydrodynamics the arrangement of the pilings is important and cannot be ignored.
- The actual design of the trestle as proposed by PNW LNG (Hatch, 2015b) is extremely porous.
- The numerical modelling approach places a substantial burden on the hydrodynamic models and their calibration and validation for local conditions.
- The reviews of PGL (2015) and Townend (2015) have noted potential problems which led to CEAA Questions #1, #3, and #4 in this Rapid Science Response. This should lead to improvements in the calibration and validation.

Advice

- As noted by the numerous reviewers, careful calibration and validation of the models is required to support the use of the models for application to sediment transport problems.
- CEAA Questions #1 (magnitude of the currents) and Question #4 (vessels at berth) need to be addressed in order to improve the calibration and validation of the hydrodynamic models and to improve the representation of the potential impacts of the marine structures on the hydrodynamics of Flora Bank.
- The modelling tools used by the proponent are suitable for assessing the potential impact of the marine structures on the hydrodynamics (waves and currents), and the results can be used by NRCan and others to assess potential changes to sediment transport about Flora Bank.

Responder: Charles Hannah Responder: Patrick Cummins

3RD QUESTION

Question:

Does DFO have any updates to your advice of January 13, 2016, arising from consideration of concerns raised regarding exclusion of the rock outcrops from the hydrodynamics modelling?

Importance: ☐ Essential ☐ Important ☐ Desirable

SCIENCE RESPONSE

Background

Document considered: PGL Environmental Consultants (2015) - in particular the report from Coldwater Consulting (M. Davies) – text on page 40 and Figures 12, 13, 14, 15.

- Dr. Davies makes the observation that there are rocky outcrops near the SW corner of Flora Bank and proposes that the presence of the outcrops may be important to the creation and maintenance of that corner of Flora Bank.
- The text and figures suggest that the most likely mechanism is that diffraction of the incoming wave field by the outcrops cause the wave fronts to line-up with the present geometry of this corner of Flora Bank.
- As this corner is the closest part of Flora Bank to the berthing facility, the implication is that changes in the

currents or waves due to the berthing facility could have an impact on this corner of Flora Bank.

Analysis

- Rocky outcrops can cause wave diffraction and perturbations in the currents on ebb and flood tide. Dr. Davies presents some interesting observations, but it is not known whether the perturbations that occur presently are important to the sediment transport dynamics.
- To determine whether the rocky outcrops need to be included in the modelling would require a determination of whether the proposed marine structures cause a change in the hydrodynamics (waves or currents) in the vicinity of the rocky outcrops.
- The modelling tools being used by the proponent are sufficient to determine whether the proposed marine structures cause a change in the hydrodynamics (waves or currents) in the vicinity of the rocky outcrops. However, Questions #1 (magnitude of the currents) and Question #4 (vessels at berth) would need to be addressed first, in order to be confident that the hydrodynamics modelling is adequate and appropriate for this specific area and the potential impacts of this specific project.

Advice

- To support an evaluation of the likely impacts of the proposed project overall, and of the potential impacts associated with rocky outcrops, correction for the underestimate in currents (Question #1) and modelling of the impact of vessels at berth (Question #4) need to be addressed first.
- The new results can then be examined by a competent expert to assess whether the changes in the hydrodynamics in the vicinity of the rocky outcrops are sufficiently large to require an assessment of the potential changes in the sediment transport in the vicinity of the rocky outcrops.
- DFO has the capacity to review the hydrodynamics modelling and evaluate the adequacy of the modelling to describe potential impacts of the project on the hydrodynamics.

Responder: Charles Hannah Responder: Will Perrie

4TH QUESTION

Question:

Does DFO have any updates to your advice of January 13, 2016, arising from consideration of concerns raised regarding potential impacts of LNG carriers (vessels) at the marine berths on currents and sediment movement on and off Flora Bank?

Importance: ☐ Essential ☐ Important ☐ Desirable

SCIENCE RESPONSE

Background

Documents considered:

- Townend (2015) and PGL Environmental Consultants Ltd (2015 – in particular the report from Dr. Isaacson).
- Tsimshian Environmental Stewardship Association (TESA) presentation provided to CEAA meeting on 4 March, 2016

Other Information

- Hatch. 2014b. Pacific Northwest LNG – LNG Jetty – Propeller Scour Analysis. Appendix of the Addendum to the Environmental Impact Statement for PNW LNG: H345670-0000-12-124-0009, Rev. 0. November 25, 2014.

Information on vessel size and berth occupancy:

- The proposed LNG Carriers (Hatch 2014) are 290 m long, 49 m wide and have a draft to 11-12 m.
- The largest LNG carriers (Q-Max) are 345 m long, 54 m wide and have a draft of about 12 m.
- During the initial stages there will be 1 vessel every 2 days and each vessel will be at the terminal for *about* 24 hours (From the EIS section on Navigation). At full capacity there will be about 1 LNG carrier per day.

So in the initial stages there will be a carrier on site about 50% of the time. At full capacity there will be at least one carrier on site 100% of the time.

Analysis

In water depth of 20 m (Figure 4-4 Hatch 2014b) the vessel will occupy approximately half the water column, with the actual amount determined in large part by the details of the bathymetry and the stage of the tide. As a consequence the vessel represents a substantial obstacle to the flow. The proposed occupancy rate of 50-100% means that the vessels at berth are effectively a large and quasi-permanent marine structure which is larger than the SW Tower and SW Anchor Block that were modelled in detail in (Hatch 2015b).

Tidal and wind-driven currents

The tidal flows will respond to the obstacle both by going around and by going underneath the vessels. Given the water depth, the vessel draft and large tidal range in the region, the partitioning of the fraction of the water that goes under compared to around will depend on the stage of the tide.

The rip-rap proposed as protection from propeller scour should also provide protection from locally enhanced currents as the water accelerates around and under the vessels.

One or two 300 m long obstacles (the vessels) will introduce energetic eddies into the flow and change the spatial pattern of the tidal stream for several vessel lengths. One potentially important effect will be the creation of a shadow zone behind the vessel where the currents will be smaller than they were before the vessel was berthed. This shadow zone will introduce an asymmetry between flood and ebb tide in the region between the berth and Flora Bank. On a flood tide there will be a shadow zone with reduced currents between the berth and Flora Bank, however, on ebb tide the shadow zone will be on the other side of the vessel. Therefore an observer in the shadow zone between the berth and Flora Bank will see stronger ebb tide currents than flood tide currents. This asymmetry does not exist at present and may alter sediment transport in the vicinity.

The wind-driven currents are more surface-intensified and so will tend to go around the vessels. Again there will be locally enhanced currents as the currents accelerate around the vessel and reduced currents behind the vessel in a shadow zone extending several vessel lengths.

Waves

The dominant wind direction is from the southeast (Fig 3-11, Hatch 2015b). For waves from this direction, the marine structures and the vessels are downstream of Flora Bank and will not affect waves arriving at Flora Bank.

The vessels will have an impact on waves from the west and northwest, which are other directions of important wave activity on Flora Bank. The presence of the vessel may induce local wave breaking and will cause a wave shadow behind the vessel. The TESA presentation of 4 March 2016 showed preliminary results from HATCH on potential wave height reductions several vessel lengths from the berths. The modelling is characterized as 'conceptual' and further modelling is required to quantify estimates of the potential changes in the wave field.

The marine terminal structure

Both Townend (2015) and PGL (2015) expressed concern that the marine terminal structure may not have been properly accounted for in the model. There is insufficient detail provided in Hatch (2015b) to determine whether the concerns are valid. It is possible, given the complex piling structure of the marine terminal in comparison with the trestle, that the porous plate loss coefficient derived using the trestle as a model is not sufficient for application to the marine terminal.

Advice

- Given the high likelihood that the vessels at berth will impact the waves and the currents between the berth and Flora Bank, it is recommended that there be a comprehensive modelling effort to quantitatively assess the magnitude of the changes so that there can be an assessment of whether the vessels at berth could materially affect the model predictions of sediment movement on and off of Flora Bank.
- It is recommended that the Proponent provide additional details on the cross-sectional area blocked by the pilings of the Northern and Southern Loading Platforms and the Central Berth Platform to determine whether a different value of the porous plate loss coefficient would be required for these structures as compared to the trestle.

- DFO anticipates that it has the expertise to review the modelling approaches and results for the waves and the currents.

Responder: Charles Hannah Responder: Will Perrie

REVIEW & APPROVAL

This response does not constitute delivery of peer reviewed Science advice; it is intended as a rapid response to an immediate requirement for Science information or advice, from those experts able to contribute within the timeframes required.

