Figure 7-2 Mosquito Creek and Habitat Approximately 2 Miles Downstream of the Pipeline Crossing Looking Upstream

Figure 7-3 Mosquito Creek and Habitat Approximately 2 Miles Downstream of the Pipeline Crossing Looking Downstream

Figure 7-4 **Mosquito Creek and Riparian Habitat Approximately 25 Miles Downstream of the Pipeline Crossing to the West of Lower Rice Lake**

Figure 7-5 **Mosquito Creek and Riparian Habitat Approximately 55 Miles Downstream of the Pipeline Crossing to the West of Lower Rice Lake**

Table 7-46 Environmental Characteristics Observed at Selected Access Points on the Mosquito Creek in May, 2016

Access Point	Latitude Longitude	Notes
211th Avenue and Mosquito Creek approximately 2 miles downstream of pipeline crossing	47.4479 -95.3396	*Habitat Description:* both sides of road are cattle pasture and nearly level. There was no water flowing in the shallow, excavated ditch (Mosquito Creek) at the time of the field visit. An approximately 36-inch CMP culvert is under road here. Dominant vegetation is nonnative, cool season pasture grasses, with scattered small patches and groves of bur oak/aspen trees. *Wildlife observed:* bobolink, yellowthroat, ruby-throated hummingbird, gray tree frog.
County State Aid Highway 4 and Mosquito Creek approximately 25 miles downstream of pipeline crossing	47.3873 -95.6367	*Habitat Description:* this segment has a broad floodplain with a mix of shrub swamp, wet/sedge meadow and lesser amounts of wet/aspen stands on slightly higher ground. The stream has good water clarity and abundant wild celery (*Vallisneria americana*). *Wildlife observed:* barn swallow, yellow warbler, American toad, yellow throat.
Creek 132 Road and Mosquito Creek approximately 50 miles downstream of pipeline crossing	47.35421 -95.76347	*Habitat Description:* this area has a relatively narrow stream corridor amid irregular, rolling hills (glacial moraine topography). The stream has riffles and pools, as well as a relatively narrow floodplain. The invasive, nonnative reed canary grass is codominant with native plants along stream margins. The dominant vegetation in stream buffer areas is lowland hardwood forest and mesic hardwood (oak) forest with good plant species richness/quality. *Wildlife observed:* veery, yellow throat, catbird, flycatcher, hairy woodpecker *Fish & Wildlife likely to occur in vicinity:* creek chub, smallmouth bass (personal communication from angler).

7.2.2 High Consequence Area Assessment for the Mosquito Creek to Lower Rice Lake Scenario

As defined in Section 7.0, HCAs include populated areas, drinking water source areas, ecologically sensitive areas, and commercially navigable waterways. Sensitive AOIs include Minnesota drinking water management areas, native plant communities, sensitive lake shores, recreational areas, tribal lands, and protected areas of several types (e.g., national forests, military lands, state parks).

While environmentally sensitive and populated HCAs are present near the confluence of Mosquito Creek and Lower Rice Lake, modeling demonstrated that neither Bakken crude oil nor CLB floating on the surface would reach these areas under any of the seasonal flow conditions (Figure 7-6). However, AOIs are present along Mosquito Creek (Table 7-47). The locations of the HCAs and AOIs are shown in Figure 7-6.

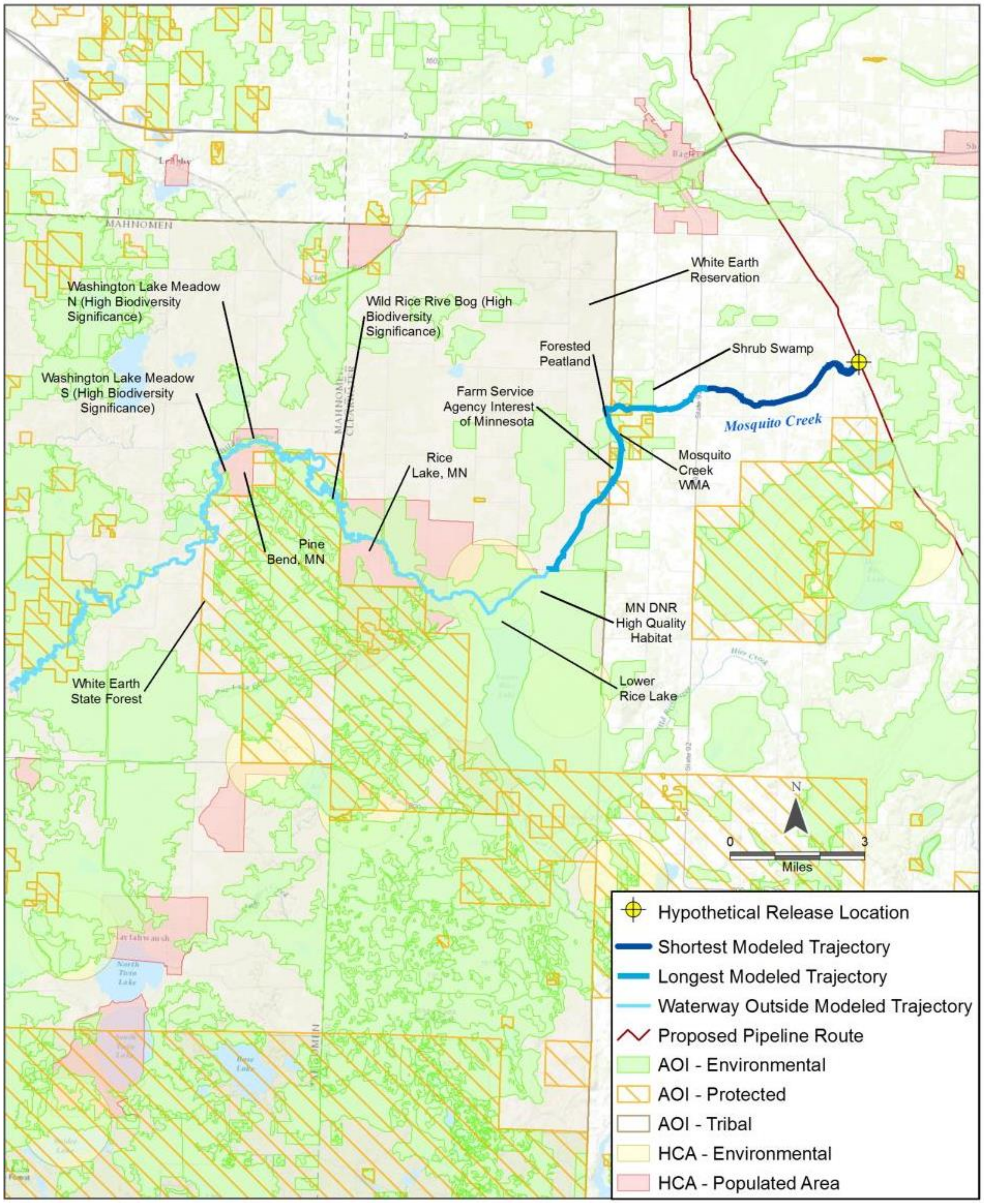

Figure 7-6 HCAs and AOIs Potentially Affected by a Crude Oil Release near Mosquito Creek

Table 7-47 Areas of Interest Potentially Affected by a Release of CLB and Bakken Crude Oil at the Mosquito Creek to Lower Rice Lake Scenario

AOI Type	AOI Subtype	Description / Locations
Environmental	Native Plant Community (Candidate)	Forested Peatland, Shrub Swamp, Tribal Lands
Protected Area	Farm Service Agency Interest of Minnesota	N/A
	Wildlife Management Area	Mosquito Creek WMA
Tribal Lands	N/A	White Earth Reservation
NOTE: Data for the AOI analysis were derived from multiple datasets provided on the Minnesota Geospatial Commons website, USGS Protected Areas Database of the United States and the Minnesota Department of Transportation.		

7.2.3 Selection of Key Ecological and Human Environment Receptors for Mosquito Creek to Lower Rice Lake Scenario

Taking into account the environmental characteristics of Mosquito Creek and Lower Rice Lake, the potential interactions of released crude oil with key ecological and human environment receptors were screened to identify key receptors for the subsequent environmental effects analysis. The rationale and results of this screening step are provided in Table 7-48.

Table 7-48 Key Ecological and Human Environment Receptors for the Mosquito Creek to Lower Rice Lake Scenario

Receptor	Relevance for Inclusion as an Environmental Receptor for the Mosquito Creek to Lower Rice Lake Scenario	Selected (Y/N)
Terrestrial Receptors		
Soils	Low. An assumption made in the fate modeling for this scenario is that released oil in spring and summer-fall conditions would flow approximately 0.6 miles overland before reaching the channel of Mosquito Creek. After reaching the creek, crude oil could be transported downstream following a defined channel. Under winter conditions, the released crude oil is not predicted to reach the creek, but could be retained by snowpack over frozen ground. It is assumed that oil that remained on land would be physically remediated to established standards.	N
Groundwater	Low. In the event of an actual oil release, effects on groundwater quality after cleanup would be localized and/or negligible.	N

Table 7-48 Key Ecological and Human Environment Receptors for the Mosquito Creek to Lower Rice Lake Scenario

Receptor	Relevance for Inclusion as an Environmental Receptor for the Mosquito Creek to Lower Rice Lake Scenario	Selected (Y/N)
Terrestrial Vegetation	Low. An assumption made in the fate modeling for this scenario is that released oil in spring and summer-fall conditions could flow approximately 0.6 miles overland before reaching the channel of Mosquito Creek. After reaching the creek, crude oil could be transported downstream following a defined channel. Under winter conditions the released crude oil is not predicted to reach the creek, but could be retained by snowpack over frozen ground. It is assumed that oil that remained on land would be physically remediated to established standards. Terrestrial vegetation communities along the flow path would be killed or impaired, but this area would be remediated, and vegetative cover would be restored as part of the cleanup process.	N
Aquatic Receptors		
River (Mosquito Creek)	High. An assumption made in the fate modeling for this scenario is that oil released under spring or summer-fall conditions could reach Mosquito Creek via overland flow, with subsequent physical transport downstream.	Y
Lake (Lower Rice Lake)	Medium. An assumption made in the fate modeling for this scenario is that oil released under spring or summer-fall conditions could reach Mosquito Creek via overland flow, with subsequent physical transport downstream towards Lower Rice Lake. While none of the simulations indicated that floating oil would reach the lake within 24 hours, this receptor was included in the assessment due to the importance of the area to Native Americans and local residents.	Y
Sediment	High. An assumption made in the fate modeling for this scenario is that oil released under spring or summer-fall conditions could reach Mosquito Creek via overland flow, with subsequent physical transport downstream. This allows potential interaction and/or deposition of crude oil residues to sediments.	Y
Shoreline and Riparian Areas	High. An assumption made in the fate modeling for this scenario is that oil released under spring or summer-fall conditions could reach Mosquito Creek via overland flow, with subsequent physical transport downstream. This allows potential interaction with shoreline and riparian habitat.	Y
Wetlands	High. An assumption made in the fate modeling for this scenario is that oil released under spring or summer-fall conditions could reach Mosquito Creek via overland flow, with subsequent physical transport downstream. This allows for potential interaction with riparian wetlands, and wetlands associated with Lower Rice Lake.	Y
Aquatic Plants	High. Mosquito Creek supports aquatic plant communities.	Y
Benthic Invertebrates	High. Mosquito Creek and Lower Rice Lake support benthic invertebrate communities.	Y
Fish	High. Mosquito Creek and Lower Rice Lake support fish communities.	Y
Semi-Aquatic Wildlife Receptors		

Table 7-48 Key Ecological and Human Environment Receptors for the Mosquito Creek to Lower Rice Lake Scenario

Receptor	Relevance for Inclusion as an Environmental Receptor for the Mosquito Creek to Lower Rice Lake Scenario	Selected (Y/N)
Amphibians and Reptiles	High. Mosquito Creek and Lower Rice Lake support amphibians and reptiles.	Y
Birds	High. Mosquito Creek and Lower Rice Lake support waterfowl and other birds.	Y
Semi-aquatic Mammals	High. Mosquito Creek and Lower Rice Lake support semi-aquatic mammals.	Y
Human and Socio-Economic Receptors		
Air Quality	High. The Mosquito Creek and Lower Rice Lake area is shared by White Earth Reservation, private land owners, and MN DNR Forestry Trust lands. Effects on air quality have the potential to temporarily disrupt human use and occupancy patterns.	Y
Human Receptors	High. The Mosquito Creek and Lower Rice Lake area is shared by White Earth Reservation, private land owners, and MN DNR Forestry Trust lands. Effects on air quality or the presence of crude oil residues in aquatic and riparian habitat have the potential to temporarily affect human health.	Y
Public Use of Natural Resources	High. The Mosquito Creek and Lower Rice Lake area is shared by White Earth Reservation, private land owners, Mosquito Creek WMA and MN DNR Forestry Trust lands. Effects on air and water quality, or the presence of crude oil residues in the sediment, riparian or wetland habitat, could potentially disrupt public use of natural resources (e.g., wild rice harvest, drinking water supplies, hunting, fishing, recreation).	Y

7.2.4 Modeled Conditions at the Release Location

A description of key modeling assumptions for the environmental effects analysis for the Mosquito Creek to Lower Rice Lake scenario is provided in this section. The OILMAP Land software was used by RPS ASA to simulate hypothetical releases of CLB and Bakken crude oils into Mosquito Creek and the flow of oil over land (Chapter 5.0) for a 24 hour period. A longer time period was not modeled as it was assumed that emergency response measures to prevent further downstream transport of released oil would be in place within the 24 hour period.

While OILMAP Land does provide an indication of the overland and downstream extent of oiling and mass balance of oil within the modeled period, it does not quantify the amounts of oil components dissolved into the water column (Chapter 5.0). The ability of the OILMAP Land model system to accurately predict overland release pathways is in large part controlled by ground cover and the vertical and horizontal resolution of the elevation grid. In this scenario, a 0.6 mile flow path of predominantly grassland/herbaceous land cover (during non-winter months) or snow/ice land cover (during winter months) extended downslope to Mosquito Creek. This is a worst-case assumption for a release of crude oil near the watercourse. In the event of an actual release, emergency response measures to prevent further possible downstream transport of oil would be expected to be in place within several hours of the release.

Based on data obtained from weather stations (Thorhult, MN and the University of Minnesota Itasca Biological Station, MN) near the hypothetical release location, long cold winters with periods of snow cover occur between October (averaging 0.5 inch) and May (averaging 0.4 inch), with maximum average coverage in February (13.7 inches). The retention of light crude oil in snow was assumed to be 20% of the snowpack depth for the Bakken crude oil, and 40% of the snowpack depth for the heavier CLWB. Elevation data used for overland flow modeling were obtained from the MN DNR (MN DNR 2014a) and have 10 ft horizontal resolution and 0.4 inch vertical resolution.

The two crude oil types provide bounding cases for oils that range from light (e.g., Bakken crude oil having low viscosity and density) to heavy (CLB/CLWB, heavy diluted bitumen crude oil types having higher viscosity and density). Seasonal variations in river flow velocity, temperature, wind speed, and snow and ice cover were all considered at the release location. A summary of key variables is provided in Table 7-49.

In the event of an actual release, the downstream extents of CLB and Bakken crude oil may be more similar, and the effects of CLB may extend farther downstream than predicted, with patchy coverage.

Table 7-49 Environmental and Hydrodynamic Conditions for the Three Modeled Periods at the Mosquito Creek Crossing

Season	Month	Air Temperature (°C)	Wind Speed (m/s)	Average River Velocity (m/s)
Low Flow (Winter)	February	-11.50	4.44	0.16
Average Flow (Summer)	July	19.25	3.68	0.21
High Flow (Spring)	April	4.17	4.88	1.03
NOTE: A velocity of 1 m/s is equivalent to 2.25 miles per hour.				

The highest average flow velocity of the Mosquito Creek coincides with the spring freshet (i.e., April-June), a result of rising temperatures and snowmelt. Average flow would typically occur in summer and fall seasons. July, the month with the warmest temperature, was selected to represent the maximum amount of evaporation. The lowest flow rate occurs in winter (i.e., January-March), and was typified by freezing conditions and probable ice cover on water.

The crude oil release volume was calculated as a full bore rupture, with a maximum time to response in the pipeline Control Center of 10 minutes, followed by a 3-minute period to allow for valve closure. Therefore, the release volume represents the volume of oil actively discharged in the period of time required to detect and respond to the event (taking into consideration the pipeline diameter, pipeline shutdown time, pipeline design flow velocity), followed by the volume of oil lost due to drain-down of the elevated segments of pipeline. The maximum 13-minute response time to valve closure is an Enbridge standard for safe operations and leak detection. This includes the combination of identification of the rupture, analysis of the pipeline condition, pipeline shutdown and full valve closure in the affected pipeline section. While 13 minutes is the maximum time for valve closure, this is a conservative assumption, since a response through to valve closure is expected to occur in less than 13 minutes in a full bore rupture leak scenario. Based on these assumptions, the site-specific hypothetical release volume was estimated to be NONPUBLIC DATA HAS BEEN EXCISED of Bakken, CLB, or CLWB crude oil.

7.2.5 Summary of Predicted Downstream Transport of Bakken and Cold Lake Crude Oils

A summary of the predicted downstream trajectories and mass balance for Cold Lake and Bakken crude oils, under the three seasonal scenarios, is provided in Figure 7-7 and Figure 7-8, respectively. These simulations are assumed to provide bounding conditions for a release of heavy or light crude oil types. The fate of most types of crude oil, if released, would lie within the envelope of predictions for the Cold Lake and Bakken crude oil types. The Cold Lake crude oil was assumed to be CLB for the high flow and average flow scenarios, and to be CLWB for the low flow (winter) scenario. As noted in Chapter 5.0, while OILMAP Land does provide an indication of the downstream extent of oiling and mass balance of oil within the modeled period, it does not quantify the amounts of oil components dissolved into the water column.

The maximum simulation duration using OILMAP Land was 24 hours, as it was assumed that emergency response measures to prevent or reduce further downstream transport of released oil would be in place within that length of time. Symbols on the drawings indicate the river seasonal flow condition (high corresponding to spring freshet, average corresponding to summer-fall conditions, and low corresponding to winter flow under ice). Numbers associated with the symbols indicate the predicted location of the leading edge of the released oil in the river after 6, 12, 18 or 24 hours. Numbers other than these (e.g., 7.9) indicate the time in hours of the predicted termination of downstream transport of the released oil due to adhesion or holdup of the oil along the river banks. Tables inserted within the Figures also provide information on the mass balance (i.e., oil remaining on the surface of the river, adhering to river banks, or evaporated to the atmosphere) of the released oil at relevant points in time after the start of the release.

