EVALUATION OF THE NATIONAL ENERGY BOARD'S TRANS MOUNTAIN EXPANSION PROJECT REPORT:

THE FATE AND EFFECT OF OIL SPILLS

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For
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EXECUTIVE SUMMARY

1. I was retained by the Tsleil-Waututh Nation ("TWN") to provide my professional opinion on the conclusions on the fate and effects oil spills from the Trans Mountain Expansion Project ("Project") reached by the National Energy Board ("NEB") in its May 2016 report.

2. In its May 2016 report, the NEB concludes that:

   (a) diluted bitumen ("dilbit") from an oil spill originating from the Project may submerge in receiving waters in only limited quantities if at all, and only after several days exposure on the sea surface, during which time most of any dilbit released would be retrieved or remediated by oil spill response actions;[1]

   In reaching this conclusion, the NEB selectively accepted evidence presented by Trans Mountain while discounting or ignoring evidence presented by intervenors that dilbit could submerge much more rapidly;

   (b) Trans Mountain's ecological risk assessment methodology to assess the effects of marine transportation spills to be "acceptable";[2] and

   (c) the adverse effects of a credible worse-case oil spill from marine tankers are significant as follows:

> As discussed further in this chapter and Chapter 10, the Board finds that based on evidence filed by Trans Mountain and intervenors, a large spill in Burrard Inlet would result in significant adverse environmental and socio-economic effects.[3]
>
> The Board is of the view that the effects of a credible worst-case spill on heritage resources could be adverse and significant.[4]
>
> The Board is of the view that the effects of a credible worst-case spill on the current use of lands, waters and resources for traditional purposes by Aboriginal people would likely be adverse and significant.[5]

3. The NEB did not, however, assess the significance of adverse effects that could be caused by a tanker spill smaller than the credible mean oil spill presented by Trans Mountain.

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[1] Canada, National Energy Board (NEB), *National Energy Board Report, Trans Mountain Expansion Project*, OH-001-2014 (Calgary: NEB, May 2016) at 136 (A5A9H0) ("**NEB, 2016**").
[2] NEB, 2016, *supra* note 1 at 163.
[3] NEB, 2016, *supra* note 1 at 377.
[4] NEB, 2016, *supra* note 1 at 399.
[5] NEB, 2016, *supra* note 1 at 401.

4. I authored a May 2015 report entitled *Fate and Effect of Oil Spills from the Trans Mountain Expansion Project in Burrard Inlet and the Fraser River Estuary* ("May 2015 Report").[6] The NEB summarily dismissed the conclusions I reached in my May 2015 Report regarding the serious ecological damage that could result from a credible worse-case oil spill from a tanker in the Strait of Georgia on the following basis:

> Trans Mountain considered a number of hypothetical oil spill scenarios. Dr. Short's report submitted by Tsleil-Waututh Nation, City of Vancouver and Living Oceans Society, questioned whether these scenarios were truly representative, whether they were close enough to particular environmentally sensitive areas, and whether they give an adequately comprehensive view of the potential effects of an oil spill. The Board is of the view Dr. Short's report modelled [sic] spill volumes that were much larger than what is considered as a credible event, and that there is little evidentiary basis to support spills of this size to be credible events...[7]

5. The NEB conclusion in relation to my report is factually incorrect and wrong. The spill sizes I assumed in my May 2015 Report *were the same* as those that Trans Mountain used for its "credible mean and worst-case" scenarios at the location they modeled. Moreover, I assessed the ecological consequences of a credible worse-case oil spill at a location where the Duke-Point-Tsawassen ferry route intersects with the marine shipping route, a mere 16 kilometers to the northwest of the location Trans Mountain used—where such an oil spill is equally likely.

6. The NEB's erroneous conclusion caused it to inappropriately ignore the conclusion in my May 2015 Report that a credible worse-case oil spill in that location could have catastrophic ecological consequences in the Fraser River Estuary and Burrard Inlet. As a result, the NEB underestimated the adverse environmental and socio-economic effects of such an oil spill by an order of magnitude or more.

7. It is my professional opinion that:

   (a) if a dilbit spill were to occur within the spring freshet of the Fraser River, including within Burrard Inlet, when the salinity of the surface waters approach that of fresh water, then warm temperatures and moderate winds (in combination with the decreased salinity of the surface waters owing to the spring freshet) could, based on the studies which were referenced in the written evidence submitted to the NEB (including in my May 2015 Report), cause the spilled dilbit to submerge within as little as one or two

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[6] C358-13-17: TWN Assessment, Appendix 3: *Fate and Effect of Oil Spills from the Trans Mountain Expansion Project in Burrard Inlet and the Fraser River Estuary*, prepared by Jeffrey W. Short, dated May 11, 2015 [TWN Record, Vol 7, Tab 4C] (A4L6A8).

[7] NEB, 2016, *supra* note 1 at 390.

days. This would not provide enough time for oil spill response actions to retrieve more than a small fraction of the dilbit before it submerged.

Contrary to the NEB's conclusions, dilbit could submerge in large quantities over widespread areas if a large oil spill occurred during the conditions leading to freshened surface waters in Burrard Inlet and/or the Fraser River Estuary;

(b) the NEB erred in concluding that Trans Mountain's ecological risk assessment provided an acceptable basis for evaluating the ecological risks of an oil spill from Project-related tankers. It is deficient for a number of reasons which I explain in the body of my report below;

(c) ecological damage from a credible, worst-case spill could result in mass mortalities of sea- and shorebirds in the hundreds of thousands, which could seriously de-stabilize the marine ecosystem of the Strait of Georgia, possibly irreversibly.

An oil spill at a location where the Duke-Point-Tsawassen ferry route intersects with the marine shipping route could expose large populations of sea- and shorebirds in the Fraser River estuary to direct contact with dilbit, which would kill most of the birds contaminated. A reasonable worst-case oil spill could result in mortalities of 100,000–500,000 birds, enough to disrupt ecosystem functioning for years or even permanently, and to affect other distant habitats occupied seasonally by migratory species. A major mortality event for seabirds and shorebirds might trigger a trophic cascade, and if it did it could be the most serious long-term consequence of such an oil spill. A large reduction of seabirds caused by exposure to spilled oil could cause a disproportionately large increase of their forage fish prey. In turn, this could depress the abundance of the planktonic organisms consumed by forage fish, including the larval stages of a host of other marine organisms such as shellfish and finfish that are important economically or for subsistence harvests.

