REVIEW OF THE PROPOSED ENVIRONMENTAL EFFECTS MONITORING (EEM) PLAN FOR THE DEEP PANUKE OFFSHORE PETROLEUM PRODUCTION OPERATIONS

Context

Fisheries and Oceans Canada's (DFO) Environmental Assessment and Major Projects Division (EAMP), Maritimes Region, requested that DFO Science, Maritimes Region, provide advice regarding Encana Corporation's proposed environmental effects monitoring (EEM) plan entitled 'Encana Deep Panuke: Offshore Production Environmental Effects Monitoring Plan (EEMP)', for the production operations of its Deep Panuke natural gas development project in the offshore of Nova Scotia (Encana Corporation, 2011). The scope of the EEM plan (the plan) includes all components of the development project located in the marine environment: the offshore production field centre (and associated infrastructure) and the offshore-onshore export pipeline into the near-shore marine environment where the pipeline comes ashore. The plan does not include monitoring of terrestrial components, as this is covered in other plans.

The request for science advice supports DFO EAMP's involvement as an expert authority in the Comprehensive Study Report for the Deep Panuke natural gas development project pursuant to the *Canadian Environmental Assessment Act*. Specifically, DFO EAMP asked:

> *1. Are the proposed monitoring components, sampling procedures, sampling frequencies, and analyses appropriate for verifying the accuracy of Environmental Assessment predictions of the potential environmental effects associated with operations of the Deep Panuke project? What additions and/or changes can be made to any monitoring component that would improve the monitoring plan?*
>
> *2. Are the proposed monitoring components, sampling procedures, sampling frequencies, and analyses appropriate for verifying the effectiveness of mitigation measures that are to be implemented to reduce the potential impacts of operations of the Deep Panuke project on the environment? What additions and/or changes can be made to any monitoring component that would improve the monitoring plan?*

A DFO Centre for Science Advice (CSA) Special Science Response Process (SSRP) was used to provide science advice. The SSRP is based on the results of DFO Science directed research, as well as the knowledge gained from monitoring programs of other petroleum operators in the offshore of Atlantic Canada and elsewhere.

In summary:

- It is believed that the proposed monitoring plan will clearly answer Question 1 noted above. In regard to Question 2, it is believed that the general and specific comments/recommendations provided in this response would help strengthen the plan and should be given consideration.

- A discussion should be included on how the proposed monitoring plan compares to and incorporates 'lessons learned' from other monitoring plans of similar offshore petroleum projects, including as appropriate a comparison to monitoring plans of offshore petroleum developments in other regions.

- If statistical measurements (e.g. Analysis of Variance – ANOVA) were used in designing the proposed sampling scheme outlined in the monitoring plan they should be stated.

- To further address potential fisheries issues in the plan, it is recommended that the Fish Health Assessment core component (Section 6.5 of the plan) consider the inclusion of additional analyses, if only for assurance.

- Numerical models, such as a Dose-related Risk and Effect Assessment Model (DREAM), should be used to help track the produced water plume to inform the EEM sampling design in real time rather than relying on tide tables, since tide direction around the platform can change significantly even during the time that sampling is occurring. This can result in inadvertent sampling outside of the produced water plume (Niu et al., 2010).

- The goal of the 'Sediment Chemistry and Toxicity' monitoring component (Section 6.3.2 of the proposed monitoring plan) focuses primarily on TPH and barium from historical drilling discharge. In response to Section 6.3.6, which suggests that some analytes could be deleted based on data collected to date, since produced water discharges may contain high concentrations of barium it is recommended to continue monitoring a full suite of metals in sediments over subsequent years of monitoring.

- Other specific comments to various sections of the proposed monitoring plan have been provided.

Background

Prior to approval of Encana's Deep Panuke natural gas development project in the offshore of Nova Scotia, a Comprehensive Study Report (CSR) was undertaken pursuant to the *Canadian Environmental Assessment Act* (refer to the Canadian Environmental Assessment Agency Registry file number 06-03-21748 for more information on the Deep Panuke Offshore Gas Development Project CSR). A condition of approval of the CSR was that a monitoring program be developed to track changes in the state of the marine environment that may result from the development project.

