BEAR DEN PHASE 2 PROJECT

ATTACHMENT 2
Bear Den Project Pipeline Risk Assessment and Environmental Consequence Analysis

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Environment

Submitted to:
Bureau of Land Management
North Dakota

Submitted by:
AECOM
Fort Collins, Colorado
60220730.260
February 2013

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List of Acronyms

°F	degrees Fahrenheit
API	American Petroleum Institute
BLM	Bureau of Land Management
BPD	barrels per day
CEBCS	CenterPoint Energy Bakken Crude Services, LLC
CFR	Code of Federal Regulations
cfs	cubic feet per second
CPM	computational pipeline monitoring
EA	Environmental Assessment
ERP	Emergency Response Program
FBE	fusion bond epoxy
HCA	high consequence area
HDD	horizontal direction drilling
HDPE	high density polyethylene
hp	horsepower
IMP	Integrity Management Program
LACT	Lease Automatic Custody Transfer
LC_{50}	lethal concentration at which 50 percent of organisms die after 48 hours
MCL	maximum contaminant levels
mg/L	milligrams per liter
MOP	maximum operating pressure
NEPA	National Environmental Policy Act
OCC	Operations Control Center
PAH	polycyclic aromatic hydrocarbons
PHMSA	Pipeline and Hazardous Materials Safety Administration
pig	pipeline inspection gauge
ppm	parts per million
psig	pounds per square inch gauge
RA	Risk Assessment
ROW	right-of-way
SCADA	Supervisory Control and Data Acquisition
TDS	Total Dissolved Solids
U.S.	United States
USA	Unusually Sensitive Area
USACE	United States Army Corps of Engineers
USC	United States Code
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
WT	wall thickness

Contents

1.0 Project Overview 1-1

2.0 Introduction 2-1

3.0 Pipeline Design Features 3-1

3.1 Pipeline 3-3

3.2 Mainline Valve Assemblies 3-5

4.0 Incident Frequency-Spill Volume Estimation 4-1

4.1 PHMSA Baseline Incident Frequencies 4-1

4.2 Spill Volume 4-2

5.0 Consequences of a Spill 5-1

5.1 Human Consequences 5-1

5.2 Environmental Consequences 5-1

5.2.1 Crude Oil Composition 5-1

5.2.2 Environmental Fate and Transport 5-1

5.2.3 Environmental Impacts 5-4

5.3 Produced Water and Analysis 5-17

5.4 Frac-out Impacts and Analysis 5-20

5.5 Risk to Populated and High Consequence Areas 5-22

5.5.1 Populated Areas 5-23

5.5.2 Drinking Water 5-23

5.5.3 Ecologically Sensitive Areas 5-24

5.5.4 Management of Risk within HCAs 5-24

6.0 CEBCS's Pipeline Safety Program 6-1

7.0 Conclusion 7-1

8.0 References 8-1

9.0 Glossary 9-1

List of Appendices

Appendix A Analysis of High Consequence Areas

List of Tables

Table 4-1 Baseline Incident Frequencies[1] 4-1

Table 4-2 Calculated Spill Occurrence Interval Associated with the Project over 10 Years Breakdown by Volume 4-2

Table 5-1 Composition of Representative Bakken Crude Oil 5-2

Table 5-2 Stream Categories 5-8

Table 5-3 Comparison of Estimated Benzene Concentrations with the Benzene MCL Resulting from a Bakken Crude Oil Spill 5-10

Table 5-4 Acute Toxicity of Aromatic Hydrocarbons to Freshwater Organisms 5-11

Table 5-5 Acute Toxicity of Crude Oil Hydrocarbons to *Daphnia magna* 5-12

Table 5-6 Chronic Toxicity of Benzene to Freshwater Biota 5-13

Table 5-7 Comparison of Estimated Benzene Concentrations Following a Bakken Crude Oil Spill to the Acute Toxicity Thresholds for Aquatic Life (7.4 ppm) for Streams Crossed by the Project 5-15

Table 5-8 Comparison of Estimated Benzene Concentrations Following a Bakken Crude Oil Spill to the Chronic Toxicity Threshold for Aquatic Life (1.4 ppm) for Streams Crossed by the Project 5-16

Table 5-9 Volume of Water Required to Dilute Benzene in Bakken Crude Oil Spills to Benchmark Values 5-17

Table 5-10 Summary of Water Quality Data for Produced Water 5-18

Table 5-11 Comparison of Estimated Chloride Concentrations with the Chloride Maximum Limit Resulting from a Produced Water Spill 5-21

Table 5-12 Mileage Summary of Pipeline Segments that “Could Affect” PHMSA-defined HCAs 5-22

Table 5-13 Predicted Frequency of Spills and Associated Volumes Within “Could Affect” Segments in 10-year Period 5-23

List of Figures

Figure 1-1 Proposed CEBCS Pipeline Route 1-3

1.0 Project Overview

The Bear Den Project (Project), which is proposed by CenterPoint Energy Bakken Crude Services, LLC (CEBCS), is a crude oil and produced water gathering pipeline system that will service multiple wells in Dunn and McKenzie Counties, North Dakota (**Figure 1-1**). Specifically, the Project pipeline system will receive crude oil at the subject wells and transport it to an aboveground facility for temporary storage and transfer to an outlet pipeline. Additionally, water produced at the subject wells will be transported to a third-party injection well for disposal. The project pipelines will generally be installed within a common right-of-way, with approximately 59 miles of right-of-way housing dual, collocated pipelines and approximately 10 miles of right-of-way housing a single crude or produced water pipeline.

The crude oil pipeline system includes approximately 14 miles of 8-inch-diameter steel trunk line designed to initially carry up to 14,000 barrels per day (BPD), with a maximum design flow rate of 23,500 BPD. An additional approximately 56 miles of gathering network pipeline comprised of 6-inch-diameter steel pipeline (24 miles), 4-inch-diameter steel pipeline (12 miles) and 3-inch-diameter steel pipeline (20 miles) would be used to construct three primary laterals that would deliver oil into the trunk line. The 6-inch-diameter lateral pipelines are designed to initially carry up to 13,000 BPD, with a maximum design flow rate of 14,000 BPD, the 4-inch-diameter lateral pipelines are designed to initially carry up to 3,500 BPD, with a maximum design flow rate of 4,500 BPD and the 3-inch-diameter laterals are designed for an initial flow rate of 2,500 BPD, with a maximum design flow rate of 3,000 BPD.

The produced water pipeline system is comprised of approximately 59 miles of 3-, 4- and 6-inch-diameter composite pipeline. Water produced at the wells (supplemental and formation water) would be transported eastward to a disposal facility located at the southeastern extent of the proposed route (**Figure 1-1**) for disposal and/or recycling by a third party.

Other surface facilities would include pipeline markers, pipeline inspection gauge (pig) launchers and receivers, cathodic protection rectifiers, and block valves. No pumping stations would be built as part of the project. The pressure provided by Lease Automatic Custody Transfer (LACT) units and electric pumps at the well pad locations would be adequate for operation of the pipeline at the currently projected flow rates.

CEBCS believes its project would help to reduce the amount of truck mileage and infrastructure necessary for hauling crude oil and produced water from the lease area to delivery point locations. The anticipated in-service date for the project is October 2014.

Federal Permitting Process

The proposed Project route crosses federal lands managed by the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM). Accordingly, the Project would require the issuance of a ROW grant by the BLM. The issuance of the right-of-way (ROW) grant and easement across federal lands are considered federal actions and; therefore, the Project is subject to environmental review pursuant to the National Environmental Policy Act (NEPA) (42 United States Code [USC] § 4321 et seq.). Per Section 28 of the Mineral Leasing Act of 1920, as amended (30 USC 185), the BLM is the lead federal agency for NEPA compliance (i.e., preparation of an Environmental Assessment [EA] for the project) and the USFS and the U.S. Fish and Wildlife Service (USFWS) are participating as cooperating agencies.

CEBCS submitted a Right-of-Way Grant Application to the BLM, North Dakota Field Office, for transportation and utility systems and facilities on federal lands on July 17, 2012. Consultation with the BLM indicated that an EA would be needed to fulfill NEPA requirements. The EA provides an objective disclosure of beneficial and adverse environmental impacts resulting from the project, as well as a set of reasonable alternatives, and mitigation measures. This Risk Assessment (RA) provides part of the

technical basis for the EA, disclosing potential environmental consequences that might occur in the unlikely event of a crude oil or produced water spill (or release) from the Project.

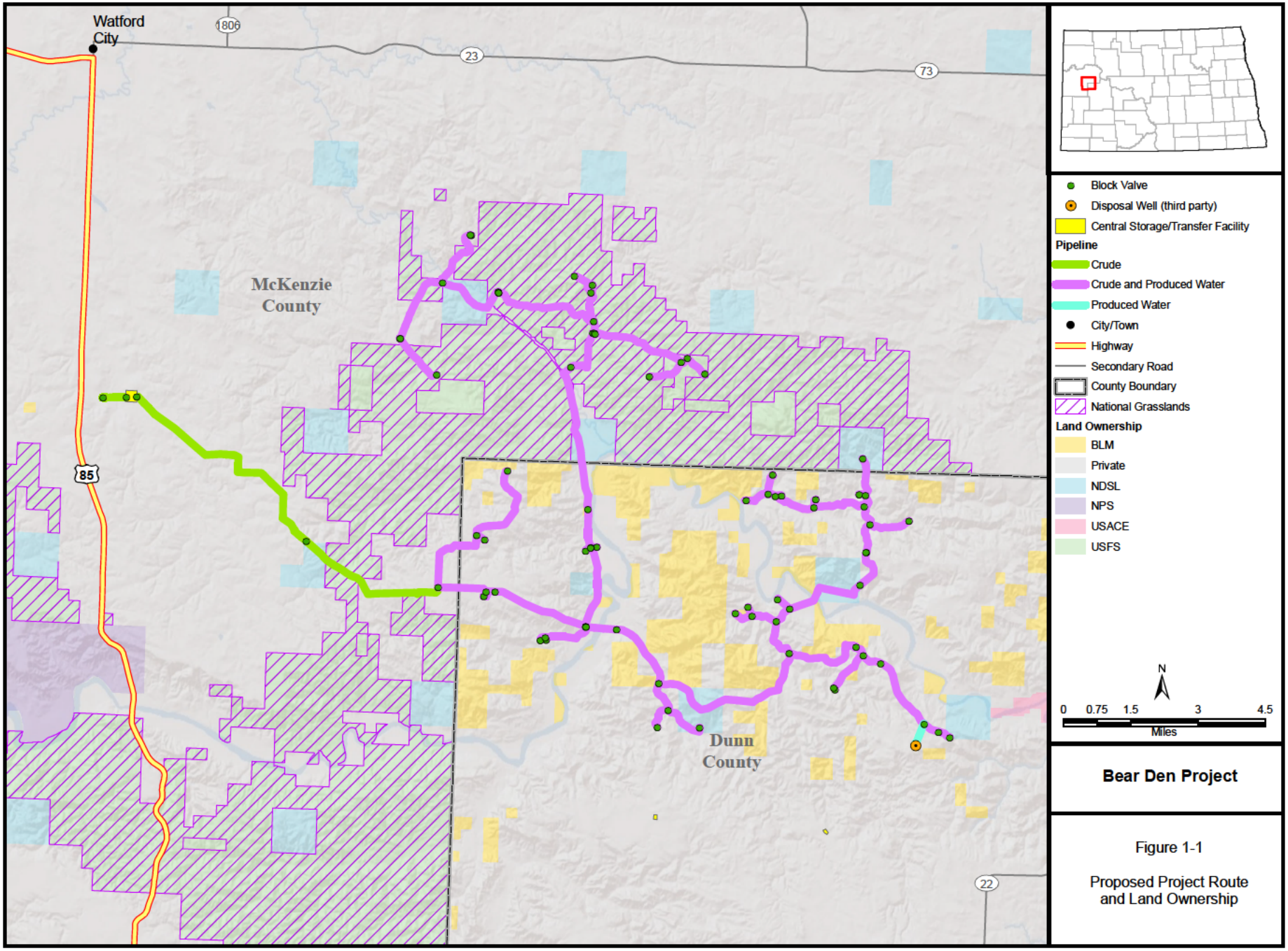

Figure 1-1

Proposed Project Route and Land Ownership

2.0 Introduction

This RA presents the results of a pipeline incident frequency analysis based on the project's design and operations criteria and applies the resulting risk probabilities to an environmental consequence analysis that incorporates project-specific environmental data. Specifically, this RA evaluates the risk of crude oil and produced water spills during pipeline operations, including probable spill volumes, contribution of natural hazards to spill risk and the subsequent potential effects on humans and other sensitive resources, particularly in areas of high environmental sensitivity, including federally designated high consequence areas (HCAs) (e.g., certain populated areas, designated zones around public drinking water intakes, and/or ecologically sensitive areas). Additional effects on public health and safety that could occur during project construction are discussed under other resource sections (e.g., air quality, water resources, transportation, land use, and aesthetics) within the EA.

