Appendix A
BakkenLink Risk Assessment and Environmental Consequences Analysis

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Dry Creek to Beaver Lodge Pipeline

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CONFIDENTIAL DATA

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Table of Contents

ACRONYMS AND ABBREVIATIONS AA-1

1.0 PROJECT OVERVIEW 1.1

2.0 INTRODUCTION 2.1

3.0 PIPELINE 3.1
3.1 MAINLINE VALVE ASSEMBLIES 3.2

4.0 INCIDENT FREQUENCY-SPILL VOLUME ESTIMATION 4.1
4.1 PHMSA BASELINE INCIDENT FREQUENCIES 4.1
4.2 SPILL VOLUME 4.3

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 5.2
5.2.3 Dispersion of Crude Oil 5.4
5.2.4 Submersion of Crude Oil 5.5
5.2.5 Environmental Impacts 5.6
5.3 LAKE SAKAKAWEA 5.20
5.3.1 Wildlife 5.20
5.4 RISK TO HIGH CONSEQUENCE AREAS 5.21
5.4.1 Populated Areas 5.22
5.4.2 Drinking Water 5.22
5.4.3 Ecologically Sensitive Areas 5.23
5.4.4 Management of Risk within HCAs 5.23
5.5 IMPACTS FROM CONSTRUCTION OF THE PROJECT AND ENVIRONMENTAL MEASURES 5.24
5.5.1 Soils 5.24
5.5.2 Vegetation and Soil Ecosystems 5.25
5.5.3 Wildlife 5.26
5.5.4 Groundwater 5.26
5.5.5 Flowing Surface Waters 5.27
5.5.6 Wetlands, Reservoirs, and Lakes 5.28

6.0 BAKKENLINK'S PIPELINE SAFETY PROGRAM 6.1

7.0 SUMMARY 7.1

8.0 REFERENCES 8.1

9.0 GLOSSARY 9.1

LIST OF TABLES

Table 3-1 Project Design Parameters ... 3.1
Table 4-1 Baseline Incident Frequencies[1] ... 4.1
Table 4-2 Spill Occurrence Interval Associated with the Project over 10 Years Breakdown by Volume ... 4.3
Table 5-1 Composition of Representative Bakken Crude Oil ... 5.2
Table 5-2 Stream Categories ... 5.10
Table 5-3 Volume of Water Required to Dilute Benzene in Bakken Crude Oil Spills Below Benchmark Values ... 5.11
Table 5-4 Comparison of Estimated Benzene Concentrations with the Benzene MCL Resulting from a Bakken Crude Oil Spill ... 5.12
Table 5-5 Acute Toxicity of Aromatic Hydrocarbons to Freshwater Organisms ... 5.14
Table 5-6 Acute Toxicity of Crude Oil Hydrocarbons to *Daphnia magna* ... 5.16
Table 5-7 Chronic Toxicity of Benzene to Freshwater Biota ... 5.17
Table 5-8 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 ... 5.18
Table 5-9 Comparison of Estimated Benzene Concentrations Following a Bakken Crude Oil Spill to the Chronic Toxicity Thresholds for Aquatic Life (1.4 ppm) for Streams Crossed by the Project ... 5.19
Table 5-10 Mileage Summary of Pipeline Segments that “Could Affect” PHMSA-defined HCAs ... 5.22
Table 5-11 Predicted Spills and Associated Volumes Within “Could Affect” Segments in 10-year Period ... 5.22

LIST OF FIGURES

Figure 1-1 Project Overview ... 1.2

LIST OF APPENDICES

ATTACHMENT A LAKE SAKAKAWEA SITE-SPECIFIC RISK ASSESSMENT

ATTACHMENT B ANALYSIS OF HIGH CONSEQUENCE AREAS

Acronyms and Abbreviations

°F	degrees Fahrenheit
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BakkenLink	BakkenLink Pipeline LLC
bbl	barrels
BLM	Bureau of Land Management
BMPs	Best Management Practices
bpd	barrels per day
CPM	computational pipeline monitoring
CFR	Code of Federal Regulations
cfs	cubic feet per second
CWA	Clean Water Act
EA	environmental assessment
ERP	Emergency Response Plan
ERW	electronic resistance welding
FBE	fusion bond epoxy
g/ml	grams per milliliter
HCA	high consequence area
HDD	horizontal direction drilling
IMP	Integrity Management Program
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
NPDES	National Pollutant Discharge Elimination System
OCC	Operations Control Center
PAH	polycyclic aromatic hydrocarbons
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIG	pipeline inspection gauge
ppm	parts per million
PSC	Public Service Commission
psig	pounds per square inch gauge

RA	Risk Assessment
ROW	right-of-way
SCADA	Supervisory Control and Data Acquisition
SPCC Plan	Spill Prevention, Control, and Countermeasures Plan
SWPPP	Storm Water Pollution Prevention Plan
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	United States Fish and Wildlife Service
USGS	United States Geological Survey
WT	wall thickness

1.0 PROJECT OVERVIEW

BakkenLink Pipeline LLC (BakkenLink), a wholly owned subsidiary of Great Northern Midstream LLC filed a right-of-way (ROW) application on March 14, 2013, proposing to amend their existing authorization (No. NDM 102507) to construct, operate, and maintain the Project on federal lands in McKenzie and Williams counties, North Dakota, as shown in **Figure 1-1**.

The Project would consist of approximately 37 miles of 16-inch-diameter steel crude oil pipeline extending from the northern terminus of BakkenLink's existing pipeline system (Dry Creek Terminal interconnect point near Johnson's Corner in McKenzie County, North Dakota), across Lake Sakakawea, to a proposed Beaver Lodge Interconnect Facility in Williams County, North Dakota, and also would include an oil receipt facility near Keene, North Dakota. The Project is a continuation of an ongoing crude oil pipeline system that BakkenLink originally proposed to construct between Fryburg, North Dakota, and the Beaver Lodge Interconnect Facility, near Tioga, North Dakota. The proposed pipeline is designed to initially carry up to 100,000 barrels (bbl) per day (bpd), with a maximum design flow rate of 135,000 bpd. The sources of the crude oil that would be transported by the Project are the middle Bakken and upper Three Forks formations (Bakken) of the Williston Basin.

Surface facilities would include pipeline markers, pipeline inspection gauge (pig) launchers and receivers, cathodic protection rectifiers, and block valves. Block valves, including those on either side of Lake Sakakawea, would be remotely actuated, meaning that they could be closed by BakkenLink operators in the event of an emergency. BakkenLink maintains that the pressure provided by storage tank transfer pumps at the receipt locations would be adequate for operation of the pipeline at the current projected flow rates, and as such, no pumping stations would be built as part of the Project.

The crude oil collected by the Project would have improved access to key markets across the United States (U.S.). BakkenLink believes its Project would help to alleviate anticipated pipeline constraints in the Bakken Formation region and reduce the amount of truck mileage for hauling crude oil to truck receipt facility locations. The anticipated in-service date for the Project is July 2015.

Federal Permitting Process

The Project would require the issuance of a ROW grant by the Bureau of Land Management (BLM) to cross federal lands. The proposed route crosses federal lands managed by the U.S. Forest Service (USFS) and U.S. Army Corps of Engineers (USACE), which would require ROW easements, special use permits, and other applicable permits. The issuance of the 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 [U.S.C.] § 4321 et seq.). Per Section 28 of the Mineral Leasing Act of 1920, as amended (30 U.S.C. 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 USACE are participating as cooperating agencies.

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 release from the Project.

Figure 1-1

Project Overview

2.0 Introduction

This RA presents the results of a pipeline incident frequency analysis based on the Project's design and operation 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 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).

Based on agency scoping comments, this RA focuses particular attention to potential impacts to Lake Sakakawea and associated resources. 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

The Project would consist of approximately 37 miles of crude oil pipeline extending from Dry Creek Terminal to Beaver Lodge, located in McKenzie and Williams counties, North Dakota (**Figure 1-1**). The 37 miles of 16-inch-diameter steel trunk line would have bi-directional capability, and would extend from the northern terminus of BakkenLink's existing pipeline system (Dry Creek Terminal interconnect point near Johnson's Corner in McKenzie County), across Lake Sakakawea, to a proposed Beaver Lodge Truck Facility in Williams County, and also would include a truck receipt facility near Keene. The proposed trunk line is designed to initially carry up to 100,000 bpd, with a maximum design flow rate of 135,000 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) 195, Transportation of Hazardous Liquids by Pipeline and 49 CFR 194, Response Plans for Onshore Oil Pipelines. 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 (ASTM), and others.

The proposed route would extend from multiple receipt points in McKenzie and Williams counties, North Dakota. An overview of the proposed route is presented in **Figure 1-1**. Initially, BakkenLink proposes to use three receipt facility locations for input of crude oil. The facilities, as depicted on **Figure 1-1**, are:

- Beaver Lodge Receipt Facility, Williams County;
- Keene Receipt Facility, McKenzie County; and
- Existing Dry Creek Terminal, McKenzie County.

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 1,480 pound per square inch gauge (psig). The Project typically would operate at 60°F and between 200 to 1,480 psig. The pipeline would be buried underground at a depth that meets or exceeds the regulations specified in 49 CFR 195.248.

Table 3-1 Project Design Parameters

Parameter	Value
Pipe Specifications	16-inch outside diameter high-strength steel (API 5L-X65).
Coating	Fusion bond epoxy (FBE) coating (or other coating technique)
Maximum Operating Pressure	1,480 psig
Depth of Cover	Generally 3 feet of cover specified in 49 CFR 195.248.
Aboveground versus Belowground Piping	Pipe will be belowground except within valve sites and receipt facilities.
Pipe Wall Thickness	16-inch pipe: 0.312-inch wall thickness (WT), typically; 0.375-inch WT for bores and horizontal directional drills (HDDs)

Table 3-1 Project Design Parameters

Parameter	Value
Intermediate Valves	Currently there are 5 mainline valves planned for the route between Beaver Lodge and Dry Creek Terminal. The valves will meet or exceed federal requirements (49 CFR 195.260).
Pump Stations	No pump stations required.
Leak Prevention Program	Multiple overlapping and redundant systems, including: • FBE or other protective pipeline coating; • 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. • ATMOS Wave System
Direct Observation Surveillance Frequency	• Aerial surveillance: 26 times per year, not to exceed 3-week intervals.

Surface facilities would be limited to pipeline markers, pig launchers and receivers, cathodic protection rectifiers, and remotely actuated block valves. BakkenLink maintains that the pressure provided by storage tank transfer pumps at the receipt locations would be adequate for operation of the pipeline at the current projected flow rates and, as such, no pumping stations would be built as part of the Project.

3.1 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 HCAs has been conducted to determine appropriate placement of the valves to minimize potential environmental impacts. Additionally, BakkenLink will cooperate with USDOT – Pipeline and Hazardous Materials Safety Administration (PHMSA) regarding their Project.

4.0 Incident Frequency-Spill Volume Estimation

4.1 PHMSA BASELINE INCIDENT FREQUENCIES

Since 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., PHMSA 2014 data).

Baseline incident frequencies are derived from historical national pipeline incident data (PHMSA 2014). Since 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 current regulatory requirements or Best Management Practices (BMPs). Further, these historical data do not account for supplemental protective measures that BakkenLink would implement.

The baseline incident frequencies identified in **Table 4-1** were generated from the PHMSA incident database (PHMSA 2014) 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/mile[3])
Corrosion	5.31E-04	1,882
Excavation Damage	1.67E-04	6,000
Incorrect Operation	3.01E-04	3,319
Material/Weld/Equip. Failure	7.76E-04	1,288
Natural Force Damage	1.12E-04	8,942
Other Outside Force Damage	4.32E-05	23,171
All Other Causes	1.30E-04	7,714
Total All Causes	**2.11E-03**	**473**

[1] Baseline statistics based on PHMSA hazardous liquid incident database (2014), excluding offshore 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 interval 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_{gm} = leak frequency from ground movement
f_{wo} = leak frequency from washout event

The resultant incident frequency is 2.11E-03 incidents/mile-year, equivalent to 1 incident in 473 years per mile of pipe[1]. While future events cannot be known with absolute certainty, this historic incident frequency can be used to estimate the number of events that might occur over a period of time on the Project. Based on this spill frequency and a total of 37 miles of pipeline, this analysis estimates that there would be 0.781 spills during a 10-year period.

Utilizing this nationwide spill data results is a significantly more statistically robust and conservative analysis compared to utilizing only data from North Dakota. For example, the nationwide PHMSA database contains data on approximately 185,000 miles of hazardous liquid pipelines, whereas North Dakota has data for only 2,900 miles of hazardous liquid pipelines. Additionally, incident reports indicate that the state-specific incident frequency is approximately 0.00165 incidents/mile-year, substantially lower than the nationwide statistic of 0.00211 incidents/mile-year (PHMSA 2014). Thus, utilizing the nationwide data overestimates spill frequency by approximately 30 percent as compared with state-specific data.

Additionally, 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 overestimates the probability of a spill.

Improved technologies and practices that are used on a newly constructed pipeline currently are not reflected in the historical PHMSA incident frequency data. This is important as many of the recent, high profile pipeline spills that have occurred have involved pre-modern pipe. For instance, the Enbridge Line 6b spill in Marshall, Michigan, and the ExxonMobil spill in Mayflower, Arkansas, involved pre-1970s pipe. Both of these ruptures involved longitudinal seam failure, a prominent failure mode in pre-modern pipe due to the method of low frequency electronic resistance welding (ERW) that was utilized at the time of manufacturing. Additionally, this older pipe typically incorporates suboptimal corrosion resistant coatings (e.g., coal tar or asphalt). Modern pipelines, on the other hand, have significantly more robust longitudinal seams due to improved high frequency ERW techniques. Modern pipelines also are coated in a highly corrosion resistant FBE coating, which significantly reduces the probability of external corrosion. These factors, and other improved technologies, contribute to the improved safety record of the modern pipe that will be utilized for this Project. Consequently, the spill frequency is considered extremely conservative and overestimates the probability of a spill.

In 2002, PHMSA instituted a 5-gallon spill reporting limit. Prior to this action, only spills over 50 bbl (1,575 gallons) were reported. This change has resulted in a significant increase in the calculated baseline incident frequency. The calculated incident frequency using all available data (from 1993 to 2011) is 0.000883 incidents/mile-year. The calculated incident frequency using data obtained after the updated reporting limit (2002 to 2014) is 0.00211 incidents/mile-year, a substantial increase in incident frequency. However, it should be noted that this increase is attributable to different reporting requirements and not an actual increase in spills.

In fact, PHMSA data show that the number of spills on crude oil pipelines has substantially declined 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

[1] This value is an estimate based on historical statistics; actual values may differ from these estimates.

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 2013)[2] indicates that the majority of actual pipeline spills are relatively small. Fifty percent of the spills consist of 4 bbl or less. In 84 percent of the cases, the spill volume was 100 bbl or less. In 95 percent of the incidents, spill volumes were less than 1,000 bbl. Oil spills of 10,000 bbl or larger occurred in 0.5 percent of cases. These data demonstrate that most pipeline spills are small and larger releases of 10,000 bbl or more are extremely uncommon. **Table 4-2** illustrates the frequencies that oil spills of different volumes are predicted to occur along the 37-mile section of pipe over a 10-year interval.

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

Spill Volume	Conservative Number of Spills in 10 Years
Spill volume 4 bbl or less	0.457
Spill volume between 4 and 50 bbl	0.180
Spill volume between 50 and 100 bbl	0.033
Spill volume between 100 and 1,000 bbl	0.077
Spill volume between 1,000 and 10,000 bbl	0.031
Spill volume greater than 10,000 bbl	0.003
Total Spills	0.782

[2] Incidents associated with offshore facilities and refining facilities were excluded from the analysis. Terminals and tanks are included.

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 reports that in 2011, the age-adjusted death rate in the U.S. from all causes was 740.6 per 100,000 (Centers for Disease Control and Prevention 2013). 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., cyclohexane); aromatics (e.g., benzene, toluene); and heavy aromatic hydrocarbons (e.g., polycyclic aromatic hydrocarbons [PAHs], asphaltenes). 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 biomagnify (increase in concentration within a food chain) and are not highly water soluble. In contrast, lightweight aromatics (i.e., benzene, toluene, ethyl benzene, xylenes) tend to be highly water soluble and have low toxicity thresholds. 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).

Table 5-1 Composition of Representative Bakken Crude Oil

Constituent	Chemical Notation	Median (% by weight)	Range Low (% by weight)	Range 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
Ethylbenzene	Ethylbenzene	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

* grams per milliliter

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 conditions. 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.

5.2.2.1 Soils

Overview

If released in soil at pipeline depth, the released oil can volatilize or sorb to soil particles, constituents can also 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.
- 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 of less oil surface area exposed to the air, and 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 usually will bind most strongly with soil particles in organic soils; crude oil usually will bind less strongly with soil particles in sandy soils.
- Dissolution. Although most components of crude oil are relatively insoluble (Neff and Anderson 1981), crude oil released into soil can migrate toward water where certain constituents can dissolve into groundwater or surface water in limited amounts. Dissolution is not a major process controlling crude oil's fate as most crude oil constituents are more soluble in oil than water and, therefore, preferentially remain in the crude oil.
- 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. 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. Spreading and thinning of spilled crude oil in water also increases the surface area of the slick, thus enhancing surface dependent fate processes such as evaporation, degradation, and dissolution.

- Dissolution. Dissolution of crude oil in water is not a significant process controlling the crude oil's fate in the environment since 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 tend to be less than their constituents since 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.
- 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 Dispersion of Crude Oil

While crude oil does not dissolve in water the same way that, for example, salt dissolves in water, turbulent water is able to drive small droplets of the oil into the water column. Experimental data suggest that the maximum size of these droplets is approximately 70 microns. If the droplets are small enough, natural turbulence in the water will prevent the oil from resurfacing, just as turbulence in the air keeps small dust particles afloat. This process is called dispersion.

Environmental conditions dictate the importance of dispersion. For oil spills during storm events, dispersion is the chief removal mechanism of the slick. During storms, the majority of the oil can be dispersed into the water column. For spills under more normal weather conditions, evaporation will usually be more significant, but dispersion still can occur.

Dispersion is considered an appropriate method to clean up high volume spills, particularly those that occur in large waterbodies, including in marine systems. The argument in favor of dispersion is that spreading the oil into the water column facilitates natural weathering processes such as biodegradation and oxidation, thus reducing exposure of aquatic organisms to elevated oil concentrations.

5.2.4 Submersion of Crude Oil

The crude oil proposed for transport by BakkenLink has an API gravity greater than 10 and will therefore float on the surface of water. All crude oils weather (i.e., light-end hydrocarbons evaporate) when exposed to the environment. With time, the remaining crude oil becomes denser as the proportion of light hydrocarbons decreases. Eventually, this process, particularly when combined with turbulent water, can result in remaining weathered oil sinking. This weathering process is not unique to diluted bitumen and occurs with all types of crude oils, regardless of their origin.

Recent spills resulting in a significant amount of submerged crude oil, for instance the 2010 Enbridge Line 6b spill in the Kalamazoo River, have given emergency response teams the opportunity to test and refine sunken and submerged oil recovery techniques. Many conventional and unconventional techniques have proven to be quite effective, including:

- Nets: specialized nets can be utilized to contain submerged globules of weathered crude oil as they migrate downstream or with a current.
- Bottom booms: bottom booms have a heavy ballast to create a seal against the bottom of a waterbody and a float chamber that extends toward the surface of the water. These booms have the potential to be very effective in containing submerged oil.
- Dams: watergates, underflow weir dams, and other dams can be set up on the bottom of a waterbody to contain oil as it migrates downstream or with a current. Underflow weir dams can be built using standard spill response equipment (i.e., sandbags, shovels, PVC piping, etc.).
- Dredging: well-established dredging techniques can be extremely effective in recovering sunken and submerged oils and have been used effectively following spills of high density crude oils.
- Manual Recovery: sunken oil has the tendency to collect in depressions and areas of low flow, where it often can be manually recovered. Techniques for manual recovery (e.g., vacuuming) are well established and can be executed using only standard spill response materials.
- Air Injection: submerged oil can be floated and recovered using injection of air similar to soil vapor extraction techniques used in remediation of contaminated soil.

5.2.5 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.

5.2.5.1 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 generally are 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 proposed 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 likely would 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 generally would 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 generally would 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. North Dakota has a wide array of soil types with varying permeability and composition. The soils of western North Dakota (McKenzie County) are primarily fertile loam soils from silty clay loams (low permeability) to sandy loams (highly permeable) (U.S. Department of Agriculture [USDA] 2006). In accordance with federal and state regulations, BakkenLink 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 on a risk-based analysis, designed to protect human health and the environment. The benchmark soil cleanup level from petroleum hydrocarbon release is 100 parts per million [ppm] of total petroleum hydrocarbons (North Dakota Department of Health 2006). Once remedial cleanup levels were achieved in the soils, 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/permeability, 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 2014), 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 2014).

5.2.5.2 Vegetation and Soil Ecosystems

Crude oil released to the soil's surface potentially could 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 5.2.5.1, Soils), BakkenLink 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.

5.2.5.3 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, typically are 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 and eggs with crude oil, causing reductions in thermal insulative capacity and buoyancy of plumage (feathers) and pelage (fur).

However, 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 available, as often will 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).

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.

Terrestrial organisms such as piping plover are known to utilize suitable breeding and critical habitat in the Project area. These species may ingest or otherwise come in contact with oil during feeding and other behaviors. However, adverse impacts to the piping plover are most likely to occur due to physical impacts, such as oiling of feathers, rather than toxicological impacts from ingestion. Additionally, the interior least tern has been known to breed on the shores of Lake Sakakawea, and exhibits similar behaviors that may lead to exposure to crude oil following a spill.