The lead regulatory authority responsible for overseeing that Encana develops and implements a monitoring program is the Canada-Nova Scotia Offshore Petroleum Board (CSNOPB). As a federal partner with expertise in the marine environment, Fisheries and Oceans Canada (DFO) has committed to providing expert advice to the CNSOPB on the marine components of the proposed monitoring program. Advice provided by DFO Science will be used by DFO EAMP to meet both its regulatory and non-regulatory requirements. DFO Science advice may also be used by the CNSOPB, as the regulator of petroleum activities in the offshore of Nova Scotia.

Analysis and Response

The analysis and response to the questions outlined above have been separated into 'general' and 'specific' comments/recommendations regarding the proposed monitoring plan. In short, it is believed that the proposed monitoring plan will clearly answer Question 1 noted above. In regard to Question 2, it is believed that the general and specific comments/recommendations that have been provided would help strengthen the plan and should be given consideration.

General Comments/Recommendations:

A discussion in the proposed monitoring plan should be included on how the proposed plan compares to other monitoring plans of similar offshore petroleum projects, including as appropriate a comparison to monitoring plans of offshore petroleum developments in other regions. It is also noted that most of the references cited in the proposed plan are those of the authors of the plan. In addition, if statistical measurements (e.g. Analysis of Variance – ANOVA) were used in designing the proposed sampling schemes outlined in the monitoring plan they should be stated.

The EEM plan has stated objectives to build on the recent findings from the Sable Offshore Energy Project (SOEP) EEM Program, to assist in research and development, and to verify predictions from the EA process. To further address potential fisheries issues in the plan it is recommended that the Fish Health Assessment core component (Section 6.5 of the plan) consider additional analyses, if only for assurance. Use of a few mussel stations alone, albeit useful, cannot provide this assurance. There is also the biological difference to consider between fish and mussels.

In line with standard practice, the acute toxicity of water and sediment is planned for study. However, in reality, although such studies are generally carried out for 'regulatory requirements' the large body of information available indicates that there is little reason to expect acute toxicity beyond a few metres of the production centre – especially considering the predicted volumes of produced water to be discharged at the Deep Panuke site. The same can not be said for chronic toxicity and potential fish health and tainting issues that are much more difficult to predict.

The fish species to be studied should be identified early. The common approach is to obtain baseline information, and this has been the approach for oil development on the Grand Banks of Newfoundland. The value of obtaining baseline information has been demonstrated in relation to other land-based petroleum developments, where *a posteriori* surveys found tumors in fish in the Athabasca River, bringing into question if the effects were normal for the river, and existed before development or caused by pollution. The findings in the Athabasca River have led to the formation of a five member national advisory panel.

Fish health and resource tainting are core components of the EEM programs being carried out by all three offshore petroleum developers on the Grand Banks. Petro-Canada has also published results on various fish health indicators studied before (Mathieu et al., 2005), and more recently, after release of substantial volumes of produced water over a period of several years (Mathieu et al., 2010).

The statement in the monitoring plan regarding MFO 'stress' and variability may be misconstrued. All physiological and ecological components can be expected to have some degree of natural variability, with the understanding that in the case of aquatic organisms, variability need not be purely 'natural' but sometimes linked to anthropogenic causes. Produced water, displacement water, and petroleum are rich in PAHs and there are dozens of studies

establishing the sensitivity of fish to MFO induction upon exposure to PAHs. There are also dozens of studies establishing MFO induction (probably of a more pronounced or prolonged nature) as a risk factor for a variety of effects in fish. This also includes mortality in the case of fish larvae. Equally, there are dozens of studies linking PAH exposure to a variety of effects in fish including histopathological, immunological, reproductive, carcinogenic, and mutagenic effects (reviewed by Payne et al., 2003). This further indicates the importance of additional studies on fish health to be considered in the plan, again, if only for assurance.

The toxicity tests carried out on produced water by the offshore petroleum industry in Newfoundland and Labrador for compliance monitoring includes the use of Microtox, sea-urchin fertilization (a very sensitive assay), as well as Atlantic silverside. There seems to be some question as to the species of fish to be used for acute toxicity testing on produced water from the Deep Panuke site. Atlantic silverside should be considered, since it is commonly used in acute toxicity tests and that standard procedures are available. Use of silverside would also permit comparisons to be made with produced water from petroleum development sites of the Grand Banks. In short, other toxicity tests, outside of those proposed in the monitoring plan, should be considered, which would permit testing for regulatory compliance monitoring and allow for broader ecological considerations, such as comparison of results to those from the Newfoundland and Labrador petroleum producing region of Atlantic Canada.

