# S. Executive Summary

The Tesoro Savage Petroleum Terminal LLC has submitted an Application for Site Certification to the Washington State Energy Facility Site Evaluation Council (EFSEC) to construct and operate the Vancouver Energy Distribution Terminal Facility at the Port of Vancouver in Vancouver, Washington. Abt Associates and Bear Peak Economics were tasked with estimating potential economic impacts to fisheries and potential natural resource damages from an effective worst-case oil spill based on a tanker grounding in the Columbia River near Vancouver, Washington. In addition, we examined potential natural resource damages from a train derailment near the Bonneville Dam.

The scope of this task was restricted to assessing the impacts in the Columbia River from these two scenarios; we did not evaluate potential impacts in the Pacific Ocean or along the Pacific Coast. We also did not separately assess how the public or Indian Tribes would value the potential losses to natural resources if either of these spills were to occur, although these values may be at least partly accounted for in the methods we used. Thus, we expect that we are underestimating the potential impacts to fisheries and the potential natural resource damages from these spill scenarios.

The "effective worst-case discharge" for a tanker grounding in the lower Columbia River is a spill of 189,845 bbls (about 8 million gallons) of Bakken crude oil (EFSEC, 2015). Based on data from a 1984 oil spill in the river as well as models presented in the Draft Environmental Impact Statement (DEIS; EFSEC, 2015), we concluded that oil spilled near Vancouver would reach Longview (approximately 40 miles downstream) in 1 day, then travel slowly through the estuary, reaching the mouth after an additional 4 days. In the reach from Vancouver to Longview (Reach 2), we estimated that most of the oil would be on the surface, based on the physical properties of Bakken crude and the oil transport models presented in the DEIS. However, even a small percentage of 8 million gallons mixing into the water column could create concentrations of polycyclic aromatic hydrocarbons (PAHs) potentially toxic to exposed fish. In the lower reach from Longview to the mouth (Reach 1), tides cause diurnal current reversals, and the model from the DEIS predicts that a higher percentage of surface oil will disperse into the water column.

The worst-case discharge for a train derailment is a spill of 20,000 bbls (840,000 gallons) of Bakken crude oil (EFSEC, 2015). The worst-case scenario would be for the oil spill to occur immediately upstream of the Bonneville Dam, with most of the oil going through the spillway. In this highly turbulent environment, much of the oil would be mixed into the water column, potentially exposing white sturgeon to highly elevated PAH concentrations in their protected spawning grounds immediately downstream of the Bonneville Dam (Reach 4), in addition to exposing adult salmon migrating upstream to spawn and juvenile salmon (smolts) migrating downstream to the Pacific Ocean. The oil would move downstream, exposing river habitat both upstream of Vancouver (Reaches 4 and 3) and downstream of Vancouver (Reaches 2 and 1) to the oil.

## Economic Impacts to Fisheries

We evaluated the potential economic impacts related to commercial and recreational fisheries for the tanker grounding scenario only. A tanker grounding that discharges 8 million gallons of Bakken crude oil into the river environment would have a substantial impact on commercial and

recreational fishing. While past spills at other sites throughout the country have not always resulted in fishing closures, some spills have resulted in closures lasting from several months to almost a full year. Given the large amount of oil discharged under this scenario and the confined river environment of the potential spill, we estimate that a 6-month closure of all fishing on the lower Columbia River is a likely outcome.

Impacts to recreational fishing are likely to continue even after a closure is lifted. In past spills, recreation impacts have usually lasted for a period of several months to a year or more. For the spill under consideration, we have assumed that impacts to recreational fishing last a full year. The first 6 months involve a 100% loss of trips during the closure, and the remaining 6 months involve losses that decline linearly to zero at the end of a year.

For the specific values estimated below, we assumed the spill would occur in May and would affect the highly valued summer and fall fishing seasons. We calculated three different types of fishing losses:

- ***Lost revenue from commercial landings***: $4.7 million. This is a measure of the economic losses to commercial fishermen. Lost revenue may differ from total losses because commercial fishermen may recoup some costs while the fishery is closed, or may continue to incur losses after the fishery is reopened due to public perceptions about fish harvested from the river.
- ***Decline in expenditures by recreational anglers:*** $14.4 million. This is a measure of the potential disruption to local economic activity, with the most direct impacts on local businesses, such as bait shops and marinas. If anglers make up for lost trips on the Columbia River by taking additional trips to other sites nearby, some of these expenditures may not be diverted from the local area.
- ***Decline in the value of recreational fishing***: $17.8 million. This is the monetary quantification of lost enjoyment by recreational anglers whose preferred fishing opportunities are degraded or eliminated by the spill.

