4.13 POTENTIAL RELEASES

4.13.1 Introduction

This section describes potential releases associated with the construction and operation of the proposed Project and connected actions and discusses mitigation measures that would avoid or minimize the frequency of releases and the severity of the potential impacts. The information, data, methods, and/or analyses used in this discussion are based on information provided in the 2011 Final Environmental Impact Statement (Final EIS), as well as new circumstances or information relevant to environmental concerns that have become available since the publication of the Final EIS, including the proposed reroute in Nebraska. The information that is provided here builds on the information provided in the Final EIS, as well as the 2013 Draft Supplemental EIS and, in many instances, replicates that information with relatively minor changes and updates; other information is entirely new or substantially altered.

Specifically, the following information, data, methods, and/or analyses have been substantially updated from the 2011 Final EIS:

- Updated Pipeline Hazardous Material Safety Administration (PHMSA) data up to July 2012 were reviewed.
- Incident[1] rate estimates from PHMSA were expanded in detail to include linear and discrete pipeline elements.
- Spill volume distributions for both linear and discrete pipeline elements were expanded, and spill volume trends were summarized as derived from PHMSA incident data.
- The spill occurrence interval for stream crossings was revised.
- Spill transport modeling was completed for various spill volumes based on spill size distribution categories derived from PHMSA data to identify potential plume sizes, including surface plumes and groundwater impact.
- Sensitivity analysis on spill transport modeling results was completed.
- Potential spill impacts to various resources were estimated such as soils, vegetation, wildlife, wetlands, water wells, and cultural resources.
- Lessons learned from recent pipeline spills, such as the spill impacting the Kalamazoo River in Michigan, were added.
- Section 4.13.6, Additional Mitigation, provides a list of additional mitigation measures to further reduce impacts from potential releases.

The following information, data, methods, and/or analyses have been substantially updated from the 2013 Draft Supplemental EIS:

- PHMSA data were compared to other pipeline incident datasets to identify the variability in incidents related to transporting dilbit and heavy crude oil.

[1] The terms *incident* and *accident* can be used interchangeably or with specified definitions in various agency reports and databases. For the purposes of this report, the term *incident* has been selected for document consistency.

- Added new information on diluted bitumen corrosivity from the National Academy of Sciences.
- Further explanation was provided on how the PHMSA Special Conditions would work to reduce the threat of a release and the benefits that would be created when the conditions are implemented.
- Pipeline leak detection standards publications were identified.
- Updated PHMSA incident data from July 2012 to July 2013 were reviewed.
- Sensitivity analysis was conducted to evaluate assumptions used to calculate incident frequencies for mainline pipe and pump stations.
- Incident rate for reported pipeline injury, fatality, fire, and explosion incidents was added.
- Incident analysis for pipelines 10 years old or less was added.
- Potential incident occurrence (year/incident) for pipeline specifications similar to the proposed Project was conducted and added.
- An incident rate analysis from PHMSA data for first year pipeline releases has been added.
- Additional text on the characteristics of sinking oil was added.
- Remediation detail of sinking oil and the inclusion Kalamazoo dredging was expanded.
- Independent engineering and environmental consequences reports were included.
- An independent risk assessment report was included.
- First-year incident spill response events for the Keystone pipeline were added.
- Lessons learned were updated based on recent pipeline incidents, bulletins, and reports.
- In response to public and agency comments, text has been revised throughout the section where necessary.
- The list of additional mitigation measures included in Section 4.13.6 was revised.

Summary

As discussed in Section 3.13, Potential Releases, several threats could lead to a potential release of pipeline contents during construction and operation of the proposed Project. An analysis of historic incidents, based on the PHMSA database, shows the following:

- Spill volumes from larger-diameter pipelines tend to be larger than those from smaller-diameter pipelines.
- The primary release causes for pipeline components are equipment failure (valves, etc.) and incorrect operations (tanks).
- The primary release causes for the pipeline, not including components, are outside forces and corrosion.

- For all crude oil pipelines, the majority of spills (96 percent) are in the small (up to 50 barrels [bbl]) to medium (50 to 1,000 bbl) size.
- A general spill frequency can statistically be estimated for the mainline pipe.

An independent analysis conducted by Battelle on the effect of applying the PHMSA Special Conditions indicates they could result in a sizable reduction in spill frequency (Leis et al. 2013).

There is potential for product spills during normal operations to affect natural resources, protected areas, human uses, and services. Although leak detection depends on a number of factors, modern pipeline systems are designed to automatically detect leaks. The amount and type of environmental resources that a spill could affect vary depending on the following:

- Cause
- Size
- Type
- Location
- Season
- Geomorphology (the changing terrain)
- Timing and degree of response actions

Spill size is also affected by the following:

- Size of the hole;
- Pipeline pressure;
- Time it takes to detect the leak;
- Time it takes to shut down the pipeline and isolate the leak after detection;
- Pipeline diameter;
- Pipeline elevation change between the valves and the leak location;
- Distance between isolation valves; and
- Effectiveness of the isolation.

The historical pipeline incident analysis (see Appendix K) shows that the majority of spills would likely be in the small to medium range and would occur on construction sites or at operations and maintenance facilities. Once identified, spill response would typically be rapid. For medium (50 to 1,000 bbl) to large (greater than 1,000 bbl) spills, spill size and impact are more sensitive to response time.

Spill modeling (see Appendix T, Screening Level Oil Spill Modeling) indicated that a spill could reach groundwater and move downgradient (essentially, *downhill* underground and on land) for a spill of any size. If a spill were to occur along the buried pipeline, contents could leak into nearby soil and move both vertically and horizontally. If it were to reach groundwater, it could potentially pool and create a dissolved area of chemicals in the groundwater. If an operating well were close enough to use the source of the affected groundwater, humans or animals could be exposed to dissolved chemicals. If the leak were to reach the surface and move horizontally along the ground, it could affect local vegetation, animal life, and surface water such as streams and rivers. Once oil were released into the environment, however, natural processes—including evaporation, degradation (i.e., where bacteria consume the oil), and dilution (the product mixes with water)—would begin to break it down immediately.

If a spill were to occur, the degree of impact to water, people, livestock, soil, and other natural resources would depend on the distance from the spill source. This could be affected by the local environmental conditions present in the area surrounding the leak (e.g., if a leak were to occur at the top of a hill it could flow over a greater distance and affect more resources). Maximum buffer zones (i.e., the estimated maximum distance that oil from a spill would be expected to travel) were calculated for surface waterbodies (10 miles), stream crossings (500 feet [ft]), and surface water drinking water resources (5 miles) (see Appendix P, Risk Assessment). As mentioned in Section 4.13.4.2, Spill Propagation, there are many factors that would generally limit the spreading of most spills over much smaller distances. In addition, maximum distances were calculated using the three different spill sizes (i.e., small, medium, and large) with the finding that oil could spread radially on a flat surface between 112 and 1,214 ft from the pipeline, and that if oil were to reach groundwater, it could spread radially between 640 and 1,050 ft away from the spill point (see Appendix T, Screening Level Oil Spill Modeling). These distances were calculated using a screening model and were based on a spill volume that pooled and spread radially away from the center. The distances were also supported by independent work done by E^xponent (E^xponent 2013).

Other potential spill propagation scenarios (e.g., ground surface to surface water, channeling, etc.) are discussed in Section 4.13.4.2, Spill Propagation. Small spills have the potential to affect groundwater encountered at depths up to 50 ft below ground surface (bgs). It is possible that, under some spill conditions, a small spill could reach groundwater encountered at depths below 50 ft, but it is unlikely. Medium and large size spills could reach groundwater encountered at depths below 50 ft.

The PHMSA Special Conditions were developed to design the pipeline above current minimum safety requirements. Applying the Special Conditions could have a sizable reduction in spill frequency (Leis et al. 2013), as well as the extent of impact if a spill were to occur. If a spill were to occur during construction activities, Keystone has prepared written procedures (i.e., Construction, Management, and Reclamation Plan; Spill Prevention, Control, and Countermeasure [SPCC] Plan) to address a response action. In summary, the response plans include notification procedures, response actions, response teams, and spill impact considerations. Keystone would work with federal, state, and local agencies to clean up any spill that occurred.

Connected actions include the Bakken Marketlink Project, the Big Bend to Witten 230-kilovolt (kV) Transmission Line, and electrical distribution lines and substations. A spill from the Bakken Marketlink Project could potentially impact similar receptors as with the proposed Project.

The scope of this assessment as it relates to pipeline risk and the potential for releases from proposed Project construction and operation within areas that would be crossed by the proposed pipeline route and connected actions is described below.

4.13.2 Proposed Project Background

The proposed Project would include processes, procedures, and systems to prevent, detect, and mitigate potential oil spills that could occur during operation of the pipeline. These are summarized in the subsections below. An Emergency Response Plan (ERP) would contain further detail on response procedures and would be completed and reviewed by PHMSA prior to granting permission to operate the proposed pipeline. PHMSA would also provide the ERP to the U.S. Environmental Protection Agency (USEPA) for their review.

To assess the likelihood of operational releases from the proposed Project, spill risk assessments were conducted as described below. These risk assessments address both the potential frequency of operational pipeline releases and the potential volumes of crude oil associated with the releases. The magnitude of a potential oil spill impact is primarily a function of spill size, oil type, and sensitivity of the receptors affected (American Petroleum Institute [API] 1992, 1997; National Research Council 1985, 2003a, 2003b). Variations in spill size and receptor type are key variables for estimating the magnitude of potential environmental impacts of oil spills from the proposed Project.

Spills ranging in magnitude from small (less than 50 bbl) to large (greater than 1,000 bbl) could occur anywhere along the pipeline system, including construction sites, operations and maintenance facilities, and within the pipeline right-of-way (ROW). Rapid containment and cleanup would be expected to reduce surface oil spreading and its potential infiltration into the ground. For all spills, especially those that reached water resources, the response time between initiation of the spill event and arrival of the response contractors would influence the potential magnitude of impacts to environmental resources. Once the responders were at the spill scene, the efficiency, effectiveness, and environmental sensitivity of the response actions (e.g., containment and cleanup of oil, protection of resources from further oiling[2]) would substantively influence the type and magnitude of potential additional environmental impacts.

The combined implementation of industry integrity management standards and practices aid in reducing the potential for spill incidents associated with the proposed Project; these include those developed by the National Association of Corrosion Engineers International and American Society of Mechanical Engineers, PHMSA regulatory requirements as defined in Title 49 of the Code of Federal Regulations (CFR) Part 195, and the set of proposed Project-specific Special Conditions developed by PHMSA and agreed to by TransCanada Keystone Pipeline, LP (Keystone). As stated in the Final EIS, the U.S. Department of State (the Department), in consultation with PHMSA, has determined that incorporation of those conditions (the below referenced industry standards and practices, combined with PHMSA regulatory requirements and the set of proposed Project-specific Special Conditions developed by PHMSA) would result in a Project that would have a degree of safety over any other typically constructed domestic oil pipeline system under current code and a degree of safety along the entire length of the pipeline system similar to that required in High Consequence Areas (HCAs), as defined in 49 CFR 195.450. Appendix B, Potential Releases and Pipeline Safety, and Section 4.13.6.1, PHMSA Special Conditions, describe each of the Special Conditions.

[2] Covering with oil.

The Keystone XL pipeline has a lower probability of experiencing a spill due to the combined application of the design standards and the addition of the Special Conditions, which add a greater degree of safety over the pipeline systems with reported spill events in the PHMSA incident database. Keystone is taking preventive actions over and above the current regulatory requirements by designing the entire pipeline to a level of protection similar to that required for an HCA (Leis et al. 2013). Federal, state, and local agencies would participate in response activities consistent with their authorities and duties under applicable regulations and in accordance with the requirements of the ERP. Additional mitigation measures have been suggested by these regulatory agencies and are described in Section 4.13.6, Additional Mitigation.

For the discussion on spills[3], the terms *release*, *leak*, and *spill* are used as follows:

- A *release* is a loss of integrity (failure to contain oil as designed) of a pipeline or its components;
- A *leak* is a release over time; and
- A *spill* is the liquid that escapes a designed containment system, if present, and enters the environment.

The total volume of a spill is a combination of the following:

- Size of breach;
- Pipeline pressure;
- Time to detect leak;
- Time to shut down pipeline and isolate the leak after detection;
- Pipeline diameter;
- Elevation profile;
- Distance between isolation valves; and
- Effectiveness of the isolation.

The hole size and pipeline pressure are the primary factors that determine the leak rate from the breach until the leak is detected and isolated. After the leak has been detected and isolated, the volume of liquid in the pipeline between the isolation valves (i.e., valves that stop the flow of pipeline contents) could continue to leak from the pipeline until the hole is repaired. The total volume released is dependent on a number of factors such as hole size, pipeline pressure, pipeline elevation, and the distance between isolation valves.

Keystone would commence shutdown in the following instances:

- On indication of multiple hydraulic or leak triggers including leak alarm, pressure indication, hydraulic signature of flow and pressure, and pump station trip;
- On notification from a third party or employee call-in identifying a release;

[3] It applies to the entire pipeline system.

- On confirmation that a single Supervisory Control and Data Acquisition (SCADA) indication or leak alarm has indicated an actual release; or
- No later than 10 minutes after the initial annunciation to the controller if a single SCADA indication or leak alarm cannot be explained.

No investigation is required before a controller initiates a shutdown of the pipeline of any kind. If the pipeline is shut down for a suspected release, Keystone's procedure requires a technician investigate and, if found to be a false alarm, to have field and Oil Control Center management approval prior to restart of the pipeline. Leak detection depends on a number of factors. In modern pipeline systems, SCADA sensors are designed to automatically detect leaks large enough to produce noticeable changes in pipeline pressure and flow rates. The sensors have a monitoring threshold because pipeline operating variables normally fluctuate within a working range. The SCADA system, in conjunction with Computational Pipeline Monitoring or model-based leak detection systems, would detect leaks to a level of approximately 1.5 to 2 percent of the pipeline flow rate. This range is consistent with the current technical standard range of 1 to 2 percent. Computer-based, non-real time, accumulated gain/loss volume trending would be used to assist in identifying low rate or seepage releases below the 1.5 percent to 2 percent by volume detection thresholds. Smaller leaks may also be identified by direct observations by Keystone or the public. Keystone has stated it could detect a leak above the 1.5 to 2 percent volume threshold within 102 minutes. If pressure, flow, and temperature sensors, in combination with software, detected a deviation exceeding a threshold, an alarm would sound and the control room would enter a 10-minute evaluation window. If the evaluation is indeterminate at the end of the window or a potential leak is confirmed, the control room would shut down the pipeline. During this detection, investigation, and subsequent shutdown time, oil could leak from the pipeline and create a spill. Oil could also spill during a smaller leak that is under the SCADA detection threshold. Keystone has indicated that it will begin validating and utilizing in-line inspection leak detection devices in its hazardous liquid pipelines in 2014 that have the potential to detect leaks below the 1.5 to 2 percent threshold.

Once the leak is detected and confirmed, the operator shuts down operating pumping units, which eliminates the force that would maintain pressure on the pipeline. Isolation valves are also closed as part of shutdown. If a valve malfunctions and does not close properly, outflow could continue after shutdown, either at a reduced or unabated rate. The volume that escapes through ineffective valves would add to the spill. The volume contained in the mainline pipe between the isolation valves may also contribute to the spill. The proportion of the volume that actually leaks into the surrounding environment would vary depending on characteristics such as the topographic location of the spill along that route.

Recognizing the importance of leak detection, PHMSA has included leak detection provisions and considerations in several sections of 49 CFR Parts 192 and 195. In addition to regulations, PHMSA also issues Advisory Bulletins to advise and remind hazardous liquid pipeline operators of the importance of prompt and effective leak detection. In December 2012, PHMSA issued their Leak Detection Study (PHMSA 2012c) that describes the current understanding of pipeline leak detection in the United States. The report does not provide any conclusions or recommendations, only data.

Currently, various standards exist that address the issue of leak detection in liquids pipelines. Some of these standards include:

- API 1130 (*Computational Pipeline Monitoring for Liquids*);
- API 1149 (*Pipeline Variable Uncertainties and Their Effects on Leak Detectability*);
- API 1161 (*Guidance Document for the Qualification of Liquid Pipeline Personnel*);
- API 1164 (*Pipeline SCADA Security*);
- API 1165 (*Recommended Practice for Pipeline SCADA Displays*);
- CSA Z662 Annex E (*Recommended practice for liquid hydrocarbon pipeline system leak detection*) (Canada); and
- TRFL (*Technical Rule for Pipeline Systems*).

Monitoring wells have been used to assist with leak detection at petroleum industry facilities such as tanks, and could be a consideration for the proposed pipeline. Locations for such wells take into account the probability of successful detection and the sensitive resource being protected. Keystone has committed to additional analysis as part of its risk assessment to determine if any specific area along the pipeline would benefit from the placement of monitoring wells, and would install them if appropriate. This analysis would include assessing the efficacy of monitoring wells compared to other methods of leak detection that could detect leaks below the threshold (1-2 percent) of the current leak detection method. Keystone has indicated that it will begin validating and utilizing in-line inspection leak detection devices in its hazardous liquid pipelines in 2014 that have the potential to detect leaks below the 1.5 to 2 percent threshold.

4.13.3 Historical Pipeline Incidents Analysis

Analysis of historical pipeline incident data was conducted to understand what has occurred with respect to pipelines in the United States and Canada, and to provide input for spill impact analysis in this Final Supplemental EIS. Details in the PHMSA incident and mileage reports were analyzed to determine the distribution of historical spill volumes, as well as incident causes and frequencies of crude oil pipeline incidents contained in the PHMSA database. Although the results were not a direct indicator of the nature of possible incidents that could occur in association with the proposed Project, they could be used to provide insight into what could potentially occur with respect to spill volume, incident cause, and incident frequency.

4.13.3.1 Background

PHMSA collects data on hazardous liquid pipeline systems operating in the United States. These data could be used to provide insight into spill volume, incident cause, and incident frequency. Although other information sources were reviewed (see Section 4.13.3.4, Pipeline Incident Information Sources), PHMSA information was the most relevant for this Final Supplemental EIS and the only database that contained raw data.[4]

PHMSA collects information that is available to the general public on reportable pipeline incidents. Information collected for each incident includes the following:

[4] Raw data are data that have not been processed; they must be analyzed and/or manipulated for any meaningful information or conclusions to be drawn from them.

- The date of each reportable incident;
- The type of hazardous liquid associated with the pipeline involved in the incident;
- The volume of hazardous liquid spilled in the incident;
- The part of the pipeline system from which the spill originated;
- The diameter of the hazardous liquid pipeline involved in the incident; and
- The cause of the incident.

The total mileage of pipelines in operation in the United States is collected for each of the following:

- The type of hazardous liquid transported; and
- The diameter of the pipeline.

In addition, for each individual pipeline system in operation in the United States, the number of breakout tanks[5] in use is also collected. As defined for this discussion, linear elements refer to mainline pipe and girth welds, and discrete elements are pipeline components such as pumping stations, mainline valves, and breakout tanks.

4.13.3.2 Objectives

The objective of this pipeline incident analysis was to use PHMSA hazardous liquid pipeline incident data and hazardous liquid pipeline annual (mileage) data to determine the historical spill volumes, incident causes, and incident frequencies of crude oil pipeline spills in the United States. Additionally, this analysis provides separate determinations for mainline pipe and pipeline system discrete components.

4.13.3.3 Method

The method used for this analysis was to filter the PHMSA hazardous liquid incident database covering a fixed period of time by commodity type to obtain a subset of data specific to crude oil pipeline systems. Subsequent filtering of pipeline system component, pipeline diameter, and incident cause resulted in separate subsets of incident counts and associated reported spill volumes for pipeline mainline pipe, mainline valves, pipeline system tanks, and other discrete pipeline components. The historical spill size distributions and incident cause distributions could then be summarized for the time period covered.

By filtering the pipeline mileage data by type and pipeline diameter, an estimate of the total mileage of pipeline in service over the same fixed time period was made. Dividing the number of incidents by the number of mile-years of pipeline in service provides the frequency of historical incidents per mile-year of pipeline (incidents per mile-year is a standard measure for pipeline incidents; it represents the number of incidents for every 1,000 miles of pipeline over a duration of 1 year). Dividing the pipeline tank incidents by the number of tanks in service over the time period provides the frequency of historical tank incidents per tank-year (i.e., per tank per year).

[5] Breakout tanks are those used to a) relieve pressure surges in a hazardous liquid pipeline system or b) temporarily receive and store hazardous liquid transported by a pipeline for continued transportation by pipeline.

Finally, by estimating the average spacing of mainline valves and pumping stations on pipeline systems in service, the number of mainline valves and pumping stations in service could be approximated. Dividing the number of mainline valve incidents with the approximate number of mainline valves in service results in an approximate frequency of incidents per valve-year. Similarly, dividing the number of pipeline discrete incidents by the approximate number of pumping stations in service results in an approximate frequency of incidents per pumping station-year.

The number of incidents resulting from each filtering set is documented to provide a reference for error checking while performing the analysis.

4.13.3.4 Pipeline Incident Information Sources

Incidents that result in unintentional releases from hazardous liquid pipelines are reported by federal and some state and regional agencies.

National Data Sources

Pipeline and Hazardous Material Safety Administration

PHMSA is part of the U.S. Department of Transportation (USDOT). PHMSA is responsible for protecting the American public and the environment by ensuring safe and secure movement of hazardous materials to industry and consumers by all transportation modes, including the nation’s pipelines. It is responsible for regulations that require safe operations of hazardous liquid pipelines to protect human health and the environment from unplanned pipeline incidents. Through PHMSA, USDOT develops and enforces regulations for the safe, reliable, and environmentally sound operation of the nation’s 2.3-million-mile pipeline transportation system and the nearly 1 million daily shipments of hazardous materials by land, sea, and air. PHMSA administers the national regulatory program to ensure the safe transportation of hazardous liquids, including crude oil, by pipeline. PHMSA develops regulations that address safety in the design, construction, testing, operation, maintenance, and emergency response for hazardous liquid pipelines and related facilities. Many of the regulations are written as performance standards that set the level of safety to be attained and allow the pipeline operators to use various technologies to achieve the required level of safety.

Among its functions, PHMSA prepares incident and mileage reports. PHMSA incident report files and their originating data are available to the general public. The incident data used to create the pipeline incidents and mileage reports are available online (PHMSA 2012a). Reported incidents are available at the PHMSA Freedom of Information Act online library, which spans more than two decades. For the historical data review and historical frequency analysis sections of this report, significant incidents as described below in the PHMSA dataset were studied.

PHMSA distinguishes a serious incident as one that involves a fatality or injury requiring in-patient hospitalization. PHMSA designates significant incidents to include serious incidents as well as any one of the following:

- $50,000 or more in total costs, measured in 1984 dollars;
- Highly volatile liquid releases of 5 bbl or more or other liquid releases of 50 bbl or more; or
- Liquid releases resulting from an unintentional fire or explosion.

The pipeline incident data have been recorded with different reporting criteria in the past decades since the 1980s. Therefore, previous databases had different structures at different times. For this report, two PHMSA databases were used: one with data spanning from January 2002 to December 2009, and the other with data spanning from January 2010 to July 2012 (PHMSA 2012a). Basic database fields are present in both regarding incident information, such as incident number, incident date, commodity type, part of system involved, reported spill volume, reported incident cause, and others incident information.

Mileage reports, termed *Liquid Annuals Data*, summarize pertinent information on a yearly basis, including commodity type, pipeline diameter, year of installation or fabrication, mileage, and other pipeline features. These reports summarize the total population of pipelines in which the relevant incidents occurred.

The information requirements for incident reporting to PHMSA have increased over the years. The January 2010 to July 2012 dataset contains more fields with regard to loss estimation and root causes, which results in a more detailed characterization of spills compared to the 2002 to 2010 dataset. Not all 2002 to 2012 incident records are complete. Several important fields—such as incident cause, system part, item involved, and pipeline diameter—are often blank or null, ambiguous (indicated as *unknown* or *miscellaneous*), or incorrectly attributed, leaving the characterization of certain incidents undetermined or open to subjective interpretation. These null or ambiguous entries are more common in the older (pre-2010) datasets, given they contain 8 years of less detailed data versus 2 years of more detailed data in the 2010 to 2012 dataset, and thus bias the data toward less detail.

The reporting requirements also mean that a number of small spill incidents (less than 50 bbl for crude oil) are not represented. This could bias the historical data to result in lower spill frequency and larger spill sizes than what actually has occurred. The combined PHMSA incident data and mileage data do not contain sufficient information on the type of crude oil involved. The incidents are recorded as *crude oil* only. Thus, historic frequencies specific to dilbit or heavy crude oil cannot be determined using the PHMSA data alone.

Finally, the protective measures used in each pipeline are not detailed in the mileage data. This means that the effects of individual protective measures can also not be determined using the PHMSA data alone.

National Response Center

The National Response Center (NRC) is the primary point of contact in the federal government for reporting oil and chemical spills in the United States. A person may report a spill by contacting the NRC via a toll-free number or by filling out a reporting form at the NRC website (NRC 2012). The NRC operates 24 hours a day, 7 days a week, 365 days a year.

The NRC maintains a database of spill incident responses where basic information of a significant spill provided by the pipeline operator's response team is logged. The report usually contains a brief incident description, location, information about released material, early estimations of released amounts, damages, and details of notifications to government agencies. NRC procedures call for notifying the USDOT regarding incidents related to facilities and operations under its jurisdiction. The NRC communicates with the USDOT at a rate of over 2,500 notifications per year.

Statistics maintained by NRC in cases of pipeline spill incidents are available to the public on an annual basis. Once USDOT is informed about a pipeline incident, PHMSA is the agency in charge of collecting the pertinent data after the spill. The NRC database is focused on emergency response details, and has more flexibility in record keeping than PHMSA. For instance, the material in crude oil spills may be logged as *oil crude, crude oil, crude water mixture, crude mixed with water*, or several other terms to represent the same spilled substance. In addition, emergency spill drills conducted during a year are also logged as *incidents* in the database. Information is recorded to clarify the virtual nature of the record, but it is apparent only after analyzing the data records individually. In brief, NRC incident data may not be comparable with PHMSA data without manipulation. Drawing estimates from combined database records at face value may grossly misrepresent statistics about pipeline system incidents.

National Transportation Safety Board

The National Transportation Safety Board (NTSB) is an independent agency of the U.S. government. It is responsible for incident investigations in civil transportation (NTSB 2012b). In this role, NTSB investigates and reports on aviation incidents, major highway crashes, ship and marine incidents, pipeline release incidents, and railroad incidents (NTSB 2012b). The NTSB is also in charge of investigating cases of hazardous materials releases that occur during transportation.

The following NTSB reports on two more recent large spills were reviewed (NTSB 2012c):

- NTSB/Pipeline Accident Report-12/01: Enbridge Incorporated Hazardous Liquid Pipeline Rupture and Release, Marshall, MI. July 25, 2010 (NTSB 2012a)
- NTSB/Pipeline Accident Report-04/01: Rupture of Enbridge Pipeline and Release of Crude Oil near Cohasset, MN. July 4, 2002 (NTSB 2004)

The purpose of reviewing the incident reports was to gain a better understanding of these two spills. A familiarization with Enbridge pipeline integrity management was considered beneficial because their system carries diluted bitumen (dilbit) and synthetic crude oil (SCO) (see Section 3.13, Potential Releases, for further definitions) in the United States.

California State Fire Marshal

Outside of the national agencies, some U.S. states collect their own internal data. In California, the Office of the State Fire Marshal (SFM) acts as an agent of the PHMSA (formerly the federal Office of Pipeline Safety) for the state (California Department of Forestry and Fire Protection 2012). California data were evaluated in this Final Supplemental EIS because oil in these pipeline systems is typically heavy crude and has characteristics similar to those of dilbit and SCO.

The California SFM exercises safety regulatory jurisdiction over interstate and intrastate pipelines used for the transportation of hazardous or highly volatile liquid substances within California. In 1983, the Pipeline Safety and Enforcement Program was created to administer this effort (California Department of Forestry and Fire Protection 2012).

In 1987, SFM acquired the regulatory responsibility for interstate lines in California when an agreement was executed with the USDOT. In doing so, SFM became an agent of the USDOT responsible for ensuring that California interstate pipeline operators meet federal pipeline safety standards. Interstate pipelines under this agreement are subject to the federal *Pipeline Safety Act* (Title 49 of the U.S. Code Chapter 601) and federal pipeline regulations. SFM's responsibility for intrastate lines is covered in the *Elder California Pipeline Safety Act* of 1981 (Chapter 5.5, California Government Code, Section 51010-51019.1).

The agency's responsibilities are twofold:

- To enforce federal minimum pipeline safety standards over regulated interstate hazardous liquid pipelines within California; and
- To enforce pipeline safety federal standards as well as the *Elder California Pipeline Safety Act* of 1981 on regulated hazardous liquid intrastate pipelines.

SFM conducts studies and gathers incident data for the California pipeline system. For this report, the data of a study conducted over a period of 10 years were analyzed (EDM Services Inc. 1993). The dataset used for the study was the only one with incident/temperature information, although limited to California 1981 to 1990 dataset.

International Data Sources

In Canada where the proposed pipeline originates, there are multiple agencies responsible for regulating pipelines, including the National Energy Board (NEB), Transportation Safety Board (TSB), and the Alberta Energy and Utilities Board (EUB).

National Energy Board

The NEB is an independent federal agency established in 1959 by the Parliament of Canada. The NEB regulates international and interprovincial pipelines, federal energy development, and federal energy trade. The NEB also regulates some aspects of the international electric utility industry. Under this mandate, the NEB carries out the organization's regulatory responsibilities in the Canadian public interest. The NEB reports to Parliament through the Minister of Natural Resources. The Board is made up of several Board members who come from the private or public sector and have various backgrounds and knowledge.

The NEB has identified four goals it hopes to achieve:

- NEB-regulated facilities and activities are safe and secure;
- The environment is protected throughout the lifecycle of NEB-regulated facilities and activities;
- Canadians benefit from efficient energy infrastructure and markets; and
- The rights and interests of those affected by NEB-regulated facilities and activities are respected.

Canadian Transportation Safety Board

The Canadian TSB is an independent agency created by an act of the Canadian Parliament (the *Canadian Transportation Accident Investigation and Safety Board Act* that came into force on 29 March 1990) (Canadian TSB 2012a). The act granted the mandate to TSB to advance transportation safety in the marine, pipeline, rail, and air modes of transportation through the following:

- Conducting independent investigations, including public inquiries when necessary, into selected transportation occurrences (incidents) in order to make findings as to their causes and contributing factors;
- Identifying safety deficiencies, as evidenced by transportation occurrences;
- Making recommendations designed to eliminate or reduce any such safety deficiencies; and
- Reporting publicly on investigations and on their findings.

As part of its ongoing investigations, the TSB also reviews developments in transportation safety and identifies safety risks that it believes government and the transportation industry should address to reduce injury and loss. Since its creation, TSB has conducted periodic reports on the national Canadian pipeline system and, for that purpose, maintained a comprehensive database with incident statistics (Canadian TSB 2012b). Monthly and annual reports are available from the TSB website. Raw incident data are not available. Public reports summarize estimates that are created on data that are aggregated according to different criteria and not solely according to the characterization of specific crude oil types. In addition, the field reporting basis for Canadian incidents was incompatible with PHMSA requirements before 2010. Data between these two datasets, pre- and post-2010, are not directly comparable. However, annual report data and statistical summaries related to incidents from 2002 to 2011 were reviewed and referenced as applicable in this Final Supplemental EIS.

Alberta Energy Resources Conservation Board

In Canada, the province of Alberta accounts for the overwhelming majority (more than 96 percent) of Canada's oil reserves (Alberta Energy 2012b). The Alberta EUB regulates the energy resource development, pipelines, transmission lines, and investor-owned electric, water, and natural gas utilities, as well as certain municipality-owned utilities in the province. The Alberta EUB reports to the Executive Council through the Ministry of Energy.

On January 1, 2008, the EUB was realigned into two separate regulatory bodies (Alberta Energy 2012a):

- The Energy Resources Conservation Board (ERCB), which regulates the oil and gas industry; and
- The Alberta Utilities Commission, which regulates the utilities industry.

The ERCB leads teams of engineers, geologists, technicians, economists, and other professionals at 14 locations in Alberta. The ERCB objectives include the following (ECRB 2012):

- Achieve high standards through effective and efficient regulation of public safety, environmental protections, and energy resource conservation;
- Be proactive in identifying and addressing emerging issues that face the industries the ERCB regulates and stakeholders affected by these issues;
- Provide its customers with easily accessible, relevant, and high-quality data, information, knowledge, and advice related to the energy sectors;

- Institute decision-making processes that are fair, efficient, and adaptable to the circumstances and that achieve a respected public interest balance; and
- Protect Albertans from exposure to long-term industry abandonment and decommissioning liabilities.

One of the reports, *Pipeline Performance in Alberta, 1990-2005* (Alberta EUB 2007), which was prepared by the Alberta EUB, was studied in detail for this Final Supplemental EIS. The purpose of reviewing that report was to compare PHMSA datasets and gain a better understanding of pipeline systems where dilbit, SCO, Bakken crude oil, and heavy crude oils are normally transported.

Other Data Sources

For some larger spills, other publicly available studies and reports were reviewed. These reports contained information regarding the effects to the environment as a result of a spill. The following spills were reviewed:

- Crude Oil Spill at Bemidji, Minnesota, August 29, 1979: Hult 1984 and U.S Geological Survey (USGS) 1998.
- Dilbit spill into Kalamazoo River, Michigan, July 26, 2010: Stratus Consulting Inc. 2005a and 2005b. Stage I Assessment Report, Volumes 1 and 2.
- Crude Oil Spill into Yellowstone River near Laurel, Montana, July 7, 2011: PHMSA 2011; USEPA 2012 and 2011; Center for Toxicology and Environmental Health 2011; Montana Department of Environmental Quality 2012.

The purpose of reviewing the studies and reports was to gain a better understanding of these spills and the results of these spills.

4.13.3.5 PHMSA Historical Data

PHMSA hazardous liquid pipeline incident reports include information on the type of hazardous material spilled, the estimated volume spilled, the part of the pipeline system that was the source of the release, and the probable cause of the incident. The PHMSA liquid incident dataset, which includes incidents from hazardous liquid pipelines, could be filtered to include only crude oil pipeline incidents. The PHMSA hazardous liquid pipeline incident data do not detail the type of crude oil involved with each incident; therefore, the historical incident summaries could not be specific to dilbit, SCO, or Bakken crude oil, but rather could only be specific to crude oil in general.

The historical incident data could be divided into discrete components (e.g., breakout tanks, pumping stations, and valves) and linear components (e.g., mainline pipe). This allows historical spill volumes and incident causes from the mainline pipe to be assessed separately from discrete elements such as pumping stations, breakout tanks, valves, and other associated equipment.

The incident and mileage databases were analyzed to show the distribution of historical spill volumes and incident causes as well as frequencies of crude oil pipeline incidents contained in the PHMSA database. This analysis was done to understand what has occurred historically with respect to pipelines in the United States and to provide input for spill impact analysis in this Final Supplemental EIS.

The analysis of incident data was used to provide insight into the basic parameters of what could potentially occur with respect to spill volume, incident cause, and incident frequency, and is not intended to predict or indicate that spill incidents would be the same or in a similar range for the proposed Project. Once a final route is determined, Keystone would conduct a detailed spill risk assessment for the proposed Project. Appendix K, Historical Pipeline Incident Analysis, summarizes the objectives and results of the PHMSA data analysis.

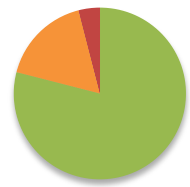
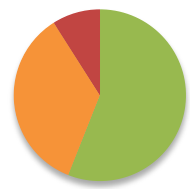
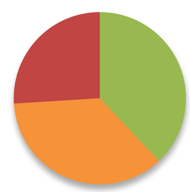
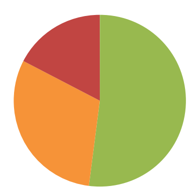
The reported data in the publicly-available PHMSA dataset include statistical data related to age and diameter of pipelines. The age and diameter data are not integrated and are included separately in the incident database, but not in the mileage database. As a result, the direct relationship between pipeline age and incidents is not readily identifiable. For the period 2002 through July 2012, it is possible to determine that the average age of crude oil pipelines in the PHMSA incident dataset is about 47 years, and the average diameter is about 20 inches.

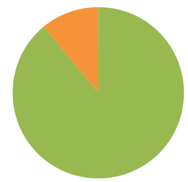
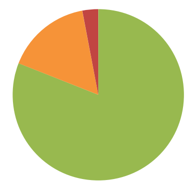
Spill Size Distribution

As discussed in Section 4.13.4, Spill Impact Assessment, spill impacts were analyzed for spill volumes of 0 to 50 bbl, 50 to 1,000 bbl, and greater than 1,000 bbl. Table 4.13-1 shows a summary of the spill size distribution, representative mileage, and frequencies for crude oil incidents in the PHMSA incident database. The estimates of pipeline mile-years shown in Table 4.13-1, along with the estimates of pipeline associated equipment-years, allow differentiating the incident rate between linear elements (mainline pipe and welds around the pipe's circumference) and discrete elements (such as pumping stations and breakout tanks). The incident frequencies contained in the table are the number of incidents divided by the associated mile-years or equipment-years. The summaries show that:

- Spill volumes from the mainline pipeline tend to be larger than spills from discrete elements, other than tanks.
- Spill volumes from larger diameter pipelines tend to be larger than spills from smaller diameter pipelines.
- Spill volumes from pipeline tanks tend to be larger than mainline pipe spills when considering all pipeline diameters.
- Spill volumes from pipeline tanks tend to be similar to mainline pipe spills for 16-inch and larger-diameter pipelines.
- The dominant causes for a release for the mainline pipeline (linear) element are corrosion and outside force.
- Equipment failure is the primary cause for discrete equipment elements.
- Incorrect operations are recorded as the cause of a large proportion of reported incidents for tanks.

Table 4.13-1 Spill Volume[a] Distribution by Pipeline Component

Pipeline Component (number of reported incidents)	0–50 bbl	>50–1,000 bbl	>1,000 bbl	Volume Distribution[b]	Pipeline Mileage[c] or Equipment Exposure[d]	Incident Rate per Mile-Year[c] or Equipment-Year[d]
Pipeline, All Elements (1,692)	79%	17%	4%		537,295 mile-years	0.00313
Mainline Pipe (321)	56%	35%	9%		537,295 mile-years	0.00059
Mainline Pipe, 16-inch Diameter and Greater (71)	38%	36%	26%		287,665 mile-years	0.00025
Pipeline System, Tanks[e] Tanks[d] (93)	51%	30%	19%		537,295 mile-years 18,937 tank-years	0.00017 0.0049

Pipeline Component (number of reported incidents)	0–50 bbl	>50–1,000 bbl	>1,000 bbl	Volume Distribution[b]	Pipeline Mileage[c] or Equipment Exposure[d]	Incident Rate per Mile-Year[c] or Equipment-Year[d]
Pipeline System, Mainline Valves (25)	89%	11%	0%		537,295 mile-years 26,865 valve-years	0.00005 0.00093
Pipeline System, Other Discrete Elements (909)[e]	84%	14%	2%		537,295 mile-years 11,647 pumping station-years	0.00168 0.055

Source: PHMSA 2012a

[a] The volume reported is the estimated amount lost in an incident and is not based on the same definition of a spill as used in this Final Supplemental EIS.
[b] Green: 0 to 50 bbl, orange: 50 to1,000 bbl, red: >1,000 bbl spill.
[c] For linear elements.
[d] For discrete element.
[e] Variability and completeness of incident reports in the PHMSA database suggests that some of these incidents could be allocated to an alternate pipeline component. If so, the frequency of the other components could increase.