The purpose of this RA is to provide a conservative range of anticipated effects from the operation of the project that is sufficient for the purposes of NEPA. Given this objective, the analysis summarized within this RA is intentionally conservative (i.e., overestimates risk). The expectation is that the spill frequencies presented in this analysis are not likely to occur, but are provided as a conservative framework to ensure agency decisions are based on knowledge of the potential range of effects.

3.0 Pipeline Design Features

The Project would consist of approximately 69 miles of crude oil and produced water gathering pipeline extending from 31 well pad sites located in Dunn and McKenzie Counties, North Dakota (**Figure 1-1**). The wells are currently serviced through a system of temporary on-site storage, with transportation accomplished by tanker truck via public and lease roads. The Project pipeline system would receive crude oil at the subject wells and transport it to an aboveground facility for temporary storage and transfer to an outlet pipeline. Additionally, water produced at those wells would be transported to a separate facility for disposal or recycling by a third party. Approximately 59 miles of produced water pipeline are proposed. With the exception of approximately 10 miles of single pipeline right-of-way, all of the Project pipelines would be installed within a common right-of-way (i.e., the nominal project ROW will contain two pipelines).

The 14-miles of unidirectional 8-inch-diameter steel trunk line would transport crude oil westward from the well pad laterals to the storage/transfer facility. The proposed trunk line is designed to initially carry up to 14,000BPD, with a maximum design flow rate of 23,500 BPD. The crude oil gathering network would comprise approximately 56-miles of 3- to 6-inch-diameter steel pipeline to connect the well pads to the trunk line. In addition, a 0.5-mile 8-inch-diameter steel crude oil delivery lateral would also be constructed from the storage/transfer facility to a crude oil interconnect with a third-party outlet pipeline. Each of the proposed lines is briefly summarized below (pipe dimensions refer to internal diameter):

- The 8-inch-diameter trunk line is designed for an initial flow rate of 14,000 BPD, with a maximum design flow rate of 23,500 BPD;
- The 6-inch-diameter lateral pipelines also are designed to initially carry up to 13,000 BPD, with a maximum design flow rate of 14,000 BPD;
- The 4-inch-diameter lateral pipelines also are designed to initially carry up to 3,500 BPD, with a maximum design flow rate of 4,500 BPD; and
- The 3-inch-diameter lateral pipelines also are designed to initially carry up to 2,500 BPD, with a maximum design flow rate of 3,000 BPD.

The project would be designed, constructed, and operated in compliance with applicable portions of the U.S. Department of Transportation (USDOT) regulations as set forth in 49 Code of Federal Regulations (CFR) Part 195, Transportation of Hazardous Liquids by Pipeline. These regulations encompass general requirements, accident reporting and safety related condition reporting, design requirements, construction, pressure testing, operation and maintenance, qualification of pipeline personnel, and corrosion control. Relevant industry standards are incorporated into these regulations by reference, including those of the American Petroleum Institute (API), American Society of Mechanical Engineers, the American Standard for Testing and Materials, and others.

In addition to the crude oil line, 18 miles of unidirectional 6-inch composite trunk line would transport produced (formation) water eastward from the well pad laterals to a third-party disposal facility located at the southeastern extent of the pipeline network. The proposed trunk line is designed to initially carry up to 3,500 BPD, with a maximum design flow rate of 8,000 BPD. The produced water gathering network would comprise approximately 42.6-miles of 3- and 4 inch-diameter composite pipeline that connect the well pads to the trunk line. Each of the proposed lines is briefly summarized:

- The 6-inch-diameter trunk line is designed to initially carry up to 3,500 BPD, with a maximum design flow rate of 8,000 BPD;
- The 4-inch-diameter lateral pipelines also are designed to initially carry up to 2,700 BPD, with a maximum design flow rate of 4,500 BPD; and

- The 3-inch-diameter lateral pipelines also are designed to initially carry up to 1,370 BPD, with a maximum design flow rate of 3,000 BPD.

Produced water is not regulated as a hazardous liquid as specified in 49 CFR Part 195. However, pipeline design, construction, and operation would be in compliance with applicable federal and relevant industry standards as indicated above.

The proposed route would extend from multiple receipt well points in Dunn and McKenzie counties, North Dakota. An overview of the proposed route is presented in **Figure 1-1**. The Project would consist of the following pipeline assets and associated receipt points:

- Approximately 68 miles of 3- to 8-inch-diameter welded steel pipeline (i.e., the crude oil gathering pipeline system);
- Approximately 0.5 mile of 8-inch-diameter welded steel pipeline (i.e., the crude oil delivery lateral pipeline; Line AR-16) that will extend from the storage/transfer facility and terminate at an interconnect with a third-party outlet pipeline (i.e., the BakkenLink Pipeline);
- Approximately 58.8 miles of 3- to 6-inch-diameter composite pipeline (i.e., the produced water gathering pipeline system);
- A storage/transfer facility, which will entail a fenced and graveled, approximately 40-acre site that will house:
  - an office building;
  - a shop/warehouse building;
  - an operations building containing control room, motor control center, and process equipment;
  - a heater/generator building;
  - two, 20,000 barrel crude oil storage tanks;
  - two, 500 barrel slop oil tanks;
  - two, 500 barrel tanks for storage of tank bottom water;
  - one, 10,000 barrel fire safety water storage tank;
  - metering facilities for the measurement of incoming and outgoing crude oil;
  - a pig receiver and associated filter/separators for the crude oil gathering pipeline;
  - a pig launcher and three, approximately 50-horsepower (hp) electric pumps for the crude oil delivery lateral;
  - block valves for all pipelines; and
  - yard piping;
- A pig receiver assembly at the terminus of the crude oil delivery lateral pipeline (Line AR-16), which will be sited and constructed on a lot owned and developed by the third-party outlet pipeline);
- Automated wellhead facilities at each of the 31 well pad sites to be serviced by the Project, with each wellhead facility typically including:
  - a LACT unit, which consists of oil measurement/metering and an electric, 100-hp pump (with provision for the addition of a future booster pump if system hydraulics and pressures dictate);

  - produced water measurement/metering and a 25-hp electric pump (with provision for the addition of a future booster pump if system hydraulics and pressures dictate);
  - pig launchers for both the crude oil and produced water gathering pipelines;
  - block valves for each pipeline; and
  - yard piping;
- Two pig launcher and receiver sites, which will each entail a fenced and graveled, approximately 1.0-acre lot that will house:
  - pig launchers/receivers for the crude oil and produced water gathering pipelines;
  - automated block valves for the crude oil and produced water gathering pipelines;
- Thirty five lateral pipeline interconnect sites at each of the gathering pipeline lateral interconnects, with each site being either fenced or barred, and including:
  - pig launchers/receivers for the crude oil and produced water gathering pipelines;
  - block and check valves for the crude oil and produced water gathering pipelines;
- Intermediate block valve sites, with each fenced and graveled site measuring approximately 50- by 50-feet to 100- by 100-feet and including automated block valves for the crude oil and produced water gathering pipelines; and
- Associated ancillary facilities (e.g., cathodic protection test leads and ground beds, pipeline markers, etc.).

Key project design parameters are identified in **Table 3-1**. The proposed pipeline is designed for a maximum temperature rating of 120 degrees Fahrenheit (°F) and a maximum operating pressure (MOP) of less than 1,440 pounds per square inch gauge (psig). The project typically would operate at 60°F to 80°F and at or below 700 psig.

Surface facilities would include pipeline markers, pig launchers and receivers, cathodic protection rectifiers, and block valves. Facilities at existing well sites would include LACT units, pumps, valves and piping. No pumping stations would be built as part of the project. The pressure provided by pumps at well sites would be adequate for operation of the pipeline at the current projected flow rates.

3.1 Pipeline

The trunk line and associated lateral pipelines would be buried underground except within valve sites and surface facilities. Key design parameters for the proposed crude oil pipeline are summarized in **Table 3-1**.

Table 3-1 Project Design Parameters: Crude Oil Pipeline

Parameter	Value
Pipe Specifications	3-, 4-, 6-, and 8.-inch nominal diameter steel (API 5L, PSL2, GRD X42-X-52)
Coating	Fusion bond epoxy (FBE) coating (or other coating technique)
Maximum Operating Pressure	Less than 1,440 psig
Depth of Cover	Generally 6.5 feet (minimum 3 feet) of cover specified in 49 CFR 195.248
Aboveground versus Belowground Piping	Pipe will be belowground except within valve sites and facilities

Table 3-1 Project Design Parameters: Crude Oil Pipeline

Parameter	Value
Pipe Wall Thickness (WT)	8.625-inch pipe (OD): 0.322-inch WT 6.625-inch pipe (OD): 0.280-inch WT 4.500-inch pipe (OD): 0.237-inch WT 3.500-inch pipe (OD): 0.216-inch WT Or as calculated in accordance with ASME B31.4 (if greater than shown above)
Intermediate Valves	Number and location to be determined, but will meet or exceed federal requirements (49 CFR 195.260)
Leak Prevention Program	Multiple overlapping and redundant systems, including: • FBE or other protective pipeline coating; • Overpressure protection • Cathodic protection; • Non-destructive testing of the girth welds per 49 CFR 195.234; • Hydrostatic testing to 125 percent of the MOP (49 CFR 195 Subpart E); • Periodic in-line inspection; • Depth of cover meeting or exceeding federal standards; • Periodic aerial surveillance in accordance with federal requirements; • Supervisory Control and Data Acquisition (SCADA) system; and • Operations Control Center (OCC) providing continuous monitoring of the pipeline, 24 hours a day, every day of the year.
Leak Detection Systems	• Remote Monitoring with SCADA; • Computational pipeline monitoring (CPM) per 49 CFR 195.444.
Direct Observation Surveillance Frequency	• Aerial surveillance: 26 times per year, not to exceed 3 weeks intervals

The proposed produced water trunk line and associated lateral pipelines would be buried underground except within valve sites and surface facilities. Key design parameters for the proposed produced water pipeline are summarized in **Table 3-2**.

Table 3-2 Project Design Parameters: Produced Water Pipeline

Parameter	Value
Pipe Specifications	3 -, 4 -, and 7 -inch nominal diameter FlexSteel (1,500 psi rating)
Maximum Operating Pressure	Less than 1,440 psig
Depth of Cover	Generally 6.5 feet (minimum 3 feet) of cover
Aboveground versus Belowground Piping	Pipe will be belowground except within valve sites and facilities

Table 3-2 Project Design Parameters: Produced Water Pipeline

Parameter	Value
Pipe Wall Thickness	7.083-inch pipe (OD): 0.740-inch WT 4.680-inch pipe (OD): 0.506-inch WT 3.682-inch pipe (OD): 0.431-inch WT
Intermediate Valves	Number and location to be determined
Leak Prevention Program	Multiple overlapping and redundant systems, including: • Non-destructive testing of the swages • Overpressure protection • Hydrostatic testing to 125 percent of the MOP • Depth of cover meeting or exceeding federal standards; • Periodic aerial surveillance in accordance with federal requirements; • SCADA system; and • OCC providing continuous monitoring of the pipeline, 24 hours a day, every day of the year.
Leak Detection Systems	• Remote Monitoring with SCADA; and • Software based volume balance systems.
Direct Observation Surveillance Frequency	• Aerial surveillance: 26 times per year, not to exceed 3 weeks intervals

3.2 Mainline Valve Assemblies

Mainline valve assemblies would be spaced along the pipeline to meet the requirements of 49 CFR 195.258 and 195.260. A study to identify locations of high consequence areas has been conducted to determine appropriate placement of the valves to minimize potential environmental impacts.