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.

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.

5.2.5.4 Water Resources

Crude oil could be released to water resources if the pipeline is breached or leaks occur. Federal regulation (49 CFR 195.260) requires valves to be placed strategically along the proposed route that can stop flow to help reduce the amount of crude oil that potentially could spill into sensitive areas, such as waterbodies. Also, spill containment measures and implementation of preventive 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.

Groundwater

Groundwater aquifers underlie the proposed Project area. 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, for instance:

- 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 (vadose) 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 5.4).

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 generally is 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 threshold 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. For human health protection, the national 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 national MCL at 0.005 ppm; therefore, it was used to evaluate impacts on drinking water supplies, whether from surface water or groundwater.

Emergency response and remediation efforts, however, have the potential for appreciable adverse environmental effects from construction/cleanup equipment. If no active remediation activities were undertaken, natural biodegradation and attenuation ultimately would 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 likely would require up to tens of years. BakkenLink 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 national MCL for benzene. Like other pipelines already in existence, the Project will cross many surficial waterbodies, most of which include major river courses as well as intermittent streams that occur along the proposed route. The majority consists of unnamed tributaries to Dry Creek, Dry Fork Creek, and Sand Creek. A complete list can be found in Appendix IX of the POD. In addition to these numerous water features, wetlands and floodplains also occur within the Project area, which are discussed further in the EA.

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 used for the assessment and identifies several representative streams within these categories.

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 of Bear Den Creek, Handy Water Creek, Sand Creek, and Clear Creek
Lower Moderate Flow Stream	100 – 1,000	50 – 500	Clear Creek, Sand Creek, Dry Fork Creek
Upper Moderate Flow Stream	1,000 – 10,000	500 – 1,000	Missouri River (i.e., Lake Sakakawea)
High Flow Stream	>10,000	1,000 – 2,500	Missouri River (i.e., Lake Sakakawea peak flow)

The following extremely conservative assumptions were developed to overestimate 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** and **5-4**). Based on these ultra-conservative assumptions, results suggest that most spills that enter a waterbody could exceed the national MCL for benzene. Although the assumptions used are highly conservative and, thus, 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.

Table 5-3 Volume of Water Required to Dilute Benzene in Bakken Crude Oil Spills Below Benchmark Values

Barrels of Crude Oil	Volume of Water Required to Dilute Benzene in Crude Oil Below 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)
4	0.7	3.2	891
50	7.5	39.8	11,140
1,000	151	796	222,796
10,000	1,505	7,957	2,227,959

[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 volume with a specific gravity of 0.8151 g/ml.

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 either side of the river was added to the crossing widths identified in **Table 5-2**. The occurrence intervals shown in **Table 5-4** 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 1,430 years for a large waterbody to 4,766 years for a small waterbody (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 would be 4 bbl or less based on PHMSA data for historical spill volumes.

In summary, while a release of crude oil directly into any given waterbody may exceed the 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. BakkenLink's ERP would contain provisions for protecting and mitigating potential impacts to drinking water.

Wetlands/Reservoirs/Lakes

Wetlands and waterbodies with persistently saturated soils are present along and adjacent to the proposed route. The effects of crude oil released into a wetland environment would depend not only upon the quantity of oil released, but also on the physical conditions of the wetland at the time of the release. 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

Table 5-4 Comparison of Estimated Benzene Concentrations with the Benzene MCL Resulting from a Bakken Crude Oil Spill

Streamflow	Stream Flow Rate (cfs)	Benzene MCL (ppm)	Product Released							
			Very Small Spill: 4 bbl		Small Spill: 50 bbl		Moderate Spill: 1,000 bbl		Large Spill: 10,000 bbl	
			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	0.005								
Lower Moderate Flow Stream	100	0.005								
Upper Moderate Flow Stream	1,000	0.005								
High Flow Stream	10,000	0.005	0.0017	1,430						

Notes:

- Historical data indicate that the most probable spill volume would be 4 bbl 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 volume benzene content of the transported material (Marathon Oil 2010).
- Shading indicates estimated benzene concentrations that could exceed the benzene MCL of 0.005 ppm.
- Occurrence intervals are based on an overall predicted incident frequency of 0.00211 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.

varies. Wetland surfaces generally are low gradient with very slow unidirectional flow or no discernible 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 ultimately would allow a return to preexisting conditions in both soil and groundwater. This likely would require a timeframe on the order of tens of years. In the unlikely event of a spill, BakkenLink would utilize appropriate cleanup procedures as determined in coordination with the applicable federal and state agencies.

BakkenLink would avoid wetlands to the extent practical by routing or by crossing using HDD technology. Wetlands that cannot be avoided by either procedure would be crossed using open cut trenching similar to conventional upland construction procedures, with modifications and limitations to reduce the potential for pipeline construction to affect wetland hydrology and soil structure.

Techniques for wetland crossing would vary according to the type of wetland to be crossed, the length of the crossing, and the level of soil saturation or standing water at the time of crossing. An open cut trench technique may be used for trenching and installation where soils are saturated. This technique consists of stringing and welding the pipe outside of the wetland and excavating the trench through the wetland using equipment supported by mats. Water that seeps into the trench is used to float the pipeline into place using attached flotation devices and by pushing or pulling the pipe with equipment. The floats are then removed from the pipe and the pipe sinks into place. The trench is then backfilled and cleanup completed. Most pipes installed in saturated wetlands would be coated with concrete or equipped with weights to provide negative buoyancy.

If trench dewatering is necessary within wetlands, water would be discharged in accordance with BakkenLink's Storm Water Pollution Prevention Plan (SWPPP) (POD, Appendix XVII) and in a manner that does not cause erosion and does not discharge silt-laden water into waterbodies. Water would be discharged into an energy dissipation device/sediment filtration device such as a straw bale structure or geotextile filter bag. Dewatering structures would be sized to handle the volume of water in the trench.

Construction mitigation measures would limit equipment working in wetlands to that necessary for clearing, excavation, fabricating, and installing the pipeline; backfilling the trench; and restoring the ROW. If equipment must operate within a wetland that cannot support the equipment weight without rutting, the contractor would use wide-track or balloon-tire construction equipment or conventional equipment operated from timber mats or prefabricated equipment mats. All timber mats, prefabricated equipment mats, and subsoil not used as trench backfill would be removed upon completion of construction. Therefore, the chance of a spill occurring at any specific wetland along the pipeline is very low.

Based on National Wetlands Inventory survey data and aerial interpretation, the Project would cross approximately 3.0 miles of wetlands. Crossed wetlands include Lake Sakakawea, freshwater ponds, and freshwater emergent wetland along the pipeline ROW. Of the estimated 0.781 spills postulated to occur during a 10-year period within the entire pipeline system, approximately 0.098 spills would be expected to occur within wetland areas (equivalent to 1 spill every 103 years). If any release did occur, it is likely that the total release volume of a spill would be 4 bbl or less based on historical spill volumes (Section 4.2, Spill Volume).

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 the toxic threshold required for fish and invertebrates (see Aquatic Organisms) also would not have toxic effects on 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. **Table 5-3** 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.

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

<u>Aquatic Organisms</u>

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 5-5** summarizes the acute toxicity values (USEPA 2001) 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 LC50 is the concentration of a compound necessary to cause 50 percent mortality in laboratory test organisms. For aquatic biota, most acute LC50 for monoaromatics range between 10 and 100 ppm. LC50 for the polyaromatic naphthalenes generally were between 1 and 10 ppm, while LC50 values for anthracene generally were less than 1 ppm.

Table 5-5 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

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

Species	Toxicity Values (ppm)				
	Benzene	Toluene	Xylenes	Naphthalene	Anthracene
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 mykis*)	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	---
Chlorella vulgaris	---	230	---	25	---
Microcystis aeruginosa	---	---	---	0.85	---
Nitzschia palea	---	---	---	2.8	---
Scenedesmus subspicatus	---	130	---	---	---
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 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 mollusks.

In aquatic environments, toxicity is a function of the concentration of a compound necessary to cause toxic effects combined with the compound's water solubility. For example, a compound may be highly toxic, but if it is not very soluble in water, then its toxicity to aquatic biota is relatively low. The toxicity of crude oil is dependent on the toxicity of its constituents. As an example, **Table 5-6** 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 of decane is much lower than for benzene or ethyl benzene 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. As an example, for this Project, it is unlikely that an oil spill into Lake Sakakawea would result in acute benzene toxicity to even the most sensitive fish species, given that benzene concentrations in affected areas would not be expected to reach a sufficient threshold of concentration.

Table 5-6 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 2001).

Relative toxicity = 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 evaporate, and the environmental persistence of this crude oil fraction tends to be low. High molecular weight aromatic compounds, including PAHs, are not very water-soluble and have a high affinity for organic material. Consequently, these compounds, if present, have limited bioavailability, which 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).

For this analysis, the potential impacts of benzene on Lake Sakakawea water resources following an oil spill were evaluated and are presented in **Appendix A**. The analysis includes a discussion of the fate and transport of benzene in the aquatic environment, as well as an estimation of benzene concentrations in the water based on a hypothetical release into Lake Sakakawea.

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 5-7 summarizes chronic toxicity values (most frequently measured as reduced reproduction, growth, or weight) of benzene to freshwater biota. 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 5-7 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 reproduction for those denoted with an asterisk (*). The test endpoint for other 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 toxicity tests (USEPA 2001). These toxicity threshold values are considered protective of acute and chronic effects to aquatic biota.

Tables 5-8 and **5-9** summarize a screening-level assessment of acute and chronic toxicity, respectively, to aquatic resources. Although trout 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. Broadly, acute toxicity potentially could 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 potentially also could 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 bbl) into moderate and large rivers would not pose a major toxicological threat. In small to moderate sized streams and rivers, some toxicity might occur in localized areas, such as backwaters where concentrations likely would be higher than in the mainstream of the river.

Table 5-8 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: 4 bbl		Small Spill: 50 bbl		Moderate Spill: 1,000 bbl		Large Spill: 10,000 bbl	
			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	1.7	4,766						
Lower Moderate Flow Stream	100	7.4	0.17	3,336	2.2	8,341				
Upper Moderate Flow Stream	1,000	7.4	0.017	2,502	0.2	6,256	4.4	25,024		
High Flow Stream	10,000	7.4	0.0017	1,430	0.02	3,575	0.4	14,299	4.4	142,993

Notes:

- Historical data indicate that the most probable spill volume would be 4 bbl 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 volume benzene content of the transported material (Marathon Oil 2010).
- 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 0.00211 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.

Table 5-9 Comparison of Estimated Benzene Concentrations Following a Bakken Crude Oil Spill to the Chronic Toxicity Thresholds 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: 4 bbl		Small Spill: 50 bbl		Moderate Spill: 1,000 bbl		Large Spill: 10,000 bbl	
			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	0.01	4,766	0.13	11,916				
Lower Moderate Flow Stream	100	1.4	0.001	3,336	0.013	8,341	0.26	33,365		
Upper Moderate Flow Stream	1,000	1.4	0.0001	2,502	0.0013	6,256	0.026	25,024	0.26	250,237
High Flow Stream	10,000	1.4	1.04E-05	1,430	0.00013	3,575	0.0026	14,299	0.026	142,993

Notes:

- Historical data indicate that the most probable spill volume would be 4 bbl 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 2010).
- It 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 since the chronic toxicity value was based on a 7-day exposure.
- Shading indicates concentrations that could potentially cause chronic toxicity to aquatic species. The darkest shading represents high probability of chronic toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of chronic toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of chronic toxicity (<toxicity threshold).
- Occurrence intervals are based on an overall predicted incident frequency of 0.00211 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.

The likelihood of a release into any single waterbody would be low, with a predicted occurrence interval of no more than once every 1,430 to 476,642 years (**Tables 5-8** and **5-9**). If any release did occur, it is likely that the total release volume of a spill would be 4 bbl 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.

5.3 LAKE SAKAKAWEA

Lake Sakakawea is a reservoir crossed by the pipeline. Its normal volume is 12,800,000 acre-feet, with a maximum capacity of 23,800,000 acre-feet (USACE 2007). The lake is used for drinking water, recreational activities, flood control, hydroelectric power, navigation, and irrigation. It also supports a coldwater fishery. Lake Sakakawea offers a wide range of water based recreational activities (USACE 2012). The lake offers swimming, boating, sailing, camping, and fishing. There also are camp grounds and a park located nearby. According to the Garrison Dam/Lake Sakakawea master plan prepared by the USACE (2007), Lake Sakakawea and the surrounding areas comprise a wide variety of habitats suitable for many different types of species. Garrison Dam National Fish Hatchery adds volume to some of the naturally reproducing fish populations.

As proposed, the pipe would be trenched across the bottom of the reservoir, so if a spill were to occur in Lake Sakakawea, the oil would immediately rise to the surface. Once at the water's surface, the oils would spread laterally, creating an oil slick. Lateral spread rates would be significantly reduced by the presence of ice. Emergency response teams would be dispatched and the oil contained and removed, even if ice is present. The magnitude of potential impacts would depend on the amount of oil released, where the oil spread prior to containment, and the amount of time prior to removal of the oil. If a spill were to occur, it is possible that there may be localized impacts to water quality and possible toxic effects to aquatic biota. Impacts to aquatic invertebrates and young fish may occur along shorelines and backwater areas where oil may be in contact with relatively small volumes of water; but, impacts to fish in the main portion of the reservoir are expected to be minimal. It is highly unlikely that a spill would impact drinking water, given the location of the drinking water intake and the distance (and associated time) from the pipeline. An in-depth, site-specific risk assessment for Lake Sakakawea is provided in **Appendix A.**

As an alternative to the trenched installation, waterbody crossings could be constructed using various methodologies including designed pipeline self-lowering, open-cut trenching, and/or HDD technology. The methodology for each waterbody location would be determined by the crossing size and sensitivity. If technically feasible, the HDD method would position the pipe tens to hundreds of feet below the lakebed. 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 waters of Lake Sakakawea. However, it is unlikely that the crossing could be directionally drilled due to the distance of the crossing.

5.3.1 Wildlife

According to the Garrison Dam/Lake Sakakawea master plan prepared by the USACE (2007), Lake Sakakawea and the surrounding areas comprise a wide variety of habitats suitable for many different types of species. Garrison Dam National Fish Hatchery adds volume to the naturally reproducing fish population. Several cold water fish species including rainbow smelt (*Osmerus mordax*) and Chinook salmon (*O. tshawytscha*) thrive near the riverine end of the lake. Warmer water species such as shovelnose and pallid sturgeon (*Scaphirhynchus platorynchusm* and *S. albus*), paddlefish (*S. platorynchus*), walleye (*Sander vitreus*), sauger (*Sander canadense*), northern pike (*Exos lucius*), and common carp (*Cyprinus carpio*) are found inhabiting the delta at the north end of the lake.

Large mammals including white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), mountain lions (*Puma concolor*), and pronghorn (*Antilocapra americana*) are commonly present in the area. Smaller mammals such as cottontail rabbit (*Sylvilagus floridanus*); myotis (*Myotis lucifugus* and *M. septentrionalis*); black-tailed prairie dogs (Cynomys ludovicianus); and many different species of bats, squirrels, shrews, and mice also are present. Species of birds that may be present near the crossing at Lake Sakakawea include the least tern (*Sterna antillarum*), piping plover (*Charadrius melodus*), and whooping crane (*Grus americana*). However, it should be noted that over 365 bird species have been known to occur in the area.

According to the U.S. Fish and Wildlife Service (USFWS), eight species occurring in the Lake Sakakawea area are federally listed or proposed to be federally listed threatened and endangered species. The black-footed ferret (*Mustela nigripes*), whooping crane, gray wolf (*Canis lupus*), interior least tern, and pallid sturgeon (*S. albus*) are listed as endangered, while the piping plover is listed as threatened (USACE 2007). The northern long-eared bat (*M. septentrionalis*) and the rufa red knot (*Calidris canutus rufa*) are proposed for listing as endangered and threatened, respectively.

5.4 RISK TO 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 are defined by federal regulation (49 CFR 195.6 and 195.450) and include populated areas, designated zones around public drinking water intakes, and unusually sensitive ecologically resource areas that could be damaged by a hazardous liquid pipeline release. **Table 5-10** 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 actually might not 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. Portions of the pipeline that potentially could affect HCAs would be subject to higher levels of inspection, as per 49 CFR 195.

Assuming that 0.781 spills occurred along the Project in a 10-year period, it is estimated that approximately 0.049 of these spills 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 5-11** shows the predicted number of spills and their anticipated sizes.

Table 5-10 Mileage Summary of Pipeline Segments that "Could Affect" PHMSA-defined HCAs

County	Miles of Pipeline				Projected Number of Spills in 10 years (occurrence interval in years)			
	Populated Areas	Drinking Water	Ecologically Sensitive Area	Total in HCAs[1]	Populated Areas	Drinking Water	Ecologically Sensitive Area	Total HCAs[1]
McKenzie	0.0	0.0	0.72	0.72	0 (na)	0 (na)	0.0152 (658)	0.0152 (658)
Williams	0.0	0.0	1.59	1.59	0 (na)	0 (na)	0.0335 (298)	0.0335 (298)
Project Total	**0.0**	**0.0**	**2.31**	**2.31**	**0 (na)**	**0 (na)**	**0.0487 (205)**	**0.0487 (205)**

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

Notes: (na) indicates no PHMSA-defined populated area within the segment.

Projected number of spills in 10 years and occurrence interval were conservatively estimated based on the conservative probability of spills (0.00211 incidents/mile*year). This conservative analysis intentionally overestimates the potential risk, and assumes risk is evenly distributed 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.

Table 5-11 Predicted Spills and Associated Volumes Within "Could Affect" Segments in 10-year Period

HCA Type	Miles of Pipe[1]	Total Number of Predicted Spills	<4 bbl	4 to 50 bbl	50 to 1,000 bbl	1,000 to 10,000 bbl
Populated Areas	0.0	0.0	0.0	0.0	0.0	0.0
Drinking Water Areas	0.0	0.0	0.0	0.0	0.0	0.0
Ecologically Sensitive Areas	2.31	0.0499	0.0244	0.0341	0.0122	0.0027

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 0.00211 incidents per mile per year (Section 4.1).

5.4.1 Populated Areas

The nearest PHMSA-defined populated area is located 13.7 miles from the proposed pipeline; therefore, no impacts are anticipated (**Table 5-11**).

5.4.2 Drinking Water

PHMSA identifies certain surface water and groundwater resources as drinking water unusually sensitive areas (USAs) (49 CFR 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 5-11**. Segments of the pipeline that potentially could affect HCAs would be subject to higher levels of inspection, as per 49 CFR 195.

5.4.3 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.

There are 2.31 miles of pipeline segments that potentially could reach ecologically sensitive areas as summarized in **Table 5-11**. Segments of the pipeline that potentially could affect HCAs would be subject to higher levels of inspection, as per 49 CFR 195.

5.4.4 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, BakkenLink 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.

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

For Homeland Security reasons, the precise risk and 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 to the document (**Appendix B, Not Provided**). Per federal regulations (Integrity Management Rule, 49 CFR 195), the site-specific evaluation of risk is an ongoing process and is regulated by PHMSA. As part of the compliance process, BakkenLink would need to develop and implement a risk-based integrity management program (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.

5.5 IMPACTS FROM CONSTRUCTION OF THE PROJECT AND ENVIRONMENTAL MEASURES

5.5.1 Soils

Soils in the Project area vary depending on the topography, slope orientation, and parent material from which the soil is derived. The Project area is located toward the center of the Williston Basin. The Greenhorn Formation, which consists of thin limestone and dark gray to black organic-rich shale, is found from the surface to a depth of approximately 4,000 feet. The Greenhorn is subdivided into lower and upper intervals of limestone and calcareous shale with a middle interval of shale. Near-surface sediment is of Recent, Pleistocene, or Tertiary age, and includes Sauk, Tippecanoe, Kaskaskia, Absaroka, Zuni, and Tejas sequences. Thirty-four soil types are found throughout the Project area. Each individual soil series may exist individually within the Project area or in combination with other soil types.

No permanent impacts to the soils in the Project area are anticipated as a result of pipeline installation or operation, except at those locations where new aboveground facilities are constructed, mainline valve sites are located, or pig receivers are placed. The majority of the soil disturbance along the proposed route would be limited to the construction ROW, but temporary access, staging areas, and additional temporary workspaces may be needed at select locations.

In order to prevent effects on the soil due to compaction by construction operations, topsoil stripping and/or soil decompaction techniques would be used during clearing, grading, and restoration activities.

Topsoil stripping would occur in the Project ROW above both the trench and the spoil side of the trench within the Project ROW along the entire length of the pipeline, except across USFS land. Across USFS land, topsoil would be stripped above the entire Project ROW (i.e., spoil, trench, and working side). In locations where topsoil is not stripped but significant compaction occurs, decompaction measures would be taken. Decompaction measures are further described in the Construction, Mitigation, and Reclamation Plan.

Soil impacts may occur due to wind and water erosion on areas that are disturbed during construction. Wind erosion would be more of a hazard in those portions with coarse-textured soils. Erosion potential can be influenced by the size of area being disturbed at any given time. Because the length of the pipeline would be disturbed in segments during the construction phase, erosion potential would be minimized. Grading may be required in some places to ensure safe working platforms for equipment, as well as to improve access roads. Generally, these areas would be on steep slopes that are not agriculturally productive. Dust control measures also would be taken to minimize wind erosion.