Reviewed by: Lesley MacDougall, A/Science Coordinator, Centre for Science Advice Pacific

Signature: <Original signed by> Date: Mar 14/16

Approved by: Dr. Carmel Lowe, Regional Director, DFO Science Pacific Region

Signature: Approved by email Date: Mar 14/16

Comments:

APPENDIX 3

DFO Centre for Science Advice Pacific

Advice re: Rational for FPP's evaluation of moderate to high magnitude of impact to Harbour Porpoise from the development of the new PNW LNG terminal

Centre for Science Advice Pacific

Non-CSAS Rapid Science Response

Request Information

Request Contact:	**Al Magnan**	Project Type/Fishery:	**LNG**
Requesting Branch	**EMB**	Requesting Program	**FPP**
Advice Title	Advice re: rationale for FPP's evaluation of moderate to high magnitude of impact to Harbour Porpoise from the development of the PNW LNG terminal		
Date of request:	**March 3, 2016**	Project footprint:	
Region of proposed impact:	**Skeena Estuary/Chatham Sound**	Habitat Type:	**Estuarine/Shallow Marine**
Relevant species:	**Marine Mammals – in particular Harbour Porpoise**		
Date required:	**March 14, 2016**	Request #:	**RSR2016-003FPP_PNW**

Overview

The project is a large scale LNG export terminal to be situated within the Skeena River estuary. Development of the project will require the construction of a Materials Off-loading Facility including dredging, blasting and pile driving; construction of a suspended trestle and terminal berths involving pile driving.

Context:

Marine mammal survey results indicate that Harbour Porpoises concentrate within the project development area year round and are found at this location in disproportional abundance compared to other areas of Chatham Sound.

The proponent proposes to conduct pile driving activities for 21 months continuously. Given the high usage and importance of the area to Harbour Porpoises we are concerned that pile driving may deter porpoises from accessing the area or displace them from the area. EA conditions can be written to require mitigation measures such as double walled piles, pile in pile and bubble curtains, however, there is inherent uncertainty as to the effectiveness of these mitigation measures at this location.

DFO provided advice to CEAA indicating that the activities and the high density of Harbour Porpoises in the Chatham Sound area posed a moderate to high risk of having significant impacts to Harbour Porpoises in the area.

The Prince Rupert Port Authority, and the Proponent have challenged CEAAs determination, indicating the following:

> " In consideration of the overall population and habitat abundance of the pacific population of the Harbour Porpoise1, the Agency's conclusion regarding the magnitude of the effect and its significance is questionable. If the CEAA Agency cannot clearly substantiate its opinion on the *magnitude* of the project effects to harbor porpoise abundance and habitat availability, the significance evaluation should be re-evaluated."

Both the Prince Rupert Port Authority and PNW LNG have submitted further information to support their challenge.

CEAA has requested further response from DFO in light of the new information and the challenge.

1ST Question

Context:

In light of the new information (Marine Mammal final report for PNW [Stantec), and the Memorandum to the Prince Rupert Port Authority [Hemmera]), the Fisheries Protection Program is seeking advice from DFO science on the following question:

Question:

Does DFO still advise that given the susceptibility of Harbour Porpoises to underwater noise, the extensive use of the Project development area by Harbour Porpoises, and the uncertainty regarding availability of suitable alternative habitats, the proposed pile driving works pose a high risk of significant adverse residual effects to Harbour Porpoise?

Importance: ☒ Essential ☐ Important ☐ Desirable

SCIENCE RESPONSE

Response:

The following provides information relevant to the question of the risk of significant adverse residual effects to Harbour Porpoises in the area of the proposed development.

Harbour Porpoise habitat requirements and movement patterns

Preferred habitats of Harbour Porpoises are coastal bays, harbours, estuaries and shallow banks with depths of less than 100 metres. Although they are occasionally seen in deeper waters over the continental shelf, densities are very low in such locations (DFO 2009; Ford et al. 2010; Ford 2014). Harbour Porpoises are normally seen in small groups of two to five individuals, but solitary animals also commonly found. On rare occasions, larger aggregations of 50 to 100 or more individuals are observed in certain preferred habitats in BC, likely in response to prey availability.

Although Harbour Porpoises have a nearly continuous distribution in nearshore waters along the Pacific coast of North America, including BC, they appear to exist in stratified population subunits that have high site fidelity, limited dispersal and reduced genetic exchange with other subunits (DFO 2009).

Harbour Porpoise occurrence in the area of concern:

Chatham Sound contains areas of important habitat for Harbour Porpoises. Surveys undertaken for the proponent and described in Stantec (2016) identify consistent areas of Harbour Porpoise concentrations, particularly to the south of Digby Island and in Porpoise Channel and Porpoise Harbour near Lelu Island (Area B in Stantec 2016). Porpoise densities in these areas were considerably higher than in the larger area of Chatham Sound (Area A). Sighting rates of Harbour Porpoises during cetacean surveys reported in Stantec (2016) are very likely biased downward due to the difficulty in visual detection of porpoises in anything but very calm sea conditions. Due to their small body size, small group sizes (typically) and often inconspicuous behaviour, sightability of Harbour Porpoises declines rapidly at sea states greater than Beaufort level 1 (light air with rippled water surface) (e.g., Taylor and Dawson 1984; Evans and Hammond 2004; Hall 2004). Such calm conditions are uncommon in the Chatham Sound area, particularly during winter. Sea state appears not to have been taken into account in descriptions of survey results in Stantec (2016) (surveys were undertaken up to Beaufort level 4), and it is unclear in the report whether sea state was included as a covariate in distance sampling models and that abundance estimates were adjusted accordingly. It is probable that variable sea states during surveys account for much of the variability and wide confidence intervals of estimated Harbour Porpoise abundances in Stantec (2016).

Unusually large aggregations of Harbour Porpoises (> 50 individuals) have been documented in southern Chatham Sound during January to March by the BC Cetacean Sightings Network (BCCSN, administered jointly by DFO and the Vancouver Aquarium; I. Winther, DFO, pers. comm.). These aggregations – some in the 100s of individuals – likely form in response to seasonal concentrations of prey such as herring and eulachon. They tend to occur in shallow areas southeast of Digby Island, east of Ridley Island, and around the Kinahan Islands. Large aggregations such as these are very uncommon in British Columbia waters (only 75 of the 6141 Harbour Porpoise sightings (~1%) in the BCCSN database have > 50 individuals) and have been documented in only a few important habitat areas along the BC coast – in Haro Strait and Juan de Fuca Strait off southern Vancouver Island, along the southwestern coast of Vancouver Island, and in southeastern Chatham Sound. The Harbour Porpoise concentration areas within Area B are thus habitats of significance at a coast-wide level and are likely critical to the population inhabiting the Chatham Sound region.

Susceptibility of Harbour Porpoises to disturbance from pile driving:

There is a considerable body of published empirical evidence in the scientific literature demonstrating that Harbour Porpoises are highly sensitive to underwater impulsive noise from pile driving. Many studies have been undertaken in Europe associated with offshore wind farm construction. A range of behavioural responses have been documented, including displacement of porpoises from habitats at ranges up to 20 km from active pile driving operations (see reviews in Tougaard et al. 2015 and Haelters et al. 2015).

Stantec (2014) presents results of acoustic modelling undertaken by McCrodan and Hannay (2014; Appendix N of Stantec 2014) and estimates that behavioural avoidance responses to impulse pile driving could occur at ranges closer than 1 km from the source, and to vibratory pile driving at ranges closer than 5.3 km from the source (Table 13-12 in Stantec 2014). These estimates are based on the following assumptions in the report:

1. air bubble curtain mitigation is employed, resulting in a 5–15 dB attenuation of sound pressure levels from pile driving operations (depending on frequency)
2. only a single pile driving operation is employed at a time
3. Cetaceans in general, including Harbour Porpoises, do not demonstrate avoidance responses from impulse pile driving at

received levels below 160 dB re 1 µPa (rms)

4. the threshold for the onset of avoidance responses by Killer Whales, and by extrapolation, Harbour Porpoises to noise from vibratory pile driving and other non-pulse sound sources is 57 dB re HT (i.e., above the species' hearing threshold).

For reasons detailed below, there is considerable uncertainty in some of these assumptions which, together with new information on Harbour Porpoise reactions to noise, likely result in underestimation of the areas over which Harbour Porpoises may display avoidance from pile driving associated with the proposed development:

Assumption 1. As stated in McCrodan and Hannay (2014), effectiveness of bubble curtains is highly variable due to a number of different factors. Not addressed in this report are the potential effects of water currents on the thickness of the bubble field and its continuity around the piling. For example, Lucke et al. (2011) noted currents of 0.5 m s^{-1} (approximately 1 knot) resulted in horizontal displacement and dispersion of a bubble curtain used in experiments to determine its effectiveness in mitigating responses by Harbour Porpoises. Currents resulting from the large tidal exchanges that occur in the proposed development area or from high sea states could potentially compromise the effectiveness of bubble curtains thus reducing the predicted attenuation values used in noise propagation models.