4.0 Incident Frequency-Spill Volume Estimation

4.1 PHMSA Baseline Incident Frequencies

Because the project has not yet been constructed, it does not have an operational history from which to derive incident frequency rates. Consequently, a conservative approach was taken by first determining the baseline incident frequencies from industry data (i.e., USDOT – PHMSA data).

Baseline incident frequencies are derived from historical national pipeline incident data (PHMSA 2010). Because the majority of pipelines in the U.S. were constructed in the "pre-modern" era (i.e., the 1970s or earlier), these baseline frequencies reflect incident rates associated with earlier pipeline design and construction methods that often do not meet the current regulatory requirements or best management practices. Further, these historical data do not account for supplemental protective measures that CenterPoint would implement.

The baseline incident frequencies identified in **Table 4-1** were generated from the PHMSA incident database (PHMSA 2010) and are expressed as per mile of pipeline per year (i.e., /mile-year).

Table 4-1 Baseline Incident Frequencies[1]

Threat Name	Incident Frequency/mile-year [2]	Occurrence Interval (years[3])
Corrosion	2.90E-04	3,400
Excavation damage	1.22E-04	8,200
Materials and Construction	3.00E-04	3,300
Hydraulic Event	1.47E-04	6,800
Ground movement	1.23E-05	81,500
Washout and flooding	1.14E-05	87,800

[1] Baseline statistics based on PHMSA hazardous liquid incident database (2010), excluding offshore and terminal data.

[2] Incident frequencies are expressed in scientific notation. A value of 2.90E-04 incidents/mile-year is equivalent to 0.00029 incident/mile-year, which is approximately equivalent to one incident every 3,400 years.

[3] Occurrence frequency is the inverse of the incident frequency (i.e., years between events per mile of pipeline) similar in concept to flood frequencies (e.g., 100-year flood event).

The overall incident frequency was calculated by summing the likelihood of each individual root cause.

$$f_{total} = f_{co} + f_{ex} + f_{md} + f_{hy} + f_{gm} + f_{wo}$$

Where:

f_{total} = total leak frequency

f_{co} = leak frequency from corrosion

f_{ex} = leak frequency from excavation

f_{md} = leak frequency from material defects or construction deficiency

f_{hy} = leak frequency from a hydraulic event

f_{hy} = leak frequency from ground movement

f_{wo} = leak frequency from washout event

While future events cannot be known with absolute certainty, historic incident frequencies can be used to estimate the number of events that might occur over a period of time. The resultant incident frequency is 8.83E-04 (or 0.000883) incidents/mile-year, equivalent to one incident in 1,100 years per mile of pipe[1]. Based on this spill frequency and a total of 129 miles of pipeline, which conservatively considers both the crude oil pipeline and associated produced water pipeline mileage, this analysis estimates that there could be 1.1 spills during a 10-year period.

This spill frequency does not account for project- and site-specific conditions, including improved technologies and practices that are used on a newly constructed pipeline and are not currently reflected in the historical PHMSA incident frequency data. Consequently, the spill frequency is considered extremely conservative and over-estimates the probability of a spill.

PHMSA data show that the number of spills on crude oil pipelines has substantially declined in recent years with the implementation of USDOT's Integrity Management Rule. Moreover, federal pipeline safety standards continue to evolve, and operators are required to comply with these standards. Implementation of current industry standards and compliance with federal regulatory standards ensures that the likelihood of spills to occur would be very small, and that the volume released, in the unlikely event of a spill, would be very small. For these reasons, it is expected that the actual number of incidents would be substantially lower than those estimated in this analysis.

4.2 Spill Volume

Examination of the current PHMSA dataset (2002 to 2009) [2] indicates that the majority of actual pipeline spills are relatively small. Fifty three percent of the spills consist of 3.0 barrel or less. In 85 percent of the cases, the spill volume was 100 barrels or less. In over 95 percent of the incidents, spill volumes were less than 1,000 barrels. Oil spills of 10,000 barrels or larger occurred in 0.34 percent of cases. These data demonstrate that most pipeline spills are small and larger releases of 10,000 barrels or more are extremely uncommon. **Table 4-2** illustrates the frequencies that oil spills of different volumes are predicted to occur over a 10-year interval and is based on the mileage of pipeline, baseline incident frequency and percent occurrence for each given spill volume.

Table 4-2 Calculated Spill Occurrence Interval Associated with the Project over 10 Years Breakdown by Volume

	Conservative Number of Spills per 10 years
Spill volume 3 barrels or less	0.60
Spill volume between 3 barrels and 50 barrels	0.32
Spill volume between 50 barrels and 100 barrels	0.05
Spill volume between 100 barrels and 1,000 barrels	0.11
Spill volume between 1,000 barrels and 10,000 barrels	0.05
Spill volume greater than 10,000 barrels	0.004
Total Spills	1.1

[1] This value is an estimate based on historical statistics; actual values may differ from these estimates.
[2] Incidents associated with offshore facilities and refining facilities were excluded from the analysis.

5.0 Consequences of a Spill

5.1 Human Consequences

The risk associated with the operation of the project can be compared with the general risks encountered in everyday life. The National Center for Health Statistics (Center for Disease Control, CDC 2003) overall average annual death rate for the general population in the U.S. is approximately 830 per 100,000. The USDOT reports the historical average risk to the general population per year associated with all hazardous liquids transmission pipelines is 0.004 in 100,000 (USDOT 2002). Therefore, the predicted risk of fatality to the public from incidents associated with the project over and above the normal U.S. death rate is very small.

5.2 Environmental Consequences

The environmental risk posed by a crude oil pipeline is a function of: 1) the probability of an accidental release; 2) the probability of a release reaching an environmental receptor (e.g., waterbody, fish); 3) the concentration of the contamination once it reaches the receptor; and 4) the hazard posed by that concentration of crude oil to the receptor. Based on spill probabilities and estimated spill volumes, this RA determines the probability of exposure to environmental receptors and the probable impacts based on a range of potential concentrations.

5.2.1 Crude Oil Composition

The composition of crude oil varies widely, depending on the source and processing. Crude oils are complex mixtures of hundreds of organic (and a few inorganic) compounds. These compounds differ in their solubility, toxicity, persistence, and other properties that profoundly affect their impact on the environment. The effects of a specific crude oil cannot be thoroughly understood without taking its composition into account.

The system would transport light sweet crude, derived from production in the middle Bakken and upper Three Forks formations (Bakken). Representative chemical assay data are presented in **Table 5-1**. The primary classes of compounds found in crude oil are alkanes (hydrocarbon chains), cycloalkanes (hydrocarbons containing saturated carbon rings), and aromatics (hydrocarbons with unsaturated carbon rings). 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., cyclyohexane); aromatics (e.g., benzene, toluene); cycloalkanes; 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 pose the most potential for environmental concern. PAHs are persistent in the environment and can cause adverse impacts. However, they do not bioaccumulate (increasing concentration within food chains) and are not highly water soluble. Studies of 69 crude oils found that benzene was the only aromatic (or PAH) compound tested that is capable of exceeding groundwater protection values for drinking water (i.e., maximum contaminant levels [MCLs] or Water Health Based Limits) (Kerr et al. 1999 as cited in O'Reilly et al. 2001). Lightweight (single aromatic ring) aromatics (i.e., benzene, toluene, ethyl benzene, xylene compounds) tend to be highly water soluble because of their lower molecular weight, while also having low toxicity thresholds.

5.2.2 Environmental Fate and Transport

Overall, the environmental fate of crude oil is controlled by many factors and persistence is difficult to predict with great accuracy. The speed and efficiency of emergency response containment and cleanup largely dictates the fate and extent of transport within the environment. This section, however, discusses environmental fate and transport of crude oil, without accounting for the benefits of emergency response.

Major factors affecting the environmental fate include spill volume, type of crude oil, dispersal rate of the crude oil, terrain, receiving media, and weather. Once released, the physical environment largely dictates the environmental persistence of the spilled material. Fate and transport of released crude oil are discussed by medium, and the primary degradation processes associated with each medium.

Table 5-1 Composition of Representative Bakken Crude Oil

Constituent	Chemical Notation	Median (% by weight)	Range	
			Low (% by weight)	High (% by weight)
Nitrogen	N2	0.0420	0.012	0.116
Methane	C1	0.9270	0.182	1.696
Carbon dioxide	CO_2	0.0200	0.000	0.063
Ethane	C2	2.5810	1.786	3.218
Propane	C3	5.4390	4.736	6.400
Iso-butane	i-C4	1.3300	1.107	1.457
N-butane	n-C4	6.2020	5.267	6.795
Iso-pentane	i-C5	2.2980	2.114	2.499
N-pentane	n-C5	4.1430	3.532	4.704
Iso-hexane	i-C6	2.1630	0.687	2.579
N-hexane	n-C6	2.2540	1.402	3.157
123-triethyl	123-triethyl	0.1150	0.100	0.162
Benzene	Benzene	0.2820	0.162	0.425
Heptanes	C7	9.9960	8.470	11.364
Toluene	Toluene	0.9210	0.651	1.593
Octanes	C8	8.8920	8.411	10.405
Ethyl benzene	Ethyl benzene	0.3250	0.289	0.441
Xylenes	m-, o-, p-xylenes	1.4030	1.239	2.110
Nonanes	C9	3.7090	3.646	5.472
Decanes plus	C10 +	46.6760	40.214	49.884
API Gravity		42.1020	40.939	44.520

Source: Marathon Oil 2010.

5.2.2.1 Soils

Overview

If released in soil at pipeline depth, the released oil can volatilize, sorb to soil particles, constituents can dissolve into the groundwater, or remain in residual form (Spence et al. 2001). The movement of crude oil and the physical and chemical transformations of its constituents are influenced by a variety of factors and processes discussed below.

- Physical Factors. The movement of crude oil across the soil surface is governed by slope, soil permeability, and, to a lesser extent, ambient temperature. Spreading across environmental surfaces reduces the bulk quantity of crude oil present in the immediate vicinity of the spill but increases the spatial area within which adverse effects may occur. Spreading and thinning of spilled crude oil in soils or water also increases the surface area of the slick, thus enhancing surface dependent fate processes such as evaporation, degradation, and dissolution.
- Evaporation. The majority of the volatile hydrocarbon fractions will evaporate quickly from pooled oil on the soil surface. Crude oil that has dispersed downward in the soil profile will evaporate more slowly because there is less oil surface area exposed to the air, and due to the presence of other binding forces (see sorption below). The rates of evaporation are primarily controlled by soil porosity, and soil temperature.
- Sorption. Crude oil dispersed in soil will bind (adhere) to soil particles. Crude oil will usually bind most strongly with soil particles in organic soils; crude oil will usually bind less strongly with soil particles in sandy soils.
- Photodegradation. Photodegradation (breakdown of hydrocarbon molecules under exposure to sunlight) is an important process for soils directly exposed to sunlight at the soil surface. Crude oil that has penetrated deeper into the soil profile is not affected by this process.
- Biodegradation. With time, soil microorganisms capable of consuming crude oil generally increase in number and the biodegradation process naturally remediates the previously contaminated soil. The biodegradation process is enhanced as the surface area of spilled oil increases (e.g., by dispersion or spreading). Biodegradation has been shown to be an effective method of remediating soils and sediments contaminated by crude oil.

5.2.2.2 Water

Overview

If released into water, crude oil will float to the water's surface[3]. If crude oil is left on the water's surface over an extended period of time, some constituents within the oil will evaporate, other fractions will dissolve, and, eventually, some material may descend to the bottom as sedimentation. The following is a summary of the major processes that occur during crude oil dispersion and degradation.

- Physical Factors. Crude oil mobility in water increases with wind, stream velocity, and increasing temperature. Most crude oils move across surface waters at a rate of 100 to 300 meters per hour. Surface ice will greatly reduce the spreading rate of oil across a waterbody. Crude oil in flowing, as opposed to contained, waterbodies may cause transitory impacts. Although reduced in intensity, a crude oil spill into flowing waters tends to move over a much larger area.
- Dissolution. Dissolution of crude oil in water is not a significant process 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 their constituents because solubility is limited to the partitioning between oil and water interface and individual compounds are often more soluble in oil than in water; thus, they tend to remain in the oil. Nevertheless, 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.