When comparing the frequencies in Table 4.13-1 to those frequencies developed in the Final EIS (see Appendix P, Risk Assessment), it is difficult to make a one-to-one comparison. The Final EIS Risk Assessment limited the review to 2008 and referenced summary tables and charts on the PHMSA website that have since been updated. Appendix K, Historical Pipeline Incident Analysis, uses PHMSA incident data from January 2002 through July 2012. In 2010, PHMSA substantially revised the reporting format. As a result, this Final Supplemental EIS utilizes two different databases to conduct the incident analysis. The frequency values in Appendix P, Risk Assessment, and Appendix K, Historical Pipeline Incident Analysis, can vary because there are different numbers of incidents between the two reporting periods, the types of incidents in the post 2010 dataset are different than historical trends, and the more recent causes and spill volumes can be different from historical trends.

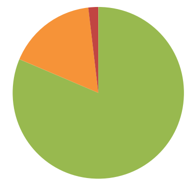
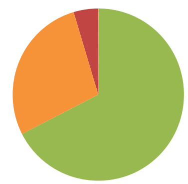
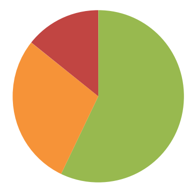
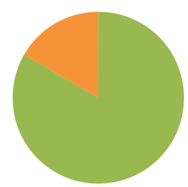
Since the completion of the Final EIS, data through August 2013 have been made available in the PHMSA database. As such, additional analysis after the July 2013 evaluation shown in Table 4.13-1 was completed to reflect the additional 1.1 years of data. This additional analysis includes the April, 2013 Mayflower, Arkansas pipeline spill, however, does not include the October 2013 Tioga, North Dakota pipeline spill that occurred after the August 2013 dataset became available. As shown in Appendix K, Historical Pipeline Incident Analysis, and summarized in Table 4.13-2 below, the additional year of data is consistent with and has nearly the same results as the initial analysis.

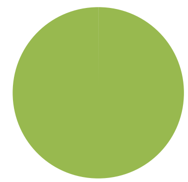
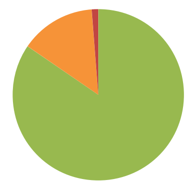
Sensitivity Analysis

A high-level sensitivity evaluation was conducted to help validate the assumptions used in calculating the frequency values for mainline valves and pump stations in service, as discussed above and in Appendix K, Historical Pipeline Incident Analysis. Based on the sensitivity evaluation, the assumptions used are valid and pump stations have the highest incident frequency, followed by mainline pipe, then tanks, and then mainline valves with the lowest incident frequency. (This priority ranking is used to focus mitigation measures.)

Based on this evaluation, to affect the calculated incident frequency for mainline valves or pump stations that would change the priority ranking for the key pipeline elements (i.e., mainline pipe, tanks, mainline valves, pump stations), unreasonable and unlikely spacing assumptions are needed. For example, to shift the priority ranking of the key pipeline elements, there would need to be one pump station every 6 miles, or fewer than 600 mainline valves for the entire U.S. pipeline system. Therefore, any reasonable changes to the spacing assumptions could change the incident frequency, but would have no material effect on the priority ranking for these elements. The assumed spacing used for mainline valves and pump stations in the incident frequency analysis is reasonable. Tables 4.13-3 and 4.13-4 show the variation on spill incident frequencies based on changing spacing assumptions. The *lower* and *upper* estimates are the points of inflection whereby the priority ranking for the mainline valves either changes from third to second (85-mile spacing) or third to fourth (3-mile spacing).

Table 4.13-2 Spill Volume[a] Distribution by Pipeline Component, July 2012–August 2013

Pipeline Component (number of reported incidents)	0–50 bbl	>50–1,000 bbl	>1,000 bbl	Volume Distribution[b]	Pipeline Mileage[c] or Equipment Exposure[d]	Incident Rate per Mile-Year[c] or Equipment-Year[d]
Pipeline, All Elements (215)	81%	17%	2%		62,661 mile-years	0.003431
Mainline Pipe (43)	67%	28%	5%		62,661 mile-years	0.000686
Mainline Pipe, 16-inch Diameter and Greater (41)	57%	29%	14%		31,263 mile-years	0.000448
Pipeline System, Tanks[e] Tanks[d] (6)	83%	17%	0%		62,661 mile-years 2,327 tank-years	0.000096 0.002578

Pipeline Component (number of reported incidents)	0–50 bbl	>50–1,000 bbl	>1,000 bbl	Volume Distribution[b]	Pipeline Mileage[c] or Equipment Exposure[d]	Incident Rate per Mile-Year[c] or Equipment-Year[d]
Pipeline System, Mainline Valves (4)	100%	0%	0%		62,661 mile-years 3,133 valve-years	0.000064 0.001277
Pipeline System, Other Discrete Elements (162)[e]	85%	14%	1%		62,661 mile-years 1,362 pump station-years	0.002585 0.118925

Source: PHMSA 2013

[a] The volume reported is the estimated amount lost in an incident and is not based on the same definition of a spill as used in this Final Supplemental EIS.
[b] Green: 0 to 50 bbl, orange: 50 to1,000 bbl, red: >1,000 bbl spill
[c] For linear elements.
[d] For discrete element.
[e] Variability and completeness of incident reports in the PHMSA database suggests that some of these incidents could be allocated to an alternate pipeline component. If so, the frequency of the other components could increase.

Table 4.13-3 Effect on Spill Incident Frequencies—Mainline Valves

	Base Case: 20-mile Spacing		Lower Estimate: 3-mile Spacing		Upper estimate: 85-mile Spacing	
	Incidents/ Year	**Years Between Incidents**	**Incidents/ Year**	**Years Between Incidents**	**Incidents/ Year**	**Years Between Incidents**
0-50 bbl	0.0450	22.2	0.0068	148.0	0.1914	5.2
50-1,000 bbl	0.0061	162.8	0.0009	1,085.4	0.0261	38.3
1,000+ bbl	0.0000	NA	0.0000	NA	0.0000	NA
Total	**0.0512**	**19.5**	**0.0077**	**130.3**	**0.2175**	**4.6**

NA = Not applicable

Table 4.13-4 Effect on Spill Incident Frequencies—Pump Stations

	Base Case: 46-mile Spacing		Lower[a] Estimate: 6 miles	
	Incidents/Year	**Years Between Incidents**	**Incidents/Year**	**Years Between Incidents**
0-50 bbl	1.3013	0.8	0.1697	5.9
50-1,000 bbl	0.2192	4.6	0.0286	35.0
1,000+ bbl	0.0360	27.8	0.0047	213.2
Total	**1.5565**	**0.6**	**0.2030**	**4.9**

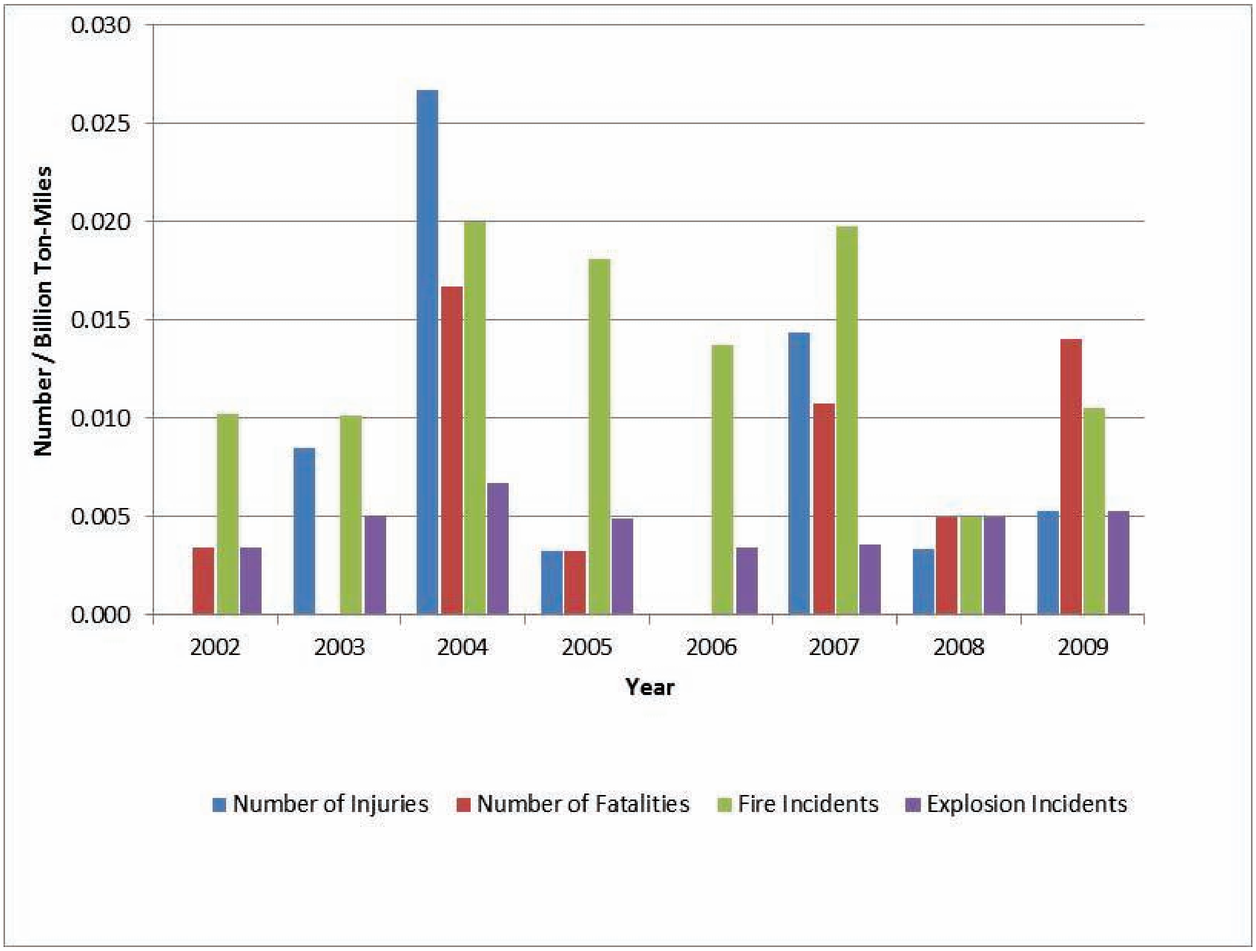
[a] Based on historic data, the priority for pump stations is ranked one (highest); therefore, there is only a lower limit whereby the priority ranking changes from first to second (6-mile spacing).

Although the frequency does vary based on the spacing assumptions, the chosen assumptions remain reasonable based on information about the proposed Project. As such, the mitigation focus based on the priority ranking is the same and any reasonable changes in the spacing would not change the focus.

Historic Pipeline Injury, Fatality, Fire, and Explosion Incidents

In addition to recording incident data on spill volume and cause, PHMSA identifies both serious and significant incidents. A *serious incident* is one that involves a fatality or injury. A *significant incident* includes serious incidents and unintentional fires or explosions, as well as those items discussed in Section 4.13.3.4, Pipeline Incident Information Sources.

A summary of PHMSA historic incidents resulting in an injury, fatality, fire, or explosion, as reported, is shown in Figure 4.13.3-1.



Sources: Incidents from PHMSA Pipeline Incident Data (PHMSA 2012a); Pipeline Ton-Mileage from Association of Oil Pipelines (AOPL 2012)

Notes: Incidents and mileage reflect petroleum and petroleum products only.

Figure 4.13.3-1 Number of Pipeline Injury, Fatality, Fire, and Explosion Incidents per Billion Ton-Miles Transported, Crude Oil and Petroleum Products, 2002 to 2009

Comparison of Different Historical Data

As discussed, there are other sources for data on pipeline incidents. However, unlike PHMSA, the majority of these do not have publicly available raw data that could be analyzed in a similar manner. To aid in identifying the consistency in spill incidences from different sources and the reproducibility of those statistics, the PHMSA data were compared to the summary tables and figures in the Alberta EUB and SFM summary reports. In addition, these other data sources supplemented the PHMSA database because they reflect a heavy crude oil type similar to that which would be transported in the proposed Project.

While, under appropriate circumstances, it may be desirable to further analyze data from pipelines installed in the past decade (i.e., since 2002), there are data gaps that would preclude deriving useful information from a subset analysis. For example, analysis of the data shows that for all incidents, 9 percent of the PHMSA records have an installation date in the last decade and 60 percent of all incidents do not have an identified installation date in the PHMSA database. For onshore crude oil incidents, the percent breakdown is roughly the same. Therefore, conducting a detailed analysis such as the number of pipeline releases based on age would have a greater degree of uncertainty because age data have such a small representation within the entire dataset.

EUB—Pipeline Performance in Alberta, 1990 to 2005

The Alberta EUB report, *Pipeline Performance in Alberta, 1990 to 2005*, analyzed pipeline incident data in Alberta from January 1990 to December 2005.[6] The report contains 411 incidents related to crude oil pipeline systems in the province, which represents approximately 27 incidents per year. Figure 12a in that report (Alberta EUB 2007) shows[7]:

- Corrosion is the main cause of spills in Alberta crude oil pipelines, accounting for 37.7 percent of the incidents. This compares to the U.S. data for pipeline systems (34.4 percent in the PHMSA dataset from Figure 2 of Appendix K, Historical Pipeline Incident Analysis).
- Third-party damage is the second highest cause of spills at 21.6 percent. This is greater than the U.S. data (6.5 percent for outside force in the PHMSA dataset).
- The *other* cause category in the Alberta dataset includes operator error, equipment malfunction, weather, and natural forces (but not earth movement). The total of *other* is 11.9 percent in the Alberta dataset (14.8 percent including earth movement). This is smaller compared to the U.S. data (45.5 percent for equipment malfunction, incorrect operations, weather, or natural forces in the PHMSA dataset).
- The Alberta EUB has several different scenarios for equipment-related incidents, including joint failure[8] and valve/fitting,[9] and only parts of *other* (*other* includes compressor, pump, and meter station, which are equipment-related, as well as operator error, weather, and natural forces [but not earth movement], which are not equipment related). Grouping these categories, including all *other*, gives a total contribution of 22.6 percent in the Alberta dataset. This is smaller than the contribution in the U.S. data (31.9 percent for equipment malfunction in the PHMSA dataset).
- Figure 28 of the report provides estimates of incident frequencies from crude oil pipelines in Alberta. The 1990–2005 average is 1.9 incidents per 1,000 km-years, which is approximately three incidents per 1,000 mile-years. This is very similar to the PHMSA crude oil incident rate of 3.1 incidents per 1,000 mile-years for pipelines and reported elements from 2002–July 2012, as shown in Appendix K, Historical Pipeline Incident Analysis, Table 4.

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[6] This is the most recent data available that had been processed and analyzed to provide meaningful information from which to compare.
[7] Values in the bullet points are not a complete summary of all categories of spill causes from the EUB report. Instead, comparisons between U.S. and Canadian data are brought forward to highlight the similarities and differences between the way the U.S. and Canadian data are reported. Therefore, the total for all percentages reported does not equal 100 percent.
[8] Mechanical joint failure (e.g., gasket failure, o-ring failure) or miscellaneous joint failure (e.g., butt fusion, interference joints)
[9] Valve failure or installation failure

California SFM—Hazardous Liquid Pipeline Risk Assessment

The dataset contained in the report is considerably older than the PHMSA dataset. The California data, from which the report draws its conclusions, span from 1981 to 1990[10] (EDM 1993). Because the California pipeline system generally manages heavy crude oil, which is similar in character to dilbit, the California study and the conclusions drawn are useful to assess the potential effects of heavy oil on pipeline corrosion and potential effects on the pipe of the proposed Project. The California report states several conclusions for the analyzed incidents, as follows:

- Smaller-diameter, older pipelines had a significantly higher external corrosion leak incident rate than larger-diameter, newer pipelines.
- Elevated pipeline operating temperatures significantly increased the frequency of leaks caused by external corrosion for all pipelines; however, the 16- to 20-inch diameter range had a relatively low leak rate despite having the highest mean operating temperature range.
- The external corrosion leak incident rate was less for pipelines greater than 16 inches in diameter than it was for smaller lines.
- Although a small number, pipelines without cathodic protection systems had a substantially higher frequency of external corrosion-caused leaks than protected lines.
- In some cases, the pipe specification and type of external corrosion coating affected external corrosion leak incident rates.

The California report states that pipelines operating at higher temperatures are also the oldest. The oldest pipelines in the dataset (50+ years old at the time of the study) tended to leak up to 20 times more frequently than the youngest pipelines (less than 10 years old at the time of the study).

The California report contained an analysis using a dataset that included all pipe diameters to determine whether or not pipe age masked pipe operating temperature effects. The analysis found that, while holding various factors constant, operating temperature correlated with the probability of a leak occurring from external corrosion.[11] However, when analyzing specific pipeline diameter ranges, the California report describes that a good deal of variance exists between pipe diameter range with leak incident rates, and points out that pipelines in the 16- to 20-inch-diameter range had a relatively low leak rate despite having the highest mean operating temperature range. In addition, the 20-inch or greater range has an order of magnitude lower leak rate than the 8- to 10-inch pipe despite a similar mean operating temperature. This means that a correlation with operating temperature and leak incident rate may not hold for large diameter pipelines.

Although temperature could increase the rate of a chemical reaction, such as corrosion for both steel pipe buried in the ground and unburied pipe exposed to the weather, the results of the California study must be evaluated with caution. The pipelines in the California study were installed with different design criteria than the proposed Project would be. Pipeline systems installed more than 20 years ago have different cathodic protection specifications, different

[10] This is the most recent dataset for which information was available.
[11] The specific factors are not detailed in the California report.

external protective coatings, if any, different SCADA systems, and different pipe specifications. Pipeline systems fabricated and installed prior to 1970 could have even less protection than 20-year-old systems, not to mention those that would be installed today. Pipe specification, coating, and cathodic protection are some factors that affect corrosion rates. Therefore, a conclusion that higher leak rates would occur at higher temperatures cannot be drawn based on the California study alone.

Temperature data are not available in the PHMSA dataset; therefore, it is not possible to directly determine if there is a relationship between operating temperature and incident frequency using this dataset.

Several PHMSA Special Conditions are to be in place for the proposed Project to mitigate potential issues associated with pipeline degradation (see Section 4.13.6.1, PHMSA Special Conditions). The ultimate rate of corrosion may not be assessed at this time with the available data. However, as noted in Section 3.13.3.7, Acidity and Corrosivity Potential, a study on the corrosivity of dilbit has been completed by the National Academy of Sciences.

Applied Incident Frequency

While any estimate based on the above historical data would be indicative and not predictive, using the above historical incident data and applying it to an 875-mile pipeline with 55 mainline valves, two tanks, and 20 pump stations—similar to the proposed Project—the number of years of operation per pipeline incident can be estimated:

- Table 4.13-5 shows the resulting years per release from mainline pipe using the historic incident frequency.
- Table 4.13-6 shows the resulting years per release from mainline pipe based on cause for spills greater than 1,000 bbl using the historic incident frequency.
- Table 4.13-7 shows the resulting years per release from a two-tank system, the same number of tanks planned for the proposed Project.
- Table 4.13-8 shows the resulting years per release from a two-tank system based on cause for spills greater than 1,000 bbl using the historic incident frequency.
- Table 4.13-9 shows the resulting years per release from an 875-mile pipeline containing 55 mainline valves. The values reflect only valve incidents and do not include mainline pipe incidents. There are no reported large spill incidents from valves in the reported period (January 2002 through July 2012).
- Table 4.13-10 shows the resulting years per release after applying historic incident frequency from an 875-mile pipeline containing 20 pumping stations, the same number of pumping stations planned for the proposed Project.
- Table 4.13-11 shows the resulting years per release from an 875-mile pipeline containing 20 pumping stations based on cause for spills greater than 1,000 bbl using the historic incident frequency.

Table 4.13-5 Historic Incident Summary, Onshore Mainline Pipe 16-inch-diameter and Larger

Spill Volume	Historic Incident Frequency[a]	875-mile Mainline Pipe, 16-inch-diameter and Greater[b] Incidents/Year	875-mile Mainline Pipe, 16-inch-diameter and Greater[b] Years/Incident
Small (0 to 50 bbl)	1 per 10,654 mile-years	0.082	12
Medium (50 to 1000 bbl)	1 per 11,507 mile-years	0.078	13
Large (>1000 bbl)	1 per 15,140 mile-years	0.056	18

[a] PHMSA 16-inch and larger mainline crude oil pipe (January 2002–July 2012).
[b] Historic 16-inch and larger mainline crude oil pipe incident frequency applied to 875 miles of mainline pipeline.

Table 4.13-6 Historic Incident Summary, Onshore Mainline Pipe 16-inch-diameter and Larger, Spill Size Greater than 1,000 Barrels

Spill Cause	Historic Incident Frequency[a]	875-mile Mainline Pipe, 16-inch Diameter and Greater[b] Incidents/Year	875-mile Mainline Pipe, 16-inch Diameter and Greater[b] Years/Incident
Outside Force/Excavation	1 per 41,095 mile-years	0.021	47
Manufacturing/Construction/ Materials-Related	1 per 71,916 mile-years	0.012	82
Weather/Natural Force	1 per 95,888 mile-years	0.009	110
Corrosion (Internal, External, Unspecified)	1 per 95,888 mile-years	0.009	110
Other	1 per 143,833 mile-years	0.006	164
Incorrect Operations/Equipment Malfunction	No incidents reported[c]	--[d]	--[d]

[a] PHMSA 16-inch and larger mainline crude oil pipe (January 2002 to July 2012).
[b] Historic 16-inch and larger mainline crude oil pipe incident frequency applied to 875 miles of mainline pipeline.
[c] No historic incidents reported in PHMSA 2002 to 2012.
[d] Because there were no historic incidents during the time period analyzed, no value has been calculated.

Table 4.13-7 Historic Incident Summary, Onshore Crude Oil Pipeline System, Tanks

Spill Volume	Historic Incident Frequency[a]	2 Tanks[b] Incidents/Year	2 Tanks[b] Years/Incident
Small (0 to 50 bbl)	1 per 403 tank-years	0.0050	201
Medium (50 to 1000 bbl)	1 per 676 tank-years	0.0030	338
Large (>1000 bbl)	1 per 1052 tank-years	0.0019	526

[a] PHMSA pipeline crude oil tanks (January 2002 to July 2012).
[b] Historic pipeline crude oil tank incident frequency applied to two tanks.

Table 4.13-8 Historic Incident Summary, Onshore Crude Oil Pipeline System, Tanks, Spill Size Greater than 1,000 Barrels

Spill Cause	Historic Incident Frequency[a]	2 Tanks[b] Incidents/Year	2 Tanks[b] Years/Incident
Outside Force/Excavation	No incidents reported[c]	--[d]	--[d]
Manufacturing/Construction/ Materials-Related	1 per 18,937 tank-years	0.0001	9,469
Weather/Natural Force	1 per 6,312 tank-years	0.0003	3,156
Corrosion (Internal, External, Unspecified)	1 per 9,469 tank-years	0.0002	4,734
Other	1 per 4,734 tank-years	0.0004	2,367
Incorrect Operations/Equipment Malfunction	1 per 2,367 tank-years	0.0008	1,184

[a] PHMSA pipeline crude oil tanks (January 2002 to July 2012).
[b] Historic pipeline crude oil tank incident frequency applied to two tanks.
[c] No historic incidents reported in PHMSA 2002 to 2012.
[d] Because there were no historic incidents during the time period analyzed, no value has been calculated.

Table 4.13-9 Historic Incident Summary, Onshore Crude Oil Pipeline System, Mainline Valves

Spill Volume	Historic Incident Frequency[a]	55 Mainline Valves[b] Incidents/Year	55 Mainline Valves[b] Years/Incident
Small (0 to 50 bbl)	1 per 1,221 valve-years	0.05	22
Medium (50 to 1000 bbl)	1 per 8,955 valve-years	0.01	163
Large (>1000 bbl)	No incidents reported[c]	--[d]	--[d]

[a] PHMSA crude oil pipeline mainline valves (January 2002 to July 2012).
[b] Historic crude oil pipeline mainline valves incident frequency applied to 55 mainline valves.
[c] No historic incidents reported in PHMSA 2002 to 2012.
[d] Because there were no historic incidents during the time period analyzed, no value has been calculated.

Table 4.13-10 Historic Incident Summary, Onshore Crude Oil Pipeline System, Pumping Stations

Spill Volume	Historic Incident Frequency[a]	20 Pumping Stations[b] Incidents/Year	20 Pumping Stations[b] Years/Incident
Small (0 to 50 bbl)	1 per 15 pumping station-years	1.31	1
Medium (50 to 1000 bbl)	1 per 91 pumping station-years	0.22	5
Large (>1000 bbl)	1 per 555 pumping station-years	0.04	28

[a] PHMSA other crude oil pipeline discrete elements (January 2002 to July 2012).
[b] Historic other crude oil pipeline discrete elements incident frequency applied to 20 pumping stations.

Table 4.13-11 Historic Incident Summary, Onshore Crude Oil Pipeline System, Pumping Stations, Spill Size Greater than 1,000 Barrels

Spill Volume	Historic Incident Frequency[a]	20 Pumping Stations[b] Incidents/Year	20 Pumping Stations[b] Years/Incident
Outside Force/Excavation	1 per 5,824 pumping station-years	0.0034	291
Manufacturing/ Construction/Materials-Related	1 per 1,456 pumping station-years	0.0137	73
Weather/Natural Force	1 per 5,824 pumping station-years	0.0034	291
Corrosion (Internal, External, Unspecified)	1 per 2,912 pumping station-years	0.0069	146
Other	No incidents reported[c]	--[d]	--[d]
Incorrect Operations/ Equipment Malfunction	1 per 2,329 pumping station-years	0.0086	116

[a] PHMSA other crude oil pipeline discrete elements (January 2002 to July 2012).
[b] Historic other crude oil pipeline discrete elements incident frequency applied to 20 pumping stations.
[c] No historic incidents reported in PHMSA 2002 to 2012.
[d] Because there were no historic incidents during the time period analyzed, no value has been calculated.

4.13.3.6 Applicability of Crude Oil Data

Ideally, incident data from pipelines transporting dilbit, SCO, and Bakken crude oil would be available for the historical data analysis conducted in this report. However, given how incident data are reported, it is not possible to distinguish dilbit, SCO, and Bakken oil spills from the general population of crude oil spills, nor is it possible to distinguish pipelines carrying dilbit, SCO, or Bakken oil from other crude oil pipelines. However, insights could be made by comparing the proposed Project conditions with the historical data:

- The oil that would be transported by the proposed Project would include dilbit, SCO, and Bakken crude oil;
- As discussed in Section 3.13, Potential Releases, dilbit, SCO, and Bakken oil total acid number values are generally consistent with those of 18 international crudes, indicating that corrosivities would be similar;
- Alberta is a source of dilbit[12] and SCO[13]; incident statistics from Alberta show that incident frequencies and corrosion-based incidents are similar for pipelines in the United States and Alberta;
- The anticipated positive effects of the PHMSA Special Conditions are not reflected in the historical data, as there has not been a pipeline designed to these more rigorous set of specifications to date; and

[12] Bitumen is generally produced from deposits in Alberta, Canada, and the Orinco tar sands in Venezuela. The source for the proposed Project is Alberta.
[13] Almost all of Alberta’s proven oil reserves are found in Alberta's oil sands. Of Alberta's total oil reserves, 169.3 billion barrels (or about 99 percent) come from the oil sands; the remaining 1.5 billion barrels come from conventional crude oil (Alberta Energy 2012b).

- The integrity threats identified in Section 3.13, Potential Releases, from the dilbit, SCO, and light crude oil that would be transported by the proposed Project are the same as those for a crude oil pipeline.

Section 4.13.6.1, PHMSA Special Conditions, presents more detail on the Special Conditions and how they would be expected to affect the risk of a spill. The Battelle risk analysis reports that Australian pipelines, which reflect smaller pipelines and are built to modern standards, have a 10-fold lower spill rate. It is reasonable to conclude that modern and larger-diameter pipelines would experience a lower spill rate than older pipelines. Modern pipelines have built-in measures to reduce the likelihood of a spill (e.g., modern protective coatings, SCADA monitoring). Using the Australian data to suggest that the Keystone XL pipeline would experience a similarly lower spill rate is not possible. However, with the application of the Special Conditions and various studies that indicate more modern pipelines are less likely to leak, it is reasonable to expect a sizable reduction in spills when compared to the historic spill record.

4.13.3.7 Keystone Pipeline First-Year Release Historical Data

In response to numerous comments received, historical incident data within the PHMSA and NRC incident databases were analyzed to show the distribution of historic spill volumes and incident causes of crude oil pipelines within the first year of operation. This analysis was done to understand what has occurred with respect to crude oil pipelines in general and the existing Keystone pipeline system more specifically. The existing Keystone pipeline system referred to in this analysis includes the Keystone pipeline extending from Hardisty, Alberta, to Patoka, Illinois, and the Cushing Extension extending from Steele City, Nebraska, to Cushing Oklahoma. Results are intended to provide insight into what could potentially occur with respect to spill size and incident cause within the first year of pipeline operation and are not a direct indicator of possible incidents that could occur in association with the proposed Project.

First-Year Historical Incident Data

The PHMSA hazardous liquid pipeline dataset was filtered to include only onshore crude oil pipeline incidents occurring between 2002 and May 2013. In addition to information on the estimated volume spilled, the part of the pipeline system involved in the release, and the probable cause of the incident, the PHMSA database often provides the year of installation. Incidents having the same pipeline operator and year of installation were assumed to be related to the same pipeline system. The year of pipeline installation was not reported for all incidents in the PHMSA database; therefore, this analysis is based only on incidents occurring between January 2002 and May 2013 where year of installation was provided. Pipelines were assumed to begin operations shortly following installation. In addition, releases less than 5 bbl are not required to be reported to PHMSA unless any of the following occurred: an explosion or fire not intentionally set by the operator; death of any person; personal injury necessitating hospitalization; or estimated property damage, including cost of cleanup and recovery, value of lost product, and damage to the property of the operator or others, or both, exceeding $50,000.

The NRC spill incident response database was reviewed for consideration in this analysis. Incident reports typically include a brief incident description, location, information about released material, early estimations of released amounts, damages, and details of notifications to government agencies. The database is focused on emergency response details and has more flexibility in record keeping than PHMSA. Materials involved in the incident are logged using different terminology for the same spilled substance, and pipeline operators are identified using slightly different names for the same operating company. In addition, installation years for the pipelines involved are not provided in the NRC incident reports. Information regarding the cause and involved part of the pipeline system is apparent only after analyzing the data records individually. In brief, NRC incident reports do not provide information regarding installation year and may not be comparable with PHMSA without manipulation.

Based on a review of historical incident reports, 79 incidents (not including the existing Keystone pipeline system) were identified to occur within the first year of pipeline operation for crude oil pipelines installed between 2002 and May 2013 (PHMSA 2013). Of the reported incidents, 49 occurred at pump/meter stations and terminal tank farms with the majority of these incidents caused by a pump related malfunctions. Mainline pipelines, including valve sites, accounted for 14 of the 79 reported incidents, only one of which was caused by a failure related to the body of the pipeline. Of the remaining reported first-year incidents, 11 occurred at aboveground storage tanks or breakout tanks and one was related to equipment and piping associated with belowground storage. The occurrence location for four incidents was not specified (PHMSA 2013). The majority of incidents occurring within the first year of operation were related to discrete elements of the pipeline system.

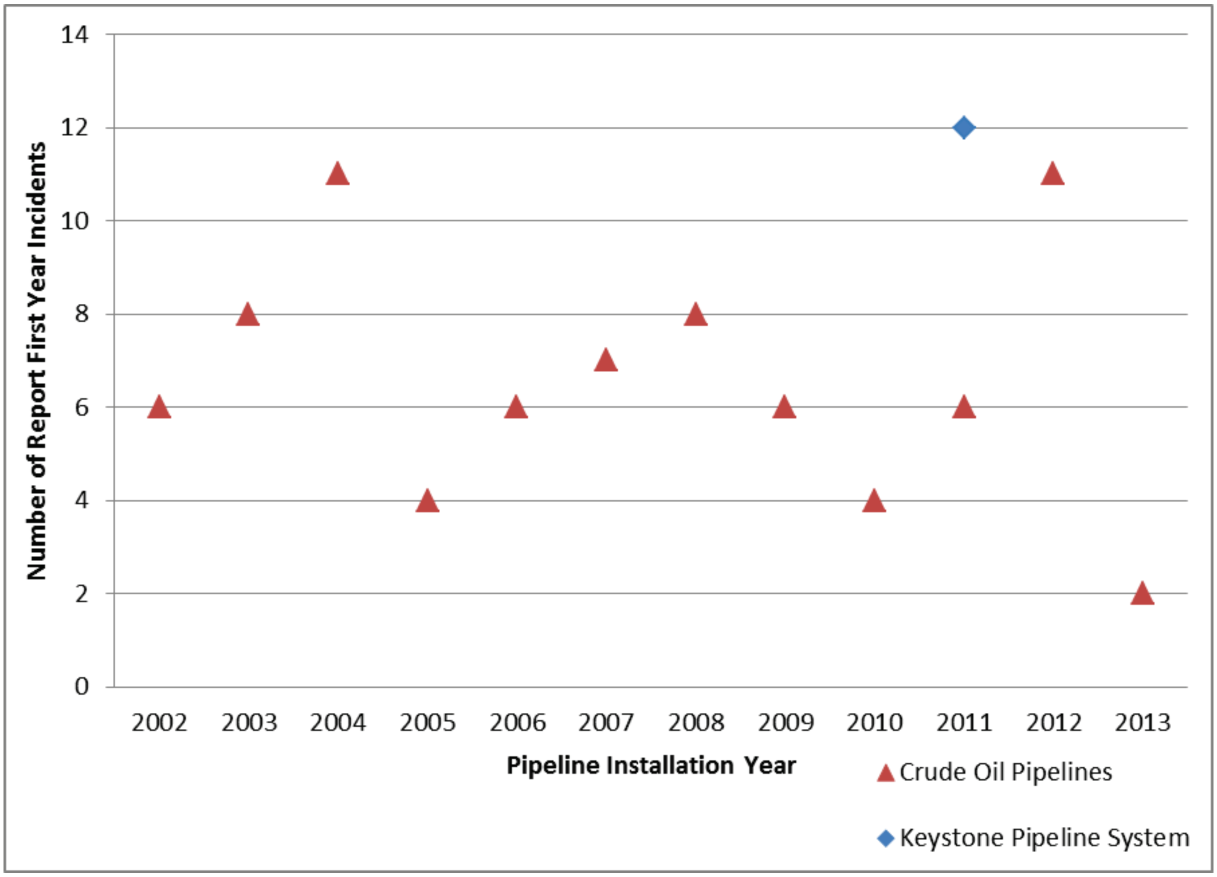
A separate review of historical PHMSA and NRC incident reports was conducted for the existing Keystone pipeline system for comparison to other crude oil pipelines. A total of 12 incidents were identified to have occurred in 2010 and 2011 (PHMSA and NRC 2013). Based on this review, 11 of the 12 reported incidents resulted in a small spill, eight of which were less than 1 bbl. These 11 incidents were contained entirely on the operator’s property and remediated. Only one of the reported incidents resulted in a medium spill (50 to 1,000 bbl) and was reported to be caused by an equipment malfunction leading to a surface release that affected an off-site property. The cleanup activities for the one medium-sized spill were initiated within hours and the remediation of the spill was completed in nine days. All reported first-year incidents for the existing Keystone pipeline system involved discrete elements of the pipeline system (i.e., pumping stations, mainline valves); none involved mainline pipe or tanks.

A summary of historic first year of pipeline operation incident data for the existing Keystone pipeline system and other crude oil pipelines installed between 2002 and May 2013 is included in Table 4.13-12 below. As discussed above, there are data gaps related to installation date reporting which can affect a detailed analysis. Figure 4.13.3-2 below shows the first year of pipeline operation reported incident distribution by pipeline installation year (where available) for both crude oil pipelines and the existing Keystone pipeline system.

Table 4.13-12 First-Year Historic Incident Summary, Onshore Crude Oil Pipeline, and Reported Elements[a,b,c]

Item	Other Crude Oil Pipelines[d]	Keystone Pipeline[d,e]	Unit
Data Range	11.42	4.42	Years of data
Range of Total Incidents per Pipeline	1-4	12	Reported first-year incidents
Total Number of Pipeline	66	1	Pipelines with reported first-year incidents
Average Incidents per Pipeline	1.2	12	Reported first-year incidents
Maximum Incident Volume Reported	5,000	400	Barrels
Median Incident Volume Reported	20	0.24	Barrels
Average Incident Volume Reported	187	35.6	Barrels
0 to 50 bbl	71%	92%	Percentage of incidents
50 to 1,000 bbl	25%	8%	Percentage of incidents
Greater than 1,000 bbl	4%	0%	Percentage of incidents

[a] Keystone Pipeline includes the Keystone pipeline from Hardisty, Alberta, to Patoka, Illinois, and the Cushing Extension.
[b] Year of installation was not available for every spill in the PHMSA database. Numbers are based only on incidents where year of installation was provided.
[c] Average Incidents per Pipeline is based only on pipeline with an incident within the first year of installation.
[d] PHMSA Incident Database 2002 – May 2013.
[e] NRC Incident Database 2009 – May 2013.



Notes: Crude oil pipeline incidents reported in PHMSA database 2002 to May 2013. Keystone Pipeline system incidents reported in PHMSA and NRC databases.