High mortalities of marine mammals could also result for species such as killer whales, porpoises, dolphins and seals that, like seabirds, routinely inhabit the sea surface, making them especially vulnerable to contact with floating dilbit. In the case of the southern resident population of killer whales, any additional mortalities resulting from oil exposure could materially contribute to the extinction risk for this stock, which would permanently alter ecosystem functioning in the Salish Sea. Also, once oiled, many of the shorelines of Burrard Inlet and the rest of the Fraser River delta would retain oil residues for months to several decades, presenting long-term reservoirs of contamination for organisms associated

with these shorelines, and hence substantial adverse consequences for subsistence uses, tourism and commercial fishing.

Finally, widespread contamination of shorelines following a large oil spill all but guarantees that people will encounter lingering pockets of oil on high-retention shorelines for many years to decades following a spill. Once stranded on shorelines, diluted bitumen released from an accidental spill may persist for days to several decades or even a century under worst-case conditions.

(d) small to medium sized oil spills on the order of 100 to 1,000 m^3 from the Project can cause substantial mortalities to seabirds, and estimated effects for small to medium spills in Canada and in Alaska have the potential to contaminate tens of kilometers of shorelines on time scales of decades.

1. INTRODUCTION

8. TWN, the City of Vancouver, and Living Oceans Society submitted my May 2015 Report as written evidence in the NEB hearing for the Project.[8] My qualifications and expertise in assessing the fate and effects of oil spills are described on pages 13–14 of my May 2015 Report and my curriculum vitae is attached as Appendix 1 to that report.

9. Since preparing my May 2015 Report, I have reviewed the relevant evidence that was filed during the NEB's hearing for the Project as well as the NEB's May 2016 report and recommendations.

10. The purpose of this report is to evaluate the conclusions in the NEB's May 2016 report on the fate and effects of oil spills from Project-related oil tankers. This issue is particularly important given the approximately seven-fold increase in marine oil tanker traffic proposed by Trans Mountain for the Project.

11. In this report, I examine the NEB's conclusions in relation to the following issues:

(a) whether dilbit from an oil spill originating from the Project may submerge in Burrard Inlet and the Fraser River Estuary;

(b) the adequacy of the ecological risk assessment for the Project; and

(c) the ecological consequences of potential oil spills from the Project in Burrard Inlet and the Fraser River estuary.

12. For each issue listed in paragraph 11, I:

[8] C358-13-17: TWN Assessment, Appendix 3: *Fate and Effect of Oil Spills from the Trans Mountain Expansion Project in Burrard Inlet and the Fraser River Estuary*, prepared by Jeffrey W. Short, dated May 11, 2015 [TWN Record, Vol 7, Tab 4C] (A4L6A8).

(a) review the NEB's conclusions and the rationale and foundation upon which the NEB's conclusions are based;

(b) evaluate the rationale and foundation the NEB used to reach its conclusions; and

(c) provide my professional opinion on the validity of the NEB's analysis and conclusions.

13. I have prepared this report in accordance with my duty as an expert to assist: (i) TWN in conducting its assessment of the Project; (ii) provincial or federal authorities with powers, duties or functions in relation to an assessment of the environmental and socio-economic effects of the Project; and (iii) any court seized with an action, judicial review, appeal or any other proceeding in relation to the Project.

14. In preparing this report, I acknowledge that it is my duty to:

(a) provide evidence that is fair, objective, and non-partisan;

(b) provide evidence that is related only to matters within my area of expertise; and

(c) provide such additional assistance as may reasonably be required to determine a matter in issue.

15. I acknowledge that my duty is to assist the entities listed in paragraph 13, not to act as an advocate for any particular party. This duty prevails over any obligation that I may owe any party, including TWN on whose behalf I have been engaged.

2. THE PROPENSITY OF DILUTED BITUMEN FROM AN OIL SPILL ORIGINATING FROM THE PROJECT TO SUBMERGE IN RECEIVING WATERS, INCLUDING IN BURRARD INLET AND THE FRASER RIVER ESTUARY

16. Once spilled oil submerges in receiving waters, it becomes far more difficult to track, locate and remediate. Failure to track submerged oil greatly increases uncertainties among spill responders and the public at large regarding the identity and location of resources impaired by exposure to oil, which can devastate commercial, sport and subsistence fisheries. Typical crude oils rarely submerge in receiving waters, but dilbit products from the Canadian oil sands (which are proposed to be shipped on the Project) are not typical crude oils and are particularly prone to submerging in water. This is because dilbit consists mainly of bitumen, a tar-like form of crude oil that would usually submerge in receiving waters, mixed with low-density petroleum products resembling gasoline. The

resulting dilbit mixture would float on receiving waters until the gasoline fraction evaporates, leaving the remaining bitumen fraction susceptible to submergence.

17. The salient issue here is then the time required for evaporation to lead to submergence of the remaining bitumen. If the residual bitumen starts to submerge in less than a day or two, it may disappear from the surface of water bodies before oil spill responders can retrieve it. Once submerged, it becomes almost impossible to track.

2.1 The NEB's conclusions about the propensity of dilbit to submerge in receiving waters

18. The NEB reaches the following conclusions regarding the behavior of spilled oil from the Project:

- "...diluted bitumen is a blended product with its own unique weathering properties", and that "...these properties include rapid initial weathering...";[9]
- "...bitumen is quite volatile during the initial stages of a spill....[and] this volatility must be considered from an oil behavior...perspective";[10]
- "...after initial weathering, diluted bitumen behaves similar to other heavy crude oils and common heavy fuel oils, such as Bunker C";[11]
- "...depending on weathering state and environmental conditions, spilled diluted bitumen could be prone to submergence in an aquatic environment";[12] and
- "...weathered diluted bitumen could pose particular challenges in response and clean up due to its potential for submergence...."[13]

19. These conclusions clearly show the NEB understands that, with respect to initial weathering behavior, dilbit products differ fundamentally from typical crude oils, in that they weather more rapidly, are prone to submerging in receiving waters as weathering proceeds, and once submerged pose challenges for oil spill responders and clean up. These conclusions are entirely consistent with findings I presented in my May 2015 Report,[14] and are well supported by relevant scientific literature.

