Revised Partial Claim for Past and Future Assessment Costs
January 2015 Bridger/Yellowstone River Oil Spill

Prepared by State and Federal Trustees,
State of Montana, and U.S. Department of the Interior

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Contents

2015 Bridger/Yellowstone River Oil Spill Assessment Plan

Appendices

Figures

Tables

Executive Summary

On January 17, 2015, the Poplar Pipeline, which is owned and operated by Bridger Pipeline, LLC (Bridger), of Casper, Wyoming, discharged at least 30,000 gallons of Bakken crude oil into the Yellowstone River just upstream of Glendive, Montana.

At the time of the spill, ice covered much of the river, but a visible oil sheen was reported at least as far downstream as Crane, Montana (59 river miles downstream from the pipeline crossing), and was also noted in several open-water areas. Ice on the Yellowstone River prevented cleanup of most of the oil. The oil remained in the river from January 17, 2015 through at least the time the ice started to break up in mid-March 2015.

Pursuant to Section 1006 of the Oil Pollution Act (OPA), 33 USC §§ 2701 et seq., Federal, State, and Federally recognized tribes are Trustees for natural resources and are authorized to act on behalf of the public to (1) assess natural resource injuries resulting from a discharge of oil or the substantial threat of a discharge and response activities, and (2) develop and implement a plan for restoration of such injured resources.

Following the Bridger oil spill, the affected Trustees initiated joint efforts to begin the collection and analysis of (1) data reasonably expected to be necessary to make a determination of jurisdiction or a determination to conduct restoration planning, (2) ephemeral data, and (3) information needed to design or implement anticipated emergency restoration and assessment activities as part of the Restoration Planning Phase. Subsequent to the spill, the Trustees collected and analyzed different types of environmental samples, including water, sediment, and fish samples; and deployed semipermeable membrane devices. In addition, the Trustees also obtained analytical results for environmental samples collected by Bridger, the U.S. Environmental Protection Agency, and the Montana Department of Environmental Quality.

Pursuant to the natural resource damage assessment (NRDA) regulations applicable to OPA, 15 CFR Part 990 (NRDA regulations), the Trustees issued a Notice of Intent to Conduct Restoration Planning (Notice). That Notice confirmed the Trustees were ready to proceed with restoration planning to fully evaluate, assess, and quantify and develop plans for restoring, replacing, or acquiring the equivalent of natural resources and their services injured by and losses resulting from the incident. The restoration planning process will include a collection of information the Trustees determine is appropriate for identifying and quantifying natural resource injuries and associated losses of resources and their services; and determination of the need for, type of, and scale of restoration actions.

This Claim document identifies assessment planning activities, including studies, that the Trustees plan to implement starting in 2018 to inform injury determination and injury quantification activities associated with the Incident. The collection of activities identified in this Claim reflect consideration of the factors identified in 15 CFR § 990.27 (use of assessment procedures), § 990.51 (injury determination), and § 990.52 (injury quantification). The assessment activities also reflect consideration of data and analyses conducted during the pre-assessment phase of the NRDA. The Trustees will also evaluate injury assessment implementation records for inclusion into the Administrative Record(s) (§ 990.61).

This Claim covers assessment activities and is entirely separate from the Pre-Assessment Costs Claim, which was received by the National Pollution Funds Center on May 2, 2017.

The document is organized to provide a description of the Trustees' proposed activities (see Section 1 in the Assessment Plan that follows this Executive Summary) and associated expenditures by resource category. A contract and agency subtotal is provided in each section of the Claim to clearly indicate the amount of money needed for a particular study or activity. This Partial Claim includes four distinct claims: (1) past incurred assessment costs (Table S.1) related to the restoration planning phase for Federal Trustees and contractors from February 1, 2016 through September 30, 2017 ($43,209.48; Appendix D), and State Trustees and contractors from October 1, 2016 through October 27, 2017 ($37,171.60; Appendix E); (2) a model-based assessment procedure related to bird injury (Table S.1; Appendix C); (3) a laboratory-based assessment procedure related to fish injury (Table S.1; Appendix B); and (4) Trustee costs for other Trustee responsibilities (Table S.1).

Table S.1. Total Federal and State Trustee costs

Expense category	Total
Past incurred assessment costs	**$80,381.08**
Future assessment costs	
Model-based assessment procedure related to bird injury	$125,909.06
Laboratory-based assessment procedure related to fish injury	$1,082,087.05
Other Trustee responsibilities	$172,588.92
Subtotal future assessment costs	**$1,380,585.03**
Total Claim	**$1,460,966.11**

This Partial Claim sets forth the Trustees' incurred and anticipated assessment costs, and the approximate date the Trustees expect to have incurred the anticipated costs. These assessment costs are reasonable assessment costs within the meaning of 15 CFR 990.30. The U.S. Department of the Interior costs are separated into the U.S. Fish and Wildlife Service; the U.S. Geological Survey; the Office of Policy, Management and Budget; and the Solicitor's Office. The State of Montana costs are separated into the Natural Resource Damage Program and Montana Fish, Wildlife & Parks. Both Trustees have retained contractors.

The Trustees' incurred assessment costs between February 1, 2016 and September 30, 2017 (Federal); and October 1, 2016 through October 31, 2017 (State) total $80,381.08 (Table S.1 and detailed with backup documentation in Appendices D and E).

The Trustees estimate their costs for a model-based assessment procedure related to bird injury, including contractor costs, to be $125,909.06 (Table S.1, and Appendices F and G).

The Trustees estimate their costs for the laboratory-based assessment procedure related to fish injury, including contractor costs, to be $1,082,087.05 (Table S.1, and Appendices F and G).

The Trustees will also have responsibilities and allowable assessment costs under the OPA regulations that are not directly tied to one of the two assessment tasks listed above. These costs include costs to coordinate with Bridger, conduct public involvement, update the Administrative Record, and quantify the injuries. The Trustees estimate their costs for these other Trustee responsibilities, including contractor costs, to be $172,588.92 (Table S.1, and Appendices F and G).

In total, the Trustees request $1,380,585.03 (Table S.1; $251,014.04 for agency support and $1,129,570.99 for contract support) to complete future NRDA activities outlined in this Claim. The Trustees are not requesting contingency funding for any of the activities.

In total, the Trustees request a sum certain of $1,460,966.11 for past and future injury assessment activities specified in this Interim Claim for Assessment (Table S.1).

I. Claim

I.1 Claimant Eligibility and Coordination with Co-Trustees

The following entities are designated natural resource Trustees under the Oil Pollution Act (OPA) and are acting as Trustees for this Incident:

1. The Governor of the State of Montana (State).
2. The Secretary of the Interior, the U.S. Department of the Interior (DOI), with its Authorized Official designated as the U.S. Fish and Wildlife Service, Regional Director, Region 6.

In addition to acting as Trustees for this Incident under OPA, the State is also acting pursuant to its applicable State laws and authorities.

The Trustees entered into a Memorandum of Understanding (MOU) in May 2015 for coordination and cooperation of the Trustees to initiate and conduct preassessment and restoration planning activities for natural resources and services under their trusteeship injured as a result of the January 2015 discharge of oil by Bridger Pipeline, LLC (Bridger) into the Yellowstone River. The U.S. Fish and Wildlife Service (FWS) and the State are Co-Lead Administrative Trustees.

I.2 Coordination between Trustees and Response Agencies

The response agencies notified the Trustees of the Incident soon after it occurred. The Trustees and response agencies worked to ensure access for natural resource damage assessment (NRDA) activities, which did not interfere with response actions. The Trustees and response agencies shared information. Where possible, the Trustees obtained relevant response data for Trustee data needs, rather than collecting data independently.

I.3 Responsible Party Information

Bridger owns and operates the Poplar Pipeline that ruptured in January 2015, spilling crude oil that caused injuries to natural resources as defined by OPA Section 1001(20). Bridger is one of the True Companies. When the term "Responsible Party" or "RP" (in the singular form) is used in the remainder of this document, it refers to Bridger.

I.4 Determination of Jurisdiction

On October 26, 2016, the Trustees issued a Notice of Intent (NOI), pursuant to 15 CFR 990.44, for the Yellowstone River oil spill. In the NOI, the Trustees set forth their determination of jurisdiction to conduct an NRDA and that doing so is appropriate in this matter. Based on information collected and evaluated since January 2015, the Trustees have made a preliminary determination that natural resources and services have been injured. Feasible restoration alternatives exist to address such injuries. As such, the Trustees stated their intent to proceed with an NRDA to identify natural resource injuries and proposed restoration alternatives. The NOI was distributed to the public via agency websites and media outlets. The NOI was provided to the RP electronically and via certified mail.

I.5 Time Limitations on Claims

This Claim for funding of reasonably necessary assessment and restoration planning procedures to inform Incident-specific injury determination and quantification analyses is presented in writing to the Director of the National Pollution Funds Center (NPFC) within the time limits specified in 33 CFR § 136.101. The NRDA for this Incident is not complete.

I.6 Legal Action

As required by 33 CFR § 136.105(12), no action has been commenced in court against the RP or guarantor of the source designated under § 136.305.

I.7 Claim Presentation

This Interim, Partial Claim for Assessment has been presented for a sum certain, in accordance with OPA to Bridger.

I.8 Coordination between Trustees and Responsible Party

As required by 33 CFR § 136.105(10), the Trustees will include a copy of written communications and the substance of verbal communications, if any, between the claimant and the responsible party if submitted to NPFC.

In April 2015, Bridger sent the Trustees a letter stating Bridger was willing to cooperate in preassessment activities, and the Trustees informed Bridger they would follow up at a later date. Bridger contacted the Trustees again on January 28, 2016, requesting information related to the Trustees' preassessment activities and reiterating a desire to cooperate in preassessment activities. On February 19, 2016, the Trustees responded and agreed to a meeting to discuss the possibility of a cooperative NRDA process. The Trustees met with Bridger in June 2016. The Trustees sent Bridger a draft letter agreement to address funding and cooperative assessment issues on August 1, 2016. Bridger sent the Trustees an email on September 8, 2016, expressing concerns with the draft letter agreement, but Bridger and the Trustees have not entered into a letter agreement. The Trustees sent Bridger a claim for partial preassessment costs on September 16, 2016. Bridger did not respond, nor pay these costs.

In October 2016, the Trustees formally invited Bridger's participation in the NRDA in a letter to Bridger enclosing the Trustees' NOI and an invitation for Bridger to participate in the NRDA. In November 2016, Bridger wrote to the Trustees noting its interest in participating in the NRDA, and proposing that the Trustees and Bridger discuss Bridger's potential involvement. The Trustees met with Bridger on March 3, 2017.

I.9 Overview of Assessment Approach

OPA regulations provide that NRDA procedures be tailored to the circumstances of the Incident and the information needed to determine appropriate restoration. With respect to standards for assessment procedures, the regulations provide that (15 CFR § 990.27(a)):

1. The procedure(s) must be capable of providing assessment information of use in determining the type and scale of restoration appropriate for a particular injury

2. The additional cost of a more complex procedure must be reasonably related to the expected increase in the quantity and/or quality of relevant information provided by the more complex procedure
3. The procedure must be reliable and valid for the particular Incident.

Compliance with the above regulations is addressed in the appendices and in subsequent sections of the Assessment Plan that follows this document. OPA regulations identify several categories of assessment procedures available to the Trustees, including, but not limited to, procedures conducted in the field or laboratory, model-based procedures, and/or literature-based procedures (15 CFR § 990.27(b)). If a range of assessment procedures providing the same type and quality of information is available, the most cost-effective procedure must be used (15 CFR § 990.27(c)). Finally, the assessment procedures must contribute to injury determination (i.e., by establishing the spatial and temporal magnitude of exposure to oil, the pathway(s) of exposure, and/or the presence of injury, as described in 15 CFR § 990.51) and/or injury quantification (i.e., quantifying the degree, spatial, and temporal extent of injury to natural resources and the associated reduction in services caused by the injury, as described in 15 CFR § 990.52).