[3] The API Gravity of a representative Bakken crude oil is 42.1. An API Gravity of 10 or more indicates that the oil would float on water. Thus, light crude oils from the Bakken Formation would float on the water's surface.

- Sorption. In water, heavy molecular weight hydrocarbons will bind to suspended particulates and this process can be significant in highly turbid or eutrophic waters. Organic particles (e.g., biogenic material) in soils or suspended in water tend to be more effective at sorbing oils 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. However, these processes also render hydrocarbons less susceptible to degradation. Sedimented oil tends to be highly persistent and can 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, 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 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 slick, increased temperature, and increased wind and wave action.
- Photodegradation. Photodegradation of crude oil in aquatic systems increases with greater solar intensity. It can be a significant factor controlling the reduction of a slick, especially of lighter oil constituents, but it will be less important during cloudy days and winter months. Photodegraded crude oil constituents can be more soluble and more toxic than parent compounds. Extensive photodegradation, like dissolution, may thus increase the biological impacts of a spill event.
- Biodegradation. In the immediate aftermath of a crude oil spill, natural biodegradation of crude oil will 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 can 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 precluded in nutrient-poor aquatic systems. It also may deplete oxygen reserves in closed waterbodies, causing adverse secondary effects to aquatic organisms.

5.2.3 Environmental Impacts

An evaluation of the potential impacts resulting from the accidental release of crude oil into the environment is discussed by environmental resource below.

5.2.3.1 Soils

Because pipelines are buried, soil absorption of spilled crude oil could occur, thus impacting the soils. Subsurface releases to soil tend to disperse slowly and are generally located within a contiguous and discrete area, often limited to the less consolidated soils (lower soil bulk density) within the pipeline trench. Effects to soils can be quite slow to develop, allowing time for emergency response and cleanup actions to mitigate effects to potential receptors.

In the event of a spill, a portion of the released materials would enter the surrounding soil and disperse both vertically and horizontally in the soil. The extent of dispersal would depend on a number of factors, including speed and success of emergency containment and cleanup, size and rate of release, topography of the release site, vegetative cover, soil moisture, bulk density, and soil porosity. High rates of release from the buried pipeline would result in a greater likelihood that released materials would escape the trench and reach the ground surface.

If a release were to occur in sandy soils encountered along the project route, it is likely that the horizontal and vertical extent of the contamination would be greater than in areas containing more organic soils. Crude oil released into sandy soils would likely become visible to aerial surveillance due to product on the soils surface or discoloration of nearby vegetation, which will facilitate emergency response and soil

remediation efforts. If present, soil moisture and moisture from precipitation would increase the dispersion and migration of crude oil.

The majority of the project alignment is located in relatively flat or moderately rolling terrain. In these areas, the oil would generally begin dispersing horizontally within the pipeline trench, and with sufficient spill volume or flow, the oil could move out of the trench onto the soils surface, generally moving toward low lying areas. If the spill were to occur on a steep slope where trench breakers had been installed during construction, then crude oil would pool primarily within the trench behind any trench breakers. If sufficient volume existed, the crude oil would breach the soil's surface as it extended over the top of the trench breaker. In either case, once on the soil's surface, the release would be more apparent to leak surveillance patrols, facilitating emergency response and remediation.

Both on the surface and in the subsurface, rapid attenuation of light, volatile constituents (due to evaporation) would quickly reduce the total volume of crude oil, while heavier constituents would be more persistent. Except in rare cases of high rate and high total volume releases with environmental settings characterized by steep topography or karst terrain, soil impacts would be confined to a relatively small, contiguous, and easily defined area, facilitating cleanup and remediation. Within a relatively short time, lateral migration would generally stabilize. Downward vertical migration would begin at the onset of a spill, with rates governed by soil permeability. For example, in soils with moderately high permeability, water may penetrate 2.5 inches per hour, while penetration rates for soils of low permeability may occur at 0.05 inch per hour. Crude oil is more viscous than water; therefore, permeability of crude oil would be slower. Modeling indicates that the penetration of crude oils into soils, even sandy soils, is limited in the vadose zone to a few feet.

In accordance with federal and state regulations, CEBCS would be responsible for cleanup of contaminated soils and would be required to meet applicable cleanup levels. In North Dakota, soil cleanup levels are determined from a risk-based analysis, designed to protect human health and the environment. Benchmark soil cleanup levels from petroleum hydrocarbon releases is 100 parts per million [ppm] of total petroleum hydrocarbons (North Dakota Department of Health 2006). This benchmark would serve as a point of departure to develop site-specific risk-based action or cleanup levels in the event of a spill. Once remedial cleanup levels were achieved in soil, no adverse or long-term impacts would be expected.

It is difficult to precisely 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, affect the final volume of affected soil to be remediated. Based on historical data (PHMSA 2008), 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 2008).

5.2.3.2 Vegetation and Soil Ecosystems

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 U.S. Environmental Protection Agency (USEPA) ECOTOX database (USEPA 2001) is 18.2 ppm for benzene, which is higher than the 7.4 ppm threshold for aquatic species and the 0.005 ppm threshold for human drinking water. Similarly, available data from the USEPA database indicate that earthworms also are less sensitive than aquatic species (toxicity threshold was greater than 1,000 ppm). If concentrations were sufficiently high, however, crude oil in the root zone could harm respiration and nutrient uptake by individual plants and organisms.

While a release of crude oil could result in the contamination of soils (see Section 5.2.3.1, Soils), CEBCS would be responsible for cleanup of contaminated soils. Once remedial cleanup levels were achieved in the soils, no adverse or long-term impacts to vegetation would be expected.

5.2.3.3 Wildlife

Spilled crude oil can affect organisms directly and indirectly. Direct effects include physical processes, such as oiling of feathers and fur, and toxicological effects, which can 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.

Wildlife, especially birds and shoreline mammals, are typically among the most visibly affected organisms in any crude oil spill. Effects of crude oil can 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).

Crude oil released to the environment may cause adverse biological effects on birds and mammals 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.

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 attenuates 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 and their bioavailability is low; therefore, the potential for impacts is low.

Unlike aquatic organisms that frequently cannot avoid spills in their habitats, the behavioral responses of terrestrial wildlife may help reduce potential adverse effects. Many birds and mammals are mobile and generally will avoid oil-impacted areas and contaminated food (Sharp 1990; Stubblefield et al. 1995). In a few cases, such as cave-dwelling species, organisms that are obligate users of contaminated habitat may be exposed. However, most terrestrial species have alternative (unimpacted) habitat resources available, as will 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).

Indirect environmental effects of spills can include reduction of suitable habitat or food supply. Primary producers (e.g., algae and plants) may experience an initial decrease in primary productivity due to physical effects and acute toxicity of the spill. However, these effects tend to be short-lived and a decreased food supply is not considered to be a major chronic stressor to herbivorous organisms after a spill. If mortality occurs to local invertebrate and wildlife populations, the ability of the population to recover will depend upon the size of the impact area and the ability of surrounding populations to repopulate the area.

5.2.3.4 Water Resources

Crude oil could be released to water resources if the pipeline is breached or leaks occur. Federal regulations (49 CFR 195.260) require block valves to be placed strategically along the project route to help reduce the amount of crude oil that could potentially spill into sensitive areas, such as water bodies. Spill containment measures and implementing actions would be identified in the project Emergency Response Plan (ERP), as required by federal regulation, and would help mitigate adverse effects to both surface water and groundwater.

<u>Groundwater</u>

Groundwater aquifers underlie the proposed project. Vulnerability of these aquifers is a function of the depth to groundwater and the permeability of the overlying soils. While routine operation of the project

would not affect groundwater, there is the possibility that a release could migrate through the overlying surface materials and enter a groundwater system.

In general, the potential for groundwater contamination following a spill would be more probable in locations where a release into or on the surface of soils has occurred:

- 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 throughout the unsaturated zone; and
- Where, in cooperation with federal and state agencies, the PHMSA (in cooperation with the U.S. Geological Survey [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 (see Section 5.3).

Depending on soil properties, the depth to groundwater, and the amount of crude oil in the unsaturated zone, localized groundwater contamination can result from the presence of free crude oil and the migration of its dissolved constituents. Crude oil is less dense than water and would tend to form a floating pool after reaching the groundwater surface. Movement of crude oil is generally quite limited due to adherence with soil particles, groundwater flow rates, and natural attenuation (i.e., microbial degradation) (Fetter 1993; Freeze and Cherry 1979). Those compounds in the crude oil that are soluble in water will form a larger, dissolved “plume.” This plume would tend to migrate laterally in the direction of groundwater flow. Movement of dissolved constituents typically extends for greater distances than movement of pure crude oil in the subsurface, but is still relatively limited. The flow velocity of dissolved constituents would be a function of the groundwater flow rate and natural attenuation, with the dissolved constituents migrating more slowly than groundwater.

Unlike chemicals with high environmental persistence (e.g., trichloroethylene, pesticides), the areal extent of the dissolved constituents will stabilize over time due to natural attenuation processes. Natural biodegradation through metabolism by naturally occurring microorganisms is often an effective mechanism for reducing the volume of crude oil and its constituents. Natural attenuation will reduce most toxic compounds into non-toxic metabolic byproducts, typically carbon dioxide and water (Minnesota Pollution Control Agency 2005). Field investigations of more than 600 historical petroleum hydrocarbon release sites indicate the migration of dissolved constituents typically stabilize within several hundred feet of the crude oil source area (Newell and Conner 1998; USGS 1998; Ruiz-Aguilar et al. 2003; Shih et al. 2004; Kamath et al., in press). Over a longer period, the area of the contaminant plume may begin to reduce due to natural biodegradation. Removal of crude oil contamination will eliminate the source of dissolved constituents impacting the groundwater.

Most crude oil constituents are not very soluble in water. The dissolved concentration of water soluble compounds (e.g., benzene) is not controlled by the amount of oil in contact with the water, but by the concentration of the specific constituent in the oil (Charbeneau et al. 2000; Charbeneau 2003; Freeze and Cherry 1979). Studies of 69 crude oils found that benzene was the only aromatic or PAH compound tested that is capable of exceeding groundwater protection values for drinking water (i.e., MCLs or Water Health Based Limits) (Kerr et al. 1999 as cited in O’Reilly et al. 2001).

If exposure to humans or other important resources would be possible from a release into groundwater, regulatory standards, such as drinking water criteria (MCL) would mandate the scope of remedial actions, timeframe for remediation activities, and cleanup levels. Emergency response and remediation efforts; however, have the potential for appreciable adverse environmental effects from construction/cleanup equipment. For human health protection, the federal MCL is an enforceable standard established by the USEPA and is designed to protect long-term human health. The promulgated drinking water standards for humans vary by several orders of magnitude for crude oil constituents. Of the various crude oil constituents, benzene has the lowest federal MCL at 0.005 ppm as

cited per North Dakota Department of Health (2006); therefore, it was used to evaluate impacts on drinking water supplies, whether from surface water or groundwater.

If no active remediation activities were undertaken, natural biodegradation and attenuation would ultimately allow a return to preexisting conditions in both soil and groundwater. Depending on the amount of crude oil reaching the groundwater and natural attenuation rates, this would likely require up to tens of years. CEBCS would utilize the appropriate cleanup procedures as determined in cooperation with the applicable federal and state agencies.

Flowing Surface Waters

This report evaluated impacts to downstream drinking water sources by comparing projected surface water benzene concentrations with the federal MCL for benzene. Like other pipelines already in existence, the project will cross many perennial, intermittent, and ephemeral streams. Rather than evaluate the risk to each waterbody crossed by the project, this RA evaluated categories of streams, based on the magnitude of streamflow and stream width. **Table 5-2** summarizes the stream categories and identifies several representative streams within these categories associated with the project.

Table 5-2 Stream Categories

	Streamflow (cubic feet per second [cfs])	**Top of Bank Stream Width (feet)**	**Representative Streams**
Low Flow Stream	10 – 100	<50	Unnamed intermittent tributaries
Lower Moderate Flow Stream	100 – 1,000	50 – 500	Little Missouri River
Upper Moderate Flow Stream	1,000 – 10,000	500 – 1,000	Little Missouri River (peak flow)

The following extremely conservative assumptions were developed to over-estimate potential spill effects for planning purposes.