Given that sediment communities are not to be studied (presumably due to the high energy and coarse sandy sediments in the vicinity of the Deep Panuke site), and amphipod tests are relatively insensitive for screening sediment toxicity, use of Microtox and/or polychaete tests should be considered. This would provide a higher level of assurance should questions be asked about the extent of sediment toxicity. Microtox studies are simple to carry out and useful for obtaining evidence of indirect toxicity, for example, from sulfides and ammoniac compounds present in discharges or associated with sediment ‘smothering’. Such compounds can be responsible for toxicity to a greater degree than toxicity from organic and metal contaminants associated with produced water. Overall, any significant impacts on sediment from produced water would be expected to be minimal; much less so than impacts from disposal of cuttings, which are still normally limited to a few tens or hundreds of metres from production sites (e.g. Buchanan et al., 2003; Hurley and Ellis, 2004; Jacques Whitford Stantec, 2009).

Specific Comments/Recommendations:

The following comments pertain to specific sections of the proposed monitoring plan. They are organized by page number of the plan:

Page	Comments/Recommendations
1, 29	It is described on page 1 of the plan “The Deep Panuke EEMP builds on results and lessons learned to date from the Sable Offshore Energy Project (SOEP) EEM program”, and also on page 29 “Based on bioassay results and knowledge of the local receiving environment, there have been no acute toxic effects of produced water beyond the immediate mixing zone at the mouth of discharge caissons at SOEP offshore platforms.” Since the volume of produced water from Deep Panuke is significantly larger than the SOEP produced water, and the composition and concentration may vary between geological formations, the sampling design for monitoring Deep Panuke produced water (e.g. number of stations and location), being modeled on the approach used for SOEP, may not be appropriate. This may be addressed by the EEM Research and Development program element to verify the application of dispersion models.

7 The protection of marine areas under the Canadian Environmental Assessment Act should be clearly stated in quotations.

19 The EEM guidelines in the Environmental Effects Monitoring Coordination Framework (i.e. CNSOPB et al., 2005) developed by CNSOPB, DFO, and Environment Canada should be included in the Appendix of the monitoring plan.

20-21 Physical measurements, in addition to those outlined in the CNSOPB, C-NLOPB and NEB's Physical Environmental Guidelines, such as pH, total organic carbon (TOC), and sediment particle size analysis should also be considered as part of the sampling design, as well as any other measurements that can be taken easily during monitoring.

21 Consideration should be given to fish population surveys (i.e. commercial fisheries) other than the benthic fish/invertebrate surveys proposed in the plan. In the least, there should be mention of why this has not been included in the plan.

22 Should consider benthic surveys to verify the recovery of benthic organisms. Surveys should be conducted once or twice a year, during the same time period, to account for seasonal differences.

22 If it is predicted that the buried sections of the subsea pipeline will not obstruct crustaceans, benthic surveys may be needed on either side of the pipeline to provide verification. Otherwise, results from other similar monitoring programs should be cited.

29 In regard to the pitfalls of other EEM programs and lessons learned, there is likely more than what has been stated in Section 6.12 of the monitoring plan. Perhaps a bulleted list can be included in the plan, so it can be clearly seen how SOEP past experiences with its sampling scheme and results influenced the plan that has been proposed. This depends on the availability of SOEP results to EnCana.

30 As the concentration and composition of produced water may change over time due to recovery from different areas from the geological formation, changes in the addition of processes chemicals, etc., the rationale for sampling fresh produced water two times per year for chemistry and one time per year for toxicity testing in the first three years should be justified. As presently discussed, it is not clear if the sampling frequency is sufficient in the first three years of monitoring.