The goal of the Trustees' assessment is to evaluate the effect of the oil spill and fill in the gaps in the assessment that were caused by the dangerous wintry and icy conditions, which prevented collecting enough data to document the severity and extent of the injury to fish and birds. As outlined below, the Trustees previously documented the pathway and exposure of discharged oil to resources and services that may have been affected by the Incident. The scale and cost of each proposed activity was carefully considered with the co-Trustees, and represents a balance between the need for a cost-effective assessment and a comprehensive evaluation.

The Trustees have determined the assessment procedures identified in the Assessment Plan meet the requirements set forth in the OPA regulations, and are integrated with and not duplicative of co-Trustee NRDA data collection and analysis activities. A description of each assessment activity's purpose and related implementation information is provided in subsequent sections of the Assessment Plan, and, in some cases, in the related work plans.

I.10 How the Trustees Estimated Assessment Costs for Each Activity

For each activity, the Trustees first estimated the number of agency staff, contractor labor hours, and any direct contract or agency costs necessary to complete all appropriate NRDA tasks. The Trustees relied upon both staff and contractor expertise and experience in similar activities to determine the level of effort required. Data management, scientific documentation, and legal review of analyses and technical deliverables are included as part of each activity's cost. The estimated Trustee hours and contractor costs are outlined in Appendices F and G. The roles of the various staff members are outlined below.

The types of deliverables described in this Claim are diverse:

- *Datasets/databases*. Datasets/databases include laboratory-based chemistry analyses, other biological laboratory analyses, field observation and measurement data, models and model outputs, and maps of observations in two and three dimensions. They include electronic data deliverables from laboratories and third-party validated data.

- *Work plans.* A work plan will need to be developed for the laboratory-based fish study, which is summarized below. The bird work plan will be implemented.
- *Reports*. Reports will include data and interpretation. Data reports and data summaries present relevant data and sometimes include descriptive statistics, basic analyses, or study methods. They typically present data in tabular format and may also include figures and maps. Quantification of injured resources and services will be included and the technical basis for our interpretation will be described using all relevant data about the release scenario, the pathway of the oil, the exposure of resources to the oil, and measureable injuries documented from the discharged oil.

We structured this Claim to present to the NPFC after 90 days if the RP declines to pay the Trustees' assessment and restoration planning costs. The repetitive style of the document helps ensure that critical information for each activity is considered.

I.10.1 U.S. Department of the Interior

Over the time period covered by this estimate, some staffing changes may occur, including reassignment of personnel and changes in hourly rates. Estimates in the tables are based on present information. The FWS indirect costs were estimated using the Cost Estimation Tool for all future costs, and the Cost Documentation Tool was used for all past costs. The Office of the Solicitor's indirect rates are 25.2% and the U.S. Geological Survey indirect rates are 7%. DOI Headquarters indirect costs are 16.84% of labor costs. Travel estimates are based on costs for trips by the FWS, and Solicitor staff to meet with the co-Trustees or Bridger, or to provide Trustee oversight during the studies. The FWS oversees the contract with Industrial Economics (IEc) for which IEc will provide support for case management, fish assessment work, and implement the Trustees' bird assessment activities.

The FWS Personnel

The Case Manager/Environmental Contaminant Specialist position is currently held by Karen Nelson. Ms. Nelson is a toxicologist at the FWS's Helena, Montana, Ecological Service Field Office. She participates in Trustee conference calls and meetings, as well as meetings with Bridger, and is responsible for all case management activities. Ms. Nelson reviews documents and work products associated with the bird injury assessment and other parts of the Trustee claim, assists with the development of budgets, provides oversight of field work and data analysis, and keeps technical and financial records. She also serves as a liaison between field staff and upper management, and coordinates the work of the FWS's contractor.

The Assistant Environmental Contaminant Specialist position is currently held by David Rouse. Mr. Rouse is a toxicologist at the FWS's Helena, Montana, Ecological Service Field Office. He participates in Trustee conference calls and meetings, and provides technical support to the avian injury assessment. Mr. Rouse reviews other documents and work products associated with other parts of the Trustee claim and assists with the development of budgets and cost tracking.

Office of Policy, Management and Budget Personnel

The Economist position is currently held by Christian Crowley. Mr. Crowley is an economist at DOI Headquarters. Mr. Crowley provides economics assistance for the avian injury assessment. He also participates in the identification of restoration requirements for injured resources.

U.S. Geological Survey Personnel

Donald Tillitt, Research Toxicologist at the Columbia Environmental Research Center, will assist in the pallid sturgeon exposure study design, benchmark selection, and interpretation of results.

Solicitor's Office Personnel

Dana Jacobsen is currently the Solicitor assigned to this matter. Ms. Jacobsen works for the DOI Solicitor's Office. The Solicitor's Office provides legal advice to agencies in the DOI, including the FWS Region 6. She is located in the DOI Solicitor's Office, Rocky Mountain Region, in Lakewood, Colorado. Solicitor costs include activities to assess natural resource damages under OPA Sections 1002(b)(2)(A) and 1006(c), including restoration planning and the development of a plan for restoration, rehabilitation, replacement, or acquisition of the equivalent natural resources under DOI trusteeship; public notice and comment activities; Trustee coordination; administrative activities; and participation in conference calls and meetings with Trustees and with Bridger.

I.10.2 State of Montana

Over the time period covered by this estimate, some staffing changes may occur, including reassignment of personnel and changes in hourly rates. Estimates in Table S.1 in the Executive Summary are based on present information. The travel estimate is based on costs for trips by Natural Resource Damage Program (NRDP) staff within Montana to meet with the co-Trustees or Bridger, or to provide Trustee oversight during studies (Appendix G).

NRDP will continue its contract with Abt Associates (Abt). Abt will provide technical assistance and support for the discussions and potential coordination with Bridger, as outlined in Table S.1 in the Executive Summary.

NRDP Personnel

The Lawyer/Program Manager position is currently held by Harley Harris. Mr. Harris provides overall management and supervision of the State's NRDA activities. He reviews documents and work products associated with the Trustee claim, and assists with the development of budgets. Mr. Harris also performs certain legal work relating to those activities, such as compliance with any operating Memoranda of Agreement or MOUs. He also participates in conference calls and meetings with the Trustees. In addition, Mr. Harris coordinates the work of Montana State's staff and its consultants.

The Assistant Attorney General positions are currently held by Katherine Hausrath and Mary Capdeville. Ms. Capdeville and Ms. Hausrath provide legal advice relating to the NRDA activities. Ms. Capdeville also serves as the backup for the Lawyer/Program Manager.

Ms. Capdeville and Ms. Hausrath participate in conference calls and meetings with the Trustees. In addition, they coordinate certain work of the Montana State's staff and its consultants.

The Environmental Science Specialist position is currently held by Beau Downing. Mr. Downing is assigned to work on and manage certain technical aspects of Montana State's NRDA activities. Mr. Downing, along with Montana Fish, Wildlife & Parks (FWP) staff, provides oversight of field work and data analysis. Mr. Downing, along with the NRDP Restoration Program Chief, Doug Martin, also participates in conference calls and meetings with the Trustees and with Bridger. In addition, Mr. Downing and Mr. Martin assist in coordinating the work of Montana State's consultants.

Accounting and administrative assistance is currently being provided by Shannon Gilskey.

FWP Personnel

The activities included in this estimate for FWP are work and management of certain technical aspects of Montana State's NRDA activities for a laboratory-based assessment procedure related to fish injury, as outlined in Appendix G.

FWP staff will provide oversight of field work and data analysis, and also participate in conference calls and meetings with the Trustees and Bridger. Over the time period covered by this estimate, some staffing changes may occur, including reassignment of personnel and changes in hourly rates. Estimates in Table S.1 in the Executive Summary are based on present information. The travel estimate is based on costs for trips by FWP staff within Montana to meet with the co-Trustees, Bridger, or to provide Trustee oversight during studies (Appendix F).

The Region 7 Operations Manager position is currently held by Brad Schmitz, who is assigned to work on technical aspects of Montana State's NRDA activities related to fishery resources. Mr. Schmitz will also participate in conference calls and meetings with the Trustees and Bridger. In addition, Mr. Schmitz assists in coordinating the work of Montana State's consultants related to fishery resources.

The Fisheries Management position is currently held by Mike Backes. Mr. Backes is assigned to work on technical aspects of Montana State's NRDA activities related to aquatics. Mr. Backes will also participate in conference calls and meetings with the Trustees and Bridger. In addition, Mr. Backes assists in coordinating the work of Montana State's consultants related to aquatics.

The Fisheries Biologist positions are held by Caleb Bollman and Mathew Rugg. Mr. Bollman and Mr. Rugg will provide input on the fish study, including work plans and reports, and perform periodic reviews of findings.

I.11 Claimant Certification

As required by 33 CFR §§ 136.105 and 136.209, the Trustee representatives:

1. Certify to the best of the claimant's knowledge and belief that the claim accurately reflects all material facts

2. Certify the accuracy and integrity of any claim submitted to the Fund, and certify that any actions taken or proposed were or will be conducted in accordance with the Act and consistent with all applicable laws and regulations

3. Certify that the assessment will be conducted in accordance with applicable provisions of the NRDA regulations promulgated under Section 1006(e)(1) of the Act (33 USC 2706(e)(1))

4. Certify that, to the best of the Trustee's knowledge and belief, no other Trustee has the right to present a claim for the same natural resource damages and that payment of any subpart of the claim presented would not constitute a double recovery for the same natural resource damages.

2015 Bridger/Yellowstone River Oil Spill Assessment Plan

1. Assessment Plan Summary

On January 17, 2015, the Bridger Pipeline, LLC (Bridger) Poplar Pipeline ruptured, spilling an estimated 30,000 gallons of Bakken crude oil into the mostly ice-covered lower Yellowstone River. Under the federal Oil Pollution Act (OPA), the State of Montana, represented by the Natural Resource Damage Program within the Montana Department of Justice, and the Department of the Interior (DOI), represented by the U.S. Fish and Wildlife Service (FWS), collectively the Trustees, have initiated a Natural Resource Damage Assessment (NRDA) to determine the nature and extent of the natural resource injuries and subsequent damages resulting from the spill, and the restoration actions needed to restore and/or compensate the public for those damages. This Assessment Plan provides information regarding assessment procedures and methods undertaken and proposed by the Trustees to determine injury and develop restoration plans.