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

Under the actual conditions of a crude oil release, the spill and mixing events outlined by these assumptions are not expected to occur at the very high levels described.

A 1-hour release period for the entire spill volume was assumed in order to maximize the product concentration in water. The estimated benzene concentrations were then compared with the human health drinking water MCL for benzene (**Tables 5-3**). Based on these assumptions, results suggest that most spills that enter a waterbody could result in exceedence of the federal MCL for benzene. Although the assumptions used are highly conservative and, thus, 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 any potentially affected drinking water intakes could be closed to bypass river water containing crude oil.

In addition to evaluating a general-case spill to flowing water, the potential for impacts to any specific waterbody also were evaluated. To do this, the occurrence interval for a spill at any one representative stream within one of the four stream categories reflected in **Table 5-2** was calculated based on spill probabilities generated from the PHMSA database. To be conservative, a 500-foot buffer on both sides of each stream was added to the crossing widths identified in **Table 5-2**. The occurrence intervals shown

on **Table 5-3** indicate the chance of a spill occurring at any specific waterbody is very low. Conservative occurrence intervals for a spill at any representative stream within any of the stream categories ranged from about once every 6,000 years for an upper moderate-size waterbody to once every 114,000 years for a small waterbody, indicating that a release is less likely to occur in any single small waterbody than any single large waterbody. If any release did occur, it is likely that the total release volume of a spill likely would be 3 barrels or less based on PHMSA data for historical spill volumes.

In summary, while a release of crude oil directly into any given waterbody would likely cause an exceedence of drinking water standards under the conservative assumptions used in this analysis, the frequency of such an event would be very low. Nevertheless, streams and rivers with downstream drinking water intakes represent sensitive environmental resources and could be temporarily impacted by a crude oil release. CEBCS's ERP would contain provisions for protecting and mitigating potential impacts to drinking water.

Aquatic Organisms

The concentration of crude oil constituents in an actual spill would vary both temporally and spatially in surface water; however, localized toxicity could occur from virtually any size of crude oil spill. **Table 5-4** summarizes the acute toxicity values (USEPA 2000) of various crude oil hydrocarbons to a broad range of freshwater species. Acute toxicity refers to the death or complete immobility of an organism within a short period of exposure. The lethal concentration at which 50 percent of organisms die after 48 hours (LC_{50}) is the concentration of a compound necessary to cause 50 percent mortality in laboratory test organisms. For aquatic biota, most acute LC_{50} values for monoaromatics range between 10 and 100 ppm. LC_{50} values for the polyaromatic naphthalene were generally between 1 and 10 ppm, while LC_{50} values for anthracene were generally less than 1 ppm.

Table 5-4 shows fish are among the most sensitive aquatic biota, while aquatic invertebrates 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 or less sensitive than fish. Planktonic (floating) species tend to be more sensitive than most benthic insects, crustaceans, and molluscs.

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 has low solubility in water then its toxicity to aquatic biota is relatively low. The toxicity of crude oil is dependent of the toxicity of its constituents. As an example, **Table 5-5** 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. The relative toxicity (i.e., the potential toxicity attributed to a given constituent at its solubility limit) of decane is much lower than for benzene or ethylbenzene because of the comparatively low solubility of decane. Most investigators have concluded that the acute toxicity of crude oil is related to the concentrations of relatively lightweight aromatic constituents, particularly benzene.

Table 5-3 Comparison of Estimated Benzene Concentrations with the Benzene MCL Resulting from a Bakken Crude Oil Spill

Streamflow	Benzene MCL (ppm)	Stream Flow Rate (cfs)	Product Released							
			Very Small Spill: 3 barrels		Small Spill: 50 barrels		Moderate Spill: 1,000 barrels		Large Spill: 10,000 barrels	
			Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)
Low Flow Stream	0.005	10	**1.1**	**11,390**	**19.2**	**18,983**	**385**	**37,966**	**3854**	**113,897**
Lower Moderate Flow Stream	0.005	100	**0.11**	**7,973**	**1.9**	**13,288**	**38.5**	**26,576**	**385.4**	**79,728**
Upper Moderate Flow Stream	0.005	1,000	**0.011**	**5,980**	**0.19**	**9,966**	**3.9**	**19,932**	**38.5**	**59,796**

Notes:

- Historical data indicate that the most probable spill volume would be 3 barrels or less. However, this entire analysis is based on conservative incident frequencies and a range of spill volumes, to provide a range of the magnitude of potential effects for the NEPA analysis.
- Estimated concentration is based on release of benzene into water over a 1-hour period with uniform mixing conditions.
- Concentrations are based on a 0.28 percent by weight benzene content of the transported material (Marathon Oil data, website: http://www.ndoil.org/image/cache/Peacock_-_March_23_2010._ppt.pdf).
- Shading indicates estimated benzene concentrations exceeding the benzene MCL of 0.005 ppm.
- Occurrence intervals are based on an overall predicted incident frequency of 0.000883 incident/mile*year (Section 4.1), 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 higher flow streams and a corresponding lower occurrence interval.

Table 5-4 Acute Toxicity of Aromatic Hydrocarbons to Freshwater Organisms

Species	Toxicity Values (ppm)				
	Benzene	**Toluene**	**Xylenes**	**Naphthalene**	**Anthracene**
Carp (*Cyprinus carpio*)	40.4	---	780	---	---
Channel catfish (*Ictalurus* sp.)	---[1]	240	---	---	---
Clarias catfish (*Clarias* sp.)	425	26	---	---	---
Coho salmon (*Oncorhyncus kisutch*)	100	---	---	2.6	---
Fathead minnow *(Pimephales promelas*)	---	36	25	4.9	25
Goldfish (*Carassius auratus*)	34.4	23	24	---	---
Guppy (*Poecilia reticulate*)	56.8	41	---	---	---
Largemouth bass (*Micropterus*)	---	---	---	0.59	---
Medaka (*Oryzias* sp.)	82.3	54	---	---	---
Mosquito fish (*Gambusia affinis*)	---	1,200	---	150	---
Rainbow trout (*Oncorhyncus mykiss)*	7.4	8.9	8.2	3.4	---
Zebra fish (*Therapon iarbua*)	---	25	20	---	---
Rotifer *(Brachionus calyciflorus)*	>1,000	110	250	---	---
Midge *(Chironomus attenuatus)*	---	---	---	15	---
Midge *(Chironomus tentans)*	---	---	---	2.8	---
Zooplankton *(Daphnia magna)*	30	41	---	6.3	0.43
Zooplankton *(Daphnia pulex)*	111	---	---	9.2	---
Zooplankton *(Diaptomus forbesi)*	---	450	100	68	---
Amphipod *(Gammarus lacustris)*	---	---	0.35	---	---
Amphipod *(Gammarus minus)*	---	---	---	3.9	---
Snail *(Physa gyrina)*	---	---	---	5.0	---
Insect *(Somatochloa cingulata)*	---	---	---	1.0	---
Cyanobacteria *(Microcystis aeruginosa)*	---	---	---	0.85	---
Algae *(Chlorella vulgaris)*	---	230	---	25	---
Algae *(Nitzschia palea)*	---	---	---	2.8	---
Algae *(Scenedesmus subspicatus)*	---	130	---	---	---
Algae *(Selenastrum capricornutum)*	70	25	72	7.5	---

[1] Indicates no value was available in the database.

Note: 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 LC_{50} values was calculated.

Table 5-5 Acute Toxicity of Crude Oil Hydrocarbons to *Daphnia magna*

Compound	48-hr LC_{50} (ppm)	Optimum Solubility (ppm)	Relative Toxicity
Hexane	3.9	9.5	2.4
Octane	0.37	0.66	1.8
Decane	0.028	0.052	1.9
Cyclohexane	3.8	55	14.5
methyl cyclohexane	1.5	14	9.3
Benzene	9.2	1,800	195.6
Toluene	11.5	515	44.8
Ethylbenzene	2.1	152	72.4
p-xylene	8.5	185	21.8
m-xylene	9.6	162	16.9
o-xylene	3.2	175	54.7
1,2,4-trimethylbenzene	3.6	57	15.8
1,3,5-trimethylbenzene	6	97	16.2
Cumene	0.6	50	83.3
1,2,4,5-tetramethylbenzene	0.47	3.5	7.4
1-methylnaphthalene	1.4	28	20.0
2-methylnaphthalene	1.8	32	17.8
Biphenyl	3.1	21	6.8
Phenanthrene	1.2	6.6	5.5
Anthracene	3	5.9	2.0
9-methylanthracene	0.44	0.88	2.0
Pyrene	1.8	2.8	1.6

Note: The LC_{50} is the concentration of a compound necessary to cause 50 percent mortality in laboratory test organisms within a predetermined time period (i.e., 48 hours) (USEPA 2000).

Relative toxicity is expressed as the quotient of the optimum solubility to the 48-hour LC_{50} (optimum solubility/LC_{50}).

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 will volatilize to the atmosphere 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 in water, have limited bioavailability, which render 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).

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. For example, aromatics with four or more rings are not acutely toxic at their limits of solubility (Muller 1987). Based on the combination of toxicity, solubility, and bioavailability, benzene was determined to dominate toxicity associated with potential crude oil spills.

Table 5-6 summarizes chronic toxicity values (most frequently measured as reduced reproduction, growth, or weight) of benzene to freshwater biota. These concentrations represent water concentrations below which adverse effects are not expected following long-term (chronic) exposure. Chronic toxicity from other oil constituents may occur, however, if sufficient quantities of crude oil are continually released into the water to maintain elevated concentrations.

Table 5-6 Chronic Toxicity of Benzene to Freshwater Biota

Taxa	Test Species	Chronic Value (ppm)
Fish	Fathead minnow (*Pimephales promelas*)	17.2 *
	Guppy (*Poecilia reticulata*)	63
	Coho salmon (*Oncorhynchus kitsutch*)	1.4
Amphibian	Leopard frog (*Rana pipens*)	3.7
Invertebrate	Zooplankton (*Daphnia* spp.)	>98
Algae	Green algae (*Selenastrum capricornutum*)	4.8 *

Note: Test endpoint was mortality unless denoted with an asterisk (*). The test endpoint for these studies was growth.

The potential impacts to aquatic organisms of various-sized spills to waterbodies were 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 ppm and 1.4 ppm, respectively, based on standardized trout toxicity tests (USEPA 2000). These toxicity threshold values are considered protective of acute and chronic effects to aquatic biota. Although trout typically are not found in any of the habitats crossed by the project, trout are among the most sensitive aquatic species and reliable acute and chronic trout toxicity data are available. Using trout toxicity thresholds, therefore, provides a conservative benchmark to screen for the potential for toxicity.

Table 5-7 and **Table 5-8** summarize a screening-level assessment of the potential for acute and chronic toxicity to aquatic resources, respectively. 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, relatively small spills (less than 50 barrels) into moderate sized (and larger) 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.

The likelihood of a release into any single waterbody would be low, with a predicted occurrence interval of no more than once every 8,000 to 114,000 years (**Tables 5-7** and **5-8**). If any release did occur, it is likely that the total release volume of a spill would be 3 barrels or less based on historical spill volumes.

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.

Wetlands/Reservoirs/Lakes

Wetlands and waterbodies with persistently saturated soils are present along and adjacent to the proposed project route, especially in association with the Little Missouri River. 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. Wetlands include a wide range of environmental conditions. Wetlands can consist of many acres of standing water dissected with ponds and channels, or they may simply be areas of saturated soil with no open water. A single wetland can even vary between these two extremes as seasonal precipitation varies. Wetland surfaces are generally low gradient with very slow unidirectional flow or no discernable flow. The presence of vegetation or narrow spits of dry land protruding into wetlands also could isolate parts of the wetland. Given these conditions, spilled materials could remain in restricted areas for longer periods than in river environments.