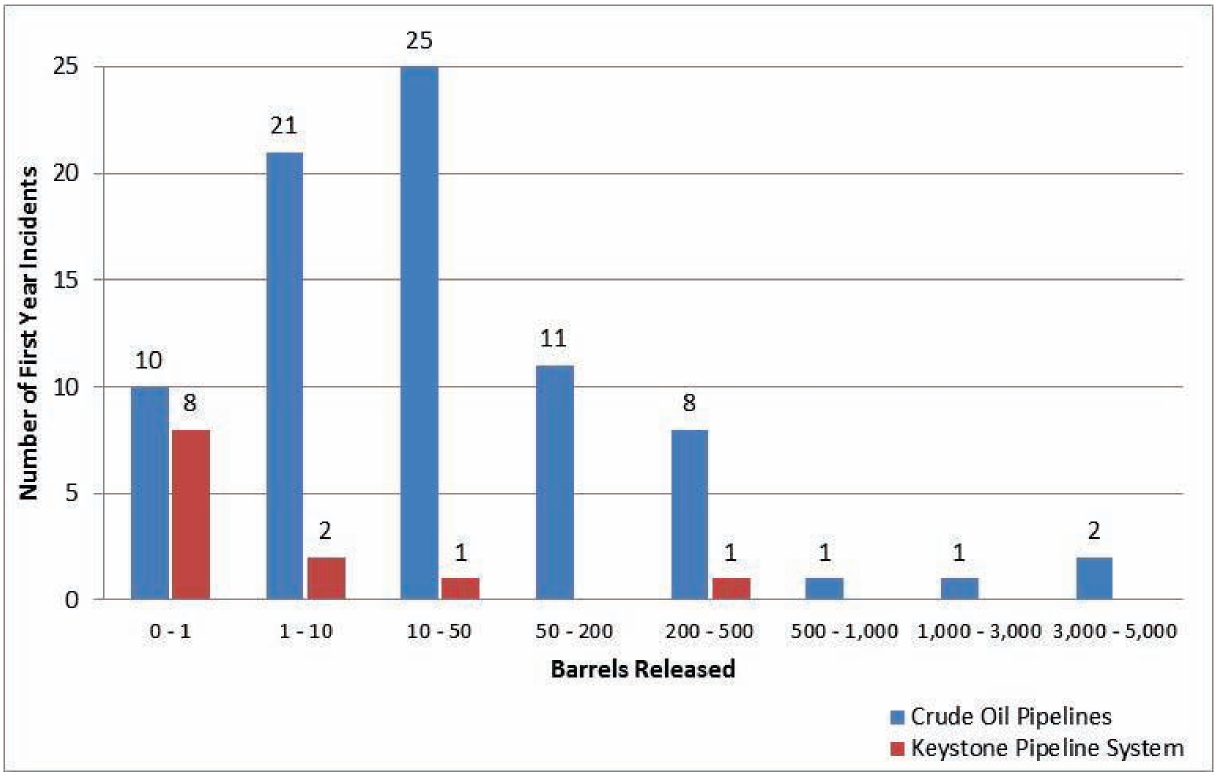
Figure 4.13.3-2 Reported Number of First-Year Incidents by Installation Year, the Keystone Pipeline System and Other Crude Oil Pipelines

First-Year Spill Size Distribution

Spill impacts were analyzed for spill volumes of 0 to 50 bbl, 50 to 1,000 bbl, and greater than 1,000 bbl for spills occurring within the first year of pipeline operation. As shown above in Table 4.13-12, small spills (0 to 50 bbl) accounted for 71 percent of crude oil pipeline first-year incidents and 92 percent of existing Keystone pipeline system first-year incidents with the majority of these incidents occurring at pump/meter stations and terminal tank farms. A total of 56 small spills were reported for crude oil pipeline within the first year of operation, 10 small spills reported were less than 1 bbl, 21 spills were less than 10 bbl, and 25 spills were less than 50 bbl. Medium spills (50 to 1,000 bbl) accounted for 25 percent of crude oil first-year spills with the majority also occurring at pump/meter stations and terminal tank farms. Of the three reported large spills (greater than 1,000 bbl), two were caused by tank malfunctions, and the largest spill of 5,000 bbl was caused by a mainline pipeline malfunction related to a bolted fitting. Based on a review of spill size distribution and associated pipeline system, discrete elements typically result in smaller spill volumes than mainline pipeline and tanks.

For the existing Keystone pipeline system within the first year of operation, eight reported incidents resulted in spill less than 1 bbl, three resulted in a spill less than 15 bbl, and one resulted in a spill of 400 bbl. Within the first year of operation, only one small spill of 0.11 bbl occurred underground and was detected by Keystone pumping station operations staff. The remaining 11 spills occurred above ground.

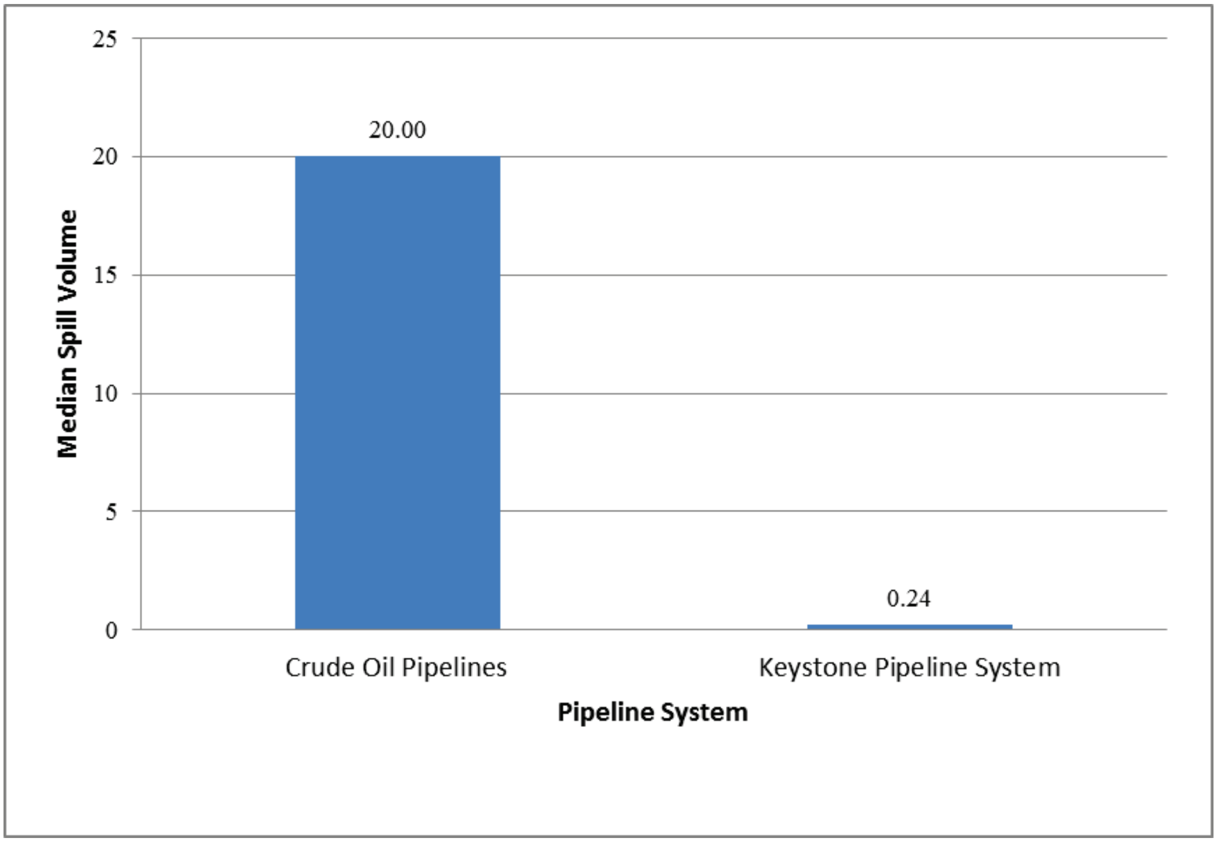
Figure 4.13.3-3 shows a summary of the spill size distribution for crude oil incidents in the PHMSA incident database in comparison to historic incidents for the existing Keystone pipeline system in the PHMSA and NRC incident database.



Notes: Seventy-nine reported crude oil pipeline incidents within the first year of operation 2002- May 2013 (PHMSA). Twelve reported Keystone pipeline system incident within the first year of operation (PHMSA, NRC). Pipeline operation was assumed to begin shortly following installation.

Figure 4.13.3-3 Volume Distribution of Spills within First Year of Pipeline Operation, the Keystone Pipeline System and Other Crude Oil Pipelines

Although the Keystone pipeline system had more reported first-year incidents than other crude oil pipelines, all except one of these incidents resulted in a small spill (less than 50 bbl). Compared to other crude oil pipelines, Keystone had a higher percentage of spills less than 1 bbl (67 percent compared to 13 percent) within the first year of operation. Equipment failure was the primary failure cause for both the Keystone pipeline system and other first-year crude oil pipelines. All reported equipment failure incidents for other crude oil pipelines within the first year of operation resulted in small spills. A comparison of the median spill volumes within the first year of installation for crude oil pipelines and the Keystone pipeline system is shown in Figure 4.13.3-4 below.



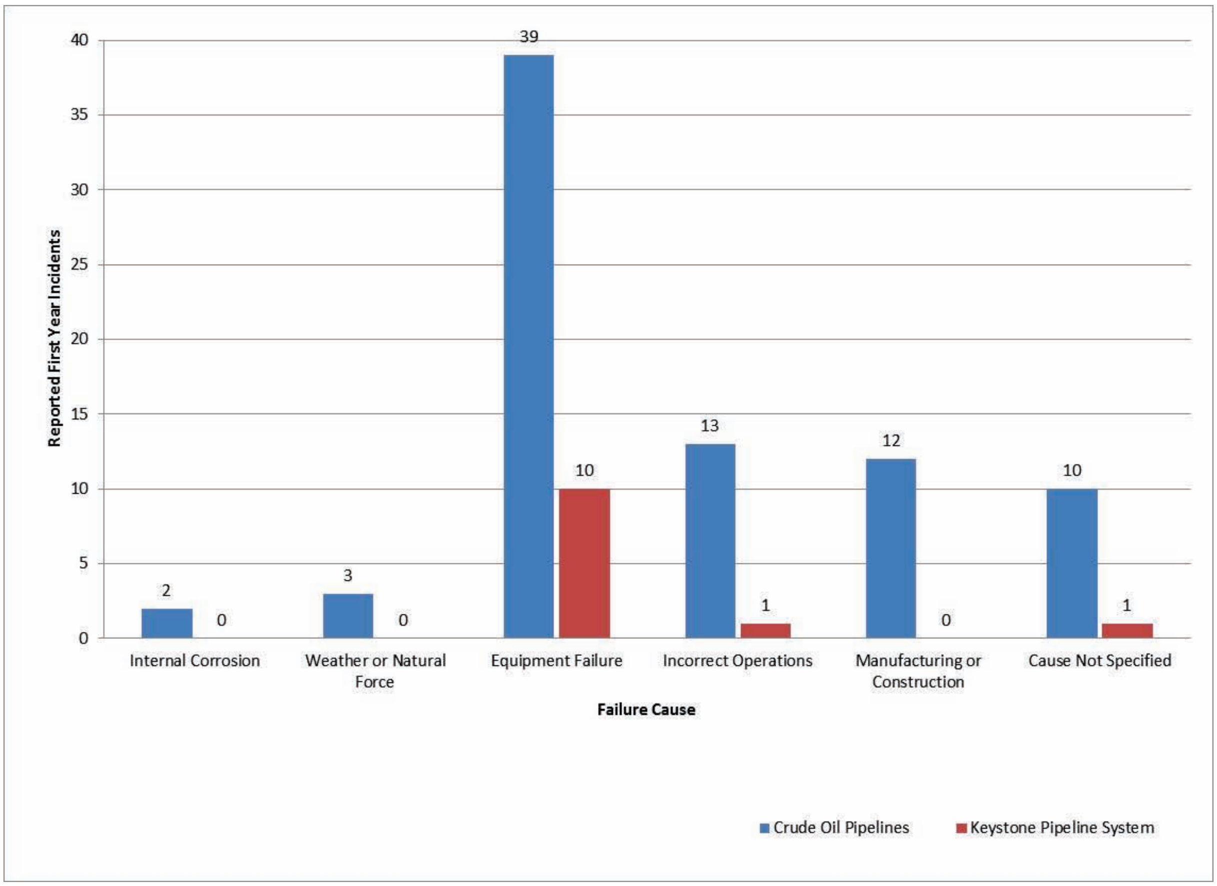
Notes: Crude oil pipeline incidents reported in PHMSA database 2002-May 2013. Keystone pipeline system incidents reported in PHMSA and NRC databases.

Figure 4.13.3-4 Median Spill Volumes Reported in the First Year of Operation, the Keystone Pipeline System and Other Crude Oil Pipelines

First-Year Failure Cause Distribution

Equipment failure was the primary cause involving discrete equipment elements within the first year of pipeline operation. Reported equipment failure causes are mainly related to ruptured or leaking seal/pump packing, or a malfunction of control/relief equipment. All reported first-year incidents caused by an equipment failure resulted in small spill volumes (less than 50 bbl). The dominant causes for a release from mainline pipeline elements and tanks within the first year of operation were incorrect operation and equipment failure. Incidents caused by internal corrosion resulted in small spills of less than 25 bbl and were related to terminal tank farm and mainline pipeline elements. Reported medium spills (50 to 1,000 bbl) were dominantly caused by incorrect operation and manufacturing/construction failures. The largest reported first-year spill (not related to Keystone) was caused by incorrect operation of a mainline pipeline system. Failure causes for other first-year pipelines (not related to the Keystone pipeline system) were not specified for ten reported incidents, two of which were large spills associated with tank malfunctions. The cause of one Keystone pipeline system first-year incidents was reported as unknown. The failure cause distribution for reported spills occurring within the first year of pipeline operation for both Keystone and other crude oil pipelines is shown in Figure 4.13.3-5 below.

For the existing Keystone pipeline system, equipment failure was the primary cause for first year of operation incidents. Reported equipment failure causes include threaded and non-threaded connection failures, pump or pump-related equipment malfunctions, and malfunction of control or relief equipment. The maximum reported spill (400 bbl) was caused by a threaded connection failure from excessive vibration. One incident was caused by incorrect operation and resulted in a spill from sump/separator component. The cause of one incident was reported as unknown.

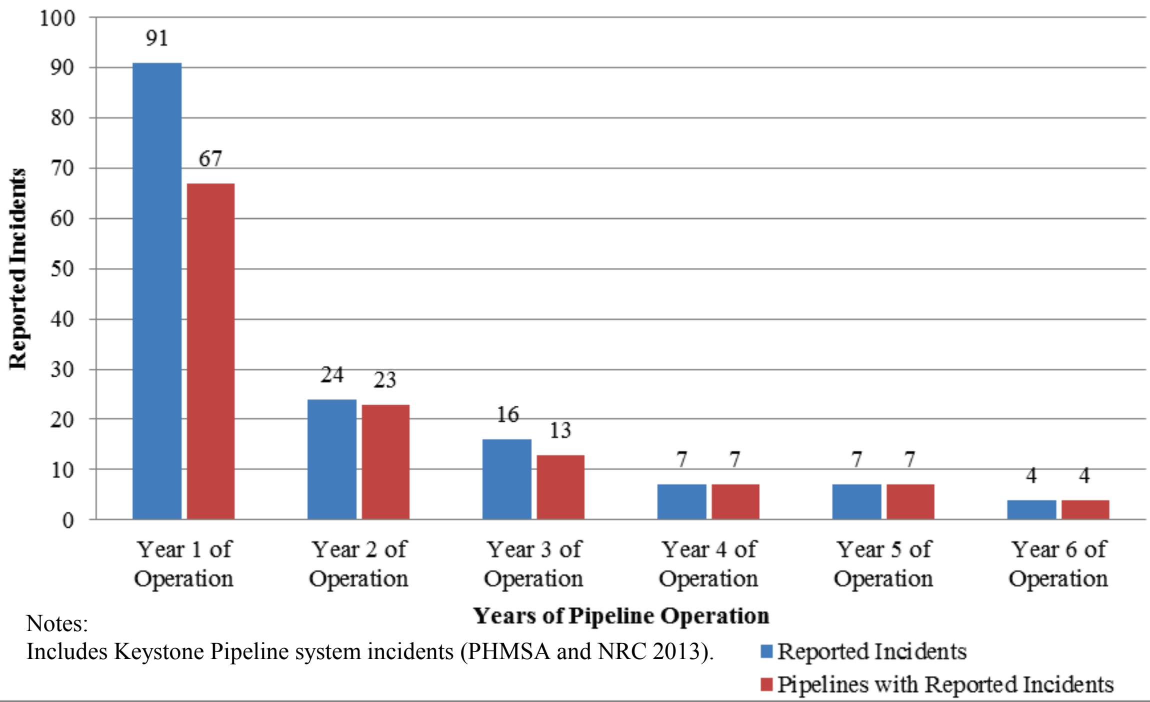


Notes: Seventy-nine other reported crude oil pipeline incidents within the first year of operation 2002-May 2013 (PHMSA). Twelve reported Keystone pipeline system incidents within the first year of operation (PHMSA, NRC). Pipeline operation was assumed to begin shortly following installation.

Figure 4.13.3-5 Failure Cause Distribution of Spills within First Year of Pipeline Operation

An additional analysis was conducted to compare the number of reported incidents for the first year of pipeline operation to subsequent years of pipeline operation. Figure 4.13.3-6 below shows the number of incidents by years of pipeline operation and the number of pipelines with reported incidents for that year of operation. Information on the total number of pipelines in service per year was not available for use in this analysis. As indicated in Figure 4.13.3-6 below, 67 pipelines, including the Keystone pipeline system, reported 91 incidents during their first year of operation, indicating that some pipelines had more than one incident during their first year

(PHMSA 2013). Of the 91 first-year incidents reported, 12 incidents related to the existing Keystone pipeline system (PHMSA and NRC 2013). In subsequent years of pipeline operation, the number of incidents compared to the number of pipelines with incidents decreases significantly from the first year of operation, as well as the number of pipelines with incidents. Since the first year of operation, only one additional incident has occurred related to the existing Keystone pipeline system (PHMSA 2013). This incident was caused by an equipment malfunction and resulted in a release less than 1 bbl that was entirely contained on the operator's property. The incident was discovered during a routine inspection of a pump station.



Notes:
Includes Keystone Pipeline system incidents (PHMSA and NRC 2013).

Figure 4.13.3-6 Reported Number of Incidents and Pipelines by Years of Operation

4.13.4 Spill Impact Assessment

4.13.4.1 Spill Volumes and Potential Impact

Potential crude or refined oil released into the environment from the proposed Project during operations may affect natural resources, protected areas, human uses, and services. Although reported information on dilbit releases is scarce in the literature, once diluents and bitumen are mixed together to form dilbit, they behave as a conventional crude oil. Therefore, this assessment focused on the impact of crude oil in general but, when applicable, evaluated the specific characteristics (i.e., viscosity) of dilbit. The degree of impact could vary depending on the cause, size, type, volume, location, season, environmental conditions, and the timing and degree of response actions. The discussion in this section presents the potential impact of three categories of spills: small, medium, and large,[14] which are defined below:

- Small spills: less than 50 bbl (2,100 gallons);
- Medium spills: greater than 50 bbl (greater than 2,100 gallons) up to 1,000 bbl (42,000 gallons); and
- Large spills: greater than 1,000 bbl (greater than 42,000 gallons) up to 20,000 bbl (840,000 gallons).

These categories were selected to be representative of the earlier Final EIS work, which used five categories; this Final Supplemental EIS reduced the categories to three to simplify the range of spill volumes provided in the PHMSA database. This simplification helps to facilitate assessing the spill-size propagation/migration along the proposed Project route.

According to PHMSA data, most small spills are related to pinhole-type corrosion leaks along the body of the pipe or by leaks from valves, flanges, pumps at pump stations, delivery type facilities, or other equipment. Medium spills are generally caused by damage from corrosion or by excavation/construction equipment damaging the body of the pipe.

The PHMSA data indicate that large spills are associated with severe damage to or complete failure of a major pipeline component (e.g., rupture in the pipe material, complete weld failures that cause pipe separation along seams or joints, third party strike).

These categories represent approximately 79 percent, 17 percent, and 4 percent, respectively, of the 1,692 crude oil spills reported[15] and capture the range of spill volumes provided in the PHMSA database, as shown in Table 4.13-1[16] and Appendix K, Historical Pipeline Incident Analysis. In addition to the volume of product spilled, the consequence of any of the above spill sizes would also be affected by response time and the response efforts. For all spills, the response time, the efficiency and effectiveness of the response actions, and the environmental sensitivity of the receptors would substantively influence the type and magnitude of impacts to environmental resources. Rapid containment and cleanup is expected to reduce surface oil spreading and potential infiltration into the ground. This Final Supplemental EIS is intended to evaluate the potential impact of the small, medium, and large spill sizes, regardless of response time and response efforts.

Potential Impact of Small Volume Spills

Small drips of oil or fluids from equipment or small, intermittent leaks of oil from flanges or gaskets to soil would typically have little effect on nearby natural resources. These types of releases would generally be detected by maintenance or operations personnel and addressed through the repair of the leak. The area impacted by this type of spill would be remediated (e.g., excavation of impacted soil, cleaning of stained concrete or containment areas, etc.) and the waste disposed, thus reducing the potential for environmental impact. Small spills of oil from a

[14] The spill sizes of *small*, *medium*, and *large* are descriptors to facilitate an analysis of spill impact. These descriptors are not intended to be a measure of potential environmental impact should a spill of these sizes occur.
[15] For crude oil spills from a pipeline 16-inch-diameter and larger, the same spill categories represented 38 percent, 36 percent, and 26 percent of the 71 reported incidents.
[16] Table 4.13-1 provides various subsets of the data with percentages based on the three spill volume sizes.

subsurface pipeline would disperse to the surrounding soil, and the oil would generally remain in the immediate vicinity of the spill site or within the pipeline ROW. A slow subsurface release, characterized as a slow drip (i.e., gallons per year as opposed to gallons per minute), would infiltrate down into soil, and could potentially reach a groundwater resource. If the rate of the spill is faster than the amount that could percolate downward through the soil, the oil may surface and potentially flow away from the release site across the ground surface, potentially affecting nearby vegetation or other resources.

While impacts to groundwater from small spills would be unlikely, a subsurface release could go undetected by both SCADA and surface inspections, resulting in impacts to permeable, sandy soils and could reach unconfined shallow groundwater resources. Chemicals in the oil could dissolve into groundwater and then migrate away from the release site. The response action to small spills or releases is generally conducted relatively rapidly once the spill/release is detected, resulting in only short-term (i.e., days to weeks) disruptions to the environment. However, small spills released directly or indirectly (e.g., via runoff from stormwater or overland flow) to lakes, rivers, reservoirs, or other potential drinking water sources as well as wetlands or natural areas could potentially impact human health and/or the environment through the contamination of drinking water supplies or oiling of vegetation or wildlife (i.e., a longer-term disruption).

Potential Impacts of Medium Volume Spills

With medium spills, a release could occur as a subsurface or surface event depending upon the cause. A slow subsurface release could infiltrate down into soil and could potentially reach a groundwater resource. Similar to a small spill, if the rate of the spill is faster than the spill could percolate through the soil, the oil could also seep to the ground surface. Once the oil reached the ground surface it would behave similarly to that of a surface release and potentially flow away from the site, affecting nearby vegetation or other resources. Once the migrating oil leaves the release site, impacts to soil, vegetation, and surface water along the flow path would occur. Some of this volume of material would tend to pool in low areas and potentially infiltrate back into the soil and to groundwater depending on the depth to groundwater. Potential behavior in shallow groundwater would be the same as for small spills that reach groundwater; a plume of chemicals could form and migrate away from the release site. Because of the increased volume of oil released from the pipeline when compared to a small release, it is also possible that oil could pool on the groundwater surface.

If the release enters flowing water or other surface water features, the extent of the release could become more widespread. Depending on the river's flow and the time to respond to the spill, the spill could potentially affect miles of river and shoreline. The same impacts to the shoreline of lakes or ponds could occur if tributaries or wind-driven currents spread the spilled material. Many of these surface water features could serve as potable water sources, and spilled material could threaten water supplies for the local population. Oiling could occur on vegetation and soil along the banks or shore of surface waterbodies. Additionally, over time, oil would degrade as well as mix with particulates in water resulting in the oil sinking below the water surface. In flowing water systems, sinking oil could be transported downstream without the obvious surface oiling of stream banks.

Wetlands and other natural areas along with their inhabitants (e.g., amphibians, reptiles, fish, and aquatic plants) could be impacted if a medium volume spill entered these ecological systems. However, compared to channelized flowing surface water systems, an oil plume within a wetlands-like environment typically would migrate slowly, oiling surface vegetation and wildlife. Additionally, impacts would not only occur from oiling of environmental features, but also from surface disturbance associated with response actions and remediation following a medium spill. Releases resulting in medium-sized spills typically would be detected by the SCADA system as well as by routine visual inspections.

Potential Impacts of Large Volume Spills

In a large land-based spill, the amount of oil contained in the immediate vicinity of the release point is dependent upon the relative size of the spill, terrain, location, soil type, weather, soil cover, and the response of operators to the release. If the spill is directly in a water source, very little of the oil released (relative to the size of the spill) would likely be contained in the immediate vicinity of the release point. The majority of the volume would migrate away from the release site, and the distribution of the oil would be influenced by the same factors as described above.

The potential impacts from a large spill would be similar to the impacts from the medium-sized spill, but on a much greater scale. More oil would seep into the soil over a larger area and could infiltrate deeper into the soil. More oil could enter surface water features and wetlands, if present in the release zone, and could also potentially affect drinking water resources to a greater extent. SCADA systems are designed to detect large volume oil releases, which are often detected by visual means, as well.

4.13.4.2 Spill Propagation

The size or extent of a spill could be affected by the terrain or topography of the release site, release setting (urban/suburban or remote), soil type and soil cover, land-based versus water-based spill, weather, and the timing and effort of the response. Understanding the effects of these factors on the oil could aid in understanding the extent of coverage and the potential impacts to humans and the environment.

Overland Flow with Infiltration to Groundwater

In the event of an undetected leak along a section of buried pipeline, the oil could saturate nearby soil and initially expand both vertically and horizontally along the pipeline. Downward movement could occur until the material reaches groundwater. At the water table, the material potentially could pool and a plume of dissolved chemicals could form. The pool of oil on the groundwater surface could continuously supply the dissolved-constituent plume, which could be carried downward away from the release site by natural flow conditions. In a scenario where a nearby operating water well is using the same groundwater resource, the dissolved chemicals could potentially be drawn to the well, exacerbating migration and potentially exposing humans, animals, and crops to the oil. Oil that moves upward to the ground surface would be noticeable. However, should the release go unchecked for an extended period of time, the oil could flow outside the proposed pipeline ROW and impact local vegetation and surface waterbodies. The oil would continue to spread until it has reached the physical limits of the volume spilled or is contained.

Overland Flow to Surface Water

The scenario discussed above has the potential to affect surface waterbodies such as streams and rivers. Once the spill reaches the surface, the oil would flow following topography or manmade structures (e.g., roads with side curbing in urban areas) and then pool in low-lying areas (i.e., topographic lows). Topographic lows could be features such as gullies, roadside drainage ditches, culverts, or storm sewers. These drainage features could eventually connect to larger ditches and possibly streams, rivers, lakes, or reservoirs. If the release enters flowing water or other surface water features, the areal extent of the release could become large. Depending on the surface water feature's flow and the spill response time, the spill could potentially affect miles of the surface waterbody and shoreline. The same impacts to the shoreline of lakes or ponds could occur if tributaries or wind-driven currents spread the spilled material. Oiling could occur on vegetation and soil along the banks or shore of surface waterbodies. It is currently understood that if oil remains on the water surface, the oil could degrade as well as mix with particulates in water, resulting in the potential for oil to sink below the water surface. In the USEPA's 1999 document entitled *Understanding Oil Spills And Oil Spill Response*, the USEPA wrote, "heavier oils, vegetable oils, and animal fats may sink and form tar balls or may interact with rocks or sediments on the bottom of the water body," and "evaporation occurs when the lighter or more volatile substances within the oil mixture become vapors and leave the surface of the water. This process leaves behind the heavier components of the oil, which may undergo further weathering or may sink" (USEPA 1999). In flowing water systems, sinking oil could be transported downstream as observed in the Kalamazoo, Michigan, spill. Sinking oil could be deposited in river or stream bottoms and could become a continual source of oil as changing water flows release the deposited oil (see Section 4.13.6.2, Safety and Spill Response, subsection Spill Response Considerations).

Degradation of Crude Oil in the Environment

Once oil is released to the environment, natural processes immediately begin to break down the oil. Many natural processes such as evaporation, biodegradation, dispersion, and dilution act upon the oil and its constituents to different degrees in soil or water. A release to subsurface soils from a buried pipeline would move throughout the nearby soil both laterally and vertically. Downward movement of oil could eventually impact groundwater resources. Crude oil that moves upward could be seen on the surface of the ground or water.

In surface soils, the constituents of the oil could be affected by evaporation, biological degradation (biodegradation), and photodegradation (i.e., degradation by ultraviolet light/sun light). The spreading and thinning of the oil increases the surface area exposed to these processes and could accelerate the degradation of the oil. Evaporation and photodegradation would generally affect the lighter hydrocarbons in the oil.

The remaining heavier, more complex hydrocarbons are typically referred to as weathered oil. This weathered oil would slowly degrade over time from biological processes. The effect these biological processes would have on the released oil would depend on the soil chemistry and the presence of suitable microbial populations.

Should oil reach groundwater or surface water, the more soluble components of oil (e.g., benzene, toluene, xylenes, among others) could dissolve in the water and form plumes that could flow away from the spill site. These dissolved plumes could continue to lengthen and spread until the all of the oil's more soluble components dissolve into the surrounding water. In groundwater, natural processes such as dispersion, dilution, and in time, biodegradation, would begin degrading the plumes. In surface waters, the oil would be diluted as it spreads across the surface in a thin sheen. Currents and wind would affect the movement of the oil. Many of the constituents of the oil sheen would evaporate due to their volatility. As these components evaporate, the oil could become heavier and sink to the bottom sediments where the oil could further degrade.

Topography of the Release Site

The topography or terrain near the spill would affect the potential impacts. Hills, valleys, low areas, and other land features could affect how a release is contained or migrates over the ground surface. A release in an area with a steep slope could accelerate the rate of oil migration and cause the spill to cover a greater area. Releases near low areas or confined valleys could pool and contain the oil and reduce aerial coverage of the release. A spill that flows into a drainage ditch or channel might flow greater distances from the release site due to the funneling of the oil in the channel as well as the slope of the channel. A spill released to level, flat ground would generally not migrate as far from the release site. Smaller drainage channels could eventually connect to larger channels, which potentially could empty to a surface water feature, thus increasing the impacts of the spill.

Effect of Location on a Spill Event

Location is a key component of the consequence of a spill. Topography has an effect, as described in the previous section, as do geomorphology and soil type for spill spreading. The location of the release relative to areas of human activity could affect the overall extent of a spill. Generally, most spills would occur and be contained within or in close proximity to the pipeline ROW or ancillary facilities (e.g., access roads, pump stations, and construction camps). Because of the larger population, urban and suburban surface spills could be noticed earlier than those in a rural setting, thus shortening the response time and mitigating the size of the impact. A spill in an urban setting generally may have different effects on human health and the environment than a rural setting.

However, excavation or construction activities occur more frequently in urban or suburban settings, increasing the chances of pipeline damage and a release. Generally, prompt reporting of the damage by the contractor would decrease the duration and size of the release in an urban or suburban setting, although the potential impact of the release could be greater depending upon the population associated with the urban/suburban area.

In remote areas, small spills may not be discovered immediately, and a small, slow release may not be detected immediately by leak monitoring systems; this could potentially allow a spill to continue for an extended period of time. In remote areas, it is possible that potential impacts from a larger spill could be less than those from a smaller, urban-type spill due to a reduced number of receptors.

The locations of greatest concern for potential oil spills are urban settings, HCAs, and other receptors within the reach of the spill. Water intakes for public drinking water or commercial/industrial users, Unusually Sensitive Areas, wetlands, flowing streams and rivers, and similar critical habitats are particularly important.

Battelle and E[x]ponent discuss in their respective reports (Leis et al. 2013, McSweeney et al. 2013, and E[x]ponent 2013) specific sections of the proposed Project referred to as contributory pipeline segments (CPSs) where, if a spill were to occur, crude oil has the potential to reach HCAs (i.e., *could affect* segments). The researchers applied a process ranking to identify the segments of the pipeline that could potentially affect HCAs, and categorize identified CPSs; the ranking process identified approximately 64 miles of the pipeline (consisting of nine CPSs) with the higher risk ranking. These segments were associated with major river crossings. Pipeline segments potentially affecting HCAs and the risk ranking process used to determine a degree of the potential risk for specific pipeline segments are discussed in more detail in E[x]ponent's Environmental Review, Section 2.5 (E[x]ponent 2013).

4.13.4.3 Effect of Soil Type, Soil Cover, and Temperature on Flow

Ground conditions and temperature could affect the size of the area affected. Ground conditions reduce spill extent by friction, which slows the movement of the oil. Two key types of ground conditions are addressed here, soil type and soil cover. Temperature also affects spill propagation by reducing spreading in colder temperatures or increasing the potential for spreading in warmer temperatures.

Soil Type

The type of soil at the site of the release affects the spread of the spill. Sands and gravels have larger spaces between the particles of soil (pore size), which could increase the upward or downward movement of the oil. Clays and silts have much smaller pore sizes and do not allow the oil to move as much. A spill of equal volume on sandy soils would tend to penetrate deeper because clays and silts allow much less downward movement. In some areas along the route, a spill may potentially penetrate through the sandy soils and impact groundwater resources. The extent of spills of equal volume would be affected by the type of soil on which the release occurred. Because spills tend to move downward in sandy soil, there are generally fewer impacts on the surface, depending on the size of the spill. The reverse is true with clay soils. In areas with a rocky surface, spills would tend to cover the rocks (known as oiling) and pool between the individual rocks.

The moisture content of the soil would influence the spill. In wet or saturated soil, the pores between the soil particles are partially or completely filled by water, leaving little or no room for the less dense oil to move downward. The lack of downward movement in this case generally would lead to a spill covering a larger surface area.

Soil Cover

The surface over which the oil spreads could affect the extent of the spill. Soil covers could include grasses, saturated ground (e.g., wetlands and related vegetation), forests, and hardscape (e.g., concrete, asphalt). Different soil covers retain different amounts of oil. As a spill spreads over land, the oil adheres to dry surfaces. Because saturated soils are less susceptible to downward movement of the oil, they tend to allow the oil to flow over the ground surface. As the oil flows over the ground surface, it would coat vegetation (oiling). The surface area of the impacted plants and the amount of oil retained would affect the overall extent of the spill. Where the oil flows into forested areas, shallow root zones may act as conduits and allow the oil to penetrate deeper into the soil. The oiling of hardscapes (e.g., concrete, asphalt) would tend to be surficial, except where expansion joint seams, cracks, or other deformities in the cover's surface exist. Cracks and joints in roadways could allow the oil to reach the potentially more permeable underlying soils and increase the depth of the impact.

Temperature

The temperature at the time of a spill could influence the extent of the spill. Temperature of dilbit is comparable to a heavy, sour crude oil. Due to friction created by the pumping action of the pipeline system, product would be transported through the pipeline at temperatures between 120°F (50 degrees Celsius [°C]) and 150°F (65°C). Ambient temperatures less than 120°F (50°C) would influence the spill by making the oil less apt to flow. In cold weather, dilbit would be far less mobile in the environment and may behave more like a solid (tar- or putty-like) than a liquid, potentially limiting the impacts and extent of a release to the environment.

Typically the areas traversed by the proposed pipeline experience very cold winters, which would limit the extent of a release during the colder months. The lower outside temperature would cool the product and increase its viscosity. This could inhibit the oil's ability to flow and limit the extent of coverage. Should a release occur in extremely cold conditions, the potential impacts would be further limited as the product would cool very quickly and behave more like a tar- or putty-type material and would not be able to flow. Conversely, the potential impacts of a release during the summer could increase due to the higher summer temperatures. The higher outside temperature would allow the oil to stay fluid longer. Generally, the cooling process is expected to take longer in the summer and could allow the oil to flow more readily. In the summer, surface temperatures (particularly on roadways and other surface covers where temperatures could approach the oil's transport temperature) could allow the oil to continue to flow over land until the source is interrupted. Average maximum summer temperatures in the states traversed by the proposed pipeline range from 75°F (24°C) in Montana to over 90°F (32°C) in Nebraska (NOAA 2013).

4.13.4.4 Types of Spill Impact

There are three types of spill impacts that could affect the spill receptors: physical impacts, chemical and toxicity impacts, and biological (ecological) impacts.

Physical Impacts

Physical impacts of spills of crude oil or petroleum products to natural resources and human uses typically result from physical oiling of soils, sediments, plants, animals, or areas used by people or from fire or explosion.

Oiling

Oiling could affect both wildlife and the physical environment in which they live. The following are common oiling effects:

- Smothering living plants and animals so they cannot feed or obtain oxygen;
- Coating feathers or fur on animals, which reduces insulating efficiency and results in hypothermia;
- Adding weight to the plant or animal so that it cannot move naturally or maintain balance;

- Coating sediments and soils, which reduces water and gas (e.g., oxygen and carbon dioxide) exchange and affects subterranean organisms (e.g., insects);
- Oiling sediment and soils such that they could become a chronic source of oil and its dissolved constituents;
- Oiling livestock, crops, clothes, water-based recreational equipment, pets, and hands/feet; and
- Oiling beaches, water surfaces, wetlands, and other resources used by people, which may result in nuisance odors and visual impacts.

In aquatic areas with high energy (e.g., turbulent river flows, and/or high sediment deposition), the oil may become buried under or mixed beneath stream sediment and soil along stream banks, where it may be trapped and remain for extended periods of time. This buried oil may later be slowly released from the sediment or soil to the environment to re-oil downstream habitats and resources. In some cases, the buried oil could be in an environment without oxygen (anaerobic) and would resist weathering by physical or biological processes, providing a source of nuisance discharges to the environment over several years.

Fire or Explosion

The PHMSA database for significant onshore hazardous liquid incidents indicates that since 2002, six of 3,916 (0.15 percent) reported incidents were attributed to fire. These six incidents were related to the release of flammable hydrocarbons, such as gasoline or liquid propane. Two of the incidences involved a subsequent release of crude oil (one less than 1 gallon and the other less than 10 gallons).

Crude oil is a flammable product; however, the appropriate concentrations of flammable vapors from the oil and oxygen would need to be available in the presence of an ignition source for a fire to occur. Oil spills released to confined areas (e.g., storm sewers and possibly some below ground spills) could potentially generate a sufficient concentration of flammable vapors and ignite. However, the flammable vapors released from a spill in an open environment would likely be dispersed throughout the surrounding area or diluted by the wind and not reach the concentration necessary to cause a fire or explosion. Very low oxygen levels and the lack of an ignition source inside a closed pipeline make it very unlikely for an explosion or fire to occur.

The pump stations for the proposed Project would be powered by electricity, although emergency generators would have integrated fuel tanks. As a result, there would not be natural gas or large quantities of other flammable fuel at the facilities. A crude oil spill at a pump station would likely result in the emission of some hydrocarbon vapors. In such cases, the vapors would typically emit into open atmosphere and be diluted to below explosive limits. Explosions at a pump station could potentially occur due to a fire unrelated to the pipeline such as at generator fuel tanks or local storage tanks.

Chemical and Toxicological Impacts

Toxicological impacts resulting from petroleum releases are a function of the chemical composition of the oil, the solubility of each class of compounds, and the sensitivity of the receptor. The chemical and toxicological characteristics of dilbit, SCO, and diluent are within the range for crude oils. Most crude oils are more than 95 percent carbon and hydrogen, with small amounts of sulfur, nitrogen, oxygen, and traces of other elements. Crude oils contain lightweight straight-chained alkanes (e.g., hexane, heptane); cycloalkanes (e.g., cyclohexane); aromatics (e.g., benzene, toluene); and heavy aromatic hydrocarbons (e.g., polycyclic aromatic hydrocarbons [PAHs], asphaltines). Straight-chained alkanes are more easily degraded in the environment than branched alkanes. Cycloalkanes are extremely resistant to biodegradation. Aromatics (i.e., benzene, toluene, ethylbenzene, and xylene compounds) pose the most potential for toxic impacts because of their lower molecular weight, making them more soluble in water than alkanes and cycloalkanes.

Toxicity to Environment

Toxicological impacts are the result of chemical and biochemical actions of petroleum-based compounds on the biological processes of individual organisms (API 1997, Muller 1987, Neff 1979, Neff and Anderson 1981, Neff 1991, Stubblefield et al 1995, Sharp 1990, Taylor and Stubblefield 1997). Impacts may include: various toxic effects to animals and birds as they try to remove the oil from their fur or feathers; direct and acute mortality; sub-acute interference with feeding or reproductive capacity; disorientation/confusion; reduced resistance to disease; tumors; reduction or loss of various sensory perceptions; interference with metabolic, biochemical, and genetic processes; and many other acute or chronic effects. A description of toxicological effects of petroleum to both human and natural environment receptors is presented in Section 4.0 of the *Pipeline Risk Assessment and Environmental Consequence Analysis* (see Appendix P, Risk Assessment).