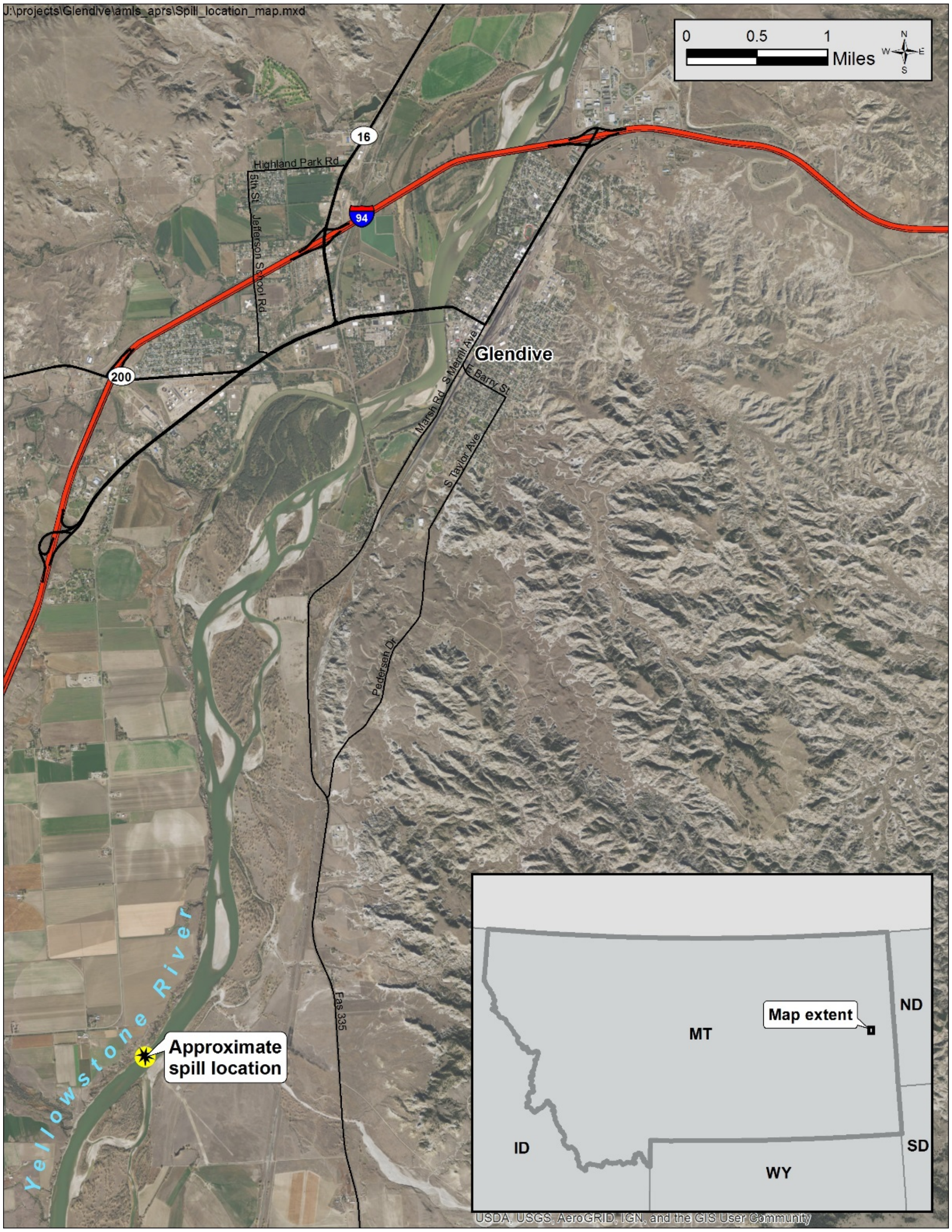
The lower Yellowstone River is a unique ecosystem with a large variety of natural resources, including surface water, sediment, soil, plants, insects and other invertebrates, fish, amphibians, reptiles, birds, and mammals. The river serves as the sole drinking water source for the City of Glendive, Montana, which is approximately 6.5 miles downstream of the spill site (Figure 1.1). The river is also home to over 40 species of fish and almost 20 species of aquatic and semi-aquatic birds, including several species with special population status (e.g., bald eagle, pallid sturgeon, burbot). During winter months, parts of the lower Yellowstone River remain unfrozen, providing some of the only open water habitat available to birds in the area.

Shortly after the incident, response crews, including federal and state agencies, and the responsible party (RP), Bridger, engaged in various response activities, including drinking water monitoring in the City of Glendive, surface water and sediment sampling, fish tissue sampling, and oil recovery. Results from these initial response activities prompted both a “do not consume” drinking water advisory for the residents of Glendive, Montana; and a fish consumption advisory for the Yellowstone River downstream of the spill site.

In addition, the Trustees conducted studies and surveys to collect ephemeral data concerning on-site conditions that would otherwise have been lost or altered. These preassessment activities included the collection of water and sediment samples, the deployment of semi-permeable membrane devices (SPMDs), and the completion of a fish health survey. They also evaluated information related to potential feasible restoration alternatives and assessment activities, pursuant to 15 CFR §§ 990.44(4) and (5).

Results from both response and the Trustee preassessment activities have established exposure and demonstrated injury to natural resources as a result of the discharged oil. Preliminary injury determinations include injury to surface water resources based on exceedances of water quality standards and screening levels, and injury to fish based on exceedances of literature-based adverse effects levels. While water column concentrations of oil constituents have indicated a potential injury to fish based on literature-based values, there is uncertainty in this assessment because (1) there is very little information on toxic effects of oil in cold conditions and, in particular, under ice; and (2) there is little to no data for the particular species in the affected area of the Yellowstone River, particularly pallid sturgeon and burbot, and due to these uncertainties, the Trustees propose to conduct toxicity testing that addresses these data gaps.

Figure 1.1. Location of Bridger oil spill on January 17, 2015, approximately 6.5 miles upstream from Glendive, Montana.



In addition, based on observations from preassessment activities, the Trustees are also concerned that migratory and other birds were exposed to oil in the form of oil sheens found in the open waters, and propose to conduct modeling to evaluate this potential impact on birds.

Finally, the Trustees present their injury quantification approach, using the data collected at the time of the spill, and the results of the fish and avian studies.

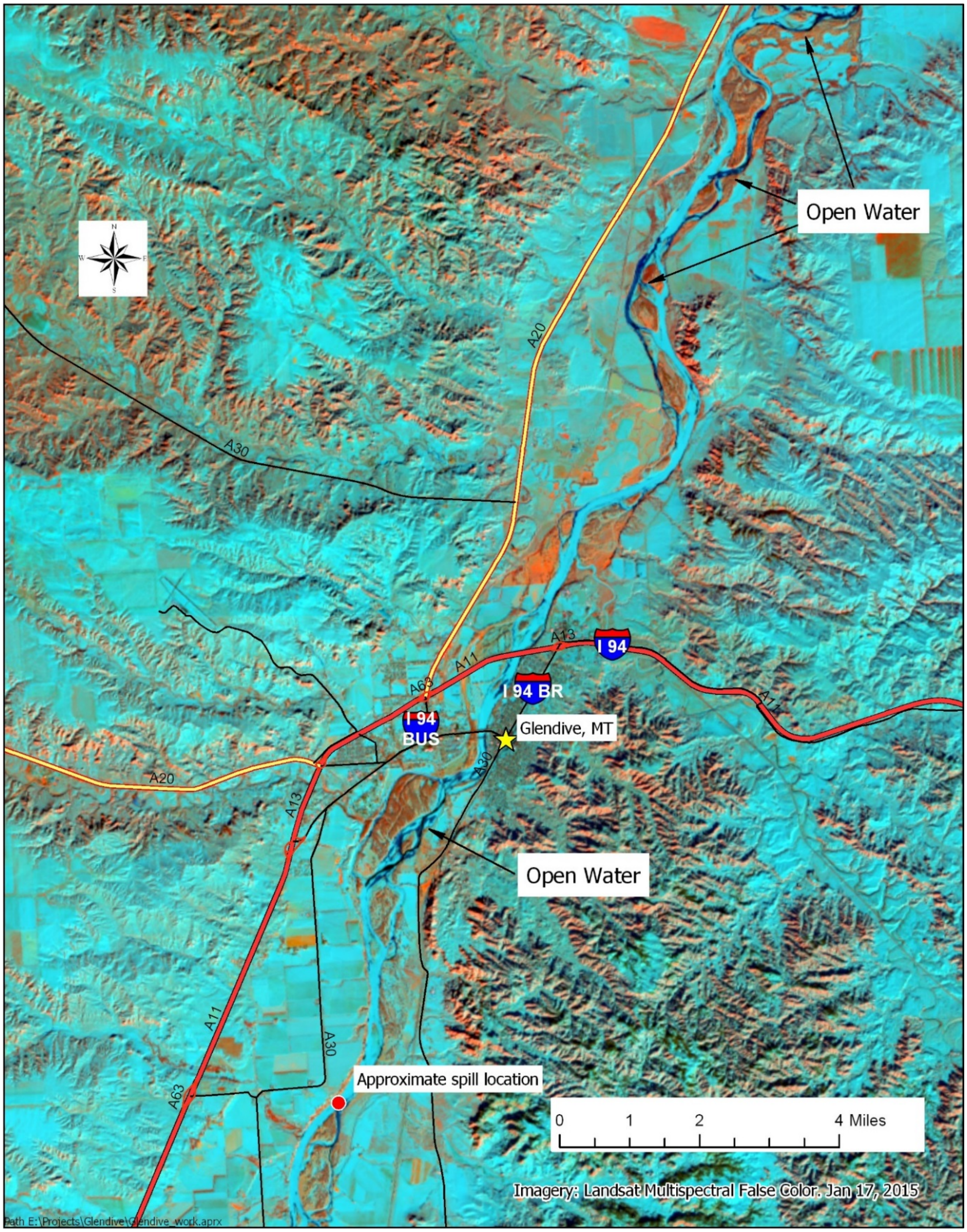
2. Introduction

The Bridger oil spill (also referred to hereafter as the spill) occurred on January 17, 2015, spilling an estimated 30,000 gallons of Bakken crude oil into the Yellowstone River just upstream of Glendive, Montana (MT-DEQ, 2015a; U.S. EPA, 2015). At the time of the spill, ice covered much of the river (Figure 2.1). Subsequent to the spill, the RP, Bridger, as well as state and federal agencies, engaged in response operations, including drinking water monitoring, oil recovery, and site cleanup. In addition, the State of Montana, represented by the Natural Resource Damage Program within the Montana Department of Justice, and the DOI, represented by the FWS, collectively the Trustees, engaged in preassessment activities to collect ephemeral data to help determine if natural resources were exposed to and adversely affected by the discharged oil, and as a result warrant restoration planning. These activities included collecting and analyzing water, sediment, and fish tissue samples; deploying SPMDs; and conducting a fish health survey. The Trustees also obtained analytical results for environmental samples collected by Bridger, the U.S. Environmental Protection Agency (EPA), and the Montana Department of Environmental Quality (MT-DEQ) to include in their preassessment analyses.

Based on the results of these activities, the Trustees have made a preliminary determination that (1) natural resources and services have been injured, (2) the limited response actions did not address the injuries, and (3) feasible restoration alternatives exist to address such injuries. As such, the Trustees determined it appropriate to conduct restoration planning, pursuant to 15 CFR § 990.42, and issued a Notice of Intent to Conduct Restoration Planning on October 26, 2016, pursuant to 15 CFR § 990.44.

This Assessment Plan describes the preassessment activities undertaken by the Trustees since January 2015. The purpose of this plan is to present the Trustees' preliminary determination of injuries to natural resources and/or services that have resulted from the incident based on the current understanding of existing data and information. In addition, the plan identifies two assessment activities the Trustees feel are needed to complete their determination of injury to two key resources: fish and birds. These assessment activities are (1) a laboratory-based assessment procedure related to fish injury, and (2) a model-based assessment procedure related to bird injury. In addition, this plan describes how the Trustees intend to quantify injury, based on the environmental data collected to date, and the results of the proposed injury studies.

Figure 2.1. Landsat false color image of the Yellowstone River near Glendive on January 17, 2015. This image combines shortwave infrared, near infrared, and blue bands, making snow-covered surfaces (including the ice on the river) appear light blue and open water areas appear dark blue.



3. Spill Incident

On January 17, 2015, Bridger's Poplar Pipeline ruptured, releasing Bakken crude oil into the Yellowstone River. The pipeline break occurred about 6.5 miles upstream from the City of Glendive, in Dawson County, Montana. The cause of the pipeline rupture was a break in a weld line in a section of 12-inch diameter pipe, located under the middle of the river (Poplar Pipeline Response, 2015). Sonar surveys conducted in the days after the spill indicated the pipeline, which had originally been buried several feet under the river bottom, had become exposed (presumably due to erosional processes in the river), and was lying on the surface of the river bed (MT-DEQ, 2015a). This position may have made the pipe more exposed to environmental conditions and vulnerable to rupture. The quantity of crude oil spilled into the Yellowstone River was estimated to be approximately 700 barrels, or 30,000 gallons (MT-DEQ, 2015a; U.S. EPA, 2015; Weston Solutions, 2015). The winter conditions during the spill created challenges for both recovering the spilled oil and characterizing the nature and extent of contamination, as ice covered large areas of the river (Figures 2.1 and 3.1; U.S. EPA, 2015).

Figure 3.1. Oil recovery operations on the Yellowstone River downstream of the spill site, January 27, 2015. Ice-covered conditions at the time of the spill created challenges for both the recovery of the spilled oil and for environmental sampling.

Source: Weston Solutions, 2015.

3.1 Bakken Crude Oil

Bakken crude is a light, sweet (i.e., low sulfur content) crude oil with a relatively high volatile organic compound (VOC) component (Aueres et al., 2014). Chemical analyses of product samples collected from the pipeline by the Trustees and the RP showed the oil contained a high percentage of VOCs (20% of total extractable hydrocarbon), which included benzene, toluene, ethylbenzene, and xylenes (BTEX); and aliphatic (straight carbon chain) hydrocarbons. The spilled oil also contained polycyclic aromatic hydrocarbons (PAHs), predominately low molecular weight PAHs, including methylated and non-methylated naphthalenes, phenanthrenes, and anthracenes, and, to a lesser extent, methylated fluorenes.