Crude oil released from a subsurface pipe within a wetland could reach the soil surface. If the water table reaches 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 minimal, due to shallow (or emergent) groundwater conditions. Conversely, groundwater impacts within the wetland are likely to be confined to the near-surface, enhancing the potential for biodegradation. If humans or other important resource exposures were to occur in proximity to the wetland, then regulatory drivers would mandate the scope of remedial actions, timeframe for remediation activities, and cleanup levels. However, response and remediation efforts in a wetland have the potential for appreciable adverse effects from construction/cleanup equipment. If no active remediation activities were undertaken, 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, CEBCS would utilize appropriate cleanup procedures as determined in coordination with the applicable federal and state agencies.

The chance of a spill occurring at any specific wetland along the pipeline is very low. Based on survey data and aerial interpretation, wetlands comprise approximately 0.80 mile of the entire project route. Of the estimated 1.1 spills postulated to occur during a 10-year period within the entire pipeline system, about 0.007 spills would be expected to occur within wetland areas (equivalent to no more than one spill every 1,416 years). If any release did occur, it is likely that the total release volume of a spill likely would be 3 barrels or less based on historical spill volumes (Section 4.2).

Table 5-7 Comparison of Estimated Benzene Concentrations Following a Bakken Crude Oil Spill to the Acute Toxicity Thresholds for Aquatic Life (7.4 ppm) for Streams Crossed by the Project

Streamflow	Stream Flow Rate (cfs)	Acute Toxicity Threshold (ppm)	Product Released							
			Very Small Spill: 3 barrels		Small Spill: 50 barrels		Moderate Spill: 1,000 barrels		Large Spill: 10,000 barrels	
			Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)
Low Flow Stream	10	7.4	1.1	11,390	**19.3**	**18,983**	**385**	**37,966**	**3,854**	**113,897**
Lower Moderate Flow Stream	100	7.4	0.11	7,973	1.9	13,288	**38.5**	**26,576**	**385**	**79,728**
Upper Moderate Flow Stream	1,000	7.4	0.011	5,980	0.2	9,966	3.9	19,932	**38.5**	**59,796**

Notes:

- Historical data indicate that the most probable spill volume would be 3 barrels or less. However, this entire analysis is based on conservative incident frequencies and a range of spill volumes, to provide a range of the magnitude of potential effects for the NEPA analysis.
- Estimated proportion of benzene in the transported material is 0.28 percent (Marathon Oil data, website: http://www.ndoil.org/image/cache/Peacock_-_March_23_2010._ppt.pdf), and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.28 percent of the total amount of material released divided by 1 hour of stream flow volume. The model assumes uniform mixing conditions.
- Benzene concentrations are compared against the acute toxicity threshold protective of aquatic organisms for benzene.
- Shading indicates concentrations that could potentially cause acute toxicity to aquatic species. The darkest shading represents high probability of acute toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of acute toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of acute toxicity (<toxicity threshold).
- Occurrence intervals are based on an overall predicted incident frequency of 0.000883 incident/mile*year (Section 4.1), 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 higher flow streams and a corresponding lower occurrence interval.

Table 5-8 Comparison of Estimated Benzene Concentrations Following a Bakken Crude Oil Spill to the Chronic Toxicity Threshold for Aquatic Life (1.4 ppm) for Streams Crossed by the Project

Streamflow	Stream Flow Rate (cfs)	Chronic Toxicity Threshold (ppm)	Product Released							
			Very Small Spill: 3 barrels		Small Spill: 50 barrels		Moderate Spill: 1,000 barrels		Large Spill: 10,000 barrels	
			Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)
Low Flow Stream	10	1.4	0.006	11,390	0.10	18,983	**2.0**	**37,966**	**20.3**	**113,897**
Lower Moderate Flow Stream	100	1.4	0.0006	7,973	0.010	13,288	0.20	26,576	**2.0**	**79,728**
Upper Moderate Flow Stream	1,000	1.4	0.00006	5,980	0.0010	9,966	0.020	19,932	0.2	**59,796**

Notes:

- Historical data indicate that the most probable spill volume would be 3 barrels or less. However, this entire analysis is based on conservative incident frequencies and a range of spill volumes, to provide a range of the magnitude of potential effects for the NEPA analysis.
- Estimated proportion of benzene in the transported material is 0.28 percent (Marathon Oil, website: http://www.ndoil.org/image/cache/Peacock_-_March_23_2010._ppt.pdf), and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.28 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 trout.
- Exposure concentrations were estimated over a 7-day period because 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 overall predicted incident frequency of 0.000883 incident/mile*year (Section 4.1), 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 higher flow streams and a corresponding lower occurrence interval.

Based on a review of publicly available toxicity literature for wetland plant groups (i.e., algae, annual macrophytes, and perennial macrophytes), crude oil is toxic to aquatic plants but at higher concentrations than observed for fish and invertebrates. Therefore, spill concentrations that are less than toxic effect levels for fish and invertebrates (see Aquatic Organisms, above) also would not affect wetland plant species.

The predicted effects of a spill reaching standing water (e.g., reservoirs, lakes) would depend largely upon the volume of crude oil entering the waterbody and the volume of water within the waterbody. However, no standing water is crossed by the proposed pipeline route.

Table 5-9 summarizes the amount of water necessary to dilute spill volumes below aquatic toxicity and drinking water thresholds. While this preliminary approach does not account for fate and transport mechanisms, mixing zones, environmental factors, and emergency response capabilities, it does provide an initial screening benchmark for identifying areas of potential concern.

Table 5-9 Volume of Water Required to Dilute Benzene in Bakken Crude Oil Spills to Benchmark Values

Barrels of Crude Oil	Volume of Water Required to Dilute Benzene in Crude Oil to Benchmark (acre-feet)[1]		
	Acute Toxicity Threshold (7.4 milligrams per liter [mg/L])	Chronic Toxicity Threshold (1.4 mg/L)	Drinking Water MCL (0.005 mg/L)
3	0.13	0.7	191
50	2.2	11	3,186
1,000	43.1	228	63,718
10,000	431	2,276	637,177

[1] Benchmarks based on aquatic toxicity and drinking water thresholds established for benzene. The estimated benzene content of the Bakken crude oil is 0.28 percent by weight and has a specific gravity of 0.8765 g/ml.

As proposed, the pipeline would be installed across the Little Missouri River using the horizontal directional drilling (HDD) method. The HDD method would position the pipe tens of feet below the riverbed. This method would reduce threats to the pipe from outside forces and scouring, when compared to a trenched installation. In the unlikely event of a pipeline release, the increased depth of cover substantially reduces the chance of released oil from reaching the surface.

In summary, while a release of crude oil into flowing, wetland and static waterbodies has the potential to cause temporary environmental impacts, the frequency of such an event would be very low.

5.3 Produced Water and Analysis

Produced water is the water that accompanies produced oil. The origin of produced water includes naturally occurring formation water and/or water from injected fluids and additives from production and/or separation activity. The composition of produced water accompanying produced oil varies dependent on source geology and initial separation processing but typically includes a mixture of hydrocarbons, dissolved or suspended solids, produced solids (sand/silt) and injected fluids and trace additives that may have been introduced to the formation as a result of exploration and production. The five primary components of produced water include: oil (dispersed and soluble), salts, metals, production chemicals and radionuclides (OGP 2002).

Dissolved and dispersed organic constituents potentially present include volatile aromatic hydrocarbons (e.g., benzene and toluene), slightly soluble semi-volatile aromatic hydrocarbons (e.g., PAHs, such as

naphthalene and phenanthrene) and emulsified droplets of crude oil (OGP 2002). These components would be consistent with those described above for produced crude oil. However, the concentration of hydrocarbons associated with produced water would be expected to be considerably lower than those associated with crude oil alone. Any potential for adverse effects associated with the hydrocarbon component of produced water is addressed through evaluation of crude oil.

With the exception of salts (dissolved solids) that may adversely affect terrestrial and aquatic environments the remaining components of produced water are typically present in trace amounts and are of negligible concern. Salinity may be expressed in various ways including:

- Total Dissolved Solids (TDS). The sum of all dissolved components in water. For freshwater this quantity is typically expressed in units of milligrams per liter. This is the most direct and applicable measure of total salinity of water.

- Individual Ions. The salinity (TDS) of water is the sum of the specific dissolved constituents. The major ions that make up the bulk of salinity are typically sulfate, carbonate, bicarbonate, chloride, sodium, magnesium, potassium, and calcium.

Table 5-10 provides a summary of the cations and anions and other water quality parameters for representative produced water data obtained from CEBCS. As indicated, the TDS average concentration is 278,180 mg/L, which represents the sum of the measured cation and anions. For comparison, seawater contains about 35,000 mg/L dissolved salts. The chloride anion concentration dominates the composition of TDS and comprises 61 percent of the total salts present; sodium comprises 29 percent and calcium about 7 percent, indicating that chlorides of sodium and calcium are the dominant species in the produced water.

Table 5-10 Summary of Water Quality Data for Produced Water

Compound	Ion	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)
sodium	Cation	74,500	90,600	81,033
calcium	Cation	16,663	22,475	20,269
magnesium	Cation	587	2,194	1,279
iron	Cation	72	177	132.3
potassium	Cation	4,060	8,530	6,583
barium	Cation	16.7	26.2	21.1
chromium	Cation	0.4	0.4	0.4
strontium	Cation	0.2	2.5	1.35
Chloride	Anion	150,294	194,550	172,898
bicarbonate	Anion	ND	97.6	32.5
sulfate	Anion	414	979	658.8
nitrate	Anion	ND	0.3	0.2
specific gravity (g/g)	Other	1.17	1.20	1.18
resistivity (ohm-meters)	Other	0.044	0.245	0.113
total dissolved solids	Other	247,246	318,253	282,847
pH (s.u.)	Other	4.6	5.7	5.1
sodium chloride	Other	247,833	320,810	285,105

In the event of a produced water release, highly saline water would enter the soil surrounding the pipeline and be dispersed horizontally and vertically. The extent of dispersal would depend on a number of factors including speed and success of emergency containment and cleanup, size and rate of release, topography at the release site, vegetative cover, and soil conditions (e.g., moisture, soil type [bulk density and soil porosity]). High rates of release and/or predisposing soil conditions (e.g., high existing moisture content) would increase the likelihood of the release reaching the ground surface thereby potentiating overland migration.

High salts concentrations in soil may lead to increased rates of erosion by contributing to clay dispersion and ultimate loss of soil structure. In areas with low annual rainfall, excess salts may accumulate in soil and become encrusted on the ground surface, further reducing water infiltration rates and soil moisture. In contrast, areas with moderate to high rainfall would flush or leach salts vertically to groundwater, or if at the surface via overland flow towards surface water (Veil et al 2004). Excessive salts at the ground surface may therefore potentially adversely affect local shallow groundwater quality in areas of high infiltration rates.

Excessive salts may also detrimentally affect vegetation by increasing the osmotic pressure of the soil pore water and reducing hydraulic conductivity and water infiltration, ultimately reducing plants ability uptake of water and nutrients; creating a condition of drought stress even in the presence of water. High levels of salt in soil are also directly toxic to many plant species, and sodium and chloride ions in high concentration also have an adverse influence on microbial activity associated with the breakdown of organic matter and the release of nutrients in soil as reported by Vavrek and Vavrek (2008).

Should produced water reach the aquatic environment, produced water is fully miscible and would readily mix with surface water. A release or migration to a water body would result in an instantaneous increase in salinity to levels in excess of established freshwater water quality levels. For chlorides, the dominant ion, the maximum surface water limit for Class II streams (e.g., Little Missouri River) is 250 mg/L (NDAC Chapter 33-I 6-02). The initial concentration of chloride entering an aquatic system is well in excess of this limit and therefore water quality of the receiving stream would be temporarily impaired. Such impairment may possibly lead to localized and potentially lethal toxicity to aquatic organisms due to this “pulse” of highly saline water.

Table 5-11 summarizes a screening-level assessment of the potential for surface water impairment that may adversely affect (via acute toxicity) aquatic resources. As shown, the likelihood of a release into any single waterbody would be low, with a predicted occurrence interval of no more than once every 38,000 to 114,000 years. If any release did occur, it is likely that the total release volume of a spill would be 3 barrels or less based on historical spill volumes (i.e., for hazardous liquids). Chronic toxicity or impairment to aquatic organisms would not be expected as highly saline conditions would likely dissipate on the order of hours or days following cessation of the release. In fact, many aquatic species would adapt to higher saline conditions over time were such conditions to persist. Following a release, acute toxicity could potentially occur if substantial amounts of highly saline produced water 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 impaired. However, emergency response, containment, and cleanup efforts would help reduce the concentrations and minimize the potential for acute toxicity. For comparison, relatively small spills (less than or equal to 50 barrels) into small to moderately sized (and larger) 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 mixing rates are attenuated and concentrations would likely be higher than in the main channel of the river.