Soils crossed by the proposed Project would be susceptible to contamination from spills or leaks of liquids used during construction. BakkenLink has developed a Spill Prevention, Control, and Countermeasures Plan (SPCC Plan) that would outline methods to reduce spills or leaks. Any contaminated soils would be excavated and removed from the Project area, and the appropriate agencies would be notified as required. Procedures for handling contaminated soil are further described in the SPCC Plan. During construction, soil erosion will be minimized by implementing procedures described in BMPs, the SWPPP, and the Reclamation Plan. Also, topsoil and subsoil will be segregated; the topsoil will be stripped and stored separately from the subsoil and replaced with minimum handling. In rocky areas, an assessment of the soil handling requirements will be made by BakkenLink. On agricultural land, subsoil will be chisel-plowed, rock-picked, and leveled prior to the replacement of topsoil.

5.5.2 Vegetation and Soil Ecosystems

The Project area occurs in the Northwestern Great Plains (ecoregion III) (USGS 2012), which is a western mixed-grass and short-grass prairie ecosystem (Bryce et al. 1998). Native grasses include blue grama (*Bouteloua gracilis*), western wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella viridula*), prairie sandreed (*Calamovilfa longifolia*), and buffalograss (*Bouteloua dactyloides*). Common wetland vegetation includes various species of sedge (*Carex* spp.), bulrush (*Scirpus* spp.), and cattails (*Typha* spp.). Common plant species found in woody draws, coulees, and drainages include Juniper (*Juniperus* spp.), silver buffaloberry (*Shepherdia argentea*), and western snowberry (*Symphoricarpos occidentalis*).

The habitat types identified during the field surveys include mixed grass prairie, native prairie, forested upland, shrubland, wetlands, and agricultural fields. Northern mixed grass prairie can include wetlands, native grassland, and grass-shrub habitats, with riparian and floodplain forests along major drainages.

Temporary impacts would occur along the route and where access is needed for Project construction activities. Wooded or forest areas within the Project ROW primarily are associated with streams and wind breaks found near current or former homesteads. Any trees along the route would be protected to the extent practicable and in a manner compatible with safe operation, maintenance, and inspection of the pipeline.

Existing agricultural and grazing practices along the route have substantially altered the original vegetative landscape. Minimal impacts are expected to occur to native plant communities. Permanent vegetative impacts from pipeline construction are not anticipated. Temporarily disturbed areas that are normally cultivated would be available after Project construction. Areas not currently in agricultural use would be seeded with native seed mixes per USFS, USFWS, and Natural Resources Conservation Service recommendations, or as otherwise negotiated with private landowners.

BakkenLink would work closely with landowners to minimize adverse impacts to vegetation associated with construction of the pipeline. A survey would be conducted to document tree species and numbers that would be impacted by Project construction. Trees and shrubs would be replaced in accordance with the North Dakota Public Service Commission (PSC) tree and shrub mitigation specifications; and as required by other governing agencies. Generally, BakkenLink would conduct an inventory of trees and shrubs that would be removed during construction of the pipeline. Trees and shrubs would be replaced by the same species or similar species suitable for North Dakota growing conditions at a 2:1 replacement ratio. The replacement location(s) would be coordinated with the landowner(s). Documentation identifying the number, variety, type, location, and date of the replacement plantings would be filed with the PSC. Monitoring of the survival rate and overall condition of the plantings would be conducted for 3 years. If the survival rate is 75 percent or less, the PSC may require additional plantings.

BakkenLink will coordinate with appropriate agencies to identify other efficient restoration and mitigation measures following construction. For areas reclaimed along the ROW, monitoring of reclamation will be conducted for the first growing season following reclamation and every other year, for

5 years thereafter. Reclamation success will be based on the revegetation to 70 percent of the background cover as stipulated in the SWPPP. The Reclamation Plan will outline the procedures to be followed to return the land to pre-existing vegetative cover and land uses.

5.5.3 Wildlife

Impacts to wildlife would include modifications to habitat, and an increase of human activity in the area. Activities may result in temporary displacement of wildlife in the area and the disturbance of avian nest locations. The Migratory Bird Treaty Act of 1918 (16 U.S.C. §§ 703-712) protects bird species, including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds and their nests. These impacts would be temporary and permanent impacts are not anticipated. Activities closer to the construction would be more concentrated, and may temporarily displace nesting birds and wildlife, or destroy nests. The impact on terrestrial wildlife would be short-term and minimal, and permanent impacts are not anticipated.

Direct impacts to wildlife populations may include limited direct mortalities from pipeline construction, habitat loss or alteration, incremental habitat fragmentation, and animal displacement. Indirect impacts could include increased noise, additional human presence, and the potential for increased vehicle-related mortalities. The degree of the impacts on terrestrial wildlife species and their upland habitats would depend on factors such as the sensitivity of the species, seasonal use patterns, type and timing of Project activity, and physical parameters (e.g., topography, cover, forage, and climate).

To protect species protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act, a presence/absence survey for active nests would be conducted prior to construction. To minimize impacts, migratory birds and nests would be avoided during construction and operation of the pipeline. Any wildlife encountered during work activities would be avoided to the extent possible. Clearing and grubbing of the Project ROW would occur in the fall or early spring to discourage bird nesting. In the event clearing and grubbing of the ROW is not possible prior to the nesting season, nesting surveys for migratory birds would be conducted where suitable nesting habitat exists prior to construction. If active nests are encountered on the ROW, the USFWS would be consulted for instructions on avoidance and/or mitigation measures. Consultation with the USFWS regarding nesting avian species would be continued during construction activities.

Adverse impacts to special status species (i.e., federally listed, proposed, or USFS sensitive) are not anticipated. One USFS sensitive plant species (i.e., Hooker's townsend daisy) has been identified at four different locations within the construction ROW. Consultation with the USFS is ongoing regarding avoidance measures. If, during construction, additional special status species are encountered, construction would be halted and the USFS and USFWS would be notified and consulted for additional information on how to proceed. The proposed Project ROW does not include any areas designated as Wildlife Management Areas (North Dakota Game and Fish Department 2014) or USFWS Waterfowl Production Areas.

5.5.4 Groundwater

Construction activities could temporarily alter overland flow and groundwater recharge. Surface soil compaction caused by the operation of heavy equipment could reduce the soil's ability to absorb water, which could increase surface runoff and the potential for erosion. These impacts would be temporary and localized following proper and sufficient de-compaction during reclamation. More details can be found in the Construction, Mitigation and Reclamation Plan (Appendix XIII of POD).

Some dewatering of construction areas and the pipeline trench may occur; however, relatively small volumes are expected and effects on the overall groundwater system would be small and temporary. Potential impacts on the groundwater would include minor fluctuations in groundwater levels and/or increased turbidity within the aquifer adjacent to the activity. Because of the relatively small amount of water removed, the short duration of the activity, and the local discharge of the water, groundwater levels would quickly recover after pumping stops.

The greatest risk for impacts to groundwater would result from the accidental release of a hazardous substance during construction or from a release during operations of the pipeline. BakkenLink has developed a SPCC Plan and a SWPPP to address preventive and mitigation measures that would be used to avoid or minimize the potential impact of hazardous material spills during construction. The Project would be monitored through a fiber optic cable control system, which would alert operations personnel to any potential leaks. Additionally, communications equipment would be installed allowing valves to be operated remotely to minimize any potential impacts of a spill. Expected actuator locations include both sides of the Lake Sakakawea crossing.

5.5.5 Flowing Surface Waters

Construction of the Project could affect surface water in several ways. Clearing, grading, trenching, and soil stockpiling activities could temporarily alter overland flow. Surface soil compaction caused by the operation of heavy equipment could reduce the soil's ability to absorb water, which could increase surface runoff and the potential for ponding. These impacts would be localized and temporary following proper and sufficient de-compaction during reclamation (Appendix XIII of POD).

Environmentally sensitive areas such as wetlands and waterbodies, if necessary and warranted, can be by-passed underground with trenchless methods. When HDD is employed, inadvertent releases of drilling fluids and lubricants through seepage may occur, which sometimes can reach surface water(s). BakkenLink has developed an Inadvertent Returns Contingency Plan and Hydrostatic Test Plan, provided in POD Appendices XXI and XIV, respectively. The Project would be designed and constructed so it would not impede the flow of any waterway. The pipeline would be installed below the bed of the waterway, at a level so the channel bed gradient does not change.

During construction of the Project, the SWPPP and BMPs will be implemented to minimize storm water transport of sediment from disturbed areas to streams and wetlands. All Project-related storm water and hydrostatic test water discharges will be in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. Persons familiar with wetland and riparian identification will post signs at the edges of the wetland/waterbody features prior to construction. No aboveground facilities or staging areas will be constructed within wetlands, riparian areas, or other waters of the U.S. Additional temporary workspace will be located a minimum of 50 feet outside wetland boundaries. BMPs will be utilized at all wetland and waterbody crossings to minimize sedimentation. For areas where additional setbacks are deemed necessary to protect the resource, the applicability of the appropriate setback will be determined in consultation with agencies on a site-specific basis.

The surface water resources in the Project area would be managed and protected according to existing federal laws and policies regarding the use, storage, and disposal of the resource during the construction and operation of the Project. Surface water resource use and protection is administered under the following federal laws:

- Clean Water Act of 1972 (CWA), as amended (33 U.S.C. 1251 et seq.);
- Federal Land Policy and Management Act of 1976 (43 U.S.C. 1711–1712);
- NEPA (42 U.S.C. 4321); and
- Safe Drinking Water Act of 1974, as amended (42 U.S.C. 300 et seq.).

Water quality is protected under the Federal Water Pollution Control Act (as amended), otherwise known as the CWA. The CWA has developed rules for regulating discharges of pollutants into waters of the U.S. and also regulates water quality standards for surface waters. The CWA also has made it unlawful to discharge any pollutant from a point source into any navigable waters of the U.S., unless a permit has been obtained from the NPDES program.

A total of 20 waterbodies crossings were identified during the field surveys, of which 19 were intermittent and 1 perennial. Each intermittent and perennial waterbody is considered to be jurisdictional due to the presence of an ordinary high water mark. No hydrophytic vegetation was noted within the delineated streams. BakkenLink is proposing to use an open-cut crossing method for installing the pipeline through perennial and intermittent streams. If it is flowing, BakkenLink will flume the stream crossing to allow water to flow continuously during construction to eliminate the impoundment of each stream. More details on waterbody crossings can be found in Appendix IX of the POD.

The Project would be designed and constructed so it would not impede the flow of any waterway. Pipeline crossings would be scheduled at times when there is as little rainfall as possible to minimize the risks of debris, stockpiled soil, and other sources of sediment from being washed into water bodies or wetlands. Temporary erosion and sediment control BMPs would be installed across the entire width of the construction ROW, upslope of and on both sides of each waterbody crossing, after clearing, and before ground surface disturbance. No silt-laden/turbid discharge water from trench dewatering operations would be allowed to enter any waterbody or wetland. The pipeline would be installed below the bed of the waterway, at a level so the channel bed gradient does not change.

5.5.6 Wetlands, Reservoirs, and Lakes

The pipeline would be routed to avoid most wetland crossings. Wetlands that cannot be avoided would be crossed using open cut methods and mitigation measures. Standard wetland construction mitigation measures would include reducing construction ROW to 75 feet and limiting equipment working in wetlands to that essential for clearing the ROW, excavating the trench, fabricating and installing the pipeline, backfilling the trench, and restoring the ROW. In areas where access to the ROW is only available through the wetland area, non-essential equipment would be allowed to travel through wetlands only if the ground is firm enough, or has been stabilized, to avoid rutting. If rutting is anticipated, non-essential equipment would be allowed to travel through the wetlands only once, and essential equipment would need to be stabilized with prefabricated mats or terra mats. Areas that would be disturbed by excavation, grading, and construction traffic may increase sedimentation into a wetland area. Reasonable efforts would be employed to limit any sediment movement within the Project area. Following completion of pipeline installation, it is anticipated that there would be no additional impacts on wetlands or water quality. Permanent impacts are not anticipated.

Erosion and sediment control BMPs would be used during construction, operation, and maintenance of the pipeline to protect topsoil and minimize soil erosion into adjacent wetlands. Vegetation clearing would be limited to trees and shrubs, and excavation would be limited to the pipeline trench only. During clearing activities, sediment barriers would be installed and maintained adjacent to wetland areas and within temporary extra workspaces, as necessary, to minimize the potential for sediment runoff.

A qualified wetland specialist will mark the boundary of all wetlands and waterbodies within the construction ROW no more than 5 days before the commencement of construction activities. The wetland specialist will use either pink wetland delineation tape or pin flags to demarcate these boundaries. No construction activities will occur within the demarcated wetland or waterbody boundaries.

Biologists recorded and delineated 14 wetlands (mainly freshwater emergent) within the 250-foot-wide survey area centered on the proposed pipe centerline. There are 2.5 acres of wetland vegetation, hydric soils, and potential hydrologic functionality that are temporarily impacted. There are 0.1 acres of permanent disturbance that would occur within a wetland due to the construction of aboveground facilities.

6.0 BakkenLink'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. 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. BakkenLink plans to use a minimum depth of cover that will meet or exceed federal requirements outlined in 49 CFR 195.248. In most circumstances, depth of cover will be 36 inches (3 feet). This would substantially reduce the chance of third-party excavation damage, a leading cause of pipeline incidents.

Per federal regulations, BakkenLink would have a maintenance, inspection, and repair program that ensures the integrity of the pipeline during operations. BakkenLink'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.

BakkenLink 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 195.440 and API RP1162. Further, BakkenLink would complete regular visual inspections (ground or aerial) of the ROW as per 49 CFR 195.412, and monitor activity in the area to prevent unauthorized trespass or access.

To mitigate the effects of corrosion on the pipeline, BakkenLink would apply a FBE or other type of protective pipeline coating to the external surface of the pipe to prevent corrosion. A cathodic protection system would be installed, comprised 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 pipeline would be inspected with a smart in-line inspection tool, which measures and records internal and external metal loss, thereby allowing BakkenLink the ability to proactively detect signs of corrosion.

In addition, the pipeline would be monitored 24 hours a day, 365 days a year from the OCC using a sophisticated SCADA system. BakkenLink 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 BakkenLink SCADA system. Remote monitoring typically is able to detect leaks down to approximately 25 to 30 percent of the pipeline flow rate.

- Software-based volume balance systems that would monitor receipt and delivery volumes. These systems typically are able to detect leaks down to approximately 5 percent of the pipeline flow rate.
- CPM or model-based leak detection systems that would break the pipeline into smaller segments and monitor each of these segments on a mass balance basis. These systems typically are capable of detecting leaks down to a level of approximately 1.5 to 2 percent of pipeline flow rate.
- Atmos Pipe is the Real Time Statistical System (RTSS) which was originally developed by Shell between 1988 and 1994 and has continuously been developed by Atmos International since then. It is pipeline leak detection software developed specifically to provide high sensitivity (in detecting leaks) with high reliability (few false alarms) in all operating conditions. Atmos Pipe applies Sequential Probability Ratio Test (SPRT) to detect changes in the overall behavior of flow and pressure at the receipt and delivery points. Although the control and operation may vary from one pipeline to another, the relationship between the pipeline pressure and flow will always change after a leak develops in a pipeline. For example, a leak will normally cause the pipeline pressure to decrease and introduce a discrepancy between the receipt and delivery flow-rate. Atmos Pipe is designed to recognize these patterns. Leak determination is based on probability calculations at regular sample intervals. Although the flow and pressure in a pipeline fluctuate due to operational changes, statistically, the total mass entering and leaving a network must be balanced by the inventory variation inside the network. Such a balance cannot be maintained if a leak occurs in a network. The deviation from the established balance is detected by SPRT. The combination of SPRT with pattern recognition provides Atmos Pipe a very high level of system reliability i.e. minimum spurious alarms. Computer-based, non-real time accumulated gain/loss volume trending that would assist in identifying low rate or seepage releases below the 1.5 to 2 percent by volume detection thresholds.
- 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 leak detection 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. In addition, there would be a redundant, stand-by OCC to be used in case of emergency.

After contracts are awarded, a Project Safety Plan and Procedures document would be developed with the Contractor. All work would be conducted in compliance with the Safety Plan and Procedures. A copy of the Safety Plan would be maintained on site at all times during work. During construction planning, emergency egress and nearest urgent care facilities would be identified and used in the Safety Plan.

The Contractor would provide an emergency conveyance vehicle (a Suburban equivalent) for transportation of an injured worker. At a minimum, this vehicle would be equipped with stretcher/cot and basic first aid supplies. BakkenLink would require the construction crew involved in a serious or critical incident injury to worker(s) and crews with similar work operations to stand down from work until an investigation is completed and mitigations put in place to minimize the risk of the incident occurring again.

Lastly, BakkenLink would have an ERP in place to respond to incidents. The ERP would contain comprehensive manuals, detailed training plans, equipment requirements, resources plans, auditing, change management and continuous improvement processes. The IMP (49 CFR 195) and ERP would ensure BakkenLink operates the pipeline in an environmentally responsible manner.

7.0 Summary

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 regulations, application of BakkenLink's IMPs and ERP, as well as adherence to 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.

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 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.

LC50

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.

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 (SCADA)

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.

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.

BakkenLink Risk Assessment and Environmental Consequence Analysis

Attachment A Lake Sakakawea Site-specific Risk Assessment

Stantec

January 2015

Attachment A

Lake Sakakawea Site-specific
Risk Assessment

Table of Contents

ABBREVIATIONS .... A-i

1.0 PURPOSE 1.1

2.0 BACKGROUND 2.2
2.1 BAKKEN CRUDE OIL 2.2
2.2 BENZENE 2.2
2.3 LAKE SAKAKAWEA 2.3

3.0 METHODOLOGY 3.1
3.1 MUNICIPAL DRINKING WATER RESOURCES 3.1
3.2 WILDLIFE AND AQUATIC SPECIES 3.2

4.0 RESULTS 4.1
4.1 MUNICIPAL DRINKING WATER RESOURCES 4.1
4.2 WILDIFE AND AQUATIC SPECIES 4.1

5.0 DISCUSSION 5.1
5.1 AQUATIC RESOURCES MODELING DISCUSSION 5.1
5.1.1 Interpretation of Municipal Drinking Water Resource Results 5.1
5.1.2 Interpretation of Wildlife and Aquatic Species Results 5.1
5.1.3 Chronic Toxicity 5.1
5.2 SPECIES OF CONCERN 5.2
5.2.1 Piping Plover 5.2
5.2.2 Interior Least Tern 5.3
5.2.3 Pallid Sturgeon 5.3
5.2.4 Protective Procedures 5.3
5.3 WINTER SPILL SCENARIO 5.4
5.4 FISH CONTAMINATION 5.4

6.0 SUMMARY 6.1

7.0 REFERENCES 7.1

LIST OF TABLES

Table 2-1 Properties of Bakken Crude 2.2
Table 2-2 Acute Toxicity of Crude Oil Hydrocarbons to *Daphnia magna* 2.3
Table 2-3 Occurrence Interval by Spill Volume 2.4
Table 3-1 Distribution of Spill Volumes 3.2
Table 4-1 Results of Benzene Modeling in Water near Four Bears Village and New Town 4.1
Table 4-2 Results of Benzene Modeling in Water 24 Hours After Release 4.1

LIST OF FIGURES

Figure 5-1 Bakken Crude Weathering 5.2

Abbreviations

°C	degrees Celsius
API	American Petroleum Institute
BakkenLink	BakkenLink Pipeline LLC
bbl	barrels
FWP	Montana Fish, Wildlife & Parks
GIS	geographical information system
L	liters
LC_{50}	lethal concentration to 50 percent of the test organisms within a specified time
LLC	Limited Liability Corporation
MCL	maximum contaminant level
mg	milligrams
mg/L	milligrams per liter
mPa•s	Millipascal-second
NOAA	National Oceanic and Atmospheric Administration
ppm	parts per million
U.S.	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

1.0 Purpose

Lake Sakakawea is the United States' (U.S.) third largest manmade lake and has over 1,500 miles of shoreline in close proximity to a number of towns as well as sensitive habitat for federally threatened and endangered species. BakkenLink Pipeline LLC (BakkenLink) has proposed to construct a crude oil pipeline crossing Lake Sakakawea and, as such, has requested that Stantec Consulting Services Inc. identify the impacts of a pipeline release beneath the lake.

The purpose of this report is to quantify the potential impacts of chemicals of concern to Lake Sakakawea water resources following a subsurface crude oil pipeline rupture. Benzene was selected as the primary chemical of concern because it has: 1) relatively high water solubility compared to other oil constituents; 2) the lowest drinking water standard; and 3) a substantially higher acute toxicity relative to other crude oil constituents. This risk assessment provides a highly conservative estimation of benzene concentrations in water based on a hypothetical release into Lake Sakakawea.

2.0 Background

2.1 BAKKEN CRUDE OIL

Bakken crude oil is classified as a light, sweet crude oil. Some primary physical properties are identified in **Table 2-1**. Bakken crude oil has a very high American Petroleum Institute (API) gravity of 42.1. Because oils with API gravities greater than 10 will float on water, Bakken crude oil would be extremely buoyant and rise quickly to the water's surface following a release. The oil also has a very low viscosity (2 to 4 centistokes at ambient temperatures), indicating that the oil will spread across the water's surface and form a thin slick on top of water. Crude oils tend to spread across surface waters at a rate between 100 to 300 meters per hour (Ramade 1978). Given Bakken crude oil's physical properties, this assessment assumes that Bakken crude oil spreading would occur at 300 meters per hour. Spreading increases the surface area of the spill and would facilitate evaporation, the primary environmental fate process governing the fate of volatile organic compounds within the oil, like benzene. Bakken crude oil contains 0.28 percent benzene by volume (Shafizadeh 2010).

Table 2-1 Properties of Bakken Crude

Parameter	Unit	Bakken Crude (North Dakota)
Viscosity	mPa•s @ 40 degrees Celsius (°C)	2.76
Gravity	API	42.1
Benzene	Percent by volume	0.28
Pour Point	°C	-12

An in-depth overview of the expected environmental fate and transport of crude oil in a water body such as Lake Sakakawea is provided in Section 5.2.2.2 of the risk assessment.