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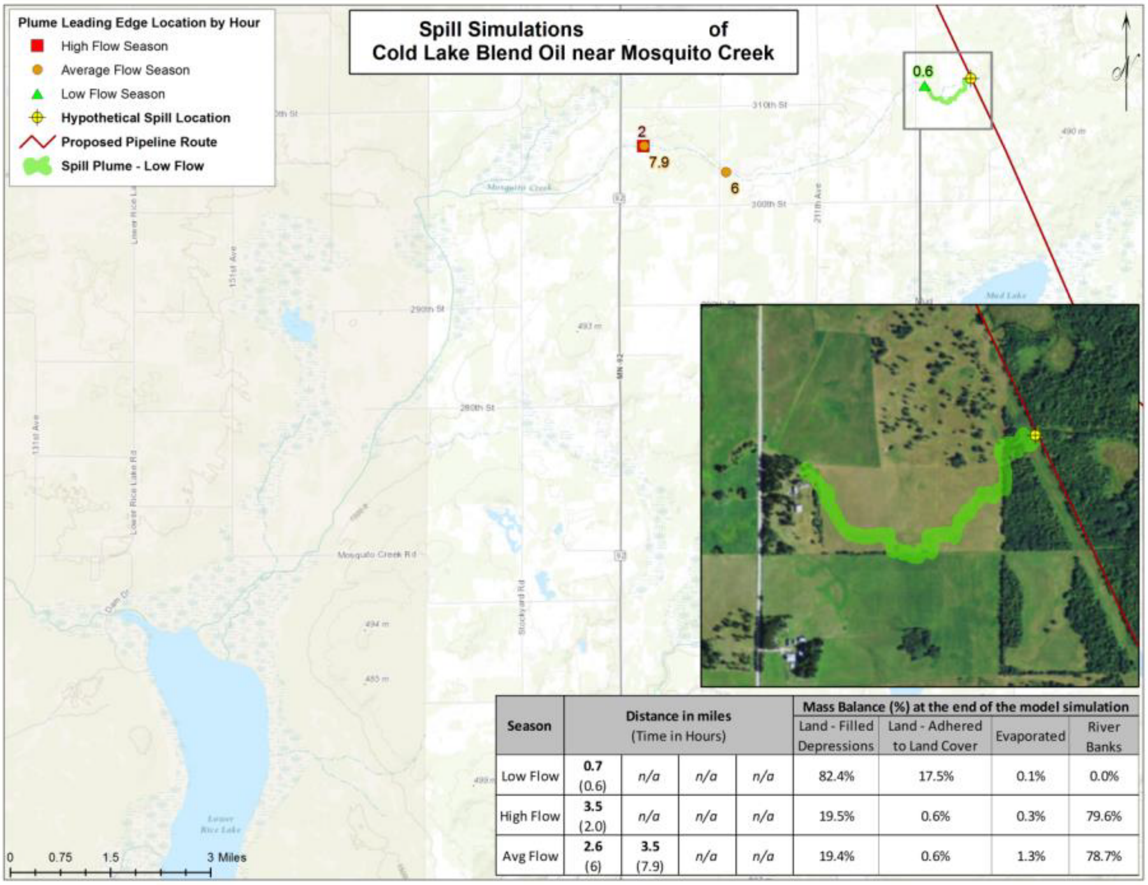

Season	Distance in miles (Time in Hours)				Mass Balance (%) at the end of the model simulation: Land - Filled Depressions	Land - Adhered to Land Cover	Evaporated	River Banks
Low Flow	0.7 (0.6)	n/a	n/a	n/a	82.4%	17.5%	0.1%	0.0%
High Flow	3.5 (2.0)	n/a	n/a	n/a	19.5%	0.6%	0.3%	79.6%
Avg Flow	2.6 (6)	3.5 (7.9)	n/a	n/a	19.4%	0.6%	1.3%	78.7%

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Figure 7-7 Predicted Downstream Transport of Cold Lake Blend Oil at the Mosquito Creek Crossing Location

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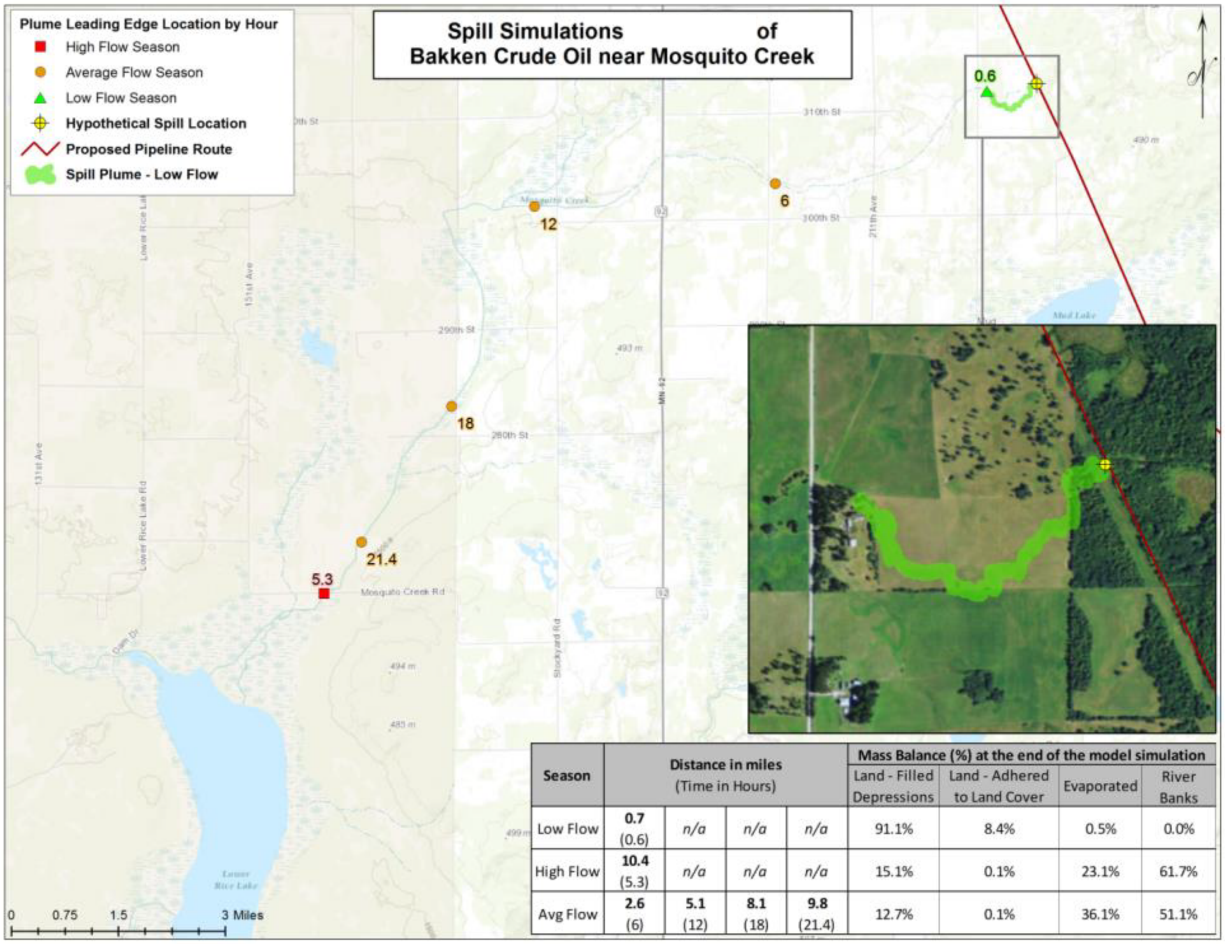

Season	Distance in miles (Time in Hours)				Mass Balance (%) at the end of the model simulation			
					Land - Filled Depressions	Land - Adhered to Land Cover	Evaporated	River Banks
Low Flow	**0.7** (0.6)	*n/a*	*n/a*	*n/a*	91.1%	8.4%	0.5%	0.0%
High Flow	**10.4** (5.3)	*n/a*	*n/a*	*n/a*	15.1%	0.1%	23.1%	61.7%
Avg Flow	**2.6** (6)	**5.1** (12)	**8.1** (18)	**9.8** (21.4)	12.7%	0.1%	36.1%	51.1%

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Figure 7-8 Predicted Downstream Transport of Bakken Crude Oil at the Mosquito Creek Crossing Location

7.2.5.1 Mosquito Creek to Lower Rice Lake Release During High Flow (Spring) Period

Under the high flow scenario, CLB was predicted to travel approximately 3.5 miles downstream in Mosquito Creek, with downstream transport being terminated 2 hours after the release. This is largely a result of crude oil being held up on land (20.1%) or adhering to shorelines (79.6%). Only a small amount (0.3%) of the CLB was predicted to have evaporated to the atmosphere during that period. In the event of an actual release, emergency response measures to prevent further possible downstream transport of oil would be expected to be in place within several hours of the release.

Bakken crude oil was predicted to be transported approximately 10.4 miles downstream (or approximately 1.4 miles upstream of Lower Rice Lake), with downstream transport being terminated within 5.3 hours of the release. After 5.3 hours, approximately 23.1% of the Bakken crude oil was predicted to have evaporated to the atmosphere, with 15.2% filling depressions on land or adhered to land cover, and the remaining 61.7% predicted to be adhering to shorelines.

The release of Bakken crude oil under high flow conditions was predicted to result in shoreline oiling nearly 3 times farther downstream in Mosquito Creek than the CLB. The difference in the extent of downstream transport was primarily due to differences in shoreline retention. Because of its higher viscosity and adhesiveness, larger amounts of CLB are predicted to strand, as a thicker layer of oil on a given length of shoreline, than for the Bakken oil. Conversely, the same amount of Bakken crude oil would affect a greater length of shoreline, with a lesser thickness of oil. This result is based on the assumption of 100% shoreline oiling coverage (i.e., all shoreline up to that point was oiled to its maximum holding capacity for that oil type) as oil made its way downstream. In the event of an actual release, the downstream extents of CLB and Bakken crude oil may be more similar, and the effects of CLB may extend farther downstream than presented, with patchy coverage or partial oiling of shorelines.

A larger proportion of the Bakken crude oil was predicted to evaporate to the atmosphere than was predicted for CLB. This was due in part to the lighter and more volatile character of the Bakken crude oil. In addition, the greater downstream transport of the Bakken crude oil took more time, and resulted in more water surface area with oil, both of which would allow more of the released oil to evaporate. Volatile components of the CLB would continue to evaporate after becoming stranded on the shoreline, but this process was not included within the OILMAP Land model for stranded oil.

7.2.5.2 Mosquito Creek to Lower Rice Lake Release During Average Flow (Summer-Fall) Period

Under the average river flow condition, CLB crude oil was predicted to travel up to 2.6 and 3.5 miles downstream after 6 and 7.9 hours, respectively, at which time the leading edge of the release is predicted to be 8.3 miles upstream of Lower Rice Lake (Figure 7-7). At that time, approximately 1.3% of the CLB was predicted to have evaporated to the atmosphere, 20.0% filled depressions on land or adhered to land cover, and the remaining 78.7% was predicted to be adhering to shorelines. Emergency response measures to prevent further possible downstream transport of oil would be in place within 24 hours of the release.

Bakken crude oil was predicted to travel approximately 2.6, 5.1, 8.1 and 9.8 miles downstream after 6, 12, 18 and 21.4 hours. Downstream transport was predicted to terminate 21.4 hours after the release. By that time, approximately 36.1% of the Bakken crude oil was predicted to have evaporated to the atmosphere, 12.7% filled depressions on land or adhered to land cover, and the remaining 51.1% was predicted to be retained on shorelines. Slightly more of the released CLB crude oil was predicted to evaporate under the average river flow condition than under the high river flow condition (Figure 7-7). This difference is due largely to the warmer temperatures in the summer-fall season as compared to the spring freshet, and also due to the greater length of time, and greater surface area of water that was predicted to be oiled during the simulation.

When compared to CLB was predicted to be transported farther downstream than Bakken crude oil. This is a result of the lower overland and shoreline oil retention values for the low viscosity Bakken crude oil, when compared to the more viscous and adhesive CLB. Although not modeled here, it is expected that a medium crude oil would exhibit fate and transport properties intermediate between those of the Bakken and CLB crude oil types, with a tendency to behave more like the Bakken crude oil. This is because the viscosity and adhesiveness properties of a medium crude oil would typically be higher but more similar to those of the Bakken crude oil, than to the CLB.

7.2.5.3 Mosquito Creek to Lower Rice Lake Release During Low Flow (Winter) Period

Under the low flow conditions of winter, it was assumed that Mosquito Creek would be frozen over (100% coverage of ice), with a layer of snow on top. Therefore, a release of CLWB from the pipeline onto land could result in a release traveling over the land surface to reach the channel of Mosquito creek, but the oil would likely pool in the dry or frozen stream channel without contacting water.

Under low flow conditions, CLWB was predicted to travel approximately 0.7 miles over the land surface, within 0.6 hours of release. At that time, approximately 82.4% of the CLWB was predicted to be held up by snow or filling depressions in the land surface, with 17.5% adhering to the land cover and only 0.1% predicted to have evaporated. A considerable amount of CLWB was predicted to adhere to the land cover and be retained in depressions along due to the high holding capacity of the snow cover. With Mosquito Creek frozen over, CLWB that reached the creek would be expected to pool in the dry stream channel, or on the surface of the ice. Little evaporation was predicted to occur under winter conditions due to low air temperature which would slow evaporation, and reduced surface area due to the predicted thick retention of CLWB on the overland flow path. Evaporation was also limited by the short (0.6 hour) duration of the simulation.

Under low flow conditions, the Bakken crude oil was predicted to travel approximately 0.7 miles over the land surface, within 0.6 hours of release. At that point, approximately 91.1% of the oil was predicted to be filling depressions in the land surface, 8.4% adhering to the land cover, and only 0.5% was predicted to have evaporated. Considerably more Bakken crude oil was predicted to adhere to land cover during low flow conditions than during high or average river flow conditions, due to the holding capacity of snow cover.

7.2.6 Qualitative EHHRA for the Mosquito Creek to Lower Rice Lake Scenario

In this section the likely environmental effects of a crude oil release at the pipeline crossing location near Mosquito Creek are described. A worst case crude oil release from a main-line pipeline, such as described here, would be an unlikely event (Chapter 4.0). The proposed pipeline would carry a variety of crude oil types, ranging from very light (e.g., Bakken crude oil) to heavy (e.g., diluted bitumens such as CLB). Therefore, the following discussion describes the likely environmental effects of a crude oil release on relevant ecological and human environment receptors (identified in Section 7.2.3), using the predicted geographic extent of effects of released Bakken or CLB crude oil types over the 24 hour simulations as bounding conditions. Effects of season (including temperature, river flow conditions, and receptor presence/absence and sensitivity) were also considered. The rationale supporting the effects analysis, based on case studies describing the effects of crude oil releases on the various ecological and human environment receptors, was provided in Section 7.1 and Table 7-48.

7.2.6.1 Terrestrial Receptors

In spring and summer-fall seasons it is assumed that a release will flow over 0.6 miles of land downslope to Mosquito Creek, with most of the released crude oil entering the creek, rather than remaining on land. Environmental effects on soils and terrestrial vegetation are assumed to be localized to the overland flow path of the released oil. This area is limited in spatial extent, and would be remediated using conventional clean-up techniques. In the winter season it is expected that virtually all of the released crude oil would be retained in snow and fill depressions on land. This type of release would also be physically remediated using conventional clean-up techniques. The environmental effects of a crude oil release on land cover receptors are not considered further for this release scenario.

7.2.6.2 Aquatic Receptors

The aquatic environmental and ecological receptors are most closely associated with Mosquito Creek. These receptors include creek water and sediment quality, shoreline and riparian areas, wetlands, aquatic plants (including wild rice), benthic invertebrates, and fish.

If crude oil was to enter Mosquito Creek during the spring (high flow), it is predicted to travel downstream, interacting with vegetation and seasonal shoreline areas. The distance travelled would depend upon river flow and oil type. Based on OILMAP Land simulations, light oils oil is predicted to travel father downstream than heavy oil. For heavy oil, stranding on shore would be the primary fate, with only small amounts of evaporative weathering of the oil occurring before the oil becomes stranded. For light oil, stranding would remain the primary fate, but considerably more of the released oil could be lost to evaporation.

The effects of crude oil releases on benthic invertebrates and fish depend on the characteristics of the released oil and environmental conditions at the time of the release. Acute toxicity to fish is commonly but not always observed in association with crude oil releases, and is an indicator that, at least briefly, concentrations of dissolved hydrocarbons (particularly mono-aromatic hydrocarbons, some low molecular weight PAHs, and short-chain aliphatic hydrocarbons) are sufficiently high to cause acute toxicity due to narcosis. Light oils have low viscosity relative to heavier oils. Turbulence in flowing water could potentially disperse light oil as small droplets in the water column, increasing the potential for toxic fractions of the light oil to dissolve into the water column. As a result of the flow conditions, and the relatively small volume of flow in Mosquito Creek providing dilution to dissolved hydrocarbons, the potential for acute toxicity to fish and benthic invertebrates could be high, and greater for the light oil than for heavy oil.

As a headwater system, the volume of water flow associated with the spring freshet in Mosquito Creek is not likely to be sufficient to dilute and limit the maximum dissolved hydrocarbon concentration in water. Therefore, it is likely that acute toxicity to fish would occur in Mosquito Creek during spring flows, extending at least as far as the longest modeled trajectory, and potentially farther as dissolved hydrocarbons could continue to be transported downstream even when the surface oil slick has terminated. Toxicity to fish would also be more likely for the light crude oil than for the heavy crude oil due to the higher proportion of low molecular weight (and relatively water soluble) hydrocarbons in the light crude oil. The lower viscosity of the light crude oil, which would enhance the potential for small droplets of oil to become entrained in the water column, would also enhance the rate of hydrocarbon dissolution into water.

There would also be high potential for chronic effects of released crude oil on fish eggs and embryos (i.e., induction of deformities or mortality collectively termed blue sac disease). Many of the fish species present in the Mosquito Creek spawn in the spring and early summer. The eggs and embryos of these species could be exposed to total PAH concentrations in the river water that could be sufficiently high to induce deformities or cause mortality. In addition the potential for phototoxicity, caused by an interaction of UV light with PAHs accumulated in fish tissues, would be greatest for a crude oil release in summer due to high light intensity and long day length. Small fish that are lightly pigmented or transparent (i.e., embryos, larval and juvenile fish) are most susceptible to phototoxicity. In addition the potential for phototoxicity, caused by an interaction of UV light with PAHs accumulated in fish tissues, would be greatest for a crude oil release in summer due to high light intensity and long day length. Small fish that are lightly pigmented or transparent (i.e., embryos, larval and juvenile fish) are most susceptible to phototoxicity. The risk of phototoxicity could be partially mitigated by periods of high concentrations of suspended sediment and dissolved organic carbon present in the water.

Entrainment of small crude oil droplets in the water column also enhances the potential for light crude oils to interact with suspended sediment particles in the water column resulting in the formation of OPAs. Such aggregates may subsequently be preferentially deposited in areas of still or slowly moving water, such as oxbows and backwaters. Formation of true OPAs is less likely to occur with heavy crude oils such as diluted bitumen, as the higher viscosity of the oil precludes the ready formation of fine droplets in the water column (Zhou et al. 2015). However, heavy oils can still contact sediment particles along the shoreline, and some accumulation of both light and heavy oils in depositional areas is likely, although the precise mechanisms of deposition may vary. Neither crude oil type is likely to reach a density greater than that of the water and sink directly to the sediment within the first few days following release. During the high flow spring period, while neither oil is predicted to be on the water surface beyond 10.4 miles downstream of the release location within the first 24 hours of the release, it is possible that oil accumulated in depositional areas could mobilize over time and move farther downstream towards, and potentially into the north end of Lower Rice Lake.

For a hypothetical release under spring freshet conditions, it is likely that most aquatic plants would still be dormant or submerged, and that environmental effects on this receptor type would be minimal. However, where they occur, floating aquatic plants would be expected to be killed if contacted by an oil slick. Submerged aquatic plants would be less vulnerable, as they would be exposed primarily to dissolved hydrocarbons, and are not considered likely to be among the more sensitive groups of aquatic biota to such exposure. Emergent aquatic plants are generally quite tolerant of moderate exposure to floating oil (such that a portion of the stem could be oiled). However, flooded riparian areas and wetland habitats would also be exposed to the released oil, and if not properly remediated, crude oil residues could kill plants in these areas. This could affect the biological integrity and productivity of the habitat, and potentially lead to erosion and further damage to the habitat.

Wild rice is an emergent aquatic plant of biological and cultural importance and occurs where Mosquito Creek enters Lower Rice Lake. Wild rice provides a food source and nesting cover for many birds, and is also harvested as a food source by people in the area. Based on the 24 hour simulations, the longest modeled trajectory during the high flow period extended 10.4 miles downstream of the releases and 1.4 miles upstream of Lower Rice Lake. This suggests that it is unlikely that released crude oil during this season would result in adverse effects to wild rice in Lower Rice Lake. However, it is possible that oil accumulated in depositional areas could mobilize with time and move farther downstream towards, and into the north end of Lower Rice Lake. This would be similar to the process that led to accumulation of diluted bitumen in the upper end of Morrow Lake following the Marshall, Michigan oil spill in 2010. The mobilization of oil that accumulates in depositional areas would be more likely to occur for the heavy crude oil which weathers more slowly and is more persistent than the light crude oil. Accumulation of crude oil in the sediment at the north end of Lower Rice Lake could be detrimental to the germination and growth of wild rice.