While lightweight aromatics such as benzene are highly volatile, they tend to be water soluble and relatively toxic. Most or all of the lightweight hydrocarbons accidentally released into the environment evaporate, and the environmental persistence tends to be low. Monitoring for benzene is typically performed after a large spill. High-molecular-weight aromatic compounds, including PAHs, are not very water soluble, could be retained in soil, and persist in the environment longer than the lightweight aromatics such as benzene. Consequently, these compounds, if present, are substantively less mobile and toxic than more water-soluble compounds (Neff 1979). The concentration of any crude oil constituent in a spill would vary both over time and distance in surface water; however, localized toxicity could occur from virtually any size of crude oil spill.

In addition, these compounds generally do not accumulate in vegetation to any great extent because they are rapidly metabolized by plants (Lawrence and Weber 1984; West et al.1984). There are some indications, however, that prolonged exposure to elevated concentrations of these compounds may result in a higher incidence of growth abnormalities in aquatic organisms (Couch and Harshbarger 1985).

Significantly, some constituents in crude oil, such as PAHs, may remain in the environment longer than lightweight compounds (e.g. benzene). These constituents are generally less mobile through soil and less toxic than other more soluble compounds. Based on the combination of toxicity, solubility, and bioavailability, benzene was determined to dominate toxicity associated with potential crude oil spills.

The toxicity of crude oil is dependent on the toxicity of its constituents. Acute toxicity refers to the death or complete immobility of an organism within a short period of exposure. Most investigators have concluded that the acute toxicity of crude oil is related to the concentrations of relatively lightweight aromatic constituents, particularly benzene. Because the diluted bitumen crude oils have a significant amount of lighter hydrocarbons added, they tend to have higher benzene concentrations than many other heavy oils (such as Mexican Maya and Venezuelan Bachaquero), but lower than many light crude oils (such as Brent Blend or Alaska North Slope) (Environment Canada 2011). Benzene concentrations of SCO and dilbit are discussed further in Section 3.3 of E^{x}ponent's Environmental Review (E^{x}ponent 2013).

Chronic toxicity values on freshwater plant and animal species most frequently represent levels at which concentrations result in reduced reproduction, growth, or weight due to benzene. Chronic toxicity from other oil constituents may occur if sufficient quantities of crude oil are continually released into the water to maintain elevated concentrations. Additional biological and ecological impacts may manifest in local populations, communities, or entire ecosystems depending on the location, size, type, season, duration, and persistence of the spill, as well as the type of habitats and biological resources exposed to spilled oil.

Birds typically are among the most affected wildlife if exposed to the chemical and toxicological effects of an oil spill, whether it is on land or on water (Holmes 1985, Sharp 1990, White et al. 1995). In addition to the potential for external oiling of the feathers and hypothermia or drowning due to loss of flotation, birds may suffer both acute and chronic toxicological effects. Birds are likely to ingest oil as they preen their feathers in an attempt to remove the oil. The ingested oil may cause acute liver, gastrointestinal, and other systemic impacts resulting in mortality, reduced reproductive capacity, loss of weight, inability to feed, and similar effects. Oiled birds that are nesting or incubating eggs may, in turn, coat the eggs or young with oil. Oiled birds may be scavenged by other birds as well as mammals.

Fish and aquatic invertebrates could also experience toxic impacts of spilled oil, and the potential impacts would generally be greater in standing water habitats (e.g., wetlands, lakes, and ponds) than in flowing rivers and creeks. Also, in general, the potential impacts would be lower in larger rivers and lakes and much lower under flood conditions since the toxic hydrocarbon concentrations would likely be diluted by the water relatively rapidly.

Crude oil released into an aquatic environment could sink to the bottom of the water column and coat the benthic substrate and sediments (see Section 4.13.5, Potential Impacts). Crude oil intermixed with sediment, trapped in the river bed or on an oiled shoreline would result in a persistent source of oil due to the slow rate of degradation of crude oil in these environments. While the sinking characteristic is true for all crude oil types it is more prevalent in heavy crude oil. Dissolved components of the crude oil such as benzene, PAHs, and heavy metals could be slowly released back to the water column for many years after the release. The dissolved components (e.g., benzene, PAHs, heavy metals) could allow for long term chronic toxicological impacts to many organisms (e.g., macro-invertebrates) in both the benthic and pelagic portions of the aquatic environment.

In aquatic environments, toxicity is a function of the concentration of a compound necessary to cause toxic effects combined with the compound’s water solubility. For example, a compound may be highly toxic, but if it is not very soluble in water, its toxicity to aquatic biota is relatively low.

The physical and chemical impact processes described previously are manifested at the organism level. Additional biological and ecological impacts may manifest in local populations, communities, or entire ecosystems depending on the location, size, type, season, duration, and persistence of the spill, as well as the type of habitats and biological resources exposed to spilled oil. Except for some endangered, threatened, or protected species and their habitat, loss of a few individuals of a larger population of organisms would result in a minimal impact at a community or ecosystem level. On the other hand, reproductive impairment caused by toxicity could reduce an entire population or biological community, resulting in a significant environmental impact. The potential impact is likely to be greater if the species affected have long recovery times (e.g., low reproductive rates, adverse genetic mutations); limited geographic distribution in the affected area; are key species in the ecosystem; are key habitat formers (those animals that substantially contribute to the formation of an environment); or are otherwise a critical component of the local biological community or ecosystem. Furthermore, if the species or community is a key recreational or commercial resource (e.g., tourist draw, hunted resource), biological impacts manifested at the population or community level may constitute a significant impact to human uses of the resource.

Human health could be affected due to exposure to crude oil and the hazardous chemicals that make up crude oils. Exposure to crude oil could occur through ingestion, inhalation of vapors, dermal (contact with skin), and ocular exposure (contact with surface of the eye). Short-term exposure effects due to each of these pathways are discussed in Section 3.13.5.1, and could include mild stomach and gastrointestinal tract disturbances, transient nausea, diarrhea, irritation of the respiratory system, eye irritation, and mild to moderate skin irritation depending on the amount and duration of exposure. Long-term exposure effects of crude oil are currently not wholly understood; however, most research indicates that effects would be similar to the long-term effects of the chemicals that make up crude oil including, but not limited to, benzene, toluene, ethylbenzene, xylene, hydrogen sulfide, and polycyclic aromatic hydrocarbons. Long-term exposure effects of these chemicals are discussed in Section 3.13.5.1, and could be seen in people who were directly interacting with crude oil for extensive periods of time (i.e., spill cleanup professionals). Human health effects from exposure to elevated level of hydrogen sulfide (H_2S) depend on the concentration of the gas and the length of exposure. In an assessment of risk to first responders at crude oil spill sites, Thayer and Tell (1999) modeled atmospheric emissions of H_2S from crude oil spills. Model results indicate that even under worst-case conditions (no wind), modeled concentrations drop to non-toxic levels in less than 4 minutes after oil leaves the pipeline and is exposed to air, assuming no further release of oil. H_2S exposure is expected to be highest where oil has been spreading for the first 4 minutes immediately after discharge from the pipeline (adjacent to the pipeline and within the ROW). The Thayer and Tell modeling effort suggests that exposure to H_2S concentrations could pose health risks in the immediate area of an ongoing release or source.

Identification of Potentially Affected Spill Receptors

Spill impact was evaluated by developing distance buffers from the proposed Project route. A distance buffer is the zone where potential exposure from a spill could occur, considering a safety factor built-in such that the buffer distance is much greater than would reasonably be expected for an actual spill. This methodology assists in screening potential receptors at a general level. Site-specific impacts cannot be addressed at this stage because specific pipeline design elements are not available. Buffers are based upon data provided in the Final EIS, technical comments by third parties, and the screening model work described below. This screening model work was performed to supplement the information in the Final EIS because of the significant public interest in the issue. A summary of the Final EIS buffers and the buffers developed as part of this work is shown below in Table 4.13-13.

Table 4.13-13 Spill Impact Buffers

Buffer Type	Impact Buffer Size	Basis for Buffer Size
Surface Waterbody (downstream distance)	10 miles	Final EIS, Third-Party Comment
Stream Crossing (width)	500 feet	Final EIS
Surface Water Drinking Water Resources	5 miles	Final EIS
Well Head Protection Area	State-specific	Final EIS, Third-Party Comment
Overland Spill (50 bbl)	112 feet	Screening Model
Overland Spill (1,000 bbl)	367 feet	Screening Model
Overland Spill (20,000 bbl)	1,214 feet	Screening Model
Dissolved-phase Flow (50 bbl)	640 feet	Screening Model
Dissolved-phase Flow (1,000 bbl)	820 feet	Screening Model
Dissolved-phase Flow (20,000 bbl)	1,050 feet	Screening Model

The screening modeling estimates that oil could spread on flat ground between 112 and 1,214 ft from the pipeline, depending on the volume spilled. If oil reached groundwater, screening modeling indicates that the components in the oil, such as benzene, could spread in groundwater between 640 to 1,050 ft downgradient of the spill point. Similarly, if oil accumulated on groundwater, then these dissolved phase components of oil could spread an additional 640 to 1,050 ft from the edge of the oil (i.e., farther from the release point, potentially as far as 2,264 ft based on modeling) and because of the limited extent would not affect an entire aquifer such as the Ogallala Aquifer (see Figure 4.13.4-1). Screening modeling also indicates that the three spill volumes could reach groundwater at a depth of 50 ft (15 meters). Larger volumes could be expected to reach groundwater deeper than 50 ft bgs. This approach assists in identifying potentially affected receptors by identifying those receptors that are within the buffer limits. For an irrigation well, as an example, if a well is within 820 ft of a pipeline ROW it could potentially be affected by a 1,000 bbl spill that impacted groundwater. Similarly, the pipeline could affect a stream if a 50 bbl spill occurred within 612 ft of a river bank (500-ft buffer for the creek plus 112 ft for an overland spill).

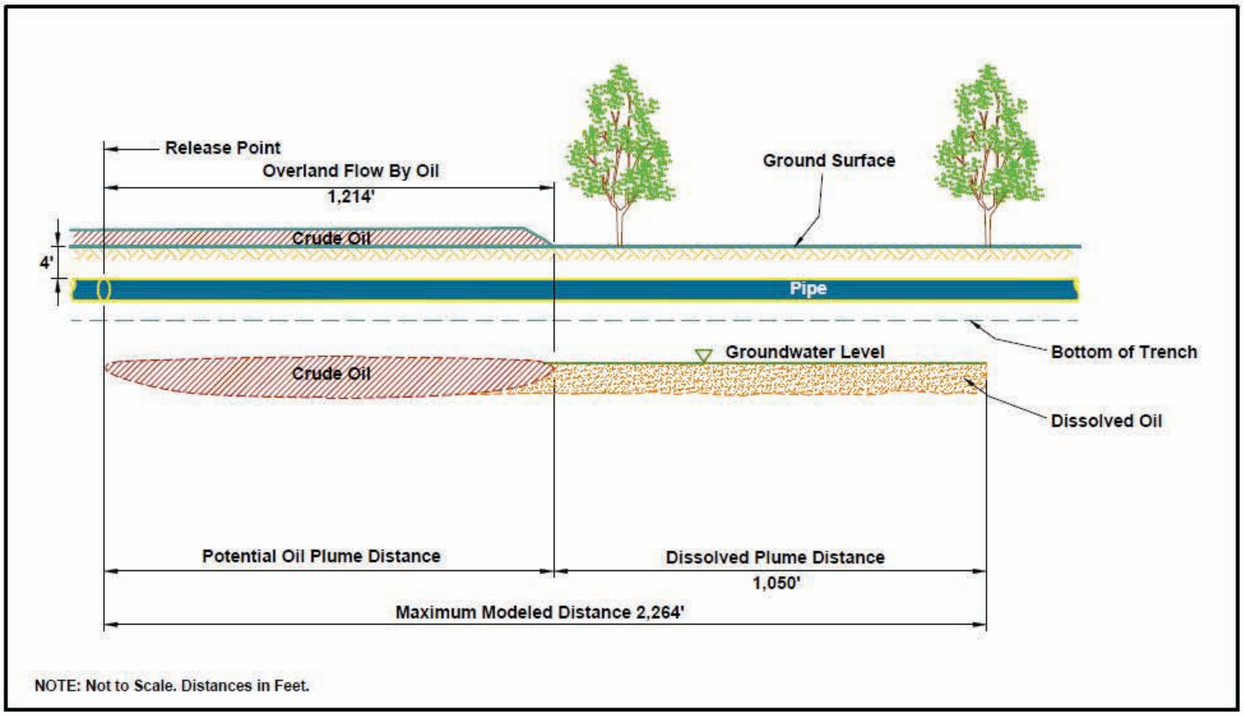


Figure 4.13.4-1 Modeled Maximum Plume Distances

The assumptions used for the screening model were conservative to build in an additional factor of safety. Model results show that the spill impact distances used in the Final EIS exceed those that resulted from the modeling herein; accordingly, the Final EIS concluded a degree of impact to the environment and to sensitive receptors that would likely be higher than expected under actual conditions.

Independent spill modeling was conducted by E^{x}ponent to determine quantitative estimates of the potential transport of oil to groundwater as well as transport over land. E^{x}ponent's modeling results are consistent with the screening model discussed above and are included in Section 4.0 of E^{x}ponent's Environmental Review (E^{x}ponent 2013).

Development of Spill Buffers

Section 4.3 of E^{x}ponent's Environmental Review (E^{x}ponent 2013) used PHMSA-defined HCAs within specified distances of the pipeline to assess potential impact. Several types of HCAs were considered such as populated areas and unusually sensitive ecological areas, which include drinking water protection areas. In addition to the HCAs, the Final EIS identified buffers for surface waterbodies, stream crossings, and surface water drinking water resources. These buffers are designated by each state’s source water protection program or their wellhead protection program, and the buffer sizes vary from state to state. An additional 500 ft on either side of a stream crossing was added for stream crossing buffers based on the Final EIS Risk Assessment (see Appendix P, Risk Assessment). Doing so overestimates the calculated risk of the stream crossing to better highlight the potential threat to a waterbody. Additionally, to assess downstream effects from a release at a stream crossing, a 10-mile buffer was used to aid in identifying the presence of sensitive receptors or HCAs along that stream reach.

PHMSA identifies certain surface water and groundwater resources as drinking water Unusually Sensitive Areas (49 CFR Parts 195.6 and 195.450). Surface water Unusually Sensitive Areas include intakes for community water systems that do not have an adequate alternative drinking water source. Groundwater Unusually Sensitive Areas include the source water protection area for community water systems that obtain their water supply from a potable Class I or Class IIA aquifer and do not have an adequate alternative drinking water source. A Class I Aquifer is shallow, permeable, and highly vulnerable to contamination. A Class IIA Aquifer is a high-yield bedrock aquifer that is consolidated and moderately vulnerable to contamination. If the source water protection area has not been established by the state, the wellhead protection area becomes the Unusually Sensitive Area. Surface water Unusually Sensitive Areas identified for their potential as a drinking water resource have a 5-mile buffer placed around their intake location. The groundwater Unusually Sensitive Areas have buffers that vary in size due to site-specific characteristics that could include hydrogeology, annual pumping rates, and local standards. Overland Flow and Groundwater Dispersion

The screening-level approach used in this Final Supplemental EIS evaluates potential receptors along the proposed Project route that could be affected by a spill. Establishing discrete site-specific scenarios or site-specific conditions for the entire length of the pipeline is beyond the scope of this evaluation. By identifying reasonable distances that spill volumes could travel overland or that dissolved-phase plumes could migrate in groundwater, the potential for impact to a receptor could be assessed. Spill volumes were assessed for overland spreading, impact to groundwater, and the resulting dispersion in groundwater of the dissolved-phase constituent benzene. This evaluation uses spill volumes of 50 bbl, 1,000 bbl, and 20,000 bbl and is consistent with spill sizes as described in Section 3.13.6, Spill Magnitudes, and shown in Appendix K, Historical Pipeline Incident Analysis. This evaluation is intended as a screening approach and is not intended to predict the actual spill fate and transport for every condition along the pipeline route. The approach used for screening is described below and the methodology is described in Appendix T, Screening Level Oil Spill Modeling.

Overland Flow

Overland spreading was evaluated by calculating the area of potential impact for each of the identified spill volumes (50 bbl, 1,000 bbl, and 20,000 bbl) using a formula proposed by Grimaz et al. (2007). The model proposed by Grimaz et al. was developed as a simplified technique for predicting the maximum potential oil seepage depth into soil immediately after a release. As part of this model, Grimaz et al. proposed a simplified predictive formula derived from gravity current theory to predict the extent of surface spreading after a release. This part of the model was used for the overland flow calculation. The overland flow estimation using Grimaz et al. was based on a heavy crude oil (see Appendix T, Screening Level Oil Spill Modeling). Based on the approach by Grimaz et al., a light oil would result in a larger overland flow distance than would a heavier oil. This formula calculates the area of an instantaneous release of oil onto a surface. The calculated areas were used to derive the radial distance a spill would travel on a smooth, flat surface. These distances were added perpendicular to the centerline of the proposed Project route to assess possible impacts to receptors.

Groundwater Dispersion

The USEPA's Hydrocarbon Spill Screening Model (HSSM) was used to calculate the extent of the dissolved phase plume. HSSM is a practical approximation tool to estimate contamination levels for uses related to emergency response, initial phases of site investigation, facilities siting, and underground storage tank programs (Weaver et al. 1994). HSSM is not suitable for application to heterogeneous geological formations and is intended to provide order-of-magnitude estimates of contamination levels only. The model was developed for light nonaqueous-phase liquid and is not suitable for denser-than-water nonaqueous-phase liquids (dense nonaqueous-phase liquids) as the light nonaqueous-phase liquids are assumed to *float* on the water table for modeling purposes. In addition, the model is not designed to address dynamic conditions such as fluctuating groundwater, changing gradient, or specific design conditions such as pipeline trench systems or pressurized leaks from a pipeline.

HSSM simulates the flow of a light nonaqueous-phase liquid (e.g., oil) and the transport of a chemical constituent of the oil (in this case benzene) from the surface to groundwater. Should the simulation lead to an impact to groundwater, HSSM simulates the oil spreading at the water table and the dispersion of a dissolved benzene plume in groundwater. To evaluate potential impact to a shallow aquifer, groundwater was assumed to be 0.3 meter (1 foot) below the base of a spill. Hydrologic parameters used in the model for permeable sands were based on Carsel and Parrish (1988). In an additional model simulation, input parameters for the model were modified (e.g., aquifer hydraulic conductivity and porosity, benzene concentration, and crude oil viscosity) for a high-level sensitivity evaluation to simulate the likely lower/upper limits for dissolved plume length that might occur for a 50 bbl and a 20,000 bbl spill. The range of dissolved-phase spill plume lengths under these conditions was between 180 ft (55 m) and 1,608 ft (490 m); however, to achieve these distances, parameters unrepresentative of the soil type along the length of the pipeline were needed. This sensitivity evaluation assisted in assessing those parameters that drive plume length in the model, identifying the magnitude of a dissolved plume, and obtaining reasonable and likely parameters that can maximize dissolved plume length. Reasonable and likely maximum spill impact buffers, based on parameters representative of soil types along the pipeline, are shown in Table 4.13-13, with dissolved-phase plume length ranging from 640 ft (195 m) to 1,050 ft (320 m). Parameters along with their sources that were used to develop these reasonable and likely maximum spill impact buffers are presented in Table 4.13-14 below.

Table 4.13-14 Summary of Key Input Values Used in HSSM Simulation[a]

Parameter	Input Value[b]	Source
Hydrologic Properties		
Depth to Groundwater (m)	0.3	
Horizontal Hydraulic Conductivity (m/d)	15	Gutentag et al. 1984; Stanton 2010
Vertical Hydraulic Conductivity (m/d)[c]	1.5	
Porosity (vol%)	15	Stanton 2010
Hydrocarbon Phase Properties[d]		
Viscosity—Dilbit (cP)[e]	325	Leis et al. 2012
Density—Heavy Crude Oil (g/cm^3)	0.93	exp Energy Services, Inc.2012; Attanasi and Meyer 2007; Enbridge 2011a
Benzene Concentration—Light Crude Oil (vol%)[f]	0.28	exp Energy Services, Inc.2012; Section 3.13, Potential Releases

[a] Input values used were representative values for the geology along the proposed Project route, except for depth to groundwater, which was selected to address immediate impact.
[b] % = percent; cP = centipoises; ft/d = feet per day; g/cm^3 = grams per cubic centimeter; m = meter or meters; m/d = meter per day
[c] Assumed 1/10th of Horizontal Hydraulic Conductivity
[d] These hydrocarbon phase properties represent the range of possible products being transported through the pipeline and are selected to increase the dissolved benzene plume length.
[e] The high-end viscosity of dilbit was used to provide a larger plume size.
[f] Light crude oil was used since it has a higher benzene content than heavy crude oil or dilbit.

Degradation of oil could occur through weathering, which chemically and physically causes the spilled oil to break down and potentially become heavier than water. In open water, the oil could then sink into the water column. When oil mixes with water and oxygen, water-soluble compounds from the oil spread into the water. As the oil loses the water-soluble compounds, the oil becomes dense, sticky tar balls. Also, as oil moves with water, particles in the water such as sand, clay, and plant matter stick to the oil, increasing the oil's density. Examples of oil sinking are found for open water (e.g., lakes) and in rivers and streams. At present, there are no readily available studies indicating that degradation of oil in soil would convert into a dense liquid, reach groundwater, and sink through an aquifer. However, if the oil did degrade below the ground surface, as it degraded the oil would become sticky (increased interfacial tension), reducing the mobility of the oil.

The results of the HSSM simulations were used to identify reasonable benzene concentrations at the source from infiltrating oil, and the distances the dissolved-phase benzene plume would migrate toward potential receptors. The model results show a spill could reach groundwater in all spill volume scenarios (e.g., 50 bbl, 1,000 bbl and 20,000 bbl) and migrate toward downgradient receptors. The configuration for the model is addressed further in Appendix T, Screening Level Oil Spill Modeling. The model was configured to assume groundwater was 1 foot (0.3 meter) below the spill source. It was also assumed that a small and medium plume would continue undetected for 6 weeks (detection by second flyover) and large leaks would be detected immediately by the SCADA. The area of infiltration was based on one-half of the overland flow distance calculated using Grimaz et al (2007). Table 4.13-15 below summarizes the axial length of surface and dissolved-phase benzene plumes developed for each of the spill volumes assessed. These were the buffer distances perpendicular to the pipeline used to identify potential impact to receptors.

Additionally, a high-level sensitivity analysis was conducted using the same parameters above. This analysis determined that the three spill volumes assessed could affect groundwater encountered at a depth of at least 50 ft (15 meters) bgs. The results in Table 4.13-15 are consistent with the results from E^{x}ponent 2013.

Table 4.13-15 Length of Potential Plumes

	50 bbl	1,000 bbl	20,000 bbl
Surface Plume Length in feet (meters)[a]	112 (34)	367 (112)	1,214 (370)
Dissolved-phase Benzene Plume Length in feet (meters)	640 (195)	820 (250)	1,050 (320)

[a] Calculated from the formula proposed by Grimaz et al. 2007

The dissolved-phase plume length of crude oil constituents, such as benzene, stabilizes in groundwater due to a balance of several natural attenuation processes that degrade and dilute the crude oil dissolved components. These processes include biodegradation, evaporation, rate of dissolved components mixing with water, the affinity of the dissolved components to bind with the soil matrix, and the rate of fresh water entering the plume area.

Contaminants Not Found in Crude Oil

Crude oil constituents can be compared against other constituents not found in crude oil, such as chlorinated hydrocarbons, which can sometimes spread over large distances due to the persistent nature of the dissolved components. These persistent plumes often are confused with the non-persistent plumes such as benzene found in crude oil. The following are two examples of persistent plumes:

- Former Nebraska Ordinance Plant Mead, Saunders County, Nebraska; and
- Former Cornhusker Army Ammunition Plant (CHAAP), Hall County, Nebraska.

From 1959 to 1960, reported information suggests that trichloroethylene (TCE, a synthetic, degreasing solvent) was released as ground spills and/or discharged into surface drainage features during the construction of the Atlas Missile facility at the Former Nebraska Ordinance Plant Mead, Saunders County, Nebraska. Other reported historical site information suggests that parts were cleaned with TCE in a laboratory and the used TCE was discharged into a sewer. In 1992, over 30 years after disposal, the U.S. Army Corps of Engineers began a groundwater investigation and discovered a TCE-contaminated groundwater plume extending over 27,000 ft (5 miles) downgradient of the facility. Other groundwater contaminants detected included explosives and metals.

The former CHAAP, which was owned by the U.S. Army, was built in 1942 to produce munitions and provide support functions during World War II. As a consequence of common disposal practices during wartime, groundwater was impacted by explosives. Groundwater containing explosive residue migrated from cesspools and leach pits located in the center of the plant approximately 2 miles beyond the CHAAP boundary into the Grand Island City limits. In 1994 (over 50 years since plant construction), the groundwater plume was 6 miles long and 0.5-mile wide. Other chemical materials used to support munitions production at CHAAP included Freon, paints, grease, oil, and solvents. Solvents reportedly used at CHAAP included acetone, TCE, and 1,1,1-trichloroethane.

4.13.5 Potential Impacts

4.13.5.1 Consequence on Receptors

The magnitude of oil spill impact is primarily a function of size of the spill, type of oil, and sensitivity of the receptors affected (API 1992; API 1997; National Research Council 1985, 2003a, 2003b). Variations in spill size and receptor type are key variables for estimating the consequence of oil spills from the proposed Project. The risk analysis conducted by Battelle Memorial Institute, which uses incident damage cost in dollars as a measure of consequence for a risk assessment of the proposed Project, found that consequence and spill volume are correlated (Battelle 2013. Spill damage costs used as a measure of consequence on receptors are affected by many factors, including spill volume.

The crude oil that would be transported by the proposed Project would primarily consist of dilbit and SCO. Information on the chemical characteristics of these crude oils is provided in Section 3.13.3, General Description of Proposed Pipeline Transported Crude Oils, Table 3.13-1. Spill volume categories used in this impact assessment are presented in Section 4.13.4.1, Spill Volumes and Potential Impacts.

Receptor sensitivity is subjective and the perception of sensitivity can be influenced by the perspectives and biases of evaluators, as well as the actual sensitivity of the receptors to the oil. For example, a farmer whose grain field is oiled could consider impacts to a crop more significant than spill-related impacts on a wetland that supports threatened and endangered species, recreational hunting, and other recreational opportunities. Conversely, a national wildlife refuge manager could evaluate relative impacts very differently. In addition, different receptors could have different sensitivities to a specific compound such as benzene. Fish could be more sensitive to low levels of benzene, whereas crops or mammals could be more tolerant of high concentrations of the same compound. In many oil spills, there are differences in the way that stakeholders (e.g., general public, non-governmental organizations, natural resource management agencies, regulatory agencies, enforcement agencies, private businesses, municipal agencies, and others) value spill-related impacts on natural resources and habitats compared to spill-related impacts on human uses.

The severity of an impact to a receptor from a spill could be described as a function of spill size and receptor sensitivity. Severity generally increases as spill size increases and as receptor sensitivity increases. Table 4.13-16 presents, for each of three representative types of receptors and for each of the three spill sizes, various descriptions of impacts to the receptor, and the qualitative severity levels (low, medium, high) that correspond to these descriptions. The severity levels are based on a subjective evaluation using experience from previous oil spills. This presentation allows for a general assessment of the risk to certain environmental receptors should a spill occur.

Table 4.13-16 Potential Impact to Three Representative Resources[a]

	Resource	Potential Frequency			Resource	Potential Frequency			Resource	Potential Frequency		
	Wildlife and Terrestrial Habitat	**Small Spill**	**Medium Spill**	**Large Spill**	**Water, Wetlands, Aquatic Habitat/ Organisms**	**Small Spill**	**Medium Spill**	**Large Spill**	**Land use**	**Small Spill**	**Medium Spill**	**Large Spill**
Increasing Resource Severity →	Complete loss of habitat (acreage or quality) and/or animal population; habitat restoration measured in terms of years.	low	low	low	Supplemental drinking water supply required. Complete loss of wetland and/or aquatic habitat and/or aquatic organisms	low	low	low	Permanent loss of land use.	low	low	low
	Substantial, clearly measureable change in habitat (acreage or quality) or animal population; occurs throughout key animal life stages (e.g. nesting, breeding)	low	low	medium	Substantial, clearly measureable change in ground water, surface water, wetland and aquatic habitat, or aquatic organism population; occurs throughout key life stages (e.g., spawning)	low	low	medium	Temporary loss of land use due to chemical effects of spill.	low	medium	medium
	Evident, measureable change in habitat (acreage or quality) or animal population; occurs for short period during key animal life stages (e.g. nesting, breeding)	low	medium	medium	Evident, measureable change in groundwater, surface water, wetland and aquatic habitat, or aquatic organism population; occurs for short period during key life stages (e.g., spawning)	medium	medium	medium	Disruption to land use for duration of recovery actions and remediation actions.	medium	medium	high
	Perceptible, but minor change in habitat (acreage or quality) or animal population; occurs only minimally during key animal life stages (e.g. nesting, breeding)	medium	medium	high	Perceptible, but minor change groundwater, surface water, in wetland and aquatic habitat, or aquatic organism population; occurs only minimally during key life stages (e.g., spawning)	medium	high	high	Disruption to land use for duration of recovery actions.	medium	high	high
	No perceptible change in habitat (acreage or quality) or animal population; does not occur during key animal life stages (e.g. nesting, breeding)	high	high	high	No perceptible change in groundwater, surface water, wetland and aquatic habitat or aquatic organism population; does not occur during key animal life stages (e.g., spawning)	high	high	high	Insignificant disruption to land use.	high	high	high

Notes: Land use = soils, vegetation, ecosystem, agricultural, recreational; Green = low potential for impact to be realized for the given spill; Yellow = medium potential for impact to be realized for the given spill; Orange = high potential for impact to be realized for the given spill; Small = <50 bbl (2,100 gallons); Medium = 50 to 1,000 bbl (2,100 to 42,000 gallons); Large - >1,000 to 20,000 bbl (42,000 to 840,000 gallons).

4.13.5.2 High Consequence Areas

As identified in Section 3.13.5, Potential Spill Receptors, HCA categories are identified and defined individually to analyze potential spill impact on each. Based on the risk profile developed by Battelle (McSweeney et al. 2013 and Battelle 2013):

- The consequence in average damage costs to the operator of large spills occurring from mainline pipe in HCA areas is larger than the consequence of large spills on non-HCA areas ($5,484,000 vs. $1,288,000 respectively);
- The consequence in average damage costs to the operator of large spills occurring from system tanks in HCA areas is also larger than the consequence of spills in non-HCA areas ($605,000 vs. $225,000); and
- The consequence in average damage costs to the operator of large spills occurring from other system components (the thousands of parts that are typically part of a pumping station) in HCA areas is significantly higher than large spills in non-HCA areas ($11,561,000 vs. $1,603,000, respectively).

Additional information regarding risk to the human population and HCAs are discussed further in Section 4.2 of E^{x}ponent's Environmental Review (E^{x}ponent 2013).

Populated Areas

In the event of a spill, the effects on populated areas would depend on the size of the spill and the size of the population in the impacted area. For this reason, populated areas are divided into two categories by the USDOT: High Population Areas and Other Populated Areas. This division is done to improve the accuracy of risk analysis of a direct impact by an oil spill. Spill impact buffers for the proposed pipeline route do not cross any populated area HCAs. However, for completeness, the potential impacts of a spill to this type of HCA are discussed below.

Potential effects of a spill on populated areas could include interruptions in daily activities such as access to safe drinking water (discussed in more detail in Drinking Water section below), decreased air quality, and socioeconomic effects (discussed in more detail in Socioeconomics section below), or temporary relocation of population in impacted areas during spill containment and remediation procedures.

A 2003 report to USEPA prepared by the API compared the health effects of SCO with those of conventional crude oil and included the following statement (API 2003, page 9):

> Synthetic crude oil, from upgraded tar sands, is compositionally similar to high quality conventional crude oil (>33º API). The conventional technologies such as delayed and fluid coking, hydrotreating, and hydrocracking, used to upgrade heavy crude oils and bitumens, are used to convert tar sands into an essentially bottomless crude, consisting of blends of hydrotreated naphthas, diesel and gas oil without residual heavier oils . . . This information was supplied to USEPA . . . to support the position that tar sands-derived synthetic crude oil is comparable to conventional crude oils for health effects and environmental testing, a position with which USEPA concurred.

If an identified oil spill occurred that resulted in the contamination of drinking water sources (surface water or groundwater), use of these sources would be prohibited and monitored under state regulatory processes until the levels return to safe drinking water levels and the appropriate agencies authorize resumption of use of these water supplies. Water-related activities would be restricted in any area where there are contaminants present at levels deemed to be unsafe.

Reported background ambient levels of hydrogen sulfide in urban areas range from 0.11 to 0.33 parts per billion (ppb), while in undeveloped areas concentrations could be as low as 0.02 to 0.07 ppb (Skrtic 2006). A rotten egg odor characterizes hydrogen sulfide at low concentrations, and olfactory perception of hydrogen sulfide occurs for most people at concentrations in the air of approximately 0.2 parts per million (ppm). Some people could detect the gas by its odor at concentrations as low as 0.5 ppb (Skrtic 2006). In an assessment of risk to first responders at crude oil spill sites, Thayer and Tell (1999) modeled atmospheric emissions of hydrogen sulfide from crude oil spills using three different crude oil hydrogen sulfide concentrations (1 ppm, 20 ppm, and 350 ppm). The results of their analysis indicate that hydrogen sulfide levels in the immediate aftermath of a crude oil spill at the two higher levels of hydrogen sulfide concentration (20 ppm and 350 ppm) could pose short-term health risks (respiratory paralysis) to first responders at the spill site. The Thayer and Tell modeling effort also suggests that exposure to H_2S concentrations could pose health risks in the immediate area of an ongoing release or source. However, initial responders do not typically arrive at spill sites immediately and model results indicate that even under worst-case conditions (no wind), modeled exposures drop to non-toxic levels in less than four minutes after the oil stops entering the atmosphere for the first time. Hydrogen sulfide exposures would hence not be expected to create substantive health hazards except in the immediate area of the spill source, and until four minutes after the flow has stopped.

The rapid atmospheric dissipation of hydrogen sulfide levels indicated by these model results also suggests that risks to the general public in the event of an oil spill would be similarly confined to the immediate area of the spill source until four minutes after the flow has stopped. Additionally, some commenters have expressed concern that in the event of a fire or explosion involving crude oil that would be transported by the proposed Project, hydrogen sulfide could be released. However, hydrogen sulfide is also flammable and would burn in an explosion or fire, combining with oxygen to form sulfur dioxide and water and greatly reducing the risk due to inhalation of the gas.

Unusually Sensitive Areas

An Unusually Sensitive Area includes a drinking water or ecological resource area that is particularly susceptible to environmental damage from a hazardous liquid pipeline release. These have been defined by the USDOT. Unusually Sensitive Areas are separated from other water resources due to their association with increased potential of direct impact to human health or particularly sensitive wildlife. Other water or ecological resources identified but not captured by the USDOT designated areas are addressed in the other resources discussion below.

Drinking Water

PHMSA identifies certain surface water and groundwater resources as drinking water Unusually Sensitive Areas (49 CFR Parts 195.6 and 195.450). An Unusually Sensitive Area drinking water resource includes a water intake for a Community Water System or a Non-Transient Non-Community Water System that obtains its water supply primarily from a surface water source and does not have an adequate alternative drinking water source. An Unusually Sensitive Area drinking water resource also includes a Source Water Protection Area (SWPA) for a Community Water System or a Non-Transient Non-Community Water System if the water supply is obtained from a USDOT Class I or Class IIA aquifer and does not have an adequate alternative drinking water source. Where a state has yet to identify a SWPA, a Wellhead Protection Area is used. In Nebraska, the Steele City Wellhead Protection Area is the only drinking water Unusually Sensitive Area that a spill buffer overlaps with the Wellhead Protection Area and could be affected by a release from the pipeline. The existing Keystone pipeline system runs through Steele City, which would be the southern terminus of the proposed pipeline.

The route as proposed by Keystone is modified from the Final EIS route to avoid the Nebraska Department of Environmental Quality (NDEQ)-identified Sand Hills Region. The previous pipeline route in Nebraska as presented in the Final EIS trended northwest to southeast beginning at the South Dakota and Nebraska border in Keya Paha County, Nebraska, and ending at Steele City, Nebraska. NDEQ identified the region that it considers to be Nebraska Sand Hills largely based on a 2001 map published by the USEPA title *Ecoregions of Nebraska and Kansas* (NDEQ 2011). The route as proposed by Keystone avoids the NDEQ-identified Sand Hills Region as well as additional areas in Keya Paha County identified by the NDEQ that have soil and topographic characteristics similar to the Sand Hills Region. In response to concerns expressed by NDEQ and other stakeholders, the proposed Project's route is located further away from and downgradient of the wellhead protection area in the Village of Clarks, Nebraska, and avoids the wellhead protection area in the city of Western, Nebraska.

As discussed above, for the purpose of the analysis described herein, surface water Unusually Sensitive Areas identified for their potential as a drinking water resource have a 5-mile buffer placed around their intake location. Groundwater Unusually Sensitive Areas have buffers that vary in size. These buffers are designated by the state's source water protection program or their wellhead protection program and the buffer sizes vary from state to state.

Certain segments of the proposed Project route cross areas that are considered HCAs by PHMSA due to potential risks to sensitive drinking water resources. Oil spilled onto surface water or into groundwater supplies that serve as human drinking water sources would interrupt drinking water supply for the impacted area. The impacted sources would be monitored under state regulatory processes until the levels return to safe drinking water levels and the appropriate agencies authorize resumption of use of these water supplies. Water-related activities would be restricted in any area where there is oil present at levels that the health agencies consider unsafe for human exposure. Private landowners could choose to undertake water-related activities (e.g., installing additional groundwater pumping wells closer to the pipeline) that would increase exposure at their own risk.

Economic effects related to potential impacts to drinking water supplies could occur in the event of a large oil spill. However, the proposed Project route was selected to avoid water supply intakes and nearby potable groundwater well heads to the extent practicable. Nonetheless, numerous water wells exist within a mile on either side of the proposed pipeline centerline. Wells within the extent of groundwater impact as a result of a release could be affected. A large municipal supply well or intake could potentially draw affected water to the well or intake since it would draw from a larger area of groundwater. In the event of oil spill impacts to water supplies for residential, agricultural (e.g., farming, ranching, and livestock grazing on wild land), commercial, or public uses, Keystone would provide alternate sources of water for essential uses such as drinking water, irrigation and livestock watering, industrial cooling water, and water for firefighting and similar public safety services.

Ecological Resource Unusually Sensitive Areas

Impacts to ecologically sensitive areas would be similar to those impacts discussed in the Water Resources, Vegetation and Soil Ecosystems, and Wildlife sections of this Final Supplemental EIS. However, loss or reproductive impairment of any portion of a population of federal threatened, endangered, proposed, and candidate species; Bureau of Land Management (BLM) sensitive species; state threatened and endangered species; and species of conservation concern could result in a significant impact at an ecosystem level. The impact is likely to be even greater if the species affected have long recovery times (i.e., low reproductive rates); limited geographic distribution in the affected area; are key species in the ecosystem; are key habitat formers; or are otherwise a critical component of the local biological ecosystem. Furthermore, if the species were a key recreational or commercial resource, biological impacts manifested to the population may constitute a significant impact to human uses of the resource.