31 Figure 6.1 shows that the produced water (blue color pipe) will be discharged at 25 m below Lowest Astronomical Tide (LAT), however, Appendix D of Volume 4 of the CSR indicated a discharge depth of 10 m, which is confusing. According to the CSR document, produced water from Deep Panuke is heavier than seawater and therefore a discharge more close to the surface (instead of at the middle of water column) may help to achieve a higher order of dilution (low environment concentration) and therefore help to mitigate the impact. Has the discharge depth been considered in the mitigation plan or production centre design – this should be indicated in the plan. Note that recognition is also given to the fact that the produced water is mixed with cooling water (presumably this is seawater) in the caisson (leg) of the platform prior to discharge.

32 As noted in the above point for Page 30, the frequency of sample collection should be adjusted to provide a more robust early warning system (i.e. an increase in sample frequency as discharge rates increase). As presently discussed, it is not clear if the sampling frequency is sufficient in the first three years of monitoring.

32 Regarding the statement in the plan “and 250 m and 2,000 m upstream from the PFC along the tide direction at the time of sampling activities” and “Encana plans to use tide tables to predict the location of the produced water plume so that water samples can be efficiently collected.” Tide tables may not be efficient or proper for this application. It is recommended that predictions from ocean circulation models, which also consider the effects of wind on currents, be used.

32 Regarding the statement in the plan ”there will be a greater rate of dilution of any contaminants due to mixing with cooling water prior to discharge” (Note: cooling water is not required at SOEP production platforms). What is the cooling water intake depth? Has re-entrainment been considered in the dilution calculation? In other words, contaminants (in seawater from produced water discharge) may be re-entrained into cooling water intake which would result in an elevated background concentration present in the cooling water. Using this water to mix with produced water will not achieve the desired dilution ratio.

33 Regarding the statement in the plan “apply contaminant dispersion/risk assessment models (DREAM/EIF32) using sampling results and physical oceanographic data to research environmental risk from produced water discharge and to identify the major components of concern;“ the model should also be used before sampling to help inform the design of the sampling program in real time.

35-36 Although the proposed monitoring plan only focuses on barium from historical drilling wastes, it should be kept in mind that there is a possibility of the transfer of barium from produced water to the sediment. A recent study has found that the SOEP platform produced water is high in barium (Niu et al., 2010). As the EEM plan has indicated the similarity of SOEP produced water with Deep Panuke produced water, sediment sampling should also be considered in subsequent years.

38 Cuttings piles are expected to disappear in a year, so video sampling on a quarterly-basis could be used to document this. This sampling frequency may be difficult due to weather. In the very least, it should be coordinated with the benthic surveys suggested above and be undertaken during the same time period each year.

39 There is a need to provide statistical evidence that the analysis of fish habitat alteration by annual video sampling is robust. Correlations should be made between video observations and changes in sediment chemistry, if any. As presently discussed, it is not clear if the sampling frequency is sufficient in the first three years of monitoring.

40 It is unclear if video will be compared to baseline video to verify cutting impacts. There is no indication that this will be done, although there is a suggestion that there may not be any pipeline video taken; should be more discussion regarding this point. It is assumed that this has been done for Venture, Thebaud, and other wells.

40 Since the production site appears to be near the Gully Marine Protected Area, more discussion on the presence of at risk species should be considered. This is mentioned in footnote 45 on page 40.

52 In Table 7.1, Ken Doe is retired, so another person needs to be identified.

52 In Table 7.1, the sampling type/method of grab seems inappropriate. Is this type not restricted to sediment? It more likely should be an online drawn sample for produced water and Niskin samples for marine water quality.

62 In regard to the reference 'Neff, J.M., K. Lee, and E.M. DeBlois, 2009 (In Proceedings of the International Produced Water Conference: Environmental Risks and Advances in Mitigation Technologies, October 17 – 18, 2007. ESRF Technical Report Series - In press)', ESRF has decided not to publish this technical report. It will appear as an overview chapter in a book by Springer Press in 2011, edited by Lee and Neff (currently 'in press').

Conclusions

- It is believed that the proposed monitoring plan will clearly answer Question 1 noted above. In regard to Question 2, it is believed that the general and specific comments/recommendations provided in this response would help strengthen the plan and should be given consideration.

- A discussion should be included on how the proposed monitoring plan compares to and incorporates "lessons learned" from other monitoring plans of similar offshore petroleum projects, including as appropriate a comparison to monitoring plans of offshore petroleum developments in other regions.

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Sources of Information

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