Because each of these losses is measuring something conceptually different, these values may not be strictly additive.

## Natural Resource Damages

To estimate potential natural resource damages from these oil spill scenarios in the lower Columbia River, we used a habitat equivalency analysis (HEA). This is a commonly used technique where damages are based on the cost to restore habitat and natural resource services equivalent to those that were harmed by the oil. We estimated the service loss from oil exposure based on available data and knowledge from other spills, noting that in the event of an actual spill, federal and state natural resource Trustees would use data collected during the spill to estimate lost habitat services. In addition, we again note that we have not accounted for impacts in the Pacific Ocean and along the coast, and we have not separately assessed potential losses in the value of natural resources to the public or to Tribes, and thus these estimates are not comprehensive.

Our HEA generally followed methods developed for natural resource damage assessments in Puget Sound (Commencement Bay/Hylebos Waterway, Elliot Bay/Duwamish River). The assumed restoration is estuarine marsh habitat. If oil caused harm (injury) to natural resources in other habitats, those service losses were converted to an amount of marsh habitat that provides equivalent services. In this analysis, we estimated service loss to estuarine and freshwater marsh habitats both in the river channel and in the floodplain adjacent to the river channel; these wetland habitats were assumed to provide the same services as a restored estuarine marsh. We also estimated service loss to riverine, subtidal, and other habitats in the river channel; these habitats were assumed to provide 10% of the services of an estuarine marsh.

In a HEA model, future service losses from the lingering effects of the spill and future service gains from habitat restoration are discounted to a base year using a 3% discount rate to reflect consumer time preference. The discounted losses and gains in each year are summed, creating an estimate of total natural resource injuries in units of discounted service acre-years (DSAYs), and an estimate of total restoration benefits in DSAYs per acre. Dividing the total injuries (DSAYs) by the benefits of restoration (DSAYs per acre) provides an estimate of the number of acres of marsh habitat restoration required to make the public whole.

For these scenarios, we assumed that the spill occurs in the spring of 2016 (present year, for discounting purposes), and that most of the service losses occur in 2016 and 2017. Complete recovery to pre-spill conditions occurs slowly thereafter until 2025. We assumed that the marsh restoration required to offset these impacts would be completed in 2021, it would take 15 years for the marsh to become fully established and provide 100% of marsh habitat services (Commencement Bay Natural Resource Trustees, 2002), and those restored services would be provided for 100 years. This provides 20.5 DSAYs of restoration "credit" per acre restored.

We found a wide range of costs for restoring estuarine marsh habitat; some projects restored hundreds of acres of habitat by breaching a dike and flooding former fields, at a cost of a few thousand dollars per acre. Other projects, including those in Commencement Bay, required land purchase, waste removal, and a complicated engineering design to restore the habitat; these projects cost over $1 million per acre. We used the recent Fir Island restoration in the Skagit Valley (WDFW, 2014) as the basis for cost estimates. This project restored 130 acres of marsh habitat supporting Chinook salmon and snow geese at a cost of $110,000 per acre.

### Tanker Grounding

An 8-million-gallon oil spill in the Columbia River near Vancouver would expose fish, birds, pinnipeds, and other biota (and their supporting habitats) to oil, with the largest impacts most likely to result if the spill occurs in the spring (mid-April to mid-May). Potential natural resource impacts from this oil spill include:

- ***Birds***: There are four wildlife refuges between Vancouver and the mouth of the river, with many thousands of birds potentially exposed to oil. In 2007, approximately 140 bald eagles were known to reside and breed along the river. Data from the literature suggest that most birds exposed to oil are impaired and may die from symptoms ranging from hemolytic anemia to hypothermia to heart failure. Oiled eggs rarely produce offspring, and oiled feathers impact flight behavior, which could lead to increased predation and decreased hunting and migration success.

- ***Pinnipeds***: Hundreds of Steller sea lions, California sea lions, and harbor seals are in the estuary in the spring; sea lions can be found throughout the lower Columbia River, including at the base of the Bonneville Dam. Data from other spills suggest adverse health effects on marine mammals exposed to oil.

- ***Adult salmon***: We calculated the potential exposure of salmon to oil from this scenario based on fish count data from the Bonneville Dam. Data from the literature suggest that adult salmon swimming upstream take up to 3 weeks to reach the dam; about 2 weeks' worth of adult salmon would intersect the oil slick as it moved downstream from Vancouver. We estimated 45,000 to 70,000 adult salmon would be exposed to the oil in Reach 1, and an additional 20,000 to 60,000 adult salmon would be exposed in Reach 2. Recent literature suggests that PAH exposure reduces the physical fitness of fish, which could affect the ability of adult salmon to reach their spawning grounds.