Federal threatened, endangered, proposed and candidate species, BLM sensitive species, state threatened and endangered, and species of conservation concern are discussed in Sections 3.8 and 4.8, Threatened and Endangered Species and Species of Conservation Concern, and are further discussed in Section 5.6 of E^{x}ponent's Environmental Review (E^{x}ponent 2013). Federally protected threatened or endangered species and federal candidate species with the potential to occur in the proposed Project area include two mammals, six birds, two fish, one invertebrate, and two plants. Potential impact analysis and preliminary findings are summarized in Table 1.3-1 of the Keystone XL Project Biological Assessment Final (see Appendix H, 2012 Biological Assessment, 2013 USFWS Biological Opinion, and Associated Documents).

Pipeline stream crossings near areas of special ecological consideration were identified as posing higher risk to ecological resources unless they utilized HDD crossings. E^{x}ponent's Report identifies areas of special ecological consideration (i.e., fisheries, wildlife habitat, wetlands, major waterbodies, or special waterbodies) where the pipeline crosses small streams. Ecological Resource Unusually Sensitive Areas and special ecological considerations are further discussed in Section 5.4 of E^{x}ponent's Environmental Review (E^{x}ponent 2013).

Commercially Navigable Waterways[17]

Commercially Navigable Waterways (CNWs) are waterways where a substantial likelihood of commercial navigation exists. CNWs are included in HCAs because these waterways are a major means of commercial transportation and are critical to interstate and foreign commerce, supply vital resources to many American communities, and are part of a national defense system. Areas defined as CNWs were provided by PHMSA. No CNW HCAs are located within a spill impact buffer as defined above.

[17] Commercially navigable waterways are included because of their importance as a supply route of vital resources to many American communities as well as their role in the national defense system (49 CFR Part 195, Federal Register / Vol. 65, No. 232 / Friday, December 1, 2000 / Rules and Regulations, pg. 75392).

The impact of an oil spill on CNWs is related to surface oil and the potential temporary closure of the CNWs to vessel traffic so that oil dispersion is not increased and response teams could contain oil safely without traffic hindering recovery operations. Temporary closure could be a few hours to a few days depending on the size of the spill.

4.13.5.3 Other Resources

Other resources include environmental resources that are not included in the USDOT definition of HCAs but that are present along the proposed Project route and therefore have been included for evaluation. A more detailed discussion of these receptors is included in Section 3.13, Potential Releases, and in Appendix P, Risk Assessment. Several categories of other resources are discussed below.

Soils

Soil includes the top layer of earth consisting of rock and mineral particles mixed with organic matter, containing living matter, and capable of supporting vegetation. For definition purposes, its upper limit is considered to be air or shallow water, and its lower limit is considered to be hard rock or earthen materials virtually devoid of biological activity. Soil ranges in depth from just a few inches to tens of meters along the proposed Project route. When discussing impacts to soil, this Final Supplemental EIS defines a release, leak, and spill as described in Section 4.13.4, Spill Impact Assessment.

Because the proposed Project pipeline is a buried structure, crude oil released from the pipeline would initially flow into the soil pore spaces. The impact of oil spills on soil would vary greatly depending on the type of soil, porosity, permeability, and water saturation of the soil at the time of the spill. Generally, subsurface releases to soil tend to disperse slowly and often preferentially flow into areas of less consolidated or higher porosity, permeability soils (such as sand layers). Most soils along the proposed route have low to moderate permeability, providing increased time to respond to the spill prior to extensive subsurface movement of the spilled material through soils.

Specific soil characteristics that were identified to be of particular interest were evaluated along the proposed Project route. They included highly erodible; prime farmland; saturated; compaction-prone; stony/rocky; shallow-bedrock; and drought-prone soils. Some of these characteristics are conducive to a greater disturbance than others if impacted (detailed descriptions of each characteristic are provided in Section 3.2.2, Soils, Environmental Setting.). As part of the evaluation, the approximate lengths in miles of the proposed route that would cross the different soils were identified by state. Of the identified total miles that would cross the key soil types (Table 3.2-1), approximately 70 and 270 miles cross the more sensitive highly erodible by wind and highly erodible by water soil types, respectively. The proposed Project route also could cross approximately 350 miles of prime farmland. Based on these mileage and potential oil overland spreading distances of the three different spill volumes used in this Final Supplemental EIS shown in 4.14-2, an estimated total area of potential spill-sensitive soils is shown in Table 4.13-17.

Table 4.13-17 Total Estimated Erodible and Prime Farmland Soils in Potential Spill Areas (acres)[a]

	Small (0 to 50 bbl)			Medium (50 to 1,000 bbl)			Large (1,000 to 20,000 bbl)		
State[b]	Wind Erodible	Water Erodible	Prime Farmland	Wind Erodible	Water Erodible	Prime Farmland	Wind Erodible	Water Erodible	Prime Farmland
MT	76.8	1,651.7	932.2	253.1	5,440.9	3,070.9	836.0	17,974.5	10,144.8
SD	246.7	1,548.3	1,628.1	812.7	5,100.3	5,363.1	2,684.9	16,849.1	17,717.2
NE	715.1	851.0	2,598.7	2,355.5	2,803.2	8,560.4	7,781.4	9,260.6	28,280.1

[a] Values assume flat, level ground, with plume volumes resting at an equilibrium thickness based on the surface tension of heavy sour crude. No potentially affected erodible or prime farmland soils identified in Kansas or North Dakota.
[b] MT=Montana, SD=South Dakota, NE=Nebraska.
Note: 1 acre = 43,560 ft.

It is difficult to estimate the volume of soil that might be contaminated in the event of a spill. Site-specific environmental conditions (e.g., soil type, weather conditions) and release dynamics (e.g., leak rate, leak duration) would result in substantially different surface spreading and infiltration rates which, in turn, would affect the final volume of affected soil. Based on historical data (PHMSA 2012a), soil remediation involved 100 cubic yards of soil or less at the majority of spill sites where soil contamination occurred, and only 3 percent of the spill sites required remediation of 10,000 cubic yards or more (PHMSA 2012a). These statistics suggest that the actual affected soils area would likely be significantly lower than the calculated areas shown in Table 4.13-17.

Spills could also affect soils indirectly by coating the vegetation, which in turn might not survive and expose the soil to water and wind erosion or solar heating. Spill cleanup could affect the soils (e.g., erodible soils) more than the presence of the spilled material itself, unless the cleanup is well controlled and heavy traffic and digging are minimized. Oil that adheres to or is retained between soil grains may weather slowly over a period of years.

Soil productivity could be negatively impacted by oil contamination particularly in the event of large spills. If long-term remediation is required, beneficial uses of the soil could be restricted for the length of the remediation period or longer.

In accordance with federal and state regulations, Keystone would be responsible for cleanup of contaminated soils and would be required to meet applicable cleanup levels (listed below). The residential soil cleanup levels for benzene from petroleum hydrocarbon releases (where applicable) are based on the inhalation of vapors, ingestion of contaminated soil, and dermal contact exposure pathways and vary by state (Montana: 0.04 ppm; South Dakota: 17 ppm; Nebraska: 3.63 ppm; North Dakota and Kansas: no levels established).

Paleontological resources exposed to a spill could also be affected. Remediation activities could also damage paleontological resources. However, in the event of a spill, a paleontological mitigation plan could be prepared to protect significant fossil resources.

Sediments

Sediments (defined here as submerged soils in wetlands and aquatic habitats) are typically fine grained and saturated with water. Crude or refined oils typically do not penetrate beyond the surface layer in sediments unless: 1) there is a substantive amount of turbulence that mixes the oil and sediments, followed by deposition of the mixture in low turbulence areas; 2) the air pockets between grains are large enough (e.g., in gravel and coarse sand) to allow for penetration of the oil as it sinks; or 3) physical activities associated with spill response actions mix the surface-deposited oil-sediment mixture into deeper subsurface levels of the sediment profile. Refined products typically would not penetrate sediments because the high water content would cause the oil to remain afloat, but it may penetrate or be mixed further into the sediments under the same turbulent conditions or cleanup actions as for crude oil.

The oil deposited on and remaining in the top sediment layer, especially in aerobic environments, may be subject to biodegradation by microbes, which would reduce or eliminate long-term impacts. Oil that is incorporated into sediments, especially in the anaerobic subsurface levels, may weather very slowly. Sediments of exposed shores could retain oil for extended periods of time, even in higher energy areas (Short et al. 2007).

For large spills that are not immediately or successfully remediated, crude oil constituents could remain in soil, aquatic sediments, or on plant tissues for several years. To the extent that residual oil leads to further contact or ingestion by mammals, effects to individual mammals could also continue.

Vegetation and Soil Ecosystems

An oil spill could result in impacts to vegetation in several ways, especially as it moves through multiple habitats. A surface release could produce localized effects on plant populations such as oil permeating through the soil affecting the root systems and indirectly affecting plant respiration and nutrient uptake. Also, without complete remediation of contaminated soil in a vegetation zone, long-term effects on vegetation could be expected. Tables 4.13-18, 4.13-19, and 4.13-20 summarize the estimated vegetation community acreage along the proposed Project route that could be affected by a surface spill. The acreage is based on spill distances shown in Table 4.13-13.

Crude oil released to the soil’s surface could potentially produce localized effects on plant populations. Terrestrial plants are much less sensitive to crude oil than aquatic species. The lowest toxicity threshold for terrestrial plants found in the USEPA ECOTOX database (USEPA 2001) is 18.2 ppm in soil for benzene, higher than the 7.4 ppm threshold for aquatic species. Similarly, subterranean organisms such as earthworms could also be adversely affected by an oil spill. Spilled oil permeating through the soil could lead to sediments and soils being coated with oil, which reduces water and gas (e.g., oxygen and carbon dioxide) exchange and affects subterranean organisms. These organisms could also be coated, reducing their ability to function naturally or gain access to nutrients necessary for survival organisms.

Table 4.13-18 Total Estimated Vegetation Community Acreage in Potential Small Spill Areas

State[a]	Cultivated Crops	Grassland/Pasture	Upland Forest	Open Water	Forested Wetlands	Emergent Herbaceous Wetlands	Shrub-scrub Wetlands	Developed Land
MT	1654.97	5067.67	16.23	8.11	40.56	10.82	841.01	97.35
SD	1333.17	6936.27	13.52	8.11	40.56	35.15	81.13	100.06
NE	4881.08	2157.95	54.08	18.93	51.38	16.23	0.00	229.86

[a] MT=Montana, SD=South Dakota, NE=Nebraska.

Table 4.13-19 Total Estimated Vegetation Community Acreage in Potential Medium Spill Areas

State[a]	Cultivated Crops	Grassland/Pasture	Upland Forest	Open Water	Forested Wetlands	Emergent Herbaceous Wetlands	Shrub-scrub Wetlands	Developed Land
MT	5451.67	16693.51	53.45	26.72	133.62	35.63	2770.37	320.69
SD	4391.62	22848.91	44.54	26.72	133.62	115.80	267.24	329.59
NE	16078.86	7108.55	178.16	62.36	169.25	53.45	0.00	757.18

[a] MT=Montana, SD=South Dakota, NE=Nebraska.

Table 4.13-20 Total Estimated Vegetation Community Acreage in Potential Large Spill Areas

State[a]	Cultivated Crops	Grassland/Pasture	Upland Forest	Open Water	Forested Wetlands	Emergent Herbaceous Wetlands	Shrub-scrub Wetlands	Developed Land
MT	18009.98	55148.20	176.57	88.28	441.42	117.71	9152.13	1059.41
SD	14508.04	75482.99	147.14	88.28	441.42	382.56	882.84	1088.84
NE	53117.66	23483.60	588.56	206.00	559.13	176.57	0.00	2501.39

[a] MT=Montana, SD=South Dakota, NE=Nebraska

Overall, most past spills on terrestrial habitats have caused minor ecological damage, and ecosystems have shown a good potential for recovery, with wetter areas recovering more quickly (Jorgenson and Martin 1997, McKendrick 2000). The length of time that the spilled material remains in contact with the environment depends on several factors, including oil and soil temperature, availability of oleophilic (oil-loving) microorganisms, soil moisture, and the concentration of the product spilled. For the most part, effects of land oil spills would be localized and are not expected to impact vegetation and associated habitat outside the immediate spill area (assuming runoff is controlled to the extent necessary). Spills that occur within or near streams, rivers, and lakes could directly and indirectly affect riparian vegetation and habitat along these waterbodies. Effects on vegetation from subsurface spills that reach the root zones of surface vegetation could assist in leak detection as a result of visible patches of affected vegetation (often indicated by dying vegetation) along the proposed pipeline ROW resulting from oil interference with water and nutrient uptake by plant root systems.

Smaller spills during construction could occur within contractor yards, along access roads, at aboveground facilities and along the proposed pipeline construction ROW, and the spilled fuel or oil would generally remain localized near the release site. These spills would typically produce minor impacts on crops, native vegetation, and associated wildlife.

Large spills during operation would likely result in greater impacts to crops, native vegetation, and associated wildlife due to the larger area covered with oil.

Winter snow cover may occasionally be sufficient to slow and limit the surficial flow of spilled oil, thus limiting the extent of damage to vegetation and habitat. In other seasons, the spilled oil may flow farther on the land surface. Spill response activities could cause impacts on vegetation and habitat if activities are not implemented carefully and with regard for minimal disturbance of the surface soils and vegetation.

A large spill could spread over larger areas and coat vegetation, including row crops, wild lands, seasonal wetlands, and range lands, especially downslope from the spill site. The vegetation within the spill zone might not survive or be damaged or coated with oil, although population level vegetation effects are unlikely. Affected vegetation may not be suitable for grazing animals and any affected commercial row or field crops would likely not be marketable.

Wildlife

Spilled crude oil could affect wildlife directly and indirectly. Direct effects include physical processes, such as oiling of feathers and fur, and toxicological effects, which could cause sickness or mortality. Indirect effects are less conspicuous and include habitat impacts, nutrient cycling disruptions, and alterations in ecosystem relationships. The magnitude of effects varies with multiple factors, the most significant of which include the amount of material released, the size of the spill dispersal area, the type of crude oil spilled, the species assemblage present, climate, and the spill response tactics employed.

The 2010 Enbridge Line 6B spill in Michigan was a 20,082 bbl (PHMSA 2012a) subsurface composite crude oil spill that emerged onto the ground surface and affected forested, scrub/shrub, wetlands, Talmadge Creek, and Kalamazoo River. By examining the effects from the 2010 Enbridge spill, the potential impacts to wildlife from a spill of similar size/magnitude could be evaluated. The Enbridge-specific impacts are detailed in the Enbridge 2011 Conceptual Site Model, where wildlife studies conducted during the response of that spill have shown that more than 90 percent of the animals (including reptiles, crustaceans, amphibians, birds, mammals, and fish) that were collected and rescued during response efforts, were subsequently released during active recovery efforts (Enbridge 2011b).

Table 4.13-21 provides an estimated potential acreage of habitat identified along the proposed Project route that could be affected by a surface release.

Table 4.13-21 Total Estimated Acreage of Habitat in Potential Surface Spill Areas

State[a]	Small (0 to 50 bbl)	Medium (50 to 1,000 bbl)	Large (1,000 to 20,000 bbl)
MT	1814.52	5977.24	19746.23
SD	584.11	1924.12	6356.46
NE	3088.20	10172.88	33606.85

[a] MT=Montana, SD=South Dakota, NE=Nebraska.

Wildlife, especially birds and shoreline mammals, are typically among the most visibly affected organisms in any crude oil spill. Effects of crude oil could be differentiated into physical (mechanical) and toxicological (chemical) effects. Physical effects result from the actual coating of animals with crude oil, causing reductions in thermal insulative capacity and buoyancy of plumage (feathers) and pelage (fur). Toxicological effects on birds and mammals could occur via inhalation or ingestion exposure. Ingestion of crude oil may occur when animals consume oil-contaminated food, drink oil-contaminated water, or orally consume crude oil during preening and grooming behaviors. Unlike aquatic organisms that frequently cannot avoid spills in their habitats, the behavioral responses of terrestrial wildlife may help reduce potential adverse effects as indicated in the Enbridge study. Many birds and mammals are mobile and generally could avoid oil-impacted areas and contaminated food (Sharp 1990; Stubblefield et al. 1995). Many terrestrial species have alternative, unimpacted habitat available, as would often be the case with localized spills (in contrast to large-scale oil spills in marine systems); therefore, mortality of these species would be limited (Stubblefield et al. 1995).

Birds

Birds typically are among the most affected wildlife if exposed to the chemical and toxicological effects of an oil spill, as described in sections above, whether on land or on water (Holmes 1985, Sharp 1990, White et al. 1995). In addition to the potential for external oiling of the feathers and hypothermia or drowning due to loss of flotation, birds may suffer both acute and chronic toxicological effects. Birds are likely to ingest oil as they preen their feathers in an attempt to remove the oil. The ingested oil may cause acute liver damage, gastrointestinal and other systemic impacts resulting in mortality, reduced reproductive capacity, loss of weight, inability to feed, and similar effects. Oiled birds that are nesting or incubating eggs may coat the eggs or young with oil and injure or kill them. Dead oiled birds may be scavenged by other birds as well as mammals.

Potential adverse effects could result from direct acute exposure. Acute toxic effects include drying of the skin, irritation of mucous membranes, diarrhea, narcotic effects, and possible mortality. While releases of crude oil may have an immediate and direct effect on wildlife populations, the potential for physical and toxicological effects reduces with time as the volume of material diminishes, leaving behind more persistent, less volatile, and less water-soluble compounds. Although many of these remaining compounds are toxic and potentially carcinogenic, they do not readily disperse in the environment, do not bioaccumulate, and, therefore, the potential for impacts is low.

Small spills on or near the roads, construction yards, or pump stations would not generally affect birds in large numbers, although a few individual shorebirds, waterfowl, raptors, and songbirds could be exposed to the spilled oil. Exposed individuals could be exposed to hypothermia or from the toxic effects of ingesting the oil during preening, or from ingestion of oiled food and water. Potential impacts would likely be limited to a few individual birds, especially waterfowl and shorebirds that use small ponds and creeks affected by very small to small spills. If a very small to small-size spill occurred during migration periods, greater numbers of birds could be affected. There could also be an associated impact to a few individual scavenging birds and mammals if they feed on oiled carcasses. Small spills would not be expected to cause population-level impacts.

A medium to large spill in terrestrial habitats could cause mortality of birds that spend time foraging or nesting on the ground, such as shorebirds, grassland nesting songbirds (passerines), and upland game birds, where they would come into direct contact with oil and oiled prey or forage. If the spilled material entered wetlands or waters, water-dependent birds such as waders, seabirds, shorebirds, and waterfowl could be exposed. The numbers of individuals oiled would depend primarily on wind conditions, volume of spill, and the numbers of birds within and proximate to the area affected by the spill. Impacts may be detectable at the local population level, especially for resident species with limited geographic distribution if the spill affected important breeding habitat for migratory birds, or if the spill occurred within migration staging habitats during active migration periods. The North Valley Grasslands, crossed by the proposed pipeline in Valley County, Montana (Montana Audubon 2008), is a designated globally significant Important Bird Area supporting resident and migrant grassland nesting birds. Although not designated as an Important Bird Area along the route of the proposed pipeline, the Platte River and associated wetlands in central Nebraska are used for migration staging from mid-February to early April by more than 500,000 sandhill cranes during their northward migration (National Audubon Society 2012).

If raptors, eagles, owls, ravens, crows, magpies, vultures, and other predatory or scavenging birds were present in the spill vicinity, they could become secondarily oiled by eating oiled prey. Mortality of breeding raptors likely would represent a minor loss for local populations but would not likely affect regional populations. Mortality of migrant or winter roosting aggregations of bald eagles attracted to waterfowl aggregations at migration staging and winter open water locations could result in more significant losses for regional bald eagle populations from exposure to oiled prey.

If a large spill moved into wetlands, adjacent riparian habitats, or open water habitats of major rivers along the ROW, waterfowl species that breed, stage, or congregate in these areas during migration could be at risk. A spill entering a major river in spring, especially at flood stage, could significantly affect waterfowl in the short term by contaminating overflow areas or open water where spring migrants of waterfowl and shorebird species concentrate before occupying nesting areas or continuing their migration.

Lethal effects would be expected to result from moderate to heavy oiling of birds. Light to moderate exposure could reduce future reproductive success because of pathological effects on liver or endocrine systems (Holmes 1985) caused by oil ingested by adults during preening or feeding that interfere with the reproductive process. Oiled individuals could lose the water repellency and insulative capacity of feathers and subsequently drown or experience hypothermia. Stress from ingested oil could be additive to ordinary environmental stresses, such as low temperatures and metabolic costs of migration. Oiled females could transfer oil to their eggs, which at this stage could cause mortality, reduced hatching success, or possibly deformities in young. Oil could adversely affect food resources, causing indirect, sub-lethal effects that decrease survival, future reproduction, and growth of the affected individuals.

In addition to the expected mortality due to direct oiling of adult and fledged birds, potential effects include mortality of eggs due to secondary exposure by oiled brooding adults; loss of ducklings, goslings, and other non-fledged birds due to direct exposure; and lethal or sub-lethal effects due to direct ingestion of oil or ingestion of contaminated foods (e.g., insect larvae, mollusks, other invertebrates, or fish). Taken together, the effects of a large spill may be significant for individual waterfowl and their post-spill brood. Population depression at the local or regional scale would be greater than for smaller spills. However, the effects of even a large spill would be attenuated with time as habitats are naturally or artificially remediated and populations recover to again use them. In general, losses from medium to very large spills would likely result in limited impacts to regional bird population levels, but may result in significant impacts to local population levels.

The Biological Assessment (BA) prepared for the proposed Project identifies federally listed and candidate species that were identified by the Department, the U.S. Fish and Wildlife Service and state wildlife agencies as potentially occurring in the proposed Project area (see Appendix H, 2012 Biological Assessment). Table 1.3-1 in the BA summarizes these species and the preliminary impact determinations based on: 1) correspondence with the U.S. Fish and Wildlife Service, the BLM, and state wildlife agencies; 2) habitat requirements and the known distribution of these species within the proposed Project area; and 3) habitat analyses and field surveys that were conducted for these species from 2008 through 2012. The BA includes two mammal species, six bird species, two fish species, one invertebrate species, and two species of plants in the analysis and findings.

Mammals

Most oil spills, including medium to large spills (1,000 to 20,000 bbl), would result in a limited impact on most of the terrestrial mammals using the area affected by the spill. The extent of impacts would depend on the type and amount of oil spilled (see Table 4.13-16); the location and terrain of the spill; the type of habitat affected; mammal distribution, abundance, and activity at the time of the spill; and the effectiveness of the spill response. Typically, the proportion of habitat affected would be very small relative to the area of habitat available for most mammals.

A large spill could affect terrestrial mammals directly or indirectly through impacts to their habitat, prey, or food. For example, a large spill likely would affect vegetation, the principal food of the larger herbivorous mammals, both wild (e.g., deer, elk, and antelope) and domestic (e.g., cattle, sheep, horses). Some of these animals probably would not ingest oiled vegetation, because they tend to be selective grazers and are particular about the plants they consume. Many predators and scavengers could experience toxic effects through feeding on birds, other mammals, reptiles, and fish killed or injured by the oil spill. However, these effects would not generally be life threatening or long term (White et al. 1995). Spill response activities would typically frighten most large mammals away from the spill. As noted previously, vegetation could be affected by the spilled oil, thus temporarily reducing local forage availability, although it is unlikely that the overall abundance of food for large herbivorous mammals would be substantially reduced.

Small mammals and furbearers could be affected directly by spills due to oiling. Furbearers, especially river otters, mink, muskrat, raccoons, and beavers that depend on or frequently use aquatic habitats would likely be exposed to oil if spills reached aquatic habitats within their range. Oiled furbearers would be susceptible to hypothermia and oil toxicity from ingestion during grooming. Impacts to small mammals and furbearers would likely be localized around the spill area and would not cause population-level impacts.

Except for some endangered, threatened, or protected species, loss of a small fraction of a population of organisms would likely result in a minimal impact at an ecosystem level. Loss or reproductive impairment of a significant portion of a population or biological community from an oil spill could result in a significant environmental impact. The impact is likely to be greater if the species affected have long recovery times (i.e., low reproductive rates); limited geographic distribution in the affected area; are key species in the ecosystem; are key habitat formers; or are otherwise a critical component of the local biological community or ecosystem. Furthermore, if the species or community is a key recreational or commercial resource, biological impacts manifested at the population or community level may constitute a significant impact to human uses of the resource. Recreational species that may occur in the proposed Project area due to habitat presence are further discussed in Section 3.6, Wildlife.

Cultural Resources

Most spills would be confined to a construction yard, access roadway, pipeline ROW, or to an adjacent area, with the primary exception being a large spill from the pipeline that affects areas beyond the ROW. Large spills could impact cultural resources identified within the Area of Potential Effect or cultural resources located outside the Area of Potential Effect. Table 4.13-22 identifies the number of previously identified cultural resource sites that are within each of the spill size buffers.

Table 4.13-22 Number of Previously Identified Cultural Resource Sites in Potential Spill Buffers[a]

State[b]	Small (0 to 50 bbl)	Medium (50 to 1,000 bbl)	Large (1,000 to 20,000 bbl)
MT	87	112	120
SD	49	61	65
NE	92	106	112

[a] Due to the size of potential spill buffers and availability of cultural resources locational information, the numbers above may not match those presented in Section 3.11, Cultural Resources.
[b] MT=Montana, SD=South Dakota, NE=Nebraska.

Cultural resources affected by a crude oil release potentially might not be returned to their original state. However, the impacts would be mitigated through documentation and/or data recovery excavations consistent with the requirements of the Programmatic Agreement (see Section 4.11.3, National Register of Historic Places Eligibility, Effects, and Mitigation).

Water Resources

Water resources are defined in Section 3.13, Potential Releases, as sources of water that are potentially useful to humans and wildlife. This includes groundwater and surface water and the ecosystem that relies on these resources. For the purposes of the potential release analysis, groundwater is defined as the first water-bearing zone below the ground surface. Surface water includes open waterbodies such as rivers, lakes, and ponds, as well as wetlands where water is at or near ground level. This section also describes potentially impacted water resources adjacent to the proposed pipeline route, including major aquifers, wells, streams, and rivers that would be crossed, as well as reservoirs and large lakes downstream of these crossings.

Previous sections have discussed the potential for overland flow, the resultant vertical and horizontal migration of the released oil, and impacts of a spill on wetlands. Impacts largely depend on the spill volume and the type of waterbody that the oil contacts. Surface waters with low energy (i.e., static waters, ponds, and small lakes) could result in high localized toxicity levels. Low energy surface waterbodies with more water volume for oil constituents would be more likely to experience higher aquatic toxicity than creeks and rivers with turbulent flow, where there could be an increase in mixing and an increase in evaporation of constituents such as benzene. In aquatic areas with high energy (e.g., waves, turbulent river flows, and/or high sediment deposition), the oil may become buried under or mixed in the sediment.

If released to water, crude oil typically floats on the water’s surface. If crude oil were left on the water’s surface over an extended period of time, some constituents within the oil would evaporate, other fractions would dissolve, and eventually some material might descend to the bottom. Oil could sink in the water column as it degrades and mixes with particulates in water. The following is a summary of the major processes that occur during crude oil dispersion and degradation; these factors are considered when predicting impacts to receptors and resources:

- **Physical Factors**—Crude oil mobility in water increases with wind, stream velocity, and increasing temperature. Most crude oils move across standing surface waters at a rate of 100 to 300 meters per hour, excluding environmental influences (i.e., wind). Surface ice would greatly reduce the spreading rate of oil across a waterbody. Crude oil in flowing as opposed to contained waterbodies may cause more widespread impacts. Although reduced in intensity (as a result of dilution), a crude oil spill into flowing waters tends to move over a much larger area.
- **Dissolution**—Dissolution of crude oil in water is a process in controlling the crude oil’s fate in the environment because most components of oils are relatively insoluble (Neff and Anderson 1981). Moreover, evaporation tends to dominate the reduction of crude oil, with dissolution slowly occurring with time. Overall solubility of crude oils tends to be less than that of their constituents, and individual compounds are often more soluble in oil than in water, thus they tend to remain in the oil. Diluents and bitumen when mixed together to form dilbit behave as a conventional crude oil, with the more soluble compound tending to remain in oil. However, some compounds could dissolve in water (i.e., dissolution). Dissolution is one of the primary processes affecting the toxic effects of a spill, especially in confined waterbodies. Dissolution increases with decreasing molecular weight, increasing temperature, decreasing salinity, and increasing concentrations of dissolved organic matter. Greater photodegradation also tends to enhance the solubility of crude oil in water.

- **Sorption**—In water, heavy molecular weight hydrocarbons would bind or adhere (i.e., sorption) to suspended particulates, and this process could be significant in water with a high particulate concentration (i.e., suspended clay or plant matter). Organic particles (e.g., biogenic material) in soils or suspended in water tend to be more effective at binding to soils than inorganic particles (e.g., clays). Sorption processes and sedimentation reduce the quantity of heavy hydrocarbons present in the water column and available to aquatic organisms. These processes, however, also render hydrocarbons less susceptible to degradation. Sediment covered with oil could be highly persistent and could cause shoreline impacts.
- **Evaporation**—Over time, evaporation is the primary mechanism of loss of low molecular weight constituents and light oil products. As lighter components evaporate, the remaining crude oil becomes denser and more viscous. Evaporation tends to reduce crude oil toxicity, but enhances crude oil persistence. In field trials, bulk evaporation of Alberta crude oil accounted for an almost 50 percent reduction in volume over a 12-day period, while the remaining oil was still sufficiently buoyant to float on the water's surface (Shiu et al. 1988). Evaporation increases with increased spreading of a spill, increased temperature, and increased wind and wave action.
- **Photodegradation**—Photodegradation of crude oil in aquatic systems increases with greater solar intensity. It could be a significant factor controlling the reduction of a slick, especially of lighter oil constituents, but it would be less important during cloudy days and winter months. Photodegraded crude oil constituents could be more soluble and more toxic than parent compounds. Extensive photodegradation, like dissolution, may thus increase the biological impacts of a spill event.
- **Biodegradation**—Soon after a crude oil spill, natural biodegradation of crude oil would not tend to be a significant process controlling the fate of spilled crude oil in environments previously unexposed to oil. Microbial populations must become established before biodegradation could proceed at any appreciable rate. Also, prior to weathering (i.e., evaporation and dissolution of light-end constituents), oils may be toxic to the very organisms responsible for biodegradation and high molecular weight constituents tend to be resistant to biodegradation. Biodegradation is nutrient and oxygen demanding and may be constrained in nutrient-poor aquatic systems. It also may deplete oxygen reserves in closed waterbodies, causing adverse secondary effects to aquatic organisms.

Groundwater

Groundwater is defined here as the first water-bearing zone below the ground surface. Groundwater aquifers are underground geological formations able to store and yield water. A groundwater aquifer is predominantly characterized as a formation with its pore spaces filled with water. Groundwater resources are primary sources of irrigation and potable water in the vicinity of the proposed pipeline route and several primary aquifers and aquifer groups are located within the proposed Project area in Montana, South Dakota, Nebraska, North Dakota, and Kansas (see Section 3.3.2, Groundwater), including the following alluvial aquifers: Northern

High Plains[18] Aquifer, Great Plains Aquifer, Western Interior Plains Aquifer, and the Northern Great Plains Aquifer System. Using the overland flow and groundwater spill impact buffers defined above in Table 4.13-13, the number of wells in the potential reach of a spill is shown below in Tables 4.13-23 through 4.13-25.

Table 4.13-23 Total Number of Wells in Potential Overland Flow Spill Impact Areas[a]

State[b]	Small (0 to 50 bbl)	Medium (50 to 1,000 bbl)	Large (1,000 to 20,000 bbl)
MT	4	17	70
SD	0	6	31
NE	14	126	553

[a] Data obtained from respective State registered well databases.
[b] MT=Montana, SD=South Dakota, NE=Nebraska.

Table 4.13-24 Total Number of Wells in Potential Groundwater Spill Impact Areas[a]

State[b]	Small (0 to 50 bbl)	Medium (50 to 1,000 bbl)	Large (1,000 to 20,000 bbl)
MT	30	46	62
SD	16	20	25
NE	248	317	463

[a] Data obtained from respective State registered well databases.
[b] MT=Montana, SD=South Dakota, NE=Nebraska

Table 4.13-25 Total Number of Wells in Potential Combined[a] Overland/Groundwater Spill Impact Areas[b]

State[c]	Small (0 to 50 bbl)	Medium (50 to 1,000 bbl)	Large (1,000 to 20,000 bbl)
MT	36	68	174
SD	18	27	49
NE	292	542	1009

[a] Combined is distance of oil spreading on groundwater, then dissolved-phase components of oil would spread an additional distance from the oil's edge.
[b] Data obtained from respective State registered well databases.
[c] MT=Montana, SD=South Dakota, NE=Nebraska.

In general, the potential for groundwater contamination following a spill would be more probable:

- Where a relatively shallow water table is present (as opposed to locations where a deeper, confined aquifer system is present);
- Where soils with high permeability are present above groundwater; and
- Where the PHMSA (in cooperation with the USGS and other federal and state agencies) has identified specific groundwater resources that are particularly vulnerable to contamination. These resources are designated by PHMSA as HCAs.

[18] Thousands of miles of pipeline carrying crude and refined products traverse throughout the region where the Ogallala Aquifer, part of the High Plains Aquifer System, is present. Pipelines installed within the last 10 to 15 years are all generally constructed and operated under similar regulatory and engineering procedures and design as would be required of the proposed Project.

The potential for crude oil migration into groundwater is influenced by several factors. These factors include the lateral extent of the oil spill, the viscosity and density of the material, the characteristics of the environment into which the material is released (particularly the characteristics of the underlying soils), and the depth to first groundwater. Groundwater in the alluvial aquifers along the ROW is characteristically shallow (typically less than 50 ft bgs) and often unconfined (meaning that groundwater could be recharged from water seeping from the ground surface). These aquifers are used as a primary source of groundwater for irrigation, domestic, and/or commercial/industrial use along much of the proposed Project route in Montana, South Dakota, and Nebraska. Table 3.3-1 in Section 3.3.2.2, Proposed Pipeline Hydrogeologic Conditions, identifies water-bearing zones shallower than 50 ft.

Generally, the crude oil being transported in the proposed pipeline would become increasingly viscous when released into the environment. As viscosity increases, the vertical migration rate decreases. In most cases, given that vertical migration is controlled by the infiltration rate of the oil into the underlying soil, the extent of vertical migration could be mitigated by rapid emergency response measures that include rapid source control (containment and collection of the oil released) (see Appendix I, SPCC and ERP). Heavy crude oils likely to be transported by the proposed Project are less dense than water and generally would initially float on the surface of waterbodies. If the crude oil infiltrates into soil formations, it would most likely form a floating lens above and slightly below the water table when groundwater is present. The crude oil plume would generally move in the direction of groundwater flow, until it reaches a steady state based on the groundwater flow rate, crude oil characteristics and soil characteristics. Plume expansion could also be affected by the rate of water being pumped out of an aquifer.

Studies related to oil and oil product releases from over 600 underground storage tank leaks indicate that potential surface and groundwater impacts from these releases are typically limited to several hundred ft or less from the release site (Newell and Conner 1998, USGS 1998) and are useful in assessing potential plume migration distances from pipelines. These studies indicate that the size of the oil release is the key factor influencing the ultimate oil plume dimensions (including the dissolved phase plume). While there are differences in the rate of oil movement through different soil types, hydrogeologic factors such as hydraulic conductivity (the rate that water moves through soil) and gradient are not as significant as the size of the release in determining ultimate plume length (Newell and Conner 1998, USGS 1998). However, on a localized basis, it is acknowledged that water withdrawals through extensive pumping could influence the gradient.

An example of a crude oil release from a pipeline system into an environment similar to the proposed Project's aquifers occurred on August 20, 1979, near Bemidji, Minnesota. In this large spill, approximately 449,400 gallons (10,700 bbl) of crude oil were released onto a glacial outwash deposit consisting primarily of sand and gravel. The water table in the spill area ranged from near the surface to about 35 ft bgs. As of 1996, the leading edge of the oil remaining in the subsurface at the water table had moved approximately 131 ft downgradient from the spill site, and the leading edge of the dissolved contaminant plume had moved about 650 ft downgradient.

The hydraulic conductivity of a soil is a property that describes the ease with which water could move through the spaces or pores between soil particles. Several hydraulic conductivity estimates for the soils in which the Bemidji spill occurred are provided below (converted from meters per second to feet per day [ft/d]); these indicate how hydraulic conductivity values could vary based on the measurement methodology:

- 1.59 ft/d estimated from particle-size distributions (Dillard et al. 1997);
- 19.85 ft/d based on a calibrated estimate (Essaid et al. 2003);
- 20.70 ft/d based on aquifer (slug) tests (Strobel et al. 1998); and
- 99.23 ft/d based on permeameter tests (Bilir 1992).

Along the proposed Project route, estimated aquifer hydraulic conductivities range from about 1 ft/d to over 200 ft/d. As an example of this variability, the High Plains Aquifer system exhibits hydraulic conductivities estimated to range from 25 to 100 ft/d in 68 percent of the aquifer, with an average hydraulic conductivity estimated at 60 ft/d (Weeks et al. 1988). In general, groundwater velocity (which takes into account porosity, hydraulic gradient [slope of the water table], and hydraulic conductivity [how easily groundwater moves through soil]) in the High Plains Aquifer system is 1 ft/d and groundwater generally flows in a direction from west to east (Luckey et al. 1986).

Other shallow groundwater resources along the proposed pipeline route may occur within soil profiles somewhat dissimilar from the previously mentioned Bemidji site. In many areas, shallow unconfined aquifers occur within alluvium in flood plains near streams and rivers. Shallow aquifers could also occur under confined conditions. Under confined conditions, the confining layer (i.e., silt or clay) would impede or prevent vertical migration of the crude oil into the aquifer. Unconfined alluvial soils comprised a range of soil constituents, including gravels, sands, silts, and clays in various percentages. As a result, these alluvial soils exhibit a range of hydraulic conductivities, but it is expected that in general vertical and lateral oil migration would follow similar patterns.

Concern was expressed relative to risks of contamination in aquifer recharge areas. Aquifer recharge occurs when overlying permeable materials connect to an aquifer unit. Shallow unconfined aquifers are overlain by such permeable materials and therefore are at risk if contamination of the overlying soils occurs. In areas where parts of deeper bedrock aquifers are exposed at the surface, they could also be at risk if they lie within an oil spill zone. Research by the USGS at the Bemidji site suggests that infiltration of nutrients to an oil spill in unconfined shallow aquifer recharge areas may actually increase the rate of natural biodegradation by microbes (Bekins et al. 2005) in the event of an oil spill.

Specific groundwater data for each shallow aquifer are presented in Section 3.3.2, Groundwater, of the Final Supplemental EIS. A review of publicly available water well data within 1 mile of the proposed Project centerline shows the following results:

- **Montana**—No public water supply wells or SWPAs are located within 1 mile of the proposed pipeline centerline; and six known private water wells are located within approximately 100 ft of the proposed pipeline centerline within McCone, Dawson, Prairie, and Fallon counties.