Assumption 2. Although Stantec (2014) assumes a single pile-driving sound source, revised construction plans indicate that up to 3 pile drivers would be operating simultaneously (EIS Addendum, December 2014, Appendix G.20 and Chapter 2, Project Description). This would result in a significant increase in the predicted source pressure level from pile driving operations and the area over which Harbour Porpoises would potentially exhibit avoidance responses.

Assumption 3. The 160 dB re 1 µPa (rms) received level threshold for pulsed sounds is applied generically as the level above which cetaceans (including Harbour Porpoises) experience disturbance and show avoidance responses. However, various studies reviewed by Tougaard et al. (2015) suggest that avoidance responses by Harbour Porpoises exposed to pulsed sounds from pile driving can occur at received levels of 130–140 dB re 1 µPa (rms). This is a substantially lower threshold that could lead to avoidance and displacement from habitat at considerably greater distances than those predicted in Stantec (2014).

Assumption 4. The threshold value of 57 dB re HT for avoidance by Harbour Porpoises is based on estimates of received noise levels that may have been experienced by northern resident Killer Whales that demonstrated responses to a moving vessel in experimental approach trials (Williams et al. 2002; MacGillvary et al. 2012). There are several reasons why this extrapolation may not be appropriate or accurate. First, responses to a moving vessel may result from the physical proximity of the approaching vessel, not simply to the sound levels it produces. Second, thresholds for avoidance responses by Killer Whales are likely very different than those for Harbour Porpoises, which are widely acknowledged to be particularly susceptible to disturbance from vessels and anthropogenic noises (COSEWIC 2003; DFO 2009). Finally, recent analyses by Tougaard et al. (2015) suggest that a value of 45 dB re HT is a more appropriate threshold for avoidance responses in Harbour Porpoises based on empirical evidence. This would result in considerably greater areas of potential disturbance and avoidance than those estimated in Stantec (2014).

Conclusion

Given the evidence that Harbour Porpoises respond to pile driving noise at lower received sound levels and thus at greater distances than estimated in Stantec (2014), plus the uncertainty in the effectiveness of bubble curtain mitigation, it is probable that the zones of potential disturbance could encompass the majority of areas of highest porpoise densities observed and modelled in Stantec (2016). These areas also include the locations where large aggregations of Harbour Porpoises form in winter and spring (BCCSN). Disturbance caused by pile driving noise levels in this zone may well result in the displacement of Harbour Porpoises from this important habitat. Although Harbour Porpoises can be found in other areas within Chatham Sound, densities tend to be low compared to the waters south of Digby Island and surrounding Ridley and Lelu islands. This suggests these areas are lower quality or marginal habitat and would be unlikely to support a large influx of animals should pile driving cause displacement from high density habitat. Evidence suggests that Harbour Porpoises can show strong site fidelity and tend not to undertake large scale movements, at least in northeast Pacific coastal waters. Thus, it is uncertain whether coastal areas beyond Chatham Sound would be occupied by displaced animals or if sufficient suitable habitat exists in such areas. Although Harbour Porpoises displaced from habitats by noise for periods of relatively short periods of hours or days have been documented to return after noise cessation, reoccupation can be fairly slow (e.g. Brandt et al. 2013; Thompson et al. 2013). Pile driving activity in the proposed development area is likely to be continuous for at least 21 months (EIS Addendum, December 2014, Appendix G.20 and Chapter 2, Project Description), thus potential displacement from important habitat could be as long as two years, which could have a significant detrimental effect on the viability of the Harbour Porpoise population in the area. If and when Harbour Porpoises would return to these areas following such a prolonged displacement is uncertain.

In summary, displacement of animals from concentration areas adjacent to the proposed pile driving activities could have significant consequences for Harbour Porpoises at the population level. It is thus reasonable to conclude that the proposed pile driving works pose a high risk of significant adverse residual effects to Harbour Porpoise.

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Responder: John Ford Responder: _____

2ND QUESTION

Context:

In light of the new information (Marine Mammal final report for PNW [Stantec], and the Memorandum to the Prince Rupert Port

Authority [Hemmera]), the Fisheries Protection Program is seeking advice from DFO science on the following question:

Question:

Does DFO agree with the characterization in the Agency's draft Environmental Assessment Report (see pages 78, 170, 178) of the magnitude of residual effects to harbour porpoise as "a measurable change in marine mammal abundance outside the range of natural variability, major changes to habitat quality or quantity or behaviour change that effects important life processes" and that such an effect would be significant given the listing under SARA of harbour porpoise as a species of special concern?

Importance: ☐ Essential ☐ Important ☐ Desirable

SCIENCE RESPONSE

Response:

Based on the information provided in the response to the 1st Question above, the Canadian Environmental Assessment Agency's (CEAA) characterization of the magnitude of resident effects to Harbour Porpoise appears to be accurate. Further, their conclusion in the EA report on page 78, that "the Project is likely to cause significant adverse environmental effects to harbour porpoise, given its susceptibility to behavioural effects from underwater noise, its current at risk status, its extensive use of the Project area year-round, and the uncertainty of suitable alternative habitat" is consistent with the information provided above and is thus reasonable.

Responder: John Ford Responder: _____

REVIEW & APPROVAL

This response does not constitute delivery of peer reviewed Science advice; it is intended as a rapid response to an immediate requirement for Science information or advice, from those experts able to contribute within the timeframes required.

Reviewed by: Lesley MacDougall, A/Science Coordinator, Centre for Science Advice Pacific

Signature: <Original signed by> Date: Mar 14/16

Approved by: Dr. Carmel Lowe, Regional Director, DFO Science Pacific Region

Signature: Approved by email Date: Mar 14/16

Comments:

APPENDIX 4

DFO Centre for Science Advice Pacific

Advice re: PNW LNG's proposed wording to Condition 6.12.4 of the draft EA conditions

Centre for Science Advice Pacific

Non-CSAS Rapid Science Response

Request Information

Request Contact:	**Al Magnan**	Project Type/Fishery:	**LNG**
Requesting Branch	**EMB**	Requesting Program	**FPP**
Advice Title	Advice re: PNWLNG's proposed wording to Condition 6.12.4 of the draft EA conditions		
Date of request:	**March 8, 2016**	Project footprint:	
Region of proposed impact:	**Skeena Estuary/Chatham Sound**	Habitat Type:	**Estuarine/Shallow Marine**
Relevant species:	**Marine Mammals – in particular Harbour Porpoise**		
Date required:	**March 14, 2016**	Request #:	**RSR2016-04_FPP_PNW**

Overview

The project is a large scale LNG export terminal to be situated within the Skeena River estuary. Development of the project will require the construction of a Materials Off-loading Facility including dredging, blasting and pile driving; construction of a suspended trestle and terminal berths involving pile driving.

Context:

Marine mammal survey results indicate that Harbour Porpoises concentrate within the project development area year round and are found at this location in disproportional abundance compared to other areas of Chatham Sound.

The proponent proposes to conduct pile driving activities for 21 months continuously. Given the high usage and importance of the area to Harbour Porpoises we are concerned that pile driving may deter porpoises from accessing the area or displace them from the area. EA conditions can be written to require mitigation measures such as double walled piles, pile in pile and bubble curtains, however, there is inherent uncertainty as to the effectiveness of these mitigation measures at this location.
DFO provided advice to CEAA indicating that the activities and the high density of Harbour Porpoises in the Chatham Sound area posed a moderate to high risk of having significant impacts to Harbour Porpoises in the area.

Within the draft environmental assessment report, the Canadian Environmental Assessment Agency (CEAA) identified numerous mitigation measures and follow up monitoring programs to mitigate impacts on the environment (draft conditions attached - "DRAFT CEAA Conditions.pdf"). The Proponent has reviewed these draft conditions and has provided feedback on some of these conditions (attached as "PNWLNG – Response to CEAA - Appendix VIII"). For one of these conditions (6.12.4), the Proponent has indicated that should the wording be maintained, it would likely be a "show stopper" for the project as it would make the project uneconomical to construct. Rational being that the recommendation was for all in-water construction works to be undertaken during daylight hours to allow for marine mammal observers to visual identify marine mammals in the exclusion zone. It appears that the proponent now wants to undertake works during both daylight and night time hours and as such are requesting an amendment to Condition 6.12.4.