3.2 Disrupted Services

Table 3.1 provides a timeline of spill events and weather and river ice conditions, which affected cleanup and sampling activities, and likely also affected the transport of contaminants. Bridger was initially alerted to a potential spill by a drop in pressure, which was detected by pipeline sensors. Immediately after the pressure drop was detected, Bridger sent a crew to investigate the site, and in the ice-covered conditions, could find no evidence of spilled oil (U.S. EPA, 2015). However, within a day of the rupture, the City of Glendive's water treatment plant (WTP) began receiving complaints of tainted water from local residents, which was quickly linked to the pipeline rupture (U.S. EPA, 2015).

Table 3.1. Timeline of notable events that occurred during the Bridger/Yellowstone River oil spill

Date	Event	Source
1/17/2015	• A rapid drop in pressure is detected in Bridger's Poplar Pipeline, near the City of Glendive. In response, Bridger shut down the flow of oil in the pipeline.	Peronard, 2015
1/18/2015	• The City of Glendive WTP begins receiving odor and taste complaints from local residents. • Samples are collected from the WTP by MT-DEQ for drinking water quality analyses. • EPA Superfund Technical Assessment and Response Team (START) personnel arrive onsite. • START personnel detect VOCs in the headspace of samples collected from residential faucets and the WTP of up to 50 ppm VOCs. • A "do not consume" tap water advisory is issued to Glendive residents. • The sheen was reported as far downstream as Crane, Montana (59 river miles downstream from the pipeline break).	Peronard, 2015; U.S. EPA, 2015; Weston Solutions, 2015
1/19/2015	• 14 µg/L benzene is measured in a water sample collected from the output of the Glendive WTP (collected by WTP operators, and analyzed by Energy Labs in Billings). • Aerators and media filters are installed at the Glendive WTP. • Glendive City water distribution system flushing begins.	Peronard, 2015; Weston Solutions, 2015
1/20/2015	• EPA mobile laboratory arrives onsite and begins collecting and analyzing WTP samples. • Mobile laboratory reports benzene up to 40 µg/L and toluene and xylene up to 700 µg/L in WTP water samples.	Peronard, 2015
1/21/2015	• MT-FWP issue a Fish Consumption Advisory (FCA) for fish caught in the Yellowstone River in the area of Glendive (as a precautionary measure in advance of sampling). • Response crews begin cleanup operations at the spill site; the section of the pipeline with the rupture is isolated (capped), and oil recovery from the broken pipeline begins.	MT-DEQ, 2015a; U.S. EPA, 2015
1/22/2015	• START personnel begin daily sampling of the WTP river intake and plant output. • MT-FWP conduct FCA sampling (collect fish for tissue analysis).	U.S. EPA, 2015; Weston Solutions, 2015
1/23/2015	• START personnel sample the Williston (North Dakota) WTP on the Missouri River, approximately 130 river miles downstream of the spill site, and benzene, xylenes, and toluene are detected at just above detection limits. • The City of Glendive WTP "do not consume" advisory is lifted.	U.S. EPA, 2015; Weston Solutions, 2015

Table 3.1. Timeline of notable events that occurred during the Bridger/Yellowstone River oil spill

Date	Event	Source
1/25/2015	• Response crews collect the first set of surface water samples from the Yellowstone River at the spill site.	Weston Solutions, 2015
1/26/2015	• Warming temperatures result in partial thawing of river ice, hampering access to the spilled oil and limiting oil recovery efforts.	MT-DEQ, 2015a; U.S. EPA, 2015
1/28/2015	• Cold weather moves in, and river ice conditions stabilize again.	MT-DEQ, 2015a
1/29/2015	• EPA START personnel depart the site. • Trustees deploy SPMDs at one upriver and five downriver locations from the spill site.	Weston Solutions, 2015; Trustee SPMD dataset[a]
2/1/2015	• Roughly 58 bbls of the total recovered oil (60 bbls) are recovered by February 1 (oil recovery operations end by mid-February).	Peronard, 2015
2/2/2015	• Warming temperatures result in unstable ice conditions, and oil recovery activities are temporarily suspended, due to unsafe conditions.	MT-DEQ, 2015a
2/9/2015	• Oil recovery activities resume after being suspended since February 2, 2015.	MT-DEQ, 2015a
2/12/2015	• An in-line VOC water monitoring instrument is installed at the Glendive WTP. • Bridger is issued a Notice of Potential Liability Letter from MT-DEQ.	MT-DEQ, 2015a
2/13/2015	• The last water sampling event is conducted by response crews.	Weston Solutions, 2015
2/20/2015	• MT-FWP issues a statement indicating that detectable levels of PAHs were found in fish collected on January 22, 2015, and the FCA remains in place.	MT-FWP, 2015
2/26/2015	• Daily sampling of Glendive WTP river intake and plant output is discontinued.	Weston Solutions, 2015
3/5/2015	• The FWS recovers the six Trustee SPMDs deployed on January 29, 2015 from the Yellowstone River.	Trustee SPMD dataset[a]
3/14/2015	• Temperatures warm, and the ice begins to break up and melt. The City of Glendive WTP in-line VOC monitor detects elevated levels of VOCs at the intake, > 200 µg/L. River water intake is temporarily halted, and the town is supplied water from backup storage tanks.	U.S. EPA, 2015
3/15/2015	• The last VOC detection is made by the Glendive WTP in-line VOC monitoring system.	MT-DEQ, 2015a
3/19/2015	• Trustees deploy SPMDs at one upriver and five downriver locations from the spill site.	Trustee SPMD dataset[a]
3/22/2015	• Federal response efforts are complete, and EPA leaves the site. • Trustees conduct a fish health survey to evaluate the effect of the spill on fish downstream of the spill.	MT-DEQ, 2015a; U.S. EPA, 2015
4/8/2015	• The 8-ft section of damaged pipeline is removed from the river.	MT-DEQ, 2015a
4/10/2015	• All response activities end.	MT-DEQ, 2015b
4/13/2015	• The FCA for fish caught on the Yellowstone River near the spill is lifted by MT-FWP.	MT-FWP, 2015
4/21/2015	• The FWS recovers the six Trustee SPMDs deployed on March 19, 2015 from the Yellowstone River.	Trustee SPMD dataset[a]

a. The Trustee SPMD dataset is currently unpublished.

The City of Glendive obtains its drinking water supply from the Yellowstone River at an intake pipe located approximately 6.5 miles downstream from the spill site. Immediately following complaints of tainted drinking water, MT-DEQ and EPA, in cooperation with the RP, began monitoring for drinking water quality at the Glendive WTP and other local residences. They found that benzene concentrations in the drinking water supply were exceeding the maximum contaminant level (MCL) of 5 µg/L benzene by several times. In response to the contamination, a "do not consume" water advisory was issued on January 18, 2015, and residents were supplied with bottled water. The advisory was held in place until January 23, 2015.

High VOCs were again detected at the WTP on March 14, 2015, at the time of the final ice breakup and melting. It is presumed that these high VOCs were the result of oil trapped in layers and cracks in the ice, which was released into the river when the ice began to melt (Figure 3.1). During this event, VOC concentrations greater than 200 µg/L were measured at Glendive's WTP intake. In response, the Glendive WTP switched its water supply from the river to water storage tanks. During this time, residents were requested to conserve water and bottled water was again made available (U.S. EPA, 2015).

As outlined in Table 3.1, most of the activities in the first few days after the spill were focused on responding to the contamination at the City of Glendive's WTP. Response activities associated with the drinking water contamination problem included extensive characterization of VOC contamination throughout the municipal water supply system, including at the treatment plant, public facilities (such as the hospital), and residents' faucets. Aeration and filtration systems were also installed to remove VOCs from the water supply system. During these monitoring activities, Bridger measured 14 µg/L of benzene in a water sample collected at the City of Glendive's WTP faucet on January 19, 2015 (Weston Solutions, 2015); and EPA reported up to 40 µg/L of benzene in samples it collected from the plant on January 20, 2015, and analyzed in its mobile laboratory (U.S. EPA, 2015).

Ultimately, measuring these levels of benzene in water 6.5 miles downstream of a spill site in a flowing river is unusual, given that benzene is a volatile compound. However, the conditions of the spill were unique in that the river was covered by ice at the time of the spill. These conditions may have served to trap constituents in the water that would have otherwise volatilized, prior to reaching the WTP intake pipe.

As a precaution, MT-FWP also issued an FCA on January 21, 2015. Subsequent analysis of fish tissue collected from the river near Glendive on January 22, 2015 revealed elevated concentrations of PAHs. This prompted MT-FWP to extend the FCA on February 22, 2015. The advisory was in place until April 13, 2015.

3.3 Oil Recovery and Sampling Activities

Response crews began oil recovery operations at the spill site on January 21, 2015. This included both recovering oil directly from the pipe, and recovering the oil that had spilled into the Yellowstone River. To recover oil directly from the pipe, the section of pipeline with the break was capped at both ends and tapped to recover oil still in the capped section. Approximately 500 barrels were recovered from the pipe itself.

Since the spill occurred in the winter, when there was ice up to 5-feet thick on the river, and frigid temperatures (average low temperature in January 2015 in Glendive, Montana was -11°C or 13°F), the recovery of oil from the Yellowstone River was challenging. While a number of different techniques were attempted to recover oil from the river, the primary techniques included ice slotting, open water boom drags, and auger ice mining (U.S. EPA, 2015). Of these three techniques, auger ice mining was reported to be the most effective. This recovery method involved auguring a hole into a thick section of river ice. Oil that had been trapped between layers of ice and in fissures in the ice then flowed into the hole, and was recovered using pumps and absorbent pads. Figure 3.2 is a photograph of an auger hole drilled to recover oil using this process, and it shows layers of oil-contaminated ice. Only a small proportion of spilled oil was ultimately collected from the river. EPA (U.S. EPA, 2015) estimated that a total of 60 bbls or 2,520 gallons of oil were recovered from the river during the response to the spill. The bulk of this volume (58 bbls) was collected by February 1, 2015, and oil recovery operations ended in mid-February.

Figure 3.2. An auger hole drilled to recover oil by "auger ice mining." Layers of oil-contaminated ice are visible in the photograph, suggesting that oil may have become trapped within ice layers and fissures as the river water froze during cold conditions in the days after the spill.

The cold weather and ice-covered conditions also created challenges for both response crews and the Trustees in collecting environmental samples for characterizing the nature and extent of the contamination. In the first month after the spill (last two weeks of January and first two weeks of February), water samples were collected mainly from holes cored into the ice, which were accessed by airboats driven on the ice surface. Samples were also collected opportunistically when openings in the ice occurred. Sampling was further limited since U.S. Coast Guard staff were the only onsite personnel with the correct training to collect samples under these conditions (U.S. EPA, 2015). Several temperature warming events led to unstable ice conditions, resulting in interruptions in oil recovery and sampling activities (see Table 3.1).