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[9] NEB, 2016, *supra* note 1 at 136.
[10] NEB, 2016, *supra* note 1 at 137.
[11] NEB, 2016, *supra* note 1 at 136.
[12] NEB, 2016, *supra* note 1 at 136.
[13] NEB, 2016, *supra* note 1 at 137.
[14] C358-13-17: TWN Assessment, Appendix 3: *Fate and Effect of Oil Spills from the Trans Mountain Expansion Project in Burrard Inlet and the Fraser River Estuary*, prepared by Jeffrey W. Short, dated May 11, 2015 [TWN Record, Vol 7, Tab 4C] (A4L6A8).

20. However, the NEB goes on to conclude that:

> The Board is satisfied that sufficient evidence has been placed on the record regarding the fate and behavior of an oil spill to support assessment of potential spill-related effects and spill response planning.[15]
>
> ...some diluted bitumen products could submerge in brackish water or potentially sink in fresh water after approximately seven days of weathering in the absence of interaction with suspended particulates.[16]
>
> Evidence filed by parties, such as Trans Mountain and the Government of Canada, and past spill examples indicated that diluted bitumen would not typically sink in large quantities, or as a continuous mat in both freshwater and marine environments", and that "[t]he weight of the evidence indicates that any sinking would likely be in limited quantities and only after sufficient weathering over a period of days or interaction with sediment and other organic matter under the right environmental conditions.[17]

21. In summary, the NEB concluded that: (i) dilbit discharged to receiving waters would require nearly a week's exposure time before evaporative losses of volatile components would cause the remaining dilbit to submerge in fresh water, and even longer in brackish or salt water, implying that spill responders would have ample time to retrieve spilled dilbit before it would submerge from volatility losses alone; and (ii) the existing record adequate to support their conclusion that, in any case, volatility losses would only cause a small proportion of discharged dilbit to submerge.

22. As I noted in my May 2015 Report, and reiterate below, it is my professional opinion that the existing record does not support either of these two conclusions.

2.2 The rationale and foundation of the NEB's conclusions about the propensity of dilbit to submerge in receiving waters

23. In reaching its conclusions about the time required for dilbit to submerge in receiving waters, the NEB relied almost exclusively on evidence submitted by Trans Mountain and the Government of Canada. In particular, four studies informed the NEB's conclusions: two that were sponsored by Northern Gateway Pipelines Limited Partnership to support the Northern Gateway Project,[18] one that

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[15] NEB, 2016, *supra* note 1 at 136.
[16] NEB, 2016, *supra* note 1 at 136.
[17] NEB, 2016, *supra* note 1 at 136.
[18] Belore, R. (2010), Properties and fate of hydrocarbons associated with hypothetical spills at the marine terminal and in the confined channel assessment area—Enbridge Northern Gateway Project. Technical Data Report, SL Ross, Calgary, Alberta.; SL Ross (2012) Meso-scale weathering of Cold Lake bitumen/condensate blend. SL Ross Environmental Research Ltd, #200 - 1140 Morrison Drive, Ottawa, ON K2H 8S9.

was sponsored by Trans Mountain[19] for the Project, and one by Environment Canada[20].

24. All four of those studies presented results of experiments aimed at measuring the effects of evaporative losses of volatile components on the physical properties of dilbit, including changes in dilbit density. Results from those studies suggest that four or more days would be required for evaporative losses to cause dilbit to submerge in fresh water, and considerably longer to cause dilbit to submerge in open oceanic water.

2.3 Critique of the rationale and foundation of the NEB's conclusions about the propensity of dilbit to submerge in receiving waters

25. The four main studies the NEB relied on in support of its conclusions all substantially overestimate the time required for dilbit to submerge in receiving waters following an accidental discharge.

26. This overestimation results primarily from the unrealistic oil film thicknesses used in those experiments, which ranged from 1.15 mm to ~20 mm (compared with a 0.4 mm thickness of dilbit that would be immediately encountered following discharge to receiving waters).[21]

27. The thick oil films used in those experiments were justified on the basis of an Environment Canada study,[22] which concludes that evaporation rates of volatile components from typical crude oils are not sensitive to oil film thickness. However, a comparison of the results from the four studies that the NEB relied on clearly indicates that oil film thickness actually strongly affects the evaporation rate of volatile dilbit components, with thinner oil films resulting in faster evaporation rates.[23] Recently, this conclusion has been confirmed by a laboratory study by Yarranton et al. (2015),[24] which directly compares evaporation losses of dilbit at varying film thicknesses but otherwise identical exposure conditions. This study clearly shows that initial evaporation rates are inversely proportional to

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[19] Witt O'Brien's, Polaris Applied Sciences, Western Canada Marine Response Corporation (2013) A study of fate and behavior of diluted bitumen oils on marine waters, dilbit experiments—Gainford, Alberta.
[20] Environment Canada, Fisheries and Oceans Canada, and Natural Resources Canada (2013). Properties, composition and marine spill behaviour, fate and transport of two diluted bitumen products from the Canadian oil sands. Federal Government Technical Report.
[21] C358-13-17: TWN Assessment, Appendix 3: *Fate and Effect of Oil Spills from the Trans Mountain Expansion Project in Burrard Inlet and the Fraser River Estuary*, prepared by Jeffrey W. Short, dated May 11, 2015 at para 131 [TWN Record, Vol 7, Tab 4C at 1171–1172] (A4L6A8).
[22] Fingas MV (2004) Modeling evaporation using models that are not boundary-layer regulated. Journal of Hazardous Materials 107:27–36.
[23] C358-13-17: TWN Assessment, Appendix 3: *Fate and Effect of Oil Spills from the Trans Mountain Expansion Project in Burrard Inlet and the Fraser River Estuary*, prepared by Jeffrey W. Short, dated May 11, 2015 at para 131 [TWN Record, Vol 7, Tab 4C at 1171–1172] (A4L6A8).
[24] Yarranton, HW, Motahhari, H, and Schoeggl, FF (2015) Evaprative weathering of diluted bitumen films. Journal of Canadian Petroleum Technology, pp. 233–244.

dilbit film thickness, with faster evaporative losses resulting from thinner dilbit films.