Crude oil released during the summer-fall (average flow) period is predicted to travel downstream, stranding on grassy and marshy banks and losing volatile components of the oil to evaporation. Results for Bakken and Cold Lake crude oil types provide bounding cases for the products likely to be carried in the pipeline. Based on a 24 hour model run, the OILMAP Land simulations indicate that crude oil could be carried between 2.6 and 9.8 miles downstream from the point of release under summer-fall average-flow conditions. For heavy oil and light oil, stranding on creek banks would be the primary fate, with only small amounts of evaporative weathering of the heavy oil and moderate amounts of weathering for lighter oils within the first 24 hour period. The lower water flow in summer-fall could result in less dilution of water soluble components in the creek as compared to spring flow. However, the lower flow rates would be accompanied by lower turbulence in the water column, and a reduced tendency for crude oil to be dispersed as fine droplets in the water column. Periodic drying of the creek headwaters during summer and fall conditions would also limit crude oil transport should a release occur during a dry summer, as well as limiting the interaction between oil and aquatic receptors. As a result, acute lethality caused by narcotic effects on fish and benthic invertebrates are less likely during the summer-fall season than in spring. The potential for blue sac disease to harm or kill developing fish eggs and embryos is also lower, due to the timing which avoids the reproductive period for most fish species. Taking into consideration the lower river flow and turbulence, deposition of crude oil residues to sediment in areas of still water is also less likely than during the spring period. These factors would also limit the potential for downstream movement of submerged crude oil into Lower Rice Lake, and subsequent interaction with aquatic plants and wetland areas.

Under low flow winter conditions, neither of the two bounding crude oil types is predicted to enter Mosquito Creek. As such, a crude oil release in winter would not be expected to seriously affect aquatic receptors.

7.2.6.3 Semi-Aquatic Wildlife Receptors

Habitat of the Mosquito Creek downstream of the hypothetical release location supports amphibians (e.g., salamander, mudpuppy), reptiles (e.g., turtles, snakes), semi-aquatic birds (e.g., ducks, geese) and semi-aquatic mammals (e.g., muskrat, otter). Habitat along Mosquito Creek varies in quality for semi-aquatic wildlife receptors. The creek is generally narrow, with grassy, marshy or boggy banks, and flows through a corridor dominated by bog/marsh, bounded by agricultural lands. Semi-aquatic wildlife receptors (e.g., amphibians, turtles, waterfowl, muskrat, and mink) will certainly be present throughout the length of Mosquito Creek. While individuals may be affected by exposure to released oil in the immediate area of the creek during the spring freshet and the summer-fall average-flow conditions, regional populations of these animals will be robustly supported by the extensive wetland and aquatic habitats in the area. Crude oil from a hypothetical release is not predicted to enter Mosquito Creek in winter, so effects on semi-aquatic wildlife would be minimal in that season. Details on predicted environmental effects for amphibians and reptiles, birds and mammals are provided below.

7.2.6.3.1 Amphibians and Reptiles

Crude oil released to the Mosquito Creek during the spring (high flow) or summer-fall (average flow) seasons is predicted to travel downstream, interacting with vegetation and seasonal shoreline areas in the riparian floodplain. The distance travelled would depend upon river flow and oil type. Based on OILMAP Land simulations, light oils oil is predicted to travel father downstream than heavy oil. For heavy oil, stranding on shore would be the primary fate, with only small amounts of evaporative weathering of the oil occurring within the first 24 hour period. For light oil, stranding would remain the primary fate, but considerably more of the released oil could be lost to evaporation.

Within the oil-exposed habitats along the river that support amphibians (adults, juveniles, and eggs), oiling effects including mortality would be observed. Turtles appear to be relatively tolerant of external crude oil exposure, and although these animals are likely to become oiled, mortality of turtles as a result of this exposure is less likely. Reptiles like lizards and snakes are primarily terrestrial species and are less intimately associated with aquatic environments. As a result, exposure of these animals to released crude oils would be limited. After the Kalamazoo River oil release in 2010 snakes did not appear to be highly exposed to released oil. A release of light crude oil during the spring would likely have a greater effect than in summer due to the greater predicted downstream transport distance and interaction with greater areas of riparian and wetland habitats than later in the year.

Under low flow winter conditions, neither of the two bounding crude oil types is predicted to enter Mosquito Creek. As such, exposure of amphibians and reptiles in winter would not be expected. In addition, amphibians and reptiles undergo a dormancy period when temperatures drop below approximately 41 to 45°F. Therefore, even if crude oil were to reach the creek, it is unlikely that amphibians and reptiles would be materially exposed to or affected by the released oil.

7.2.6.3.2 Birds

Aquatic and semi-aquatic birds are those that use rivers, lakes, wetlands, and riparian areas as components of their habitat, particularly for nesting and feeding. These birds belong to a variety of guilds including but not limited to waterfowl, divers, gulls and terns, raptors, shorebirds, waders, and some songbirds. They have a variety of dietary preferences, including piscivory, insectivory, omnivory and herbivory. If exposed to external oiling, the ability of birds to maintain body temperature may be compromised, leading to death as a result of hypothermia. Even if they survive their initial exposure to crude oil, the exposure may require an increase in metabolic rate to survive. In turn this may compromise other life functions such as reproduction or growth. Birds that survive external oiling may experience toxicological stresses as a result of ingesting crude oil residues while preening or attempting to clean and restore the normal properties and functions of feathers. Birds can also transfer potentially lethal quantities of crude oil residue from their feathers to the external surface of eggs, resulting in death of developing embryos.

Unlike many other vertebrate receptors, aquatic bird species in the northern temperate zone are nearly all seasonal migrant species which leave their summer (and often breeding) habitat in the fall for wintering areas farther south where they can find open-water habitat. However, some birds (e.g., Canada goose) will opportunistically remain in freezing conditions if there is reliable open water and a source of food available. Timely capture and rehabilitation of oiled birds may help to mitigate the environmental effects of a crude oil release. During the spring (high flow) season, many migratory birds would be returning to riverine and lacustrine habitats in Minnesota, or migrating through these areas on their way to breeding habitats farther north. With cold water temperatures prevailing, aquatic and semi-aquatic birds contacted by crude oil are likely to die as a result of hypothermia. Waterfowl and other semi-aquatic birds present in the affected river reach would be most affected. Animals upstream, farther downstream, or occupying other nearby habitats, would likely be less affected as it is assumed that emergency response measures to prevent or reduce further possible downstream transport of oil would be in place within 24 hours of the release.

Environmental effects of a crude oil release in the summer-fall period are likely to be of similar or lesser magnitude. With rising water temperatures, mortality of lightly oiled adult birds due to hypothermia becomes less likely than in the spring. However, in the early summer, environmental effects could include egg mortality due to transfer of oil from the feathers of lightly oiled adult birds in the nest. Chronic adverse effects on the health of birds that survive their initial exposure to crude oil are also possible as a result of ingesting crude oil residues while preening, or while consuming food items. However, as in the spring, effects are expected to be limited to areas of oil exposure and areas of the creek with suitable habitat, which could range from 2.6 to 9.8 miles downstream from the release point.

Under low flow winter conditions, neither of the two bounding crude oil types is predicted to enter Mosquito Creek, and most aquatic or semi-aquatic birds would have migrated away from the area for wintering habitat farther south. As such, exposure of birds to released crude oil in winter would be very limited.

7.2.6.3.3 Semi-aquatic Mammals

While the semi-aquatic mammal species found in Minnesota include terrestrial species such as moose and raccoon, this assessment focuses particularly upon species that have a primary association with the aquatic environment such as muskrat and beaver (herbivores), American mink (*carnivore-piscivore*), and river otter (*piscivore*). These species are at greater risk of exposure to an oil release in water than terrestrial mammals.

Effects to semi-aquatic mammals are typically described in terms of direct physical effects (e.g., hypothermia due to loss of insulation), direct toxicological effects (e.g., gastro-enteropathy caused by ingestion of crude oil residues while grooming oiled fur or ingesting food), and indirect effects caused by changes to habitat (e.g., land cover and food availability). The spatial extent along Mosquito Creek where effects may occur, and the magnitude of effects, is related to the oil type released, season and flow rate. Effects to semi-aquatic mammals relate more to the amount of time spent in the water (and consequent exposure to physical oiling) than to dietary preferences. Timely capture and rehabilitation of oiled mammals may help to mitigate the environmental effects of a crude oil release.

During the spring (high flow) season, with cold water temperatures prevailing, semi-aquatic mammals contacted by crude oil are likely to die as a result of hypothermia. Based on the OILMAP Land simulations, the leading edge of the releases could range from 3.5 to 10.4 miles in extent. Animals upstream, farther downstream where there is no exposure, or occupying other nearby habitats, would likely be unaffected. Therefore, although mortality of some semi-aquatic mammals could be expected, large-scale (i.e., regional) population level effects are unlikely.

Environmental effects of a crude oil release in the summer-fall period are likely to be of similar or lesser magnitude than those associated with a release during a spring freshet. With rising water temperatures, mortality of lightly oiled semi-aquatic mammals due to hypothermia is expected to be less likely than in the spring. Chronic adverse effects on the health of semi-aquatic mammals that survive their initial exposure to crude oil also are possible as a result of ingesting crude oil residues while grooming, or while consuming food items.

In the winter months, muskrat and beaver are likely to reduce their activity levels, although American mink and river otter would remain active. Animals that became oiled in the winter would be likely to rapidly die as a result of hypothermia.

7.2.6.4 Human and Socio-Economic Receptors

Crude oils are complex mixtures of hydrocarbon compounds. Light crude oils typically contain more VOCs than heavier crude oils, although diluted bitumens may contain similar amounts of VOCs to light crude oils, depending upon the type and amount of diluent they contain. Air quality in the vicinity of a crude oil release, and along the downstream corridor, would be affected by the release of VOCs (such as benzene, which is often used as an indicator substance) primarily within the first 24 hours of an oil release. Under spring and summer-fall conditions, most of the released CLB or Bakken crude oil is predicted to reach Mosquito Creek, spreading on land and on the water. In contrast, under winter conditions virtually all of the released crude oil is predicted to be retained in snow or fill depressions on land. Low air temperatures, as well as the relatively thick layer and limited surface area of crude oil retained in the snow pack, are expected to minimize release of volatile components to the atmosphere in winter.

Typical human health effects associated with short-term (acute) inhalation of volatiles from crude oil include headache, dizziness, nausea, vomiting, cough, respiratory distress, and chest pain. Short-term or repeated skin contact with crude oil may result in dermatitis. The case studies (Section 7.1) do not reveal any instances of human fatality as a result of inhalation of crude oil vapor. Similarly, ATSDR (1995) report that there are no known instances of human fatality as a result of inhalation of vapor from fuel oils, which would be comparable to light crude oils.

The potential for VOC inhalation exposures by the public would be greatest near and downwind from the release site and near to Mosquito Creek while the released oil is on the water surface. For the most part, the areas around Mosquito Creek are sparsely populated (i.e., farms and country dwellings). The nearest HCA representing a populated area is located west of Lower Rice Lake, and not within the area identified to be potentially contacted by released oil within 24 hours of a release. One farm is located within approximately 300 ft of the overland flow path between the hypothetical point of release and the head of Mosquito Creek, and a number of other homes are located within a similar distance of Mosquito Creek, upstream of Lower Rice Lake. In the unlikely event of a crude oil release, a human fatality is highly unlikely. Most of the volatile hydrocarbons would be lost within the first 24 hours following a release of crude oil.

Residents in close proximity to the flow path would become aware of a strong hydrocarbon odor that would alert them to the presence of a hazard. It is also expected that emergency response personnel would contact such residents and advise them to evacuate. Actual or potential exposure to crude oil vapor may result in residents leaving, or being advised to leave their homes for a period of time while the emergency response takes place.

No drinking water HCAs were identified along the path of the release. However, a number of homes are located along the trajectory of the overland flow path and adjacent to Mosquito Creek upstream of Lower Rice Lake. It is assumed that residents of these homes rely on groundwater as a drinking water source. In the event of a crude oil release, people would be notified and testing would be completed to confirm the safety of the water supply. Based upon case studies involving crude oil releases elsewhere, this process could take a few days to two weeks, but reports of crude oil releases affecting private wells are rare, making this an unlikely effect.

Relatively little has been published regarding the long-term effects of exposure to an oil release. Health effects observed in residents and clean-up workers in the months following an oil release generally do not persist over the long term (Eykelbosh 2014). The International Agency for Research on Cancer (IARC 1989) has determined there is “limited evidence of carcinogenicity” of crude oil in experimental animals and "inadequate evidence of carcinogenicity” of crude oil in humans. Although toxicological effects from short-term exposure to volatile hydrocarbons are reversible when exposure is reduced, other health effects such as anxiety and depression may occur, and may persist, regardless of whether the individual was physically exposed to hydrocarbons.

Effects of a crude oil release on human receptors would be generally similar for the spring (high flow) and summer-fall (average flow) seasons, except that warmer temperatures and slower river flow velocities in the summer would promote more rapid evaporation of volatile hydrocarbons in a smaller area, whereas higher river flow velocity in the spring freshet period would transport the released oil farther downstream within the first 24 hours, potentially resulting in lesser exposures, but to a larger number of people. The distance of downstream oil transport depends upon river flow rate, oil type and bank type. Based on OILMAP Land simulations of lighter oils are predicted to travel father downstream than heavier oils (Figure 7-7 and Figure 7-8). As a result, a release of the light crude oil may affect a larger number of individuals than a release of the heavy crude oil type. Both Bakken crude oil and Cold Lake diluted bitumen are expected to contain similar overall amounts of volatile hydrocarbons, so differences related to the chemical characteristics of the released oil are likely to be minor.

Recreation, tourism, forestry and agriculture are the major land uses in the area of Mosquito Creek and Lower Rice Lake. Based on the 24 hour simulations and taking release response activities into account, neither heavy nor light crude oil is predicted to move on the water surface beyond 10.4 miles downstream of the releases. However, it is possible that oil accumulated in depositional areas would mobilize with time and move farther downstream, towards and potentially into the north end of Lower Rice Lake. Such accumulation of crude oil could potentially affect the growth and harvesting of wild rice in this area. Emergency response workers, in cooperation with public health and safety officials, would be active in isolating, containing and recovering released crude oil, as well as notifying the public about the release. Recreational activities along the predicted downstream migration route would be disrupted following a release of crude oil. Under winter conditions the released crude oil would remain on land near the release location. Fisheries and public health officials typically close fisheries or issue guidance to avoid consuming fish until it is confirmed through monitoring that fish consumption is not a threat to public health. This standard approach is an effective mitigation strategy to protect human receptors for contact with chemical constituents of released crude oil.

7.2.6.5 Summary and Conclusions

Expected environmental effects to key ecological and human environment receptors after a hypothetical large crude oil release to Mosquito Creek, upstream of Lower Rice Lake, have been assessed. The proposed pipeline could carry a variety of crude oil types ranging from very light (e.g., Bakken crude oil) to heavy (e.g., diluted bitumen such as CLB), and the discussion of expected environmental effects on receptors considers these crude oil types as bounding conditions. Potential terrestrial receptors, aquatic receptors, semi-aquatic wildlife receptors and human and socio-economic receptors were screened to identify those most likely to have interactions with released crude oil. The results of this assessment are summarized in Table 7-50.

Table 7-50 Environmental Effects Summary Table for Pipeline Crude Oil Releases to Mosquito Creek

Receptor	Expected Environmental Effects of Released Crude Oil to Mosquito Creek	Relative Effect	
		Light Crude Oil	**Diluted Bitumen**
Terrestrial Receptors			
Soils	An assumption made in the fate modeling is that crude oil released under spring and summer-fall conditions would flow over 0.6 miles of land before reaching the headwater of Mosquito Creek, where the majority would be transported downstream. Under winter conditions released crude oil would remain on land. In the event of an actual oil release, any oil on land would undergo prompt and effective remediation. Residual effects on plant communities, soil or groundwater quality are unlikely.	SAME	SAME
Groundwater		SAME	SAME
Terrestrial Vegetation		SAME	SAME
Aquatic Receptors			
River (Mosquito Creek)	Both light and heavy oil would reach Mosquito Creek via overland flow under spring and summer-fall conditions, with subsequent physical transport downstream from the release location. Lighter crude oils are predicted to travel farther downstream than heavier crude oils, but would be thinner and less persistent on the water. Light oils have low viscosity relative to heavier oils and turbulence in the river water could potentially disperse the light oil as small droplets in the water column, meaning potentially toxic fractions of the light oils would more readily dissolve into the water column. Under winter conditions the released crude oil would remain on land. Light oils have a larger bioavailable component to aquatic organisms.	MORE	LESS
Lake (Lower Rice Lake)	Neither heavy nor light crude oil is predicted to move on the water surface beyond 10.4 miles downstream of the releases (based on the 24 hour simulations, and taking release response activities into account). Therefore, direct effects of released crude oil on Lower Rice Lake are unlikely. However, it is possible that oil accumulated in and not recovered from depositional areas could mobilize over time and move farther downstream, into the north end of Lower Rice Lake. This phenomenon would be more likely for the more persistent diluted bitumen than for a lighter crude oil which would undergo more rapid weathering and biodegradation.	LESS	MORE

Table 7-50 Environmental Effects Summary Table for Pipeline Crude Oil Releases to Mosquito Creek

Receptor	Expected Environmental Effects of Released Crude Oil to Mosquito Creek	Relative Effect	
		Light Crude Oil	Diluted Bitumen
Sediment	Lighter crude oils are predicted to travel farther downstream than heavier crude oils under spring and summer-fall conditions. Neither the light nor the heavy oil type is likely to reach a density greater than that of the water and sink directly to the sediment within the first few days following release. The low viscosity of the lighter type crude oils could potentially result in a larger amount of oil entrainment as fine droplets as compared to heavier blends, resulting in the formation of OPAs, which could both sink, and enhance biodegradation. Such aggregates may subsequently be preferentially deposited in areas of still or slowly moving water. The diluted bitumen crude oil type is less likely to be entrained into the water as fine droplets, and therefore true OPA formation is unlikely to occur. However, contact between the weathered diluted bitumen and shorelines is also likely to result in mixing of mineral particles into the crude oil, which could then be deposited to sediments as aggregates of oil and mineral in larger droplets or globules. If not recovered, these aggregates could move downstream with bedload until a stable depositional environment was reached, potentially in the north end of Lower Rice Lake.	LESS	MORE
Shoreline and Riparian Areas	Both light and heavy oil would travel downstream from the release location. Lighter crude oils are predicted to travel farther downstream than heavy crude oil under spring and summer-fall conditions, but would be thinner and less persistent where they contacted shorelines and riparian habitat. For heavy oil, thicker oiling of shorelines is predicted, with shorter overall transport distance. For light oil, stranding would also be the primary fate, but considerably more of the released oil would be lost to evaporation. Flooding of riparian and wetland habitats in spring could lead to stranding of crude oils in this habitat, with heavy crude oil likely to be deposited as patties or tar balls, which would be persistent. This is in contrast to light crude oil which would be deposited as a thin layer or sheen.	LESS	MORE
Aquatic Plants	Where they occur, floating aquatic plants would be expected to be killed if contacted by an oil slick. Submerged aquatic plants are less vulnerable. Emergent aquatic plants are generally quite tolerant of moderate exposure to floating oil (such that a portion of the stem was oiled). Wild rice is an emergent aquatic plant of ecological and cultural importance, and occurs where Mosquito Creek enters Lower Rice Lake. Based on the 24 hour model simulations, neither heavy nor light floating crude oil is predicted to move on the water surface beyond 10.4 miles downstream of the hypothetical release point (which is approximately 1.4 miles upstream of Lower Rice Lake). The light oil is predicted to be more mobile, and would affect a larger area of habitat. However, it is also possible that heavy oil accumulated in depositional areas would mobilize with time and move farther downstream towards and into Lower Rice Lake, thus interacting with this resource.	SAME	SAME

Table 7-50 Environmental Effects Summary Table for Pipeline Crude Oil Releases to Mosquito Creek