- ***Juvenile salmon***: Salmon smolts migrate downstream in the spring. The literature suggests that smolts migrate with the current until they reach the estuary, where they linger for several days before swimming out to sea. We assume that one daily cohort of smolts would follow the oil downstream, and several additional daily cohorts would then intersect the oil in the estuary. In total, we estimate 1.4 million to 1.6 million smolts would be exposed to the oil in the river over the approximately 5 days that the oil is primarily in the river before discharging into the Pacific Ocean. Although few studies have exposed juvenile fish oil, the literature suggests that the concentrations of PAHs expected in the Columbia River from this spill scenario would exceed thresholds for multiple toxic endpoints in early life-stage fish.

To determine the appropriate compensation for the impacts of oil exposure, we calculated the total area of the river channel from Vancouver to the mouth (Reaches 1 and 2, extending nearly 100 river miles). Using bathymetric and National Wetlands Inventory (NWI) data in a geographic information system (GIS), we calculated 16,152 acres of wetland habitat and 91,579 acres of riverine/subtidal habitat would be oiled in the river channel. We estimated a 90% loss of habitat services in Reach 2 and a 75% loss in Reach 1 in 2016, recovering to a 10% service loss by the end of 2017, and reaching pre-spill conditions by 2025. This results in 21,276 DSAYs of natural resource injury (HEA "debit").

With a total calculated debit of 21,276 DSAYs, and using a credit of 20.5 DSAYs per acre of restored wetland calculated above, the total the total quantity of restoration required to offset the injuries in Reach 1 and Reach 2 of the river channel is 1,040 acres. At a cost of $110,000 per acre, the total damages for injuries to the river channel habitats would be about $114.4 million (Table S.1).

**Table S.1. Estimated cost to restore marsh habitat sufficient to offset injuries to river channel habitats in the lower Columbia River downstream of Vancouver**

| Debit (DSAYs) | Credit (DSAYs/acre) | Restoration required (acres) | Unit cost ($/acre) | Total |
|---|---|---|---|---|
| 21,276 | 20.5 | 1,040 | $110,000 | $114.4 million |

To capture likely natural resource injuries to birds that are exposed to oil in the river but are found in adjacent floodplain habitats, we estimated habitat service loss in wetlands in the 100-year floodplain but outside of the area designated as river channel. These wetlands could be

directly exposed to oil if the river stage is high, they could have stranded oil on the margins, and the birds residing in the wetlands could be exposed to oil on the river channel.

Using NWI data in a GIS, we calculated 29,867 acres of floodplain wetlands in Reaches 1 and 2 downstream of Vancouver. We estimated a 25% loss in Reaches 1 and 2 in 2016, recovering to a 5% service loss by the end of 2017, and reaching pre-spill conditions by 2025. For the 29,867 acres of floodplain wetland habitat, the total HEA debit is 10,580 DSAYs.

With a total calculated debit of 10,580 DSAYs and a credit of 20.5 DSAYs per acre, the total quantity of restoration required to offset the injuries to refuge habitat and biota is 517 acres. At a cost of $110,000 per acre, the total damages would be about $56.9 million (Table S.2).

**Table S.2. Estimated cost to restore marsh habitat sufficient to offset injuries to floodplain wetland habitat in the lower Columbia River downstream of Vancouver**

| Debit (DSAYs) | Credit (DSAYs/acre) | Restoration required (acres) | Unit cost ($/acre) | Total |
|---|---|---|---|---|
| 10,580 | 20.5 | 517 | $110,000 | $56.9 million |

## Train Derailment

Although the worst-case train derailment scenario is a spill of roughly 10% of the oil spilled in a worst-case tanker grounding, it will expose a greater area of the lower Columbia River to oil. Assuming most of the oil goes through the Bonneville Dam spillway, it will be mixed into the water column and expose fish in the 4.8-mile reach below the dam (Reach 4) to highly elevated PAH concentrations. This oil will then continue downstream, exposing biota in Reach 3 (which extends downstream to Vancouver) and, to a lesser degree, biota in Reaches 2 and 1 downstream of Vancouver. In total, this is approximately 140 river miles of potential oil exposure.