28. Also, the same Environment Canada study suggests that wind speed has little effect on the evaporation rate of volatile components from typical crude oils, but that study expressly notes that wind speed strongly affects the evaporation rates of the gasoline-range components of diluents typically added to make dilbit. This finding was confirmed by the Yarranton et al. (2015) for one of the two dilbits they tested.[25] Consequently, the widely-held assumption that wind speed does not affect evaporation rates of typical crude oils is not necessarily valid when considering dilbits. In particular, *none of the four studies that the NEB relied on to evaluate the time required for dilbit to submerge in receiving waters included the combination of realistically-thin oil films together with modest wind speeds as exposure conditions, which resulted in considerable over-estimation of the time required for submergence.*

29. Other scientific studies, some of which appear to have been discounted by the NEB despite having been cited in the NEB hearing record for the Project,[26] clearly show that oil film thickness and wind speed are important factors affecting evaporation rates of volatile components from spilled petroleum products, including typical crude oils. Furthermore, as evaporative losses of volatile components causes the density of the remaining dilbit to approach that of water, submergence of dilbit will depend on the precise values of the temperature and salinity of the surface water.

30. If a dilbit spill were to occur within the spring freshet of the Fraser River, including within Burrard Inlet, when the salinity of the surface waters approach that of fresh water, then warm temperatures and moderate winds (in combination with the decreased salinity of the surface waters owing to the spring freshet) could, based on the studies which were referenced in the written evidence submitted to the NEB (including in my May 2015 Report), cause the spilled dilbit to submerge within as little as one or two days.

31. Contrary to the NEB's conclusions, dilbit could submerge in large quantities over widespread areas if a large oil spill occurred during the conditions leading to freshened surface waters in Burrard Inlet and/or the Fraser River Estuary.

32. More fundamentally, these possibilities do not support the NEB's conclusion "...that sufficient evidence has been placed on the record regarding the fate and behavior of an oil spill to support assessment of potential spill-related effects and

[25] Yarranton, HW, Motahhari, H, and Schoeggl, FF (2015) Evaprative weathering of diluted bitumen films. Journal of Canadian Petroleum Technology, pp. 233–244.
[26] Gros J, Nabi D, Wurz B, Wick LY, Brussard CPD, Huisman J, van der Meer JR, Reddy CM, Arey JS (2014) First day of an oil spill on the open sea: Early mass transfers of hydrocarbons to air and water. Environmental Science and Technology 48:9400–9411; cited in footnote 1

spill response planning." [27] Despite the experimental evidence presented, considerable uncertainty remains regarding the time required for dilbit to submerge in receiving waters. This uncertainty could be largely resolved by experiments designed to mimic likely environmental conditions during an actual spill. In that regard, the one study[28] of evaporation rates of volatile components during an experimental oil spill that I referenced in my May 2015 Report strongly suggests that dilbit would submerge much more rapidly than was indicated by any of the four studies that the NEB relied on to reach its deficient conclusions on this issue.

2.4 Professional opinion on the propensity of dilbit to submerge in receiving waters

33. Dilbit products are likely much more prone to submerge in receiving waters within the Fraser River plume in the Georgia Strait than is currently recognized by the NEB.

34. As I concluded in my May 2015 Report, in my professional opinion:

    (a) spilled dilbit could submerge within as little as one or two days of a spill within the spring freshet of the Fraser River, including within Burrard Inlet, as a result of the combined effect of the decreased salinity of the surface waters, warm temperatures and moderate winds.[29]

    (b) such a spill could result in large quantities of dilbit becoming submerged over widespread areas in Burrard Inlet and elsewhere within the Fraser River estuary.[30]

35. My conclusions here have important consequences for the GIC's decisions under the *National Energy Board Act* and the *Canadian Environmental Assessment Act, 2012* for the reasons explained below.

36. Trans Mountain's ecological risk assessment (which the NEB relied on) did not adequately assess the potential adverse effects that submerged oil may have on fisheries, tourism, subsistence food-gathering, Indigenous peoples and their title and rights (including the Tsleil-Waututh Nation), as well as other affected industries and activities. Similarly, Trans Mountain's oil spill response plan,

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[27] NEB, 2016, *supra* note 1 at 136.
[28] Yarranton, HW, Motahhari, H, and Schoeggl, FF (2015) Evaporative weathering of diluted bitumen films. Journal of Canadian Petroleum Technology, pp. 233–244.
[29] C358-13-17: TWN Assessment, Appendix 3: *Fate and Effect of Oil Spills from the Trans Mountain Expansion Project in Burrard Inlet and the Fraser River Estuary*, prepared by Jeffrey W. Short, dated May 11, 2015 at para 208 [TWN Record, Vol 7, Tab 4C at 1201] (A4L6A8).
[30] C358-13-17: TWN Assessment, Appendix 3: *Fate and Effect of Oil Spills from the Trans Mountain Expansion Project in Burrard Inlet and the Fraser River Estuary*, prepared by Jeffrey W. Short, dated May 11, 2015 at para 216 [TWN Record, Vol 7, Tab 4C at 1203] (A4L6A8).

which the NEB relied on does not address how possibly widespread submerged or sunken oil would be cleaned up and the environment subsequently remediated.

37. Importantly, the GIC can take steps now, prior to making any decision to approve the Project, to reduce the existing uncertainty in relation to dilbit submergence (and the resulting effects of that submergence) by ordering the NEB to require Trans Mountain to conduct a new experiment on dilbit submergence using: (i) dilbit films that can spread to natural film thicknesses determined only by surface tension and viscosity instead of artificial limits imposed by the container walls used for the experiments; (ii) temperature ranges that span those characterizing the receiving waters of the Fraser River discharge plume; and (iii) exposures that include winds in addition to quiescent conditions.

38. The GIC could also order the NEB to require Trans Mountain to subsequently amend its ecological risk assessment based on the results of that experiment, and to re-consider its recommendations in that regard.

3. ADEQUACY OF THE ECOLOGICAL RISK ASSESSMENT

39. The NEB required Trans Mountain to provide an ecological risk assessment for the Project. The quantitative ecological risk assessment provided by Trans Mountain includes evaluation of environmental effects from hypothetical oil spills originating at each of five locations deemed "representative",[31] one of which is located in the Strait of Georgia. These five locations were selected by Trans Mountain in part because they were considered to be places where "credible worst-case" oil spills were most likely to occur, for example where the marine shipping route for the Project intersects with a ferry route between Vancouver Island and the mainland. Oil spill trajectories were modeled for mean and "credible worst-case" spills of 8,250 m^3 and 16,500 m^3 based on seasonal wind and current data, and the consequent ecological effects of these spills were evaluated based on the modeled slick trajectories and oiled shorelines.