2.2 BENZENE

Benzene is a colorless liquid with a sweet odor that is associated with various impacts in humans and wildlife (U.S. Department of Health 2007). Benzene is highly volatile and moderately soluble in water. Evaporation is the controlling physical property in the environmental fate and transport of benzene. While only a comparatively small amount of benzene potentially would solubilize into water from an oil release, this is an important fate process as it can impact water quality. Benzene that partitions into the water column to a 1-meter depth would have a half-life of 4.8 hours due to its rapid volatilization (Keykendall 2010).

Benzene was selected as the primary chemical of concern due to its combination of solubility and toxicity. Benzene tends to be the most toxic crude oil constituent based on drinking water standards and aquatic toxicity. **Table 2-2** demonstrates how the combination of solubility and toxicity result in a relative toxicity of benzene that is orders of magnitude greater than other crude oil constituents. Consequently, screening for environmental impacts based on benzene as the benchmark is considered a conservative method of analysis.

Table 2-2 Acute Toxicity of Crude Oil Hydrocarbons to *Daphnia magna*

Compound	48-hr LC_{50} (parts per million [ppm])[1]	Optimum Solubility (ppm)	Relative Toxicity[2]
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

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

[2] Relative toxicity = optimum solubility/LC_{50}.

2.3 LAKE SAKAKAWEA

Lake Sakakawea is a reservoir crossed by the pipeline. Its normal volume is 12,800,000 acre-feet, with a maximum capacity of 23,800,000 acre-feet (USACE 2007). The lake is used for drinking water, recreational activities, flood control, hydroelectric power, navigation, and irrigation. It also supports a coldwater fishery.

Given the incident frequency of 0.00211 incidents/mile*year (Section 4.1 of Risk Assessment) and the Lake Sakakawea crossing distance of 2.5 miles, the baseline occurrence interval for a release on this portion of the line is 190 years (1 spill in 190 years). Occurrence intervals for specific spill sizes are presented in **Table 2-3**.

Table 2-3 Occurrence Interval by Spill Volume

Crossing Distance (miles)	Baseline Occurrence Interval (years)	Occurrence Interval (years) by Spill Volume (bbl)			
		4	50	1,000	10,000
2.5	190	379	654	3,791	37,915

The crossing of a major water body is not a unique trait to this Project. According to a Report to Congress (2012), there are at least 2,572 liquid pipeline crossings of water bodies in the U.S. that are greater than 100 feet in width (i.e., a "major" water body). During the 21-year span between 1991 and 2012, only 20 accidents involving water crossings occurred. Of those, 16 were associated with a depletion of cover, sometimes in the waterway and other times in new channels cut by floodwaters. These 16 accidents represent 0.3 percent of all reported accidents for liquid pipelines during the time period. The number of incidents was evenly distributed among crude oil, refined petroleum products, and highly volatile liquids. The salient points are: 1) water body crossings by pipelines are extremely common, 2) the number of incidents at these locations are low, and 3) the safety of the pipeline is not affected by the material transported.

3.0 Methodology

The model used to estimate benzene concentrations within the water column combines site-specific conditions (e.g., surface area of Lake Sakakawea, distance to drinking water receptors) and highly conservative modeling assumptions.

Key Assumption 1: The model assumed that all benzene within the spilled oil would solubilize directly into the water. This is an extremely conservative assumption given the dominating fate process of evaporation and the relatively low solubility of benzene. Under field conditions, actual concentrations of benzene would not approach optimal solubility limits because benzene preferentially remains in the crude oil or evaporates, rather than dissolving into the water.

Key Assumption 2: The model assumed that the half-life of benzene in water 1-meter deep as a result of volatilization is 4.8 hours, based on empirical data (Keykendall 2010).

Key Assumption 3: Bakken crude oil was assumed to spread at a rate of 300 meters per hour (Ramade 1978).

Key Assumption 4: The analysis assumes no emergency response containment or cleanup.

Key Assumption 5: The analysis did not account for evaporation from the oil's surface, even though this is the dominant fate process.

Key Assumption 6: The model assumes that the 300-meter per hour spread rate of crude oil will be the primary driver in environmental transport of crude oil, thereby overriding winds and current.

3.1 MUNICIPAL DRINKING WATER RESOURCES

Four Bears Village and New Town are the nearest communities to BakkenLink's crossing of Lake Sakakawea. The surface area of Lake Sakakawea between the pipeline and the communities was calculated by geographical information system (GIS) (assuming uniform spread east and west of the pipeline). This surface area was then converted to a volume of water in cubic meters, assuming that the benzene solubilizes to a depth of 1 meter. Although Lake Sakakawea is much deeper than 1 meter at the Project area, this assumption is realistic due to the buoyancy of Bakken crude and benzene and is conservative in that it maximizes benzene concentrations.

Based on a transport rate of 300 meters per hour from a hypothetical rupture point at the center of the lake crossing, it would take 114 hours for a spill to reach Four Bears Village and New Town, as diagrammed in **Attachment 1**, **Figure A-1**.

After this calculation was completed, the volume and weight of benzene within each release volume in **Table 3-1** were determined based on the median benzene content of Bakken crude (0.28 percent by volume). Release volumes modeled were 4, 50, 1,000, and 10,000 barrels (bbl) (**Table 3-1**). The spill volumes examined range from the median spill volume of 4 bbl up to 10,000 bbl, representing the most common spill size to rare occurrences (0.5 percent of all spills) respectively, based on PHMSA data (PHMSA 2014).

Table 3-1 Distribution of Spill Volumes

Spill Volume (bbl)	% of Spills Smaller[1]
4	50
50	79
1,000	95
10,000	99.5

[1] Values derived from PHMSA historical incident data.

To establish conservative benzene concentrations in the water at Four Bears Village and New Town, the amount of benzene from each of the four release volumes was divided by the volume of water into which the chemical would solubilize and adjusted to account for the 4.8-hour half-life of benzene in a column of water 1 meter deep.

The analysis did not account for evaporation from the oil's surface or emergency containment and cleanup.

The results of this analysis are benzene concentrations in the water surrounding Four Bears Village and New Town that were compared with the USEPA drinking water maximum contaminant level (MCL). Results are presented in Chapter 4.0.

3.2 WILDLIFE AND AQUATIC SPECIES

To assess the potential impacts of a subsurface crude oil release to wildlife and aquatic species, the same methods detailed in Section 3.1.1 were utilized, but for a smaller 24-hour spread due to the proximity and mobility of wildlife and aquatic receptors rather than the 114-hour spread necessary for a release to reach Four Bears Village and New Town. This resulted in a smaller volume of contaminated water with a higher concentration of benzene, which was then compared to acute toxicity levels for various aquatic species. Results are presented in Chapter 4.0.

4.0 Results

4.1 MUNICIPAL DRINKING WATER RESOURCES

Results of the modeling of benzene concentrations in water surrounding Four Bears Village and New Town are provided in **Table 4-1**.

Table 4-1 Results of Benzene Modeling in Water near Four Bears Village and New Town

Spill Volume (bbl)	Benzene Concentration in Water at Four Bears Village and New Town (milligrams per liter [mg/L])[1]
4	4.1E-13
50	5.2E-12
1,000	1.0E-10
10,000	1.0E-09

[1] Calculated using water volume of $2.68x10^{11}$ L, the surface area of a release reaching Four Bears Village and New Town multiplied by a depth of 1 meter and converted to liters.

4.2 WILDIFE AND AQUATIC SPECIES

The results of the modeling of benzene concentrations in affected water 24 hours after a release are provided in **Table 4-2**.

Spill Volume (bbl)	Benzene Concentration in Water 24 Hours After Release (mg/L)[1]
4	8.3E-07
50	1.0E-05
1,000	0.00021
10,000	0.0021

[1] Calculated using water volume of $5.89x10^{9}$ L, the surface area of a release after spreading for 24 hours multiplied by a depth of one meter and converted to liters.

5.0 Discussion

5.1 AQUATIC RESOURCES MODELING DISCUSSION

5.1.1 Interpretation of Municipal Drinking Water Resource Results

The results of the 114-hour spill model indicate that, assuming benzene is solubilized completely into the water and accounting only for the half-life within the water column, the estimated concentration would be significantly below levels capable of raising water quality concerns. After 114 hours, a worst-case scenario release into the lake will produce benzene concentrations well below the U.S. Environmental Protection Agency (USEPA) MCL of 0.005 mg/L, even when assuming that benzene will solubilize completely from the oil into the water.

5.1.2 Interpretation of Wildlife and Aquatic Species Results

The results of the 24-hour spill model indicate that, assuming benzene is solubilized completely into the water and accounting only for the half-life within the water column, the estimated concentration would be orders of magnitude below levels capable of causing toxicity to sensitive aquatic species.

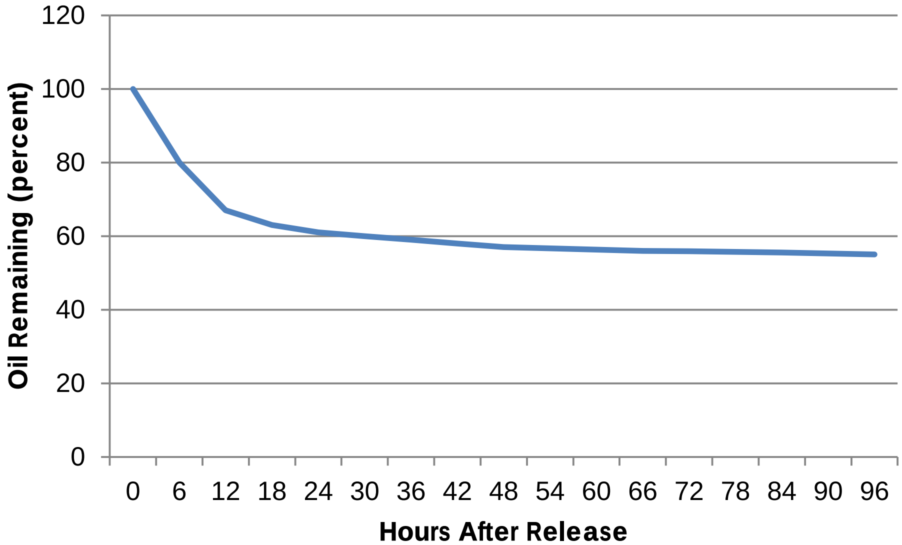
The acute toxicity level of benzene in rainbow trout (*Oncorhyncus mykiss*), one of the most sensitive species of freshwater fish, is 7.4 mg/L over a 4-day exposure period (**Table 5-5** in Risk Assessment). This represents a benzene concentration over two orders of magnitude greater than a worst-case scenario release into Lake Sakakawea is capable of eliciting. Although not present in Lake Sakakawea, rainbow trout are toxicological test organisms frequently used to evaluate toxicity because they generally are the most sensitive species to many chemicals. Thus, the use of rainbow trout is a conservative and appropriate model organism for toxicity.

5.1.3 Chronic Toxicity

Chronic toxicity levels, although lower than acute toxicity levels, are based upon 7-day exposure periods. The chronic toxicity level of benzene in coho salmon (*Oncorhynchus kitsutch*), one of the most sensitive species of freshwater fish, is 1.4 ppm. Due to the ephemeral nature of benzene, chronic toxicity levels will not be sustained at levels over 1.4 ppm for the interval necessary to raise concern.

Additionally, due to the low probability of a spill, high probability that any spill will be relatively small (50 bbl or less in 80 percent of cases), and requirement for containment and cleanup, the potential for significant long-term impacts is very low. Additionally, the weathering of crude oil due to natural processes (e.g., evaporation, photodegradation, biodegradation, etc.) dictates that any lingering crude oil will naturally dissipate to a fraction of its original volume within a matter of days (**Figure 5-1**).

Figure 5-1 Bakken Crude Weathering[1]



[1] Calculated using National Oceanic and Atmospheric Administration's Automated Data Inquiry for Oil Spills oil weathering model.

5.2 SPECIES OF CONCERN

Lake Sakakawea provides habitat for many wildlife species, several of which are federally listed threatened (piping plover) and endangered (interior least tern, pallid sturgeon).

5.2.1 Piping Plover

Although the piping plover (*Charadrius melodus*) was listed as endangered December 11, 1985, the populations near Lake Sakakawea fall under the threatened classification (50 FR 50726; U.S. Fish and Wildlife Service [USFWS] 2009). Piping plover nesting occurrence in the Project area is unknown, though consultation with the USFWS identified suitable breeding and critical habitat within the Project area at Lake Sakakawea (USFWS 2013; 67 FR 57638).

Piping plover feed by probing the sand and mud for insects, small crustaceans, and other invertebrates in or near shallow water (Sherfy et al. 2012). These tendencies could lead to contact with a crude oil spill, resulting in adverse effects such as oiling of plumage, ingestion of crude oil from contaminated plumage and prey, transfer of crude oil to eggs and young, and inhalation of volatile organic compounds.

Although benzene does not bioaccummulate or biomagnify, consumption of fresh oil directly from plumage or contaminated prey potentially could lead to acute toxicity, if ingested in sufficient amounts. Severe adverse impacts to the piping plover are most likely to occur due to physical impacts, such as oiling of feathers, rather than toxicological impacts. Because piping plover are not piscivorous and often feed on the shore, physical impacts to this species may be less severe compared to those of interior least tern, as piping plover are less likely to dive through the oil slick while gathering prey.

5.2.2 Interior Least Tern

The interior least tern (*Sterna antillarum* ssp. *athalassos*) was listed as endangered on May 28, 1985 (50 FR 21784). Although breeding habitat for the interior least tern generally is restricted to less altered river segments, it has been known to breed on the shores of Lake Sakakawea. The interior least tern also is piscivorous, feeding in shallow waters of rivers, streams, and lakes. These characteristics could lead to physical contact with a crude oil spill, resulting in adverse effects such as oiling of plumage, ingestion of crude oil from contaminated plumage and prey, and transfer of crude oil to eggs and young.

Although benzene does not bioaccummulate or biomagnify, consumption of fresh oil directly from plumage or contaminated prey could potentially lead to acute toxicity, if ingested in sufficient amounts. Severe adverse impacts to the interior least tern are most likely to occur due to physical impacts, such as oiling of feathers, rather than toxicological impacts.

5.2.3 Pallid Sturgeon

The pallid sturgeon (*Scaphirhynchus albus*) was listed as endangered on September 6, 1990 (55 FR 36641). Although pallid sturgeon are extremely rare, they have a relatively wide distribution in the U.S., particularly in the Missouri and Mississippi river basins. The North Dakota Game and Fish Department has found larval and mature pallid sturgeon in parts of Lake Sakakawea, therefore leading the USFWS to identify the lake crossing as potential habitat for pallid sturgeon.

Despite this designation, it is unlikely that an oil spill into Lake Sakakawea would result in acute benzene toxicity to pallid sturgeon. Even following a worst-case scenario spill volume, benzene levels in affected areas are not expected to raise benzene concentrations to a level sufficient to cause acute toxicity in the most sensitive fish species, such as rainbow trout.

5.2.4 Protective Procedures

Although the chance of a release into Lake Sakakawea is low (as presented in **Table 2-3**), there is a small probability that a release may occur while piping plover and interior least tern are in the area. The USFWS has determined that these species are likely to be in the area between April 1 and August 31. Based on the spill frequency of 0.00211 incidents/mile*year, it is estimated that a spill will occur while piping plover and interior least tern are in the area approximately once every 473 years.

To mitigate the potential for impacts to interior least tern and piping plover, BakkenLink will incorporate the following mitigation measures into its Emergency Response Plan:

> If a spill occurs between April 1 and August 31: 1) Contact the USFWS; 2) Deploy a trained wildlife biologist to the site to determine if either species is present and to locate aggregation and potential nesting areas; 3) If approved by USFWS, employ scare tactics at the spill site to ward birds away from the site without disrupting nesting behavior;

4) capture, clean, and rehabilitate oiled wildlife; and 5) Deploy boom to protect these species' nesting areas.

5.3 WINTER SPILL SCENARIO

During the winter, Lake Sakakawea freezes over with a layer of ice that, in very cold years, can be as thick as 36 to 48 inches. This layer of ice will trap oil released below the lake's surface and prevent benzene evaporation from occurring. Therefore, during the winter, evaporative loss will be negligible, and will allow a longer contact between the crude oil and the water column. However, natural undulations in the bottom of the ice will trap the material and prevent it from spreading horizontally, potentially causing very localized impacts to organisms in prolonged contact with the near-surface water (e.g., phytoplankton) (Dickens 2011). Exposure to fish deeper in the water column would not likely experience adverse impacts.

The natural containment of winter releases facilitates cleanup efforts as the pockets of oil can be drilled to and removed using vacuum trucks. Thus, winter releases are predicted to have lower impacts, particularly with respect to area of extent, as compared to releases occurring during the warmer seasons.

5.4 FISH CONTAMINATION

In the event of a spill, the concentration of contaminants in fish flesh would be examined as part of the human health impact assessment. Because benzene does not bioaccumulate or biomagnify, concentrations in fish are not likely to cause human health effects. However, it is possible that a precautionary fish consumption advisory will be put into effect following a spill into Lake Sakakawea.

Following the Enbridge oil spill in the Kalamazoo River and the ExxonMobile oil spill in the Yellowstone River, the Michigan Department of Community Health and Montana Fish, Wildlife & Parks (FWP), respectively, issued precautionary fish consumption advisories for the regions affected by the spills (FWP 2011; Minicuci 2012). Both agencies tested fish to establish chemical concentrations present within the flesh and, based on these results, lifted the advisories ("Montana Sport Fishing Consumption" n.d.; Minicuci 2012). Therefore, it is probable that a similar precaution will be taken for Lake Sakakawea, though the threat of fish contamination is unlikely.

6.0 Summary

Concentrations of benzene in water were modeled for several hypothetical crude oil releases originating from the BakkenLink Pipeline crossing of Lake Sakakawea. Benzene was chosen as the primary contaminant of concern due to its relatively high toxicity and solubility, which results in the highest relative toxicity of crude oil hydrocarbons.

Results indicate that by the time a release reaches Four Bears Village and New Town, benzene concentrations in the water are highly unlikely to exceed water quality standards even when conservative assumptions are used. Evaporative loss and emergency containment and cleanup would further reduce the potential for impacts to water quality. Consequently, crude oil and its constituent benzene do not pose a significant or reasonable threat to water quality adjacent to Four Bears Village and New Town.

Similarly, benzene concentrations would be orders of magnitude lower than those required to cause adverse impacts to aquatic species during open water conditions. Under ice conditions, very localized impacts to aquatic biota occupying the near surface, such as phytoplankton, might occur, but are not anticipated for pelagic (open water) and benthic (bottom) dwelling species. Widespread toxicity to aquatic organisms is unlikely to occur following a release of Bakken crude into Lake Sakakawea, regardless of spill volume size.

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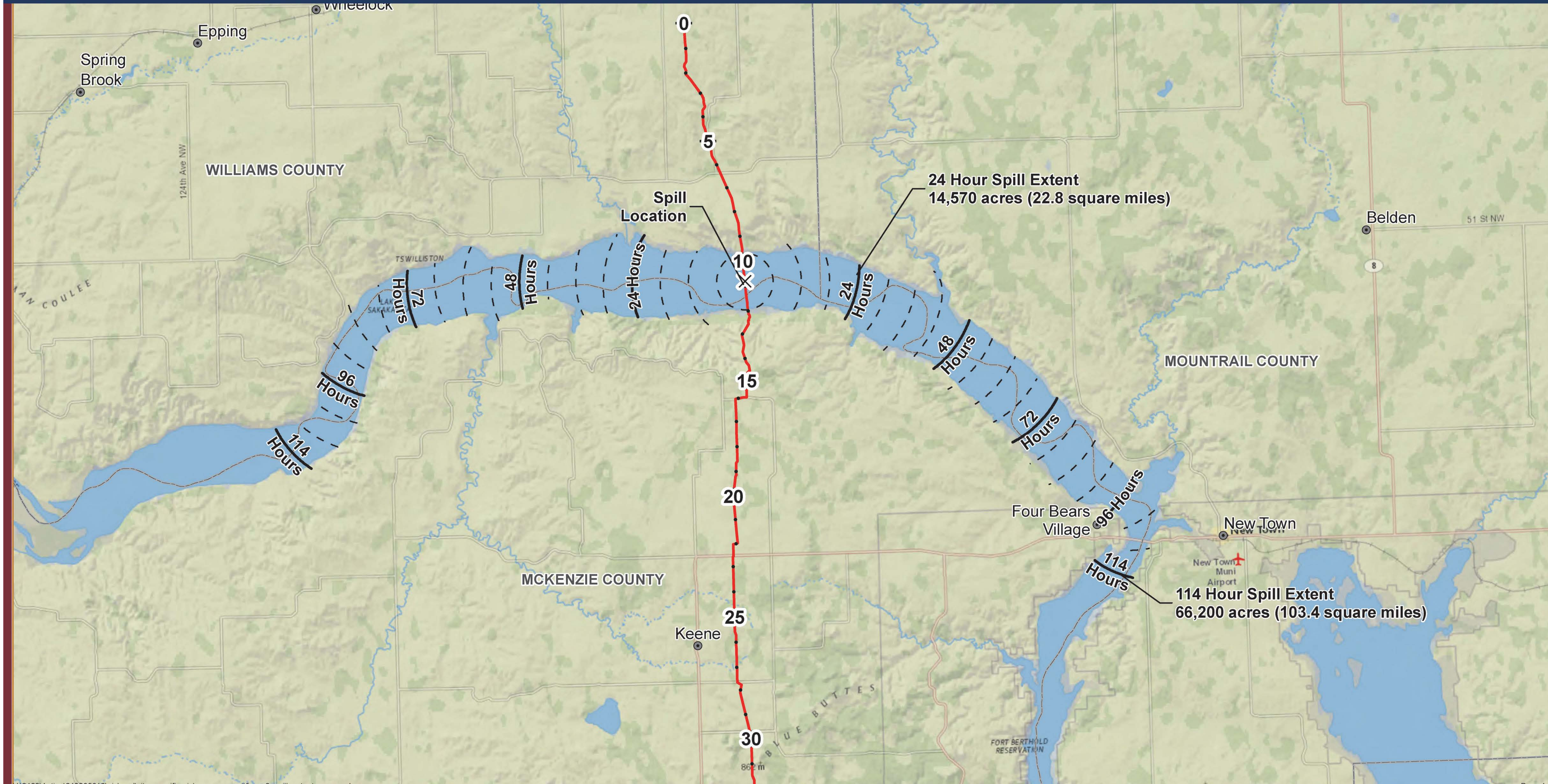
Attachment 1 Figure A-1



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Page 1 of 1

Map Area Shown in Red

BakkenLink Dry Creek to Beaver Lodge Project

Figure A-1. Spill Extent Map

Location
Williams & McKenzie Co., ND

Project Information
Project Number: 212205012
Last Modified: November 05, 2013

0 10,000 20,000
Feet

Legend
24-Hour Spill Extent
6-Hour Spill Extent
Pipeline Segment
Spill Location

Data Sources include: NDNHI, Stantec, USGS, USFWS, and ESRI.