Natural resource damages are not scalable based on the quantity of oil spilled; therefore, we would not expect damages from this spill scenario to be 10% of the damages from the previous scenario. Although the quantity of oil is less and the oil exposure will decrease with distance from the dam, the amount of exposed habitat in the lower Columbia River is greater than in the tanker scenario. In addition, as noted previously, we would expect a large quantity of oil in the tanker scenario to be discharged into the ocean and deposited on the coastline. We have not quantified damages in those habitats.

Similar to the previous scenario, an 840,000-gallon oil spill in the Columbia River just upstream of the Bonneville Dam would expose fish, birds, pinnipeds, and other biota (and their supporting habitats) to oil, with the largest impacts most likely to result if the spill occurs in the spring (mid-April to mid-May). Potential natural resources exposed to the oil include:

- ***Birds***: There are seven wildlife refuges (and one small game management area) between the Bonneville Dam and the mouth of the river. As described previously, these refuges are home to thousands of birds that would potentially be exposed to the oil, and the oil directly or indirectly would cause mortality for many of these exposed birds.
- ***Pinnipeds***: Sea lions congregating at the base of the Bonneville Dam would be exposed to highly elevated oil concentrations. Other pinnipeds would be exposed to lower concentrations of oil in the estuary (Reach 1).

- ***Adult salmon***: For this scenario, we only calculated the number of salmon exposed at the base of the dam (Reach 4). The number of adult salmon per day counted at the Bonneville Dam in mid-May from 2011 to 2015 ranged from 2,000 to 9,000, with an average of 4,000. The daily cohort present at the base of the dam when the spill occurs would be exposed to highly elevated PAH concentrations. As mentioned previously, it takes adult salmon approximately 3 weeks to travel from the mouth of the river to the dam; each of those daily cohorts would be exposed to the oil as well, at lesser concentrations with distance downstream.
- ***Juvenile salmon***: The number of salmon smolts per day counted at the Bonneville Dam in mid-May between 2011 and 2015 ranged from 27,000 to 220,000, with an average of 112,000. This daily cohort would be exposed to highly elevated PAH concentrations near the dam, and their exposure would likely continue for several days as they traveled downstream with the oil plume. Additional daily cohorts of smolts would be exposed in the estuary before swimming out to sea.

Using the same methods described for the tanker grounding scenario, we calculated the total area of the river channel from the Bonneville Dam to the mouth (Reaches 1 through 4, extending nearly 140 river miles). Using bathymetric and NWI data in a GIS, we calculated that 16,687 acres of wetland habitat (primarily in the estuary, Reach 1) and 110,316 acres of riverine/subtidal habitat would be oiled in the river channel. Because 866 acres of riverine habitat in Reach 4 is protected white sturgeon spawning habitat, we assumed this reach provides the equivalent of 100% of estuarine marsh habitat services, rather than the 10% estimate that we used for all other riverine habitat.

We estimated a 90% loss of habitat services in Reach 4, a 50% loss in Reach 3, and a 15% loss in Reaches 2 and 1 in 2016. Reaches 4 and 3 would recover to a 10% service loss by the end of 2017 and to pre-spill conditions by 2025. Reaches 2 and 1 would recover to a 5% service loss by the end of 2017 and to pre-spill conditions by 2025. This results in 10,135 DSAYs of natural resource injury (HEA debit).

With a total calculated debit of 10,135 DSAYs and a credit of 20.5 DSAYs per acre, the total quantity of marsh restoration required to offset the injuries to river channel habitats is 495 acres. At a cost of $110,000 per acre, the total damages would be about $54.5 million (Table S.3).

**Table S.3. Estimated cost to restore marsh habitat sufficient to offset injuries to river channel habitats in the lower Columbia River downstream of the Bonneville Dam**

| Debit (DSAYs) | Credit (DSAYs/acre) | Restoration required (acres) | Unit cost ($/acre) | Total |
|---|---|---|---|---|
| 10,135 | 20.5 | 495 | $110,000 | $54.5 million |

To capture likely natural resource injuries to birds that are exposed to oil in the river but are found in adjacent floodplain habitats, we again estimated habitat service loss in wetlands in the 100-year floodplain but outside of the area designated as river channel. Using NWI data in a GIS, we calculated 32,055 acres of floodplain wetlands downstream of the Bonneville Dam.

We estimated a 75% loss of habitat services in Reach 4, a 25% loss in Reach 3, and a 10% loss in Reaches 2 and 1 in 2016. Reach 4 would recover to a 25% service loss by the end of 2017 and

to pre-spill conditions by 2025. Reach 3 would recover to a 10% service loss by the end of 2017 and to pre-spill conditions by 2025. Reaches 2 and 1 would recover to a 2% service loss by the end of 2017 and to pre-spill conditions by 2025. This results in 5,643 DSAYs of natural resource injury (HEA debit).