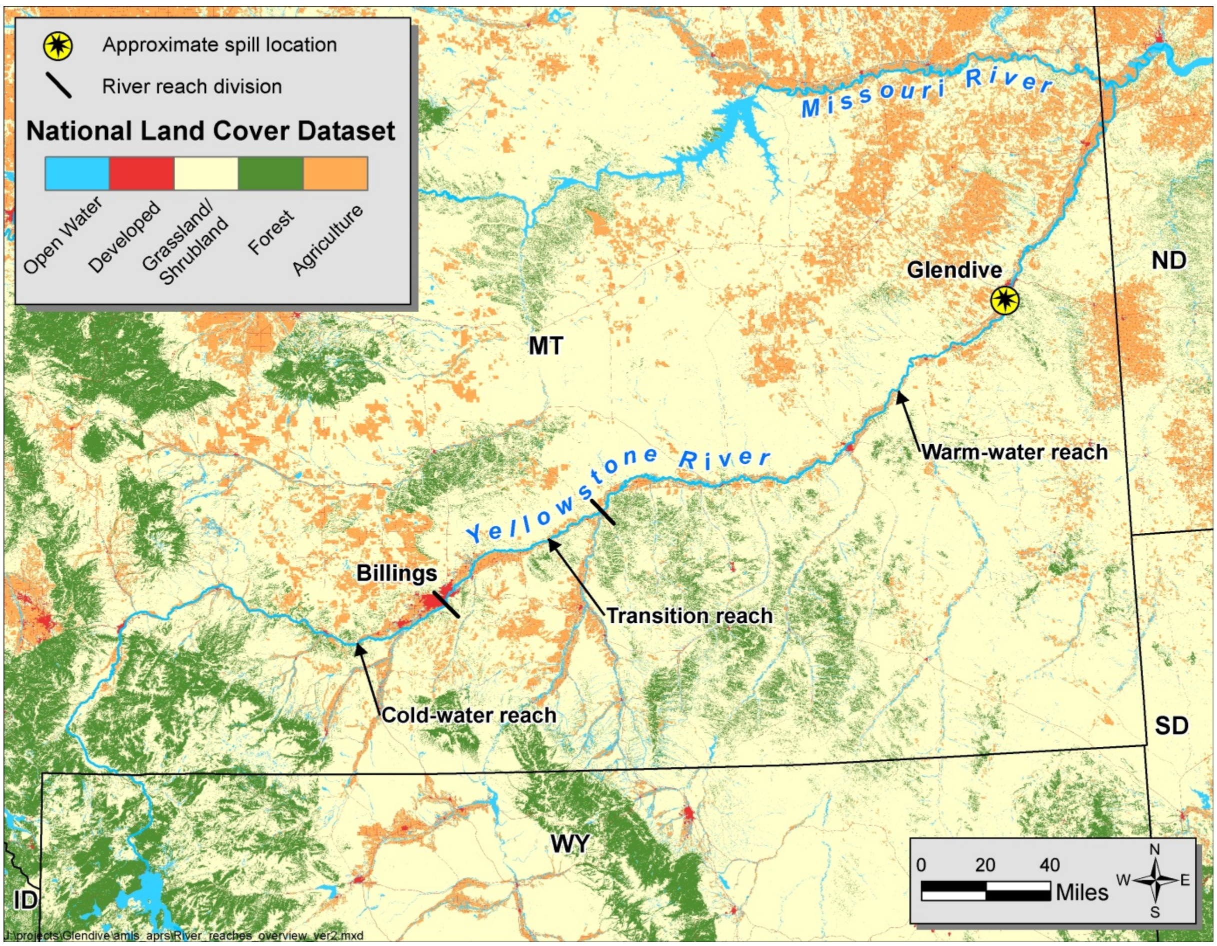
The Trustees were able to collect additional surface water samples opportunistically when river conditions allowed for the collection of water from the river bank. These opportunistic sampling events occurred on three separate occasions: January 28–29, March 19, and March 22–24, 2015. The Trustees also collected sediment samples where possible (at locations not covered with snow and ice), deployed SPMDs, and conducted a fish health study. However, the Trustees did not conduct wildlife surveys designed to quantify dead or oiled birds. Additional details of these sampling events are provided in Section 5.

The EPA left the site on March 22, 2015, and the State of Montana officially ended cleanup operations on April 10, 2015.

4. Site Description

Reaching from its headwaters in northern Wyoming to its confluence with the Missouri River in North Dakota, at 670 miles, the Yellowstone River is the longest undammed river in the contiguous United States and, as such, has retained much of the historical habitat characteristics and flows (Ryckman, 2000, as cited in USGS, 2011; NRC, 2002). The river is characterized as having three broad reaches – upper (cold-water fishery), middle (transition), and lower (warm-water fishery) reaches. The spill occurred in the lower reach of the river, near the Town of Glendive, Montana, approximately 90 miles from its confluence with the Missouri River (Figure 4.1).

Figure 4.1. Overview of the Yellowstone River showing upper cold-water, middle transition, and lower warm-water reaches. The spill occurred approximately 6.5 miles upstream of the City of Glendive, Montana, in Dawson County.



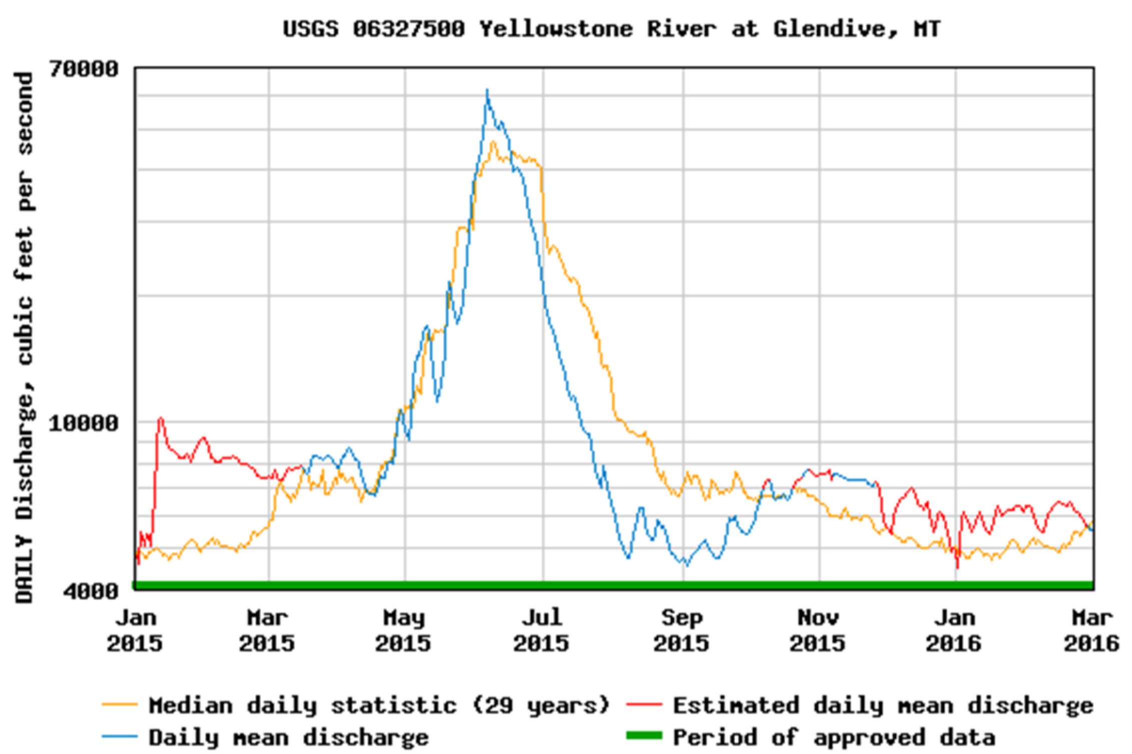
4.1 Physical Characteristics – Floodplain, Flow Rates

The physical characteristics of the Yellowstone River change dramatically from its headwaters to the lowlands near the confluence with the Missouri River. Upstream reaches characterized by turbulent flows, steep gradients, cold water temperatures, and coarse substrates give way to gentler gradients, warmer water temperatures (especially during summer), turbidity, sediment deposition, and fine substrates (muddy bottoms) in the lower reach (USGS, 1999). In the lower reach, the river meanders across a relatively wide channel migration zone (CMZ), the area within the river valley where the river channel will likely move laterally (or migrate) within a 100-year timeframe. The CMZ contains the active floodplain (defined as the modern five-year floodplain) and supports riparian habitat (DTM and AGI, 2009; USACE and Yellowstone River Conservation District Council, 2015).

Winter temperatures reach an average high of -3°C (27°F) and low of -15°C (5°F) in January (USGS, 1999). The river is often covered with ice in winter months, with ice typically melting in early spring (Becker, 2015). At the time of the spill, ice covered much of the river (see Figure 2.1).

The mean daily discharge in this reach of the river [as measured by the U.S. Geological Survey (USGS) at site 06327500 near Glendive] ranges from less than 5,000 cfs in winter months to over 60,000 cfs at its peak in early to mid-summer (Figure 4.2; USGS, 2017). The lower Yellowstone River experiences two peak runoff events annually. The first peak is associated with lowland snowmelt and occurs in winter and early spring; the second peak occurs in late spring or early summer and is caused by intense and localized thunderstorms, and coincides with the highest mean daily precipitation rates of the year (up to 2.7 mm mean daily precipitation; USGS, 1999). Due to winter conditions, the USGS gage at the time of the spill was frozen, and flow rates could only be estimated. The flow rate on January 17, 2015 was estimated to be 8,600 cfs (USGS, 2017).

Figure 4.2. USGS measured and estimated daily discharge from January 1, 2015 to March 1, 2016, and median daily discharge for the last 29 years at Glendive. The daily discharge was estimated during some winter months due to ice cover.



Source: USGS, 2017.

4.2 Surrounding Terrain – Habitat Types and Land Use

Vegetation immediately adjacent to the river within the floodplain riparian zone includes cottonwood gallery forests that support bald eagles and blue heron; and diverse wetlands, including sedge meadows, willow bottoms, cottonwood, and wet aspen. Because it has remained undammed and historical ecosystem processes continue to function, many of the wildlife species that would have been present before European settlement in the area are present (Jean and Crispin, 2001).

More broadly, this reach of the river is located in the Northwest Great Plain ecoregion, characterized by grassland habitat (USGS, 1999). Climate in this region is semi-arid, with large fluctuations in temperature across seasons; most precipitation falls from April through June (USGS, 1999). Droughts were historically common in the Yellowstone River. Tree-ring analysis indicates that the 20th century was wet relative to historical conditions (USACE and Yellowstone River Conservation District Council, 2015).

The predominant land use in the Glendive region is agricultural, especially irrigated agriculture, with some grazing on open rangeland (USGS, 1999). Land use is 95% agricultural in the lower Yellowstone River basin, except in the community of Glendive, which is primarily urban or ex-urban (USACE and Yellowstone River Conservation District Council, 2015, Appendix 01). Figure 4.1 shows the intensity of agricultural land use in the lower Yellowstone River. In addition, most of the grasslands shown in Figure 4.1 are used for open grazing. Oil and gas development has been expanding in the Glendive region in recent years, mainly through fracking operations (USACE and Yellowstone River Conservation District Council, 2015, Appendix 05).

4.3 Natural Resources

Pursuant to 15 CFR § 990.30, natural resources are "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources." Below, we describe the nature of the physical and biological resources that were injured, or likely injured, by the incident.

4.3.1 Surface Water Resources

The area affected by the spill includes the lower Yellowstone River. The surface water resources of the river include not only the water column, but the suspended and deposited sediment within and along the river. As described above, this reach of the river is characterized by gentler gradients, warmer water temperatures (especially during summer), turbid waters, and muddy bottoms. The river itself provides habitat for aquatic biota and riparian and terrestrial species, which depend on this natural resource for shelter, food, and shade. In addition, the City of Glendive relies on the Yellowstone River for drinking water as the sole source for its municipal water. The WTP provides approximately 7.5 million gallons of water per day to its customers (Glendive, MT, 2012). The river also supports recreational activities such as fishing, hunting, swimming, and boating (USACE and Yellowstone River Conservation District Council, 2015, Appendix 10).

4.3.2 Biological Resources

The lower reach of the Yellowstone River provides year-round and seasonal habitat for a diverse assemblage of aquatic biological resources, including fish, birds, soft-shelled turtles, native mussels [fatmucket (*Lampsilis siliquoidea*) and mapleleaf (*Quadrula quadrula*)], and benthic invertebrates (Dood et al., 2009; MTNHP, 2010; Heinlein, 2013; USACE, 2015). This reach contains braided channels, sandbars, islands, mid-channel pools, runs, riffles, and backwaters that provide and support essential habitats for many aquatic species (Heinlein, 2013; USACE, 2015). The following sections provide a brief description and inventory of fish and bird resources that reside within the lower Yellowstone River. The Trustees have focused their assessment on natural resources that were present and likely exposed and injured as a result of the spill.