Receptor	Expected Environmental Effects of Released Crude Oil to Mosquito Creek	Relative Effect	
		Light Crude Oil	Diluted Bitumen
Benthic Invertebrates	In the short-term, the low viscosity of light crude oil would result in greater potential for oil entrainment as fine droplets, as compared to heavier blends. This would enhance dissolution of low molecular weight aliphatic and aromatic hydrocarbons into water (potentially resulting in acute toxicity), in addition to promoting oil-particle interaction and potential deposition of oil to sediment. For heavy crude oil, there would be less potential for dissolution of hydrocarbons into the water, but greater long-term potential for deposition of tar balls and patties as a result of oil interaction with sediment. These could accumulate in depositional areas, resulting in chronic effects on benthic invertebrates.	MORE	LESS
Fish	Environmental effects on fish would be limited to areas affected by the released oil. Light oils have low viscosity relative to heavier oils and turbulence in the river water could potentially disperse the light oil as small droplets in the water column. This would enhance the dissolution of potentially toxic fractions of the light oil into the water column. As a result, the potential for acute toxicity to fish due to narcosis would be greater for the light oil than for heavy oil. Potential chronic effects on fish eggs and embryos (i.e., blue sac disease) could also occur, but would be most likely to occur in spring and early summer, when most species spawn.	MORE	LESS
Semi-Aquatic Wildlife Receptors			
Amphibians and Reptiles	Light crude oil is predicted to travel farther downstream under spring and summer conditions than heavy crude oil, but would be thinner and less persistent on the water. Flooding of riparian habitat and marshes in spring could lead to stranding of crude oils in this habitat. Higher potential would exist for effects to amphibians than for adult turtles (e.g., external oiling and narcotic effects similar to fish and benthic invertebrates), which appear to be somewhat tolerant of external oiling.	MORE	LESS
Birds	Light crude oil is predicted to travel farther downstream under spring and summer conditions than heavy crude oil, so environmental effects could be more spatially extensive for light crude oil types than for heavy crude oil. Cold water in the spring, in combination with greater downstream movement of released oil, suggests that environmental effects of released oil could be greatest for a light crude oil in spring. In winter few if any aquatic or semi-aquatic birds would be present. Crude oil from a hypothetical release in that season is not predicted to enter Mosquito Creek, so effects on birds would be minimal.	MORE	LESS

Table 7-50 Environmental Effects Summary Table for Pipeline Crude Oil Releases to Mosquito Creek

Receptor	Expected Environmental Effects of Released Crude Oil to Mosquito Creek	Relative Effect	
		Light Crude Oil	Diluted Bitumen
Semi-aquatic Mammals	Light crude oil is predicted to travel farther downstream under spring and summer conditions than heavy crude oil, so environmental effects could be more spatially extensive for light crude oil types than for heavy crude oil. Cold water in the spring, in combination with greater downstream movement of released oil, suggests that environmental effects of released oil could be greatest for a light crude oil in spring. In winter crude oil from a hypothetical release is not predicted to enter Mosquito Creek, so effects on semi-aquatic mammals would be minimal in that season.	MORE	LESS
Human and Socio-Economic Receptors			
Air Quality	Effects on air quality have the potential to temporarily disrupt human use and occupancy patterns. Light crude oils typically contain more VOCs than heavier crude oils, although the VOC content of diluted bitumen may be similar to that of light crude oil, depending on the type and quantity of diluent used in its manufacture. Air quality in the vicinity of the oil release would be most affected within the first 24 hours of an oil release. Light crude oil is likely to be transported farther downstream within 24 hours than heavy crude oil. As a result, environmental effects on air quality could be more spatially extensive for light crude oil. Under winter conditions, the cold temperatures and absorption of crude oil into snow pack would strongly limit emissions of VOCs, in addition to constraining the area of effects.	MORE	LESS
Human Receptors	Typical human health effects associated with short-term inhalation of VOCs from crude oil releases include headache, dizziness, nausea, vomiting, cough, respiratory distress, and chest pain; fatality is unlikely. Residents in close proximity would become aware of a strong hydrocarbon odor that would alert them to the presence of a hazard. Most volatile hydrocarbons would be lost within 24 hours following a release. Effects on air quality or the presence of crude oil residues in aquatic and riparian habitat have the potential to temporarily affect human health. Under winter conditions, cold temperatures and absorption of crude oil into snow pack would strongly limit emissions of VOCs, in addition to constraining the area of effects.	MORE	LESS
Public Use of Natural Resources	Emergency response workers, in cooperation with public health and safety officials, would be active in notifying the public about the release, and isolating, containing and recovering released crude oil. No drinking water HCAs were identified along the path of the release. However, a number of homes are located near the flow path. In the event of a crude oil release, residents would be notified and testing would be completed to confirm the safety of private drinking water supply wells. Recreational activities would be disrupted along the predicted downstream migration route following a release of crude oil.	SAME	SAME

7.3 EXPECTED ENVIRONMENTAL EFFECTS OF LARGE RELEASES OF CRUDE OIL TO THE MISSISSIPPI RIVER AT BALL CLUB

The proposed pipeline could potentially cross under the Mississippi River 1.25 miles west of Ball Club, Minnesota and 400 ft south of U.S. Highway 2. This scenario captures a hypothetical release of crude oil directly to the Mississippi River, with downstream transport from the hypothetical release point to the south and east. The river channel in this area is relatively well defined, with many oxbows, backwaters and sloughs. The river margins include extensive riparian wetlands in a wide floodplain.

The Mississippi River to the south and east of the hypothetical release location is joined by the Leech Lake River approximately 4.7 miles downstream. Below the Leech Lake River confluence, the Mississippi River deepens and the riparian marsh expands as flow moves towards White Oak Lake (MN DNR 2016e). Beyond White Oak Lake the Mississippi River flows south and then east towards Grand Rapids, Minnesota. As identified in Chapter 4, the Mississippi River near Ball Club is part of the Chippewa Plains, a subsection of the Northern Minnesota Drift and Lake Plains Section of the greater Laurentian Mixed Forest Province (MN NDR 2006).

7.3.1 Description of the Freshwater Environment

The Mississippi River near Ball Club, Minnesota flows through a forested area, but the river has a wide floodplain lined with extensive marsh and grass. The riparian marshes and numerous abandoned river segments (oxbows) downstream of the crossing are considered important but they are afforded no special protection as WMAs (MN DNR 2016e). The river channel near the hypothetical release point is about 70 ft wide. The average velocity of the Mississippi River changes with season, with slowest velocities (e.g., about 0.4 ft per second) expected during low flow periods in the winter, and greater velocities (e.g., about 1.5 ft per second) during the spring high flow period. As a result of the flow regime, sand bars are often present on the inside of river bends, and occasionally present in the river channel.

Under low and average flow conditions the main channel of the Mississippi River passes to the south of White Oak Lake, with only small marshy streams connecting them. Under high river flow conditions, more substantial hydraulic connections exist between the river and lake. White Oak Lake is 38 acres in size and approximately 16 ft deep and is bordered to the north by the communities of Zemple and Deer River. The MN DNR does not report any information about aquatic wildlife on White Oak Lake; however, in nearby Ball Club Lake, many fish species are present (e.g., northern pike, black crappie, smallmouth bass; MN DNR 2016f).

The oxbows along the Mississippi River downstream of the potential pipeline crossing location are expected to support spawning fish, mink, raccoon, otter, wood ducks, mallard, and merganser (MN DNR 2016e). Within the Chippewa Plains subsection, 83 species are considered SGCN; these include birds (60 species), fish (4 species), insects (8 species), mammals (6 species), mollusks (2 species), and reptiles (2 species) (MN DNR 2006). Of these, 22 are listed by the federal government as endangered, threatened, or species of concern (MN DNR 2006; MN DNR 2016d). It is foreseeable that some of these SGCN would utilize aquatic habitats along the Mississippi River and White Oak Lake.

Several access points downstream from the proposed pipeline crossing location were visited in May, 2016, to provide additional insight into baseline environmental conditions for the Mississippi River downstream of Ball Club. Representative site photographs are provided in Figure 7-9 through Figure 7-12. Field observations are summarized in Table 7-51.

Figure 7-9 Mississippi River and Riparian Habitat Approximately 4.7 Miles Downstream of Pipeline Crossing Looking South (Confluence of Leech Lake River)

Figure 7-10 Mississippi River and Riparian Habitat Approximately 4.7 Miles Downstream of Pipeline Crossing Looking West (Upstream)

Figure 7-11 Mississippi River and Riparian Habitat Approximately 31 Miles Downstream of Pipeline Crossing

Figure 7-12 Mississippi River and Riparian Habitat Approximately 56 Miles Downstream of Pipeline Crossing

Table 7-51 Environmental Characteristics Observed at Selected Access Points on the Mississippi River Downstream of Pipeline Crossing Near Ball Club, MN in May 2016

Access Point	Latitude Longitude	Notes
Mississippi River #10 State Water Access Site (Boat Ramp) 4.7 miles downstream of pipeline crossing	47.3022 -93.9037	Habitat Description: At the confluence of the Mississippi and Leech Lake rivers. Broad floodplain with sedge wet/meadow, shrub swamp, and emergent marsh as the dominant plant community types. Some hardwood swamp and temporarily flooded aspen woods also present. The invasive plant Phragmites (reed grass) is common in the vicinity. Wildlife observed: yellow-bellied sapsucker, yellowthroat, green heron, tree swallow.
Mississippi River, #2 State Water Access Site (Boat Ramp) 31 miles downstream of pipeline crossing	47.6256 -93.7610	Habitat Description: River margin has good quality emergent marsh and wet/sedge meadow plant communities present. The invasive plants hybrid/narrowleaf cattail and Phragmites are common in some areas. Submergent vegetation is dominated by water celery. Floodplain forest is also present in the area. Adjacent upland areas include good quality forest dominated by aspen-birch. Wildlife observed: red-wing blackbird, yellowthroat

Table 7-51 Environmental Characteristics Observed at Selected Access Points on the Mississippi River Downstream of Pipeline Crossing Near Ball Club, MN in May 2016

Access Point	Latitude Longitude	Notes
Mississippi River at Herb Beers State Water Access Site 56 miles downstream of pipeline crossing	47.1288 -93.4051	Habitat Description: The floodplain in this area is dominated by a mix of floodplain forest and wet/sedge meadow. The invasive, nonnative reed canary grass occurs occasionally here. Floodplain transitions into terrace forest dominated by bur oak and green ash on Mississippi soils. Wildlife observed: Yellow throat, Baltimore oriole

7.3.2 High Consequence Area Assessment for the Mississippi River near Ball Club Crossing Location

As defined in Chapter 7.0, HCAs include populated areas, drinking water source areas, ecologically sensitive areas, and commercially navigable waterways. Sensitive AOIs include Minnesota drinking water management areas, native plant communities, sensitive lake shores, recreational areas, tribal lands, and protected areas of several types (e.g., national forests, military lands, state parks).

The locations of the various HCAs and AOIs near the hypothetical release location and the predicted trajectory of the floating oil are illustrated in Figure 7-13. Table 7-52 and Table 7-53 provide brief descriptions of the HCAs and AOIs for the hypothetical crude oil release location.

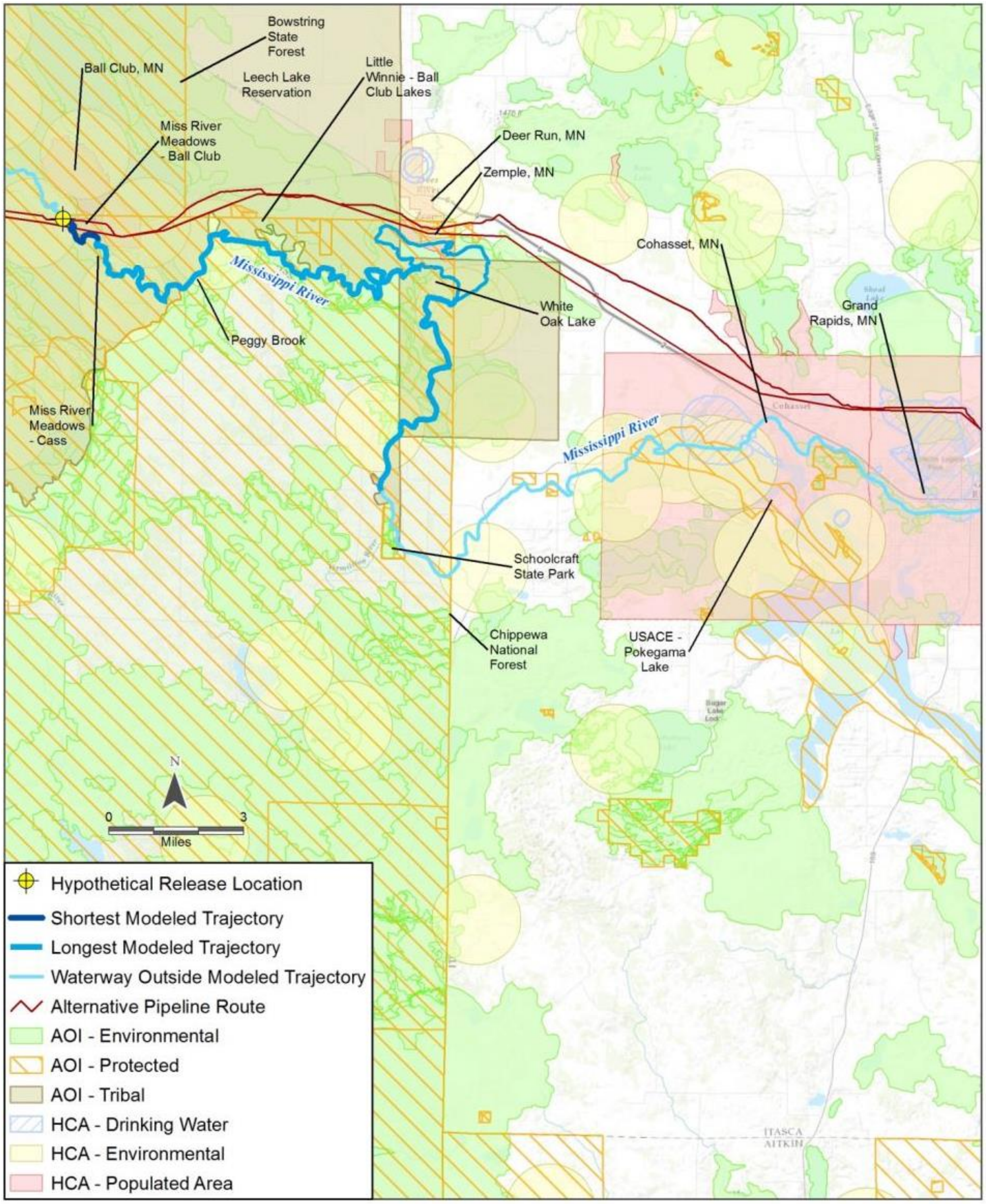

Figure 7-13 HCAs and AOIs Potentially Affected by a Crude Oil Release at the Mississippi River near Ball Club Crossing Location

Table 7-52 HCAs Potentially Affected by a Release of CLB and Bakken Crude Oil at the Mississippi River near Ball Club Crossing Location

HCA Type	HCA Subtype	Description / Locations
Environmentally Sensitive Area	N/A	N/A
Population Area	Other	Ball Club, MN Zemple, MN
NOTE: Data for the HCA analysis were obtained from the United States Department of Transportation: Pipeline and Hazardous Materials Safety Administration (USDOT PHMSA) HCA datasets plus additional HCAs compiled by Enbridge during 2010 and 2013.		

Table 7-53 AOIs Potentially Affected by a Release of CLB and Bakken Crude Oil at the Mississippi River near Ball Club Crossing Location

AOI Type	AOI Subtype	Description / Locations
Environmental	Native Plant Community (Candidate)	Little Winnibigoshish (Winnie) - Ball Club Lakes, Mississippi River Meadows - Ball Club, Mississippi River Meadows - Cass, Northern Wet Ash Swamp, Peggy Brook, Sedge Meadow, White Oak Meadows, White Oak Swamp
	Sensitive Lake Shore	White Oak Lake
	Wild Rice Lake	White Oak Lake
Protected Area	Lake of Biological Significance	White Oak Lake
	National Forest-National Grassland	Chippewa National Forest
	State Forest	Bowstring
Tribal Lands	N/A	Leech Lake Reservation
NOTE: Data for the AOI analysis were derived from multiple datasets provided on the Minnesota Geospatial Commons website, USGS Protected Areas Database of the United States and the Minnesota Department of Transportation.		

7.3.3 Selection of Key Ecological and Human Environment Receptors for Mississippi River near Ball Club Crossing Location

Taking into account environmental characteristics of the Mississippi River near Ball Club, the potential interactions of released crude oil with key ecological and human environment receptors were screened to identify key receptors for the subsequent environmental effects analysis. The rationale and results of this screening step are provided in Table 7-54.

Table 7-54 Key Ecological and Human Environment Receptors for the Mississippi River Near Ball Club

Receptor	Relevance for Inclusion as an Environmental Receptor for the Mississippi River near Ball Club Scenario	Selected (Y/N)
Terrestrial Receptors		
Soils	Low. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Mississippi River with no holdup of oil on land. Any oil that reaches soil would be physically remediated to established standards.	N
Groundwater	Low. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Mississippi River with no holdup of oil on land. In the event of an actual oil release, effects on groundwater quality would be localized and/or negligible.	N
Terrestrial Vegetation	Low. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Mississippi River with no holdup of oil on land. Any oil that reaches soil would be physically remediated and vegetative cover would be restored as part of the cleanup process.	N
Aquatic Receptors		
Rivers (Mississippi River)	High. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Mississippi River with subsequent physical transport downriver.	Y
Lakes (White Oak Lake)	High. An assumption made in the fate modeling for this scenario is that oil released under spring conditions, could be transported downstream in the Mississippi River and enter White Oak Lake.	Y
Sediment	High. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Mississippi River with subsequent physical transport downriver. This allows potential interaction and/or deposition of crude oil residues to sediments.	Y
Shoreline and Riparian Areas	High. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Mississippi River with subsequent physical transport downriver. This allows potential interaction with shoreline and riparian habitat.	Y
Wetlands	High. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Mississippi River with subsequent physical transport downriver and potential interaction with wetlands along the river and White Oak Lake.	Y
Aquatic Plants	High. Mississippi River and White Oak Lake support aquatic plant communities.	Y
Benthic Invertebrates	High. Mississippi River and White Oak Lake support benthic invertebrate communities.	Y
Fish	High. Mississippi River and White Oak Lake support fish communities.	Y
Semi-Aquatic Wildlife Receptors		
Amphibians and Reptiles	High. Mississippi River and White Oak Lake support semi-aquatic amphibians and reptiles.	Y

Table 7-54 Key Ecological and Human Environment Receptors for the Mississippi River Near Ball Club

Receptor	Relevance for Inclusion as an Environmental Receptor for the Mississippi River near Ball Club Scenario	Selected (Y/N)
Birds	High. Mississippi River and White Oak Lake support waterfowl and other semi-aquatic birds.	Y
Semi-aquatic Mammals	High. Mississippi River and White Oak Lake support semi-aquatic mammals.	Y
Human and Socio-Economic Receptors		
Air Quality	High. The community of Ball Club, Minnesota is 1.25 miles west of the hypothetical release location. The communities of Deer River and Zemple, Minnesota are approximately 1 mile from White Oak Lake. Some homes are located along the downstream flow path for released crude oil. Effects on air quality have the potential to temporarily disrupt human use and occupancy patterns.	Y
Human Receptors	High. The community of Ball Club, Minnesota is 1.25 miles west of the hypothetical release location. The communities of Deer River and Zemple, Minnesota are approximately 1 mile from White Oak Lake. Some homes are located along the downstream flow path for released crude oil. Effects on air quality or the presence of crude oil residues in aquatic and riparian habitat have the potential to temporarily affect human health.	Y
Public Use of Natural Resources	High. The Mississippi River near Ball Club, Minnesota and White Oak Lake area is shared by the Leech Lake Reservation and Bowstring State Forest. Effects on air and water quality, or the presence of crude oil residues in the sediment, riparian or wetland habitat, could potentially disrupt public use of natural resources (e.g., wild rice harvest, drinking water supplies, hunting, fishing, recreation).	Y

7.3.4 Modeled Conditions at the Release Location

A description of key modeling assumptions for the environmental effects analysis for the Mississippi River near Ball Club scenario is provided in this section. The OILMAP Land software was used by RPS ASA to simulate hypothetical releases of CLB and Bakken crude oils into the Mississippi River near Ball Club (Chapter 4.0) for a 24 hour period. A longer time period was not modeled as it was assumed that emergency response measures to prevent further downstream transport of released oil would be in place within the 24 hour period. While OILMAP Land does provide an indication of the downstream extent of oiling and mass balance of oil within the modeled period, it does not quantify the amounts of oil components dissolved into the water column (Chapter 5.0). No overland transport of released CLB or Bakken crude oil was modelled for this hypothetical release location, as it was assumed that released oil would directly enter the watercourse (Chapter 4.0). This is a worst-case assumption for a release of crude oil near the watercourse.

The two crude oil types provide bounding cases for oils that range from light (e.g., Bakken crude oil having low viscosity and density) to heavy (CLB/CLWB, heavy diluted bitumen crude oil types having higher viscosity and density). Seasonal variations in river flow velocity, temperature, wind speed, and snow and ice cover were all considered at the release location. A summary of key variables is provided in Table 7-55.