	Initials	Date
Prepared by	BLC	04/29/2013
Peer Review by		
Final Review by		

DRAFT

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Attachment B Analysis of High Consequence Areas

HCA figure is not included but can be made available to agencies only upon request.

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Appendix B
Geologic and Horizontal Directional Drill Review of the Proposed Crossing and Missouri River/Lake Sakakawea Crossing Alternatives

Geologic and Horizontal Directional Drill Review of the Proposed Crossing and Missouri River/Lake Sakakawea Crossing Alternatives

BakkenLink Dry Creek to Beaver Lodge Pipeline Project

Prepared for:
BakkenLink Pipeline LLC

Prepared by:
Stantec Consulting Services Inc.

January 2015

Sign-off Sheet

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Table of Contents

ABBREVIATIONS II

1.0 INTRODUCTION 1.1

2.0 PROPOSED CROSSING 2.1
2.1 GEOLOGIC OVERVIEW 2.1
2.2 HDD OVERVIEW 2.1

3.0 ALTERNATIVE LAKE CROSSINGS 3.1
3.1 SIX MILES WEST CROSSING ALTERNATIVE 3.1
3.1.1 Geologic Overview 3.1
3.1.2 HDD Overview 3.1
3.2 WILLISTON CROSSING ALTERNATIVE 3.1
3.2.1 Geologic Overview 3.1
3.2.2 HDD Overview 3.4
3.3 NEW TOWN CROSSING ALTERNATIVE 3.4
3.3.1 Geologic Overview 3.4
3.3.2 HDD Overview 3.6

4.0 SUMMARY 4.1

5.0 REFERENCES 5.1

LIST OF FIGURES

Figure B-1 Lake Sakakawea Crossing Alternatives 1.2
Figure B-2 Proposed Crossing – Geologic Stratigraphy 2.2
Figure B-3 Williston Crossing Alternative – Geologic Stratigraphy 3.2
Figure B-4 New Town Crossing Alternative – Geologic Stratigraphy 3.5

Abbreviations

BakkenLink	BakkenLink Pipeline LLC
BLM	Bureau of Land Management
HDD	horizontal directional drill
U.S.	United States
USACE	United States Army Corps of Engineers

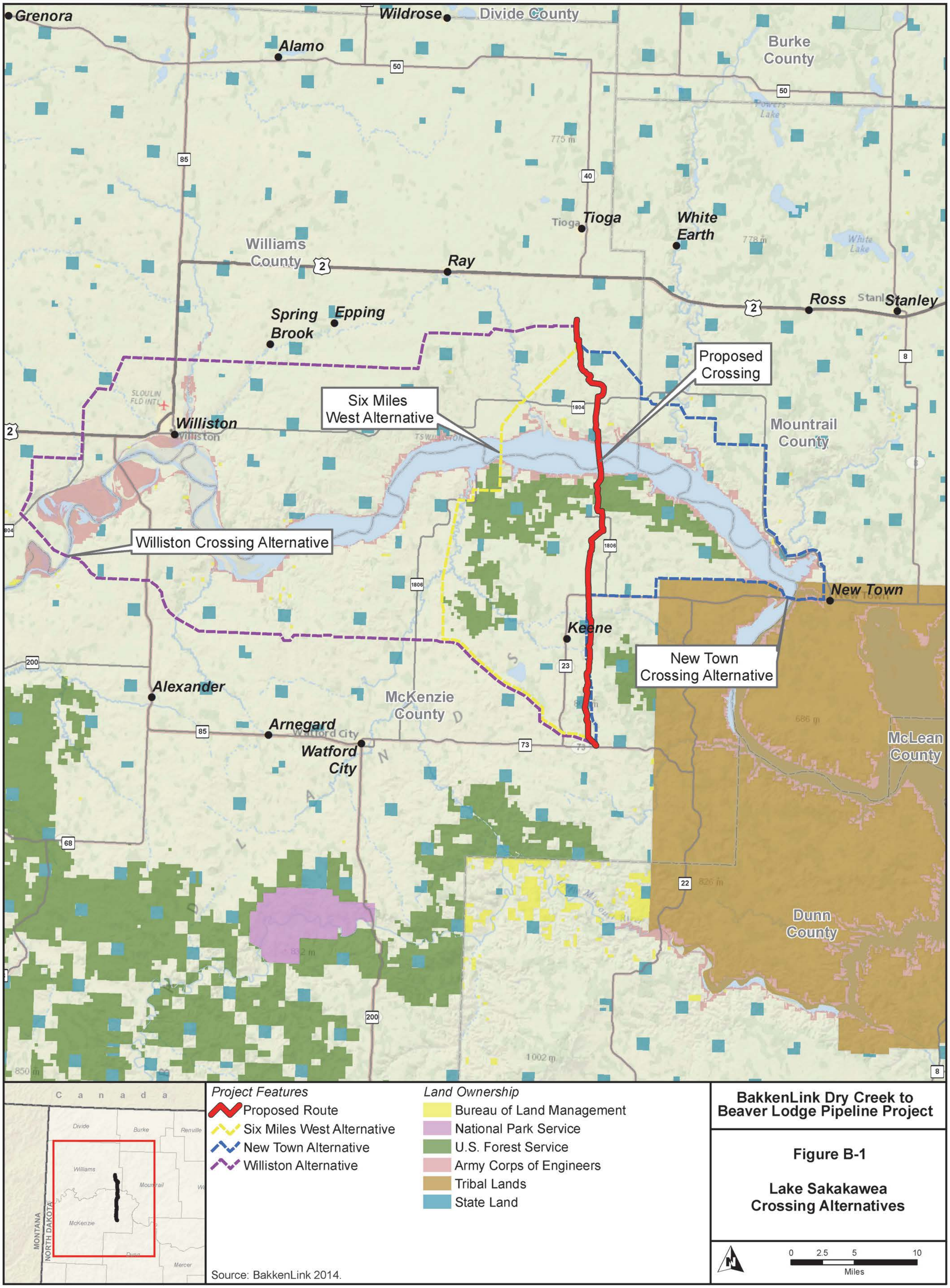
1.0 INTRODUCTION

BakkenLink Pipeline LLC (BakkenLink) submitted a Right-of-Way Grant application to the Bureau of Land Management (BLM), North Dakota Field Office, to construct a 37-mile-long, 16-inch-diameter crude oil pipeline from the Dry Creek Terminal to Beaver Lodge, North Dakota (**Figure B-1**). A segment (12,923 feet) of the proposed route would cross Lake Sakakawea. Based on environmental concerns associated with the proposed lake crossing that were expressed by United States (U.S.) Army Corps of Engineers (USACE) staff, BakkenLink completed horizontal directional drill (HDD) feasibility and geotechnical boring evaluation reports for the Lake Sakakawea crossing, which included the following:

- Horizontal Directional Drilling Feasibility Report, BakkenLink Pipeline Project Lake Sakakawea HDD, Williams and McKenzie Counties, North Dakota; prepared by Laney Direction Drilling Co., February 15, 2013; and
- HDD Geotechnical Boring Evaluation Report, BakkenLink Pipeline Lake Sakakawea, Tioga, North Dakota; prepared by Braun Intertec Corp., January 22, 2013.

BakkenLink, BLM, Stantec Consulting Services Inc. (Stantec), and USACE staff held a meeting in the USACE – Omaha District Office on November 7, 2013. At the meeting, BakkenLink requested that USACE staff review the geotechnical information they had acquired for the proposed lake crossing to determine if they agreed that the HDD method would not be feasible. After review of this information, the USACE provided a letter to the BLM on May 21, 2014, indicating the HDD method would not be feasible at the proposed crossing. In this letter, the USACE also requested that alternative lake crossings be evaluated to determine if the HDD method could be used to successfully to cross the Missouri River/Lake Sakakawea at other locations. As stated in the letter, the Garrison Dam/Lake Sakakawea Oil and Gas Management Plan states that "HDD is the preferred method of pipeline installation, but if not feasible other locations should be investigated and if not found, alternate installation methods can be considered" (USACE 2014).

This technical report provides information regarding the geologic setting of and geologic stratigraphy present at the proposed crossing and three alternative crossings of Lake Sakakawea to determine if the HDD construction method would be feasible. In addition, an overview of the engineering limitations and constraints considered in the evaluation of the HDD construction method at these crossings is provided.



Grenora
Wildrose
Divide County
Alamo
Burke County
Tioga
White Earth
Williams County
Ray
Ross
Stanley
Spring Brook
Epping
Proposed Crossing
Six Miles West Alternative
Williston
Mountrail County
Williston Crossing Alternative
New Town
Keene
New Town Crossing Alternative
Alexander
McKenzie County
Arnegard
Watford City
McLean County
Dunn County
Project Features
Proposed Route
Six Miles West Alternative
New Town Alternative
Williston Alternative
Land Ownership
Bureau of Land Management
National Park Service
U.S. Forest Service
Army Corps of Engineers
Tribal Lands
State Land
Source: BakkenLink 2014.
BakkenLink Dry Creek to Beaver Lodge Pipeline Project
Figure B-1
Lake Sakakawea Crossing Alternatives
0 2.5 5 10
Miles

2.0 PROPOSED CROSSING

2.1 GEOLOGIC OVERVIEW

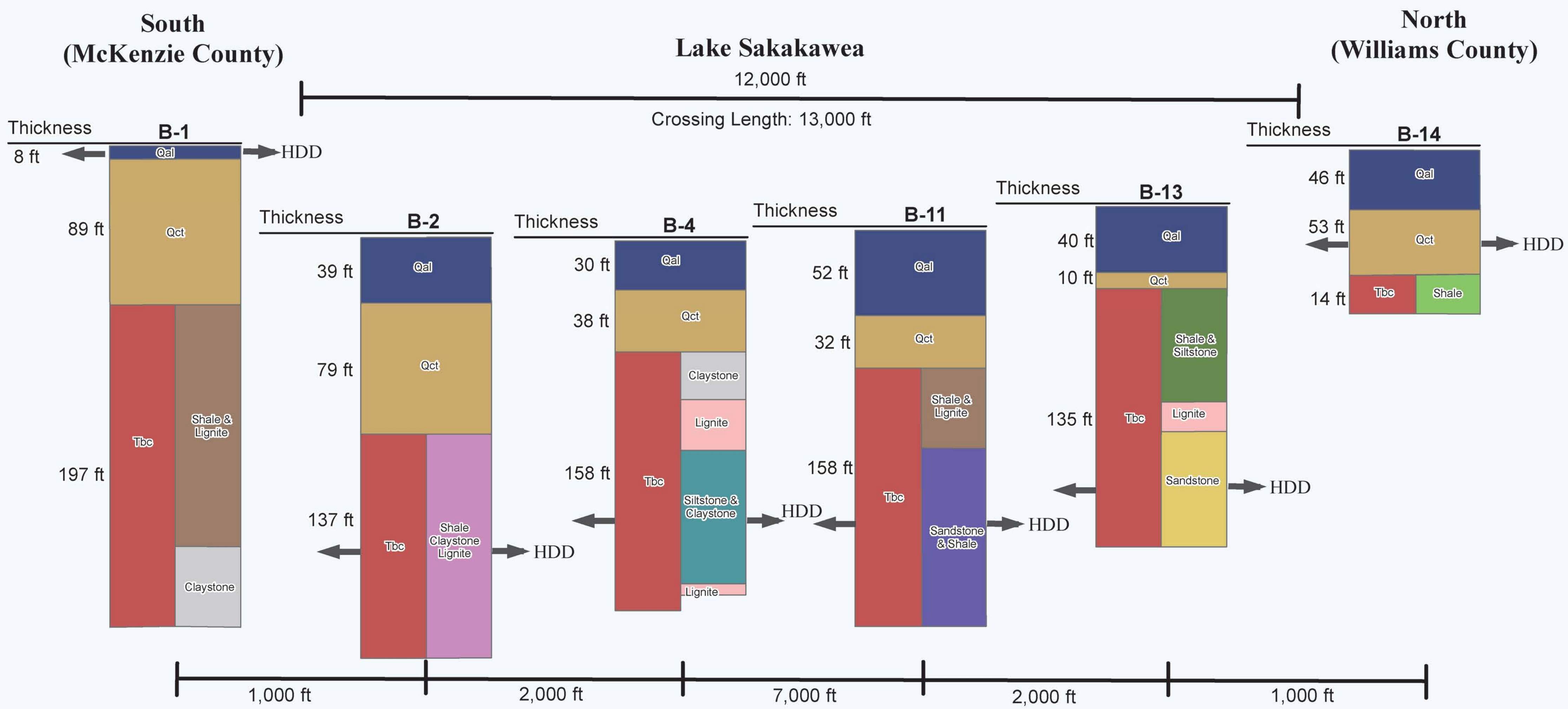
The proposed crossing of Lake Sakakawea is illustrated on **Figure B-1** and the geologic stratigraphy is illustrated in **Figure B-2**. The length of the crossing for HDD at the proposed crossing would be 12,923 feet, as identified by Laney Directional Drilling (Laney 2013). Geotechnical evaluation of this crossing, as completed by Braun Intertec Corporation (Braun 2013), indicated potential problems with the use of the HDD method, which included caving sands, extensive gravel and cobbles, and lignite. The report completed by Laney (2013) concluded that HDD was not feasible at the proposed crossing and the USACE concurred with this conclusion, as stated in a letter dated May 21, 2014.

The geotechnical evaluation of the proposed crossing completed by Braun (2013) revealed the following geotechnical issues for installation of the proposed pipeline using the HDD method:

1. Glacial deposits on the north side of the lake (entrance side) and the south side of the lake (exit side) at the proposed crossing have abundant gravel and cobbles that resulted in refusal of the borings in 6 of the 12 borings (B-02, B-08, B-08 offset, B-10, and B-10 offsets 1 and 2). These glacial deposits range in thickness from 40 to 80 feet and must be crossed on both the north and south sides of the lake with inclined borings in order to reach the proposed crossing elevation of 1,640 feet above mean sea level (approximately 160 feet below the bottom of the lake).
2. Drilling in the Bullion Creek Formation member of the Fort Union Group encountered caving sands in 5 of the 12 test borings. The Bullion Creek would be the main unit intersected by the pipeline beneath the lake at the proposed crossing. The Bullion Creek Formation lies directly below the glacial deposits.
3. The Bullion Creek Formation is typical of the Fort Union Group and contains abundant lignite, along with carbonaceous clays, shales, siltstones, and claystones (Braun 2013; Freers 1970). Evaluation of the lignite and its potential effect on the HDD method by Laney (2013) indicated that the abundant lignites in the Bullion Creek Formation pose a problem for the drilling fluid pH. The acidity of the lignites may reduce the pH of the drilling fluids used in HDD and thus, reduce the carrying capacity of the fluids for cuttings and possibly raise the annular pressure during drilling, leading potentially to hydraulic fracturing.
4. An additional issue raised by Laney (2013) was the length of the lake crossing at the proposed crossing for HDD, which would be 12,923 feet. The HDD method has never been used successfully at this length. Hole caving, drilling materials becoming lodged in the boring resulting in abandonment of the boring, and problems pushing and pulling pipe over that length were identified as a concern.

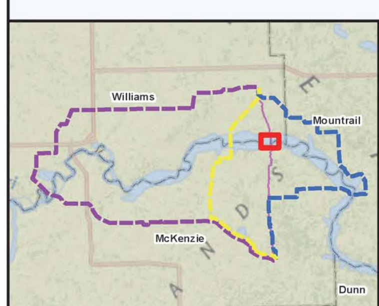
2.2 HDD OVERVIEW

At a horizontal length of 12,923 feet, the conceptual Lake Sakakawea HDD crossing would be the longest HDD crossing ever attempted by HDD contractors in the U.S. The longest successful



Stratigraphic Legend

- Claystone
- Lignite
- Qal - Quaternary Alluvium. Interlayed sands, silts and clays. Thick clay zones common.
- Qct - Quaternary Coleharbor Till.
  Unsorted glacial till consisting of boulders,
  cobbles, and pebbles in a sandy to silty clay-rich matrix.
  Outwash gravels and sands with interbedded clays and silts.
  Referred to simply as glacial till and outwash in Braun (2013) boring logs.
- Sandstone
- Sandstone and Shale
- Shale
- Shale and Lignite
- Shale and Siltstone
- Shale, Claystone, and Lignite
- Siltstone and Claystone
- Tbc - Tertiary Bullion Creek Formation. Interbedded sandstone, siltstone, mudstone, claystone, carbonaceous shale, and lignite. Color consists of subdued grays and browns. Ironstone concretions, claystone beds, and petrified wood common. Middle member of the Tongue River Formation of the Fort Union Group in North Dakota. Lignite beds usually in zones with overlying shales and underlying claystones or sandstones. Sands often unconsolidated and subject to caving when penetrated with a drill. Formation is stratigraphically equivalent to the Tongue River Formation at the Williston and New Town crossings.



Location
Williams & McKenzie Co., ND

Project Information
Project Number: 212205012
Last Modified: October 20, 2014

Note: Not to Scale

Data Sources:
Braun Intertec Corporation (Braun 2013).
HDD Geotechnical Boring Evaluation Report.
Bakkenlink Pipeline, Lake Sakakawea, North Dakota.
Prepared for Bakkenlink, January 22, 2013. Data sourced from boring logs in Appendix A to report.

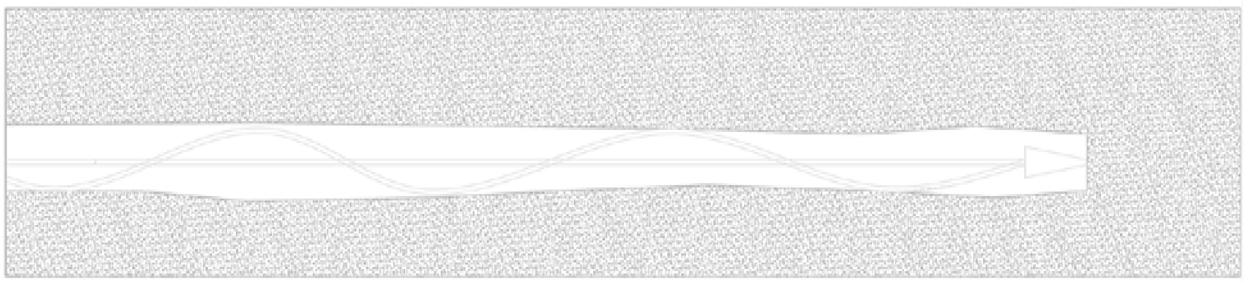
BakkenLink Dry Creek to Beaver Lodge Pipeline Project

Figure B-2

Proposed Crossing - Geologic Stratigraphy

crossing in the U.S. currently is 10,971 feet. The length presents a huge challenge in addition to the unfavorable geotechnical conditions.

The challenges for an HDD of the proposed length include the ability to push nearly 13,000 feet of drill pipe through a drilled hole to connect both sides in order to start the hole-opening process. Drill pipe is fabricated to be placed in tension and not compression; therefore, trying to push (place the pipe in compression) greatly reduces the ability to exert axial loads high enough to push the drilling assembly to the ground surface. Essentially, at some point, the drill pipe would compress on itself and become a very long spring (see illustration below).



If the pilot hole was able to be completed, the hole would then need to be opened to a minimum of 24 inches in order to accept the product pipe and reduce the potential for the pipeline coating to be damaged. The high torque required to turn the hole opener at the constant required speed would become difficult to achieve. This variability in the torque applied to the drill pipe would decrease its strength and may lead to failure of the drill pipe. This type of failure would cause the hole opener to become lodged in the hole and may not be able to be retrieved. If the tool was unable to be retrieved or if parts of the tools stayed lodged in the hole, the hole would then need to be abandoned and another attempt in a new location would be required.

Tracking of the initial cutting tool that creates the pilot hole has its own challenges. The cutting tools for HDDs are tracked utilizing magnetic guidance systems. Coils of wire placed on the ground surface create magnetic signatures that are used to steer the path of the drill. Often, river crossings are short enough where the coils can be placed on each shoreline and still be identified. For longer crossings, there may be a “blind” segment where the operator must rely on experience to properly steer the tools. For this length of crossing, “blind” steering would not be feasible. Wire coils would need to be placed on the lake bottom to establish a magnetic grid to steer the cutting tool. In order to achieve a length in excess of 7,000 feet, two drilling rigs (one on each shoreline) are required (Project Consulting Services [PCS] 2012). Accurate tracking is mandatory as the two initial pilot holes would need to intersect at the midpoint in order to create a single, continuous path.