Fish

The lower reach of the Yellowstone River is characterized as warm-water fish habitat (Heinlein, 2013). Native species in this reach are adapted to warm and fluctuating water temperatures and flows, high turbidity, and slower current velocities. A comprehensive list of fish species found in this reach is provided in Table 4.1, which ranges from large native migratory species, including the federally listed endangered pallid sturgeon, to small resident minnow species. It is important to understand the life stages that were likely present at the time of the spill, because early life stages are typically most sensitive to oil, followed by juveniles, then adults (Boufadel et al., 2015; DWH NRDA Trustees, 2016). Below we describe the species and life stages that are typically present in this reach of the Yellowstone River in the winter months.

Table 4.1. List of lower Yellowstone River fish species. This list was compiled by Montana Fish, Wildlife & Parks (MT-FWP) personnel during spill preassessment activities. Additional species, not listed by MT-FWP, are also included if they were identified as occurring in this reach in *A Field Guide to Montana Fishes* (Holton and Johnson, 2003).

Common name	Scientific name
Bigmouth buffalo	*Ictiobus cyprinellus*
Black bullhead	*Ameiurus melas*
Blue sucker[a]	*Cycleptus elongates*
Brook stickleback[b]	*Culaea inconstans*
Burbot[b]	*Lota lota*
Channel catfish	*Ictalurus punctatus*
Common carp	*Cyprinus carpio*
Crappie spp.	*Pomoxis spp.*
Emerald shiner	*Notropis atherinoides*
Fathead minnow	*Pimephales promelas*
Flathead chub	*Platygobio gracilis*
Freshwater drum	*Aplodinotus grunniens*
Goldeye	*Hiodon alosoides*
Largemouth bass	*Micropterus salmoides*
Longnose dace	*Rhinichthys cataractae*
Longnose sucker	*Catostomus catostomus*
Mountain sucker	*Catostomus platyrhynchus*
Paddlefish[a]	*Polyodon spathula*
Pallid sturgeon[c]	*Scaphirhynchus albus*
River carpsucker	*Carpiodes carpio*
Sauger[a]	*Sander canadensis*
Shorthead redhorse	*Moxostoma macrolepidotum*
Shortnose gar[a]	*Lepisosteus platostomus*

Table 4.1. List of lower Yellowstone River fish species. This list was compiled by Montana Fish, Wildlife & Parks (MT-FWP) personnel during spill preassessment activities. Additional species, not listed by MT-FWP, are also included if they were identified as occurring in this reach in *A Field Guide to Montana Fishes* (Holton and Johnson, 2003).

Common name	Scientific name
Shovelnose sturgeon	*Scaphirhynchus platorynchus*
Smallmouth bass	*Micropterus dolomieu*
Smallmouth buffalo	*Ictiobus bubalus*
Stonecat	*Noturus flavus*
Sunfish spp.	*Lepomis spp.*
Walleye	*Sander vitreus*
Western silvery minnow/plains minnow	*Hybognathus argyritis*
White sucker	*Catostomus commersonii*
Yellow bullhead	*Ameiurus natalis*
Yellow perch	*Perca flavescens*
Additional fish species that inhabit the lower Yellowstone River	
Brassy minnow[b]	*Hybognathus hakinsoni*
Creek chub[b]	*Semotilus atromaculatus*
Golden shiner	*Notemigonus crysoleucas*
Green sunfish	*Lepomis cyanellus*
Lake chub	*Couesius plumbeus*
Northern pike	*Esox lucius*
Northern redbelly dace[a]	*Phoxinus eos*
Plains killifish	*Fundulus zebrinus*
Rainbow smelt	*Osmerus mordax*
Sand shiner	*Notropis stramineus*
Sturgeon chub[a]	*Macrhybopsis gelida*
Western mosquitofish	*Gambusia affinis*

a. Montana State species of concern.
b. Montana State potential species of concern.
c. Montana State species of concern and federally listed endangered species.

Migratory fish. For migratory fish such as sturgeon (*Scaphirhynchus* spp.), suckers (*Catostomus* spp.), sauger (*Sander canadensis*), catfish (*Ameiurus* spp.), and walleye (*Sander vitreus*), life history information indicates that juveniles and adults were likely present in this stretch of the river at the time of the spill, but early life stages probably were not. These species are found throughout the lower Yellowstone River; the adults move upriver and/or up into side channels to spawn. They begin their spawning migrations soon after ice-off, when water flow and turbidity increase, and they spawn in late spring (around May). During spawning, they broadcast gametes into the water column, and embryos develop as they drift downriver or deposit into the substrate. Upon settlement or hatching, larval and juvenile fish reside year-round in main-channel habitats until they reach maturity, and only then begin spawning behavior [MT-FWP, Undated (a), Undated (b)]. Thus, both adults and juveniles were likely present at the time of the spill. Sturgeon, sauger, and catfish were caught by MT-FWP during sampling efforts for FCAs, undertaken in January 2015, confirming that adult and juveniles of these species were present and likely exposed to oil constituents.

Pallid sturgeon. Pallid sturgeon is a federally listed endangered species that occurs in the lower Yellowstone River. Pallid sturgeon requires large turbid river habitats with natural flow regimes and sandy or gravel bottoms (Holton and Johnson, 2003; FWS, 2014). In the spring after ice-off, adult sturgeon migrate upstream from the Missouri River to spawn in the lower Yellowstone River (Fuller et al., 2007). These migrations are closely monitored by tracking radio-tagged fish. Typically, spawning aggregations occur below the Intake Structure Dam, located approximately 30 river miles downriver from the spill site. During most years, the Intake Structure Dam is a barrier to adult sturgeon upriver migration (Fuller et al., 2007). During spawning events, eggs are released into the water and, if successfully fertilized, embryos develop as they drift downriver with the current. Unfortunately, there are too few river miles available for embryos and larvae to develop before drifting into unsuitable Lake Sakakawea habitats, where they do not survive (FWS, 2014). The successful natural recruitment of young sturgeon in this reach has not been documented for over 100 years, when the Intake Diversion Dam was constructed (French, 2014); the estimated population of wild adults is less than 200 individuals (Braaten et al., 2009). The sturgeon population is currently maintained by stocking hatchery-raised fish (Jaeger et al., 2005; Fuller et al., 2007). The FWS collects eggs and sperm in the wild, rears them at the hatchery, and then releases them as juveniles. Hatchery-reared sturgeon have been released throughout the lower Yellowstone River, and above and below the Intake Diversion Dam (Jaeger et al., 2005). Released fish are monitored, and monitoring surveys show that fish rear in suitable habitats near their release location before moving into the lower Yellowstone River and Missouri River reaches. Therefore, juveniles are present year-round above the Intake Diversion Dam.

After the spill, pallid sturgeon were monitored using radio telemetry from fixed wing aircraft. Two overflight surveys were conducted to locate tagged pallid sturgeon on January 21 and 27, 2015 (MT-FWP, 2016b). The detection of radio-tagged fish is greatly reduced when the river is covered with ice. Observations do not necessarily represent all of the fish in this reach because not all hatchery-raised fish are tagged and therefore are not located in a telemetry flight. During the January 21, 2015 survey, five pallid sturgeon were located in the Yellowstone River. One of the five was located near Elk Island, which is approximately 50 river miles downriver from the spill site, and four were located just upriver from the Yellowstone/Missouri River confluence. A total of 11 individual pallid sturgeon were located in the Yellowstone River during the January 27, 2015 survey. These 11 fish were distributed between Elk Island and the Yellowstone/Missouri River confluence. A number of them were aggregated near Sidney, approximately 70 miles downriver from the spill site. One wild pallid sturgeon was observed during both surveys, the remaining 10 were hatchery-reared fish. Therefore, adult sturgeon may have been exposed to oil as they moved upriver during their spring migration, and as the oil moved downriver from the spill site. In addition, juvenile pallid sturgeon residing throughout the river downstream of the spill site were likely exposed to the spilled oil. On March 22, 2015, MT-FWP personnel caught a 2-foot juvenile pallid sturgeon that was not radio-tagged between Glendive and the spill site during the Trustee-led fish health survey. This capture was made just after the ice had melted, before spring high-water, and approximately two months after the pipeline ruptured. This observation confirms that juvenile sturgeon were present and were therefore likely exposed to the spilled oil.

Resident non-migratory species, such as emerald shiner (*Notropis atherinoides*), western silvery minnow (*Hybognathus argyritis*), flathead chub (*Platygobio gracilis*), sand shiner (*Notropis stramineus*), and longnose dace (*Rhinichthys cataractae*) spawn in the summer and mature quickly, often completing their full lifecycle in a year or less (Duncan et al., 2016). Therefore, for these small-bodied resident fish species, adults were likely the only life stage present at the time of the spill.

This reach of the Yellowstone River also contains a fish species with a notably unique life history: the burbot (*Lota lota*), which is also a Montana State potential species of concern. Burbot move from their deep water habitat to shallow waters from January to February to spawn, typically when ice is still covering the river (Dickson, 2008). Adults congregate and broadcast gametes into the water column, eggs are fertilized, and embryos are semi-buoyant. After about 11 to 23 days, the larval burbot are mobile and begin feeding in shallow water habitats (McPhail and Paragamian, 2000). During fish sampling to establish the need for FCAs, MT-FWP personnel trapped an 18-inch burbot through a hole in the ice, approximately 5 miles downriver from the spill site on January 30, 2015, 13 days after the pipeline release. Therefore, burbot were present at the time of the spill, and it is possible that early life stages of this species – embryos and larvae – were exposed to oil constituents.

Birds

Throughout the year, the lower Yellowstone River supports a wide-array of migratory birds, protected by the Migratory Bird Treaty Act, including bald eagles (*Haliaeetus leucocephalus*), which are also protected by the Bald and Golden Eagle Protection Act (Table 4.2). Because of the known bird use the lower Yellowstone River receives, this stretch of river is routinely used as a survey segment for the FWS Central Flyway Mid-Winter Waterfowl surveys. Beginning in 1935, mid-winter waterfowl surveys have been conducted across the Central Flyway, typically in January, to track overwintering waterfowl population trends. Wintering grounds with major concentrations of waterfowl are selected as units to survey within the flyway and the lower Yellowstone River is one of three areas in Montana surveyed due to the high number of birds present during the winter. The other two survey locations in Montana include the upper Yellowstone River and Fort Peck Reservoir.

Table 4.2. Lower Yellowstone River aquatic and semiaquatic bird species. Species list compiled from BLM, 1980; Cavitt et al., 2014; USDOI and USACE, 2014; Fisher, 2015; Ensign, 2016; and MT-FWP, 2016a.

Common name	Scientific name
Non-migratory, resident aquatic birds found in the spill area year-round:	
Bald eagle[a]	*Haliaeetus leucocephalus*
Canada goose	*Branta canadensis*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Mallard	*Anas platyrhynchos*
Northern flicker	*Colaptes auratus*

Table 4.2. Lower Yellowstone River aquatic and semiaquatic bird species. Species list compiled from BLM, 1980; Cavitt et al., 2014; USDOI and USACE, 2014; Fisher, 2015; Ensign, 2016; and MT-FWP, 2016a.

Common name	Scientific name
Migratory, resident aquatic birds found in the spill area from mid-April to September:	
Belted kingfisher	*Megaceryle alcyon*
Blue-winged teal	*Anas discors*
Great blue heron[b]	*Ardea herodias*
Interior least tern[b]	*Sterna antillarum*
Piping plover[b, c]	*Charadrius melodus*
Spotted sandpiper	*Actitis macularius*
Migratory, resident songbirds that nest and/or feed in riparian and aquatic habitats found in the spill area from mid-April to September:	
Bank swallow	*Riparia riparia*
Cliff swallow	*Petrochelidon pyrrhonota*
Eastern kingbird	*Tyrannus tyrannus*
Least flycatcher	*Empidonax minimus*
Willow flycatcher	*Empidonax traillii*
Transient aquatic birds that may be found in the spill area during migration stopovers in April and September:	
Sandhill crane	*Grus canadensis*
Whooping crane[d]	*Grus americana*

a. State special status species.
b. State species of concern.
c. Federally listed threatened.
d. Federally listed endangered.