The shore type for the majority of the Mississippi River in the region of the hypothetical release is marsh. Marsh shore types have high potential to trap and retain crude oil. Because of the uncertainty around how much oil would be able to infiltrate the marshy shoreline under the seasonal flow conditions, the downstream trajectory of released oils was simulated also assuming a grass shoreline, for which oil retention capacity is lower. Both sets of results are presented here independently. It is anticipated that if an actual release were to occur, downstream oil transport would be somewhere between the two predicted downstream distances.

Table 7-55 Environmental and Hydrodynamic Conditions for the Three Modeled Periods at the Mississippi River at Ball Club Crossing

Season	Month	Air Temperature (°C)	Wind Speed (m/s)	Average River Velocity (m/s)
Low Flow (Winter)	March	-3.61	4.51	0.12
Average Flow (Summer-Fall)	August	18.92	3.51	0.31
High Flow (Spring)	April	5.00	4.88	0.47
NOTE: A velocity of 1 m/s is equivalent to 2.25 miles per hour.				

The highest average flow velocity of the Mississippi River at Ball Club coincides with the spring freshet (i.e., April–June), a result of rising temperatures and snowmelt. Average flow would typically occur in summer and fall seasons. August, the month with the warmest temperature, was selected to represent the maximum amount of evaporation. The lowest flow rate occurs in winter (i.e., January-March), and was typified by freezing conditions and probable ice cover on water.

The crude oil release volume was calculated as a full bore rupture, with a maximum time to response in the pipeline Control Center of 10 minutes, followed by a 3-minute period to allow for valve closure. The release volume therefore represents the volume of oil actively discharged in the period of time required to detect and respond to the event (taking into consideration the pipeline diameter, pipeline shutdown time, pipeline design flow velocity), followed by the volume of oil lost due to drain-down of the elevated segments of pipeline. The maximum 13-minute response time to valve closure is an Enbridge standard for safe operations and leak detection. This includes the combination of identification of the rupture, analysis of the pipeline condition, pipeline shutdown, and full valve closure in the affected pipeline section. While

13 minutes is the maximum time for valve closure, this is a conservative assumption, since a response through to valve closure is expected to occur in less than 13 minutes in a full bore rupture leak scenario. Based on these assumptions, the site-specific hypothetical release volume was estimated [NONPUBLIC DATA HAS BEEN EXCISED] of Bakken, CLB or CLWB crude oil.

7.3.5 Summary of Predicted Downstream Transport of Bakken and Cold Lake Crude Oils

A summary of the predicted downstream trajectories and mass balance for Cold Lake and Bakken crude oils, under the three seasonal scenarios and for two shore types (i.e., marsh or grass), are provided in Figure 7-14 to Figure 7-17. These simulations are assumed to provide bounding conditions for a release of heavy or light crude oil types. The fate of most types of crude oil, if released, would lie within the envelope of predictions for the Cold Lake and Bakken crude oil types. The Cold Lake crude oil was assumed to be CLB for the high flow and average flow scenarios, and to be CLWB for the low flow (winter) scenario. As noted in Chapter 5, while OILMAP Land does provide an indication of the downstream extent of oiling and mass balance of oil within the modeled period, it does not quantify the amounts of oil components dissolved into the water column.

The maximum simulation duration using OILMAP Land was 24 hours, as it was assumed that emergency response measures to prevent or reduce further downstream transport of released oil would be in place within that length of time. Symbols on the drawings indicate the river seasonal flow condition (high corresponding to spring freshet, average corresponding to summer-fall conditions, and low corresponding to winter flow under ice). Numbers associated with the symbols indicate the predicted location of the leading edge of the released oil in the river after 6, 12, 18 or 24 hours. Numbers other than these (e.g., 5.2) indicate the time in hours of the predicted termination of downstream transport of the released oil due to adhesion or holdup of the oil along the river banks. Tables inserted within the Figures also provide information on the mass balance (i.e., oil remaining on the surface of the river, adhering to river banks, or evaporated to the atmosphere) of the released oil at relevant points in time after the start of the release.

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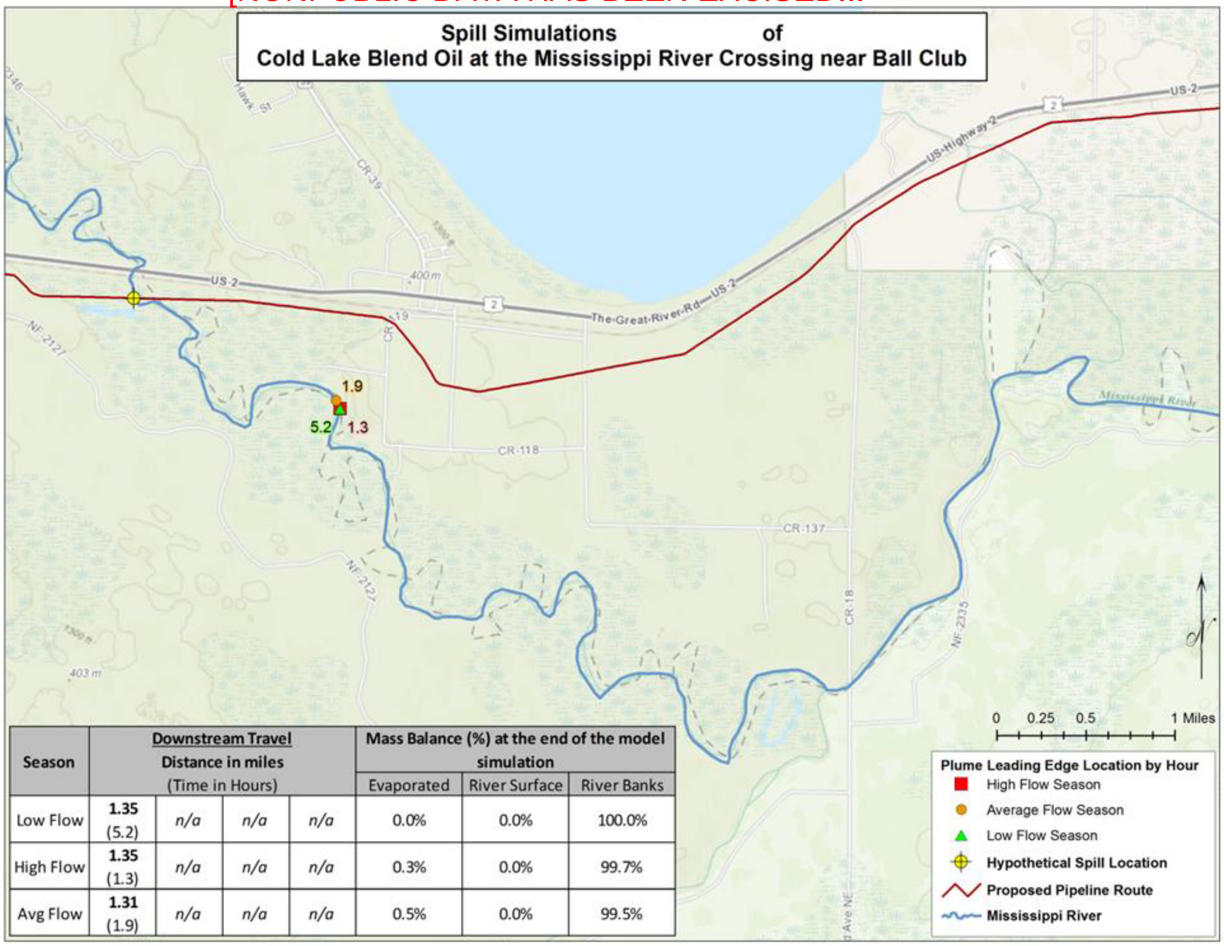

Season	Downstream Travel Distance in miles (Time in Hours)				Mass Balance (%) at the end of the model simulation		
					Evaporated	River Surface	River Banks
Low Flow	1.35 (5.2)	n/a	n/a	n/a	0.0%	0.0%	100.0%
High Flow	1.35 (1.3)	n/a	n/a	n/a	0.3%	0.0%	99.7%
Avg Flow	1.31 (1.9)	n/a	n/a	n/a	0.5%	0.0%	99.5%

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Figure 7-14 Predicted Downstream Transport of CLB Oil at the Mississippi River at Ball Club Crossing Location Assuming Marshy Shore

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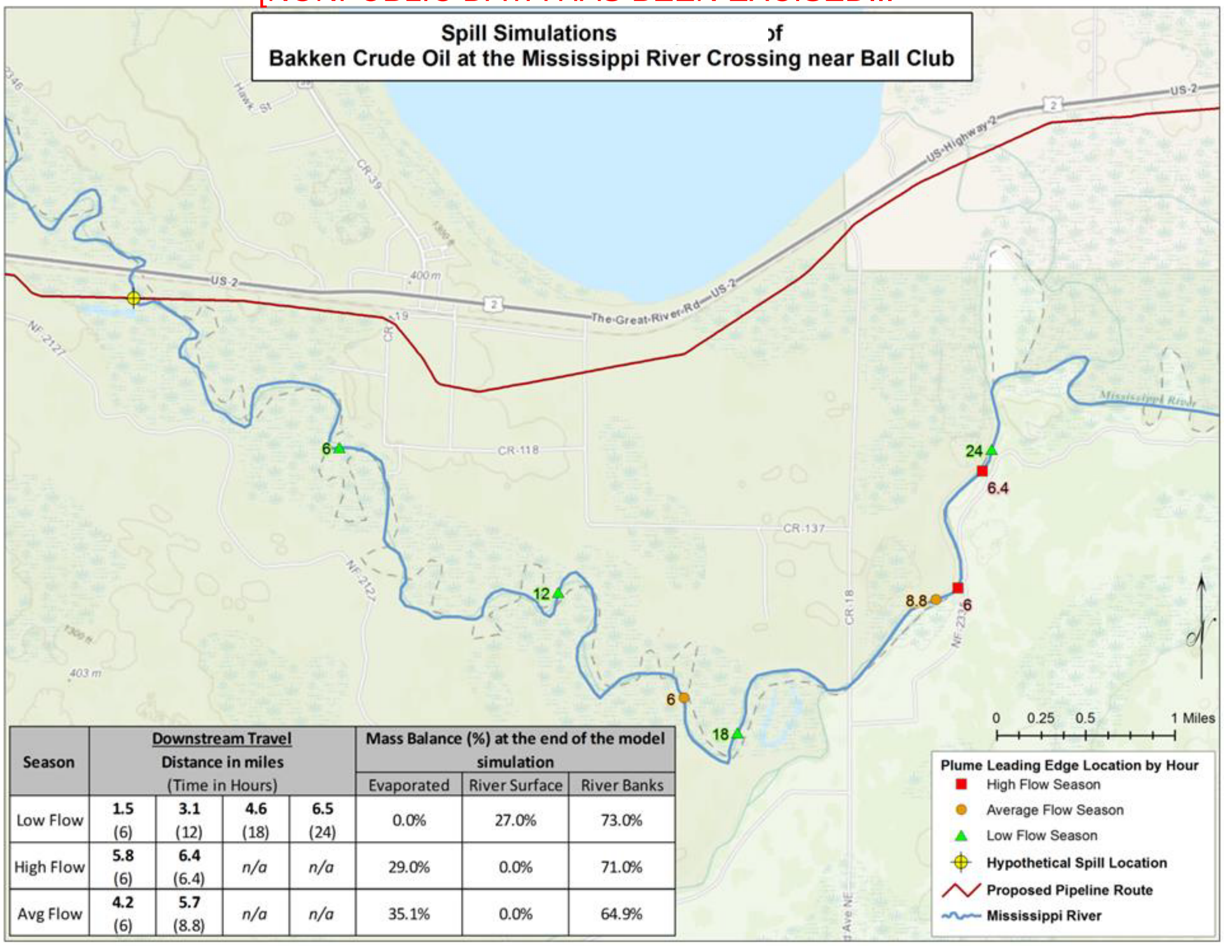

Season	Downstream Travel Distance in miles (Time in Hours)				Mass Balance (%) at the end of the model simulation		
					Evaporated	River Surface	River Banks
Low Flow	1.5 (6)	3.1 (12)	4.6 (18)	6.5 (24)	0.0%	27.0%	73.0%
High Flow	5.8 (6)	6.4 (6.4)	n/a	n/a	29.0%	0.0%	71.0%
Avg Flow	4.2 (6)	5.7 (8.8)	n/a	n/a	35.1%	0.0%	64.9%

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Figure 7-15 Predicted Downstream Transport of Bakken crude at the Mississippi River at Ball Club Crossing Location Assuming Marshy Shore

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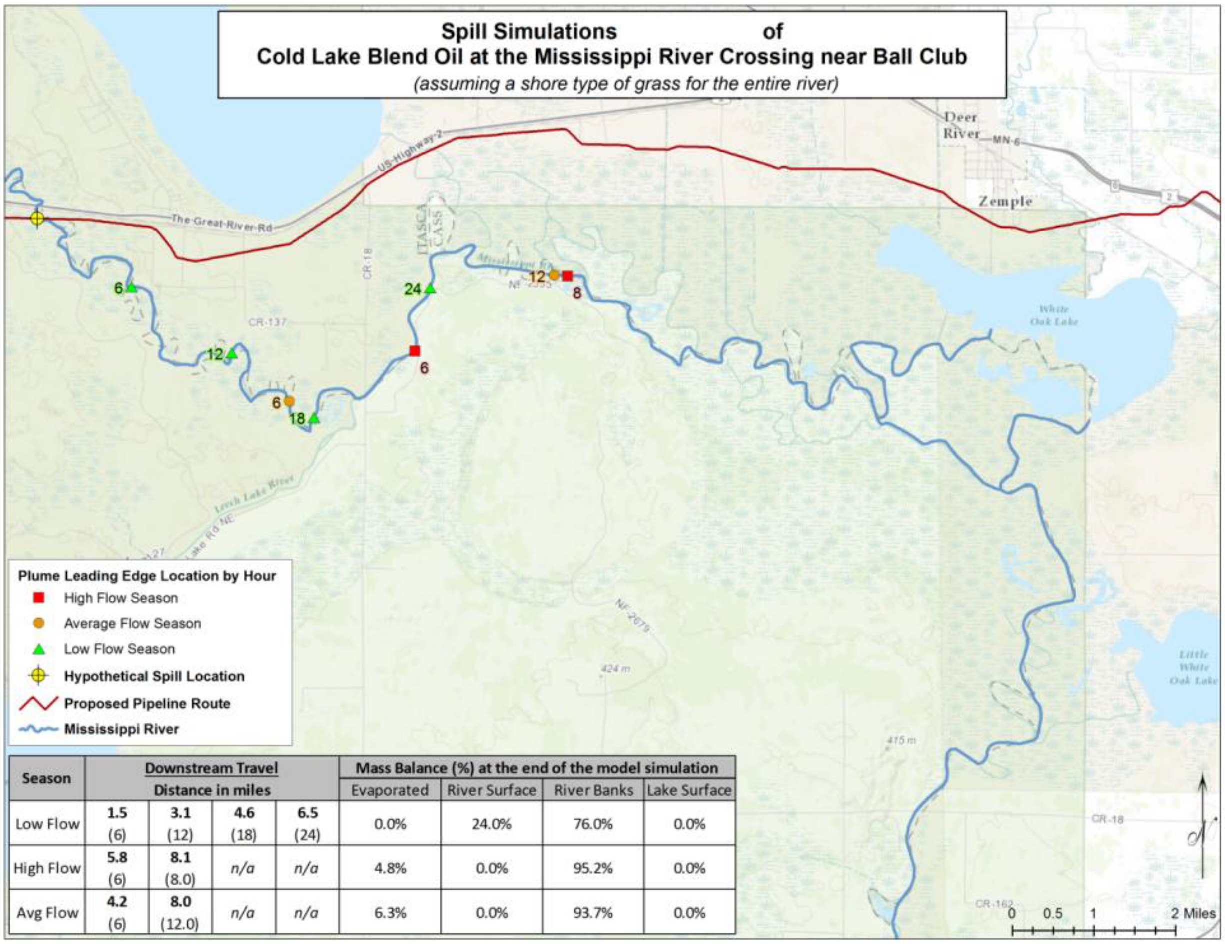

Season	Downstream Travel Distance in miles				Mass Balance (%) at the end of the model simulation			
					Evaporated	River Surface	River Banks	Lake Surface
Low Flow	**1.5** (6)	**3.1** (12)	**4.6** (18)	**6.5** (24)	0.0%	24.0%	76.0%	0.0%
High Flow	**5.8** (6)	**8.1** (8.0)	*n/a*	*n/a*	4.8%	0.0%	95.2%	0.0%
Avg Flow	**4.2** (6)	**8.0** (12.0)	*n/a*	*n/a*	6.3%	0.0%	93.7%	0.0%

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Figure 7-16 Predicted Downstream Transport of CLB Oil at the Mississippi River at Ball Club Crossing Location Assuming Grassy Shore

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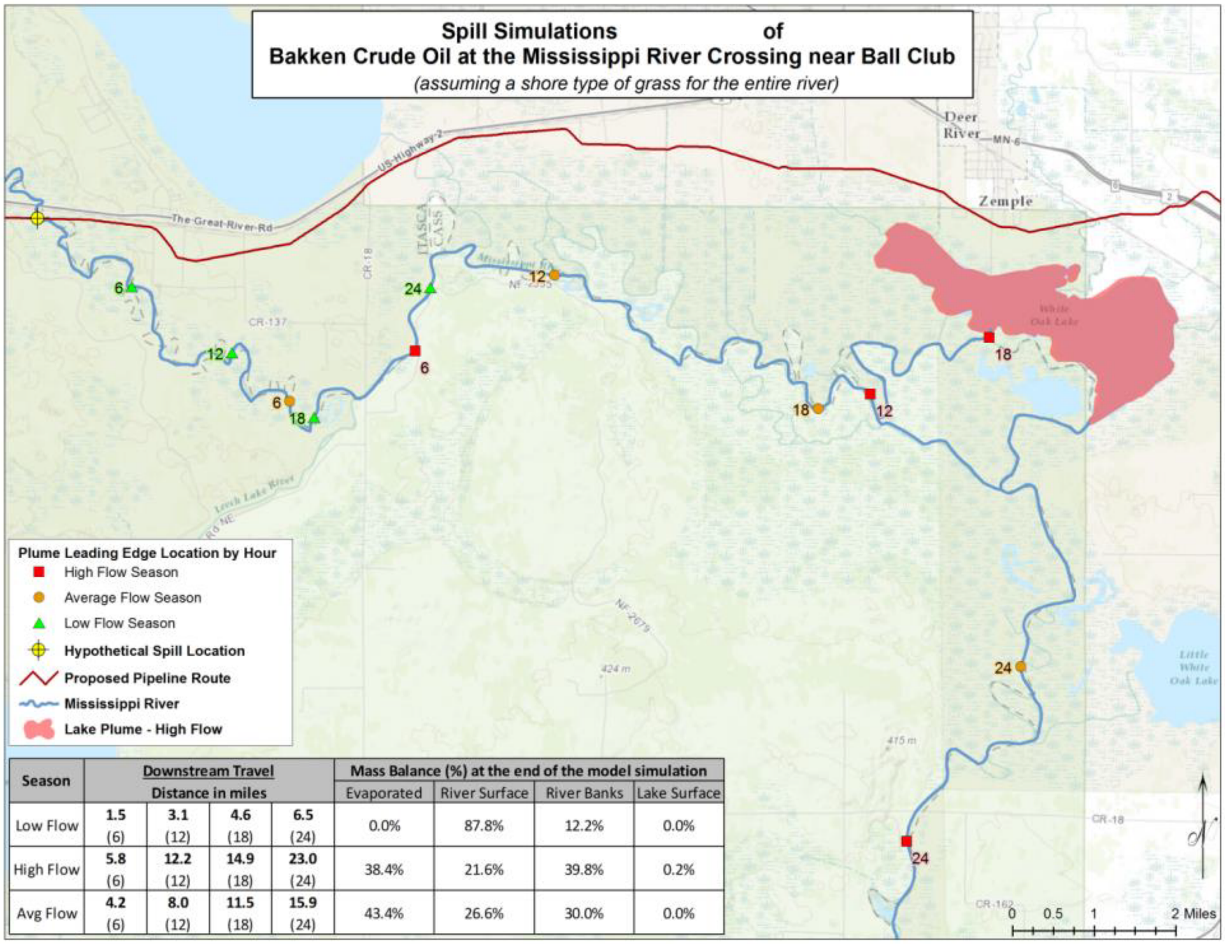

Season	Downstream Travel Distance in miles				Mass Balance (%) at the end of the model simulation			
					Evaporated	River Surface	River Banks	Lake Surface
Low Flow	1.5 (6)	3.1 (12)	4.6 (18)	6.5 (24)	0.0%	87.8%	12.2%	0.0%
High Flow	5.8 (6)	12.2 (12)	14.9 (18)	23.0 (24)	38.4%	21.6%	39.8%	0.2%
Avg Flow	4.2 (6)	8.0 (12)	11.5 (18)	15.9 (24)	43.4%	26.6%	30.0%	0.0%

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Figure 7-17 Predicted Downstream Transport of Bakken crude at the Mississippi River at Ball Club Crossing Location Assuming Grassy Shore

7.3.5.1 Mississippi River at Ball Club Release During High Flow (Spring) Period

Under the high flow scenario and assuming a predominantly marshy shore, CLB was predicted to travel approximately 1.35 miles downstream in Mississippi River, with downstream transport being terminated 1.3 hours after the release (Figure 7-14). Almost all of the released crude oil (99.7%) was predicted to adhere to shorelines, with the balance evaporating. With the assumption of a grassy shore having less oil retention capacity, CLB was predicted to travel farther downstream (8.1 miles in 8 hours), with the majority also adhering to shorelines (Figure 7-15). It was assumed that emergency response measure to prevent further possible downstream transport of oil would be in place within 24 hours of the release.