3.1 Summary of the NEB's conclusions regarding the ecological risk assessment

40. The NEB concludes that while a large oil spill could cause serious and widespread ecological damage, any such spills are so unlikely to occur that the potential for damage may be summarily dismissed as follows:

> The Board is of the view that although a large spill from a tanker associated with the Project would result in significant adverse environmental and socio-economic effects, such an event is not likely.[32]

41. The NEB indicated that these conclusions hold especially for Burrard Inlet and English Bay as follows:

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[31] B18-29: Trans Mountain Expansion Project Application, Volume 8A, at 8A-524, Table 5.2.2 (A3S4Y3).
[32] NEB, 2016, *supra* note 1 at 378.

> The Board finds that...a large spill in Burrard Inlet would result in significant adverse environmental and socio-economic effects... However...the Board finds that a large spill in Burrard inlet is not a likely event. The Board does not accept...that spill volumes ranging from 8 000 m^3 at the Westridge Marine Terminal to 16 000 m^3 at other locations in Burrard Inlet are credible worst-case scenarios.[33]

> The Board accepts Trans Mountain's evidence in response to the assertion made by Tsleil-Waututh Nation, City of Vancouver and the City of Burnaby that a potential large spill for a tanker at anchor in English Bay is not credible. Among other reasons, Trans Mountain said that there is no incident on record of a vessel being struck by another while at anchor in English Bay; in the event of a collision, there would not be sufficient energy to puncture both hulls of a double hull tanker; and a laden tanker would not be likely to anchor in English Bay.[34]

42. The NEB concluded that the ecological consequences of a large oil spill can be discounted (and essentially ignored) because such a large oil spill is, in its view, unlikely. In effect, the NEB has ignored and failed to consider all low-probability, high-consequence events if they fail to meet the NEB's unstated threshold for credible likelihood. Importantly, this summary dismissal extends to spills that are smaller than their modeled spill volumes, yet smaller spills are both more likely to occur, and can cause serious, widespread ecological damage.

43. The NEB concludes that only shorelines and species shown to be exposed to oil from the specific spill locations that Trans Mountain included for their oil spill trajectory modeling are susceptible to oiling. Shorelines and species that would be oiled by spills originating from other locations are excluded from consideration by the NEB:

> Trans Mountain considered a number of hypothetical oil spill scenarios. Dr. Short's report submitted by Tsleil-Waututh Nation, City of Vancouver and Living Oceans Society, questioned whether these scenarios were truly representative, whether they were close enough to particular environmentally sensitive areas, and whether they give an adequately comprehensive view of the potential effects of an oil spill. The Board is of the view Dr. Short's report modelled [*sic*] spill volumes that were much larger than what is considered as a credible event, and that there is little evidentiary basis to support spills of this size to be credible events...[35]

44. Trans Mountain did not model oil spill trajectories for spills that are smaller than the mean spill volume scenario of 8,250 m^3 along the marine shipping route. Consequently the NEB does not consider effects from large oil spills that are smaller than the mean spill volume they considered, and that may occur at other locations along the marine shipping route.

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[33] NEB, 2016, *supra* note 1 at 378.
[34] NEB, 2016, *supra* note 1 at 378.
[35] NEB, 2016, *supra* note 1 at 390.

3.2 Basis and rationale supporting the NEB's conclusions

45. The NEB justifies limiting its consideration of vulnerable shorelines and species to those that Trans Mountain's modeling indicate would be oiled following "credible" spills from the spill origin locations included in Trans Mountain's models on the following basis: because these locations are assumed to be "representative", the shorelines and species that are vulnerable to oiling from spills originating at these locations are also assumed to be "representative". In effect, Project-related oil spills from any other location along the marine shipping route within the Strait of Georgia are assumed to contaminate the same mix of shorelines and species as are those spill origin locations that were included in Trans Mountain's modeling. This includes all spills that are not as large as the "credible" spills considered in Trans Mountain's modeling, and assumes that the likelihood of smaller spills at locations other than those included in Trans Mountain's modeling is the same as the likelihood of a "credible" spill at the locations they did consider.

46. Despite numerous concerns raised by multiple intervenors, the NEB explicitly approved the methods used by Trans Mountain for the ecological risk assessment as follows:

> With regard to concerns raised by intervenors on the spill evaluation methodology used by Trans Mountain, the Board finds Trans Mountain's methods to assess effects from marine transportation spills to be acceptable.[36]

47. The NEB justified its acceptance on the following procedural grounds:

> Trans Mountain followed the approach in the Board's Filing Requirements...which requires assessment of potential accidents and malfunctions at representative locations along marine shipping routes.[37]

48. The NEB reached its conclusions regarding the acceptability of risks of large oil spills, while acknowledging that there are no generally-recognized standards for evaluating when those risks are acceptable:

> ...the Board accepts Trans Mountain's evidence that there are no proposed or widely accepted risk acceptance criteria for marine oil spills.[38]

49. Thus, the NEB dismisses risks of adverse ecological (and socio-economic) harm from large accidental marine oil spills from the Project on the basis of Trans Mountain's subjective impression that such risks are too low to warrant more

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[36] NEB, 2016, *supra* note 1 at 390.
[37] NEB, 2016, *supra* note 1 at 390.
[38] NEB, 2016, *supra* note 1 at 377.

serious consideration, despite concerns in this regard having been voiced by the Concerned Registered Professional Engineers[39] and in my May 2015 Report.

3.3 Critique of the basis and rationale supporting the NEB's conclusions

50. The NEB justified its acceptance of Trans Mountain's ecological risk assessment in part based on its finding that Trans Mountain evaluated risks of spills at representative locations. The NEB used the term "representative locations" in the sense of "example" rather than in the strict scientific sense of accurately reflecting average conditions:

> The Board has not considered Trans Mountain's scenarios as a demonstration of all the potential locations and volumes of a spill. Rather, the Board has used them as examples that provide an idea of the potential effects pathways that could occur, and together with the evidence from other hearing participants, has generalized such pathways to predict the type of effects that could result from a spill.[40]

51. This distinction has very important consequences for the adequacy of Trans Mountain's risk assessment, and the NEB's decision to rely on it. These consequences are illustrated by the following example.