- **South Dakota**—One public water supply well (associated with the Colome SWPA) is located within 1 mile of the proposed pipeline centerline in Tripp County (within the Tertiary Ogallala aquifer); the proposed pipeline passes through the Colome SWPA in Tripp County; and no known private water wells are located within approximately 100 ft of the proposed pipeline centerline in South Dakota.

- **Nebraska**—Thirty-eight known public water supply wells are located within 1 mile of the proposed pipeline centerline in Boone, York, Fillmore, Saline, and Jefferson counties; there are nine SWPAs within 1 mile of the proposed pipeline centerline and the only SWPA traversed by the pipeline route in Nebraska is in Steele City in Jefferson County; there are a total of 14 known private water wells located within approximately 100 ft of the proposed pipeline centerline within Antelope, Polk, York, Fillmore, and Jefferson counties.

An independent environmental review conducted by E^x^ponent (E^x^ponent 2013) considered potential factors that could be used to identify non-HCA shallow groundwater areas that could be at risk in the event of a spill. E^x^ponent's analysis determined wells located within 1,000 ft from the project centerline could be affected by a spill from the proposed Project and that this distance was reasonable to evaluate spill risk. The E^x^ponent spill model distance is similar to the Department's modeled distance discussed in Section 4.13.4.2, Spill Propagation, and in Appendix T, Screening Level Oil Spill Modeling. Even though spill modeling suggests that a shorter spill distance can be protective, this Final Supplemental EIS used a distance of 1 mile (5,280 ft) for potential impact from a spill to provide a more protective analysis.

Flowing Surface Waters

Flowing surface water includes open waterbodies such as rivers and streams. There are several streams and bodies of water crossed by the proposed route. Table 4.13-26 summarizes the number of water crossings by state. Table 4.13-27 shows the estimated total miles of proposed pipeline from which a spill could affect waterbodies, based on the spill impact buffers listed in Table 4.13-13; note that the mileage is based on oil spreading on flat ground and effects of topography on spill flow were not addressed.

Table 4.13-26 Waterbody Crossings by the Proposed Project

State[a]	Number of Crossings
MT	459
SD	333
NE	281

[a] MT=Montana, SD=South Dakota, NE=Nebraska.

Table 4.13-27 Estimated Total Pipeline Mileage that Could Affect Identified Waterbodies[a]

State[b]	Small (0 to 50 bbl)	Medium (50 to 1,000 bbl)	Large (1,000 to 20,000 bbl)
MT	109.88	154.22	301.48
SD	79.72	111.88	218.72
NE	67.27	94.41	184.57

[a] Based on number of streams the buffer distance shown in Table 4.13-13.
[b] MT=Montana, SD=South Dakota, NE=Nebraska. There are no waterbodies crossed in North Dakota and Kansas.

Water resource projects on designated segments that are determined to have a direct and adverse effect on the free-flowing condition, water quality, or the values for which the rivers were established are prohibited unless impacts can be avoided or eliminated.

As part of the surface water impact evaluation, a sub-analysis was conducted at the request of the National Park Service, to assess the potential impact of a release from the proposed Project to protected waterbodies (NSR, WSR, and NRR) of the Niobrara and Missouri River. This analysis calculated the probability of a spill occurring from the proposed pipeline, focusing on the tributary streams that could convey a spill to the specially designated waterbody. Stream crossings, stream widths, and spill travel distances were identified using GIS and the National Hydrology Dataset. Spill incident frequencies were calculated using two different sets of historical pipeline spill data from PHMSA: first, a broader dataset including crude oil pipelines greater than 16 inches in diameter and second, a more focused dataset narrowed to pipeline spills that impacted surface water (See Section 4.13.3.5 and Appendix K, Historical Pipeline Incident Analysis, for additional information.)

The analysis identified that there are 39 stream crossings within 40 miles upstream of the specially designated waterbodies that could connect a spill from the proposed Project to the waterbody. Seven of these streams flow perennially and the remaining streams either flow intermittently or are undefined. Most stream crossings are not large; the average width of the stream crossings is 9 feet and the largest crossing is 110 feet.

Spill frequencies for stream crossings were calculated based on the total combined distance of all stream widths including an additional 500-ft buffer distance from each stream bank. The probability of any spill occurring within 500 ft of a stream crossing that could convey a spill to a protected waterbody is one spill every 542 years, based on all historical spills from pipelines greater than 16 inches in diameter. Using data for historical spills that impacted surface water, the probability of any spill occurring within 500 ft of a stream crossing that could convey a spill to a protected waterbody is one spill every 1,202 years. The shortest distance a spill would have to travel to impact a protected waterbody is approximately 28.5 miles.

Based on the above spill probability, it is unlikely that a spill event would occur during the operational life of the pipeline at one of the identified stream crossings. Additionally, the distance from the proposed pipeline to the specially designated river segments further reduces the probability of a spill reaching the protected waterbodies. Nonetheless, in the event of a large spill or undetected release of sufficient duration, some oil could reach a specially designated river segment if flowing water was present within the stream at the time of a release.

The Final EIS Risk Assessment applied the following criteria which overestimated the potential spill impacts:

- The entire volume of a spill was released directly into a waterbody;
- Complete, instantaneous mixing occurred; and
- The entire benzene content was dissolved into the water column.

The Risk Assessment evaluated impacts to downstream drinking water sources by comparing projected surface water benzene concentrations with the national maximum contaminant level (MCL) for benzene (0.005 ppm). Similar to existing pipelines, the proposed Project would cross hundreds of perennial, intermittent, and ephemeral streams. The Risk Assessment evaluated categories of streams based on the magnitude of streamflow and stream width. These categories included Low Flow Stream, Lower Moderate Flow Stream, Upper Moderate Flow Stream, and High Flow Stream. A 1-hour release period for the entire spill volume was assumed to maximize the product concentration in water. The estimated benzene concentrations were then compared with the human health drinking water MCL for benzene. E^{x}ponent concluded in their review of the Risk Assessment that the assessment is useful for comparing worst-case benzene concentrations that could affect human and ecological receptors. Transport and fate of a spill to surface waters and the potential risk drivers to human health and ecological receptors are discussed further in Section 4.4 and Section 3.3, respectively, of E^{x}ponent's Environmental Review (E^{x}ponent 2013).

This report updates the Risk Assessment from the Final EIS to include the revised spill volume categories (small, medium, and large) discussed above and to use the new calculated occurrence interval of 0.00025 incident/mile-year (see Appendix K, Historical Pipeline Incident Analysis, Table 6). The incident frequency is based on historical data for mainline pipe and the revised streamflow results are presented in Tables 4.13-28 and 4.13-29.

Based on these conservative assumptions, results suggest that most spills that enter a waterbody could exceed the national MCL for benzene. Although the assumptions used are highly conservative and, thus, potentially overestimate potential benzene water concentrations, the analysis indicates the need for rapid notification of managers of municipal water intakes downstream of a spill so that potentially affected drinking water intakes from affected surface waterbodies could be closed. Section 2.2, External Notifications, of Keystone's ERP (see Appendix I, SPCC and ERP) contains notification procedures to ensure that these water managers are rapidly notified. Under anaerobic conditions (little to no dissolved oxygen), benzene typically degrades at a slower rate and could be more persistent in groundwater and travel longer distances than benzene in aerobic (normal or abundant dissolved oxygen) conditions. However, the distance of the migration is not unlimited and would be restricted by attenuating processes. In surface water, the mixing of benzene with fresh water, evaporation of benzene, and biodegradation would reduce the concentration of benzene in surface water quickly. Benzene, as a single component, would be reduced to non-detectable levels in a shorter distance in a flow surface water system than in a flowing groundwater system.

Although toxicity threshold values could be exceeded based upon the conservative assumptions, the potential for a release is low based on the risk evaluation above (and described in Appendix K, Historical Pipeline Incident Analysis). Spill occurrence intervals for a diluted bitumen or synthetic crude spill are shown in Tables 4.13-28 and 4.13-29, respectively. For a representative stream size and spill size category, a potential spill occurrence was calculated from data obtained from the PHMSA database. To be conservative, a 500-foot buffer on either side of the river was added to the crossing widths. Conservative occurrence intervals for a diluted bitumen ranged from approximately one spill event in 8,638 years for a high-flow stream to one spill event in 502,857 years for a small low-flow stream. If a release did occur, it is likely that the total release volume of a spill would be 50 bbl or less based on PHMSA data for historical spill volumes (see Appendix K, Historical Pipeline Incident Analysis, Figure 1).

Table 4.13-28 Estimated Surface Water Benzene Concentrations Resulting from a Diluted Bitumen Spill[a]

			Product Released					
			Small Spill		Medium Spill		Large Spill	
Streamflow	Benzene MCL (ppm)	Stream Flow Rate (cfs)[b]	Benzene Concentration (ppm)	Occurrence Interval (years)[c]	Benzene Concentration (ppm)	Occurrence Interval (years)[c]	Benzene Concentration (ppm)	Occurrence Interval (years)[c]
Low Flow Stream	0.005	10	10.9	25,461	218	118,319	2175.0	502,857
Lower Moderate Flow Stream	0.005	100	1.1	17,823	21.8	82,824	218.0	352,000
Upper Moderate Flow Stream	0.005	1,000	0.1	13,367	2.2	62,118	21.8	264,000
High Flow Stream	0.005	10,000	0.01	7,638	0.2	35,496	2.2	150,857

[a] Historical data indicate that the most probable spill volume would be 3 bbl or less. However, this analysis is based on conservative incident frequencies and volumes defined for this Final Supplemental EIS, which overestimates the proportion of larger spills. Consequently, the assessment is conservative in its evaluation of the magnitude of environmental consequences. Estimated concentration is based on release of benzene into water over a 1-hour period, with uniform mixing conditions. Concentrations are based on a 0.15 percent by weight benzene content of the transported material. Occurrence intervals are based on a historical incident frequency of 0.00025 incidents/mile-year (see Appendix K, Historical Pipeline Incident Analysis, Table 6), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.
[b] cfs = cubic feet per second.
[c] Occurrence Interval (years) = the number of years that could pass before a spill incident would occur on a stream with this streamflow.

Table 4.13-29 Estimated Surface Water Benzene Concentrations Resulting from a Synthetic Crude Spill[a]

			Product Released					
			Small Spill		Medium Spill		Large Spill	
Streamflow	Benzene MCL (ppm)	Stream Flow Rate (cfs)	Benzene Concentration (ppm)	Occurrence Interval (years)[b]	Benzene Concentration (ppm)	Occurrence Interval (years)[b]	Benzene Concentration (ppm)	Occurrence Interval (years)[b]
Low Flow Stream	0.005	10	0.2	25,461	3.6	118,319	725.0	502,857
Lower Moderate Flow Stream	0.005	100	0.02	17,823	0.4	82,824	72.5	352,000
Upper Moderate Flow Stream	0.005	1,000	0.002	13,367	0.04	62,118	7.2	264,000
High Flow Stream	0.005	10,000	0.0002	7,638	0.004	35,496	0.7	150,857

[a] Historical data indicate that the most probable spill volume would be 3 bbl or less. However, this analysis is based on conservative incident frequencies and volumes defined for this Final Supplemental EIS, which overestimates the proportion of larger spills. Estimated concentration is based on release of benzene into water over a 1-hour period with uniform mixing conditions. Concentrations are based on a 0.15 percent by weight benzene content of the transported material. Occurrence intervals are based on a historical incident frequency of 0.00025 incidents/mile-year (see Appendix K, Historical Pipeline Incident Analysis, Table 6), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.
b Occurrence Interval (years) = the number of years that could pass before a spill incident would occur on a stream with this streamflow.

In general, the impacts would be lower in flowing waters than in static water since constituent concentrations would be more rapidly diluted in flowing waters, although spills into rivers and creeks might result in some toxicity within the water column itself. Under certain conditions, oil may sink in the water column as previously described. In large rivers, the impact to the water column would be reduced. In small streams, an oil spill could create direct aquatic toxicity in the water column because of the lower relative volume and rate of water flow. This would lead to a higher likelihood of direct contact between aquatic organisms and the dispersed oil. Some toxicity might persist in these streams for a few weeks to months, until toxic compounds trapped in the sediment were washed out or until impacted sediment was covered by cleaner sediment.

Spills could affect surface water quality if spilled material reaches waterbodies directly or from flowing over the land. However, the vast majority of spills would likely be confined to construction yards, areas in or adjacent to the proposed pipeline ROW, or along access roads. As shown on Table 4.13-1 and in Appendix K, Historical Pipeline Incident Analysis, the volumes of most spills would likely be small. In addition, for some portion of the winter months each year, spill responders could remove much of the spilled material from frozen ground or ice-covered waterbodies prior to snowmelt. During the rest of the year, spills could reach and affect wetlands, ponds, and lakes, as well as creeks and rivers before spill response is initiated or completed.

An oil spill that reaches a surface waterbody not only could cause oiling and constituent toxicity levels, but could also reduce dissolved oxygen (DO) concentrations, particularly from dissolved phase hydrocarbons (e.g., benzene, toluene, ethylbenzene, and xylene). A reduced DO concentration results in a lower sustainable capacity for the plant and aquatic life, thus reducing the overall waterbody population. Because oil slicks are less permeable to oxygen than water, spilled material that reaches wetlands, ponds, or small lakes could lower DO concentrations due to a decreased influx of atmospheric oxygen and the relatively high rate of natural sediment respiration in many shallow waterbodies. In small, shallow waterbodies with limited water movement and presence (e.g., small lakes, farm reservoirs, and stock ponds), the presence of oil could increase biodegradation activity, further reducing oxygen levels.

In winter, however, a small spill may contribute less to an oxygen deficit in still waters than in other seasons, because biological abundance and activity are lower than during other times of the year and the need for oxygen is reduced. Furthermore, sediment respiration has less relative effect in lakes that are too deep to freeze to the bottom. Such lakes tend to be supersaturated with DO in winter (BLM and Minerals Management Service 1998). An exception to such conditions could occur if spilled material were introduced to a waterbody beneath the ice cover, in very restricted waters with depleted oxygen levels and a concentrated population of overwintering fish. During open water periods in most waterbodies, especially larger lakes, rivers, and streams, spilled materials would likely result in little detectable decrease in DO levels. The high water volume (relative to the volume of oil) or the high rate of water flow would disperse oil before it affected DO concentrations.

Long-term aquatic toxicity is considered less likely to occur in larger lakes and rivers because oil would be diluted or dispersed within the sediment over large areas by currents and wind and wave action. Spills into larger rivers and creeks, especially during open water periods, might result in some toxicity within the water column itself. However, in larger rivers, because of the large and rapid dilution of the oil relative to the flow volumes, these impacts would likely be limited to back eddies, calm water regions, and reservoir pools down current of where the spill enters the river. In smaller flowing streams, an oil spill could create direct aquatic toxicity in the water column because of the lower relative volume and rate of water flow, and thus there would be a higher likelihood of direct contact between the biota and the dispersed oil. Some toxicity might persist in these streams for a few weeks or longer, until toxic compounds trapped in the sediment were washed out or until oiled sediment was covered by cleaner sediment.

Since the majority of oil spills are small in volume, these smaller spills, if reaching larger lakes, would result in minimal effects on overall water quality, assuming the lake volume is substantially larger than the volume of spilled oil. Decreases in DO levels would be negligible in most cases but may be greater in large to very large spills that cover much of the water surface for a day or more. Direct toxicity would be short term because of the high dilution volume in these lakes and the rapid evaporation of most of the potentially toxic lighter hydrocarbons. Spreading of a spill over a lake surface may have a minor to major effect on water aesthetics and recreational use. This effect could exist for days to a few weeks until the oil was removed. Removal could include both physical removal by response teams and natural attenuation. Natural attenuation could include biodegradation, evaporation, components dissolving in water and degrading naturally, and dispersion and dilution.

Minor temporary to short-term surface water quality degradation is possible from smaller maintenance equipment and vehicle spills or leaks. Longer-term water quality degradation could be associated with large to very large spills. A larger spill could also affect potable surface water sources and irrigation water supplies. As mentioned previously, the crude oils transported by the proposed Project would tend to float on the surface water column. However, as with any crude oil, over time key components of oil would evaporate and biodegrade resulting in a weathered oil that could potentially sink.

Aquatic Organisms

As defined in Section 3.13, Potential Releases, aquatic organisms include plants, animals, and microorganisms for which life is completely sustained within an aquatic habitat. There are three fish species listed with special status that were identified during field surveys, including Blacknose shiner, Finescale dace, and the Northern redbelly dace. Table 4.13-30 shows that fish are among the most sensitive aquatic organisms, while aquatic clams, snails, etc., generally have intermediate sensitivities, and algae and bacteria tend to be the least sensitive. Nevertheless, even when major fish kills have occurred as a result of oil spills, population recovery has been observed and long-term changes in fish abundance have not been reported. Benthic (bottom-dwelling) aquatic invertebrates tend to be more sensitive than algae, but are equally as or less sensitive than fish. Planktonic (floating) species tend to be more sensitive than most benthic insects, crustaceans, and mollusks.

Table 4.13-30 Acute Toxicity of Aromatic Hydrocarbons to Freshwater Organisms[a]

	Toxicity Values (ppm)				
Taxa/Species	**Benzene**	**Toluene**	**Xylenes**	**Naphthalene**	**Anthracene**
Amphipod/ (*Gammarus lacustris*)	NA[b]	NA	0.35	NA	NA
Amphipod/ (*Gammarus minus*)	NA	NA	NA	3.9	NA
Fish/Carp (*Cyprinus carpio*)	40.4	NA	780	NA	NA
Fish/Channel catfish (*Ictalurus sp.*)	NA[a]	240	NA	NA	NA
Fish/Clarias catfish (*Clarias* sp.)	425	26	NA	NA	NA
Fish/Coho salmon (*Oncorhyncus kisutch*)	100	NA	NA	2.6	NA
Fish/Fathead minnow (*Pimephales sp.*)	NA	36	25	4.9	25
Fish/Goldfish (*Carassius auratus*)	34.4	23	24	NA	NA
Fish/Guppy (*Poecilia reticulate*)	56.8	41	NA	NA	NA
Fish/Largemouth bass (*Micropterus sp.*)	NA	NA	NA	0.59	NA
Fish/Medaka (Oryzias sp.)	82.3	54	NA	NA	NA
Fish/Mosquito fish (*Gambusia affinis*)	NA	1,200	NA	150	NA
Fish/Rainbow trout (*Oncorhyncus mykis*)	7.4	8.9	8.2	3.4	NA
Fish/Zebra fish (*Therapon iarbua*)	NA	25	20	NA	NA
Insect/ *Chlorella vulgaris*	NA	230	NA	25	NA
Insect/ *Microcystis aeruginosa*	NA	NA	NA	0.85	NA
Insect/ *Nitzschia palea*	NA	NA	NA	2.8	NA
Insect/ *Scenedesmus subspicatus*	NA	130	NA	NA	NA
Insect/ *Selenastrum capricornutum*	70	25	72	7.5	NA
Insect/ (*Somatochloa cingulata*)	NA	NA	NA	1.0	NA
Midge/ (*Chironomus attenuatus*)	NA	NA	NA	15	NA
Midge/ (*Chironomus tentans*)	NA	NA	NA	2.8	NA
Rotifer/ (*Brachionus calyciflorus*)	>1,000	110	250	NA	NA
Snail/(*Physa gyrina*)	NA	NA	NA	5.0	NA
Zooplankton/ (*Daphnia magna*)	30	41	NA	6.3	0.43

	Toxicity Values (ppm)				
Taxa/Species	Benzene	Toluene	Xylenes	Naphthalene	Anthracene
Zooplankton/ (*Daphnia pulex*)	111	NA	NA	9.2	NA
Zooplankton/ (*Diaptomus forbesi*)	NA	450	100	68	NA

Source: Appendix P, Risk Assessment, Table 4-4

[a] Data summarize conventional acute toxicity endpoints from USEPA's ECOTOX database. When several results were available for a given species, the geometric mean of the reported LC50 values was calculated. The LC50 is the concentration of a compound necessary to cause 50 percent mortality in laboratory test organisms within a predetermined time period (e.g., 48 hours) (USEPA 1994).
[b] NA = not available. Indicates no value was available in the database.

The toxicity of crude oil is dependent on the toxicity of its constituents. Table 4.13-31 summarizes the toxicity of various crude oil hydrocarbons to the water flea, *Daphnia magna*. This species of water flea is used as a standard test organism to determine acute and chronic responses to toxicants. Most investigators have concluded that the acute toxicity of crude oil is related to the concentrations of relatively lightweight aromatic constituents, particularly benzene.

Table 4.13-31 Acute Toxicity of Crude Oil Hydrocarbons to *Daphnia magna*

Compound	48-hr LC50[a] (ppm)	Optimum Solubility (ppm)	Relative Toxicity[b]
Anthracene	3	5.9	2
Benzene	9.2	1,800	195.6
Biphenyl	3.1	21	6.8
Cumene	0.6	50	83.3
Cyclohexane	3.8	55	14.5
Decane	0.028	0.052	1.9
Ethylbenzene	2.1	152	72.4
Hexane	3.9	9.5	2.4
9-methylanthracene	0.44	0.88	2
Methyl cyclohexane	1.5	14	9.3
Octane	0.37	0.66	1.8
1-methylnaphthalene	1.4	28	20
2-methylnaphthalene	1.8	32	17.8
Phenanthrene	1.2	6.6	5.5
Pyrene	1.8	2.8	1.6
Toluene	11.5	515	44.8
1,2,4,5-tetramethylbenzene	0.47	3.5	7.4
1,2,4-trimethylbenzene	3.6	57	15.8
1,3,5-trimethylbenzene	6	97	16.2
p-xylene	8.5	185	21.8
m-xylene	9.6	162	16.9
o-xylene	3.2	175	54.7

Source: Appendix P, Risk Assessment, Table 4-4

[a] The LC50 is the concentration of a compound necessary to cause 50 percent mortality in laboratory test organisms within a predetermined time period (e.g., 48 hours) (USEPA 1994).
[b] Relative toxicity = optimum solubility/LC50

While lightweight aromatics such as benzene tend to be water soluble and relatively toxic, they also are highly volatile. Thus, most or all of the lightweight hydrocarbons accidentally released into the environment evaporate, and the environmental persistence of this crude oil fraction tends to be low. High molecular weight aromatic compounds, including PAHs, are not very water-soluble and have a high affinity for organic material. Consequently, these compounds, if present, have limited bioavailability, which renders them substantially less toxic than more water-soluble compounds (Neff 1979). Additionally, these compounds generally do not accumulate to any great extent because these compounds are rapidly metabolized (Lawrence and Weber 1984; West et al. 1984). There are some indications, however, that prolonged exposure to elevated concentrations of these compounds may result in a higher incidence of growth abnormalities and hyperplastic diseases in aquatic organisms (Couch and Harshbarger 1985).

A summary of chronic toxicity values (most frequently measured as reduced reproduction, growth, or weight) of benzene to freshwater biota is provided in Table 4.13-32. Chronic toxicity from other oil constituents may occur if sufficient quantities of crude oil are continually released into the water to maintain elevated concentrations.

Table 4.13-32 Chronic Toxicity of Benzene to Freshwater Biota[a]

Taxa	Test Species		Chronic Value (ppm)
Algae	Green algae	(*Selenastrum capricornutum*)	4.8*
Amphibian	Leopard frog	(*Rana pipens*)	3.7
Fish	Fathead minnow	(*Pimephales promelas*)	17.2*
	Guppy	(*Poecilia reticulata*)	63.0
	Coho salmon	(*Oncorhynchus kitsutch*)	1.4
Invertebrate	Zooplankton	(*Daphnia* spp.)	>98.0

Source: Appendix P, Risk Assessment, Table 4-4

[a] Test endpoint was mortality unless denoted with an asterisk (*). The test endpoint for these studies was growth.

Significantly, some constituents in crude oil may have greater environmental persistence than lightweight compounds (e.g., benzene), but their limited bioavailability renders them substantially less toxic than other more soluble compounds. Based on the combination of toxicity, solubility, and bioavailability, benzene was determined to dominate toxicity associated with potential crude oil spills. E^{x}ponent investigated the possibility that other crude oil constituents may pose a greater toxicological risk to aquatic organisms than benzene. Of the crude oil constituents evaluated, only nickel and vanadium were likely to exceed water quality thresholds based on chronic exposure level and these constituents were only likely to exceed for large (10,000 barrels) or medium (1,000 barrels) spills. Because these findings show less risk than predicted for benzene, E^{x}ponent concluded that the evaluation of toxicity resulting from spills to surface water appears to be sufficient for judging the potential for toxic effects on aquatic organisms (E^{x}ponent 2013).

The potential impact to aquatic organisms of various-sized spills to waterbodies was modeled assuming the benzene content within each type of crude oil completely dissolved in the water. The benzene concentration was predicted based on amount of crude oil spilled and streamflow. The estimated benzene concentrations were compared to conservative acute and chronic toxicity values for protection of aquatic organisms. For aquatic biota, the lowest acute and chronic toxicity thresholds for benzene are 7.4 and 1.4 ppm, respectively, based on standardized trout and Coho salmon toxicity tests (USEPA 1994). These toxicity threshold values are considered protective of acute and chronic effects to aquatic biota. Although trout or Coho salmon are not found in many of the habitats crossed by the proposed Project route, these two species are among the most sensitive aquatic species and reliable acute and chronic toxicity data are available. Using these toxicity thresholds, therefore, provides a conservative benchmark to screen for the potential for toxicity.

Tables 4.13-33 through 4.13-35 summarize a screening-level assessment of acute and chronic toxicity to aquatic resources.

Broadly, acute toxicity could potentially occur if substantial amounts of crude oil were to enter rivers and streams. If such an event were to occur within a small stream, aquatic species in the immediate vicinity and downstream of the rupture could be killed or injured. Chronic toxicity also could potentially occur in small and moderate-sized streams and rivers. However, emergency response, containment, and cleanup efforts would help reduce the concentrations and minimize the potential for chronic toxicity. In comparison, small spills (less than 50 bbl) into moderate and large rivers would not pose a major toxicological threat. In small to moderate sized-streams and rivers, some toxicity might occur in localized areas, such as backwaters where concentrations would likely be higher than in the mainstream of the river. While a release of crude oil into any given waterbody might cause immediate localized toxicity to aquatic biota, particularly in smaller streams and rivers, the frequency of such an event would be very low. Nevertheless, streams and rivers with aquatic biota represent the sensitive environmental resources that could be temporarily impacted by a crude oil release. Environmentally, much information has been acquired and lessons continue to be learned from the Marshall Michigan dilbit spill. The release of dilbit to a river or other aquatic environment introduces the potential for additional impacts and additional recovery challenges for responders of such an event to the environment.

The Department examined existing studies and information to evaluate the impacts of other components of dilbit (e.g., PAHs, heavy metals, etc.), which are similar to heavy crude. These impacts would generally be similar to those discussed in Section 4.13.4.3, Effect of Soil Type, Soil Cover, and Temperature Flow. Allowing for the specific chemical properties and toxicological effects of the other components of heavy crude, anecdotal comparisons could be made regarding the impacts of these components from a submerged dilbit release on the environment and the organisms that inhabit the water column and the underlying sediments and soils.

Table 4.13-33 Comparison of Estimated Benzene Stream Concentrations Following a Diluted Bitumen Spill to the Chronic Toxicity Threshold for Aquatic Life (1.4 ppm)[a]

			Product Released					
			Small Spill		Medium Spill		Large Spill	
Throughput 435,000 bpd	Stream Flow Rate (cfs)	Acute Toxicity Threshold (ppm)	Benzene Concentration (ppm)	Occurrence Interval (years)[b]	Benzene Concentration (ppm)	Occurrence Interval (years)[b]	Benzene Concentration (ppm)	Occurrence Interval (years)[b]
Low Flow Stream	10	1.4	0.06	25,461	1.3	118,319	12.9	502,857
Lower Moderate Flow Stream	100	1.4	0.006	17,823	0.13	82,824	1.3	352,000
Upper Moderate Flow Stream	1,000	1.4	0.0006	13,367	0.013	62,118	0.13	264,000
High Flow Stream	10,000	1.4	0.00006	7,638	0.0013	35,496	0.013	150,857

[a] Historical data indicate that the most probable spill volume would be 3 bbl or less. However, this analysis is based on conservative incident frequencies and volumes defined for this Final Supplemental EIS, which overestimates the proportion of larger spills. Estimated proportion of benzene in the transported material is 0.15 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.15 percent of the total amount of material released divided by 7 days of stream flow volume. The model assumes uniform mixing conditions. The chronic toxicity value for benzene is based on a 7-day toxicity value of 1.4 ppm for Coho salmon. Exposure concentrations were estimated over a 7-day period since the chronic toxicity value was based on a 7-day exposure. Shading indicates concentrations that could potentially cause chronic toxicity to aquatic species. The darkest shading represents high probability of chronic toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of chronic toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of chronic toxicity (<toxicity threshold). Occurrence intervals are based on a historical incident frequency of 0.00025 incidents/mile-year (see Appendix K, Historical Pipeline Incident Analysis, Table 6), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.
[b] Occurrence Interval (years) = the number of years that could pass before a spill incident would occur on a stream with this streamflow.

Table 4.13-34 Comparison of Estimated Benzene Stream Concentrations Following a Synthetic Crude Spill to the Acute Toxicity Threshold for Aquatic Life (1.4 ppm) [a]

			Product Released					
			Small Spill		Medium Spill		Large Spill	
Throughput 435,000 bpd	Stream Flow Rate (cfs)	Acute Toxicity Threshold (ppm)	Benzene Concentration (ppm)	Occurrence Interval (years)[b]	Benzene Concentration (ppm)	Occurrence Interval (years)[b]	Benzene Concentration (ppm)	Occurrence Interval (years)[b]
Low Flow Stream	10	7.4	3.6	25,461	72	118,319	725	502,857
Lower Moderate Flow Stream	100	7.4	0.4	17,823	7.2	82,824	72.5	352,000
Upper Moderate Flow Stream	1,000	7.4	0.04	13,367	0.7	62,118	7.2	264,000
High Flow Stream	10,000	7.4	0.004	7,638	0.07	35,496	0.7	150,857

[a] Historical data indicate that the most probable spill volume would be 3 bbl or less. However, this analysis is based on conservative incident frequencies and volumes defined for this Final Supplemental EIS, which overestimates the proportion of larger spills. Estimated proportion of benzene in the transported material is 0.15 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.15 percent of the total amount of material released divided by 7 days of stream flow volume. The model assumes uniform mixing conditions. The acute toxicity value for benzene is based on a 7-day toxicity value of 7.4 ppm for trout. Exposure concentrations were estimated over a 7-day period since the chronic toxicity value was based on a 7-day exposure. - Shading indicates concentrations that could potentially cause chronic toxicity to aquatic species. The darkest shading represents high probability of chronic toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of chronic toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of chronic toxicity (<toxicity threshold). Occurrence intervals are based on an historical incident frequency of 0.00025 incidents/mile-year (see Appendix K, Historical Pipeline Incident Analysis, Table 6), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.
[b] Occurrence Interval (years) = the number of years that could pass before a spill incident would occur on a stream with this streamflow.

Table 4.13-35 Comparison of Estimated Benzene Stream Concentrations Following a Diluted Bitumen Spill to the Acute Toxicity Threshold for Aquatic Life (7.4 ppm)[a]

Throughput 435,000 bpd	Stream Flow Rate (cfs)	Acute Toxicity Threshold (ppm)	Product Released: Small Spill: Benzene Concentration (ppm)	Small Spill: Occurrence Interval (years)[b]	Medium Spill: Benzene Concentration (ppm)	Medium Spill: Occurrence Interval (years)[b]	Large Spill: Benzene Concentration (ppm)	Large Spill: Occurrence Interval (years)[b]
Low Flow Stream	10	7.4	0.06	25,461	1.3	118,319	12.9	502,857
Lower Moderate Flow Stream	100	7.4	0.006	17,823	0.13	82,824	1.3	352,000
Upper Moderate Flow Stream	1,000	7.4	0.0006	13,367	0.013	62,118	0.13	264,000
High Flow Stream	10,000	7.4	0.00006	7,638	0.0013	35,496	0.013	150,857

[a] Historical data indicate that the most probable spill volume would be 3 bbl or less. However, this analysis is based on conservative incident frequencies and volumes defined for this Final Supplemental EIS, which overestimates the proportion of larger spills.
Estimated proportion of benzene in the transported material is 0.15 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.15 percent of the total amount of material released divided by 7 days of stream flow volume. The model assumes uniform mixing conditions.
The acute toxicity value for benzene is based on a 7-day toxicity value of 7.4 ppm for trout.
Exposure concentrations were estimated over a 7-day period since the chronic toxicity value was based on a 7-day exposure.
Shading indicates concentrations that could potentially cause chronic toxicity to aquatic species. The darkest shading represents high probability of chronic toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of chronic toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of chronic toxicity (<toxicity threshold).
Occurrence intervals are based on an historic incident frequency of 0.00025 incidents/mile-year (see Appendix K, Historical Pipeline Incident Analysis, Table 6), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.
[b] Occurrence Interval (years) = the number of years that could pass before a spill incident would occur on a stream with this streamflow.

As with some other types of oil, dilbit would not float on water indefinitely. The dilbit-specific characteristics, water temperature, and particulate load in the water could result in oil being submerged in the water column. Submerged oil could be suspended in the water column, suspended just above the river bed, or intermixed with sediment and trapped in the river bed and shoreline. In flowing waters, the spreading of the oil in three dimensions creates many challenges for responders to minimize the impacts of the release. Consideration of submerged oil in a flowing water environment would require to a certain extent different response action planning and response equipment to contain and recover the submerged oil. Dilbit intermixed with sediment and trapped in the river bed and shoreline results in a persistent source of oil and has the potential to present additional response and recovery challenges. The understanding and adaptation of response and recovery techniques to dilbit spills in flowing water scenarios continues along the Kalamazoo River in response to the 2010 Enbridge release near Marshall, Michigan. As the response to the Marshall Michigan dilbit spill continues to mature and evolve, the lessons learned from the response and recovery efforts are included in Section 4.13.5.2, and Keystone has stated that these lessons learned would be considered to facilitate the implementation of proper response planning and response strategies to improve the overall response to dilbit spills.

Wetlands/Reservoirs/Lakes

Wetlands are considered in this analysis as lands where saturation with water determines the type of soil, wildlife, and vegetation found in the area. Wetlands include swamps and marshes. Reservoirs are natural or artificial lakes used as a source of water. Lakes are a large body of water surrounded by land. Wetlands, reservoirs, and lakes are grouped together as semi-static waterbodies.

Although planning and routing efforts have attempted to minimize the overall number of wetlands and static waterbody environments crossed by the proposed Project route, wetlands and waterbodies with persistently saturated soils are present along and adjacent to the proposed route. The effects of crude oil released into a wetland environment would depend not only upon the quantity of oil released, but also on the physical conditions of the wetland at the time of the release. Table 4.13-36 identifies the total estimated potential wetland acreage along the proposed route that could be affected by a surface release, based on buffer distance assumptions.

Table 4.13-36 Total Estimated Wetlands Acreage in Potential Surface Spill Areas

State[a]	Small (0 to 50 bbl)	Medium (50 to 1,000 bbl)	Large (1,000 to 20,000 bbl)
MT	81.67	269.02	888.73
SD	197.14	649.39	2145.31
NE	108.98	358.99	1185.95

[a] MT=Montana, SD=South Dakota, NE=Nebraska

An oil spill that reaches these types of waterbodies could result in reduction of oxygen levels within the water. In winter, however, a small spill would not have as much of an impact on oxygen levels as in other seasons, due to the already lowered biological activity that is a part of the natural cycle of freezing waterbodies. If a spill were to occur underneath ice of a frozen lake, oil could accumulate under the ice, the temperature could increase the viscosity, light components could dissolve in water, and recovery efforts could be slowed because of the location and characteristics of the oil. Spills in these conditions are addressed by the Keystone

ERP, which would be updated for the proposed Project. For spills occurring during the rest of the year, most of the product would float on the water or wet soil surface, although some of the light components of the oil (e.g., benzene) could dissolve or disperse in water.

Since most oil spills are statistically small in size, there would be minimal effects in water quality in large lakes, assuming the lake volume is substantially larger than the volume of spilled oil. Decreases in oxygen levels would be negligible in most cases but may be greater in large to very large spills that cover much of the water surface for a day or more. Direct toxicity would be short-term because of the high dilution volume in these lakes and the rapid evaporation of most of the potentially toxic lighter hydrocarbons. Spreading of a spill over a lake surface may have a minor to major effect on water aesthetics and recreational use. This effect could exist for days to a few weeks until the oil was removed.

Impacts of crude oil spills or refined product spills on wetlands are influenced by the type of oil or oil product, the amount and proportion of water surface area covered, the type of vegetation present in the wetland, and cleanup response actions. Refined products tend to be more toxic than crude oil, while crude oil tends to cause more physical impacts (e.g., smothering). Most spilled oil would remain on the water surface where vegetation and wildlife may become coated as the oil disperses.

As the purposed pipeline would carry only crude oil, spills of refined product (e.g., diesel, gasoline) would be more likely to occur during construction. The majority of these spills would be small spills from construction pads or access roads. If the spills occur in winter, the wetland may be covered in ice and spilled product may be contained by snow or remain on top of the ice. In either case, the spilled oil likely would be recovered before it directly affected wetland habitat and associated organisms. Although gasoline spills evaporate quickly, there may be short-term acute effects on wetland wildlife and vegetation. Diesel spills tend to be more persistent, and diesel may infiltrate sediments as well as adhere to emergent vegetation.

Crude oil spills that occur during operation of the proposed Project could affect wetlands either where the proposed pipeline would cross wetlands or waterbodies (e.g., ponds, lakes, reservoirs, streams, rivers, or adjacent riparian habitats) or where the spill site is on land but upgradient of the wetland. Due to the viscosity of heavy crude oils, spills would likely be restricted in areal extent, particularly in colder months. Snow could serve as a medium to hold and further restrict the spill migration. Larger spills in open water seasons could flow into wetlands, cover the water surface, coat wetland wildlife and vegetation, and restrict oxygen exchange between air and water. Some spilled crude oil could sink through the water into underlying sediments and remain there for years, depending on the amount of biodegradation and chemical or physical weathering that takes place.

Smaller refined product or crude oil spills would generally produce minor impacts on wetlands unless the wetland is small and isolated from other waterbodies. In these cases, impacts could be substantive if the majority of the wetland is exposed to the oil. Large to very large crude oil spills could result in substantive impacts on wetlands due to the size of the spill and the proportion of the wetlands that would be affected. Impacts could include a substantial reduction in wildlife population and ecological damage where the wetlands are heavily used by migratory waterfowl and the spill occurred during the spring or fall migration.

Crude oil released from a subsurface pipe within a wetland could reach the surface. If the water table is at the surface, the release would manifest as floating crude oil. The general lack of surface flow within a wetland would restrict crude oil movement. Where surface water is present within a wetland, the spill would spread laterally across the water's surface and be readily visible during routine ROW surveillance. The depth of soil impacts likely would be limited to the depth to groundwater. Conversely, due to shallow groundwater, impacts within the wetland are likely to be confined to the near-surface, enhancing the potential for biodegradation.