Should the pilot hole drilling and hole opening processes be successful, the terrain on each shoreline poses the final challenge. When pulling the product pipe back through the completed hole, minimizing the number of starts and stops reduces the risk of the pipe sticking in the hole partially through or the hole collapsing in front of the product pipe. At this location, approximately 14 individual segments would be needed (PCS 2012).

3.0 ALTERNATIVE LAKE CROSSINGS

3.1 SIX MILES WEST CROSSING ALTERNATIVE

3.1.1 Geologic Overview

This alternative crossing includes a crossing length of approximately 10,032 feet. Geologically, this alternative crossing would intersect the same glacial units and the Bullion Creek member of the Fort Union Group as intersected by the proposed crossing (**Figure B-2**). Some key geological issues for this crossing include the following:

1. This area of Lake Sakakawea lies above the pre-glacial drainage of the Little Missouri River (Freers 1970). This pre-glacial drainage contains abundant gravel and was dammed by glacial ice during the movement of glacial lobes into North Dakota (Freers 1970). This resulted in extensive deposits of glacial gravels, cobbles, boulders, and silts. The Six Miles West crossing can be expected to encounter the same issues with gravel, cobbles, and boulders in the glacial material as identified by Braun (2013) at the proposed crossing.
2. The Fort Union Group underlies the glacial material at the Six Miles West Crossing. The Bullion Creek member can be expected to occur at this crossing since it is only 6 miles west of the proposed crossing, where Braun (2013) completed a geotechnical evaluation. Thus, issues with caving sands and lignite experienced at the proposed crossing can be expected at the Six Miles West Crossing.

The Six Miles West Crossing offers little advantage over the proposed crossing. The geological issues with glacial gravels and cobbles, caving sands in the Fort Union, and abundant lignites in the Fort Union Group described by Braun (2013) and Laney (2013) for the proposed crossing apply to the Six Miles West Crossing.

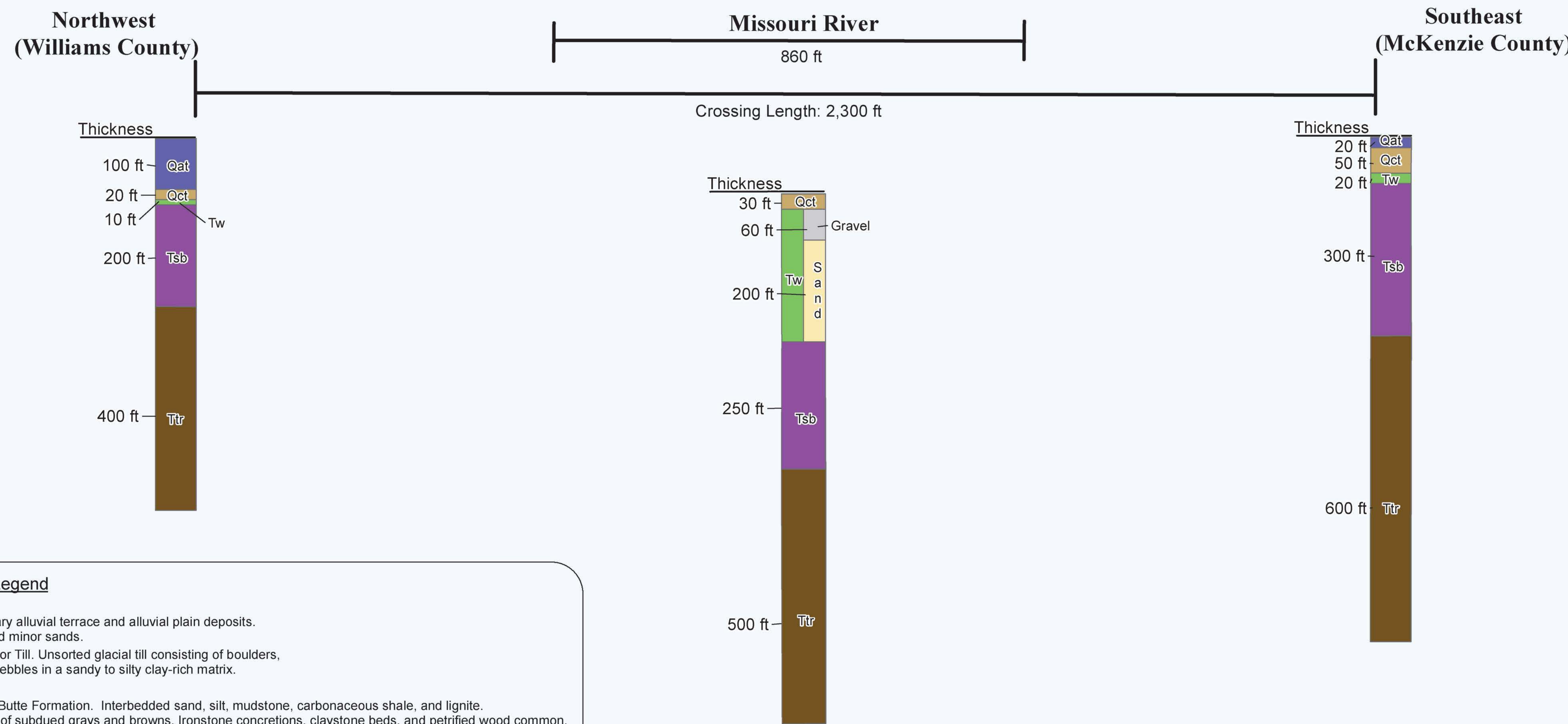
3.1.2 HDD Overview

Conceptually, the crossing length would be approximately 10,032 feet. While the length does place it within the current record capabilities, the same risks as the proposed crossing location apply with one exception. The flat terrain on the north side of the crossing would allow the full length of the product pipe to be fabricated in a single segment.

3.2 WILLISTON CROSSING ALTERNATIVE

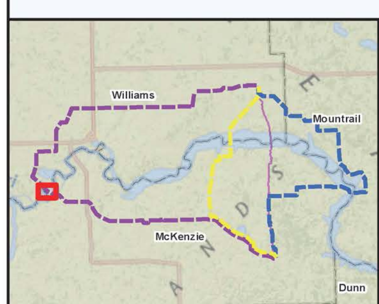
3.2.1 Geologic Overview

The Williston Crossing is located 12 miles southwest of Williston, North Dakota, along the Missouri River upstream of Lake Sakakawea (**Figure B-1**). The length of the crossing is approximately 2,300 feet. Generalized geologic stratigraphy based on geologic data near the crossing is illustrated in **Figure B-3**.



Stratigraphic Legend

- Gravel
- Qat - Quaternary alluvial terrace and alluvial plain deposits. Silts, clays, and minor sands.
- Qct - Coleharbor Till. Unsorted glacial till consisting of boulders, cobbles, and pebbles in a sandy to silty clay-rich matrix.
- Sand
- Tsb - Sentinel Butte Formation. Interbedded sand, silt, mudstone, carbonaceous shale, and lignite. Color consists of subdued grays and browns. Ironstone concretions, claystone beds, and petrified wood common. Upper member of the Fort Union Group in North Dakota.
- Ttr - Tongue River Formation. Similar in lithology to the Sentinel Butte Formation, but consists of bright or buff yellow and gray colors, rather than somber colors of the overlying Sentinel Butte. Dominated by lignites averaging 10 feet in thickness and interbedded with clays and claystones. Bullion Creek Formation is a member of the Tongue River in the Missouri River region. Middle member of the Fort Union Group in North Dakota.
- Tw - Wiota Gravel. Gravels and sands of the pre-glacial Yellowstone River. Well-sorted quartzite-rich gravels consisting of alternating layers of coarse gravel and sand.



Location
Williams & McKenzie Co., ND

Project Information
Project Number: 212205012
Last Modified: October 20, 2014

Note: Not to Scale

Data Sources:
Braun Intertec Corporation (Braun 2013).
HDD Geotechnical Boring Evaluation Report.
Bakkenlink Pipeline, Lake Sakakawea, North Dakota.
Prepared for Bakkenlink, January 22, 2013. Data sourced from boring logs in Appendix A to report.

BakkenLink Dry Creek to Beaver Lodge Pipeline Project

Figure B-3

Williston Crossing Alternative - Geologic Stratigraphy

This crossing is located in an area of bottom land flats (Freers 1970) underlain by Quaternary glacial sands and gravels and the Tertiary Sentinel Butte member of the Fort Union Group. This crossing also is located in the area of the pre-glacial drainage of the Yellowstone River (Freers 1970). As with the pre-glacial Little Missouri River drainage at the Six Miles West Crossing, this buried paleo-drainage was dammed by glacial ice lobes and thus contains layers of gravels, sands, cobbles, and boulders. The Sentinel Butte Formation is the upper facies of the Tongue River member of the Fort Union Group (Freers 1970) and contains lignites; loosely consolidated to unconsolidated sands; and carbonaceous clays, siltstones, and claystones. The crossing probably would require boring through the glacial sands and maybe even the gravels of the pre-glacial Yellowstone River to reach the desired crossing depth in the underlying Sentinel Butte Formation. Key geological issues for this crossing include the following:

1. Coleharbor Glacial Till: The Coleharbor Till is approximately 20 to 50 feet thick and consists of clay, sand, and boulders. Sands and gravels are most common and are thickest in the paleo-valley of the pre-glacial Yellowstone River. The amount of cobbles and boulders in the glacial till at the crossing would need to be determined by geotechnical drilling.
2. Wiota Gravel: The Wiota Gravel is the pre-glacial gravel of the Yellowstone River deposited in the northward flowing Yellowstone that was subsequently dammed by glacial lobes (Freers 1970). These gravels are 260 feet thick north of Williston. This maximum thickness has been assumed for the generalized geologic stratigraphy in **Figure B-3**. The Wiota Gravel consists of an upper member of gravel underlain by a thick layer of sands with cobbles and pebbles. It underlies the Missouri River area, with minor exposures on either bank of the Missouri River.
3. Sentinel Butte Formation: The Sentinel Butte Formation consists of a cross-bedded fine- to medium-grained sandstone with abundant carbonaceous clays and lignites. Lithologically, this formation is similar to the Tongue River member of the Fort Union Group that lies stratigraphically below the Sentinel Butte. The Bullion Creek Formation found in the Fort Union Group at the crossing is the middle member of the Tongue River Formation (Carlson 1985). The Sentinel Butte Formation is lithologically similar to the Tongue River member of the Fort Union Group, with the main difference being the somber color of the Sentinel Butte (Freers 1970). Therefore, the Sentinel Butte Formation has the potential for caving sands like the Bullion Creek and would present the same lignite issue for HDD that was presented by the Bullion Creek at the proposed crossing.
4. Tongue River Formation: The Tongue River Formation is the main upper member of the Fort Union Group. Lithologically it is similar to the Sentinel Butte Formation and probably lithologically similar to the Bullion Creek Formation found at the proposed crossing.

The Williston Crossing offers the advantage of a much shorter crossing distance compared to the proposed crossing. The issue with gravels and cobbles in the glacial till present at the proposed crossing likely also would occur at the Williston Crossing because of the need to cross the pre-glacial valley of the Yellowstone River. The lignites of the Fort Union Group at the proposed crossing also would be present in the Sentinel Butte Formation and the Tongue River Formation at the Williston Crossing. Based on review of the geologic strata at this crossing, using the HDD construction methodology may be extremely difficult.

3.2.2 HDD Overview

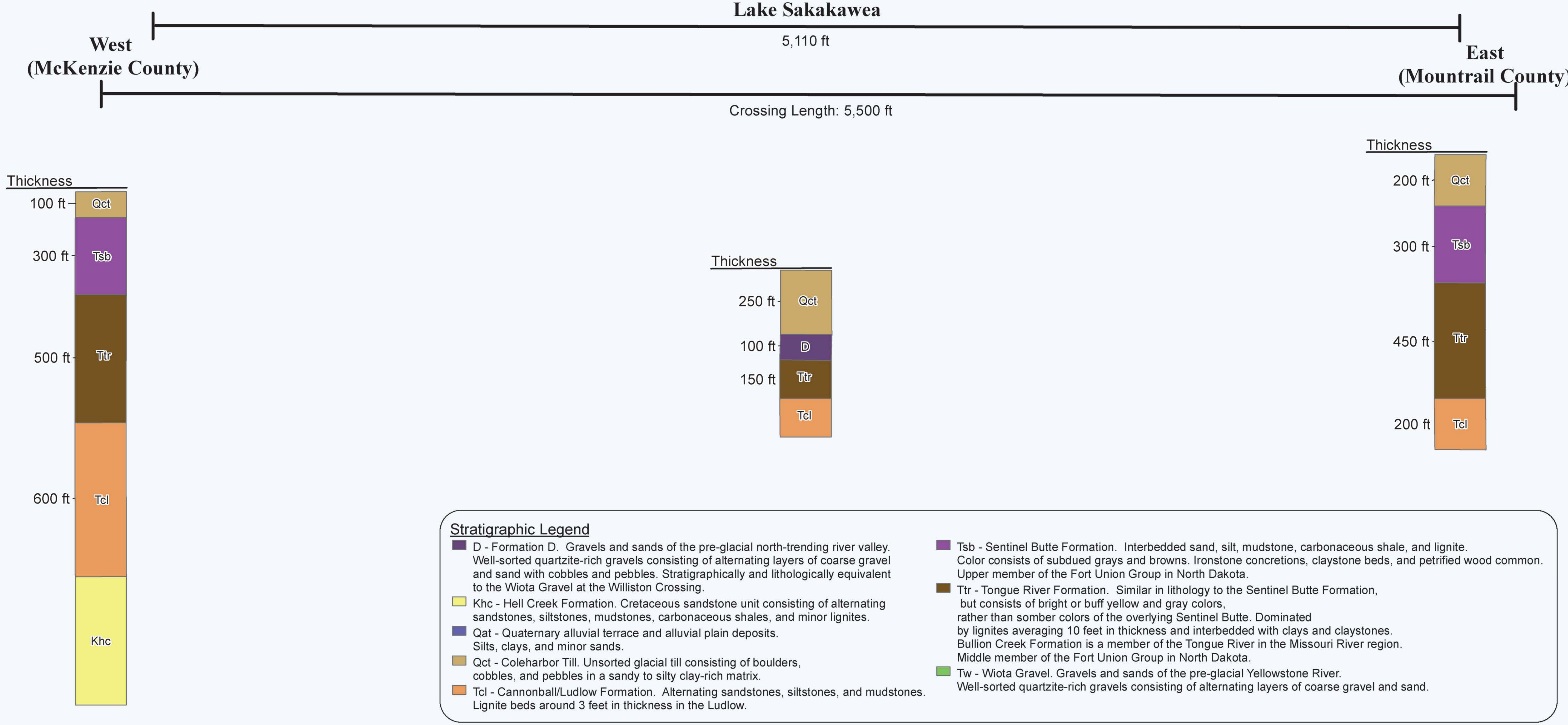
With a conceptual length of about 2,300 feet, this crossing would be the most traditional of all the alternative crossing locations. There appears to be ample flat terrain on either side of the crossing for pipe fabrication. This crossing poses no extraordinary engineering challenges beyond the normal risk profile for HDDs. North Dakota's Western Area Water Supply Project (2,500 foot-long, 20 inch diameter pipeline) was recently installed under the Missouri River near Williston, North Dakota using the HDD construction method.

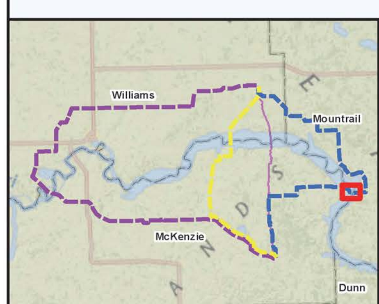
3.3 NEW TOWN CROSSING ALTERNATIVE

3.3.1 Geologic Overview

The New Town Crossing would begin in Mountrail County and cross Lake Sakakawea and exit in McKenzie County, North Dakota. Geologically, the crossing would encounter the Quaternary Coleharbor Formation glacial tills and gravels underlain by Formation D and the Tertiary Sentinel Butte and Tongue River members of the Fort Union Group (Clayton 1972). The Coleharbor Formation is 200 to 300 feet thick in Mountrail County and thins to the southwest across the county. The Sentinel Butte and Tongue River members of the Fort Union Group are very similar lithologically and are grouped as one unit by Clayton (1972). Their combined thickness ranges from 300 to 600 feet. The New Town Crossing would be much shorter than the proposed crossing and require about 5,500 feet of HDD boring (Istre 2014). A generalized geologic stratigraphy for the New Town area is presented in **Figure B-4.** Geological issues present at the New Town Crossing include:

1. Coleharbor Formation: The Coleharbor Formation is a glacial till consisting of 87 percent pebbly sandy to silty clays with cobbles and boulders up to 10 feet in diameter (Clayton 1972). Approximately 8 percent of the formation consists of sand and gravel and 5 percent silt and clay. The high content of pebbles and the potential for large boulders in the Coleharbor Formation may present the same problems for HDD as found with the glacial tills at the proposed crossing.
2. Formation D: Formation D of Clayton (1972) is a pre-glacial formation of quartzite-rich gravels and sands deposited in a north-trending river valley prior to deposition of the Coleharbor Formation. Lithlogically and stratigraphically, Formation D is similar to the Wiota Gravel at the Williston crossing.
3. Sentinel Butte and Tongue River Formations: The Sentinel Butte and Tongue River members of the Fort Union Group consist of about 60 to 80 percent silt and clay with abundant lignite and sands. The Sentinel Butte member is about 35 percent sand and the Tongue River member is about 15 percent sand (Clayton 1972). The sands are cohesive, but generally are not cemented. They carry water and are a source of water in Mountrail County. Thus, the Sentinel Butte and Tongue River members of the Fort Union Group potentially may pose the same problem with caving sands due to water in the sands, as was found at the proposed crossing. The lignites may have the same effect on drilling fluid pH as was found with the Bullion Creek lignites at the proposed crossing.





Location
Williams & McKenzie Co., ND

Project Information
Project Number: 212205012
Last Modified: October 20, 2014

0 250 500
Feet
(Scale is Approximate)

Data Sources:

Carlson,C.G. 1985. Geology of Mckenzie County, North Dakota. North Dakota Geological Survey Bulletin 80.

Clayton, L.1972. Geology of Mountrail County North Dakota. North Dakota Geological Survey Bulletin 55-IV.

BakkenLink Dry Creek to Beaver Lodge Pipeline Project

Figure B-4

New Town Crossing Alternative - Geologic Stratigraphy

4. Cannonball/Ludlow Formation: This lower member of the Fort Union Group consists of clays, claystones, shales, and lignites. The lignites average around 3 feet in thickness. This unit should not be intersected by an HDD crossing.
5. Hell Creek Formation. The Hell Creek is Cretaceous in age and consists of sands, sandstones, shales, and lignites. This unit should not be intersected by an HDD crossing.

The New Town Crossing provides a shorter crossing distance than the proposed crossing. There appears to be a pre-glacial river channel beneath the crossing area, as evidenced by Formation D. The Coleharbor Formation appears to present the same geotechnical issues with glacial gravels and cobbles as was found at the proposed crossing. The Fort Union Group members present at the New Town Crossing, the Sentinel Butte and the Tongue River formations, are similar lithologically to the Bullion Creek Formation encountered at the proposed crossing.

3.3.2 HDD Overview

Conceptually, this crossing would be approximately 5,500 feet and would parallel to the Four Bears Memorial Bridge. This crossing length is well within the practical range of HDDs. While not as critical, tracking across the water would be important to avoid interfering with the bridge and other nearby infrastructure. To avoid Four Bears village on the west side of the crossing, the product pipe would need to be fabricated along Highway 23 on the east side toward New Town. This area also has some significant relief and elevation changes in the terrain creating challenges in fabrication of the pipe. Two pipe segments would be likely in order to avoid housing and other commercial developments.

4.0 SUMMARY

Based on the review of the geologic information, two of the crossing alternatives (Six Miles West and New Town Crossing Alternatives) would not be suitable for the HDD construction method and one of the crossing alternatives (Williston Crossing Alternative) has some geologic constraints that would make it extremely difficult to use the HDD construction method. The Six Miles West Crossing has the same geologic constraints as the proposed crossing. The Williston and New Town alternative crossings may have significant geotechnical issues with the glacial tills, pre-glacial river gravels, and the Fort Union Group sediments. Consideration should be given to crossing Lake Sakakawea using construction methods other than HDD since this is allowed under the Garrison Dam/Lake Sakakawea Oil and Gas Management Plan when it has been determined, based on geologic and engineering constraints, that the HDD construction method would not be feasible (applies to the Six Miles West and New Town Crossing Alternatives).