On January 7, 2015, approximately 10 days prior to the spill, state biologists counted 2,881 Canada geese and 100 mallards from the air in the 6-mile reach between the spill site and Glendive as part of the 2015 mid-winter waterfowl survey (Ensign, 2016). An additional 1,450 geese and 200 mallards were observed in open-water areas downriver of Glendive to 13 river miles below Sydney, Montana. These surveys provide a snapshot of waterfowl using the waterbodies as overwintering habitat during a single point in time and may not account for all of the species that use a location during the season. The northern flicker (*Colaptes auratus*) and the two species of waterfowl that are commonly observed during other mid-winter waterfowl surveys – the common goldeneye (*Bucephala clangula*) and common merganser (*Mergus merganser*) – also inhabit the floodplain and riparian areas of the lower Yellowstone River during the winter months (BLM, 1980; Ensign, 2016; MT-FWP, 2016a).

In addition to providing waterfowl overwintering habitat, the lower Yellowstone River provides stopover and breeding habitats for a variety of spring aquatic and semi-aquatic migrants that forage for food in the river, nest and breed in riverine and floodplain habitats, and rear young before migrating out of the area in the fall to overwinter elsewhere. Beginning in February, thousands of geese and ducks will use the Yellowstone River as roosting habitat between periods of feeding in the adjacent upland habitats; and observations confirmed large numbers of birds were in the area in the weeks after the spill, many of which could have been exposed to oil (Brad Schmitz, MT-FWP, February 12, 2015, personal communication). Many of these species will continue north as temperatures increase, while others will remain along the lower Yellowstone River to breed. Nonresident bald eagles that nest along the lower Yellowstone River will also begin to arrive in January and February, and there are at least 14 known nests between the spill location and Sidney, Montana (MTNHP, 2017). Other spring migrants that return to the lower Yellowstone River include the Montana State species of concern great blue herons (*Ardea herodias*), the federally listed endangered least tern (*Sternula antillarum*), and the federally listed threatened piping plover (*Charadrius melodus*) (MTNHP, 2017). Although rare, other species, such as the sandhill crane (*Grus canadensis*) and federally listed endangered whooping crane (*Grus americana*), are transient species that might use the lower Yellowstone River aquatic habitats as a stopover in April and again in the fall, to forage before moving on to breeding and overwintering habitats, respectively (MT-FWP, 2016c). These migratory species could have been exposed to oil that remained in the environment before and after ice-out.

5. Summary of Preassessment Activities

5.1 Overview of Environmental Sampling that Occurred Subsequent to the Spill

Figure 5.1 shows locations where environmental samples were collected by Bridger (and their contractors), and state and federal agencies during the response to the spill (red symbols). The bulk of the environmental samples collected over the course of the response to the spill were surface water samples, and most of the water sampling locations shown in Figure 5.1 were sampled on at least three different dates over the course of the response (Table 5.1). In addition, eight sediment samples were collected by response crews at the five locations shown on Figure 5.1 (red squares – three on the main map, and an upstream and farthest downstream locations shown on the inset), with the first three locations downstream from the spill site sampled twice, and the upstream and farthest downstream sampling location sampled once. Given the winter ice and snow-covered conditions, there were limited opportunities to collect sediment samples.

Figure 5.1 also shows locations that were sampled by the Trustees across different media, including surface water samples, sediment/vegetation samples, locations where SPMDs were deployed, and locations where MT-FWP collected fish for FCA tissue analysis. Most of the Trustee sampling locations represent unique sampling events, with the exception of the SPMDs, for which there were two deployments. The Trustees opportunistically collected a total of 12 water samples at the locations shown on Figure 5.1 during three different sampling events – January 28–29, March 19, and March 22–24, 2015. The Trustees also analyzed a split sample of pooled oil and water, collected on March 28, 2015, by Bridger contractors approximately 8.5 miles downstream of the spill site.

The Trustees deployed six SPMDs on January 29, and retrieved them on March 5, 2015. SPMDs were then deployed again on March 19, and recovered on April 21, 2015. SPMDs were placed at one location upriver from the spill site, and the remaining SMPDs were deployed at five locations downriver from the spill site (Figure 5.1). The Trustees also collected sediment samples, with a total of eight samples collected and analyzed for PAHs by the Trustees on January 29, March 19, and April 16, 2015. The sediment samples included random sediment grabs and targeted sampling of areas with visibly contaminated substrate. In addition to the sediment samples, the Trustees also collected one oiled vegetation sample approximately 27 miles downstream from the spill site on March 23, 2015. Fish samples were collected for FCA tissue analysis by MT-FWP on January 22, 2015. Approximately 34 fish were caught, representing 9 species, and the fish tissue samples were analyzed for PAHs and BTEX.

Figure 5.1. Response crew and Trustee sampling locations.

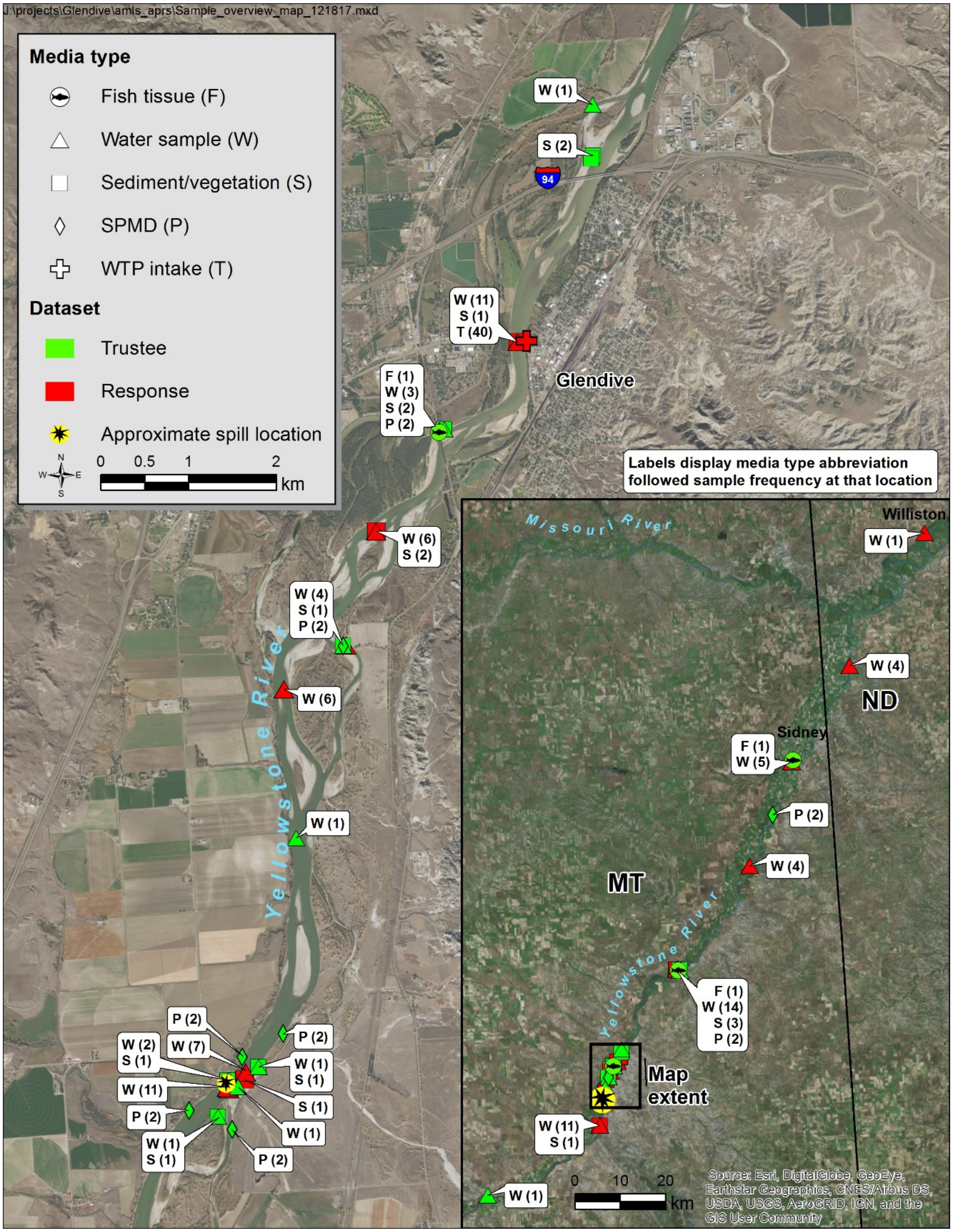


Table 5.1. Summary of surface water sampling during response efforts, by location, date, and oil constituent. Except where noted, each sample is comprised of two sub-samples, one collected at the top and one at the bottom of the water column.

Sampling reach	Sampling date	Benzene	PAHs
At the spill site			
	1/25/2015	2	1
	1/27/2015	2	1
	2/5/2015	2	1
	2/8/2015	1	NS
	2/12/2015	1[b]	NS
	2/13/2015	1	NS
	2/24/2015	1[b]	NS
	Reach subtotals =	10	3
Between spill site and Glendive (river mile 3.3 to 4.5)			
	1/22/2015	1[a]	NS
	1/24/2015	2	1
	1/25/2015	2	1
	2/2/2015	1[b]	NS
	2/3/2015	1	NS
	2/6/2015	1	NS
	2/8/2015	1	NS
	Reach subtotals =	9	2
At Glendive (river mile 6.6)			
	1/20/2015	1[b]	1[b]
	1/23/2015	1	1
	1/30/2015	1	NS
	2/6/2015	1	NS
	2/9/2015	1	NS
	Reach subtotals =	5	2
~ 30 river miles downriver from the spill site			
	1/24/2015	2	1
	4/8/2015	3	3
	Reach subtotals =	5	4
River mile 30 to 100			
	1/23/2015	5[c]	2
	1/24/2015	2	1
	Reach subtotals =	7	3
	Grand totals =	36	14

NS = not sampled.

a. Single sample collected at slot 3.3, no mention of sample collection depth.

b. Single sample collected at surface.

c. Total number of benzene samples included two single samples collected at two separate locations; remaining three samples are top/bottom collections.

Finally, the Trustees conducted a fish health survey on March 21–24. The fish were collected from one reference reach and three reaches downriver from the spill site (see Stratus Consulting, 2015, for sampling reach locations). The fish were inspected for gross abnormalities, the blood was sampled for hematocrit analysis, and tissues were collected for histology assessments. The survey focused on five species common to the entire study area: goldeye, channel catfish, shorthead redhorse, river carpsucker, and shovelnose sturgeon.

5.2 Analytical Methods Summary

In general, the environmental samples collected during response activities by the Trustees were analyzed for BTEX and PAHs. For the BTEX compounds, samples collected by both the response crews and the Trustees were analyzed using EPA Method 8260. However, for the PAH compounds, different analytical methods were employed to measure the oil constituents in collected environmental samples. For example, the Trustees' samples were analyzed using EPA Method 8270, with extended alkylated PAHs by selective ion monitoring (SIM). This method provides high-resolution measurements of 50 individual PAHs, including both parent and alkylated PAHs. Alkylated PAHs are the parent PAH compounds with short hydrocarbon carbon side chains attached to their sides. For example, naphthalene is a "parent PAH compound" and C1-naphthalene, C2-naphthalene, etc., are naphthalenes with short hydrocarbons attached to its side. For the Trustee samples, we summed concentrations of each of the 50 PAHs to arrive at "total PAH" concentrations reported in this section. By contrast, the samples collected by response crews were analyzed using methods that sampled a much smaller number of PAHs. The response samples were analyzed using either EPA Method 8260, which detects only one PAH – naphthalene – or EPA Method 8270/8270-SIM, which analyze up to 16 PAHs. Therefore, for response samples, the "total PAH concentration" reported in this section is either the concentration of a single PAH – naphthalene – or it is the sum of 16 PAHs. In summing PAHs, non-detections were conservatively treated as zeroes. Ultimately, this has important implications for how the total measured PAH concentration is interpreted. Appendix A provides the list of individual PAHs analyzed by the different methods.