Condition 6.12.4 as written by CEAA in the draft EA conditions:

> CEAA Condition 6.12.4. conducting in-water construction activities identified in 6.12.1 only during daylight hours so marine mammal observers are able to conduct the observations referred to in 6.12.3;

PNW's understanding of the objective:

> The objective is to incorporate into the marine mammal observation program a restriction to marine in-water construction to only daylight hours to minimize potential adverse acoustic effects to cetaceans (porpoises, whales). The premise is that observers would need to be able to visually see the cetaceans in daylight hours.

PNW's Comments and Concerns

> Compliance with this Condition, as drafted, would significantly extend the period of construction, perhaps doubling it. Further, the condition does not need to be so restrictive in order to protect marine mammals as once the safety zone is clear, the construction will begin with a ramp-up. There is no expectation that marine mammals will enter the safety zone once the work begins and for as long as construction noise continues.

If work stops, it can only commence again in accordance with 6.12.4 or 6.12.5 (the safety zone is clear).

PNW's Suggested Revision

6.12.4. ~~conducting~~ **commencing** in-water construction activities identified in 6.12.1 only after marine mammal observers are able to conduct the observations referred to in 6.12.3.

Based on the information received by the Proponent on Condition 6.12.4, the Fisheries Protection Program requests advice from DFO Science on the following questions.

1ST QUESTION

Question:

For Condition 6.12.4 of CEAA's draft conditions, is the rationale and recommended wording provided by the Proponent sufficient to provide the necessary protection of marine mammals, including Harbour Porpoises?

Importance: ☒ Essential ☐ Important ☐ Desirable

SCIENCE RESPONSE

Response:

As described in the response to request RSR2016-003FPP_PNW, behavioural avoidance responses by Harbour Porpoises to pile driving noise leading to displacement from habitat adjacent to construction operations may occur at received sound levels as low as of 130–140 dB re 1 µPa (rms). It is thus unlikely that animals would remain in or enter an area ensonified by pile driving noise to received levels of 160 dB 1 µPa (rms) or higher. However, it would be precautionary to maintain mitigation as described in draft conditions 6.12 to avoid the risk of injury should individuals become exposed to high sound pressure levels. However, given the low probability of individuals being present in or entering an exclusion zone based on a 160 dB 1 µPa (rms) isopleth after pile driving has commenced, continuation of pile driving in situations where the exclusion zone is not visible to the marine mammal observer (e.g., at night or in fog) would pose a relatively low risk. As a result, protection of individual Harbour Porpoises and other marine mammals from injury with the suggested changes to 6.12.4 would likely be adequate.

Responder: John Ford

Responder: Yvan Simard

2ND QUESTION

Question:

Are there alternative mitigation measures that should be used (e.g. underwater microphones) in the absence of visual observations?

Importance: ☐ Essential ☒ Important ☐ Desirable

SCIENCE RESPONSE

Response:

As described in the response to request RSR2016-003FPP_PNW, there is considerable uncertainty in the effectiveness of pile driving noise mitigation and the cumulative noise levels from multiple pile drivers operating concurrently. Underwater noise monitoring once pile driving operations commence would determine source noise levels and the effectiveness of proposed bubble curtain mitigation, as well as sound pressure levels over the ensonified area. Alternative methods of reducing the noise generated by vibratory or impact hammer pile driving could be explored and utilized especially if the proposed bubble curtain mitigation proves ineffective at attenuating noise to expected levels. Acoustic monitoring before and during pile driving operations could determine if Harbour

Porpoises are present within the exclusion zone or at greater ranges from the pile driving site. Monitoring systems could be used to detect Harbour Porpoises during pile driving operations and mitigate the risk of physical injury should individual porpoises enter the area of high intensity noise. The deployment of arrays of acoustic systems that can detect and record the high-frequency echolocation clicks from Harbour Porpoises could be used to determine, with an appropriate signal processing algorithm of proven performance, the presence or absence, range and direction of Harbour Porpoises at various distance from pile driving activities.

Responder: John Ford Responder: Yvan Simard

3RD QUESTION

Question:

Based on the Proponent's rationale, is there a need for these additional mitigation measures (e.g. underwater microphones)?

Importance: ☐ Essential ☒ Important ☐ Desirable

SCIENCE RESPONSE

Response:

Use of these additional assessment and mitigation measures is advised.

Responder: John Ford Responder: Yvan Simard

REVIEW & APPROVAL

This response does not constitute delivery of peer reviewed Science advice; it is intended as a rapid response to an immediate requirement for Science information or advice, from those experts able to contribute within the timeframes required.

Reviewed by: Lesley MacDougall, A/Science Coordinator, Centre for Science Advice Pacific

Signature: <Original signed by> Date: Mar 14/16

Approved by: Dr. Carmel Lowe, Regional Director, DFO Science Pacific Region

Signature: Approved by email Date: Mar 14/16

Comments:

Annex 2 **Letter from Natural Resources Canada to the Agency, March 15, 2016**

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Natural Resources Canada | Ressources naturelles Canada

March 15, 2016

Catherine Ponsford
Project Manager
Canadian Environmental Assessment Agency
Pacific and Yukon Region

CEAR Reference number: #80032

Re: Response to the Canadian Environmental Assessment Agency's March 2, 2016 Request for Advice on comments from the Lax Kw'alaams and Tsimshian Environmental Stewardship Authority for the Pacific Northwest LNG Project submitted in December, 2015

The attached submission represents Natural Resources Canada's (NRCan) continued efforts in support of a scientifically rigorous review process for the Pacific Northwest LNG Project focused on assessing the potential effects of the marine structures on hydrodynamics and sediment deposition, including potential impacts on Flora Bank. This submission also responds to the Canadian Environmental Assessment Agency's (CEAA) March 2, 2016 request for advice to inform the federal assessment and finalize the EA Report and proposed federal enforceable conditions. Specifically, CEAA requested whether NRCan has updates to our January 2016 advice (found on CEAA's public registry: http://www.ceaa.gc.ca/050/document-eng.cfm?document=104462) arising from consideration of the December 2015 submissions of the Lax Kw'alaams and the Tsimshian Environmental Stewardship Authority (TESA). CEAA also shared with us for information the March 2016 comments from the Lax Kw'alaams on the draft EA Report and proposed federal conditions.

NRCan is required under the *Canadian Environmental Assessment Act 2012* to provide specialist or expert information or knowledge to CEAA who is the Responsible Authority for the designated project. NRCan staff involved in the technical review have expertise in marine and coastal geology, sedimentology, sediment transport and marine geohazards.

NRCan's extensive involvement since December 2014 is witnessed through our participation in technical meetings with the Proponent, Aboriginal groups, and federal experts (most recently on March 4), as well as through our review of the various PNW LNG studies supporting the modeling work. As a result of several separate technical reviews by NRCan and Fisheries and Oceans Canada (DFO) scientists, the proponent's work evolved from the original 2D modelling study to a far more advanced and comprehensive 3D study, allowing for a better understanding of the potential effects of marine structures on site hydrodynamics, sediment transport and fish and fish habitat, including on Flora Bank.

NRCan's Review:

As part of their March 2 request for advice, CEAA asked NRCan and DFO to consider a number of questions related to the issues raised by the Lax Kw'alaams and TESA in their December 2015 submissions. NRCan's responses to the questions are found hereafter. NRCan's detailed review of materials in support of our responses to the questions can be found in Annex 1.

NRCan's Responses to CEAA's March 2 questions on the December 2015 submissions of the Lax Kw'alaams and TESA:

CEAA question #1: Concerns raised by McLaren and Davies regarding the inability of the model to explain observable sand grain sizes and bedforms on Flora Bank, as well as concerns regarding the accuracy of current speeds

NRCan response:

NRCan agrees with the opinions expressed by Dr. McLaren and Dr. Davies on behalf of the Lax Kw'alaams and TESA that the dominance of medium sand and occurrence of sand waves on Flora Bank are indicative of moderate to high energy conditions. The aerial photographs taken at low tide on Flora Bank and presented in McLaren's Reports (2015, 2016) provide new information on the occurrence of these sand waves, which are also referenced in the March 2016 Lax Kw'alaams submission to CEAA. NRCan is of the view that these photographs support the interpretation that the Bank hosts coarse sediments and that significant wave and tidal processes must be acting on the Bank.

NRCan also suggests that the characterization of the Bank as "low energy" is misleading when discussing sediment transport. As NRCan has commented in our review of the November 2015 3D Modeling Update Report, the Proponent predicted tidal currents up to 30-40 cm/s (pages K16 to K24) and storm currents up to 0.8 – 1 m/s (Fig. 5-3), which are sufficient to cause sediment transport and likely the development of sand waves. However, the Proponent also provides information to show that there would typically be dissipation of wave and current energy across the Bank and that sediment transport over much of the Bank would occur relatively infrequently due to this energy dissipation and periods of low tidal currents and very shallow water or exposure at low tide. Thus the Bank surface might in truth be characterized as high energy some of the time and low energy for the rest of the time. This understanding helps reconcile the views of the various experts who have commented and provided analysis on these issues (McLaren - Lax Kw'alaams December 2015 submission, Davies - TESA December 2015 submission and the Proponent's numerical modellers).