52. Within the Strait of Georgia, Trans Mountain selected a single location to "represent" likely effects from a large oil spill anywhere else within the Strait. This location is at the intersection of the marine shipping route through the Strait and the Swartz Bay-Tsawassen ferry route. Trans Mountain attempted to justify its use of this location as "representative" on the basis of its subjective evaluation of the likelihood of a large oil spill occurring there. Trans Mountain cited the high frequency of ferry traffic that runs perpendicular to the marine shipping lanes as increasing the likelihood of a collision between a Project-related oil tanker and a ferry that could result in a large oil spill at that location. It then proceeded to model shoreline oiling caused by spills originating at this location. That modeling indicated that while shorelines within Boundary Bay may become heavily oiled, the much more ecologically-sensitive shorelines along Roberts Bank, which include the extremely sensitive Fraser River mouth and delta, would not. Similarly, Trans Mountain's oil spill trajectory modeling suggests that oil spilled at this location would not affect shorelines further north in English Bay or Burrard Inlet.

53. However, Trans Mountain's results, and corresponding conclusions about the magnitude of potential oil spill effects, would have been very different if it had conducted the same analysis for a large oil spill where the other major ferry route intersects the marine shipping route in the Strait of Georgia, a mere 16 kilometers to the northwest of the location Trans Mountain actually used. Although Trans

[39] NEB, 2016, *supra* note 1 at 374.
[40] NEB, 2016, *supra* note 1 at 390.

Mountain initially considered the intersection of the Duke Point-Tsawassen ferry route with the marine shipping route as another location to model and assess the ecological effects from a major oil spill, Trans Mountain ultimately did not use that location because it concluded that the likelihood of an oil spill there was too low to warrant consideration[41].

54. Trans Mountain's decision was not based on any stated standard(s) or criteria to assess the likelihood of oil spill occurrence, and despite the fact that (i) ferry traffic frequency is only modestly lower along the Duke Point-Tsawassen ferry than along the Swartz Bay-Tsawassen route, (ii) any reduction of risk because of the lower frequency of traffic along the Duke Point-Twawassen ferry route is considerably offset by the fact that the Duke Point-Tsawassen route runs parallel and within the marine shipping route for more than ten kilometers (compared with the perpendicular intersection of the Swartz Bay-Tsawassen route), and (iii) all else being equal, smaller-sized spills occur more frequently than larger-sized spills, so a spill below the credible mean size threshold used for Trans Mountain's modeling could still cause extensive ecological damage if it occurred along the Duke Point-Tsawassen ferry route, and most of this damage is not reflected by the modeled ecological effects resulting from Trans Mountain's "representative" spill location on the Swartz-Bay ferry route.

55. **Despite the similarity of the likelihood of a large oil spill occurring at the two major ferry routes within the Strait of Georgia, the ecological consequences of oil spills occurring at those locations would be very different**. Based on oil spill trajectory modeling performed by Tsleil-Waututh, a major oil spill originating at the intersection of the Duke Point-Tsawassen ferry route with the marine shipping route would heavily oil shorelines along the length of Roberts Bank, and could oil shorelines within English Bay and perhaps even Burrard Inlet. If a large oil spill contaminated those locations during the spring or fall bird migrations, it could have catastrophic consequences for migratory waterfowl. These consequences would be much worse that those anticipated on the basis of the location used by Trans Mountain for its ecological risk assessment within the Strait of Georgia.

56. This comparison therefore illustrates how much the effects of a major oil spill can vary with even small distances separating prospective spill origins – in this case, a mere 16 kilometers. That such a drastic difference in ecological effects could result from such small differences in spill origin shows that the oil spill origin location chosen by Trans Mountain, and subsequently relied on by the NEB, cannot be taken as "representative" of even spills considered as meeting the vague standards for "credibility" adopted by Trans Mountain, and even within the meaning assigned to the term "representative location" by the NEB.

[41] B18-29: Trans Mountain Expansion Project Application, Volume 8A, at 8A-524, Table 5.2.2 (A3S4Y3).

57. The NEB summarily dismissed the concerns I raised in my May 2015 Report regarding serious ecological damage that could result from large oil spills that originate from locations other than the Swartz Bay-Tsawassen ferry route intersection with the marine shipping route that was selected by Trans Mountain for its oil spill risk assessment modeling. The NEB erred in so doing for the reasons I set out below.

58. Furthermore, conditioning the assignments of vulnerability on species' and habitats' likelihood of exposure to oil from a single spill location in the Strait of Georgia distorts the evaluation of vulnerability. For example, seabirds were considered more vulnerable than shorebirds to oil exposure because Trans Mountain's oil spill trajectory modeling indicated that seabirds were more likely to be exposed to oil from the single spill origin location used in the model. Had Trans Mountain instead relied on modeling from the location of the Duke Point-Tsawassen ferry crossing intersection with marine shipping route, it would have concluded that shorebirds were more vulnerable than seabirds. This limitation fails to recognize the range of differing outcomes that have comparable probabilities of occurrence.

3.4 Professional opinion on the adequacy of the ecological risk assessment

59. In my professional opinion, the NEB erred in concluding that Trans Mountain's ecological risk assessment provided an acceptable basis for evaluating the ecological risks of an oil spill from Project-related oil tankers. In particular, Trans Mountain's risk assessment, which was accepted by the NEB, violates a basic precept of risk assessment, which is that probability of occurrence and severity of effects (or consequences) must be evaluated separately and independently. Contrary to Trans Mountain's approach, overall risk must be evaluated as the product of these two factors. Trans Mountain failed to consider spills smaller in size than their "credible mean" size, and spills that may occur at alternate locations with a greater likelihood than for Trans Mountain's "credible mean" size scenario. By eliminating adverse outcomes that are not associated with Trans Mountain's extremely limited selection of "credible" oil spill origin locations, and especially with the meaning of "credible" left undefined, Trans Mountain's ecological risk assessment is arbitrary and is substantially incomplete. The consequence of this error is that Trans Mountain, and the NEB, have significantly underestimated the risks of large, medium and small oil spills from marine tankers associated with the Project. As such, it is not an acceptable basis for evaluating actual ecological risks, and should not have been accepted and relied on by the NEB.

60. Moreover, and in any event, the NEB was at minimum required, but failed, to clearly state what level of risk it considers acceptable, and the method(s) it used to estimate that risk.

4. ECOLOGICAL CONSEQUENCES OF POTENTIAL OIL SPILLS FROM THE PROJECT IN BURRARD INLET AND THE FRASER RIVER ESTUARY

61. Oil spill ecological risk assessments require evaluation of likely effects. Major concerns include evaluation of the numbers of individuals likely to be adversely affected within each impacted species, the extent and persistence of oiling for each different shoreline type, and risks posed to the viability of threatened or endangered species. The locations of high marine productivity and essential habitats for breeding, rearing and growth are very unevenly distributed geographically and also across spatial scales. Proper evaluation of ecological risks therefore requires assessments of the magnitudes of species and habitats at risk as well as their relative vulnerabilities.