5.0 REFERENCES

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Appendix C
Plant and Wildlife Species Identified for the USFS McKenzie Ranger District

Common/Scientific Names

Plants

Common name	Scientific name
Adder's tongue	*Ophioglossum vulgatum*
Alfalfa	*Medicago sativa*
Alkali cordgrass	*Spartina gracilis*
Alkali grass	*Puccinellia nuttaliana*
Alkali sacton	*Sporobolus airoides*
Alyssum-leaf phlox	*Phlox alyssifolia*
American elm	*Ulmus americana*
American plum	*Prunus americana*
American sea blite	*Suaeda caleoliformis*
Annual ragweed	*Ambrosia artemisiifolia*
Arrowhead	*Sagittaria spp*
Aspen	*Populus spp*
Austrian pine	*Pinus balfouriana austrina*
Baltic rush	*Juncus balticus*
Barr’s milkvetch	*Astragalus barii*
Basin wild rye	*Leymus cinerus*
Basswood	*Tilia americana*
Beach heather	*Hudsonia tomentosa*
Beaked willow	*Salix bebbiana*
Bearded wheatgrass	*Agropyron subsecundum*
Beebalm	*Monarda spp*
Big bluestem	*Andropogon gerardii*
Birdfoot sagebrush	*Artemisia pedatifida*
Black greasewood	*Sarcobatus vermiculatus*
Black-eyed Susan	*Rudbeckia hirta*
Blanket flower	*Gaillardia spp*
Blowout grass	*Redfieldia flexuosa*
Blowout penstemon	*Penstemon haydenii*
Blue grama	*Bouteloua gracilis*
Blue lips	*Collinsia parviflora*
Bluebunch wheatgrass	*Agropyron spicatum*
Bluejoint	*Calamagrostis canadensis*
Bog willow	*Salix pedicellaris*
Boston ivy	*Parthenocissus tricuspidata*
Boxelder	*Acer negundo*
Broad-leaved goldenrod	*Solidago flexcaulis*
Broom snakeweed	*Gutierrezia dracunculoides*
Buckbean	*Menyanthes trifoliata*
Buffaloberry	*Shepherdia spp*
Buffalograss	*Buchloe dactyloides*
Bulrush	*Scirpus spp*
Bur oak	*Quercus macrocarpa*
Canada anemone	*Anemone candensis*
Canada goldenrod	*Solidago canadensis*
Canada thistle	*Cirsium canadensis*
Canada wild rye	*Elymus canadensis*
Cattail	*Typha spp*
Cheatgrass	*Calamagrostis spp*
Chokecherry	*Prunus virginiana*
Club moss	*Lycopodium spp*
Common rabbitbrush	*Chrysothamnus nauseosus*
Common scouring rush	*Equisetum hyemale*
Common spikesedge	*Carex spp*
Coneflower	*Rudbeckia spp*
Corn	*Zea mays*
Cottonwood	*Populus deltoides*
Creeping cedar	*Juniperus horizontalis*
Crested shield fern	*Dryopteris cristata*
Crested wheatgrass	*Agropyron cristatum*
Crested woodfern	*Dryopteris cristata*
Dakota buckwheat	*Eriogonum visheri*
Delicate sedge	*Carex leptalea*
Dogberry	*Ribes cynosbati*
Dotted gayfeather	*Liatris punctata*
Douglas knotweed	*Polygonum douglasii*
Downy brome	*Bromus tectorum*
Dwarf juniper	*Juniperus communis*
Eastern red cedar	*Juniperus virginiana*
Fescue sedge	*Carex alopecoidea*
Fleabane	*Erigeron spp*
Four-wing saltbush	*Atriplex canescens*
Fowl bluegrass	*Poa palustris*
Foxtail barley	*Hordeum jubatum*
Foxtail sedge	*Carex alopecoidea*

Fringed sage	*Artemisia frigida*
Frostweed	*Helianthemum bicknelli*
Gardner's saltbush	*Atriplex gardneri*
Gayfeather	*Liatris spp*
Golden stickleaf	*Mentzelia pumila*
Goldenrod	*Solidago spp*
Grass-leaved goldenrod	*Euthamia graminifolia*
Gray sagewort	*Artemisia ludoviciana*
Greasewood	*Sarcobatus vermiculatus*
Green ash	*Fraxinus pennsylvanica*
Green needlegrass	*Stipa viridula*
Green sagewort	*Artemisia dracunculus*
Gumbo lily	*Oenothera caespitosa*
Hackberry	*Celtis occidentalis*
Hairy grama	*Bouteloua hirsuta*
Handsome sedge	*Carex formosa*
Hardstem bulrush	*Scripus acutus*
Harebell	*Campanula rotundifolia*
Hawthorn	*Crataegus spp*
Hedge-nettle	*Stachys palustris*
Hoary cress	*Cardaria draba*
Hoary vervain	*Verbena stricta*
Hooker's townsendia	*Townsendia hookeri*
Ill scented sumac	*Rhus trilobata*
Indian grass	*Sorghastrum nutans*
Inland saltgrass	*Distichlis spicata spicata*
Ironwood	*Ostrya virginiana*
Jack pine	*Pinus bansian*
Japanese brome	*Bromus japonicus*
Joe Pye weed	*Eupatorium macutatum bruneri*
Junegrass	*Koeleria pyramidata*
Juniper	*Juniperus spp*
Kentucky bluegrass	*Poa pratensis*
Kochia	*Kochia scoparia*
Labrador bedstraw	*Galium labradoricum*
Lady fern	*Athyrium filix-femina*
Lancefeaf cottonwood	*Populus x acuminata*
Large gayfeather	*Liatris spp*
Lead plant	*Amorpha canescens*
Leafy bulrush	*Scirpus polyphyllus*
Leafy spruge	*Euphorbia esula*
Leathery grapefern	*Botrychium multifidum*
Limber pine	*Pinus flexilis*
Little bluestem	*Andropogon scoparius*
Little bluestem	*Schizachyrium scoparium*
Little grapefern	*Botrychium simplex*
Little-seed ricegrass	*Oryzopsis micrantha*
Locust	*Robina pseudo-acacia*
Loesels twayblade	*Liparis loeselii*
Long-headed coneflower	*Rudbeckia spp*
Lupine	*Lupinus spp*
Marsh bellflower	*Campanula aparinoides*
Marsh fern	*Thelypteris palustris*
Marsh horsetail	*Equisetum palustre*
Mat muhly	*Muhlenbergia richardsonis*
Meadow brome	*Bromus erectus*
Meadow horsetail	*Equisetum pratense*
Meadow Willow	*Salix petiolaris*
Milkweed	*Asclepias spp*
Mountain brome	*Bromus marginatus*
Mountain mahogany	*Cercocarpus montanus*
Musk thistle	*Carduus nutans*
Narrow-leaved purple coneflower	*Echinacea angustifolia*
Needle-and-thread	*Stipa comata*
Needleleaf sedge	*Carex duriuscula*
Nodding buckwheat	*Eriogonum cernuum*
Northern green orchid	*Platanthera hyperborea*
Northern pin oak	*Quercus ellipsoidalis*
Northern reedgrass	*Calamagrostis stricta*
Nuttall alkali grass	*Puccinellia nuttaliana*
Oakfern	*Gymnocarpium dryopteris*
Oregon grape	*Berberis repens*
Pale echinacea	*Echinacea pallida*
Panicled aster	*Aster simplex*
Paper birch	*Betula papyrifera*
Peachleaf willow	*Salix amygdaloides*
Penstemon	*Penstemon spp*
Plains cactus	*Opuntia spp*
Plains muhly	*Muhlenbergia cuspidata*
Poison ivy	*Toxicodendron spp*
Ponderosa pine	*Pinus ponderosa*
Porcupine-grass	*Stipa spartea*
Prairie cordgrass	*Spartina pectinata*
Prairie dropseed	*Sporobolus heterolepsis*
Prairie rose	*Rosa arkansana*
Prairie sandreed	*Calamovilfa longifolia*
Prairie spiderwort	*Trandescantia spp*
Prickly pear	*Opuntia polyacantha*
Purple prairie clover	*Dalea purpurea*
Pussy willow	*Salix discolor*
Quaking aspen	*Populus tremuloides*
Red clover	*Trifolium pratense*

Red osier dogwood	*Cornus sericea*	Snowberry	*Symphoricarpos occidentalis*
Red threeawn	*Aristida purpurea robusta*	Soft-leaf muhly	*Muhlenbergia richardsonis*
Redtop	*Agrostis stolonifera*	Softstem bulrush	*Scripus tabernaemontani*
Ricegrass	*Oryzopsis spp*	Sorghum	*Sorghum halepense*
Rocky Mountain juniper	*Juniperus scopulorum*	Soybean	*Glycine max*
Rose	*Rosa spp*	Spikerush	*Eleocharis spp*
Rubber rabbitbrush	*Chrysothamnus nauseosus*	Spinulose woodfern	*Dryopteris spinulosa*
Rush	*Juncus spp*	Spotted evening primrose	*Oenothera canescens*
Russian knapweed	*Centaurea repens*	Spotted knapweed	*Centaurea maculosa*
Rydberg's sunflower	*Helianthus spp*	Squaw currant	*Ribes cereum colubrinum*
Salsify	*Tragopogon spp*	Stiff sunflower	*Helianthus rigidus*
Sand bluestem	*Andropogon hallii*	Sumac	*Rhus spp*
Sand dropseed	*Sporobolus cryptandrius*	Sun sedge	*Carex inops heliophila*
Sand lily	*Leucocrinum montanum*	Sunflower	*Helianthus spp*
Sand lovegrass	*Eragrostis trichodes*	Sweetclover	*Melilotus spp*
Sand muhly	*Muhlenbergia arenicola*	Switchgrass	*Panicum virgatum*
Sand sagebrush	*Artemisia filifolia*	Tall goldenrod	*Solidago gigantea*
Sandbar willow	*Salix exigua*	Tall white aster	*Aster ericoides*
Sandberg bluegrass	*Poa sandbergii*	Tawny crescent	*Phyciodes batesii*
Sandgrass	*Triplasis purpurea*	Thickspike wheatgrass	*Agropyron dasystachyum*
Scotch pine	*Pinus sylvestris*	Thistle	*Cirsium spp*
Sensitive fern	*Onoclea sensibilis*	Threadleaf sedge	*Carex filifolia*
Serviceberry	*Amelanchier spp*	Three-square bulrush	*Scirpus pungens*
Shadscale	*Atriplex spp*	Timothy	*Phleum pratense*
Shadscale saltbrush	*Atriplex confertifolia*	Torrey's cryptantha	*Cryptantha torreyana*
Shining flatsedge	*Cyperus bipartitus*	Umbrella flatsedge	*Cyperus diandrus*
Showy lady's slipper	*Cypridpedium reginae*	Upright pinweed	*Lechea stricta*
Shrubby cinquefoil	*Pentaphylloides floribunda*	Ute ladies'-tresses	*Spiranthes diluvialis*
Sideoats grama	*Bouteloua curtipendula*	Violet	*Viola spp*
Silky prairie clover	*Dalea villosa*	Wahoo spindle-tree	*Euonymus atropurpureus*
Silver buffaloberry	*Shepherdia argentea*	Wedge-leaf frog-fruit	*Phyla cuneifolia*
Silver sage	*Artemisia cana*	Western prairie fringed orchid	*Platanthera praeclara*
Silver sagebrush	*Artemisia cana*	Western ragweed	*Ambrosia psilostachya*
Silverberry	*Elaegnus commutata*	Western snowberry	*Symphoricarpos occidentalis*
Silverweed cinquefoil	*Potenilla argentea*	Western wheatgrass	*Agropyron smithii*
Skunkbrush	*Rhus aromatica*	Western wheatgrass	*Pascopyrum smithii*
Skunkbrush sumac	*Rhus aromatica*	Western yarrow	*Achillea millefolium*
Slendar cottongrass	*Eriphorum gracile*	Wheat	*Triticum aestivum*
Slendar wheatgrass	*Agropyron trachycaulum*	White prairie clover	*Dalea candida*
Small white lady's slipper	*Cypripedium candidum*	White prairie clover	*Petalostemum candidum*
Smartweed	*Polygonum spp*	White sweetclover	*Melilotus alba*
Smooth brome	*Bromus inermis*	Wilcox dicanthelium	*Dicanthelium wilcoxianum*
Smooth goosefoot	*Chenopodium subglabrum*	Wild plum	*Prunus americana*
Smooth scouring rush	*Equisetum laevigatum*	Wild strawberry	*Fragaria virginiana*
Smooth sumac	*Rhus glabra*	Wildrose	*Rosa spp*
Smoothbark cottonwood	*Populus x acuminata*	Willow	*Salix spp*

Willow buckbrush	*Symphoricarpos occidentalis*
Wolfberry	*Symphoricarpos occidentalis*
Wood lily	*Lilium philadelphicum*
Woolly sedge	*Carex lanuginosa*
Wyoming big sagebrush	*Artemisia tridentata wyomingensis*
Yellow alyssum	*Alyssum desertorum*
Yucca	*Yucca glauca*

Animals

Alkali fairy shrimp	*Branchinecta spp*
American bittern	*Botaurus lentiginousus*
American burying beetle	*Nicrophorus americanus*
American crow	*Corvus brachyrhynchos*
American goldfinch	*Carduelis tristis*
American peregrine falcon	*Falco peregrinus*
American wigeon	*Anas americana*
Argos skipper	*Atrytone arogos*
Badger	*Taxidea taxus*
Baird's sparrow	*Ammodramus bairdii*
Bald eagle	*Haliaeetus leucocephalus*
Beaver	*Castor canadensis*
Belfragii's bug	*Chlorochroa belfragii*
Bell's vireo	*Vireo bellii*
Belted kingfisher	*Ceryle alcyon*
Bison	*Bison bison*
Black bullhead	*Ameiurus melas*
Black tern	*Chlidonias niger*
Black-backed woodpecker	*Picoides arcticus*
Black-billed cuckoo	*Cuccyzus erythropthalmus*
Black-billed magpie	*Pica hudsonia*
Black-capped chickadee	*Poecile atricapilla*
Black-footed ferret	*Mustela nigripes*
Black-tailed prairie dog	*Cynomys ludovicianus*
Blanding's turtle	*Emydoidea blandingii*
Blue grosbeak	*Guiraca caerulea*
Blue jay	*Cyanocitta cristata*
Bluegill	*Lepomis macrochirus*
Blue-winged teal	*Anas discors*
Bobcat	*Felis rufus*
Bobolink	*Dolichonys oryzivorus*
Box turtle	*Terrapene ornata*
Brewer's sparrow	*Spizella brewi*
Brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Bull snake	*Pituophis melanoleucus sayi*
Bullfrog	*Rana catesbeiana*
Bullock's oriole	*Icterus bullocki*
Bumble bees	*Bombus spp*
Burrowing owl	*Speotyto cunicularia*
California bighorn sheep	*Ovis canadensis californiana*
Canada goose	*Branta canadensis*
Cardinal	*Cardinalis cardinalis*
Channel catfish	*Ictalurus punctatus*
Chestnut-collared longspur	*Calcrius ornatus*
Chorus frog	*Pseudacris spp*
Clark's nutcracker	*Nucifraga columbiana*
Clay-colored sparrow	*Spizella pallida*
Common loon	*Gavia immer*
Cooper's hawk	*Accipiter cooperii*
Cottontail	*Sylvilagus spp*
Coyote	*Canis latrans*
Crappie	*Pomoxis spp*
Dakota skipper	*Hesperia dacotae*
Dickcissel	*Spiza americana*
Downy woodpecker	*Picoides pubescens*
Dwarf shrew	*Sorex nanus*
Eastern bluebird	*Sialia sialis*
Eastern screech-owl	*Otus asio*
Eastern wood-pewee	*Contopus virens*
Elk	*Cervus elaphus*
Fathead minnow	*Pimephales promelas*
Ferruginous hawk	*Buteo regalis*
field sparrow	*Spizella pusilla*
Finscale dace	*Phoxinus neogaeus*
Flathead chub	*Platygobio gracilis*
Fox sparrow	*Passerella iliaca*
Fox squirrel	*Sciurus niger*
Franklin's ground squirrel	*Spermophilus franklinii*
Fringed-tailed myotis	*Myotis thysanodes*

Gadwall	*Anas strepera*	Moose	*Alces alces*
Garter snake	*Thamnophis radix*	Mountain bluebird	*Sialia cursucoides*
Golden eagle	*Aquila chrysaetos*	Mountain lion	*Puma concolor*
Goshawk	*Accipiter gentilis*	Mountain plover	*Charadrius montanus*
Grasshopper sparrow	*Ammodramus savannarum*	Mourning dove	*Zenaida macroura*
Gray catbird	*Dumetella carolinensis*	Mule deer	*Odocoileus hemionus*
Gray fox	*Urocyon cinereoargenteus*	Muskrat	*Ondatra zibethicus*
Gray partridge	*Perdix perdix*	Northern bald eagle	*Haliaeetus leucephalus alascanus*
Gray squirrel	*Sciurus carolinensis*	Northern flicker	*Colaptes auratus*
Great blue heron	*Ardea herodias*	Northern goshawk	*Accipiter gentilius*
Great horned owl	*Bubo virginianus*	Northern grasshopper mouse	*Onychomys leucogaster*
Great-crested flycatcher	*Myiarchus crinitus*	Northern harrier	*Circus cyaneus*
Greater prairie chicken	*Tympanuchus cupido pinnatus*	Northern leopard frog	*Rana pipiens*
Green-winged teal	*Anas crecca*	Northern oriole	*Icterus bullocki*
Ground squirrel	*Spermophilus sp*	Northern pike	*Esox lucius*
Hairy woodpecker	*Picoides villosus*	Northern pocket gopher	*Thomomys talpoides*
Hispid pocket mouse	*Chaetodipus hispidus*	Northern short-horned lizard	*Phrynosoma douglasii douglasii*
Hog-nose snake	*Heterodon nasicus*	Olive-backed pocket mouse	*Perognathus fasciatus*
Horned lark	*Eremophila alpestris*	Orchard oriole	*Icterus spurius*
Horse	*Equus caballus*	Osprey	*Pandion haliaetus*
House wren	*Troglodytes aedon*	Ottoe skipper	*Hesperia ottoe*
Iowa darter	*Etheostama exile*	Ovenbird	*Sciurus aurocapiilus*
Jack rabbit	*Lepus townsendii*	Pale milk snake	*Lampropeltis triangulum*
Large-mouthed bass	*Micropterus salmoides*	Pallid sturgeon	*Scaphirhynchus albus*
Lark bunting	*Calamospiza melanocorys*	Pearl dace	*Semotilus margarita*
Lark sparrow	*Chondestes grammacus*	Peregrine falcon	*Falco peregrinus*
Lazuli bunting	*Passerina amoena*	Pintail	*Anas acuta*
Least flycatcher	*Empidonax minimus*	Plains harvest mouse	*Reithrodeontomys montanus*
Least weasel	*Mustela nivalis*	Plains pocket mouse	*Perognathus flavescens*
LeConte's sparrow	*Ammodramus belconteii*	Plains spadefoot	*Spea bombifrons*
Lewis woodpecker	*Melanerpes lewis*	Plains spotted skunk	*Spilogale putorius interrupta*
Loggerhead shrike	*Lanius ludovicianus*	Plains topminnow	*Fundulus sciadicus*
Long-billed curlew	*Numenius americanus*	Porcupine	*Erithizon dorsalis*
Long-eared owl	*Asio otus*	Powesheik skipper	*Oarisma powesheik*
Longnose dace	*Rhinichthys cataractae*	Prairie falcon	*Falco mexicanus*
Longnose sucker	*Catostomus catostomus*	Prairie rattlesnake	*Crotalus viridis viridis*
Long-tailed weasel	*Mustela frenata*	Prairie skink	*Eumeces septentrionalis*
Mallard	*Anas platyrhyncos*	Prairie vole	*Microtus ochrogaster*
Marbled godwit	*Limosa fedoa*	Pronghorn	*Antilocapra americana*
Marmot	*Marmota spp*	Pygmy nuthatch	*Sitta pygmaea*
Marsh wren	*Cistothorus palustris*	Raccoon	*Procyon lotor*
McCown's longspur	*Calcarius mccownii*	Red crossbill	*Loxia curvirostra*
Meadowlark	*Sturnella spp*	Red fox	*Vulpes vulpes*
Merlin	*Falco columbarius*	Red shiner	*Notropis lutrensis*
Milk snake	*Lampropeltis triangulum*	Red-breasted nuthatch	*Sitta canadensis*
Mink	*Mustela vison*	Red-headed woodpecker	*Melanerpes erythrocephalus*

Red-tailed hawk	*Buteo jamaiicensis*
Regal fritillary	*Spyeria idalia*
Richardson's ground squirrel	*Spermophilus richardsonii*
Ring-necked pheasant	*Phasianus colchicus*
River otter	*Lantra canadensis*
Rocky Mountain bighorn sheep	*Ovis canadensis canadensis*
Ruby-throated hummingbird	*Archilochus colubris*
Rufous-sided towhee	*Pipilo erythrophthalmus*
Sage grouse	*Centrocerus urophasianus*
Sage sparrow	*Amphispiza belli*
Sage thrasher	*Oreoscoptes montanus*
Sage vole	*Lagurus curtatus*
Sand shiner	*Notropis stramineus*
savannah sparrow	*Passerculus sandwichensis*
Scarlet tanager	*Piranga ludoviciana*
Sedge wren	*Cistothorus platensis*
Sharp-shinned hawk	*Accipiter striatus*
Sharp-tailed grouse	*Tympanuchus phasianellus jamesi*
sharp-tailed sparrow	*Ammodramus nelsoni*
Short-eared owl	*Asio flammeus*
Shorthead redhorse	*Maxostoma macrolepidotum*
Shoveler	*Anas clypeata*
Skunk	*Spilogale spp*
Spiny softshell turtle	*Trionyx spinifer*
Spotted bat	*Euderma maculatum*
Sprague's pipit	*Anthus spragueii*
Stonecat	*Noturus flavus*
Striped skunk	*Mephitus mephitus*
Sturgeon chub	*Macrohybopsis gelida*
Summer tanager	*Piranga rubra*
Swainson's hawk	*Buteo swainsoni*
Swift fox	*Vulpes velox*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
Tiger salamander	*Ambrystoma tigrinum*
Topeka shiner	*Notropis topeka*
Townsend's big-eared bat	*Corynorhinus townsendii*
Trumpeter swan	*Cygnus buccinator*
Turkey vulture	*Cathartes aura*
Upland sandpiper	*Bartramia longicauda*
Vesper sparrow	*Pooecetes gramineus*
Warbling vireo	*Vireo gilous*
Western big-eared bat	*Plecotus townsendii*
Western burrowing owl	*Speotyto cunicularia*
Western screech-owl	*Otus kennicottii*
Western smooth green snake	*Liochlorophis vernalis*
Western tanager	*Piranga ludoviciana*
White sucker	*Catostomus commersoni*
White-breasted nuthatch	*Sitta carolinensis*
White-faced ibis	*Plegadis chihi*
White-footed mouse	*Arborimus albipes*
White-tailed deer	*Odocoileus virginianus*
White-tailed jackrabbit	*Lepus townsendii*
Whooping crane	*Grus americana*
Wild turkey	*Meleagris gallopavo*
Willow flycatcher	*Empidonax trailii*
Wood duck	*Aix sponsa*
Woodhouse's toad	*Bufo woodhousii*
Yellow perch	*Perca flavescens*
yellow warbler	*Dendroica petechia*
Yellow-billed cuckoo	*Coccyzus americanus*
Yellow-breasted chat	*Icteria virens*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Yellow-throated vireo	*Vireo flavifrons*