Similarly, the numerical model results are not completely inconsistent with the observation of bedforms on Flora Bank. The estimated velocity range for the formation of sand waves in medium to very coarse sand is 0.4 – 1.0 m/s (see Amos and King, 1984 and Ashley, 1990). The numerical model predicted storm-induced currents up to 1 m/s over Flora Bank at the peak of the 50-year storm (Fig. 5-3 on p. 57). Thus the model simulates conditions under which such bedforms could develop. However such conditions occur infrequently under the present simulations. NRCan notes that a detailed field examination of these bedforms has not been reported to date. In NRCan's view, such a study would permit more detailed analysis of the nature of sediment transport processes (e.g. asymmetry and migration of sand waves, the relative importance of tidal currents and waves in sediment transport and maintenance of Flora Bank). In addition, NRCan suggests that the proposed draft federal condition, based on our January 2016 advice to CEAA, to improve calibration of the numerical models will likely improve correspondence between model predictions and observations on grain size and bedforms

There is contrary information about the accuracy of model predictions of currents over Flora Bank. The Proponent's November 2015 Modeling Update Report shows that the model predicts tidal currents up to 30-40 cm/s for selected points on Flora Bank (Figs. K-14 to K-22). Comparison between model prediction and the Acoustic Doppler Current Profiler (ADCP) current data over Flora Bank collected in February 2015 by the Proponent shows that the measured currents range from 20 to 40 cm/s while the maximum of the model predicted currents is up to 20 cm/s. This would suggest that the model may

under-predict tidal currents by 50%. If the model should predict tidal currents up to 40 cm/s, the magnitude and duration of sediment transport will increase. However, easterly transport during flood and westerly transport during ebb both will increase. In NRCan's view, the changes to the net transport would likely be small. This would suggest that the main conclusion that the construction of the marine structures will not cause significant loss of sand from the Flora Bank will not likely be changed.

CEAA question #2: Concerns regarding effects of the proposed Project infrastructure (construction and operations) on Flora Bank's stability

NRCan Response:

NRCan conducted a review of Dr.McLaren's (2015, 2016) Sediment Trend Analysis (STA) and the subsequent McLaren review of the Proponent's November 2015 Modeling Update Report. The STA analysis focusses on issues related to the origins of Flora Bank and the potential of adverse effects on the stability of Flora Bank from proposed developments.

In NRCan's view, the STA results (McLaren, 2015) are not quantitative in terms of actual rates of transport or in terms of any time scale, but they do provide an averaged general pattern of overall sediment movement in the area. NRCan agrees with the conclusions of the STA analysis that the sediments of Flora Bank are likely derived from in situ reworking of underlying glacial deposits and have not been transported onto the bank from surrounding channels.

However, in terms of Flora Bank stability, NRCan considers McLaren's conclusion of the "Great Escape" to be a hypothetical concept. McLaren suggests that the structure and/or berthed LNG carriers, will sufficiently reduce wave and tidal current energy to break the metaphorical "wall of energy" that holds the sand on Flora Bank in place. The hypothesis is based on an assertion that the net effects of the processes must be equal on both the NW and SE sides of the Bank in order to maintain its stability. This concept of a bi-directional equilibrium is somewhat simplified but implies that there must be a long term equilibrium in net sediment transport that retains sediment on the Bank. For Flora Bank's equilibrium to become unstable there would need to be a significant change of the net sediment transport direction so that sediment transport would diverge away from the Bank or net transport in one direction would be significantly increased or decreased. NRCan believes that this is not an inevitable consequence of a reduction in wave and/or tidal current energy. If the equilibrium is relatively stable, it would be possible for the energy to be reduced and for the net sediment transport to still remain approximately balanced. If the equilibrium is unstable, loss of sediment through sediment transport off the Bank would be a possibility. Results from the Proponent's November 2015 Modeling Update Report suggest that the equilibrium on Flora Bank is relative stable. Maps of the net transport flux for the 28 day freshet simulation for tide-dominant situation (Fig. 6-12) show that the magnitude and patterns of net transport with the marine structures did not change substantially from that of the existing conditions. The morphological changes for the 1-year simulation including all natural processes (Fig. 6-21 and Table 6-5) demonstrate insignificant changes in the seabed erosion/deposition patterns and a slight decrease in the net loss of sediment after the construction of the marine structures.

The Proponent's Delft-3D numerical model could be used to test the stability of the equilibrium by examining the threshold at which a reversal of net sediment transport direction would occur (if at all) and compare this to the expected change in processes due to the project. It might also provide some constraints on the rates of transport involved and on the feasibility of mitigation or adaptive management.

NRCan also reviewed the Lax Kw'alaams December 2015 review of the Proponent's November 2015 3D Modeling Update Report by Ian Townend who commented on long-term morphological changes resulting from Extreme Storms. Townend notes that even though the Proponent has done an enormous amount of additional modeling, it does not contribute in any substantive way to our understanding of the geomorphological stability of Flora Bank.

Townend observes that there has been a lot of additional work done on extreme storms by the Proponent and he points out that the work is useful as it now covers all directions of potential exposure (SSE, SW, W, and NW). Townend highlights that the modelling has been undertaken for a sustained event lasting 11 days, and such an event can be considered a hypothetical extreme (return periods of >1,000 years) and could be argued to be a (very) conservative estimate of impact. As such, Townend concludes that the results are fairly meaningless in terms of the actual impact within the context of long-term morphological change.

As recommended previously by NRCan, the erosion and depositional changes for extreme storms could be added to the morphological changes from the 1-year time series model runs to assess the possible maximum erosional and depositional changes. In this sense the results of the extreme storm modelling are useful. NRCan agrees with Townend that the Proponent could improve the analysis in this area by integrating the results of extreme storms with time series modelling of various durations to demonstrate how extreme storms impact the predictions of long-term morphological changes on Flora Bank.

CEAA question #3: How the presence of one or two LNG carriers at the marine berths could materially affect the model predictions of sediment movement on and off of Flora Bank

NRCan response:

In the December 2015 TESA submission, Dr. Davies and Dr. Isaacson recommended that further exploration of the possible effects of berthed vessels on waves and wind to verify whether this would have an impact on the morphology of Flora Bank.

In NRCan's view, qualitatively, the berthing of LNG ships could change (either increase or decrease) the local currents and reduce waves in the immediate areas around the ships. However, it is outside of the NRCan expertise to quantify these changes. NRCan notes that CEAA has proposed a draft federal condition (6.2) to consider the impact of two berthed LNG vessels in future modeling efforts prior to the start of in-water construction activities. If additional modeling efforts undertaken by the Proponent show significant effects to regional predictions of waves and currents, NRCan has the expertise to review the potential local and regional changes to sediment transport and morphology in the project area. It is also NRCan's understanding that the Proponent has discussed this issue with TESA and has commenced some preliminary analysis through a conceptual examination of ships at berth in the high resolution (MORPHO) model. The results of this analysis would be important for CEAA's consideration.

CEAA question #4: Concerns raised regarding the exclusion of the rock outcrops from the modelling efforts

NRCan Response:

In the December 2015 TESA submission, Dr.Davies observes the presence of rock outcrops at the southwest corner of Flora Bank and close to the ship berthing area and suggests the exclusion of these

rock outcrops in the model may lead to incorrect assessment of hydrodynamics and sediment stability near the berthing area and may have affected the accuracy in the model's reproduction of physical processes over Flora Bank.

In NRCan's view, these features are very small compared to the modelled region. The rock outcrops may have some local influence on the wave, current and sediment transport processes but in NRCan's view, should not significantly affect the broad regional predictions for the entire Flora Bank area. If additional modeling efforts undertaken by the Proponent show significant effects to regional predictions of waves and currents, NRCan has the expertise to review the potential local and regional changes to sediment transport and morphology in the project area.

Conclusion:

NRCan's review points to the need for convergence between the McLaren hypothesis and the numerical model results to confidently predict the potential effects caused by the project marine structures. NRCan believes that both tools have contributions to make to the evaluation of project effects and that such a convergence would be possible particularly with additional collection of wave, current and suspended sediment data on Flora Bank leading to improved model calibration. This is consistent with our January 2016 advice to CEAA where we recommended collection of additional field data on Flora Bank, completion of modeling efforts using Flora Bank data for model calibration, and monitoring of morphological changes on Flora Bank to verify EA predictions. NRCan notes, that a number of draft CEAA conditions are aligned with this advice. In addition, NRCan notes that TESA has proposed conditions to CEAA that aligns well with NRCan's January 2016 advice (as presented by TESA during the March 4, 2016 meeting with Aboriginal groups and federal representatives). TESA's proposed condition would require the Proponent to conduct additional modeling using new field data collected on Flora Bank , and ensure using best available technology to monitor "real world response" to the project. The condition would require the Proponent to provide the results of future modeling to CEAA, DFO, NRCan and Aboriginal groups.