While a release of produced water 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 low. Nevertheless, streams and rivers with aquatic biota represent the sensitive environmental resources that could be temporarily impacted by a produced water release.

5.4 Frac-out Impacts and Analysis

Where CEBCS utilizes the HDD method of construction at water crossings, there is the potential for a "frac-out" (i.e., the inadvertent release of drilling fluids). The HDD method of crossing a waterbody involves drilling a pilot hole under the waterbody and its banks, then enlarging the hole through successive reamings until the hole is large enough to accommodate a prefabricated segment of pipe. Throughout the process of drilling and enlarging the hole, a slurry of drilling mud, consisting mainly of water and bentonite clay, would be circulated to power and lubricate the down-hole tools, remove drill cuttings, and hold the hole open. Pipe sections long enough to span the entire crossing would be staged and welded along the construction work area on the opposite side of the waterbody and then pulled through the drilled hole. Ideally, use of the HDD method results in no impact on the banks, bed, or water quality of the waterbody being crossed.

In the event of a frac-out, drilling muds would penetrate from the subsurface drill site and would spread over the land surface or river bottom. Impacts from drilling muds are attributable to the physical impacts caused by the gelatinous mud, rather than from any potential toxicological threat. On the land, drilling muds flow over the land's surface and pool in depressions within the terrain causing localized impacts to the affected area. In the aquatic environment, impacts typically consist of localized impacts to the benthic community due to the smothering and temporary increased turbidity within the waterbody. Most aquatic impacts would occur to low-mobility sediment dwelling organisms (e.g., snails, mollusks) and to any spawning areas covered by the drilling muds. In the Little Missouri River, where current is low to moderate, turbidity issues would be localized and temporary, and reduced by rapid detection, containment, and cleanup. Most pelagic (free-swimming) aquatic species are accustomed to moderate levels of turbidity and are capable of leaving the affected area until conditions return to normal.

Because drilling operators use different constituents within their drilling muds, it is not possible to conduct an *a priori* quantitative toxicological analysis. However, based on previous reviews, the components within the drilling muds are primarily non-toxic materials. The chemicals capable of potentially causing toxicological impacts are generally present in very small amounts, if any, and concentrations are generally insufficient to pose a toxicological threat. It is recommended that drilling fluid additives be limited to non-toxic compounds to the extent practicable.

Table 5-11 Comparison of Estimated Chloride Concentrations with the Chloride Maximum Limit Resulting from a Produced Water Spill

Streamflow	Chloride Maximum Limit (ppm)	Stream Flow Rate (cfs)	Product Released							
			Very Small Spill: 3 barrels		Small Spill: 50 barrels		Moderate Spill: 1,000 barrels		Large Spill: 10,000 barrels	
			Chloride Conc. (ppm)	Occurrence Interval (years)	Chloride Conc. (ppm)	Occurrence Interval (years)	Chloride Conc. (ppm)	Occurrence Interval (years)	Chloride Conc. (ppm)	Occurrence Interval (years)
Low Flow Stream	250	10	**80.9**	**11,390**	**1,348**	**18,983**	**26,965**	**37,966**	**269,653**	**113,897**
Lower Moderate Flow Stream	250	100	**8.1**	**7,973**	**134.8**	**13,288**	**2,697**	**26,576**	**26,965**	**79,728**
Upper Moderate Flow Stream	250	1,000	**0.81**	**5,980**	**13.5**	**9,966**	**269.7**	**19,932**	**2,697**	**59,796**
High Flow Stream	250	10,000	**0.081**	**3,417**	**1.35**	**5,695**	**26.9**	**11,390**	**269.7**	**34,169**

Notes:

- Historical data hazardous liquid pipelines indicate that the most probable spill volume would be 3 barrels or less. However, this entire analysis is based on conservative incident frequencies and a range of spill volumes, to provide a range of the magnitude of potential effects for the NEPA analysis.
- Estimated concentration is based on release of chloride into water over a 1-hour period with uniform mixing conditions.
- Concentrations are based on representative produced water ion data provided by CEBCS.
- Shading indicates estimated chloride concentrations exceeding the North Dakota Standards of Quality for Waters of the State, numeric maximum limit standard for Class II streams (NDAC Chapter 33-I 6-02).
- Occurrence intervals are based on an overall predicted incident frequency of 0.000883 incident/mile*year (Section 4.1), 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.

Because impacts to the environment can be minimized by the prompt detection, containment, and removal of the frac-out materials, a frac-out plan will be prepared in advance of drilling. The frac-out plan will summarize the responsibilities of the driller and procedures for detection, containment, and cleanup. The plan also will specify the types and amount of equipment (e.g., vacuum trucks) that will be on-site to contain and cleanup, in the event of a frac-out. Notification procedures, including contact names and phone numbers, will be incorporated into the plan. Proper preparation and implementation of a frac-out plan will minimize the duration and severity of a potential frac-out at river crossings.

5.5 Risk to Populated and High Consequence Areas

Consequences of inadvertent releases from pipelines can vary greatly, depending on where the release occurs. Pipeline safety regulations use the concept of HCAs to identify specific locales and areas where a release could have the most significant adverse consequences. HCAs include populated areas, designated zones around public drinking water intakes, and unusually sensitive ecologically resource areas[4] that could be damaged by a hazardous liquid pipeline release. **Table 5-12** identifies the types and lengths of HCAs crossed by the project. These HCA data are compiled from a variety of data sources, including federal and state agencies (e.g., state drinking water agencies, the USEPA). PHMSA acknowledges that spills within a sensitive area might not actually impact the sensitive resource and encourages operators to conduct detailed analysis, as needed. This assessment represents a preliminary evaluation of HCAs crossed or located downstream of the pipeline (**Appendix A**). Portions of the pipeline that could potentially affect HCAs would be subject to higher levels of inspection, as per 49 CFR Part 195.

Table 5-12 Mileage Summary of Pipeline Segments that "Could Affect" PHMSA-defined HCAs

County	Miles of Pipeline				Projected Number of Spills in 10 years (occurrence interval, years)			
	Populated Areas	**Drinking Water**	**Ecologically Sensitive Area**	**Total in HCAs[1]**	**Populated Areas**	**Drinking Water**	**Ecologically Sensitive Area**	**Total HCAs[1]**
Dunn	0.0	0.0	15.2	15.2	0 (na)	0 (na)	0.1339 (75)	0.1339 (75)
McKenzie	0.0	0.41	0.057	0.47	0 (na)	0.00366 (2,730)	0.0005 (19,998)	0.004163 (2,402)
Project Total	**0.0**	**0.41**	**15.2**	**15.7**	**0 (na)**	**0.00366 (2,730)**	**0.1345 (74)**	**0.1381 (72)**

[1] Numbers are not necessarily additive because some miles overlap in the different types of HCAs.

Note: na indicates no PHMSA-defined USA within the segment.

Projected number of spills in 10 years and occurrence interval were conservatively estimated based on the conservative probability of spills (0.000883 incidents/mile*year). This conservative analysis intentionally overestimates the potential risk, and assumes risk is evenly distr buted along the entire project. Occurrence interval is the reciprocal of the overall incident rate and is given in units of years per incident for the defined pipeline miles.

[4] A sole source municipal drinking water intake or an ecological resource that is particularly sensitive to environmental damage from a hazardous liquid pipeline release are referred to as Unusually Sensitive Areas (USAs), as defined in 49 CFR 195.6).

Assuming that 1.1 spills occurred along the project in a 10-year period, it is estimated that approximately 0.14 of these spills (based on 15.7 miles of pipeline associated with HCAs) would occur in HCAs. Although the number of predicted spills in HCAs is relatively small, the potential impacts of these individual spills are expected to be greater than in other areas due to the environmental sensitivity within these areas. **Table 5-13** also shows the predicted number of spills and their predicted sizes.

Table 5-13 Predicted Frequency of Spills and Associated Volumes Within "Could Affect" Segments in 10-year Period

HCA Type	Miles of Pipe[1]	Number of Predicted Spills (incidents per mile pipeline)				
		Total	<3 barrels	3 to 50 barrels	50 to 1,000 barrels	1,000 to 10,000 barrels
Populated Areas	--	--	--	--	--	--
Drinking Water Areas	0.41	0.00366	0.00193	0.00104	0.000517	0.00085
Ecologically Sensitive Areas	15.2	0.134	0.0709	0.0190	0.00578	0.00621

[1] The amount of pipe located within HCAs was quantified by the project's geographical information system and was based on the intersection of the pipeline's centerline and PHMSA-defined HCAs. Probability of a spill was based on the conservative incident frequency of 0.000883 incidents per mile per year (Section 4.1).

5.5.1 Populated Areas

As indicated in **Tables 5-12** and **5-13**, no pipeline segments are present within or in areas that could potentially reach a PHMSA-defined populated area occur along the project route.

5.5.2 Drinking Water

PHMSA identifies certain surface water and groundwater resources as drinking water USAs (49 CFR Sections 195.6 and 195.450). Surface water USAs include intakes for community water systems and non-transient, non-community water systems that do not have an adequate alternative drinking water source. Groundwater USAs include the source water protection area for community water systems and non-transient non-community water systems that obtain their water supply from a Class I or Class IIA aquifer and do not have an adequate alternative drinking water source. If the source water protection area has not been established by the state, the wellhead protection area becomes the USA.

Surface water USAs identified for their potential as a drinking water resource have a 5-mile buffer placed around their intake location. The groundwater USAs 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.

Miles of pipeline segments that potentially could reach sensitive drinking water resources are summarized in **Table 5-12**. Segments of the pipeline that could potentially affect HCAs would be subject to higher levels of inspection, as per 49 CFR Part 195.

5.5.3 Ecologically Sensitive Areas

Certain ecologically sensitive areas are classified as HCAs by PHMSA due to potential risks to unusually sensitive ecological resources. These areas focus on the characteristics of rarity, imperilment, or the potential for loss of large segments of an abundant population during periods of migratory concentration. These include:

- Critically imperiled and imperiled species and/or ecological communities;
- Threatened and endangered species (or multi-species assemblages where three or more different candidate resources co-occur);
- Migratory waterbird concentrations;
- Areas containing candidate species or ecological communities identified as excellent or good quality; and
- Areas containing aquatic or terrestrial candidate species and ecological communities that are limited in range.

Portions of the project would cross ecologically sensitive HCAs (**Table 5-12**). These ecologically sensitive HCAs are frequently associated with river systems. As with other HCAs, these locations would be subject to higher levels of inspection, as per 49 CFR Part 195, in order to reduce the chance of pipeline incident.

5.5.4 Management of Risk within HCAs

To protect particularly sensitive resources, HCAs would be subject to a higher level of inspection per USDOT regulations. Federal regulations require periodic assessment of the pipe condition and timely correction of identified anomalies within HCAs. Under federal pipeline regulations, CEBCS would be required to develop management and analysis processes that integrate available integrity-related data and information and assess the risks associated with segments that can affect HCAs.

CEBCS also would be required conduct routine surveys to locate HCA changes along the pipeline system. If portions of the pipeline become population HCAs during the operational pipeline life, CEBCS would be required to integrate the information into their Integrity Management Plan (IMP), which is audited by PHMSA.

For Homeland Security reasons, the precise risk for specific locations of HCAs is highly confidential. Therefore, additional information on risk to HCAs is provided to federal and state regulatory agencies, if requested, as a confidential appendix (**Appendix A**). Per federal regulations (Integrity Management Rule, 49 CFR Part 195), the site-specific evaluation of risk is an ongoing process and is regulated by the PHMSA. As part of the compliance process, CEBCS would need to develop and implement a risk-based IMP. The IMP will use state-of-practice technologies applied within a comprehensive risk-based methodology to assess and mitigate risk associated with all pipeline segments including HCAs.