With a total calculated debit of 5,643 DSAYs and a credit of 20.5 DSAYs per acre, the total quantity of marsh restoration required to offset the injuries to floodplain wetland habitat and biota is 276 acres. At a cost of $110,000 per acre, the total damages would be about $30.4 million (Table S.4).

**Table S.4. Estimated cost to restore marsh habitat sufficient to offset injuries to floodplain wetland habitat in the lower Columbia River downstream of the Bonneville Dam**

| Debit (DSAYs) | Credit (DSAYs/acre) | Restoration required (acres) | Unit cost ($/acre) | Total |
|---|---|---|---|---|
| 5,643 | 20.5 | 276 | $110,000 | $30.4 million |

## Conclusions

We examined potential impacts to commercial and recreational fisheries from a tanker grounding near Vancouver, and we estimated potential natural resource damages from both the tanker grounding scenario near Vancouver and a train derailment scenario near the Bonneville Dam. The scope of this work was restricted to impacts in the Columbia River. Though oil in the Columbia River (particularly from a tanker grounding near Vancouver) would be discharged to the Pacific Ocean and would impact natural resources along many miles of coastline, we have not quantified those impacts.

To estimate natural resource damages, we used a HEA model that calculates damages based on the cost to restore habitat equivalent to what the oil injured. If a major spill were to occur in the Columbia River, Trustees would incorporate laboratory and field data to calculate the habitat losses. Trustees might also choose to estimate damages based on values that humans place on natural resources, including Tribal cultural values. A damages estimate incorporating these values could be substantially higher than the restoration-based calculations in this analysis.

The estimated fisheries impacts from a tanker grounding near Vancouver include a 6-month fisheries closure, plus lingering effects on recreational fishing for an additional 6 months, range from $4.7 million to $17.8 million (Table S.5). As noted previously, these losses are not strictly additive.

**Table S.5. Summary of estimated losses to fisheries from a worst-case vessel grounding near Vancouver**

| Type of loss | Value |
|---|---|
| Lost revenue from commercial landings | $4.7 million |
| Decline in expenditures by recreational anglers | $14.4 million |
| Decline in value of recreational fishing | $17.8 million |

The estimated damages to Columbia River habitats from a worst-case vessel grounding in Vancouver is $171.3 million, including $114.4 million for injured habitats in the river channel and $56.9 million for injuries to floodplain wetlands adjacent to the river (Table S.6).

**Table S.6. Summary of estimated restoration-based damages to Columbia River habitats from a worst-case vessel grounding near Vancouver**

| Habitat | Damages |
|---|---|
| Wetland and non-wetland (riverine, subtidal) habitats in the lower Columbia River channel downstream of Vancouver | $114.4 million |
| Wetland habitat in the 100-year floodplain adjacent to the lower Columbia River channel downstream of Vancouver | $56.9 million |
| **Total** | **$171.3 million** |

The estimated damages to Columbia River habitats from a worst-case train derailment near the Bonneville Dam is $84.9 million, including $54.5 million for injured habitats in the river channel and $30.4 million for injuries to floodplain wetlands adjacent to the river (Table S.7).

**Table S.7. Summary of estimated restoration-based damages to Columbia River habitats from worst-case train derailment near the Bonneville Dam**

| Habitat | Damages |
|---|---|
| Wetland and non-wetland (riverine, subtidal) habitats in the lower Columbia River channel downstream of the Bonneville Dam | $54.5 million |
| Wetland habitat in the 100-year floodplain adjacent to the lower Columbia River channel downstream of the Bonneville Dam | $30.4 million |
| **Total** | **$84.9 million** |

These estimates are considerably less than major oil spill settlements such as *Exxon Valdez* or *Deepwater Horizon*. Although damages are not scalable based on the volume of oil discharged, such calculations can provide useful context. Summarizing data from multiple incidents, the range of damages from other oil spill incidents scaled by the volume of oil spilled in the Columbia River scenarios is $232 million to $1.16 billion for the tanker grounding, and $24.4 million to $122 million for the train derailment. The restoration-based damages estimate of $171.3 million calculated for the vessel grounding is below this range; the damages estimate of $84.9 million calculated for the train derailment is within this range. These estimates do not include damages from oil discharged to the ocean, which, if considered, would result in substantially higher estimated damages.

## References

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