NRCan officials would like to acknowledge the ongoing efforts put forth in this review by federal scientists from Fisheries and Oceans Canada (DFO) and NRCan; Aboriginal groups and their technical representatives, CEAA staff and PNW LNG and their consultants.

Regards, Jessica

Original signed by

Jessica Coulson

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Lisa Walls, Canadian Environmental Assessment Agency
Donna Kirkwood and Linda Richard, Natural Resources Canada

Annex 1: NRCan's review of comments from the Lax Kw'alaams and Tsimshian Environmental Stewardship Authority for the Pacific Northwest LNG Project submitted in December, 2015

Part 1: NRCan comments related to the stability, wave and surficial characteristics of Flora Bank

For part 1 of NRCan's submission, NRCan reviewed: 1) the December 15, 2015 report by PGL Consultants to the Tsimshian Environmental Stewardship Authority (TESA); 2) the December 3, 2015 report by Patrick McLaren, SedTrend Analysis Limited, for the Lax Kw'alaams Band and the Skeena Fisheries Commission; 3) the January 2016 scientific article published by McLaren in Journal of Coastal Research.

SUMMARY OF REPORTS

1) December 15 report by PGL Consultants to the Tsimshian Environmental Stewardship Authority (TESA):

The report from PGL Environment Consultants (2015) was developed in consultation with experts in coastal engineering and defines some issues related to the stability of Flora Bank and, in particular, in respect to the findings within the Sediment Trend Analysis undertaken by Dr. P. McLaren (2015). The key points raised in the PGL report are:

1. Sand wave or subaqueous dunes occur on Flora Bank and align with the key tidal flow patterns and do not represent drainage features.
2. The coarse well-sorted clean sand and sand waves that occur on Flora Bank suggest that current velocities must be over 30 cm/s regularly, otherwise finer sediments would be present.
3. The sediment transport patterns predicted from Flora Bank by the 3D model do not agree with the apparently stable geometry of the bank as it exists today. Dr. M. Davies argues that, if this balance of sediment transport is not correctly reproduced in the model, then the model will be unable to predict the effects of changes to this balance that occur when the marine terminal facilities are constructed. If the present balance is not properly understood, then we are not yet able to properly understand the effects of changes to that balance.
4. The sedimentary bedforms clearly seen on Flora Bank suggest a dynamic sediment environment with flow conditions generally well in excess of the sediment transport threshold. Evidence suggests that Flora Bank has been stable over the past century without any obvious gain or loss in size. For this to be the case, the back and forth movements of sediments caused by waves and/or tidal currents, must be balanced.

The report concludes that when contradictions around various lines of evidence occur they are generally resolved through collection of real-world data that can be used to verify and calibrate the model. The report by Dr. Davies notes that while some real-world data was used to calibrate the model, this data was recorded in channels adjacent to Flora Bank rather than on Flora Bank itself. Best practices for impact assessment suggest that further work should be done to increase confidence in the predictions of impact.

2) Dec 3 2015 report by Patrick McLaren, SedTrend Analysis Limited for the Lax Kw'alaams Band and the Skeena Fisheries Commission entitled "An assessment of the "Supplemental Report for 3D Modelling Update" prepared by Hatch for PNWLNG, November 10, 2015".

This report provides further arguments on the results and proposed implications of the STA analysis. Key points include:

1. The surface of Flora Bank contains the coarsest and most well-sorted sand found throughout the whole of the Prince Rupert marine and coastal region. Its grain-size distribution is unique in that all sizes smaller than 3.0 phi (0.125 mm) are essentially absent. If sand has not been transported onto Flora Bank, it must have formed in situ or be a remnant from a pre-existing environment.
2. Virtually the entire surface of Flora Bank is covered with sand waves. Although no detailed analyses have been made, rough measurements from vertical mosaics show the wave lengths in each of these fields to be extremely regular. The considerable literature on sand wave formation shows that, for the range of grain sizes on Flora Bank, currents must be from 2 to 6 times larger than the 30 cm/sec currents, that is the threshold for the movement of Flora Bank.
3. Neither the STA nor the modeling have resolved the paradoxical nature of Flora Bank; namely, if the energy of the processes are so low that they cannot move the coarse sand off the bank, how do the sediments remain the coarsest and best sorted of sandy sediment found throughout the entire Prince Rupert area?
4. From the STA it was concluded that high energy process events must not only be responsible for maintaining the coarse and well-sorted sediment, but they are also instrumental in creating the barrier necessary to keep the sand on the bank rather than being lost to the offshore waters.

The report does conclude that as a kinematic model, the STA is unable to analyze the specific nature of processes responsible for sediment transport.

3) January 2016 scientific article published in the Journal of Coastal Research (McLaren 2016).

In this article, McLaren reprises the information presented in his original January 3 2015 report for the Lax Kw'alaams (A Sediment Trend Analysis (STA®) of Prince Rupert Harbour and its Surrounding Waters) and in report 2) above. The peer-reviewed paper includes sections on the origin and dynamics of Flora Bank and predicted fate of Flora Bank based on STA results.

The author provides a theoretical concept of how sediment processes may change if facilities are built adjacent to the bank, but provides no data to support or refute the concept. The key prediction in this paper based on this concept is that "in order for Flora Bank sand to remain in place, the net effect of the processes (i.e. the energy produced by the combined action of tidal, river, wave, and wind-driven currents) must be equal on both the NW and SE sides of the bank. If this were not so, the sand would be unable to remain and Flora Bank, as it is seen today, would not exist. For this reason, it is believed that a reduction of energy along any portion of the perimeter of the bank caused by the pilings obstructing the currents (regardless of which process or combination of processes are responsible for generating the currents) will result in an inability for the sand to continue being held in place".

Part 1 - NRCAN REVIEW COMMENTS:

These review comments supplement comments previously submitted to CEAA by NRCan in February 2015.

1. The STA results (McLaren, 2015) are not quantitative in terms of actual rates of transport or in terms of any time scale, but they do provide an averaged general pattern of overall sediment movement in the area. NRCan agrees with the conclusions of the STA analysis that the sediments of Flora Bank are likely derived from in situ reworking of underlying glacial deposits and have not been transported onto the bank from surrounding channels. Aerial photographs taken at low tide on Flora Bank and presented in reports 2) and 3) provide new information on the occurrence of sand waves. NRCan agrees that these photographs support the interpretation that the bank hosts coarse sediments and that significant wave and tidal processes must be acting on the bank. We note that a detailed field examination of these bedforms has not been reported to date. Such a study would permit more detailed analysis of the nature of sediment transport processes (e.g. whether tidal currents, waves or both combined play a role in sediment transport and maintenance of Flora Bank).

2. NRCan considers the "Great Escape" to be a hypothetical concept. McLaren suggests that the structure and/or berthed LNG carriers, will sufficiently reduce wave and tidal current energy to break the metaphorical "wall of energy" that holds the sand on Flora Bank in place. The hypothesis is based on an assertion that the net effects of the processes must be equal on both the NW and SE sides of the bank in order to maintain stability of the bank. This concept of a bi-directional equilibrium is somewhat simplified but implies that there must be a long term equilibrium in net sediment transport that retains sediment on the bank. For the bank equilibrium to become unstable there would need to be a significant change of the net sediment transport direction so that sediment transport would diverge away from the bank or net transport in one direction would be significantly increased or decreased. NRCan believes that this is not an inevitable consequence of a reduction in wave and/or tidal current energy. If the equilibrium is relatively stable, it would be possible for the energy to be reduced and for the net sediment transport to remain approximately balanced. If the equilibrium is unstable, loss of sediment through sediment transport off the bank would be a possibility. The Delft-3D numerical model could be used to test the stability of the equilibrium by examining the threshold at which a reversal of net sediment transport direction would occur (if at all) and compare this to the expected change in processes due to the project. It might also provide some constraints on the rates of transport involved and on the feasibility of mitigation or adaptive management.

3. The above comments and those provided by the experts in the three reports point to the need for convergence between the McLaren hypothesis and the numerical model results.

NRCan believes that both tools have contributions to make to the evaluation of project effects and that such a convergence would be possible particularly with ongoing wave and current data collection on Flora Bank leading to improved model calibration. The following comments attempt to indicate two areas of convergence.