Bakken crude oil was predicted to be transported approximately 6.4 miles downstream within 6.4 hours of a release assuming a predominantly marshy shore (Figure 7-14). At this time, approximately 29% of the Bakken crude oil was predicted to have evaporated to the atmosphere, with 71% adhering to shorelines. With the assumption of a grassy shore, Bakken crude oil was predicted to travel approximately 23 miles downstream over the 24-hour modeled period (Figure 7-15). Under these assumptions, the oil was predicted to reach and spread over the surface of White Oak Lake (1.47 square miles) to a thickness of 0.00004 inches. The Bakken crude oil was also predicted to continue to move downstream from White Oak Lake, another 6.9 miles. Approximately 39.8% of the Bakken crude oil was predicted to adhere to the shorelines of the Mississippi River and White Oak Lake, 0.2% was predicted to remain on the surface of White Oak Lake, 21.6% would remain on the river surface, and 38.4% was predicted to have evaporated into the atmosphere at the end of the 24 hour simulation. If left unmitigated, the Bakken crude oil remaining on the river surface after 24 hours could continue to move downstream, with weathering and oiling of shorelines continuing until all of the oil was removed from the water surface.

The release of Bakken crude oil under high flow conditions was predicted to result in oiling approximately farther downstream in Mississippi River than the CLB. The difference in the extent of downstream transport was primarily the result of the difference in shoreline retention. Because of its higher viscosity and adhesiveness, larger amounts of CLB are predicted to strand, as a thicker layer of oil on a given length of shoreline, than for the Bakken oil. Conversely, the same amount of Bakken crude oil would affect a greater length of shoreline, with a lesser thickness of oil. This result is based upon the assumption of 100% shoreline oiling coverage (i.e., all shoreline up to that point was oiled to its maximum holding capacity for that oil type) as oil made its way downstream. In the event of an actual release, the downstream extents of CLB and Bakken crude oil may be more similar, and the effects of CLB may extend farther downstream than presented, with patchy coverage or partial oiling of shorelines.

A larger portion of Bakken crude oil was predicted to evaporate to the atmosphere than was predicted for CLB. This was due in part to the lighter and more volatile character of the Bakken crude oil. In addition, the greater downstream transport of the Bakken crude oil took more time, and resulted in more water surface area with oil, both of which would allow more of the released oil to evaporate. Volatile components of the CLB would continue to evaporate after becoming stranded on shoreline, but this process was not included within the OILMAP Land model for stranded oil.

7.3.5.2 Mississippi River at Ball Club Release During Average Flow (Summer-Fall) Period

Under average river flow conditions, and assuming a predominantly marshy shore, CLB crude oil was predicted to travel up to 1.31 miles downstream within 1.9 hours of the release at which time the downstream transport was predicted to terminate (Figure 7-14). At that time, approximately 0.5% of the released crude oil was predicted to have evaporated to the atmosphere, with the remaining 99.5% predicted to be adhering to shoreline. With the assumption of a grassy shore, CLB was predicted to travel farther downstream (8.0 miles in 12 hours) with the majority of the release also adhering to banks (Figure 7-38).

Slightly more of the CLB crude oil was predicted to evaporate under the average river flow condition than under the high river flow condition (Figure 7-14 and Figure 7-15). This difference is due largely to the warmer temperatures in the summer-fall season as compared to the spring freshet, as well as the greater length of time and greater surface area of water that was predicted to be oiled before the end of the simulation.

Under average river flow conditions, Bakken crude oil was predicted to travel approximately 5.7 miles downstream within 8.8 hours of release, assuming a predominantly marshy shore (Figure 7-14). At this time approximately 35.1% was predicted to have evaporated to the atmosphere, with the remaining 64.9% predicted to be retained on shorelines. Under average river flow conditions, the Bakken crude oil was transported downstream at a slower velocity than under high river flow conditions, allowing more time for evaporation from the stream surface. With the assumption of a grassy shore with less oil retention capacity, Bakken crude oil was predicted to travel approximately 15.9 miles downstream over the 24-hour modeled period (Figure 7-15). The Bakken crude oil was predicted to be transported down the Mississippi River, past but not entering White Oak Lake due to low water levels, and to terminate just west of Little White Oak Lake. Approximately 30% of the Bakken crude oil was predicted to oil shorelines of the Mississippi River, 43.4% to evaporate into the atmosphere, and 26.6% to remain on the river surface at the end of the 24 hour simulation. If left unmitigated, the remaining Bakken crude on the river surface after 24 hours would be expected to continue downstream, with weathering and oiling of shorelines continuing until all the oil was removed from the water surface.

When compared to CLB under average river flow conditions, the Bakken crude oil was predicted to be transported farther downstream due to the lower shoreline oil retention values for the low viscosity Bakken crude oil, when compared to the more viscous and adhesive CLB. Although not modeled here, it is expected that a medium crude oil would exhibit fate and transport properties intermediate between those of the Bakken and CLB crude oil types.

7.3.5.3 Mississippi River at Ball Club Release During Low Flow (Winter) Period

Under low winter flow conditions it was assumed that Mississippi River would be frozen (100% ice coverage). It was also assumed that oil would be released directly into the river from the pipeline, which is located under the riverbed. Oil released into the water would remain in the water or be trapped under the ice. The ice cover would strongly limit or prevent evaporation to the atmosphere. Flow rates for the Mississippi River during these winter conditions result in minimum river velocities during March.

Under low river flow and assuming a predominantly marshy shore, CLWB was predicted to travel approximately 1.35 miles downstream in approximately 5.2 hours (Figure 7-14). After this time, all of the CLWB was predicted to be trapped along the river margins between the ice and the river bottom, or in hollows under the ice. With the assumption of a grassy shore with less oil retention capacity, CLB was predicted to travel farther downstream (6.5 miles over the full 24-hour modeled period). Approximately 76% of the CLWB was predicted to be trapped along the river margins between the ice and the river bottom, or in hollows under the ice, and the remaining 24% was predicted to remain potentially mobile in the river below the ice. If left unmitigated, it is expected that the remaining CLWB would continue to move downstream until all of the oil was removed from the water.

Under low flow conditions, regardless of whether the shoreline was marshy or grassy, the Bakken crude oil was predicted to be transported approximately 6.5 miles downstream over the 24-hour modeled period. With a predominantly marshy shore, approximately 73% of the Bakken crude oil was predicted to be trapped along the river margins between the ice and the river bottom, or in hollows under the ice, with 27% remaining potentially mobile in the river below the ice at the end of the 24 hour simulation. With a grassy shore, approximately 12.2% was predicted to be trapped along the river margins between the ice and the river bottom, or in hollows under the ice, and the remaining 87.8% was predicted to remain potentially mobile in the river at the end of the 24 hour simulation. If left unmitigated, it is expected that the remaining Bakken crude in the river after 24 hours would continue to move downstream until all the oil was removed from the water.

Under winter conditions, the oil was predicted to move more slowly and to travel a shorter distance then than the average and high river flow conditions. Because the Bakken crude was released below the ice of the river, no oil was predicted to evaporate to the atmosphere.

7.3.6 Qualitative EHHRA for the Mississippi River near Ball Club

In this section the likely environmental effects of a crude oil release at the pipeline crossing location on the Mississippi River are described. A worst case crude oil release from a main-line pipeline, such as described here, would be an unlikely event (Chapter 4.0). The proposed pipeline could carry a variety of crude oil types, ranging from very light (e.g., Bakken crude oil) to heavy (e.g., diluted bitumen such as CLB). Therefore, the following discussion is based on the likely environmental effects of a crude oil release on relevant ecological and human environment receptors (identified in Section 7.3.3), using the predicted geographic extent of effects of released Bakken or CLB crude oil types over the 24 hour simulations as bounding conditions. Effects of season (including temperature, river flow conditions, and receptor presence/absence and sensitivity) were also considered in the analysis. The rationale supporting the effects analysis, based on case studies describing the effects of crude oil releases on the various ecological and human environment receptors, was provided in Section 7.1 and Table 7-54.

7.3.6.1 Terrestrial Receptors

For this modeling scenario, the hypothetical release of crude oil is assumed to enter into the Mississippi River with no overland flow. Environmental effects on soils, terrestrial vegetation and groundwater quality are assumed to be localized, limited in spatial extent, and readily remediated using conventional clean-up techniques. The environmental effects of a crude oil release on land cover receptors are not considered further for this release scenario.

7.3.6.2 Aquatic Receptors

The aquatic environmental and ecological receptors that are most closely associated with the Mississippi River at Ball Club scenario are addressed in this section. These receptors include water and sediment quality in rivers and lakes, shoreline and riparian habitat, wetlands, aquatic plants, benthic invertebrates, and fish.

Crude oil released accidentally into the Mississippi River during the spring (high flow) or summer-fall (average flow) seasons would be predicted to travel downstream, interacting with vegetation and seasonal shoreline areas. The distance travelled would depend upon river flow, oil type and shoreline type. Based on OILMAP Land simulations, light oils oil is predicted to travel father downstream than heavy oil. Marshy shorelines are predicted to strongly limit the scope of downstream movement of crude oil, due to their high capacity to trap and retain released oil when compared to grassy shorelines (Figure 7-14 and Figure 7-15). Under high flow conditions and assuming a grassy shore (low retention), it was predicted that the Bakken crude oil could reach White Oak Lake and spread over its surface as a thin slick (0.00004 inches). For heavy oil, stranding on shore (whether marshy or grassy) would be the primary fate.

The effects of a crude oil release on benthic invertebrates and fish would depend on the characteristics of the released oil, and environmental conditions at the time of the release. Acute toxicity to fish is commonly but not always observed in association with crude oil releases, and is an indicator that, at least briefly, concentrations of dissolved hydrocarbons (particularly mono-aromatic hydrocarbons, some low molecular weight PAHs, and short-chain aliphatic hydrocarbons) are sufficiently high to cause acute toxicity due to narcosis. Light oils have low viscosity relative to heavier oils. Turbulence in the river water could potentially disperse light oil as small droplets in the water column, increasing the potential for toxic fractions of the light oil to dissolve into the water column. During the spring freshet, flow in the Mississippi River at Ball Club is likely to be sufficiently rapid and turbulent for such droplet formation to occur for the light crude oil, although heavy crude oil is less likely to be affected. As a result, the potential for acute toxicity to fish and benthic invertebrates could be greater for the light oil than for heavier oils.

During the spring high flow condition, the water level in the Mississippi River rises so that some of the oil transported down the river could spread over the surface of White Oak Lake. Approximately 0.2% of Bakken crude oil is predicted to be on White Oak Lake 24 hours after the release, as a very thin layer (0.00004 inches). The CLB crude oil is not predicted to reach White Oak Lake under any scenario. The large surface area of the lake would promote the rapid evaporation of volatile (and potentially water soluble) hydrocarbon constituents from the Bakken crude oil. Rapid evaporation could limit potential toxicity to fish within the lake. However, wind speeds are also potentially high during spring, so wave action on White Oak Lake could create turbulent conditions that would disperse light oil as small droplets in the water column. In the unlikely event of a crude oil spill at Ball Club, Minnesota, narcotic effects of Bakken crude oil on fish and benthic invertebrates would be likely to occur in the Mississippi River upstream and downstream of White Oak Lake during the spring and summer-fall season. Narcosis could also occur in White Oak Lake in the spring, if water levels and flow conditions allowed the released Bakken crude oil to enter the lake.

There would also be high potential for chronic effects of released crude oil on fish eggs and embryos (i.e., induction of deformities or mortality collectively termed blue sac disease). Many of the fish species present in the Mississippi River spawn in the spring and early summer. The eggs and embryos of these species could be exposed to total PAH concentrations in the river and lake water that could be sufficiently high to induce deformities or cause mortality. In addition the potential for phototoxicity, caused by an interaction of UV light with PAHs accumulated in fish tissues, would be greatest for a crude oil release in summer due to high light intensity and long day length. Small fish that are lightly pigmented or transparent (i.e., embryos, larval and juvenile fish) are most susceptible to phototoxicity. The risk of phototoxicity could be mitigated by high concentrations of dissolved oxygen content (DOC) present in the water of the Mississippi River and White Oak Lake, which would absorb and limit the penetration of UV light into the water column.

Entrainment of small crude oil droplets in the water column during the spring freshet also enhances the potential for light crude oils to interact with suspended sediment particles in the water column resulting in the formation of OPAs. Such aggregates may subsequently be preferentially deposited in areas of still or slowly moving water such as sediments near the many oxbows and twists in the Mississippi, as well as slowly moving areas and backwaters in the habitats where the Mississippi connects with White Oak Lake, and in addition, White Oak Lake could provide a depositional environment where crude oil might eventually accumulate, regardless of the season when an accidental release occurred. Formation of true OPAs is less likely to occur with heavy crude oils such as diluted bitumen, as the higher viscosity of the oil precludes the ready formation of fine droplets in the water column (Zhou et al. 2015). However, heavy oils can still contact sediment particles along the shoreline, and some accumulation of both light and heavy oils in depositional areas is likely, although the precise mechanisms of deposition may vary. Neither crude oil type is likely to reach a density greater than that of the water and sink directly to the sediment within the first few days following release.

The Mississippi River and White Oak Lake support emergent, floating and submerged aquatic plants. Where they occur, floating aquatic plants would be expected to be killed if contacted by an oil slick. Submerged aquatic plants would be less vulnerable, as they would be exposed primarily to dissolved hydrocarbons, and are not considered likely to be among the most sensitive groups of aquatic biota to such exposure. Emergent aquatic plants are generally quite tolerant of moderate exposure to floating oil (such that a portion of the stem could be oiled). Wild rice is an emergent aquatic plant of biological and cultural importance in Minnesota, and is found in White Oak Lake. Wild rice provides a food source and nesting cover for many birds, and is also harvested as a food source by people in the area. For a hypothetical release under spring freshet conditions, it is likely that most aquatic plants would still be dormant or submerged, and that environmental effects on this receptor type would be minimal. However, flooded riparian areas and wetland habitats would also be exposed to the released oil, and if not properly remediated, crude oil residues could kill plants in these areas. This could affect the biological integrity and productivity of the habitat, and potentially lead to erosion and further damage to the habitat. In the early summer, oiling of emerging wild rice plants could lead to growth inhibition or death. Later in the summer, oiling at water level of the stems of emerged plants (deposited during spring is unlikely to affect the plants. A release of crude oil in winter would have little direct effect on aquatic plants, as they would be in a dormant state.

Crude oil released during the winter (low flow) period could potentially pool on the frozen river surface. If the release was to occur directly to the river below the ice (as is assumed in the OILMAP Land model), or if there were openings in the ice that the released oil could penetrate, the oil could travel downstream under the ice, accumulating in the narrow gap between the ice and the river sediment, or accumulating in hollows under the ice as it moved. Results provided in Section 7.2.5.3 provide bounding cases for the products likely to be carried in the pipeline. The OILMAP Land simulations indicate that crude oil could be carried 1.35 to 6.5 miles downstream from the point of release under winter low-flow conditions. For both oil types, the winter ice would effectively inhibit evaporation, while providing greater potential for dissolution into the water column during the period of lowest dilution flow. Therefore, a release in winter could cause fish mortality due to narcosis. This result would be more likely for the light crude oil, which would spread out over a larger area, facilitating release of more water soluble constituents. The heavy crude oil would tend to remain in thicker localized accumulations, and rapid release of more water soluble constituents from a thick layer of crude oil is unlikely. Fish eggs and larvae would generally not be present during the winter, so effects on these life stages due to blue sac disease are not likely, although crude oil residues in water and sediment could, if not adequately remediated, affect fish eggs and larvae in the following spawning season. Phototoxicity is not likely to occur following a release of crude oil in winter due to short day length and lower light intensity in winter, reflection and absorbance of light by snow and ice cover on the lake, and absorbance of UV light by DOC in the water beneath the ice.

Both crude oil types could be accumulated in sediment after a release in winter, and both crude oil types would be subject to re-mobilization with spring breakup of the ice, and increasing water flow rates.

7.3.6.3 Semi-Aquatic Wildlife Receptors

Habitat along the Mississippi River downstream of the hypothetical release location supports amphibians (e.g., frogs, salamander), reptiles (e.g., turtles, snakes), birds (e.g., ducks, geese, shorebirds, raptors), and semi-aquatic mammals (e.g., muskrat, beaver, mink and otter). Details on predicted environmental effects for amphibians and reptiles, birds and mammals are provided below.

7.3.6.3.1 Amphibians and Reptiles

Crude oil released to the Mississippi River during the spring (high flow) and summer-fall (average flow) seasons is predicted to travel downstream, interacting with vegetation and seasonal shoreline areas. The distance travelled would depend on the oil and shoreline type. The OILMAP Land simulations indicate that light oil will travel father downstream than heavy oil, with both types being retained more strongly by marshy shores, as compared to grassy shores (Figure 7-14 and Figure 7-15). Under spring (high flow) conditions and assuming a grassy shore, it was predicted that the Bakken crude oil could reach White Oak Lake and spread over its surface as a thin slick (0.00004 inches). For heavy oil, stranding on shore would be the primary fate.

Within the oil-exposed habitats along the river and lake that support amphibians (adults, juveniles, and eggs), oiling effects including mortality would be observed. Turtles appear to be relatively tolerant of external crude oil exposure, and although these animals are likely to become oiled, mortality of turtles as a result of this exposure is less likely. Reptiles like lizards and snakes are primarily terrestrial species and are less intimately associated with aquatic environments. As a result, exposure of these animals to released crude oils would be limited. After the Kalamazoo River oil spill in 2010 snakes did not appear to be highly exposed to spilled oil. A release of light crude oil during the spring would likely have a greater effect than in summer due to the greater predicted downstream transport distance and interaction with greater areas of riparian and wetland habitats than later in the year.

Amphibians and reptiles undergo a winter dormancy period when temperatures drop below approximately 41 to 45°F. At this time, amphibians and turtles typically bury themselves in river bottom substrates or other similar habitats. Therefore, during the winter (and likely up until April or May when winter ice is gone), these organisms would have very little exposure to released oil moving on the water surface or within the water column.

7.3.6.3.2 Birds

Aquatic and semi-aquatic birds are those that use rivers, lakes, wetlands, and riparian areas as components of their habitats, particularly for nesting and feeding. These birds belong to a variety of guilds including but not limited to waterfowl, divers, gulls and terns, raptors, shorebirds, waders, and some songbirds. They have a variety of dietary preferences, including piscivory, insectivory, omnivory and herbivory. If exposed to external oiling, the ability of birds to maintain body temperature may be compromised, leading to death as a result of hypothermia. Even if they survive their initial exposure to crude oil, the exposure may require an increase in metabolic rate to survive. In turn this may compromise other life functions such as reproduction or growth. Birds that survive external oiling may experience toxicological stresses as a result of ingesting crude oil residues while preening or attempting to clean and restore the normal properties and functions of feathers. Birds can also transfer potentially lethal quantities of crude oil residue from their feathers to the external surface of eggs, resulting in death of developing embryos.