Spills to any environment that result in regulatory notification would likely trigger regulator involvement and assessment to implement remedial action. However, response and remediation efforts in a wetland have the potential for appreciable adverse effects from construction/cleanup equipment. Aggressive cleanup methods could mix oil and water, which may result in longer lasting impacts to sensitive wetland habitat. Physical disruption of wetland resources below the water line during spill response could be reduced in some cases through ignition of the oil floating on the water surface. Passive cleanup methods (including natural attenuation) are less likely to impact wetland resources. If no active remediation activities were undertaken, with concurrence of the regulatory body (e.g., state Department of Environmental Quality), natural biodegradation and attenuation would ultimately allow a return to preexisting conditions in both soil and groundwater. This would likely require a timeframe on the order of tens of years. In the unlikely event of a spill in wetlands, Keystone would use the most appropriate cleanup procedures as determined in coordination with the applicable federal and state agencies. At the request of regulators, Keystone would perform the Net Environmental Benefit Analysis, described in further detail below in *Spill Response Considerations*.

Socioeconomics

The Final EIS discussed impacts of oil spills to components of the socioeconomic environment, including populated areas; agricultural activities, water intakes and water supplies, other commercial activities, and single-family home sales and property value. The Final EIS noted, and as stated above, that in the event of oil spill impacts to water supplies for residential, agricultural, commercial, or public uses, Keystone would provide alternate sources of water for essential uses such as drinking water, irrigation, industrial cooling water, and water for firefighting and similar public safety services.

Economic impacts related to short-term disruption in local agricultural production could result from a spill that enters agricultural lands or wild lands used by grazing livestock. The extent and duration (i.e., short term or long term) of the economic impacts would depend on the number of productive acres affected, the response time, the remedial method selected and implemented by the response team, and the length of time required to return land services to conditions similar to those prior to the spill.

If a spill affected recreational lands and/or waterways, businesses relying on hunting, fishing, sightseeing, and other recreational activities could experience a short-term negative economic impact. During response and restoration actions, access to oil-impacted areas would generally be limited or prohibited to anyone except the cleanup and monitoring crews, thus limiting recreational access. Adverse publicity about the impacts of large to very large spills could reduce use by recreationists from the local and regional areas, or even from other areas in the United States for an extended period of time. For small to very small spills, there would likely be negligible economic impacts to businesses relying on recreational uses. In some cases, response to oil spills could generate positive local economic activity for the limited duration of the spill response activities as a result of the need for lodging, meals, equipment, and other facilities, materials, and logistic support for the cleanup crews and the incident command team.

The Final EIS also reviewed the findings of two studies (Simons et al. 2001; Hansen et all 2006) of economic impacts to land and residence values in areas affected by oil spills and concluded that the data suggest that the economic consequences of an oil spill could include a temporary reduction in housing prices that would likely decrease over time. In light of high profile pipeline oil spills on the Kalamazoo River in Calhoun County, Michigan, in 2010, and in Mayflower, Faulkner County, Arkansas, in 2013, other academic studies and anecdotal information were reviewed for this Final Supplemental EIS. The findings of this additional research are consistent with the other literature in that the oil spills appear to have had an immediate to short-term negative effect on house desirability and prices in local real estate markets. The literature on long-term impacts to house values from noxious or incompatible land uses or facilities (such as oil refineries, natural gas wells, or landfills) suggests that a negative effect on residential property occurs so long as the noxious effect of the use or facility exists. Assuming noxious effects lead to negative impacts to property values for as long as they exist, the long term effect of oil spills would likely depend on the resolution of these incidents in terms of remediation, compensation, and management of future risk (Hite et al. 2000), with the stigma effect to property values of a noxious facility existing after a successful resolution only for those homes or properties that are located "in very close proximity" to the site (McCluskey and Rausser 1999).

Environmental Justice Considerations

Information on minority and low-income populations within the proposed Project socioeconomics analysis area including locations that are designated as Health Professional Shortage Areas and Medically Underserved Areas/Populations are presented in Section 4.10, Socioeconomics. Depending on the location and volume of an accidental crude oil release from the proposed Project, it is possible that minority or low-income populations could be affected by the release. Minority and low-income populations could be more vulnerable to health impacts associated with the crude oil release, particularly if access to health care is less available in the release area.

Exposure pathways could include direct contact with the crude oil, inhalation of airborne emissions from the crude oil, or consumption of food or water contaminated by either the crude oil or components of the crude oil. Keystone would be liable for all costs associated with cleanup and restoration as well as other compensations for any release that could affect surface water. Therefore potential impact to minority or low-income populations would be mitigated by the operator's liability for the release. Additionally, Keystone has committed to provide an alternative water supply if an accidental release from the proposed Project contaminates groundwater or surface water used as a source of potable water or for irrigation or industrial purposes, which includes water uses by minority and low-income populations.

Given the potential vulnerability of these populations to health impacts, it is essential that spill response planning considers appropriate communications directed to these populations in the unlikely event of an accidental crude oil release. As a measure to avoid or minimize impacts to minority or low-income populations, response planning would include outreach to Local Emergency Planning Committees (see Sections 3.10.2.5, Public Services, Tax Revenues, and

Property Values, and 4.13.6.2, Spill and Safety Response) to ensure due consideration of the potential issues involved in emergency response in areas where minority and low-income populations have been identified along the proposed Project corridor. Specific consideration for environmental justice communities would involve ensuring that adequate communication—in the form of public awareness materials regarding the construction schedule and construction activities—is provided. Materials would be in appropriate languages and would contain information on how to seek needed services in the event of a health or other social service disruption related to construction activities. Additionally, the Keystone ERP discusses how calls to 911 concerning petroleum spills could alert Local Emergency Planning Committees.

4.13.6 Additional Mitigation

This section addresses the additional measures that have the potential to increase safety and reduce the severity and likelihood of a spill. Increased levels of protection are addressed by implementing the PHMSA Special Conditions discussed below. These measures provide for an additional safety factor on the proposed Project that exceeds those typically applied to a domestic oil pipeline projects. If a spill occurred, pre-defined and systematic plan response actions could take effect to rapidly mitigate the impact.

4.13.6.1 PHMSA Special Conditions

PHMSA in consultation with the Department developed a set of Special Conditions that increases public safety above current minimum requirements. Keystone agreed that if the Presidential Permit is granted, it would incorporate those conditions into the proposed Project and in its manual for operations, maintenance, and emergencies required by 49 CFR Part 195.402. PHMSA has the legal authority to inspect and enforce any items contained in a pipeline operator's operations, maintenance, and emergencies manual, and would therefore have the legal authority to inspect and enforce the Special Conditions if the proposed Project is approved. Pipeline operation is also regulated by PHMSA in cooperation with other agencies such as the Occupational Safety and Health Administration (OSHA), the U.S. Army Corps of Engineers, various state public service or public utility commissions, and other state agencies. Jurisdiction of some of the agencies over the proposed Projected is detailed in Section 1.5, Agency Participation. Additionally, environmental inspectors could review the proposed Project construction activities for compliance with state, federal and local regulatory requirements and could have the authority to stop specific tasks as described in Section 2.1.10.2, Environmental Inspection.

Appendix B, Potential Releases and Pipeline Safety, and Section 4.13.6.1, PHMSA Special Conditions, describe each of the Special Conditions. As stated in the Final EIS, the Department, in consultation with PHMSA, has determined that incorporation of those conditions (referenced industry standards and practices, combined with PHMSA regulatory requirements and the set of proposed Project-specific Special Conditions developed by PHMSA) would result in a Project that would have a degree of safety over any other typically constructed domestic oil pipeline system under current code and a degree of safety along the entire length of the pipeline system similar to that which is required in HCAs, as defined in 49 CFR 195.450.

Similarly, Battelle concluded that the "…Special Conditions imposed by the PHMSA make for a safer pipeline with less operational risk." For example, Battelle points out that "the use of tough steel acts to limit the size of a breach in the wall, and facilitates detection of anomalies within the mandated periodic re-inspection of the pipeline." (Leis et al. 2013.)

The majority of the Special Conditions relate to reduction in the likelihood of a release occurring; in addition, some provide mitigation that reduces the consequences and impact of a spill, discussed earlier in this section, should such an event occur. To understand how each one acts, they were considered for their role as preventive controls for the loss of pipeline contents (barriers that could stop a possible threat) and controls in the event of a spill (controls used to mitigate the consequences of a spill). The basis for a barrier/control was if the Special Condition by itself or in conjunction with another (constituting a single barrier) reduces the likelihood of the pipeline threat from causing a release or acts to reduce the consequences of a spill once a release occurs. The following are criteria for identifying a condition as a barrier or control once implemented:

- **Independence**—For the Special Condition to be a barrier or control, its functionality should be independent of other barriers and controls. It is independent if it accomplishes its function without assistance from other barriers/controls, tasks not implied in the conditions, or external equipment.
- **Functionality**—A barrier or control should be able to prevent the threat from developing or progressing further and be capable of serving the purpose for which it was designed or implemented. In other words, the barrier could reduce or prevent a potential threat from becoming a release, and the control would reduce the severity of a release.

A Special Condition might be a barrier for more than one threat, meaning it could prevent a release from occurring or, in certain situations, it could also minimize the impact (i.e., consequence) once a release occurs. In other words, it could help prevent a release from occurring, minimize the effects of the release, or both.

Table 4.13-37 shows that the Special Conditions provide 24 independent barriers, with one to five independent barriers to prevent a release from occurring for each threat. The Special Conditions that are considered threat barriers, and also consequence barriers, include Numbers 24, 25, 26, 30, and 53. Table 4.13-38 describes the 24 barriers that develop by applying one or a combination of the Special Conditions; a brief description is provided of how the Special Condition could prevent threats from causing a release. A detailed description of the PHMSA Special Conditions is provided in Appendix B, Potential Releases and Pipeline Safety.

Table 4.13-37 Special Conditions as Barriers to Threats[a]

Threat	Threat Category	Independent Barrier 1	Independent Barrier 2	Independent Barrier 3	Independent Barrier 4	Independent Barrier 5
Internal corrosion	Time-dependent	SC[b] 33 and 47	SC 34			
External corrosion	Time-dependent	SC 9, 15 and 39	SC 10 and 11	SC 35, 36, 21, 37 and 38		
Stress corrosion cracking (SCC)	Time-dependent	SC 3	SC 45, 44 and 46			
Materials-related	Stable	SC 1	SC 2 and 8	SC 4 and 12	SC 5	SC 6
Construction-related	Stable	SC 14	SC 17 and 18	SC 22 and 23	SC 42 and 43	SC 49 and 51
Equipment malfunction	Stable	SC 24-30, 50 and 53	SC 15, 16, 25-26 and 31			
Weather conditions	Time-independent	SC 24-30, 50 and 53				
Excavation/ third-party damage	Time-independent	SC 7, 19 and 53	SC 40-41, 48 and 54			
Operational error	Time-independent	SC 13, 20 and 53	SC 24-30, 50 and 53			

[a] Because not all Special Conditions are designed as a barrier, not all Special Conditions are listed
[b] SC = Special Condition number

Table 4.13-38 Barrier Assessment of Special Condition Threat Mitigations

Threat	Independent Barrier	Brief Barrier Description	Special Condition Reference
Internal corrosion	1	The design of the pipeline, which would allow for 100% internal inspection by smart tools combined with periodic pigging to assess pipe thickness changes would facilitate the early detection of internal corrosion signs as implicit in the provisions of the referenced Special Conditions.	SCs[a] 33 and 47
	2	The following actions stated in the Special Condition are considered capable of decreasing the pipe corrosion rate: 1) limiting sediment and water content to 0.5% by volume; 2) running cleaning tools periodically; and 3) implementing a crude oil monitoring and sampling program that ensures transported products meet pipeline specifications.	SC 34
External corrosion	1	The application of corrosion resistant coating on pipes, and compliance to Canadian Standards Association, National Association of Corrosion Engineers, and International Organization for Standardization standards, plus controls for operating temperature and periodic coating surveys are considered the basis for a good external corrosion program as detailed in the referenced Special Conditions.	SCs 9, 15, and 39

Threat	Independent Barrier	Brief Barrier Description	Special Condition Reference
	2	The use of abrasion resistant coating for trenchless installations and a field joint coating quality control program for holiday detection (a gap or hole in the coating) are considered complementary preventive measures for decreasing external corrosion rates.	SCs 10 and 11
	3	The installation of cathodic protection with periodic performance studies and stray current studies comprise a preventive control against pipe corrosion. Additional measures detailed in the referenced Special Conditions complement a cathodic protection program as a barrier against external corrosion.	SCs 35, 36, 21, 37, and 38
SCC	1	The implementation of fracture control and integrity verification plans addressing the steel pipe properties necessary to resist crack initiation and crack propagation would likely become a preventive control against the SCC threat as detailed in the referenced Special Condition.	SC 3
	2	Complete annual fatigue analysis and flaw growth assessment and periodic in-line inspections consistent with 49 CFR Part 195.452(j)(3), are considered preventive measures against SCC as explicitly stated in the referenced Special Conditions.	SCs 45, 44, and 46
Materials related	1	Steel must be of high quality with specific materials structure and composition, which are fundamental for meeting design specifications, and future pipe performance. This constitutes a barrier to manufacturing threat as implicit in the Special Condition provisions, and to some extent for future corrosion issues.	SC 1
	2	Manufacturer's adherence to API 5L Product Specification Level 2, supplementary requirements for maximum operating pressures and minimum operating temperatures, and quality assurance/ quality control are considered complementary measures against manufacturing threat as outlined in the referenced Special Conditions.	SCs 2 and 8
	3	Steel plate/coil quality control, pipe mill quality assurance/quality control plan, and the implementation of procedures for high quality welding of components as explained in the referenced Special Conditions constitute a barrier against materials related issues.	SCs 4 and 12
	4	Specific pipe seam quality control requirements for pipe manufacturers are considered a barrier against seam welding issues.	SC 5
	5	Special monitoring for seam fatigue from transportation, traceability of tests, and manufacturing records would create a barrier against manufacturing defects as explicitly stated in the referenced Special Condition.	SC 6

Threat	Independent Barrier	Brief Barrier Description	Special Condition Reference
Construction related	1	The post-construction survey to identify changes that would impact design, once implemented, would likely constitute a barrier against many construction related issues as implicit in the referenced Special Condition.	SC 14
	2	Submittal of construction plans and schedules to PHMSA, welding procedures, stress analysis, lowering-in procedures, and engineering critical assessments, are considered best industry practices that would reduce the risks of construction related defects as outlined in the referenced Special Conditions.	SCs 17 and 18
	3	Pipeline hydro-test to 100% specified minimum yield strength and conducting a failure analysis should a test failure occur are considered complementary measures that would assist in correcting construction related issues.	SCs 22 and 23
	4	Performing a baseline geometry tool run after completion of the hydrostatic strength test and backfill of the pipeline with a high-resolution magnetic flux leakage tool would assist in detecting construction flaws and serve for future reference of the system integrity baseline as detailed in in the referenced Special Conditions.	SCs 42 and 43
	5	Complete immediate dig-ups to investigate and/or repair as necessary based on anomalies reported by smart inspection, removal of dents exceeding 2%, and reporting on compliance to the conditions within 180 days of in-service are considered measures that would reduce the risk of construction related issues.	SCs 49 and 51
Equipment malfunction	1	The installation of a sophisticated computerized SCADA system to provide remote control and monitoring of the entire pipeline system, the activities necessary to maintain it in optimum condition, and additional measures detailed in the referenced Special Conditions are measures against the threat of equipment malfunction.	SCs 24-30, 50, and 53
	2	Overpressure control requirements, pressure and temperature controls, enhanced SCADA scan rate to detect small leaks, alarm management policy, and trained personnel in leak detection per Canadian Standards Association guidelines are considered complimentary measures against the threat of equipment malfunction.	SCs 15, 16, 25-26, and 31
Weather conditions	1	The installation of a sophisticated SCADA system to provide remote control and monitoring of the entire pipeline system plus the activities necessary to maintain it in an optimum condition are measures to reduce the risk of a release due to natural forces as implicit in the referenced Special Conditions.	SC 24-30, 50, and 53

Threat	Independent Barrier	Brief Barrier Description	Special Condition Reference
Excavation/ third-party damage	1	Specific requirements for steel pipe to be puncture-resistant to excavators, deeper pipeline cover depths, and the use of a threat matrix are considered measures to prevent loss of containment due to third parties as outlined in the referenced Special Conditions.	SC 7, 19, and 53
	2	Pipeline markers in addition to frequent ROW patrols constitute a proven barrier to prevent inadvertent third party damage as explicitly stated in the referenced Special Conditions.	SC 40-41, 48 and 54
Operational error	1	Traceability of components to the correct intended operating pressure, requirements for operator's qualifications, and the use of a threat matrix for the pipeline system are considered measures against inadvertent operational errors as detailed in the referenced Special Conditions.	SC 13, 20, and 53
	2	The installation of a sophisticated SCADA system to provide remote control and monitoring of the entire pipeline system plus the activities necessary to maintain it in an optimum condition would likely assist in detecting operational errors promptly. Additional measures detailed in the referenced Special Conditions would also assist in executing recovery procedures before the spill occurs.	SC 24-30, 50, and 53

[a] SC = Special Condition

Subsequent to agreeing with the PHMSA Special Conditions, Keystone agreed to incorporate the following additional conditions into the written design, construction, and operating and maintenance plans and procedures:

- Keystone would develop and implement a Quality Management System that would apply to the construction of the entire Keystone XL project in the United States to ensure that this pipeline is, from the beginning, built to the highest standards by both Keystone personnel and its many contractors; and
- Keystone would hire an independent third-party inspection company (TPIC) to monitor the construction of the Keystone XL project. PHMSA must approve the TPIC from among companies Keystone proposes. Keystone and PHMSA would work together to develop a scope of work to help ensure that all regulatory and technical EIS conditions are satisfied during the construction and commissioning of the pipeline project. The TPIC would oversee the execution and implementation of the DOS-specified conditions and the applicable pipeline safety regulations and would provide monitoring summaries to PHMSA and Keystone concurrently. Keystone would address deficiencies or risks identified in the TPIC's assessments.

4.13.6.2 Safety and Spill Response

The United States (through PHMSA) collaborates with several other countries to provide guidelines on emergency response. The publication entitled *Emergency Response Guidebook - A Guidebook for First Responders during the Initial Phase of a Dangerous Goods/Hazardous Materials Transportation Incident* (PHMSA, 2012b) is available at http://phmsa.dot.gov/ staticfiles/PHMSA/DownloadableFiles/Files/Hazmat/ERG2012.pdf and describes safety precautions related to hazardous material identification and emergency contact information.

The Keystone Oil Pipeline System ERP was previously developed for the existing Keystone Mainline and Cushing Extension project and approved by PHMSA. The Keystone ERP would be used as a template for the ERP for the proposed Project and would include the necessary proposed Project-specific information. A review of the Keystone ERP (not the Keystone XL-specific plan) provided in Appendix I, SPCC and ERP, shows that response personnel, whether Keystone employees or contractors, must complete the appropriate Keystone and OSHA training in line with their responsibilities in order to implement a safe and effective response action to oil spills. All Keystone and contractor personnel are expected to follow the facility-specific safety plan for addressing a spill. Several of the aspects of responder training are provided below as listed in the ERP in Appendix I:

- Any concern regarding health or safety issues should be immediately addressed.
- The First Responder must consider the spill site as dangerous and the local atmosphere explosive until air monitoring procedures prove that the area is safe.
- The First Responder must exit the area against or across the wind, if possible, and must also evacuate others who are working in the area.
- All injuries, no matter how minor, must be reported to the Incident Commander in a timely manner.
- Prior to entering a spill area, a qualified person must perform an initial safety and health evaluation of the site.

In the event of a spill during construction and reclamation activities, Keystone has identified and prepared written procedures to address a response action. These response activities are provided in Keystone's Draft SPCC Plan (see Appendix I, SPCC and ERP). This draft SPCC document has been submitted as a template for the proposed Project's SPCC Plan. The SPCC's primary purpose is minimizing the potential for releases of hazardous materials, fuels, and lubricants during the construction phase of the proposed Project.

A Facility Response Plan (FRP), which would include the project-specific ERP, would be prepared and submitted to PHMSA prior to initiating operation of the proposed Project in accordance with requirements of 49 CFR Part 194. PMHSA would also provide it to the USEPA for review. A project-specific, worst-case spill scenario including location, available resources, and response actions is addressed in the FRP/ERP. A general discussion of worst-case discharges is provided in Appendix P, Risk Assessment. The project-specific ERP, which is not available at the time of this report, would address the procedures to implement in the event of a release and the location of response teams and resources. These plans rely on final permitting requirements and detailed design and construction information. While not available at the time of this report, consistent with standard practice and current regulations, the applicant would be required to submit the FRP/ERP for review 6 months prior to the operation of the proposed Project.

The draft plans provided in the Final Supplemental EIS would be subject to change pending final permitting requirements as well as design and construction details. As such, a formal plan is not included in this Final Supplemental EIS although the initial response actions for a variety of emergency conditions are provided in the Keystone ERP in Appendix I, SPCC and ERP. There are four key measures addressed in the Keystone ERP that would likely be similar to the ERP for the proposed Project:

- Notification procedures;
- Response actions;
- Response teams; and
- Spill impact considerations.

Notification Procedures

According to the Keystone ERP, for the purpose of this notification procedure, immediate reporting means reporting as soon as a person (Keystone personnel, public, industry partners, or emergency response agencies) has knowledge of an actual or suspected leak, uncontrolled release of product, any unplanned spill, or other pipeline system failure (see Appendix I, SPCC and ERP, Section 2.2). The internal and external notification procedures in the ERP are separated to provide clarity with no implied order of preference. All notifications are of extreme importance and must be completed in a timely manner (see Appendix I, SPCC and ERP, Section 2.0).

Upon discovery of a leak or if a leak is suspected, reporting procedures call for contacting Keystone's Oil Control Center initially, followed by local emergency services (e.g., fire department, police or sheriff, emergency medical technicians, as needed). The Keystone Oil Control Center is contacted first to ensure the pipeline is shut down and then to activate a response by both internal and external responders. In addition, the NRC, appropriate federal agencies, county emergency management, state environmental management, and utilities services are contacted. The internal response units establish the command structure, engage the appropriate internal support teams, contact emergency spill response contractors, and fulfill federal and state notification obligations. The ERP lists contact phone numbers for the Local Emergency Planning Committees in each county through which the proposed Project runs. All entities along the pipeline that could be affected by oil migration would be included in the ERP. These entities include local municipalities, American Indian and First Nations, Local Emergency Planning Committees, Sheriff's Offices, and Fire Departments. These entities along with contracted Oil Spill Removal Organizations would evaluate, prioritize, and respond to impacts on city infrastructure and stormwater systems, and coordinate evacuations as necessary.

Keystone would reach out to first responders at least annually via a public awareness program which includes, as a baseline, contact information, pipeline location, and how to respond. Additionally, Keystone would conduct multiple exercises and training sessions annually, which first responders would be invited to attend and participate. Training and exercises include Incident Command System (ICS), table top, deployment, and full scale exercises. Exercise planners would invite first responders to full scale exercises, which include the development of an incident management team and the simultaneous deployment of equipment resources to approximate a real event. These exercises would be conducted in various locations along the pipeline system. Keystone has stated that they would commit in their ERP to spill drills and exercises that address both floating and submerged oil.

On November 20, 2012, Keystone conducted an emergency response drill at their regional office in Omaha, Nebraska. The objective of the drill was to identify and distribute appropriate Material Data Safety Sheets (MSDS) to first responders at the scene of the spill based upon the time and location of the incident. The drill scenario was based on a third party severing a buried portion of a pipeline while excavating. The location of the strike was selected at random by an observer at the drill that was not a Keystone employee. The drill commenced with a simulated call from the equipment operator who severed the pipeline. The equipment operator called the number posted on the pipeline ROW signs who in turn contacted Keystone. Once this information was received by Keystone, a local first responder was called and sent to the site to confirm the leak and gather specific location information (the actual site inspection was not done for this simulation). The Keystone Oil Control Center was notified of confirmation of the release and the spill response process was initiated, which included simulated shut down of the pipeline and multi-level notifications by phone by local/regional representatives to local responders (law enforcement, local emergency responders, and officials). Simultaneously, while local contacts were being informed, notifications are being made by corporate team members to Nebraska Emergency Management Agency, NRC, PHMSA, state Department of Environmental Quality, and the USEPA. The randomly selected location of the pipeline strike resulted in a scenario where the potential for two different types of oil could be present in the pipeline at the spill scene. The batches were identified by the Oil Control Center and the MSDSs for both products were distributed electronically to the first responders at the scene. Receipt of the MSDSs was confirmed by phone. The objective of the drill was achieved in roughly 17 minutes. Keystone has stated that they could provide specific MSDS to emergency responders within 1 hour of a release. The MSDS would contain the product specifications related to the released oil.

Emergency Communication

Detailed emergency communication procedures and contact information for internal and external notifications are provided in the ERP. In the event of a release, the specific MSDSs and exact composition of the product shipped (and released) would be provided to emergency responders (including any state, local, or federal agencies involved in spill response actions) within 1 hour of the release. Keystone would maintain a point of contact (and procedure to contact this point of contact with this hour timeframe) for requests for MSDSs and the identification of the exact composition of the product (both crude and diluents) shipped in the pipeline (when a release occurs) who would be authorized to release the MSDS and chemical composition information (as described above) to first responders.

In the event of a release or other emergency incident pertaining to the pipeline, Keystone would notify local First Responders (i.e., fire, police, and rescue departments), Keystone's emergency response contractors, and appropriate entities such as the U.S. National Response Center, which in turn would disseminate telephonic and electronic reports to the USEPA or Coast Guard, as appropriate, and other agencies. Keystone would also contact the appropriate federal agencies, the leading provincial/state environmental agency, State Emergency Response Center, the county emergency management department, Local Emergency Planning Committee, and service utilities, as appropriate. In the event that the incident met the criteria of a crisis (e.g., emergency-level interagency coordination were required to protect human health and the environment), the NRC would activate the National Response Team if required and Keystone would notify TransCanada's Crisis Management Team.

As required by the incident-specific circumstances, and as soon as practical following the incident, a written report would be submitted to such entities as PHMSA, USEPA, and the leading provincial/state environmental agency, as appropriate. Other entities, such as the state/local health department, county commission, and state parks and wildlife department, may also be subsequently notified by Keystone.

Response Actions

The ERP provides guidance on how first responders are to classify a spill to the environment or a complaint made within the community. These classifications—minor, serious, major, or critical—are based on the potential for impacts to public safety and the environment. Provided in the ERP is the checklist of actions to be taken to minimize the potential impact of a release as shown below:

- Take appropriate personal protective measures;
- Secure the site;
- Call for medical assistance if an injury has occurred;
- Notify the Oil Control Center and area management of the incident;
- Eliminate possible sources of ignition in the near vicinity of the spill;
- Take necessary fire response actions by trained staff and responding fire departments;
- Advise personnel or public in the area of any potential threat and/or initiate evacuation procedure;
- Identify/isolate the source and minimize the loss of product;
- Restrict access to the spill site and adjacent area as the situation demands;
- Take additional steps necessary to minimize any threat to health and safety; and
- Verify the type of product and quantity released (Material Safety Data Sheet(s) are available).

There are 11 potential emergencies that could be presented in the ERP (listed below) that have been identified and response guidance is provided on each:

- Initial response for public safety measures
- Fire
- Line break or leak
- Release to groundwater
- Severe thunderstorm/flash flooding/landslide
- Winter storm

- Tornadoes
- Earthquake
- Volcanic eruptions
- Bomb threat/terrorist activity
- Abnormal operations

Guidance is also provided to document initial response actions, oil containment, recovery and waste minimization, and management procedures. Emergency medical treatment and safety awareness are also addressed (e.g., first aid, site safety plan, air monitoring, decontamination procedures, personal protective equipment).

Prior to PHMSA granting permission to operate the proposed Project, Keystone would be required to prepare the proposed Project-specific ERP to facilitate rapid response in the event of an oil release. However, there are many factors that could affect a response action and the extent of the release. Some of these include:

- Geographic location and site access;
- Position of the leak (surface or subsurface leak);
- Time to expose a leak (subsurface location);
- Time of day (night versus day);
- Terrain, topography, or geomorphology;
- Weather; and
- Natural disaster-related causes (e.g., flooding, landslides, excessive snow fall, earthquake).

Based on the response time to a release site, level of effort needed for containment measures, characteristics of the spill location and containment location, and the volume of spilled material, the areal extent and receptors affected could be significantly different for every potential spill.

Response Teams

The initial response to a release would be provided by the local Keystone personnel, whose tasks include initiating the notification process and providing pertinent release information to the Operations Control Center. The Operations Control Center would engage response team members to provide the appropriate level of support, personnel and contractors, emergency services, and resources needed to address the release. As part of Keystone's implementation of the ICS, the first company employee onsite would become the Incident Commander and the duties of the Incident Commander are transferred to more senior company personnel as they arrive on site. The ICS is a nationally recognized response framework for responding to various emergencies, allowing communication between responders and a scaled response. The effective execution of the ICS would generally lead to safer, more organized, and more focused response action. With an authoritative command structure established and support roles defined, this focused effort would have the potential to reduce response time and potential impact and increase the confidence and support from local, federal, state, and public sector emergency response personnel.

The ERP for the proposed Project would have the same general approach as presented in the Keystone ERP but would have many specific differences, such as the names and contact information for responders along the proposed Project route and the differing environmental and public health vulnerabilities along the pipeline corridor. Once the proposed Project route is finalized, fieldwork would commence to collect relevant information to be incorporated into the ERP for the proposed Project, which would then be submitted to PHMSA for review and approval. The USEPA would also be provided with the ERP for their review. Keystone has committed to consult and communicate with the Local Emergency Response Planning Committees and other emergency service agencies during ERP development to ensure ERPs are aligned. During an emergency, Keystone would form a Unified Command with local first responders and liaise with all impacted community stakeholders, including the Local Emergency Response Planning Committees.

A spill response is initiated by the reporting of a suspected or confirmed release (e.g., direct observation, SCADA detection, community report, or other notification). As stated in the Keystone ERP, "For the purpose of this procedure, immediate reporting means reporting the instant a person has knowledge of an actual or suspected leak, uncontrolled release of product, any unplanned spill or other pipeline system failure. Information that causes any employee to reasonably suspect a leak or uncontrolled release of product must be immediately reported, even when the actual existence or location of a leak or release cannot yet be confirmed."

As discussed above, many factors influence the response to a release. The time between the actual occurrence of the release and the reporting of the release is critical to the response effort and the potential impact from the spill to human health and the environment. In general, the sooner an effective, efficient response action begins, the sooner the impacts from a release could be addressed, reduced, or eliminated. Keystone's response times to transfer the necessary resources to a potential release site as required by 49 CFR Part 194.115 are shown in Table 4.13-39 below. Depending on the nature of site-specific conditions and resource requirements, Keystone would meet or exceed the requirements along the entire length of the proposed pipeline system.

Table 4.13-39 Response Time Requirements of 49 CFR Part 194.115

Area	Tier 1 Resources	Tier 2 Resources	Tier 3 Resources
High-volume area[a]	6 hours	30 hours	54 hours
All other areas	12 hours	36 hours	60 hours

[a] High-volume area indicates an area where an oil pipeline with a nominal outside diameter of 20 inches or more crosses a major river or other navigable waters; because of the velocity of the river flow and vessel traffic on the river, this area would require a more rapid response in the case of a worst-case discharge or the substantive threat of such a discharge.

As stated above, as soon as an effective, efficient response action begins, the sooner the impacts from a release could be addressed, reduced, or eliminated. For releases to streams or rivers, these response times affect the distance which oil could be transported downstream before an effective containment system is encountered. For overland flow, these response times affect where nearby streams or rivers could be affected or if spreading is contained before a sensitive receptor is impacted. Once the flow is controlled and containment of the spill is achieved, reclamation, remediation, and restoration of the release site and affected areas could begin.

In general, Tier 1 emergency response equipment would be pre-positioned for access by Keystone along the proposed route. Equipment could include pick-up and vacuum trucks; containment boom, skimmers, pumps, hoses, fittings, and valves; communications equipment including cell phones, two-way radios, and satellite phones; containment tanks and rubber bladders; expendable supplies including absorbent boom and pads; assorted hand and power tools including shovels, manure forks, sledge hammers, rakes, hand saws, wire cutters, cable cutters, bolt cutters, pliers, and chain saws; personnel protective equipment including rubber gloves, chest and hip waders; and air monitoring equipment to detect hydrogen sulfide, oxygen, lower explosive level, and benzene.

Additional equipment, including helicopters, fixed-wing aircraft, all-terrain vehicles, snowmobiles, backhoes, dump trucks, watercraft, bull dozers, and front-end loaders also may be accessed depending on site-specific circumstances. Other types, numbers, and locations of equipment would be determined upon concluding the detailed design of the proposed pipeline and completing Keystone‘s final ERP. This plan would be completed and submitted to PHMSA for review prior to commencing operations as described above.

The primary task of the Tier 1 response team is to reduce the spread of the spill on the ground surface or water to protect the public and Unusually Sensitive Areas, including ecological, historic, and archeological resources and drinking water locations. The Incident Commander would perform an initial assessment of the site for specific conditions, including the following:

- The nature and amount of the spilled material;
- The source, status, and release rate of the spill;
- Direction(s) of spill migration;
- Known or apparent impact of subsurface geophysical features that may be affected;
- Overhead and buried utility lines and pipelines;
- Nearby population, property, or environmental features and land or water use that may be affected;
- Location of HCAs including Unusually Sensitive Areas downstream or downgradient from the spill site; and
- Concentration of wildlife and breeding areas.

The Incident Commander would request additional resources in terms of personnel, equipment, and materials from the Tier 2 and if necessary, the Tier 3 response teams. Once containment activities have been successfully concluded, efforts would then be directed toward the recovery and transfer of free oil. Site cleanup and restoration activities would then follow, all of which would be conducted in accordance with the ERP and in conjunction with regulatory agencies having jurisdiction. Keystone is required to prepare to respond to a worst-case discharge (WCD) by regulations in 49 CFR Part 194. This consists of calculating and identifying where the WCD may potentially occur, plans to ensure that adequate personnel and equipment resources are available to respond, and scenario development. By developing such plans for a WCD, Keystone could be better prepared to respond to a large-scale incident such as the 20,000 bbl spill on the Kalamazoo River in Marshall, Michigan, in 2010. Keystone would ensure internal personnel are trained to respond to oil spills through annual exercises and training sessions including full scale field exercises held in various locations in various operating environments and weather.

When developing the ERP, Kalamazoo River Spill lessons learned would be considered, including ensuring consultants are contracted as appropriate to facilitate a large-scale and prompt response; developing source containment plans including strategies and tactics; minimizing response times with appropriate equipment; identifying equipment resources required to respond to sunken and submerged oil, and ensuring personnel are appropriately trained.

Spill Response Considerations

The ERP would address spill impact response requirements including oil containment and removal for land or surface spills, spills occurring in waterbodies, on or under ice, urban areas, and wetlands. The ERP would also address socioeconomic sensitivities by providing guidance and procedures to reduce or mitigate impacts to heritage resources, archeological sites, fisheries, and wildlife in the event of a spill or when conducting reclamation or remediation activities (see Appendix I, SPCC and ERP Sections).

As identified above, oil spill response actions and remediation could affect receptors or the environment. If requested by regulators, Keystone would perform a Net Environmental Benefit Analysis, which is a tool used to compare the interactions between oil spill prevention, planning, and response actions and the effects they could have on potential receptors in a given situation. The process tries to balance the advantages and disadvantages of oil spill prevention techniques and efficient response actions against the potential these countermeasures may have to ecological, social, economic, environmental, and the other receptors discussed in Section 4.13.5, Potential Impacts. This approach considers the potential impact to affected resources and receptors, assesses the degree of protection that could be provided to each under the existing spill conditions and the available response resources present, and seeks to implement a response that provides the best overall outcome to a spill. The process could also be used to identify existing data gaps and often reveals the differences in the stakeholders' concerns related to the various resources.

The Net Environmental Benefit Analysis process described above would weigh the potential impact to the various resources and receptors that could be affected by ensuring that response actions limit the impact to the surrounding areas and result in net environmental benefit. For example, proper use of mats or other materials when moving or operating heavy equipment could minimize potential impact to soils by reducing ruts and damage to soil cover. Similar means could be used for drill rigs installing monitor or recovery wells and treatment systems to reduce the potential impact to the area surrounding a spill response action. In waterbodies, the use of flat-bottom, shallow draft boats, which reduce the potential for damage to shorelines, aquatic plants and animals, would be considered.

The methods for remediating spills in both construction and operation phases of the proposed Project would generally vary only in the magnitude of the effort. As discussed in the Construction, Mitigation and Reclamation Plan (see Appendix G), many of the spills that occur during construction would be generally small in volume and could be addressed by containment, excavation, and other remedial processes. Many of these same processes are also discussed in the ERP (see Appendix I, SPCC and ERP) as related to potentially larger spill volumes. Recovery, reuse, and recycling are the best choices for remediation of a spill. The more effort applied to recovery of spilled product generally means shorter-lived remediation efforts and less impact to the environment.

The use of skimmers, vacuums, sorbent materials, and other means of recovery of spilled products would be managed during remediation efforts to help to prevent further impacts to the local environment or receptors. The reuse of hydrocarbon-affected soils as road base or in asphalt mixtures (as approved by the appropriate agencies) is another way to remediate affected soil at a spill site. Recovered product from skimming or vacuum operations could be recycled by removing water and debris and re-blending. Incineration or burning of oiled media for energy recovery may be other options to consider. However, there could be limitations on incineration and local air quality authorities would need to be contacted for approval. Disposal of oiled soil and debris at a solid or hazardous waste landfill is the least environmentally sound method of disposal and would be considered only as the last option. Once the spill recovery effort is no longer effective or efficient, more passive remediation methods could be implemented to further the remediation and restoration of affected soil, groundwater, and surface water.

There are many ways to remediate hydrocarbon-affected soil, groundwater, and surface water. Action would include: soil excavation, bioremediation of oil, groundwater recovery with pumps and water treatment, oil recovery from surface water as well as groundwater, degradation of oil compounds using other chemical compounds, and natural degradation.

Many of the technologies and methods used to address the detection, containment, and recovery of spilled crude oil listed below are well-established and have been employed in the field over the past several decades. Technological refinements and advances in addressing oil spills continue to improve and advance the state-of-the-art oil spill response.

Oil that is heavier than water would likely become submerged in the water column or sink to the bottom. Oil that sinks may act much like oil on dry land, collecting in low lying areas and thus resting on the bottom. Sinking or submerged oil is oil that has not reached the bottom yet or has been disturbed and is currently suspended in the water column by tide or current. In water with a current of less than 0.7 knots, oil that is heavier than water would tend to sink to the bottom. Any current above 0.7 knots has the potential to remove oil from its resting place on the bottom and carry the oil downstream. Types of equipment used to contain oil that is sunken or submerged include net booms, bottom hugging weighted booms and watergate dams, silt curtains, and gabion baskets lined with impermeable membranes. Filter fences such as Turner Valley Gates can also be lined with impermeable membranes, and booms with deep skirts to help resurface submerged oil.

Natural attenuation of residual oil is a potential remedial option for the removal of crude oils. Significant components of conventional crude oils include straight hydrocarbon chains and light compounds, both of which biodegrade relatively easily. Dilbit, on the other hand, is largely comprised of branched hydrocarbon chains and heavy hydrocarbons, which are less readily biodegradable. A biodegradation study conducted by the USEPA in response to the 2010 Enbridge dilbit spill in the Kalamazoo River in Michigan concluded that only 25 percent of the residual hydrocarbons impacting the river could be reasonably removed by natural attenuation (USEPA 2013). Due to the capacity for dilbit to precipitate out in water and its very slow biodegradation rate, more difficult cleanup scenarios (e.g., dredging) for dilbit may be expected in the event of a release to a waterbody than with other types of crude oil.