- With regard to concerns raised by McLaren and Davies regarding the inability of the model to explain observable sand grain sizes and bedforms on Flora Bank, some of the disagreement about whether the bank surface is a low or high energy environment may be more semantic than real. NRCan agrees that the Proponent report is incorrect to suggest that the STA results support the finding that the Flora bank is a low energy environment. They do not. We would also suggest that the characterization of the bank as "low energy" is misleading when discussing sediment transport. As NRCan has commented, in our review of the November 2015 report, the Proponent report predicts tidal currents up to 30-40 cm/s (pages K16 to K24) and storm currents up to 0.8 – 1 m/s (Fig. 5-3), which are sufficient to cause sediment transport. However, the Proponent also provides information to show that there would typically be dissipation of wave and current energy across the bank and that sediment transport over much of the bank would occur relatively infrequently due to this energy dissipation combined with periods of very shallow water or exposure at low tide. Thus the bank surface might in truth be characterized as high energy some of the time and low energy for the rest of the time. This understanding helps reconcile the views of McLaren, Davies and the numerical modellers.

- Similarly, the numerical model results are not completely inconsistent with the observation of bedforms on Flora Bank. The estimated velocity range for the formation of sand waves in medium to very coarse sand is 0.4 – 1.0 m/s (see Amos and King, 1984 and Ashley, 1990). The numerical model predicted storm-induced currents up to 1 m/s over Flora Bank at the peak of the 50-year storm (Fig. 5-3 on p. 57). Thus the model simulates conditions under which such bedforms could develop. However such conditions occur infrequently under the present simulations as explained above. NRCan suggests that the proposed CEAA condition to improve calibration of the numerical model will likely improve correspondence between model predictions and observations on grain size and bedforms.

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Ashley, G.M., 1990. Classification of large-scale subaqueous bedforms: a new look at an old problem. Journal of Sedimentary Petrology,60, 160–172.

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McLaren, P., 2015. An Assessment of the "Supplemental Report for 3D Modelling Update" Prepared by Hatch for PNW LNG, November 10, 2015. Prepared for the Lax Kw'alaams Band and the Skeena Fisheries Commission in support of CEAA's request for updated advice from Aboriginal groups. 10p.

McLaren, P. 2016. The environmental implications of sediment transport in the waters of Prince Rupert, British Columbia, Canada: A comparison between Kinematic and Dynamic approaches. Journal of Coastal Research, in press.

Part 2: NRCan comments related to the review by third parties of the Proponent's November 2015 3D Modeling Update Report.

For Part 2, NRCan reviewed the following documents: 1. An Assessment of the "Supplemental Report for 3D Modelling Update" (McLaren Report, Dec 3, 2015) 2. Expert Review – Pacific Northwest LNG Supplemental Modelling Report, PGL Environmental Consultants, Dec. 15, 2015 (PGL Report) 3. Coastal Science & Engineering Applications Review of Supplemental Modelling Report (Townend Report, Dec 17, 2015)

1. **Review of "An assessment of the "Supplemental Report for 3D Modelling Update" prepared by Hatch for PNWLNG, November 10, 2015". (McLaren Report, Dec 3, 2015)**

This report provides further arguments on the results and proposed implications of the STA analysis. Key points include:

1. Medium sand grain size and energy level on Flora Bank:
One of the main objections of the McLaren report is that the STA is a kinematic model and is unable to analyze the specific nature of processes responsible for sediment transport, and for this reason the Proponent's November 10 report was incorrect to suggest that the STA results support the low energy findings of the dynamic model.

While NRCan agrees with the McLaren Report that the Proponent report should not cite the STA results to support the low energy finding, this will not significantly change the overall conclusions by NRCan as the Proponent's Report provided adequate information to support their key conclusion points (p. xii of the November 2015 Modeling Update Report). The report shows evidence of gradual dissipation of waves for the 50-year storm and the gradual dissipation of waves and tidal currents during the modelled October 2012 storm. Tidal currents for the freshet period demonstrate the low to moderate energy for tide-dominant conditions. The wave and storm-induced currents for the 50-year storm presented in the report demonstrate high energy during storms. The sediment transport for the freshet period under tide dominant conditions and the analysis of sediment transport frequency show episodic sediment transport. The report also presents low levels of net transport evidenced for the 50-year storm, for the freshet period and for the natural storm of October 2012. As NRCan has commented in our review of the Proponent's November 2015 Report, it is likely inappropriate that the Proponent classifies the conditions on Flora Bank as "low energy" as the Proponent actually predicts tidal currents up to 30-40 cm/s and storm currents up to 0.8 – 1 m/s over Flora Bank.

2. The second key point of the McLaren report was that the presence of sand waves on Flora Bank indicates high energy and that the patterns of sand wave fields suggest that the east side is influenced by strong ebb currents while the west side is strongly wave affected.

If the large-scale features are sand waves, then the statement of currents must be 2 to 6 times larger than the 30 cm/sec currents for the occurrence of the sand waves was essentially correct. However, the upper limit of 1.8 m/s may be too high because the estimated velocity range for the formation of sand waves in medium to very coarse sand should be 0.4 – 1.0 m/s (e.g. Amos and King, 1984; Ashley, 1990). The performance of the flow model on Flora Bank could not be evaluated at the time the November 2015 report was reviewed due to the lack of measured current data over Flora Bank. However, the flow model was shown to adequately predict tidal currents up to 1.2 m/s in the Porpoise Channel and that the model also predicted storm-induced currents up to 1 m/s over Flora Bank at the peak of the 50-year storm. It is thus appropriate to suggest that Flora Bank could be episodically under moderate and high energy. In theory the sand waves could be developed under the strong storm-induced currents. NRCan is not aware of any analysis of the asymmetry and/or net migration direction of the sand waves. Without the information of the asymmetry and/or net migration of the sand waves, it is premature to conclude that sand waves on the east side of Flora Bank are influenced by strong ebb currents while those on the west side are strongly wave affected. Therefore it is not realistic to expect that the Proponent could use the numerical model results to determine whether the transport regimes on the east and west sides of the bank are respectively dominated by ebb currents and waves.

3. The Conclusion re-emphasizes two key concerns, (1) Both the kinematic approach of the STA and the observations of sand waves demand that the current velocities occurring over the bank must be stronger and more frequent than the values determined by the model; and (2) Unless the model can provide a better understanding of how the processes are actually interacting to hold the sand in place, including an assessment of how the tidal vs. wave dominance affect the sand transport regimes on each side of the bank, the risk of losing the sand from Flora Bank appears to be far greater than the “no harmful effects” conclusion purported by the model.

NRCan assessment indicates that although the model prediction of currents has not been calibrated with measured data over Flora Bank, the model actually predicted tidal currents up to 30-40 cm/s which agree with the ADCP data over Flora Bank which was collected by the Proponent and recently shown in the TESA presentation during the March 4 meeting. The model also predicted storm-induced currents up to 1 m/s (Fig. 5-3) during extreme storms. Thus it is not unrealistic to suggest that the model could predict currents greater than 30 cm/s on Flora Bank.

Although the November 2015 report did not specifically address the issue how the processes are interacting to hold the sand in place over Flora Bank, NRCan’s opinion is that some results presented in the Report could potentially be used to qualitatively address this issue. The net transport during the modelled freshet period dominated by tidal processes is to the northwest. The net transport is to the southeast during the 50-year storm that approaches from the west. It is thus feasible that these opposing net transport directions could strike a balance so that the amount of net transport to the southeast due to storms approaching from the west could be approximately equal to the amount of net transport to the northwest due to tidal currents over the long term so that the sand will be held in place on the Flora Bank. For the bank equilibrium to become unstable there would need to be a significant change of the net sediment transport direction so that sediment transport would diverge away from the bank or net transport in one direction would be significantly increased or decreased. Results from the Proponent’s November 2015 Report do not suggest this is the case. Maps of the net transport flux for the 28 day freshet simulation for tide-dominant situation show that the magnitude and patterns of net

transport with the marine structures did not change substantially from that of the existing conditions. The morphological changes for the 1-year simulation including all natural processes demonstrate insignificant changes in the seabed erosion and deposition patterns and that the net loss of sediment was slightly reduced after the construction of the marine structures. All these suggest that the proposed structures will not significantly alter the net transport conditions on Flora Bank and that the risk of significant loss of sand from Flora Bank is low.

References:

Amos, C.L., King, E.L., 1984. Bedforms of the Canadian eastern seaboard: A comparison with global occurrences. Mar. Geol. 57, 167–208.

Ashley, G., 1990. Classification of large-scale subaqueous bedforms: a new look at an old problem. J. Sediment. Petrol. 60, 160–172.