4.1 Summary of the NEB's conclusions regarding the ecological consequence of potential oil spills from the Project

62. The NEB acknowledges that:

> ...the environmental effects of a spill from a tanker would be highly dependent on the particular circumstances, such as the amount and the type of product(s) spilled, location of the spill, response time, the effectiveness of containment and clean up, the valued components that are impacted, and the weather and time of year of the spill.[42]

63. The NEB also concluded that an oil spill from tankers associated with the Project would cause significant adverse environmental effects as follows:[43]

> The Board is of the view that although a large spill from a tanker associated with the Project would result in significant adverse environmental and socio-economic effects, such an event is not likely.
>
> The Board finds that based on evidence filed by Trans Mountain and intervenors, a large spill in Burrard Inlet would result in significant adverse environmental and socio-economic effects.

64. The NEB concludes that in relation to certain affected species and areas, ecological recovery would be relatively rapid and approach pre-spill conditions:

> The Board is of the view that although impacts from a credible worst-case spill would probably be adverse and significant, natural recovery of the impacted areas and species would likely return most biological conditions to a state generally similar to pre-spill conditions. Such recovery may be as quick as a year or two for some valued components, or may take as long as a decade or more for others.

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[42] NEB, 2016, *supra* note 1 at 397.
[43] NEB, 2016, *supra* note 1 at 378.

65. However, the NEB also concludes that recovery to pre-spill conditions may not occur for other species, including SARA-listed species as follows:

> For some valued components, including certain SARA-species, recovery to pre-spill conditions may not occur.[44]

66. In essence, the NEB affirms that in addition to credible mean and worst-case spills being so unlikely as to not warrant serious consideration (see section 3 above), even if one were to occur, overall ecological recovery would, with some exceptions, be rapid.

4.2 Basis and rationale supporting the NEB's conclusions

67. Trans Mountain relied heavily on the extensively documented recovery of Prince William Sound, Alaska following the 1989 *Exxon Valdez* oil spill to inform its assessment of likely recovery from a major spill along the marine shipping route through the Strait of Georgia.[45]

68. The ecological risk assessment presented by Trans Mountain in its application relied heavily on relative ranking methods to evaluate possible harm to vulnerable populations. Each of four major ecological damage categories including shorelines, fish, birds and mammals were evaluated on the basis of a ranking system that assigned relative sensitivities to major groups of shoreline types or animal species within each of the ecological damage categories. Overall ecological damage was based on the likelihood that sensitive shorelines or species would be exposed to oil from spills originating at the locations considered. Within the Strait of Georgia, assessment of these sensitivities was conditioned on their likelihood of exposure to oiling, based solely on the single oil spill origin location selected by Trans Mountain for its oil spill trajectory modeling there.

69. The NEB summarily dismissed the concerns I raised in my May 2015 Report regarding the serious ecological damage that could result from a credible worse-case oil spill from a tanker in the Strait of Georgia on the following basis:

> Trans Mountain considered a number of hypothetical oil spill scenarios. Dr. Short's report submitted by Tsleil-Waututh Nation, City of Vancouver and Living Oceans Society, questioned whether these scenarios were truly representative, whether they were close enough to particular environmentally sensitive areas, and whether they give an adequately comprehensive view of the potential effects of an oil spill. The Board is of the view Dr. Short's report modelled [sic] spill volumes that were much larger than what is considered as a credible event, and

[44] NEB, 2016, *supra* note 1 at 398.
[45] B18-33: Trans Mountain Expansion Project Application, Volume 8A: Marine Transportation (December 2013) at 8A-620 (A3S5Q3).

> that there is little evidentiary basis to support spills of this size to be credible events...[46]

4.3 Critique of the basis and rationale supporting the NEB's conclusions

70. The NEB conclusion in relation to my report is factually incorrect and wrong. The spill sizes I assumed in my May 2015 Report *were the same* as those that Trans Mountain used for its "credible mean and worst-case" scenarios at the location they modeled. Moreover, I assessed the ecological consequences of a credible worse-case oil spill at a location where the Duke-Point-Tsawassen ferry route intersects with the marine shipping route, a mere 16 kilometers to the northwest of the location Trans Mountain used—where such an oil spill is equally likely.

71. Furthermore, the NEB dismissed the potential for adverse ecological effects from major oil spills in English Bay or Burrard Inlet, and the concerns I raised regarding such effects in my May 2015 Report, because it does not believe a credible worst-case spill could occur in these waterbodies, and it ignored any possibility that oil from credible mean or worst-case spills at nearby locations that are outside these water bodies (such as the intersection of the Duke Point-Tsawassen ferry route with the marine shipping route) could be carried into English Bay or Burrard Inlet by winds or currents:

> The evidence...indicates that a large spill of 8 000 m^3 for a tanker at the WMT or a 16 000 m^3 spill within Burrard Inlet and English Bay area are not credible worst-case spill scenarios. The Board has therefore given little weight to evidence showing potential effects associated with such a scenario or the response capacity analysis commissioned by the City of Vancouver, Tsleil-Waututh Nation and Tsawaout First Nation for these areas.[47]

72. The NEB's conclusion in that regard is erroneous as it fails to appreciate or even acknowledge the drastic differences in oil trajectories that may result from modest differences in spill origin location. Even if major spills within English Bay or Burrard Inlet are as unlikely as the NEB thinks, the spill trajectory modeling done by Tsleil-Waututh shows that these shorelines could be heavily contaminated by oil transported there by currents following release at the Duke Point-Tsawassen intersection with the marine shipping route. The NEB erroneously failed to even consider, let alone assess, the potential effects associated with such an event.

73. The NEB's erroneous conclusion caused it to inappropriately ignore the conclusion in my May 2015 Report that a credible worse-case oil spill in that location could have catastrophic ecological consequences in the Fraser River Estuary and Burrard Inlet. As a result, the NEB underestimated the adverse

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[46] NEB, 2016, *supra* note 1 at 390.
[47] NEB, 2016, *supra* note 1 at 388.

environmental and socio-economic effects of such an oil spill by an order of magnitude or more.