Unlike many other vertebrate receptors, aquatic bird species in the northern temperate zone are nearly all seasonal migrant species that leave their summer (and often breeding) habitat in the fall for wintering areas farther south where they can find open-water habitat. However, some birds (e.g., Canada goose) will opportunistically remain in freezing conditions if there is reliable open water and a source of food available. Timely capture and rehabilitation of oiled birds may help to mitigate the environmental effects of a crude oil release.

During the spring (high flow) season, many migratory birds would be returning to riverine and lacustrine habitats in Minnesota, or migrating through these areas on their way to breeding habitats farther north. With cold water temperatures prevailing, aquatic and semi-aquatic birds contacted by crude oil are likely to die as a result of hypothermia. Waterfowl and other semi-aquatic birds present in the affected river and lake reach would be most affected. Animals upstream, farther downstream, or occupying other nearby habitats, would likely be less affected as it is assumed that emergency response measures to prevent or reduce further possible downstream transport of oil would be in place within 24 hours of the release.

In addition to the habitat offered by the Mississippi Rivers and its riparian habitats, White Oak Lake represent ideal habitat for a variety of aquatic and semi-aquatic bird species, including both breeding and migratory individuals. Therefore, potential for mortality of a large number (i.e., several hundred) of aquatic and semi-aquatic birds would exist, depending upon the precise circumstances and timing (e.g., spring and fall migration periods) of an accidental crude oil release. However, owing to the tremendous regional habitat resources for these birds, large-scale population-level effects are unlikely.

The environmental effects of a crude oil release in the summer-fall period are likely to be of similar or lesser magnitude. With rising water temperatures, mortality of lightly oiled adult birds due to hypothermia becomes less likely than in the spring, and the temporary presence of large numbers of migrating individuals is unlikely. However, in the early summer, environmental effects could include egg mortality due to transfer of oil from the feathers of lightly oiled adult birds in the nest, or mortality of young birds due to direct oil exposure or the loss of a parent bird. Chronic adverse effects on the health of birds that survive their initial exposure to crude oil are also possible as a result of ingesting crude oil residues while preening, or while consuming food items. However, as in the spring, effects are expected to be limited to areas of oil exposure. Potential effects on aquatic and semi-aquatic birds in the fall would be similar to those in spring, although a smaller overall length of river habitat would be affected due to lower river flows. White Oak Lake is not predicted to be materially affected by a crude oil release under summer-fall conditions, and therefore substantial mortality of waterfowl and other semi-aquatic bird species in White Oak Lake is not an expected outcome in these seasons.

Under winter conditions (March), it was assumed that the Mississippi River would be frozen (100% ice cover). In addition, most waterfowl and other semi-aquatic bird species would migrate south in the winter. Therefore, a crude oil release in winter would be expected to have very limited effects on birds.

7.3.6.3.3 Semi-aquatic Mammals

While the semi-aquatic mammal species found in Minnesota include terrestrial species such as moose and raccoon, this assessment focuses particularly upon species that have a primary association with the aquatic environment such as muskrat and beaver (herbivores), American mink (*carnivore-piscivore*), and river otter (*piscivore*). These species are at greater risk of exposure to an oil release in water than terrestrial mammals.

Effects to semi-aquatic mammals are typically described in terms of direct physical effects (e.g., hypothermia due to loss of insulation), direct toxicological effects (e.g., gastro-enteropathy caused by ingestion of crude oil residues while grooming oiled fur or ingesting food), and indirect effects caused by changes to habitat (e.g., land cover and food availability). The spatial extent along the Mississippi River where effects may occur, and the magnitude of effects, is related to the season and river flow rate, and the type of oil released. Effects to semi-aquatic mammals relate more to the amount of time spent in the water and oil-contaminated riparian habitat (and consequent exposure to physical oiling) than to dietary preferences. Timely capture and rehabilitation of oiled mammals may help to mitigate the environmental effects of a crude oil release.

During the spring (high flow) season, with cold water temperatures prevailing, semi-aquatic mammals contacted by crude oil are likely to die as a result of hypothermia. Based on the OILMAP Land simulations, the potentially affected river reach could range from 1.3 to 23 miles in extent, and could include White Oak Lake during the spring, when it is directly connected to the Mississippi River. Animals upstream, farther downstream where there is no exposure, or occupying other nearby habitats, would likely be unaffected. Therefore, although mortality of a considerable number of semi-aquatic mammals could be expected, large-scale (i.e., regional) population level effects are unlikely. Environmental effects of a crude oil release in the summer-fall period are likely to be of a magnitude similar to or lesser than those associated with a release during spring. With rising water temperatures, mortality of lightly oiled semi-aquatic mammals due to hypothermia is less likely than in the spring. Chronic adverse effects on the health of semi-aquatic mammals that survive their initial exposure to crude oil are possible as a result of ingesting crude oil residues while grooming, or while consuming food items. However, as in the spring, effects are expected to be limited to areas of oil exposure.

In the winter months, muskrat and beaver are likely to reduce their activity levels, although American mink and river otter would remain active. Animals that became oiled in the winter would be likely to rapidly die as a result of hypothermia.

7.3.6.4 Human and Socio-Economic Receptors

Crude oils are complex mixtures of hydrocarbon compounds. Light crude oils typically contain more VOCs than heavier crude oils, although diluted bitumen may contain similar amounts of VOCs to light crude oils, depending upon the type and amount of diluent they contain. Air quality in the vicinity of a crude oil release, and along the downstream corridor, would be affected by the release of VOCs (such as benzene, which is often used as an indicator substance) primarily within the first 24 hours of an oil release. For the Mississippi River at Ball Club hypothetical release location, human receptors would likely be present and in proximity to the river in the community of Ball Club. Scattered farms and country homes are located at intervals along the downstream flow path, although much of the area is quite isolated. The communities of Zemple and Deer River are located north of White Oak Lake, and could potentially be exposed to hydrocarbon vapors under certain circumstances, and were identified through the HCA analysis as "other population areas".

Under the spring, high flow condition, the Mississippi River flow is expected to spread into White Oak Lake due to high water levels. Released Bakken crude oil could move out from the main river channel and into this lacustrine habitat. This behavior is identified as a possibility for the Bakken crude oil, but not for the CLB, as the more viscous oil is predicted to be more strongly retained along shorelines closer to the release point. The spreading of the released oil onto the surface of White Oak Lake would provide a large surface area, which would promote the rapid evaporation of volatile hydrocarbon constituents from the light crude oil, with potential effects on human receptors located nearby in Zemple, Minnesota. Released crude oil is not predicted to enter White Oak Lake in the summer-fall seasons, and therefore air quality effects at Zemple would be minimal. In winter, the released crude oil is predicted to remain in the upper section of the river reach, and to be confined beneath ice in the river, so effects on air quality in winter would be negligible.

Typical human health effects associated with short-term (acute) inhalation of volatiles from crude oil include headache, dizziness, nausea, vomiting, cough, respiratory distress, and chest pain. Short-term or repeated skin contact with crude oil may result in dermatitis. The case studies (Section 7.1) do not reveal any instances of human fatality as a result of inhalation of crude oil vapor. Similarly, ATSDR (1995) report that there are no known instances of human fatality as a result of inhalation of vapor from fuel oils, which would be comparable to light crude oils.

The potential for VOC inhalation exposures to the public would be greatest near and downwind from the release site and near White Oak Lake, while the released oil is on the water surface. In the unlikely event of a crude oil release, residents in close proximity would become aware of a strong hydrocarbon odor that would alert them to the presence of a hazard. Most of the volatile hydrocarbons would be lost within the first 24 hours following a release of crude oil. It is also expected that emergency response personnel would contact such residents and advise them to evacuate. Actual or potential exposure to crude oil vapor may result in residents leaving, or being advised to leave their homes for a period of time while the emergency response takes place.

No drinking water HCAs were identified along the path of the release. However, in the event of a crude oil release, people would be notified and testing would be completed to confirm the safety of the water supply. Based upon case studies involving crude oil releases elsewhere, this process could take a few days to two weeks, but reports of crude oil releases affecting private wells are rare, making this an unlikely effect.

Relatively little has been published regarding the long-term effects of human exposure to a crude oil release. Health effects observed in residents and clean-up workers in the months following such releases generally do not persist over the long term (Eykelbosh 2014). The International Agency for Research on Cancer (IARC 1989) has determined there is "limited evidence of carcinogenicity" of crude oil in experimental animals and "inadequate evidence of carcinogenicity" of crude oil in humans. Although toxicological effects from short-term exposure to volatile hydrocarbons are reversible when exposure is reduced, other health effects such as anxiety and depression may occur, and may persist, regardless of whether the individual was physically exposed to hydrocarbons.

Effects of a crude oil release on human receptors would be generally similar for the spring (high flow) and summer-fall (average flow) seasons. In summer, the warmer temperatures and slower river flow velocities in the summer would promote more rapid evaporation of volatile hydrocarbons in a smaller area. The distance of flow depends upon oil type and bank type: based on OILMAP Land simulations (for a 24 hour model run) lighter oils oil are predicted to travel father downstream than heavier oils, with the downstream transport distance being a function of shoreline type and oil retention capacity (Figure 7-14 and Figure 7-15). Under spring (high flow) conditions and assuming a grassy shore, Bakken crude oil was predicted to reach White Oak Lake and to spread over its surface. As a result, a release of the light crude oil could affect a larger number of individuals than a release of the heavy crude oil type.

No overland transport of released crude oil was modelled for this hypothetical release location. Infiltration of crude oil into soil and subsequently into groundwater is assumed to be negligible.

The Mississippi River near Ball Club and White Oak Lake area is shared by the Leech Lake Reservation and Bowstring State Forest. Effects on air and water quality, or the presence of crude oil residues in the sediment, riparian or wetland habitat, could potentially disrupt public use of natural resources (e.g., wild rice harvest, drinking water supplies, hunting, fishing, recreation). Emergency response workers, in cooperation with public health and safety officials, would be active in isolating, containing and recovering released crude oil, as well as notifying the public about the release. Recreational activities would be disrupted following a release of crude oil along the predicted downstream migration route. Fisheries regulators and public health officials typically close fisheries until it is confirmed through monitoring that fish consumption is not a threat to public health. This standard approach is an effective mitigation strategy to protect human receptors for contact with constituents in the oil.

7.3.6.5 Summary and Conclusions

Expected environmental effects to key ecological and human environment receptors after a hypothetical large crude oil release to the Mississippi River near Ball Club, Minnesota have been assessed. The proposed pipeline could carry a variety of crude oil types (ranging from very light [e.g., Bakken crude oil] to heavy [e.g., diluted bitumen such as CLB], and the discussion of expected environmental effects on receptors is based on these crude oil types as bounding conditions. Potential terrestrial receptors, aquatic receptors, semi-aquatic wildlife receptors and human and socio-economic receptors were screened to identify those with the most likely interactions with released oil. The results of this assessment are summarized in Table 7-56.

Table 7-56 Environmental Effects Summary Table for Pipeline Crude Oil Releases to the Mississippi River at Ball Club

Receptor	Expected Environmental Effects of Released Crude Oil to the Mississippi River at Ball Club	Relative Effect	
		Light Crude Oil	Diluted Bitumen
Terrestrial Receptors			
Soils	It is assumed in the model that crude oil would enter directly into the Mississippi River with no holdup of oil on land. In the event of an actual oil release, any oil on land would undergo prompt and effective remediation. Residual effects on plant communities, soil or groundwater quality are unlikely.	SAME	SAME
Groundwater		SAME	SAME
Terrestrial Vegetation		SAME	SAME
Aquatic Receptors			
Rivers (Mississippi River)	Both light and heavy oil would travel downstream from the release location, affecting the Mississippi River. Lighter crude oils are expected to travel farther downstream than heavier crude oils in spring and summer conditions, but would be thinner on the water, and less persistent where they contact shoreline habitat. Both light and heavy crude oils are predicted to travel similar travel distances under winter conditions, although more of the heavy oil would be likely to remain trapped along the edges of the rivers. Light oils have low viscosity relative to heavier oils and turbulence in the river water could potentially disperse the light oil as small droplets in the water column, meaning that potentially toxic fractions of the light oils would more readily dissolve into the water column.	MORE	LESS
Lakes (White Oak Lake)	While light and heavy oil would both travel downstream from the release location in all three flow conditions, only light oil (e.g., Bakken crude oil) was identified as having the potential to enter White Oak Lake, under spring high flow conditions.	MORE	LESS

Table 7-56 Environmental Effects Summary Table for Pipeline Crude Oil Releases to the Mississippi River at Ball Club

Receptor	Expected Environmental Effects of Released Crude Oil to the Mississippi River at Ball Club	Relative Effect	
		Light Crude Oil	Diluted Bitumen
Sediment	Lighter crude oils are predicted to travel farther downstream than heavier crude oils in spring and summer-fall conditions, with both oil types travelling similar distances under winter conditions. Neither the light nor the heavy oil type is likely to reach a density greater than that of the water and sink directly to the sediment within the first few days following release. The low viscosity of the lighter type crude oils could potentially result in a larger amount of oil entrainment as fine droplets as compared to heavier blends, resulting in the formation of OPAs, which could both sink, and enhance biodegradation. Such aggregates may subsequently be preferentially deposited in areas of still or slowly moving water such as sediments near the many oxbows and twists in the Mississippi, as well as slowly moving areas and backwaters in the habitats where the Mississippi connects with White Oak Lake. Contact between crude oil and shorelines is also likely to result in mixing of mineral particles into the crude oil, which could then be deposited to sediments as aggregates of oil and mineral in larger droplets or globules. If not recovered, these aggregates could move downstream with bedload until a stable depositional environment was reached. Low molecular weight aromatic hydrocarbons would be expected to dissolve into the water column of White Oak Lake, where they could adsorb onto suspended sediment and organic matter.	LESS	MORE
Shoreline and Riparian Areas	Both light and heavy oil would travel downstream from the release location. Lighter crude oils are expected to travel farther downstream than heavier crude oils in spring and summer conditions, but would be thinner and less persistent where they contacted shorelines and riparian habitat. Crude oil released under ice during the winter would not contact shoreline or riparian areas, although crude oil that was not recovered could be dispersed over a large area during the spring freshet (and possible enter White Oak Lake). For heavy oil, stranding on shore would be the primary fate. For light oil, stranding would remain the primary fate, but considerably more of the released oil could be lost to evaporation. Flooding of riparian and wetland habitats in spring could lead to stranding of crude oils in these habitats, with heavy crude oil likely to be deposited as patties or tar balls, which would be persistent. This is in contrast to light crude oil which would be deposited as a thin layer or sheen.	LESS	MORE

Table 7-56 Environmental Effects Summary Table for Pipeline Crude Oil Releases to the Mississippi River at Ball Club

Receptor	Expected Environmental Effects of Released Crude Oil to the Mississippi River at Ball Club	Relative Effect	
		Light Crude Oil	Diluted Bitumen
Aquatic Plants	The Mississippi River and White Oak Lake support emergent, floating and submerged aquatic plants. Where they occur, floating aquatic plants would be expected to be killed if contacted by a floating oil slick. Submerged aquatic plants would be less vulnerable. Emergent aquatic plants are generally quite tolerant of moderate exposure to floating oil (such that a portion of the stem was oiled). However, given the extent of predicted oiling in White Oak Lake in spring, death of emergent plants from contact with crude oil, particularly the lighter crude oil type, is also possible.	MORE	LESS
Benthic Invertebrates	Environmental effects on benthic invertebrates would be limited to areas affected by the released oil. In the short-term, the low viscosity of light crude oil would result in greater potential for oil entrainment as fine droplets, as compared to heavier blends. This would enhance dissolution of low molecular weight aliphatic and aromatic hydrocarbons into water (with resulting acute toxicity), in addition to promoting oil-particle interaction and potential deposition of oil to sediment. For heavy crude oil, there would be less potential for dissolution of hydrocarbons into the water, but greater long-term potential for deposition of tar balls and patties as a result of oil interaction with sediment. These could accumulate in depositional areas, resulting in chronic effects on benthic invertebrates.	MORE	LESS
Fish	Environmental effects on fish would be limited to areas affected by the released oil. Light oils have low viscosity relative to heavier oils and turbulence in the river water could potentially disperse the light oil as small droplets in the water column. This would enhance the dissolution of potentially toxic fractions of the light oil into the water column. As a result, the potential for acute toxicity to fish due to narcosis would be greater for the light oil than for heavy oil. Potential chronic effects on fish eggs and embryos (e.g., blue sac disease) could also occur, but would be most likely to occur in spring and early summer, when most species spawn. The potential for phototoxicity, caused by an interaction of ultraviolet light with PAHs accumulated in fish tissues, would be greatest in summer due to high light intensity and long day length.	MORE	LESS

Table 7-56 Environmental Effects Summary Table for Pipeline Crude Oil Releases to the Mississippi River at Ball Club

Receptor	Expected Environmental Effects of Released Crude Oil to the Mississippi River at Ball Club	Relative Effect	
		Light Crude Oil	Diluted Bitumen
Semi-Aquatic Wildlife Receptors			
Amphibians and Reptiles	Environmental effects on amphibians and reptiles would be limited to areas affected by the released oil. Light crude oil is expected to travel farther downstream under spring and summer conditions than heavy crude oil, but would be thinner and less persistent on the water. Crude oil released under ice during the winter would not contact shoreline or riparian areas, although crude oil that was not recovered could be dispersed over a large area during the spring freshet. Flooding of riparian habitat in spring could lead to stranding of crude oils in this habitat. Within these habitats, oiling effects on adults, juveniles, and eggs could potentially be observed. Higher potential would exist for effects on amphibians than for turtles, which appear to be somewhat tolerant of external oiling. Dormancy of amphibians and reptiles in winter and early spring means exposure to oil released at this time of year could be negligible, and adverse environmental effects unlikely.	MORE	LESS
Birds	Mortality of oiled aquatic and semi-aquatic birds would be limited to areas affected by the released oil. Released light crude oil is generally transported farther than heavy crude oil (for the three flow conditions modeled), so environmental effects could be more spatially extensive for light crude oil types. During the spring high flow season, many migratory birds would be returning to riverine and lacustrine habitats in Minnesota, or migrating through these areas on their way to breeding habitats farther north. As such, oiling of birds in White Oak Lake in spring could be the primary outcome of a release of light oil. Few birds are present in winter, so effects would be minimal in that season.	MORE	LESS
Semi-aquatic Mammals	Mortality of oiled semi-aquatic mammals would be limited to areas affected by the released oil. Released light crude oil is generally transported farther than heavy crude oil in all seasons, and spreading of the light crude oil into White Oak Lake is also possible under spring high flow conditions. Therefore, effects to semi-aquatic mammals could be more spatially extensive for light crude oil types. Adverse effects on mink and otter would be particularly severe in winter, due to the effects of oil in the insulating properties of fur, in combination with cold water temperatures. However, muskrat and beaver might be spared due to their lower activity levels in winter.	MORE	LESS

Table 7-56 Environmental Effects Summary Table for Pipeline Crude Oil Releases to the Mississippi River at Ball Club

Receptor	Expected Environmental Effects of Released Crude Oil to the Mississippi River at Ball Club	Relative Effect	
		Light Crude Oil	Diluted Bitumen
Human and Socio-Economic Receptors			
Air Quality	Effects on air quality have the potential to temporarily disrupt human use and occupancy patterns. Light crude oils typically contain more VOCs than heavier crude oils, although the VOC content of diluted bitumen may be similar to that of light crude oil, depending on the type and quantity of diluent used in its manufacture. Air quality in the vicinity of the oil release would be most affected within the first 24 hours of an oil release. Light crude oil is likely to be transported farther downstream within 24 hours than the heavy crude oil, and could also enter White Oak Lake under spring high flow conditions. As a result, environmental effects on air quality are predicted to be more spatially extensive for light crude oil types. Under winter conditions, cold temperatures, ice cover and absorption of crude oil into snow pack would strongly limit emissions of VOCs, in addition to constraining the area of effects.	MORE	LESS
Human Receptors	Typical human health effects associated with short-term inhalation of VOCs from crude oil releases include headache, dizziness, nausea, vomiting, cough, respiratory distress, and chest pain; fatality is unlikely. Residents in close proximity would become aware of a strong hydrocarbon odor that would alert them to the presence of a hazard. Most volatile hydrocarbons would be lost within 24 hours following a release. The communities of Ball Club and Zemple, Minnesota were identified through the HCA analysis as "other population areas". The human receptors most likely to be exposed to VOCs under this hypothetical crude oil release scenario would be located in Ball Club, or in isolated farms and country homes close to the Mississippi River, within about 5 to 10 miles of the release point. Under certain circumstances, the light crude oil could be carried farther downstream, and/or enter into White Oak Lake, resulting in potential exposure of residents of Zemple to VOCs. Under winter conditions, cold temperatures, ice cover and absorption of crude oil into snow pack would strongly limit emissions of VOCs, in addition to constraining the area of effects.	MORE	LESS

Table 7-56 Environmental Effects Summary Table for Pipeline Crude Oil Releases to the Mississippi River at Ball Club

Receptor	Expected Environmental Effects of Released Crude Oil to the Mississippi River at Ball Club	Relative Effect	
		Light Crude Oil	Diluted Bitumen
Public Use of Natural Resources	Emergency response workers, in cooperation with public health and safety officials, would be active in isolating, containing and recovering released crude oil, as well as notifying the public about the release. Light crude oil is predicted to be transported farther downstream than heavy crude oil following a release, affecting a larger area and potentially interrupting public use of natural resources over a larger area. No drinking water HCAs were identified along the path of the release. However, some homes are located along the trajectory of a predicted release and could rely on groundwater as a drinking water source. In the event of a crude oil release, people would be notified and testing would be completed to confirm the safety of the water supply. It is unlikely that a crude oil release to the Mississippi River would result in adverse health effects to consumers of drinking water. Recreational activities would be disrupted following a release of crude oil along the predicted downstream migration route. In the event that the light crude oil was to enter White Oak Lake during the spring high flow season, it could affect the early development of wild rice plants, potentially affecting the productivity and utilization of this resource.	MORE	LESS

7.4 EXPECTED ENVIRONMENTAL EFFECTS OF LARGE RELEASES OF CRUDE OIL AT THE SANDY RIVER CROSSING

The proposed pipeline is expected to cross under the Sandy River approximately 3.4 miles northeast of McGregor, Minnesota and 0.2 miles north of Highway 210. Downstream of the proposed crossing the Sandy River passes through riparian wetlands, agricultural lands and wooded areas, as well as flowing through several lakes before it joins the Mississippi River at the northwest side of Big Sandy Lake. The main river channel at the Sandy River crossing is approximately 15 to 30 ft wide, and shows evidence of having been channelized, presumably for agricultural drainage purposes, within what was formerly a broad meandering floodplain (Chapters 3.0 and 4.0).