2. Review of December 2015 report by PGL Consultants to the Tsimshian Environmental Stewardship Authority (TESA):

The report from PGL Environment Consultants (2015) was developed in consultation with experts (e.g. Isaacson, Davies) in coastal engineering and defines some issues related to the stability of Flora Bank and, in particular, in respect to the findings within the Sediment Trend Analysis undertaken by Dr. P. McLaren (2015). The key points raised in the PGL report are:

1. The Delft3d model is a good tool for predicting effects associated with the Project and current data measured over Flora Bank could have been used to better calibrate the model prediction.

   NRCan agrees with these comments. Although measured wave and current data in areas around the Flora Bank were used to adequately calibrate the models, NRCan repeatedly commented in previous submissions that field data of waves, currents, and sediment transport collected over the Flora Bank would help to better calibrate the models.

2. Dr. Davies' findings indicate that the earlier 2-D model appears to indicate currents stronger than the threshold of sediment motion and thus suggests active sediment transport occurs over Flora Bank.

   NRCan's view is that this is not an issue as the 3-D model used in the November 2015 Report did predict low to moderate sediment transport under tide-dominant conditions.

3. Dr. Davies noted the presence of rock outcrops at the southwest corner of Flora Bank and suggested the exclusion of these rock outcrops in the model likely affected the accuracies in the model's reproduction of physical processes over Flora Bank.

   NRCan's opinion is that these features are very small relative to the modelled region and any effects will be local and thus should not significantly affect the broad regional predictions over the entire Flora Bank.

4. Dr. Davies' findings indicate the construction of the proposed structures will result in reduction of sediment transport by 20 to 40%; and given that the model likely under-predicts sediment transport, the actual effects of the Project may be even larger.

NRCan's opinion on this is that the Proponent's reports demonstrate that the project will reduce both the erosion and accretion volumes from the existing conditions which should enhance the stability of the Flora Bank. The more important values are the net volume changes over the bank. Table 6-5 for the 1-year simulation shows that the Flora Bank is losing 28000 m^3 sediments per year under the existing conditions while that value decreases to 25000 m^3 after the project construction. Therefore the construction of the proposed structures slightly reduces the net loss of sands and hence improves the stability of the Flora Bank.

5. The Proponent's report shows a consistent pattern of sediment moving from the western edge of Flora Bank toward the center of the bank. None of the simulations showed a reverse scenario where material moves from the centre of the Bank to the western edge of the Bank. As a result, sediment transport patterns from the model do not agree with the apparently stable geometry of the bank as it exists today. Dr. Davies suspects that this is because the tidal currents predicted by the Delft3D model are too small to move the sand on Flora Bank. This may lead to the opinion that if this balance of sediment transport is not correctly reproduced in the model, then the model will be unable to predict the effects to this balance by the changes that could occur due to the proposed structures.

   NRCan would like to highlight that the strongest storms in the project area come from the southeast and these storms would produce the reverse scenario where sediments will be transported from southeastern and central parts of the bank and be deposited on the northwestern part of the bank. This reversed pattern is demonstrated in the modelled seabed changes for the 20-year storm approaching from 170 degrees and for the 50-year storm approaching from 170 degrees (Appendix H of the November 2015 Report).

   Some results presented in the proponent's report are contrary to the notion that the tidal currents predicted by the Delft3D model are too small to move the sand on Flora Bank. For example, the model predicts tidal currents up to 30-40 cm/s for selected points on Flora Bank and episodic sand transport for these points. Also low to moderate total transport and net transport to the northwest were predicted for the freshet period under tide-dominant conditions.

   Recently ADCP current data along transects on Flora Bank collected on September 21, 2013 and on February22, 2015 became available and the data were compared with model predictions. The data collected in September 2013 show current speeds ranging from 5-30 cm/s. These are slightly lower or comparable with the model predicted tidal currents on Flora Bank. The February 2015 ADCP data show measured currents range from 20 to 40 cm/s while the model predicted maximum currents are up to 20 cm/s.. It is thus likely that the model under-predicted tidal currents by 50% based on this single ADCP transect data. If the model would predict tidal currents up to 40 cm/s, the magnitude and duration of sediment transport will increase. However, the reversal of flood and ebb flow direction means that easterly transport during flood and westerly transport during ebb both will increase. In NRCan's view, the changes to the net transport thus will be small.

   Thus the above point would suggest that the main conclusion that the marine structure will not cause significant loss of sand from the Flora Bank will not likely be changed.

3. NRCan Comments on Coastal Science & Engineering Applications Review of Supplemental Modelling Report (Townend Report, Dec 17, 2015)

Summarized below are the key points raised by Townend in his assessment of the Proponent's report entitled "*Pacific Northwest LNG, 3D modelling Update, Supplemental Modelling Report, 16/9/15, Rev C*"

1. Townend commented that the report does not contribute significant new knowledge to our understanding of the geomorphological stability of Flora Bank.

Townend noted that it is unclear just what is being reported regarding the long-term morphological changes. The Townend report questioned that the September 2015 report does not add to the understanding of the morphology of Flora Bank already provided by the May 2015 modelling report since it does not relate the new modelling to the previous modelling.

NRCan's review suggests that the following differences from the May 2015 report add to the understanding of the geomorphological stability of Flora Bank:

- May 2015 report used the weekly base method while the September, 2015 and November 10, 2015 reports used hourly time series wind and wave data. This improved methodology ensured that the models adequately simulate the real physical processes and the maximum magnitude of the tides and storms.
- Erosion and deposition volume changes were presented for several key modelled cases. These include the 50-year extreme storm (Sections 5.1 and 6.1), 3 month of stormy period (sections 5.3.4.1 and 6.1.4.1), 4 month of calm period (sections 5.3.4.1and 6.1.4.2), and 1 year time series simulation (sections 5.3.4.3 and 6.1.4.3).
- The time series and maximum values of sediment-transport related parameters such as suspended sediment concentration, sediment transport flux and net sediment transport flux, are needed to substantiate the predictions of long-term morphological changes. The May report was not consistent in presenting these types of results for key modelled cases. The November report consistently presented this information for several modelling cases: (i) the 50-year extreme storm (Sections 5.1 and 6.1), (ii) the freshet simulations (sections 5.2 and 6.1.3), and (iii) the total-load transport flux and net transport flux for the Oct 2012 natural storm (Appendix H) and impact on total suspended solids for the 3-month stormy period (Appendix H).

2. Extreme storms and relevance of results to long-term morphological changes:

The Townend report states that there has also been a lot of additional work done on extreme storms (Appendix G). This is useful as the work now covers all directions of potential exposure (SSE, SW, W, and NW). However the modelling has been undertaken for a sustained event lasting 11 days, although the logic behind this selection is not made clear. Such an event can be considered a hypothetical extreme (return periods of >1,000 years) and so could be argued to be a (very) conservative estimate of impact. As such, the results are fairly meaningless in terms of the actual impact within the context of long-term morphological change.

NRCan believes that erosion and depositional changes for extreme storms could be added to the morphological changes from the 1-year time series model runs to assess the possible maximum

erosional and depositional changes. In this sense the results of the extreme storm modelling are not meaningless. NRCan agrees with the Townend report that the Proponents could do a better job to integrate the results of extreme storms with time series modelling of various durations to demonstrate how extreme storms impact the predictions of long-term morphological changes on Flora Bank.

3. Different results of sediment mobility calculations:

The Townend report states that the work presented in Chapter 3 making use of Sedtrans05 would be more useful than the sediment mobility analysis results presented in Appendix K. Mr. Townend ran the same model using some "representative" conditions. The Townend report suggests that their results presented in the Appendix provide a rather different picture to the one suggested by Table 3-1 of the Proponent's 2015 September report. The 2015 September report suggests that there is only a short period of transport (around 20% of the time) regardless of grain size. In contrast, the results in Appendix A of the Townend report suggest that a sediment grain size of 0.35mm is transported much more frequently.

In NRCan's view, the methods used in the September 2015 report and the Townend report were different and thus the results would be different. The Proponent's September 2015 Report compared the instantaneous currents through tidal cycles, which vary from zero to peak speeds of ~30 cm/s in a flood-ebb tidal cycle (~12 hours), with the threshold velocity for medium sand (median grain size 0.35 mm) to assess the frequency and magnitude of total transport over the 28-day freshet simulation (Fig. 3-22 and Table 3-1). The Proponent's results suggest that transport only occurs near the peaks of flood and ebb when tidal currents are the strongest. The Townend report, however, used constant peak tidal currents of 20 or 30 cm/s to compare with the threshold velocity. Therefore the Appendix A of the Townend report shows much higher frequency of sediment transport. NRCan's opinion is that the results and approach of the Proponent's September 2015 Report are more realistic. The Townend report was correct in stating that the fine sediment should be far more likely to be transported than the coarser fraction.