Methods to detect submerged oil include the use of Sonar, which has been used to locate submerged oil in calm water such as lakes, ponds, and bays with some success. Remote and diver operated underwater video detection systems are useful, but success is dependent on visibility and the water's current. Visual observation can be used in shallow water, although expert analysis is essential for this technique as aquatic biota (vegetation) in the water may be mistaken for oil. Currently, the best method for sampling for submerged oil is to drop weighted sorbent materials such as *pom-pom* snare boom or sorbent chain drags into low areas for short distances and then visually inspect them for oil to map oil distribution. This provides a bottom sample indicating whether or not oil is present. Gabion baskets filled with sorbent materials are also used for detection of sunken and mobile oil. These sorbent filters allow water to flow through them, thus capturing any suspended or sunken oil. By examining the filter, it can be determined if submerged or sunken oil is present. Collection of core samples can also be a method to detect sunken oil. The sampling area of the core may be too small to be effective, but historically cores have been used for subsurface contamination assessments.

A cost effective method to recover oil is the use of a vacuum system to collect concentrations of submerged oil. Another common method is to dredge the bottom and remove the oil. Where appropriate, dredging is used to remediate contaminated sites but may generate a large amount of waste material that must be properly managed and disposed. Both vacuum systems and dredging only work for completely sunken oil. To capture suspended oil, an underwater filter can be constructed. This filter can be created using multiple types of porous containers such as gabion baskets, prawn or crab traps, silt fences, and chicken wire. The container is filled with sorbent material such as oil snares, weighted down and submerged into the water column. The sorbent materials are monitored and replaced as needed for oil recovery.

In shallow water where oil can be seen from the surface, dip nets or pool nets have been successfully used as an effective way to collect oil. This method is useful if the oil has emulsified or is thick enough to scoop up with the nets.

In considering the treatment methods listed above, it would be necessary to weigh the effectiveness of the remediation technique used against the intrusiveness of the remedial effort on the environment and potential receptors. These methods would be implemented following approval of the appropriate agencies and managed by qualified persons knowledgeable in the application of the technology.

After safety, the highest priority for a spill response is to prevent product from reaching water and then to mitigate oil migration out of the source area. To accomplish this, there are many different ways to contain or deflect oil. Oil can be trapped in ditches and gullies by earth dams. Where excavating machinery is available, dams can be created to contain the oil. Dams could be effectively employed to protect priority areas such as inlets to drains, sewers, ducts and watercourses. Dams can be constructed of earth, sandbags, absorbents, planks, pillow (inflatable with air/water) dams, or any other effective method. The terrain would dictate the placement of the dams. If the spill is minor, natural dams or earth absorption could stop the oil before it advances a significant distance. Whenever possible, potential routes of migration should be closed off by the use of sandbags, planks, earth, or other dams. This is used as a preventative measure in case precipitation begins and the oil starts to migrate.

In urban locations such as city streets or concrete drainage ditches, a combination of sorbent booms in front with a layer of sandbags behind holding the boom in place can be used as an effective means to create containment along with some collection. Instead of building dikes and dams, another method of containment is to dig collection pits. This creates a new low point for the oil to run off into, providing a recovery point for removal. Approaches to remove oil from urban infrastructure include:

- Removal with suction equipment to tank truck if concentrated in volumes large enough to be collected. Channels can be formed to drain pools of oil into storage pits. The suction equipment can then be used.
- Small areas can be cleaned by hand. Use of sorbent pads to soak up the oil is the preferred method.
- Storage of contaminated soil, if not immediately shipped off site for appropriate disposal, should be done using plastic lined containers. This would prevent loss of oil and run-off.
- For ground contaminated with oil that cannot be removed, such as paved roads, concrete curbing, or concrete drainage ditches, an effective cleaning method is heated pressure washing. The collection of produced wastes, including the water used for cleaning, is important; therefore, a vacuum truck or some other type of collection must be available.
- Cleaning agents (surfactants) may also be used to lift the oil off hard surfaces such as concrete for collection and recovery.

Facility Response Plan

The Facility Response Plan (which includes the ERP) would be prepared and submitted to PHMSA prior to initiating operation of the proposed Project, in accordance with requirements of 49 CFR Part 194. The FRP/ERP would detail Keystone's spill response plan and describe the location and volume of a worst case scenario discharge, as well as the procedures and resources in place to manage the discharge. The FRP/ERP requires PHMSA review and approval; however, there is a 2-year grace period under which operation of the pipeline could proceed while PHMSA reviews and approves the FRP/ERP. This period would allow PHMSA to review the proposed Project in its final, as-built state.

While the draft FRP/ERP for the proposed Project is not yet available, Keystone prepared similar plans for the existing Keystone pipeline and the Gulf Coast Project. These plans for the proposed Project would have the same general approach as those plans but would have differences specific to the proposed Project, such as the contact information for the local fire, law enforcement, and emergency service departments; local government officials; and response team members along the proposed Project route.

Keystone First-Year Spill Response

Between May 21, 2010 and May 29, 2011 (the first year of operation), 12 spills occurred along the Keystone pipeline. Of the 12 spills, 11 were small in size (less than 50 bbl), and of these, nine were less than 3 bbl, or 126 gallons. None of these spills were related to the failure of the mainline pipe, but rather were related to fittings, pump seals, and valves generally located within pump station facilities. The spills were generally contained on site. Once identified, the spills were contained and remediated, and the cases were closed by the respective state environmental departments, generally within 90 days of the incident.

One of the 12 spills was medium-sized (500 bbl or 21,000 gallons). This spill occurred near Brampton, North Dakota, where roughly 500 bbl (21,000 gallons) were spilled at the Ludden Pump Station and onto a small area of adjacent farmland. The spill was due to the failure of a small pipe nipple on discharge piping. The cleanup activities (both on site and off site) were initiated within hours, and the collection of all free-phase oil, excavation of contaminated soil, and the decontamination of equipment and fencing was completed in nine days.

A more detailed assessment of first-year spill data is provided in Section 4.13.3.7, Keystone Pipeline First-Year Release Historical Data.

Keystone Southern Segment Pipe Replacement

Keystone is constructing the Gulf Coast Project in compliance with the Special Conditions developed by the Department of State and PHMSA during the review of the proposed Keystone XL Pipeline project. In accordance with Special Condition 43 and the interim guidelines referenced in that condition, Keystone is required to perform inline inspection (ILI) of the entire pipeline using specific tools capable of high resolution detection of deformation in the pipe wall in the form of dents or expansion. This inline inspection must be performed subsequent to hydro-testing the pipeline. Further, Keystone's specification requires examination for ovality (the overall deformation) of the pipe as a means to ensure the pipe can allow passage of ILI tools in the future that are used to monitor both corrosion integrity and third-party damage.

The ILI tool is run through continuous segments of pipeline (approximately 30-mile sections), and the data are analyzed in accordance with the analysis methodology, conforming to Special Conditions 43 and 49. All dents, expansion, and ovality reported by the ILI tool greater than the limits predefined by Special Conditions 43 and 49 and TransCanada's specifications are investigated by excavating the pipeline. Subsequent to excavation and removal of overburden that may be causing the deformation, physical field measurements are conducted to confirm permanent deformation equal or greater than the predefined criteria; if confirmed, a segment of affected pipe is removed. Further, any pipe segments with dents that occur directly on a field weld or factory weld are removed in accordance with 49 CFR 195.452. The pipe predominantly used on the Gulf Coast Project has a helical factory weld seam, which leads to more pipe seam exposure. As of mid-June 2013, 5 percent of the anomalies investigated required replacement in accordance with the pre-defined conditions. Expanded pipe occurs when a pipe diameter expands greater than 0.60 percent of the nominal or actual rolled pipe diameter following pressure testing. None of the pipeline segments investigated has confirmed expanded pipe issues (e.g., bulges, swelling, outward deformities) in excess of the applicable standards. Expanded pipe is generally a result of low-strength steel, which is not intended to be used for the proposed Project.

Removed pipe segments are replaced with previously hydro-tested pipe. The field welds of the new pipe segments are subjected to non-destructive testing using two methods: gamma radiation with high resolution film and, after a 24-hour period, retesting using a form of automated ultrasonic examination. The welds are then recoated with field applied epoxy coating, and the coating of the entire exposed segment of pipe is retested to ensure integrity.

Denting and ovality of the pipeline occur subsequent to burying the pipeline and are caused by conditions not detected by rigorous visual inspection during installation and backfilling the pipe in the trench. Dents generally occur at locations of smooth but hard trench bottom (hard pan) rock that is shallow buried on the trench bottom and rock that is not detected in backfill. Ovality can occur in areas of hard pan and where additional backfill compaction is required along the sides of the pipeline. Expanded pipe has not been detected on the Gulf Coast Project. Figure 4.13.6-1 illustrates these anomalies.

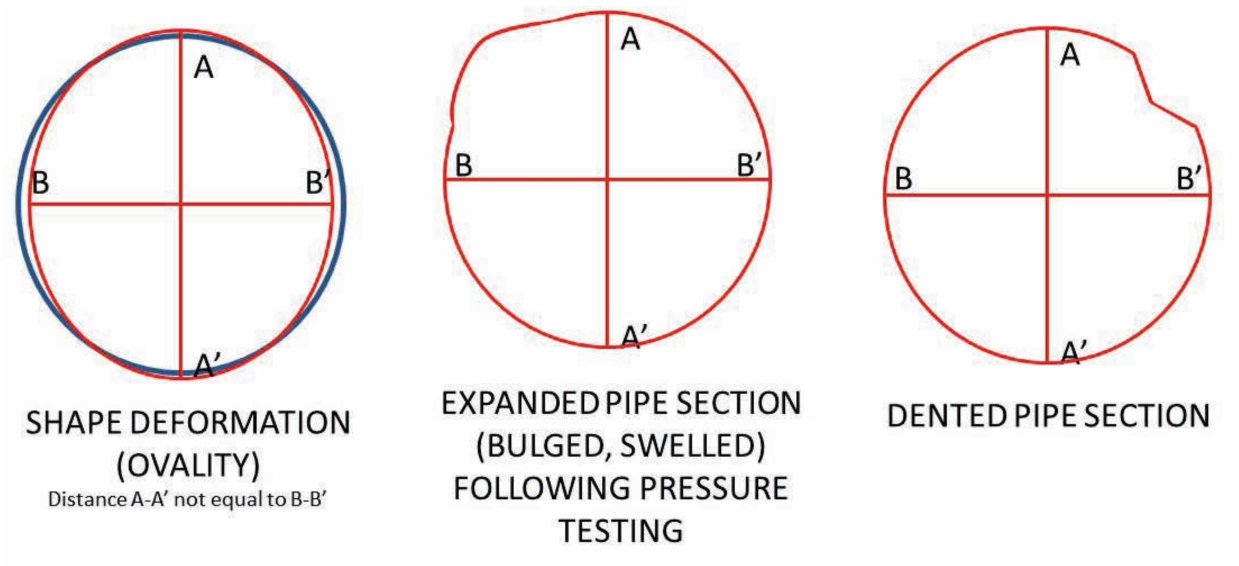


Figure 4.13.6-1 Types of Pipe Wall Deformations

TransCanada's specifications are designed to minimize the occurrence of these conditions and include requirements such as trench bottom sand padding, backfill operations that screen out rock size that could be damaging to the pipe, use of rock shielding materials in soils with abundant small rock, use of foam pads to prevent the bottom of pipe from contacting a hard or rocky trench bottom, and other measures.

Keystone has employed industry best construction and inspection practices whereby all construction and inspection staff are trained and verified to perform activities in accordance with Special Condition 20. The final inspection of the pipeline via hydrostatic testing, high resolution deformation ILI, and physical verification of reported ILI results help ensure the pipeline's reliability and integrity prior to crude oil service.

The conditions described herein are typical to the construction of large diameter pipelines. The PHMSA Special Conditions and TransCanada's specifications demand that rigorous testing for integrity of the pipeline be conducted, that all anomalies meeting pre-defined criteria be investigated and evaluated, and that following physical verification of such anomalies, corrective action be implemented as described above.

Lessons Learned

The pipeline involved in the Marshall, Michigan, incident was constructed in the 1950s. Pipeline standards have evolved, and new technologies have resulted in improvements in pipeline safety performance. Pipelines are now constructed with higher quality steel that is stronger, has better fracture resistant properties, and helps reduce the impacts of external forces such as flooding and excavation damage. Improvements in external pipeline coatings, the use of cathodic protection, and mandatory ILI tools have resulted in significant reductions in corrosion-related incidents. Keystone has not experienced a corrosion-related failure on any of its pipelines that utilize modern fusion-bonded epoxy coatings. Federal pipeline regulations have evolved over time, and pipeline operators are now required to actively manage their pipelines to reduce the possibility of incidents. Operating procedures and leak detection capabilities have improved to more rapidly detect leaks, thereby reducing the amount of crude oil released and subsequent impacts.

Commenters have raised concerns about the possibility of a spill on the proposed Project comparable to the Kalamazoo spill in Marshall, Michigan. Based on the lessons learned from the Kalamazoo spill, Keystone has indicated that it recognizes the additional potential challenges that could result from a release of dilbit to a water environment. In the event of such a release, Keystone intends to allocate additional manpower and resources towards the timely response, containment, and cleanup of releases to a waterbody. Pre-positioned equipment and materials would be stationed for timely access, and local response teams would be utilized to minimize response times. Additionally, Keystone intends to minimize the potential challenges discussed above by placing a strong focus on spill prevention and early detection of releases.

Environmentally, the lessons learned from the Marshall, Michigan, dilbit spill and related response implications include the following:

- The total volume of dilbit released to a river would not float on water indefinitely, and dilbit characteristics, water temperature, and particulate load in the water could result in much of the oil being submerged in the water column (USEPA 2013). Keystone has asserted that, in the event of a release to a body of water, Keystone would focus initially on timely containment and recovery efforts to remove floating material. However, Keystone response teams would be prepared to lend additional efforts for timely detection, containment, and recovery of submerged oil, as well, particularly in colder-temperature waterbodies with significant suspended sediment loads. Response personnel and contractors would be trained for the proper deployment and use of a number of submerged oil containment options (e.g., net booms, silt curtains, bottom-hugging weighted booms and watergate dams) and recovery alternatives (e.g., weighted sorbent, vacuum systems, dredging.)
- Submerged oil could be suspended in the water column, suspended just above the river bed, or intermixed with sediment and trapped in the river bed and shoreline (USEPA 2013). Keystone has asserted that their response teams and contractors would be trained and prepared to employ multiple remedial alternatives for effective removal of floating, submerged, and suspended oil. To contain and recover suspended oil, multiple types of underwater filters are available and may be replaced as needed for continued recovery.
- Submerged oil in a flowing water environment introduces additional recovery challenges for responders. In the event of a release to a flowing water environment, Keystone has stated that initial efforts would include prevention of the downstream migration of released material and that subsequent efforts for cleanup of submerged oil would extend to downstream areas.

Depending upon the characteristics of the flowing water environment, a number of methods for detecting submerged oil would be available and may include remote and diver-operated underwater video systems, visual observations, and/or sampling to delineate the lateral and vertical extent of submerged oil impacts.

- Response action planning and response equipment to contain and recover submerged oil should be considered. As such, the ERP and FRP would directly address submerged oil in a surface water release scenario. Response equipment and materials designated for containment and recovery of submerged oil would be pre-positioned in order to ensure timely response. These aspects are discussed further in the Spill Response Considerations subsection.
- Dilbit intermixed with sediment and trapped in the river bed and shoreline may result in a persistent source of oil and dissolved components such as benzene, polycyclic aromatic hydrocarbons, and heavy metals that could be slowly released back to the water column and transported down current. Various sampling techniques may be employed in order to delineate the extent of impacts to water from leaching contaminants, and long-term implementation of containment and recovery alternatives may be required to reduce the downstream migration of contaminants.
- Dilbit intermixed with sediment could persist for years. A biodegradation study conducted by the USEPA in response to the 2010 Enbridge dilbit spill in the Kalamazoo River in Michigan concluded that only 25 percent of the residual hydrocarbons impacting the river could be reasonably removed by natural attenuation (USEPA 2013). As such, in the event of a release to a water environment, Keystone is prepared to implement a number of other remedial alternatives, such as vacuum excavation, dredging, and/or treatment.

The NTSB 2012c Marshall, Michigan, Accident Report identified conditions that led to operational failures on the pipeline and resulted in the spill. Keystone would include mitigations learned from this event, including the following:

- According to Keystone, timeliness of a tactical response to an oil spill into water is imperative. While Keystone has stated that it already uses this philosophy, the Kalamazoo spill reinforced this need to respond with as many resources as possible, as rapidly as possible. To that end, Keystone would strategically store specialized spill equipment and employ personnel and contractors along the length of the pipeline. Keystone asserts that it is their objective and intent to respond as rapidly and as safely as possible for all operating areas, regardless of High Volume Area status. As per 49 CFR 194, responders must be on site within 6 hours in a High Volume Area and within 12 hours in non-High Volume Areas; however, Keystone asserts that it is their goal to respond sooner in all situations if it is safe to do so.
- Pre-qualify a large contractor network: Contractors would be used to supplement any response Keystone would make to an oil spill. By ensuring that a large pool of trained/skilled contractors along the length of the pipeline have been pre-qualified and contracted with Keystone, the response time would be minimized and the resources (equipment and personnel) available would be maximized.
- Emergency response planning details need to include source containment: source containment plans including strategies and tactics would be included in the overarching ERP.

- Equipment resources required for sunken and submerged oil: Keystone would further identify equipment resources required to respond to sunken and submerged oil and ensure personnel are appropriately trained. A primary strategy for oil spill response would still be required to contain and recover as much oil as possible, as rapidly as possible, to prevent oil from weathering and therefore potentially becoming submerged and sinking. In addition, Keystone already owns and practices the use of containment devices that would prevent downstream migration of submerged and sunken oil such as dams. This type of equipment would be further identified and procured for the proposed Project.

Keystone would use relevant PHMSA advisory bulletins, relevant NTSB incident reports, and applicable major Standards and Association recommended practices, as appropriate, within the applicable phase of the project. Specifically, lessons learned that are documented in these industry publications would be obtained from:

- PHMSA Advisory Bulletins: These items could be incorporated in the applicable phase (i.e., design, construction, or operations) through modification of specific design requirements, construction scope of work, or incorporation into an Integrity Management Plan or Operations Manual.
- NTSB Incident Reports: The draft and final reports can be reviewed for pertinent findings and incorporated into design basis or procedures, if applicable.
- Industry Publications: These serve as representation on major Standards and Association Committees and incorporate appropriate feedback into specification revisions for pipeline assets through company engineering standards.
- PHMSA Special Conditions 25c and 43: These are examples of where NTSB incident reports and PHMSA advisory bulletins are incorporated into the proposed Project.

Spill Liability and Responsibility

In addition to Keystone staff and resources and consistent with the requirements of the proposed Project's ERP, federal, state, and local agencies would engage in response activities where soil, surface water, and groundwater cleanup are needed. Participation would be within agencies' authorities and duties under applicable regulations. Required mitigation for crude oil or oil products spill impacts would be determined by these agencies. In addition, the state, tribal, and federal natural resource trustee agencies could require a Natural Resource Damage Assessment under either the Oil Pollution Act (OPA 90) or the Comprehensive Environmental Restoration Compensation and Liability Act, depending on the types of materials spilled and the assessment of the magnitude of the impacts and the type/amount of suitable restoration actions to offset the loss of natural resource services resulting from a spill. The Nebraska Environmental Protection Act, Nebraska RRS S 81-1501, et seq. and the Nebraska Administrative Code Title 126, Chapter 18, provide for operator liability in the event a pipeline spills oil or a hazardous substance in or on land or waters of the state. Table 4.13-40 summarizes potentially applicable federal and state soil, surface water, and groundwater cleanup regulations.

Table 4.13-40 Potentially Applicable Federal and State Soil, Surface Water, and Groundwater Cleanup Regulations

Statute/Regulation	Description
Resource Conservation and Recovery Act, 42 U.S. Code (USC) § 6973.	USEPA may issue an order or bring a suit in district court against any person who has contributed or who is contributing to the handling, treatment, storage, transportation, or disposal of solid or hazardous waste which may present an imminent and substantial endangerment to health or the environment. Persons who violate an order are subject to civil penalties of up to $7,500 per day. Section 7003(a) of Resource Conservation and Recovery Act, 42 USC 6973(a), authorizes USEPA upon receipt of evidence that the past or present handling, storage, treatment, transportation or disposal of any solid waste or hazardous waste may present an imminent and substantial endangerment to health or the environment, to bring suit in district court or to issue an administrative order to any person who contributed or is contributing to that handling, storage, treatment, transportation to restrain or take any other action in response. Oil released from a pipeline would constitute solid or hazardous waste, and the authority allows USEPA to require action even if the spill may present an imminent and substantial endangerment.
Safe Drinking Water Act (SDWA), 42 USC §§ 300f, et seq.	USEPA may issue orders to any person in circumstances where contaminant is present in or is likely to enter a public water system or an underground source of drinking water (defined broadly to include virtually almost all groundwater) which may present an imminent and substantial endangerment to the heal of persons and states (to whom primary responsibility is granted under the SDWA) are not acting. The orders may require that person to take such actions as USEPA deems necessary to protect health. 42 USC § 300i (a). Civil penalties are available for failure to comply with such an order. Section 1431(a) of SDWA, 42 USC 300i(a), authorizes USEPA upon receipt of information that a contaminant which is present in or is likely to enter a public water system or an underground source of drinking water which may present an imminent and substantial endangerment to the health of persons, to take such actions as [it] deems necessary, including issuance of orders and civil judicial actions. Again, this authority is quite broad. An underground source of drinking water is virtually any underground water that has the potential to be used for drinking water, and a contaminant is any biological, chemical, or physical substance in water.
Pipeline Safety Act, 49 USC §§ 60101, et. seq.	The Pipeline Safety Act, as amended in 2011, provides authority for PHMSA to establish minimum safety standards for interstate hazardous liquid pipelines, including petroleum pipelines. The standards may apply to the design, installation, inspection, emergency plans and procedures, testing, construction, extension, operation, replacement and maintenance of pipeline facilities. § 60102(a)(2). Penalties Violations of PHMSA requirements are subject to civil judicial enforcement actions, with varying penalty amounts depending on the nature of the violation (generally $200,000 for each violation, with a maximum of $2,000,000 for a related series of violations).

Statute/Regulation	Description
	Written Procedures Regulations require that a pipeline operator prepare and implement a manual for operations, maintenance and emergencies. 49 CFR Part 195.402. For emergencies, the manual must include procedures for (a) receiving, identifying and classifying notices of events which need immediate response and (b) responding promptly to the emergency, including fire or explosion near or involving a pipeline, accidental release of materials from a pipeline, operational failures and natural disasters. 49 CFR Part 195.402(e). Notification Regulations require that a pipeline operator make an incident report, including telephonic report, for pipeline failures which result in (a) explosion or fire, (b) release of 5 gallons or more of petroleum (with certain exceptions), (c) death, (d) personal injury necessitating hospitalization, or (e) property damage (including cleanup) in excess of $50,000. 49 CFR Parts 195.50-195.54.
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 USC §§ 9601, et. seq.	Similar to the OPA 90, but addresses releases of hazardous substances and specifically excludes oil and petroleum. Provides for liability for response costs and natural resource damages against owners or operators of a vessel or facility and persons who arranged for disposal of hazardous substances. The act contains similar defenses as for the OPA 90, as well as contribution rights. Also provides USEPA authority to issue administrative orders requiring response actions.
Montana	There is no single statutory scheme under Montana law governing liability for pipeline spills on land and in groundwater, but one or more of the following provisions could apply depending on the circumstances: Montana Code Annotated (MCA) 75-10-705 et seq., Montana‘s ―Comprehensive Environmental Cleanup and Responsibility Act (Montana‘s version of CERCLA) MCA 75-10-401 et seq., the ―Montana Hazardous Waste Act – while crude oil is not specifically listed in the definition of hazardous waste‘ the definition may be broad enough to apply to a crude oil spill MCA 75-5-101 et seq., Montana‘s water quality statutes – applicable to both surface water and groundwater MCA 75-20-101 et seq., the ―Montana Major Facility Siting Act – applicable to ―facilities, including pipelines, that fall under the MFSA. Keystone XL falls under MFSA. The regulations that relate to the statutes and may apply are: Administrative Rules Montana (ARM) 17.55.101 et seq. dealing with Comprehensive Environmental Cleanup and Responsibility Act ARM 17.53.101 et seq. dealing with hazardous waste ARM 17.30.101 et seq. dealing with water quality ARM 17.20.101 et seq. dealing with MFSA There are also various common law grounds under Montana law for asserting liability for pipeline spills, and Montana also has clean and healthful environment constitutional provisions that could be used to assert liability.

Statute/Regulation	**Description**
South Dakota	First, South Dakota Public Utilities Commission permit HP09-001 authorizing the project in the state, issued in final form June 29, 2010, provides at Condition 48: No person would be held responsible for a pipeline leak that occurs as a result of his/her normal farming practices over the top of or near the pipeline. The permit provides further at Condition 49: Keystone shall pay commercially reasonable costs and indemnify and hold the landowner harmless for any loss, damage, claim or action resulting from Keystone's use of the easement, including any resulting from any release of regulated substances . . . except to the extent such loss, damage claim or action results from the gross negligence or willful misconduct of the landowner or its agents. Second, statutes contained in South Dakota Codified Law (SDCL) Chapter § 34A-12, which create the regulated substance response fund, provide for corrective action in case of a spill or leak from a tank. The definition of tank includes pipeline facilities which transport and store regulated substances. SDCL § 34A-12-1(12). A regulated substance is defined to include crude oil. SDCL § 34A-12-1(8). Under the chapter, the Department of Environment and Natural Resources is directed to take corrective action to clean up any unauthorized discharge of a regulated substance, but only after first ordering the responsible person to take corrective action. A responsible person is as a person who has caused a discharge of a regulated substance, or a person who is an owner or operator of a tank at any time during or after a discharge. SDCL § 34A-12-1(10). If the responsible person fails to act, then the department may seek injunctive relief to compel corrective action. SDCL § 34A-12-10. If a responsible person cannot be identified or refuses to undertake corrective action, or if emergency action is needed to prevent an imminent threat to public health or safety, then the department may undertake correction action with funds from the response fund. SDCL § 34A-12-4(2), (3). The department may recover corrective action costs from either the responsible person, SDCL § 34A-12-6, or from any person who has caused a discharge of a regulated substance. SDCL § 34A-12-12. That statute also provides that the person causing a discharge is strictly liable for the corrective action costs expended by the department. Third, SDCL Chapter § 34A-2 addresses the discharge of petroleum substances into state waters. SDCL § 34A-2-96 imposes liability on the owner or operator of a facility that stores or transports petroleum substances for the costs of containment and recovery of discharges into the waters of the state. SDCL § 34A-2-96. This section also provides that ―any person causing the discharge shall be strictly liable to the owner or operator for all costs and proximate damages resulting from the discharge. A violation of an order issued pursuant to the statute is a class 1 misdemeanor. SDCL §§ 34A-2-96, 34A-2-75. Finally, landowners who experience a discharge have civil court remedies for damage to their property, including loss of use and loss of future productivity. Cleanup costs incurred by the landowner are a recoverable element of damage.
Nebraska	The Nebraska Environmental Protection Act, Nebraska RRS § 81-1501, et seq. (Act) and the Nebraska Administrative Code Title 126, Chapter 18, provide for liability in the event a pipeline spills oil or a hazardous substance in or on land or waters of the State. Waters of the State include both surface waters and groundwater. In the event of a release, the person responsible for the release has various responsibilities. Responsible person means any person producing, handling, storing, transporting, refining, disposing of an oil or hazardous substance when a release occurs, either by accident or otherwise. This includes carriers or any other person in control of an oil or hazardous substance when a release occurs, whether they own the oil or hazardous substances or are operating under a lease, contract, or other agreement with the legal owner thereof. Nebraska Administrative Code Title 126, Chapter 18-038.

Statute/Regulation	Description
	The responsible person must: (1) notify the Nebraska Department of Environmental Quality (NDEQ) if the release exceeds threshold quantities, or, regardless of quantity, if the release occurs beneath the surface of the land or impacts or threatens waters of the State or threatens the public health and welfare, (2) must take all necessary steps to stop the release and contain all released material, and take action to preclude continued or future releases, (3) investigate the release, to determine its impact, and the investigation must be reported to NDEQ, (4) take remedial action, which remedial action is subject to the review and approval of NDEQ, (5) properly dispose of any waste generated from the cleanup. Compliance with these requirements does not relieve the responsible person from liabilities, damages, or penalties resulting from the release, cleanup and disposal. The Act also has civil and criminal penalties that may be assessed in the event of a release. The Act further provides for reimbursement to the State for any loss of fish or wildlife as a result of a release.

Keystone is committed to ensuring the safe operation of its pipeline system and to prevent any incidents from occurring. Should a release occur from the Keystone XL pipeline, Keystone is committed to clean up any releases that may occur. Keystone is also legally required to clean up spills under Title 118 and OPA 90. Keystone has stated that they would commit in their ERP to the implementation of a long-term groundwater sampling/monitoring program after a spill in the event that Keystone determines, in consultation with relevant agencies, that post cleanup and restoration and site conditions suggest an ongoing potential risk to water and/or the potential for residual contamination. In addition to all of the above, and in response to public concern, Keystone would commit to file annually with the Nebraska DEQ by May 1 of each year:

(a) A certificate of insurance as evidence that it is carrying a minimum of $200 million in third-party liability insurance as adjusted by calculating the gross domestic product implicit price deflator from the date a Presidential permit is issued for the Project and adjusting the amount of the third-party liability insurance policy by this percentage. The third-party liability insurance shall cover sudden and accidental pollution incidents from Keystone XL Pipeline in Nebraska.

(b) A copy of Keystone’s Securities and Exchange Commission Form 10-K and Annual Report. Keystone’s Major Facilities Siting Act (MFSA) Certificate contains a similar requirement.

Keystone is willing to adopt a similar requirement in South Dakota.

Section 1001(32)(B) of the OPA 90 states that in the case of an onshore facility, any person owning or operating the facility is the responsible party. Additionally, under Section 1002 of OPA 90, Keystone would be liable for discharge of oil (or threat of discharge) to navigable waters of the United States and their adjoining shorelines. The term "navigable waters" is defined in OPA 90 as the waters of the United States, including the territorial sea. Groundwater is not within the scope of the OPA 90 unless a direct connection to surface waters could be affirmed.

If there is an accidental release that could affect surface water, no matter what the reason, Keystone would be liable for all costs associated with cleanup and restoration, including damages to natural resources; to real or personal property for the loss of subsistence use of natural resources; for the net loss of taxes, royalties, rents, fees, or net profit shares from injuries to real or personal property or natural resources; for loss of profits or impairment of earning capacity by any claimant; or for net cost of providing increased or additional public services, up to a maximum of $350,000,000 per OPA 90 (U.S. Department of Homeland Security 2012). However, this statutory liability limit does not apply where the incident was proximately caused by 1) gross negligence or willful misconduct, or 2) the violation of an applicable federal safety construction or operating regulation by Keystone or a person acting pursuant to a contractual relationship with Keystone. Additionally, under the Clean Water Act, Keystone would be liable for up to $50 million for U.S. removal costs for harmful quantities of oil discharged from a Keystone-owned or operated facility unless the discharge was caused solely by an act of God, an act of war, negligence by the United States, or the act or omission of a third party. Liability for the full cost of oil removal applies if the discharge resulted from Keystone‘s willful negligence or willful misconduct.

The limits of liability under OPA 90 are also expanded in Section 1018, which allows for additional liabilities to be imposed by the state (or political sub-division thereof) in which the incident occurred. Keystone would also be subject to penalty provisions of the Rivers and Harbors Act and the Pipeline Safety Act. In addition to the provisions described above, in the event that a release of crude oil contaminates groundwater, Keystone has agreed that it would be responsible for cleanup and restoration, and for providing an appropriate alternative water supply for groundwater that was used as a source of potable water, or for irrigation or industrial purposes.

Per 26 CFR, Chapter 38, Section 4611, *Environmental Taxes*, the Oil Spill Liability Trust Fund financing rate is 8 cents a barrel in the case of crude oil received or petroleum products entered before January 1, 2017 and increases to 9 cents a barrel for crude oil received or petroleum products entered after December 31, 2016. The liability for this tax is as follows:

- If the crude oil is received into the United States at a refinery, the tax imposed shall be paid by the operator of the refinery.
- If the crude oil is imported into the United States, the tax imposed shall be paid by the person/operator entering or importing the crude oil for consumption, use, or warehousing into the United States.

In May 2011, the Internal Revenue Service concluded that imported oil sands, which includes diluted bitumen, were excluded from the excise tax based on the definitions of *crude oil* and *petroleum products* obtained from a 1980 House Committee Report on the 1980 CERCLA, which states "…The term crude oil does not include synthetic petroleum, e.g., shale oil, liquids from coal, *tar sands* [emphasis added], or biomass or refined oil." Keystone has asserted that it reads the IRS conclusion to mean that *certain products* are therefore exempt "from excise tax because the IRS conclusion does not rest on any stated findings regarding the physical or chemical properties of the exempted products". The Department does not take a view on the accuracy of Keystone's assertion, and for purposes of this Final Supplemental EIS uses the term *crude oil* throughout this document to refer to the physical and chemical properties of the material transported by the proposed pipeline.

Regardless of the origin of an oil, should an oil spill require federal intervention, funds from the Oil Spill Liability Trust Fund may be utilized by federal on-scene coordinators and trustees to ensure rapid and effective response to oil spills. The Oil Spill Liability Trust Fund was authorized with the passage of OPA 90 and is used to cover expenses associated with mitigating the threat of a spill, spill containment, countermeasures, cleanup, and waste disposal. The National Pollution Funds Center administers the payments from the fund to cover response action costs incurred by the U.S. Coast Guard or the USEPA, state response activities, payments for natural resource damage assessments and restoration, payment of claims for uncompensated costs or damages, research and development, and other allocations. The Oil Spill Liability Trust Fund is currently funded in part from cost recoveries from responsible parties that are liable for costs and damages, and the fines or civil penalties incurred by responsible parties liable for incidents.

However, if a release is caused by negligent or willful acts of others, Keystone may ultimately recover costs from those committing the acts since individuals are not automatically protected from liability associated with negligent acts or willful misconduct leading to property destruction and environmental damage. Specific liability warrants and indemnifications are included within individual easement agreements. The Department has no regulatory authority to intervene in the negotiation of those agreements. In addition, consideration of liability is beyond the scope of National Environmental Policy Act environmental reviews and is therefore not addressed in this Final Supplemental EIS.

In summary, Keystone has committed to a number of mitigation measures beyond the spill cleanup measures required by federal and state regulations. This commitment would be formalized in a legally binding agreement, as appropriate, as a condition of the proposed Project proceeding, should it be approved. These measures include:

- Consulting and communicating with the Local Emergency Response Planning Committees and other emergency service agencies during ERP development to ensure ERPs are aligned.
- Cleaning up any releases that may occur.
- Preparing a paleontological mitigation plan to protect significant fossil resources in the event that a spill affects a paleontological resource.
- In the event that a spill contaminates groundwater, being responsible for cleanup and restoration and for providing an appropriate alternative water supply for groundwater that was used as a source of potable water, or for irrigation or industrial purposes. If the permit were approved, Keystone would memorialize that agreement through an appropriate written agreement with the Environmental Protection Agency.
- Filing annually with the Nebraska DEQ by May 1 of each year:
  - A certificate of insurance as evidence that it is carrying a minimum of $200 million in third-party liability insurance as adjusted by calculating the gross domestic product implicit price deflator from the date a Presidential permit is issued for the Project and adjusting the amount of the third-party liability insurance policy by this percentage. The third-party liability insurance shall cover sudden and accidental pollution incidents from Keystone XL Pipeline in Nebraska.
  - A copy of Keystone's Securities and Exchange Commission Form 10-K and Annual Report. Keystone's MFSA Certificate contains a similar requirement.
- On request, filing the documents listed above with other appropriate state agencies.

Additional Mitigation

In addition to the mitigation measures that Keystone would implement as discussed above, additional mitigation measures may be identified and required by agencies during other permitting processes (e.g., USACE, State DEQs, other state agencies, local authorities). For example, some of those mitigations identified by agencies, which were learned from the Kalamazoo River spill, include:

- Spill response would be coordinated with statutory authorities of other agencies with responsibility for conducting response to and/or response oversight for an oil discharge. The development of an ERP could be incomplete without this coordination and potentially limit its effectiveness and efficiency of implementation. It is likely that interaction, coordination and communication with governmental regulators and/or response authorities (i.e., USEPA, USDOT, and U.S. Coast Guard) for a potentially integrated response would be necessary. For example, under the Federal Emergency Management Agency's (FEMA), ICS, a response to a spill of sufficient scope/magnitude would most likely involve unified command.

- The ERP and FRP would address submerged oil as well as floating oil in a surface water release scenario. The USDOT Pipeline Response Plan would be reviewed in coordination with USEPA and include contingency plans to address a submerged oil response and cold weather response. Section 4.13.6.2, Safety and Spill Response, focuses on a traditional oil spill response and not a strategy to address submerged oil or cold weather.
- Pre-positioned response assets would include equipment that could address submerged oil. Response strategies, such as pre-positioning of equipment to address submerged oil, would be considered and may be fine-tuned with USEPA consultation.

Mitigation measures related to potential releases and pipeline safety are included in Appendix B, Potential Releases and Pipeline Safety. Keystone has committed to implement the measures in Appendix B.

4.13.7 Connected Actions[19]

4.13.7.1 Bakken Marketlink Project

A spill from the Bakken Marketlink Project would potentially impact similar receptors as the proposed Project. Groundwater, surface water, and soil impact would be the key affected media with consequence on resident receptors (e.g., birds, fish, and snails) dependent upon spill size.

Spills from the pipeline could result in surface spreading or infiltration to groundwater. Surface spreading could potentially reach nearby creeks. Groundwater of the Upper Cretaceous Hells Creek/Fox Hills Aquifer shallower than 50 ft potentially could be affected by a small spill volume (less than 50 bbl). Spills at water crossings could affect larger downstream surface waterbodies. These spill migration pathways are the same as those of the proposed Project.

Leaks or spills from storage tanks would likely be contained within regulatory required berm or containment system. Therefore, overland spreading would be restricted. The threat of infiltration to groundwater and soil impact would still remain.

High-quality groundwater is not present in the area, and therefore, drinking water users are limited.

4.13.7.2 Big Bend to Witten 230-kV Transmission Line

A spill along the Big Bend to Witten 230-kV Transmission Line would be related to construction and maintenance activities. If a spill occurred, groundwater might be affected; however, because construction and maintenance activities are managing hundreds of gallons of fuel or less, related to vehicles, temporary localized refueling tanks, fuel powered equipment, etc., the impact from a release by one of these sources would be much less than from proposed pipeline construction and operation activities. In addition, spill response would generally be immediate because of the presence of staff during these activities.

[19] Connected actions are those that 1) automatically trigger other actions which may require environmental impact statements, 2) cannot or will not proceed unless other actions are taken previously or simultaneously, 3) are interdependent parts of a larger action and depend on the larger action for their justification.

4.13.7.3 Electrical Distribution Lines and Substations

Potential spill impacts for electrical distribution lines and substations would be similar to those associated with construction and maintenance activities as described above for the Big Bend to Witten 230-kV Transmission Line.

4.13.8 References

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