Appendix D
Special Status Species Potentially Occurring within the Project Area

Table D-1 Special Status Species Potentially Occurring within the Project Area

Species	Scientific Name	Status[1]	Habitat Association	Primary Habitat	Potential for Occurrence Within Project Area	Eliminated from Detailed Analysis	Counties	Source
MAMMALS								
Northern long-eared bat	*Myotis septentrionalis*	FP	Habitat generally includes many trees, where northern long-eared bats roost during the day, either singly or colonially. Northern long-ear bats are opportunistic roosters, readily roosting in live trees of multiple species, snags, and isolated instances of using manmade structures as roosts. Trees and snags generally are considered good roosts if they have suitable cavities or retain bark, under which the bats often roost.	Shrublands, woodlands, and riparian areas.	Yes. Suitable habitat is present within the Project area.	No.	McKenzie and Williams.	USFWS 2014a.
Black-footed ferret	*Mustela nigripes*	FE	This species is an obligate of prairie dog colonies, which provide both shelter (i.e., burrows) and a prey base to support ferret populations.	Black-tailed prairie dog colonies.	No.	Yes. Suitable habitat does not exist in the Project area.	None.	Hagen 2005; Carlson McCain 2013.
Gray wolf	*Canis lupis*	FE	This species occurs in a wide range of habitats with large ungulates present. Gray wolves utilize mixed hardwood- coniferous forests in wilderness and sparsely settled areas, to forest and prairie landscapes dominated by agricultural and pasture lands.	Wide variety of habitats with sufficient prey base.	No.	Yes. The gray wolf is an occasional visitor in North Dakota, but no breeding records have been documented in the state.	McKenzie and Williams.	Hagen 2005.
Black-tailed prairie dog	*Cynomys ludovicianus*	USFS	The species inhabits prairie communities with short vegetation and flat topography. Black-tailed prairie dogs are often found in areas grazed by livestock and other disturbed areas with exposed soil.	Short and mixed grasslands, usually well- grazed lands.	Yes. No colonies have been documented near the Project area; however, suitable habitat exists within the Project area.	No.	McKenzie.	Carlson McCain 2013; Hagen 2005.
Rocky Mountain bighorn sheep	*Ovis canadensis*	USFS	Bighorn sheep inhabit steep, precipitous, rocky terrain and feed on grasses and forbs. Bighorn sheep require considerable acres of rough terrain and limited disturbance for lambing habitat.	Steep, rocky terrain; badlands.	No.	Yes. The known range of this species in North Dakota does not overlap with the Project area.	McKenzie.	Armstrong et al. 2011; Leier 2009; NDGFD 2014.
BIRDS								
Interior least tern	*Sterna antillarum athalassos*	FE	This species inhabits sparsely vegetated sandbars or shoreline salt flats of lakes along the Missouri River System. The Missouri River, Lake Sakakawea, and Lake Oahe are the only areas in North Dakota known to support interior least tern populations. Interior least terns are present in North Dakota from mid-May to mid-August. The peak breeding season occurs from early June to mid-July.	Sparsely vegetated sandbars or shorelines.	Yes. Potential habitat exists at Lake Sakakawea.	No.	McKenzie and Williams.	Hagen 2005; USFWS 2014b.

Table D-1 Special Status Species Potentially Occurring within the Project Area

Species	Scientific Name	Status[1]	Habitat Association	Primary Habitat	Potential for Occurrence Within Project Area	Eliminated from Detailed Analysis	Counties	Source
Whooping crane	*Grus americana*	FE	This species primarily utilizes wetlands and cropland ponds for roosting and feeding during migration. Spring and fall migration through the Project area generally occurs from April to mid-May and from mid-September to October, respectively. The Project route would intersect a known whooping crane migration route that includes 75-percent of all reported whooping crane sightings in North Dakota.	Wetlands bordered by agricultural fields.	Yes. The Project area is at the western edge of the species' migratory route through North Dakota.	No.	McKenzie and Williams.	Hagen 2005; USFWS 20014b.
Piping plover	*Charadrius melodus*	FT	This species nests on exposed, sparsely vegetated shores and islands of shallow, alkali lakes and impoundments. Nests are placed in sand or gravel, generally near a clump of grass, rock, or small log. The peak breeding season occurs from late May to mid-July.	Sand or gravel beaches, alkaline wetlands.	Yes. Designated critical habitat exists along the Missouri River in McKenzie and Williams counties. Potential habitat exists at Lake Sakakawea.	No.	McKenzie and Williams.	Hagen 2005; USFWS 2002; USFWS 2012.
Rufa red knot	*Calidris canutus* ssp. *rufa*	FP	This shorebird breeds in the central Canadian Arctic, with primary breeding grounds in Nunavut Territory. The rufa red knot winters along the Atlantic coasts of Argentina and Chile, the north coast of Brazil, and further north into Mexico and the southeast U.S. During migration (July-August and March-June), the rufa red knot primarily follows the Atlantic coastline to and from breeding and wintering grounds. However, geolocator results from red knots wintering in Texas showed that some birds migrate using a central flyway across the midwestern U.S. and may have a northern Great Plains stopover .	Sand or gravel beaches, alkaline wetlands.	Yes. Potential stop-over habitat occurs at Lake Sakakawea and wetlands crossed by the Project.	No.	McKenzie and Williams.	NDNHI 1998; USFWS 2014b.
Sprague's pipit	*Anthus spragueii*	FC	This species requires large expanses of native grasslands of intermediate height and sparse to intermediate vegetation density, low forb density, and little bare ground but low litter depth. The abundance of this species is positively correlated with the percent of clubmoss cover and dominant native grass species. Sprague's pipit is present in North Dakota from mid-April to mid-October. Peak breeding season occurs from early May to mid-August.	Large expanses of native grasslands.	Yes. Potential habitat occurs within the Project area.	No.	McKenzie and Williams.	Hagen 2005.

Table D-1 Special Status Species Potentially Occurring within the Project Area

Species	Scientific Name	Status[1]	Habitat Association	Primary Habitat	Potential for Occurrence Within Project Area	Eliminated from Detailed Analysis	Counties	Source
Baird's sparrow	*Ammodramus bairdii*	USFS	This species inhabits extensive tracts of native prairie, but will utilize idle, agricultural grasslands and lightly to moderately grazed pastures. Baird's sparrow is present in North Dakota from May to August. The peak breeding season occurs from early June to late July.	Grasslands and pastures.	Yes. Potential habitat occurs within the Project area.	No.	McKenzie and Williams.	Hagen 2005.
Bald eagle	*Haliaeetus leucocephalus*	USFS	This species typically occurs near large waterbodies, which supports suitable roosting, nesting, and foraging habitat. Winter habitat typically includes areas of open water, adequate food sources, and sufficient diurnal and nocturnal roosts. Nest sites are usually located in mature trees close to open water. Bald eagles are present in North Dakota year-round. Peak breeding season occurs from early March to July.	Large rivers and waterbodies with mature stands of trees.	No.	Yes. Suitable nesting habitat does not occur within the Project area. The nearest nest is approximately 7 miles west of the Project area. Occurrence would be limited to migrating or foraging individuals.	McKenzie and Williams.	Hagen 2005; USFS 2014.
Burrowing owl	*Athene cunicularia*	USFS	This species inhabits open grasslands with short vegetation and bare ground. Burrowing owls rely exclusively on burrowing mammals (primarily prairie dogs) to create burrows for nest sites. The species is present in North Dakota from April to September. Peak breeding season occurs from early May to mid-August.	Short-grass/bare ground.	Yes. While preferred habitat (i.e., black-tailed prairie dog colonies) does not occur within the Project area, burrowing owls can also inhabit other mammalian burrows.	No.	McKenzie and Williams.	Hagen 2005.
Greater prairie chicken	*Tympanuchus cupido*	USFS	This species inhabits grassland and agricultural lands. Leks are located in areas of bare ground or short vegetation. Peak breeding season occurs from late April to early July.	Grasslands, short-grass/bare ground.	No.	Yes. The Project area is outside the known range for this species.	None.	Hagen 2005; USFS 2011.
Greater sage-grouse	*Centrocercus urophasianus*	USFS	This species primarily inhabits big sagebrush communities. Riparian, upland meadows and agricultural land are also utilized, especially for brood-rearing habitat. Leks are located in areas of bare ground or short vegetation. Peak breeding and nesting season occurs from mid- March to mid-July.	Big sagebrush, short-grass/bare ground, meadows, and agricultural land.	No.	Yes. The Project area is outside the known range for this species.	None.	Hagen 2005; USFS 2011.
Loggerhead shrike	*Lanius ludovicianus*	USFS	This species inhabits open country with thickets of small trees, shrubs, and shelterbelts. The loggerhead shrike is present in North Dakota from mid-March to October. Peak breeding season occurs from early May to mid-July.	Open country with intermittent woody vegetation.	Yes. Potential habitat occurs within the Project Area.	No.	McKenzie and Williams.	Hagen 2005.

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Species	Scientific Name	Status[1]	Habitat Association	Primary Habitat	Potential for Occurrence Within Project Area	Eliminated from Detailed Analysis	Counties	Source
Long-billed curlew	*Numenius americanus*	USFS	This species inhabits expansive short-grass prairie with topography that is open, flat to gently rolling, or sloping. Proximity to water is an important habitat component. Nests are usually located near cowpies or other conspicuous objects for concealment and are often on hummocks for improved visibility. Peak breeding season occurs from early May to early July.	Grasslands.	Yes. Potential habitat occurs within the Project area.	No.	McKenzie.	Hagen 2005.
INVERTEBRATES								
Dakota skipper	*Hesperia dacotae*	FT	This species inhabits wet tall-grass or mixed-grass native prairies, often with mountain death camas. The larvae feed on grasses, especially little bluestem. Dakota skippers produce one brood in mid-June to early July.	Native prairie containing a high diversity of wildflowers and grasses.	Yes. Potential habitat occurs within the Project area. Proposed critical habitat is located 3.2 miles west and 2.3 miles east of the Project area on USFS-administered lands south of Lake Sakakawea.	No.	McKenzie.	Royer 2004; USFWS 2014c.
Argos skipper	*Atrytone arogos iowa*	USFS	This species inhabits mesic, undisturbed tall- to mixed-grass native bluestem prairies. Caterpillars hibernate and pupate the following spring. Adult flight is one brood from June to July.	Native prairie.	No.	Yes. The Project area is outside the known range for this species.	None.	Butterflies and Moths of North America 2014; Royer 2004.
Broad-winged skipper	*Poanes viator*	USFS	This species inhabits oxbow marshes with hairy sedge and swamp milkweed. Adult flight is one brood from late June to early August.	Oxbow marshes.	No.	Yes. The Project area is outside the known range for this species.	None.	Butterflies and Moths of North America 2014; Royer 2004.
Dion skipper	*Euphyes dion*	USFS	This species inhabits marshes with sedge, swamp milkweed, and cattails. Adult flight is one brood in July.	Marshes.	No.	Yes. The Project area is outside the known range for this species.	None.	Royer 2004.
Mulberry wing	*Poanes massasoit*	USFS	This species inhabits woody hummock meadows with sedge and dogwood. Adult flight is one brood in July.	Sedge meadows.	No.	Yes. The Project area is outside the known range for this species.	None.	Royer 2004.
Ottoe skipper	*Hesperia ottoe*	USFS	This species inhabits ungrazed or lightly grazed native prairie hilltops, often found on purple coneflower blooms. The larvae feed on bluestem, grama, stipa, and bluegrass. The Ottoe skipper produces one brood in mid-June to early July.	Native prairie.	Yes. Potential habitat occurs within the Project area.	No.	McKenzie and Williams.	Royer 2004.
Powesheik skipperling	*Oarisma powesheik*	USFS	This species inhabits native tall-grass meadows.	Tallgrass meadows.	No.	Yes. The Project area is outside the known range for this species.	None.	Royer 2004.

Table D-1 Special Status Species Potentially Occurring within the Project Area

Species	Scientific Name	Status[1]	Habitat Association	Primary Habitat	Potential for Occurrence Within Project Area	Eliminated from Detailed Analysis	Counties	Source
Regal fritillary butterfly	*Speyeria idalia*	USFS	This species inhabits native prairie, feeding on milkweed, thistle, and blazing star. The larvae feed on birdfoot violet. The regal fritillary overwinters shortly after enclosure. Adult flight occurs in late June (males) through August (mostly females).	Native prairie.	Yes. Potential habitat occurs within the Project area.	No.	McKenzie and Williams.	Royer 2004.
Tawny crescent	*Phyciodes batesii*	USFS	This species inhabits woodland roadsides, usually near bluestem prairie, feeding on dogbane and leafy spurge. The larvae feed on aster. The tawny crescent produces one brood, which usually emerges during the first week in June.	Woodland.	Yes. Potential habitat occurs within the Project area. This species has been documented near the Project area at milepost 20.4.	No.	McKenzie.	Royer 2004; USFS 2013.
FISH								
Pallid sturgeon	*Scaphirhynchus albus*	FE	This species is generally found in large, slow moving turbid rivers. Chutes between sandbars are commonly utilized. Spawning occurs from June through August.	Large, turbid rivers with sand substrate.	Yes. Potential habitat exists in Lake Sakakawea and the Missouri River upstream of Lake Sakakawea.	No.	McKenzie and Williams.	Hagen 2005; Ashton and Dowd 2008.
Northern Redbelly Dace	*Phoxinus eos*	USFS	This species inhabits cold, clear, spring- fed streams.	Cold, clear headwater streams.	No.	Yes. The Project area is outside the known range for this species.	McKenzie.	Hagen 2005.
PLANTS								
Smooth goosefoot	*Chenopodium pallescens*	USFS	The species inhabits sandbars, terraces, and dune complexes along rivers and creeks. Exposed sandy substrates in uplands, blowouts, outcrops, colluvium, etc. Elevation range 656 to 3609 ft. amsl. Flowering period: June to September.	Sand dunes.	No.	Yes. Potential habitat for this species is not present within the Project area.	Billings.	eFloras 2008; Mohlenbrock 2002; USFS 2011b.
Blue lips	*Collinsia parviflora*	USFS	This species inhabits woody understories, including green ash/elm draws, Rocky Mountain juniper, mesic shrub communities, and occasional xeric shrub communities. Elevation range unknown. Flowering period: March to June.	Woodlands and shrublands.	Yes. Potential habitat occurs within the Project area.	No.	Billings and Dunn.	Elle and Carney 2003; NatureServe 2014; USFS 2011b
Torry's cryptantha	*Cryptantha torreyana*	USFS	This species inhabits open areas at low to mid-elevation ranges within dry plains and pine slopes. Within the Little Missouri National Grassland, the species has been reported from scoria ridgelines, dry plains, rocky outcrops, escarpments, and pine slopes. Elevation range 1148 to 6562 ft. amsl. Flowering period May to July.	Varies.	No.	Yes. Potential habitat for this species is not present within the Project area.	Billings.	Jepson 1993 NatureServe 2014; USFS 2011b.

Table D-1 Special Status Species Potentially Occurring within the Project Area

Species	Scientific Name	Status[1]	Habitat Association	Primary Habitat	Potential for Occurrence Within Project Area	Eliminated from Detailed Analysis	Counties	Source
Nodding wild buckwheat	*Eriogonum cernuum*	USFS	This species inhabits exposed sand substrates with low plant cover in grasslands, hillsides, and sandstone outcrops. Elevation range 1,970 to 10,170 feet. Flowering period: late June to September.	Sandy substrates	No.	Yes. Potential habitat for this species is not present within the Project area.	Dunn.	Jepson 1993; Niehaus, 1998; USFS 2011b.
Dakota buckwheat	*Eriogonum visheri*	USFS	This species inhabits relatively exposed clay/silt substrate with low plant cover such as outwash zones around eroding buttes, saddles, steep convex slopes, and erosional breaks on prairie slopes. Occasional populations among dense saltgrass communities. 1,886 to 2,707 feet amsl. Flowering period: June to late September.	Barren, Prairie.	Yes. Potential habitat occurs within the Project area.	No.	Billings and McKenzie.	eFloras, 2014; Ladyman 2006; Montana Field Guide 2014; NatureServe 2014; USFS 2011b.
Missouri pincushion cactus	*Escobaria missouriensis*	USFS	This species inhabits prairie slopes and plains and stony to loamy to clayey short-grass to mixed-grass prairies. Also reported in woodlands of ponderosa pine or *Quercus* spp. Elevation range unknown. Flowering periodApril to June.	Prairie, Woodlands.	Yes. Potential habitat occurs within the Project area.	No.	McKenzie.	efloras 2014; NRCS 2014; USFS 2011b.
Sand lily	*Leucocrinum montanum*	USFS	This species inhabits shortgrass communities with fine textured substrates but also found in crested wheatgrass communities. Reported from open coniferous woodlands and hillsides, sagebrush scrub, and sandy flats. Elevation range 2,620 to 7,875 feet amsl. Flowering period March-June.	Varies.	Yes. Potential habitat occurs within the Project area.	No.	Billings and McKenzie.	efloras 2014; NatureServe 2014; USFS 2011b.
Golden stickleaf	*Mentzelia pumila*	USFS	This species inhabits scoria exposures and colluvium with low plant cover. Also reported on slopes and sandy plains; occasionally on hard clays and rocky soils. Elevation range unknown. Flowering period: June to early July.	Varies.	Yes. Potential habitat occurs within the Project area.	No.	N/A – No known populations within the Project- affected counties.	Nature Serve 2014; Montana Field Guide 2014; USFS 2011b.
Alyssum-leaved phlox	*Phlox alyssifolia*	USFS	This species inhabits sandy or gravelly soil on and around Bullion Butte. Also reported on clay banks and limestone ridges of open prairie. Elevation range unknown. Flowering period May.	Prairie, sandy and gravelly substrates.	Yes. Potential habitat occurs within the Project area.	No.	Billings and Williams.	NPWRC 2013; NatureServe 2010; USFS 2011b.
Limber pine	*Pinus flexilis*	USFS	This species inhabits semi-arid exposed rocky ridges and foothills in the Limber Pines RNA, likely of native-American origin. Elevation range 4,000 to 12,500 feet amsl. Fruiting period: August-September.	Rocky ridges, Foothills.	No.	Yes. Potential habitat for this species is not present within the Project area.	Slope	Johnson 2001; NRCS 2014; USFS 2011c.

Table D-1 Special Status Species Potentially Occurring within the Project Area

Species	Scientific Name	Status[1]	Habitat Association	Primary Habitat	Potential for Occurrence Within Project Area	Eliminated from Detailed Analysis	Counties	Source
Lance-leaf cottonwood	*Populus acuminata*	USFS	This species inhabits mesic woody draws, often with springs/seeps, and is found occasionally near springs on open hillsides, floodplains, and stream banks. Elevation range 4,921 to 7,874 feet. Flowering period: April-May.	Riparian.	No.	Yes. Potential habitat for this species is not present within the Project area.	Billings, Slope	NatureServe 2014; eFloras, 2014; NRCS 2014; USFS 2011b.
Alkali sacaton	*Sporobolus airoides*	USFS	This species inhabits secondary succession on clay outwash where tolerant of saline conditions, also on dry to moist sandy or gravelly soil. Elevation range 2,500 to 8,000 feet. Flowering period: June to October.	Desert, Prairie.	No.	Yes. Potential habitat for this species is not present within the Project area.	Billings.	Johnson, 2000; Brakie 2007; NatureServe 2014; USFS 2011b.
Stemless townsend daisy	*Townsendia exscapa*	USFS	This species inhabits dry plains and hillsides, often with loamy or increased soil development and increased plant cover relative to T. *hookeri*. Elevation range: up to 10,000 feet amsl. Flowering period: April to May.	Plains.	Yes. A population of *Townsendia* spp. has been documented within the Project area.	No.	Billings, Burke, Divide, Dunn, Slope, Stark, Williams	Carlson McCain 2014a,b; NPWRC 2013; NatureServe 2014; NRCS 2014; USFS 2011b.
Hooker's townsendia	*Townsendia hookeri*	USFS	This species inhabits areas with low to moderate plant cover on dry plains, hillsides, gravelly benches and weathered scoria, but often clay matrix subsoil 2,296 to 5,905 feet amsl. Flowering period: March to June.	Plains.	Yes. A population of Townsendia spp. has been documented within the Project area.	No.	Billings.	Carlson McCain 2014a,b; Efloras 2014; NatureServe 2014; USFS 2011b.

[1] FE = Federally Endangered.
FT = Federally Threatened.
FC = Federal Candidate.
FP = Federally Proposed
USFS = USFS Region 1 Sensitive Species.

Note: There are no greater sage-grouse leks along the project route (Carlson McCain 2013).