As identified in Chapter 4.0, the Sandy River flows through McGregor and Grayling WMAs of the Tamarack Lowlands Subsection. The subsection is a low-lying area of the Northern Minnesota Drift and Lake Plains Section within the greater Laurentian Mixed Forest Province (MN DNR 2016i). The Tamarack Lowlands is characterized by flat and rolling hills and lowland hardwood and coniferous forest cover (MN DNR 2006). The river flows about 1 mile north of populated sections of McGregor, and is about one half mile north of the airport, where it crosses Minnesota Highway 65.

7.4.1 Description of the Freshwater Environment

The Sandy River flows west through several marshy areas for approximately 6.2 miles before passing through two small lakes (Steamboat Lake and Davis Lake). Below these lakes the river turns to the northwest and becomes wider (an average of 53 ft during low flow conditions and 270 ft during high flow conditions). It then passes through Flowage Lake and Sandy River Lake before entering Big Sandy Lake, which supports considerable cottage development. A short distance below the outlet to Big Sandy Lake, the Sandy River merges with the Mississippi River (Smude 2013), which flows southwest, towards Palisade, Minnesota.

The seasonal extent or surface area of Steamboat, Davis, and Flowage lakes varies depending on river flow condition. During low and average river flow conditions, the area of Steamboat Lake is approximately 0.036 square miles, and during high river flow conditions the area is typically 0.065 square miles. During low and average river flow conditions, the area of Davis Lake is approximately 0.07 square miles, and during high river flow conditions the area is typically 0.117 square miles. During low river flow conditions, Sandy River does not join Flowage Lake until approximately 7 miles north of Davis Lake. Under high river flow conditions, the river becomes lake-like after approximately 3.5 miles.

The most common land uses in the Tamarack Lowlands Subsection are forestry, tourism, and outdoor recreation, along with some agriculture and peat mining (MN DNR 2006). Game fish include walleye, lake trout, and northern pike. Less sought-after fish include white sucker and yellow perch (MN DNR 2016j). The Tamarack Lowlands Subsection provides important wintering areas for boreal birds in times of food shortage and is home to a predicted 69 SGCN. These include birds (51 species), fish (3 species), insects (5 species), mammals (4 species), mollusks (2 species), reptiles (4 species) and spiders (1 species) (MN DNR 2006). Of these species, 16 are afforded federal or state endangered, threatened, or of special concern status (MN DNR 2006; MN DNR 2016d). It is foreseeable that some of these SGCN could utilize aquatic habitats along the Sandy River and its associated lakes. The McGregor and Grayling Wildlife WMAs are home also to deer, mink, muskrat, white-breasted nuthatch, hairy woodpecker, sandhill crane, woodcock, sharp-tailed grouse, Canada goose, mallard, swamp sparrow, gray catbird and gray wolf (MN DNR 2006, MN DNR 2016k, MN DNR 2016l).

Several access points downstream from the proposed pipeline crossing location were visited in May, 2016, to provide additional insight into baseline environmental conditions for the Sandy River. Representative site photographs are provided in Figure 7-18 through Figure 7-21. Field observations are summarized in Table 7-57.

Figure 7-18 Sandy River and Riparian Habitat Approximately 4 Miles Downstream of Pipeline Crossing

Figure 7-19 Sandy River and Riparian Habitat Approximately 4 Miles Downstream of Pipeline Crossing

Figure 7-20 Sandy River and Riparian Habitat Approximately 19 Miles Downstream of Pipeline Crossing to the East of Sandy River Lake

Figure 7-21 Sandy River and Riparian Habitat Approximately 28 Miles Downstream of Pipeline Crossing to the North of Big Sandy Lake

Table 7-57 Environmental Characteristics Observed at Selected Access Points on the Sandy River in May 2016

Access Point	Latitude Longitude	Notes
Sandy River at Highway 65, 4 miles downstream of pipeline crossing	46.6291 -93.3174	_Habitat Description:_ this crossing is an excavated ditch with very broad, flat floodplain dominated by wet/sedge meadow and shrub Swamp. Dominant plant species are lake bank sedge and several species of willow (especially pussy willow). Quality of vegetation in the area is generally good to very good. _Wildlife observed:_ mallard, red-wing blackbird, American toad, warbler sp.
Sandy River at boat landing, 8 miles north of McGregor, 19 miles downstream of pipeline crossing	46.7239 -93.3036	_Habitat Description:_ area is a broad flowage of the impounded Sandy River. Water clarity is very good with abundant submerged vegetation. The water edge includes emergent marsh (river bulrush abundant) that transitions into willow shrub swamp and floodplain/terrace forest. Surrounding upland areas are mesic oak forest. Vegetation quality is generally good to very good. _Wildlife observed:_ American toad, mallard, Canada goose, northern oriole, hairy woodpecker.
Sandy River at Big Sandy Lake, 28 miles	46.7884 -93.3188	_Habitat Description:_ at Big Sandy Lake outlet dam. Lake fringe includes relatively narrow band of emergent marsh vegetation

Table 7-57 Environmental Characteristics Observed at Selected Access Points on the Sandy River in May 2016

Access Point	Latitude Longitude	Notes
downstream of pipeline crossing		(cattail-dominated), which then transitions into a narrow band of wet meadow that includes a mix of desirable native species and invasive/nonnatives (phragmites and reed canary grass). Floodplain/terrace forest vegetation occurs along the shoreline that rises quickly from the water. _Wildlife observed:_ beaver, osprey, water boatmen (Family Corixidae; aquatic insect).

7.4.2 High Consequence Area Assessment for the Sandy River, MN

As defined in Section 6.3, HCAs include populated areas, drinking water source areas, ecologically sensitive areas, and commercially navigable waterways. AOIs include Minnesota drinking water management areas, native plant communities, sensitive lake shores, recreational areas, tribal lands, and protected areas of several types (e.g., national forests, military lands, state parks).

Under low flow conditions, floating plumes for both oil types are predicted to end before they reach Steamboat Lake, but could pass McGregor, Minnesota. Bakken crude oil was predicted to flow farther downstream than the CLB under average and high flow conditions, but both oils passed the same number of HCAs during average and high flow seasons (i.e., McGregor, Minnesota and one environmentally sensitive area, Table 7-58).

The Sandy River flows through several protected areas and environmental AOIs. Modeling demonstrated that under low flow conditions, floating oil of both types passed the same AOIs, including the McGregor 8 site of biodiversity significance, Steamboat Lake, and the Grayling Marsh and McGregor WMAs. Under average flow conditions, floating oil was predicted to pass a similar number of AOIs in addition to Davis Lake. Under high flow conditions, Bakken crude oil was predicted to pass the same AOIs and also reach Flowage Lake, which is a sensitive lake shore and wild rice lake, and Big Sandy Lake, which is military land (Table 7-59). The HCAs and AOIs are shown in Figure 7-22.

Table 7-58 HCAs Potentially Affected by a Release of CLB and Bakken Crude Oil at the Sandy River Crossing Location

HCA Type	HCA Subtype	Description / Locations
Population Area	Other	McGregor, MN
Environmentally Sensitive Area	N/A	N/A

Table 7-58 HCAs Potentially Affected by a Release of CLB and Bakken Crude Oil at the Sandy River Crossing Location

HCA Type	HCA Subtype	Description / Locations
NOTE: Data for the HCA analysis were obtained from the USDOT PHMSA HCA datasets plus additional HCAs compiled by Enbridge during 2010 and 2013.		

Table 7-59 AOIs Potentially Affected by a Release of CLB and Bakken Crude Oil at the Sandy River Crossing Location

AOI Type	AOI Subtype	Description / Locations
Environmental	Sensitive Lake Shore	Flowage Lake
	Site of Biodiversity Significance	McGregor 8
	Wild Rice Lake	Steamboat Lake, Davis Lake, Flowage Lake
Protected Area	Lake of Biological Significance	Flowage Lake
	Military Land	Big Sandy Lake
	Wildlife Management Area	Grayling Marsh WMA, McGregor WMA
NOTE: Data for the AOI analysis were derived from multiple datasets provided on the Minnesota Geospatial Commons website, USGS Protected Areas Database of the United States and the Minnesota Department of Transportation.		

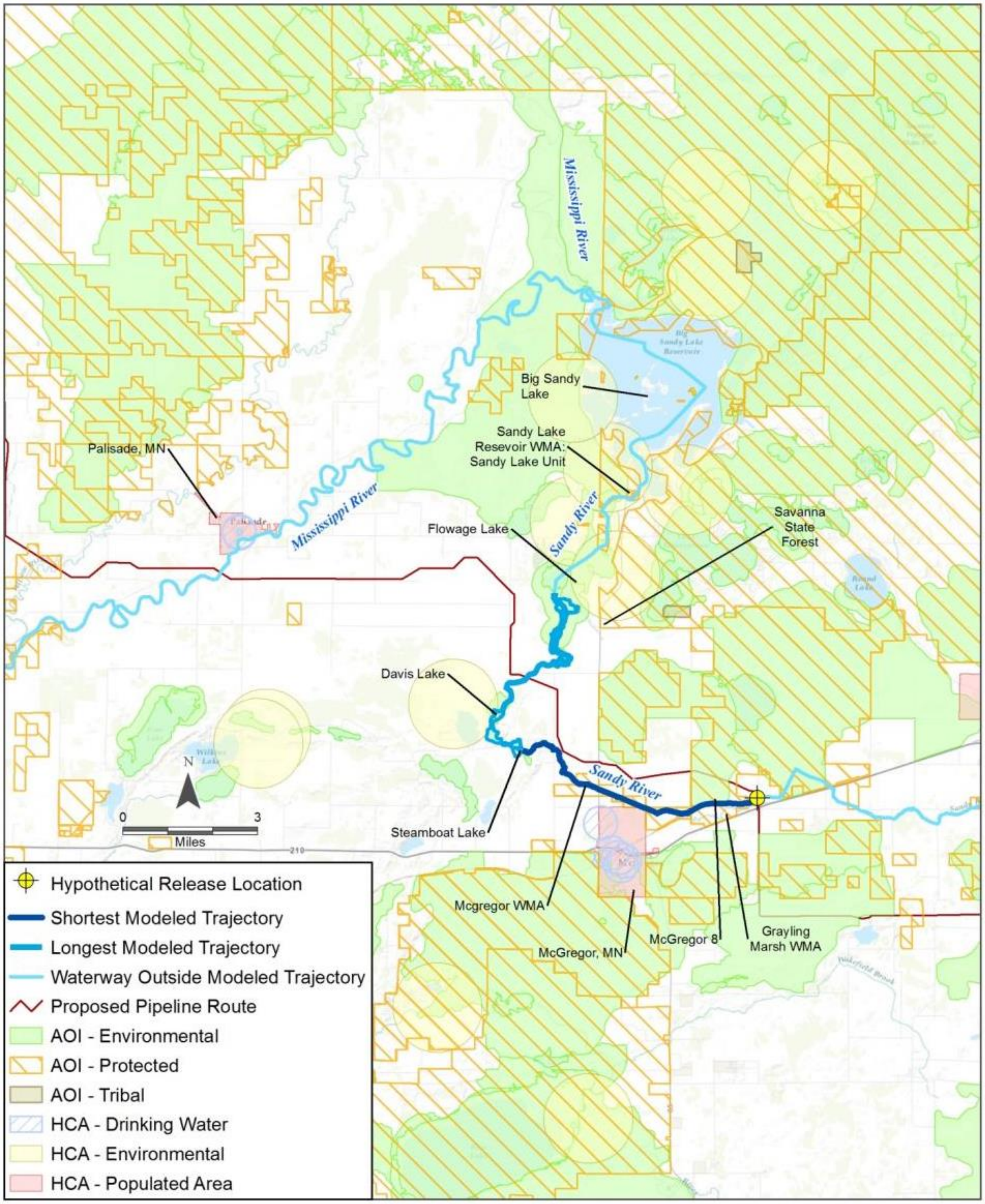

Figure 7-22 HCAs and AOIs Potentially Affected by a Crude Oil Release at the Sandy River Crossing Location

7.4.3 Selection of Key Ecological and Human Environment Receptors for Sandy River

Taking into account environmental characteristics of the Sandy River, the potential interactions of released crude oil with key ecological and human environment receptors were screened to identify key receptors for the subsequent environmental effects analysis. The rationale and results of this screening step are provided in Table 7-60.

Table 7-60 Key Ecological and Human Environment Receptors for the Sandy River

Receptor	Relevance for Inclusion as an Environmental Receptor for the Sandy River Scenario	Selected (Y/N)
Terrestrial Receptors		
Soils	Low. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Sandy River with no holdup of oil on land. Any oil that reaches soil would be physically remediated to established standards.	N
Groundwater	Low. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Sandy River with no holdup of oil on land. In the event of an actual oil release, effects on groundwater quality would be localized and/or negligible.	N
Terrestrial Vegetation	Low. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Sandy River with no holdup of oil on land. Any oil that reaches soil would be physically remediated and vegetative cover would be restored as part of the cleanup process.	N
Aquatic Receptors		
Rivers (Sandy River)	High. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Sandy River with subsequent physical transport downriver of floating oil.	Y
Lakes (Steamboat, Davis, Flowage lakes)	High. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Sandy River with subsequent physical transport into Steamboat Lake, Davis Lake and Flowage Lake.	Y
Sediment	High. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Sandy River upstream of Steamboat, Davis and Flowage lakes with subsequent physical transport downriver. This allows potential interaction and/or deposition of crude oil residues to sediments.	Y
Shoreline and Riparian Areas	High. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Sandy River upstream of Steamboat, Davis and Flowage lakes with subsequent physical transport downriver. This allows potential interaction with shoreline and riparian habitat.	Y

Table 7-60 Key Ecological and Human Environment Receptors for the Sandy River

Receptor	Relevance for Inclusion as an Environmental Receptor for the Sandy River Scenario	Selected (Y/N)
Wetlands	High. An assumption made in the fate modeling for this scenario is that released oil would enter directly into Sandy River upstream of Steamboat, Davis and Flowage lakes with subsequent physical transport downriver and potential interaction with wetlands along the river and lakes.	Y
Aquatic Plants	High. An assumption made in the fate modeling for this scenario is that released oil would enter directly into the Sandy River upstream of Steamboat, Davis and Flowage lakes with subsequent physical transport downriver and potential interaction with plants. Aquatic plants are present in Sandy River and associated lakes, and riparian and wetland habitats.	Y
Benthic Invertebrates	High. The Sandy River and Steamboat, Davis and Flowage lakes support benthic invertebrate communities.	Y
Fish	High. The Sandy River and Steamboat, Davis and Flowage lakes support fish communities.	Y
Semi-Aquatic Wildlife Receptors		
Amphibians and Reptiles	High. The Sandy River and lake systems downstream of the release location support aquatic and semi-aquatic amphibians and reptiles.	Y
Birds	High. The Sandy River and lake systems downstream of the release location support a diverse bird community.	Y
Semi-aquatic Mammals	High. The Sandy River and lake systems downstream of the release location support semi-aquatic mammals.	Y
Human and Socio-Economic Receptors		
Air Quality	High. The community of McGregor, Minnesota is approximately 3.3 miles northeast the hypothetical release location. The Sandy River, Steamboat Lake and Davis Lake are also bordered by homes and used for recreational activities (e.g., hunting, fishing, boating, canoeing). Effects on air quality have the potential to temporarily disrupt human use and occupancy patterns.	Y
Human Receptors	High. The Sandy River, Steamboat Lake and Davis Lake are sporadically bordered by homes and used for many recreational activities (e.g., hunting, fishing, boating, canoeing). Effects on air quality or the presence of crude oil residues in river water and riparian habitat have the potential to temporarily affect human health.	Y
Public Use of Natural Resources	High. The Sandy River, Steamboat Lake and Davis Lake are sporadically bordered by homes and used for many recreational activities (e.g., hunting, fishing, boating, canoeing). Effects on air quality, water quality, or the presence of crude oil residues in rivers, lakes and riparian habitat could potentially disrupt public use of natural resources (e.g., drinking water supplies).	Y

7.4.4 Modeled Conditions at the Release Location

A description of key modeling assumptions for the environmental effects analysis for the Sandy River scenario is provided in this section. The OILMAP Land software was used by RPS ASA to simulate hypothetical releases of CLB and Bakken crude oils into the Sandy River (Chapter 4.0) for a 24 hour period. The maximum simulation duration using OILMAP Land was 24 hours, as it was assumed that emergency response measures to prevent farther downstream transport of released oil would be in place within that length of time. Symbols on the drawings indicate the predicted trajectory during river seasonal flow condition (high corresponding to spring freshet, average corresponding to summer-fall conditions, and low corresponding to winter flow under ice).

The two crude oil types provide bounding cases for oils that range from light (e.g., Bakken crude oil having low viscosity and density) to heavy (CLB/CLWB, heavy diluted bitumen crude oil types having higher viscosity and density). Seasonal variations in river flow velocity, temperature, wind speed, and snow and ice cover were all considered at the release location. A summary of key variables is provided in Table 7-61.

Table 7-61 Environmental and Hydrodynamic Conditions for the Three Modeled Periods at the Sandy River Crossing

Season	Month	Air Temperature (°C)	Wind Speed (m/s)	Average River Velocity (m/s)
Low Flow (Winter)	March	-3.07	4.21	0.13
Average Flow (Summer/fall)	July	19.96	3.50	0.24
High Flow (Spring)	April	5.00	4.73	0.35
NOTE: A velocity of 1 m/s is equivalent to 2.25 miles per hour.				

The highest flow velocity of the Sandy River coincides with the spring freshet (i.e., April), a result of rising temperatures and snowmelt. Average flow would typically occur in summer and fall seasons. July, the month with the warmest temperature was selected to represent the maximum amount of evaporation. The lowest flow rate occurs in winter (i.e., January-March), and was typified by freezing conditions and probable ice cover on water.

The crude oil release volume was calculated as a full bore rupture, with a maximum time to response in the pipeline Control Center of 10 minutes, followed by a 3-minute period to allow for valve closure. The release volume therefore represents the volume of oil actively discharged in the period of time required to detect and respond to the event (taking into consideration the pipeline diameter, pipeline shutdown time, pipeline design flow velocity), followed by the volume of oil lost due to drain-down of the elevated segments of pipeline. The maximum 13-minute response time to valve closure is an Enbridge standard for safe operations and leak