74. The NEB underestimated the magnitude of the ecological consequences of oil spills from in or around Burrard Inlet and the Fraser River Estuary in the following three ways:

(a) The ranking scheme used by Trans Mountain largely fails to appropriately value the overall ecological importance of the Fraser River delta and its receiving waters in the Strait of Georgia. The Fraser River estuary is the most productive diverse and important estuary anywhere along the Pacific coast of North America. As such, oil spill effects there will in all likelihood be markedly worse than elsewhere along the Pacific coast, including Prince William Sound, the location of the 1989 *Exxon Valdez* oil spill that provided much of the basis for Trans Mountain's ecological assessment of oil spill effects. The approach used by Trans Mountain for their ecological risk assessment, and accepted by the NEB, fails to adequately address the scale of damage that a major oil spill in the Strait of Georgia could inflict in absolute terms compared the other spill locations along the North American Pacific coast.

Also, application of the same ranking scheme for sensitivity to oiling to each of the four major ecological damage categories considered creates the appearance of false equivalencies for sensitivities to oiling across species and habitats. For example, all birds are correctly viewed as highly sensitive to oil exposure, yet shorebirds were assigned the lowest sensitivity to oiling in the Trans Mountain ranking scheme, equating their sensitivity to that of pelagic fish or marine invertebrates such as worms, mussels, and crab, all of which are much less sensitive to oil exposure than are shorebirds. These false equivalencies are artifacts of an inappropriate ranking scheme that is not based on fundamental differences in sensitivity, but on taxonomic similarities that are largely blind to the inherent sensitivities of the organisms involved.

(b) Trans Mountain and the NEB are largely silent with regard to serious ecological damage that could result from substantial-size spills that are smaller than their credible mean or worst-case scenarios. Even spills considerably smaller than the credible mean scenario of 8,250 m^3 can have substantial adverse effects on sea- and shorebirds as well as marine mammals and other organisms inhabiting the sea surface, and shorelines, and on organisms inhabiting the water column if the oil submerges. Small to medium sized oil spills on the order of 100 to 1,000 m^3 can cause substantial mortalities to seabirds, and estimated effects for small to

medium spills in Canada and in Alaska have the potential to contaminate tens of kilometers of shorelines on time scales of decades.[48]

(c) Finally, neither Trans Mountain nor the NEB adequately appreciate the potential for long-term ecosystem-level effects of a major oil spill near the Fraser River delta. Large-scale mortalities of birds and mammals could have de-stabilizing effects on the marine food web of Burrard Inlet and the Fraser River estuary and cause ecosystem-level effects there and beyond. Evidence for cascading effects on the nearshore marine food web that was triggered by mass mortalities of sea- and shorebirds following the *Deepwater Horizon* oil spill in the Gulf of Mexico has been presented recently in a provisionally-accepted manuscript.[49] Given the seasonally-high densities of migratory shorebirds on Roberts Bank that could be vulnerable to an oil spill, which could reach as high as ~500,000 birds, such concerns extend to large oil spills that result from Project-related tankers in the Strait of Georgia.

4.4 Professional opinion regarding the ecological consequences of potential oil spills from the Project

75. In my professional opinion the NEB erred in failing to consider adverse ecological effects that would ensue from oil spills that could originate from locations along the marine shipping route other than those included in Trans Mountain's modeling efforts. At least at one other location than was considered in Trans Mountain's models, a credible worst-case oil spill is nearly as likely, but the ecological effects would be considerably worse.

76. The NEB erred in not evaluating possible ecological effects from credible spills that are smaller than Trans Mountain's worst-case scenarios but that are more likely to occur. Even 100 m^3 to 1,000 m^3 spills can cause extensive and prolonged ecological damages.

77. The NEB also erred in failing to consider how oil originating from locations other than those included in Trans Mountain's modeling could be transported to sensitive shorelines and species such as English Bay and Burrard Inlet.

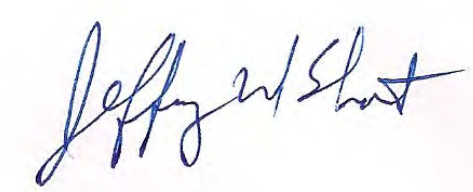
78. Neither Trans Mountain nor the NEB consider possibilities for long-term ecosystem-level effects, which have to potential to alter marine ecosystem functioning on decadal time scales or longer. An oil spill in the Fraser River estuary could expose large populations of sea- and shorebirds to direct contact

[48] WSP Canada (2014) Risk Assessment for Marine Spills in Canadian Water: Phase 1, Oil Spills South of the 60th Parallel. Report from WSP Canada Inc. to Transport Canada. 172 p. and appendices.
[49] Short JW, Geiger HJ, Haney JC, Voss CM, Vozzo ML, Guillory V, and Peterson CH (provisionally accepted) Anomalously high recruitment of the 2010 Gulf Menhaden (*Brevoortia patronus*) year class: Evidence of indirect effects from the *Deepwater Horizon* blowout in the Gulf of Mexico. Archives of Environmental Contamination and Toxicology.

with diluted bitumen, which would kill most of the birds contaminated. A reasonable worst-case oil spill could result in mortalities of 100,000–500,000 birds, enough to possibly disrupt ecosystem functioning for years or even permanently, and to affect other distant habitats occupied seasonally by migratory species. A major mortality event for seabirds and shorebirds might trigger a trophic cascade, and if it did it could be the most serious long-term consequence of a major oil spill in the Fraser River estuary. A large reduction of seabirds caused by exposure to spilled oil could cause a disproportionately large increase of their forage fish prey. In turn, this could depress the abundance of the planktonic organisms consumed by forage fish, including the larval stages of a host of other marine organisms such as shellfish and finfish that are important economically or for subsistence harvests.

79. High mortalities of marine mammals could also result for species such as killer whales, porpoises, dolphins and seals that, like seabirds, routinely inhabit the sea surface, making them especially vulnerable to contact with floating diluted bitumen. In the case of the southern resident population of killer whales, any additional mortalities resulting from oil exposure could materially contribute to the extinction risk for this stock, which would permanently alter ecosystem functioning in the Salish Sea. Also, once oiled, many of the shorelines of Burrard Inlet and the rest of the Fraser River delta would retain oil residues for months to several decades, presenting long-term reservoirs of contamination for organisms associated with these shorelines, and hence substantial adverse consequences for subsistence uses, tourism and commercial fishing.

Dated: November 24, 2016



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