6.0 CEBCS's Pipeline Safety Program

Pipelines are one of the safest forms of crude oil transportation and provide a cost-effective and safe mode of transportation for oil on land. Overland transportation of oil by truck or rail produces higher risk of injury to the general public than the proposed pipeline (USDOT 2002). The project will be designed, constructed, and maintained in a manner that meets or exceeds industry standards.

Safeguards have been implemented during design and will be implemented during construction and operations of the pipeline. These safeguards include construction and operation procedures that meet or exceed industry standards. In addition to robust procedures, CenterPoint will use qualified personnel to ensure procedures are implemented in a safe manner.

Historically, one of the most significant risks associated with operating a crude oil pipeline is the potential for third-party excavation damage. To minimize the risk of third-party damage, the pipeline will be built within an approved ROW and markers will be installed at all road, railway, and water crossings. CEBCS plans to use a minimum depth of cover of 84 inches (7 feet) in most circumstances, which exceeds federal requirements. This would substantially reduce the chance of third-party excavation damage, a leading cause of pipeline incidents.

Per federal regulations, CEBCS would have an established maintenance, inspection, and repair program that ensures the integrity of the pipeline during operations. CEBCS's pipeline maintenance program would be designed to maintain the safe and reliable operation of the pipeline. Data collected during maintenance would be fed back into the decision-making process for the development of the ongoing maintenance program.

CEBCS also would mitigate third-party excavation risk by implementing comprehensive Public Awareness and Damage Prevention programs focused on education and awareness in accordance with 49 CFR Section 195.440 and API RP1162. Further, CEBCS would complete regular visual inspections (ground or aerial) of the ROW as per 49 CFR Section 195.412 and monitor activity in the area to prevent unauthorized trespass or access.

To mitigate the effects of corrosion on the pipeline, CEBCS will construct the produced water system out of a reinforced high-density polyethylene (HDPE) pipeline material that is resistant to corrosion. In addition, CEBCS would apply a FBE or other type of protective pipeline coating to the external surface of steel pipe to prevent corrosion. A cathodic protection system would be installed on the steel pipeline, composed of engineered metal alloys or anodes, which would be connected to the pipeline. A low voltage direct current would be applied to the pipeline; the process corrodes the anodes rather than the pipeline. During operations, the pipeline would be routinely cleaned. The steel pipeline segments 4-inch and greater are designed to be inspected utilizing one of a variety of inspections methods including internal inspection tools, pressure testing, direct assessment; or other technologies which are demonstrated to be equivalent to the previous three methods. These inspection methods may be interchanged or used in combination, thereby allowing CEBCS the ability to proactively detect corrosion and third party damage.

In addition, the pipeline would be monitored 24 hours a day, 365 days a year from the OCC using a sophisticated SCADA system. CEBCS would implement multiple leak detection methods and systems that are overlapping in nature and progress through a series of leak detection thresholds. The leak detection methods are as follows:

- Remote monitoring performed by the OCC Operator, which would consist of monitoring pressure and flow data received from pump stations and valve sites fed back to the OCC by the CEBCS SCADA system. This system will provide the real time data used to detect leaks and allow Operators to initiate system shutdowns.

- Computer-based, non-real time accumulated gain/loss volume trending that would assist in identifying low rate or seepage.
- Direct observation methods, which include aerial patrols, ground patrols, and public and landowner awareness programs that would be designed to encourage and facilitate the reporting of suspected leaks and events that may suggest a threat to the integrity of the pipeline.

The system would be configured in a manner capable of alarming the OCC operators through the SCADA system and also would provide the OCC operators with a comprehensive assortment of display screens for incident analysis and investigation.

Lastly, CEBCS would have an ERP in place to respond to incidents. The IMP (49 CFR Part 195) and ERP would ensure CEBCS operates the pipeline in an environmentally responsible manner

7.0 Conclusion

In summary, this conservative analysis of the proposed project shows that the predicted frequency of incidents is very low, the probability of a large spill occurring is very low, and, consequently, risk of environmental impacts is minimal. Compliance with applicable regulations, application of CEBCS's IMP and ERP, as well as adherence to applicable safety procedures would help to ensure long-term environmentally responsible and safe operation of the pipeline.

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9.0 Glossary

Accidental Release

An accidental release is an unplanned occurrence that results in a release of oil from a pipeline.

Acute exposure

Exposure to a chemical or situation for a short period of time.

Acute toxicity

The ability of a substance to cause severe biological harm or death soon after a single exposure or dose.

Adverse effect

Any effect that causes harm to the normal functioning of plants or animals due to exposure to a substance (i.e., a chemical contaminant).

Algae

Chiefly aquatic, eukaryotic one-celled or multicellular plants without true stems, roots and leaves that are typically autotrophic, photosynthetic, and contain chlorophyll. They are food for fish and small aquatic animals.

Aquifer

An underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be usefully extracted using a water well.

Barrel

A barrel is a standard measure of a volume of oil and is equal to 42 gallons.

Benthic invertebrates

Those animals without backbones that live on or in the sediments of a lake, pond, river, etc.

Bioavailability

How easily a plant or animal can absorb a particular contaminant from the environment.

Biodegradation

Biodegradation is the breakdown of organic contaminants by microbial organisms into smaller compounds. The microbial organisms transform the contaminants through metabolic or enzymatic processes. Biodegradation processes vary greatly, but frequently the final product of the degradation is carbon dioxide or methane.

BPD

Abbreviation for barrels per day.

Cathodic Protection System

A technique to provide corrosion protection to a metal surface by making the surface of the metal object the cathode of an electrochemical cell. In the pipeline industry that is done using impressed current. Impressed current cathodic protection systems use an anode connected to a DC power source (a cathodic protection rectifier).

Chronic toxicity

The capacity of a substance to cause long-term poisonous health effects in humans, animals, fish, or other organisms. Biological tests use sublethal effects, such as abnormal development, growth, and reproduction, rather than mortality, as endpoints.

Contaminant

Any physical, chemical, biological, or radiological substance found in air, water, soil or biological matter that has a harmful effect on plants or animals; harmful or hazardous matter introduced into the environment.

Ecosystem

The sum of all the living plants and animals, their interactions, and the physical components in a particular area.

Emergency Flow Restricting Device

An emergency flow-restricting device is a device used to restrict or limit the amount of oil that can release out of a leak or break in a pipeline. Check valves and remote control valves are types of emergency flow restricting devices.

Exposure

How a biological system (i.e., ecosystem), plant, or animal comes in contact with a chemical.

Event

An event is a significant occurrence or happening. As applicable to pipeline safety, an event could be an accident, abnormal condition, incident, equipment failure, human failure, or release.

Facility

Any structure, underground or above, used to transmit a product.

Geographical Information System

A computer data system for creating and managing spatial data and associated attributes.

Habitat

The place where a population of plants or animals and its surroundings are located, including both living and non-living components.

High Consequence Area (HCA)

A high consequence area is a location that is specially defined in PHMSA pipeline safety regulations as an area where pipeline releases could have greater consequences to health and safety or the environment. For oil pipelines, HCAs include high population areas, other population areas, commercially navigable waterways, and areas unusually sensitive to environmental damage, including certain ecologically sensitive areas and drinking water resources. Regulations require a pipeline operator to take specific steps to ensure the integrity of a pipeline for which a release could affect an HCA and, thereby, provide protection of the HCA.

High Population Area

A high population area is an urbanized area, as defined and delineated by the U.S. Census Bureau, which contains 50,000 or more people and has a population density of at least 1,000 people per square mile. High population areas are considered HCAs.

Incident

As used in pipeline safety regulations, an incident is an event occurring on a pipeline for which the operator must make a report to the Office of Pipeline Safety. There are specific reporting criteria that define an incident that include the volume of the material released, monetary property damage, injuries, and fatalities (Reference 49 CFR Section 191.3, 49 CFR Section 195.50).

Incident Frequency

Incident frequency is the rate at which failures are observed or are predicted to occur, expressed as events per given timeframe.

Incident Probability

Incident probability is the probability that a structure, device, equipment, system, etc. will fail on demand or will fail in a given time interval, expressed as a value from 0 to 1.

Incident Rate

Incident rate is the rate at which failures occur. It is the number of failure events that occur divided by the total elapsed operating time during which those events occur or by the total number of demands, as applicable.

Integrity Management Program (IMP)

An IMP is a documented set of policies, processes, and procedures that are implemented to ensure the integrity of a pipeline. An oil pipeline operator's IMP must comply with the federal regulations (i.e., the Integrity Management Rule, 49 CFR Part 195).

Integrity Management Rule

The Integrity Management Rule specifies regulations to assess, evaluate, repair, and validate the integrity of hazardous liquid pipelines that, in the event of a leak or failure, could affect HCAs.

Invertebrates

Animals without backbones: e.g., insects, spiders, crayfish, worms, snails, mussels, clams, etc.

LC_{50}

A concentration expected to be lethal to 50 percent of a group of test organisms.

Leak

A leak is a small opening, crack, or hole in a pipeline allowing a release of oil.

Likelihood

Likelihood refers to the probability that something possible may occur. The likelihood may be expressed as a frequency (e.g., events per year), a probability of occurrence during a time interval (e.g., annual probability), or a conditional probability (e.g., probability of occurrence, given that a precursor event has occurred).

Maximum Contaminant Level (MCL)

The maximum level of a contaminant allowed in drinking water by federal or state law and is based on the avoidance of health effects and currently available water treatment methods.

National Pipeline Mapping System (NPMS)

The National Pipeline Mapping System is a geographical information system database that contains the locations and selected attributes of natural gas transmission lines, hazardous liquid trunk lines, and liquefied natural gas facilities operating in onshore and offshore territories of the U.S.

One-Call System

A one-call system is a system that allows excavators (individuals, professional contractors, and governmental organizations) to make one telephone call to underground facility operators to provide notification of their intent to dig. The facility operators or, in some cases, the one-call center can then locate the facilities before the excavation begins so that extra care can be taken to avoid damaging the facilities. All 50 states within the U.S. are covered by one-call systems. Most states have laws requiring the use of the one-call system at least 48 hours before beginning an excavation.

Other Populated Areas

An ‘other populated area’ is a census designated place, defined and delineated by the U.S. Census Bureau as settled concentrations of population that are identifiable by name but are not legally incorporated under the laws of the state in which they are located. Other populated areas are considered HCAs by PHMSA.

Operator

An operator is a person who owns or operates pipeline facilities (Reference 49 CFR Section 195.2).

Polycyclic Aromatic Hydrocarbons (PAHs)

Group of organic chemicals.

Pipeline

Used broadly, pipeline includes all parts of those physical facilities through which gas, hazardous liquid, or carbon dioxide moves in transportation. Pipeline includes but is not limited to: line pipe, valves and other appurtenances attached to the pipe, pumping/compressor units and associated fabricated units, metering, regulating, and delivery stations, and holders and fabricated assemblies located therein, and breakout tanks.

Receptor

The species, population, community, habitat, etc. that may be exposed to contaminants.

Risk

Risk is a measure of both the likelihood that an adverse event could occur and the magnitude of the expected consequences should it occur.

Sediment

The material of the bottom of a body of water (i.e., pond, river, stream, etc.).

Stressor

Any factor that may harm plants or animals; includes chemical (e.g., metals or organic compounds), physical (e.g., extreme temperatures, fire, storms, flooding, and construction/development) and biological (e.g., disease, parasites, depredation, and competition).

Supervisory Control and Data Acquisition System

A supervisory control and data acquisition system is a pipeline control system designed to gather information such as pipeline pressures and flow rates from remote locations and regularly transmit this information to a central control facility where the data can be monitored and analyzed.

Throughput

The volume of oil through a pipeline during a specified time (e.g., barrels per day).

Toxicity Testing

A type of test that studies the harmful effects of chemicals on particular plants or animals.

Toxicity Threshold

Numerical values that represent concentrations of contaminants in abiotic media (sediments, water, soil) or tissues of plants and animals above which those contaminants are expected to cause harm.

Unusually Sensitive Areas (USAs)

USAs refers to certain drinking water and ecological resource areas that are unusually sensitive to environmental damage from a hazardous liquid pipeline release, as defined in 49 CFR Section 195.6.

Zooplankton

Small, usually microscopic animals (such as protozoans) found in lakes and reservoirs.

Appendix A

Analysis of High Consequence Areas

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