5.3 Wildlife Reconnaissance

Although not completed as part of the spill response or NRDA preassessment, a single waterfowl survey was conducted along the entire lower Yellowstone River by fixed-wing aircraft 10 days prior to the spill as part of the Central Flyway Mid-Winter Waterfowl Survey. During Phase I of the response, Incident Command denied the request of the Wildlife Branch of the Operations Section for wildlife rescue support resources and, due to dangerous ice conditions on the river during Phase I (see Figures 2.1 and 3.1), no organized oiled wildlife searches were conducted (CTEH, 2015a; Karen Nelson, personal communication). During Phases II and III (as the ice was breaking up and after it broke up), MT-FWP-managed Fishing Access Sites were monitored weekly for observations of bird use, ice conditions, and presence of oiled habitat (CTEH, 2015b). The number of sites visited every week varied and ranged from 3 to 8 locations along the roughly 70 miles of river between the spill location and Sidney, Montana (Brad Schmitz, personal communication). Also, bald eagle nests were monitored at different times by air and ground from March 2015 to June 2015.

6 Injury Determination – Establishing Exposure and Pathway (15 CFR § 990.51(d))

Consistent with the process described in 15 CFR § 990.51, the Trustees must confirm that (1) the definition of injury as defined in the OPA regulations at 15 CFR § 990.30 has been met; and (2) injured natural resources have been exposed to the discharged oil, and a pathway can be established from the discharge to the exposed natural resource. To determine that injuries have occurred, the Trustees have analyzed data from the preassessment activities to establish exposure of natural resources to the discharged oil, as discussed in this section. Section 7 describes how the Trustees have made determinations of injury based on existing data, and the studies needed to complete this determination, consistent with 15 CFR § 990.51(c).

Pursuant to 15 CFR § 990.51(d), as part of determining injury, the Trustees must "establish whether natural resources were exposed, either directly or indirectly, to the discharged oil from the incident, and estimate the amount or concentration and spatial and temporal extent of the exposure. Trustees must also determine whether there is a pathway linking the incident to the injuries. Pathways may include, but are not limited to, the sequence of events by which the discharged oil was transported from the incident and either came into direct physical contact with a natural resource, or caused an indirect injury." Here, we present the results of the preassessment environmental sampling that establishes exposure and a pathway for that exposure to site natural resources as a result of discharged oil from the incident.

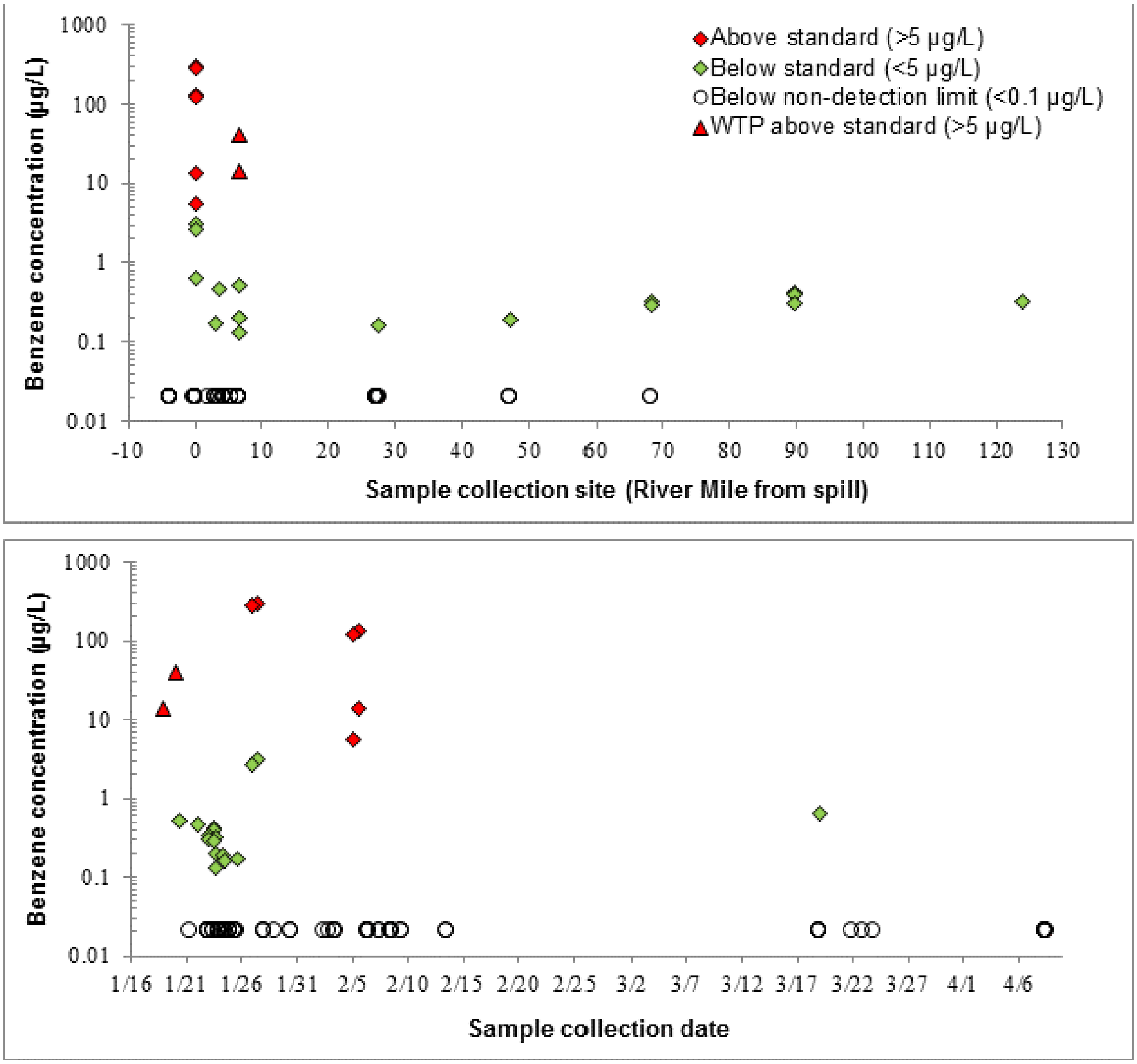
6.1 Surface Water Resources

Bakken crude oil was discharged directly into the Yellowstone River following the rupture of the Bridger Poplar Pipeline. Subsequent to the spill, surface water sampling demonstrated elevated concentrations of many oil constituents in water samples collected downstream of the spill site, confirming oil constituents traveled down the river following release. While many different oil constituents were detected, elevated concentrations of benzene and total PAHs were detected with the greatest frequency. Thus, the Trustees have focused their analyses on these oil constituents. Below, we discuss the concentrations and the spatial and temporal patterns of benzene and total PAH that confirm exposure of natural resources subsequent to the spill. In addition, we discuss the SPMD data (for PAHs) and data for the sediment samples (for PAHs and BTEX), which further confirm oil exposure to surface water resources.

6.1.1 Benzene

Subsequent to the spill, benzene was detected in the Yellowstone River as far as 130 miles downstream of the spill site, in both river samples and at the Williston, North Dakota WTP plant. The Town of Williston takes its water from the Missouri River just below the confluence with the Yellowstone River, and samples from at the Williston WTP on January 23, 2015 contained low levels of benzene (Figure 6.1) and other VOCs.

Figure 6.1. Benzene water concentrations, by river mile from the spill site (top) and collection date (bottom).



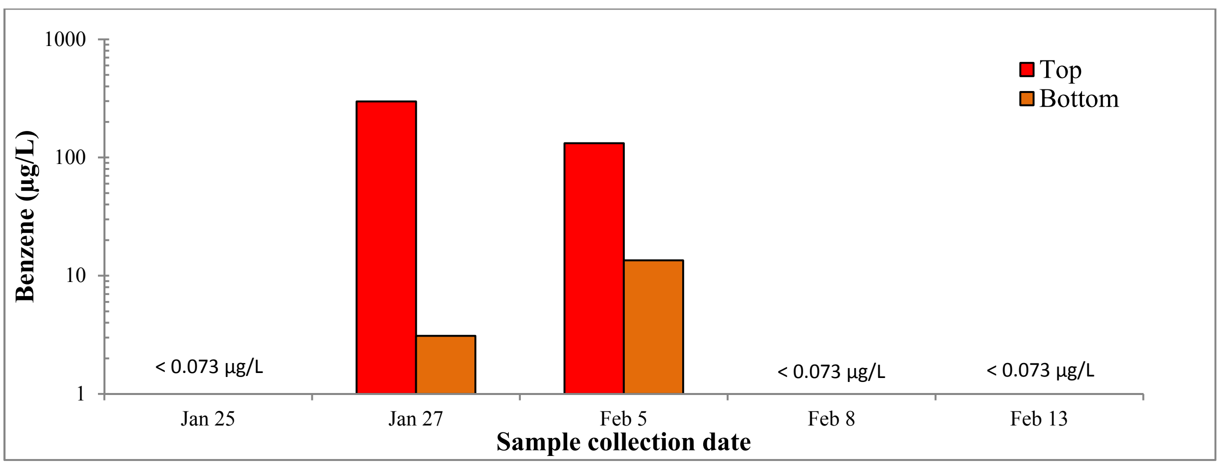
However, the highest benzene concentrations were measured in samples collected between the spill site and the City of Glendive, located 6.5 miles downstream of the pipeline (Figure 6.1). The two highest benzene concentrations measured in the Yellowstone River after the spill (298 and 285 µg/L) were measured at the spill site on January 27, 2015, 10 days after the initial pipeline rupture. It is possible that concentrations were even higher immediately after the spill, but this is unknown, as the spill site was not sampled until seven days after the pipeline rupture occurred (Figure 6.1).

Elevated benzene concentrations (14 and 40 µg/L) were also measured at the Glendive WTP in the first few days after the spill. Measuring these levels of benzene at the Glendive WTP was unusual, given that benzene is a volatile compound, and the WTP is 6.5 miles downstream along a large, flowing river. Comparatively little is known about the fate and transport of oil constituents under cold climate conditions, as there have been few studies examining this

(Bejarano et al., 2014). The ice-covered river conditions at the time of the spill may have served to trap constituents in the water that would have otherwise volatilized, prior to reaching the WTP intake pipe. The next sampling location was approximately 17 miles downstream of Glendive, at which point benzene concentrations were much lower (< 1 µg/L). The concentration profile between these two points is unknown, but elevated concentrations likely persisted at least some distance beyond Glendive. Further, benzene concentrations in samples collected upstream of the pipeline were below detection limits (Figure 6.1), confirming that the spill was the source of the benzene.

Also of note, the intake pipe for the WTP plant is located at the river bottom, between the bank and the center of the river. Elevated concentrations measured in samples collected from the river bottom suggests that the oil constituents were mixed in the flowing river water, and not constrained to the top of the water column. This is confirmed by many of the top/bottom sampling pairs. While benzene concentrations were typically higher at the top of the water column, it was also detected at depth (Figure 6.2). These results indicate that surface water resources across the full depth of the Yellowstone River were exposed to benzene subsequent to the spill.

Figure 6.2. Benzene concentrations for each top/bottom sampling pair collected at the oil spill site, illustrating that while benzene concentrations were highest near the top of the water column, it was also measured at depth.



While the highest benzene concentrations were measured in the river the week after the spill, benzene was detected in samples collected in mid-March (Figure 6.1). Further, total VOCs were measured at > 200 µg/L at the Glendive WTP on March 14, 2015, at the time of ice break-up and melting. It is believed that, as the ice melted, oil that had been trapped between layers or pockets and cracks in the ice was suddenly released, sending another large pulse of contaminants down the river (see Table 3.1; U.S. EPA, 2015). Water samples were not collected anywhere else along the river at this time due to safety concerns limiting access to the river because of the ice, but presumably VOC concentrations (including benzene and other volatile compounds) would have been at least as high in the river upstream of Glendive, and for some distance downstream of Glendive. It is noteworthy that between the time of the spill and final ice-out, there were multiple "mini" warming and refreezing events (see Table 3.1). It is possible that similar releases from the ice may have occurred associated with these events that went undetected, given that the ice was unstable at these times, and samples could not be collected.

The elevated benzene concentrations confirm that surface water was exposed to benzene, and information presented in Section 7 below shows that these levels exceeded injury criteria, pursuant to 990.51(b).

6.1.2 Total PAHs

Total PAHs were measured above detection limits in water samples collected as far as 27 miles downstream of the spill site (Figure 6.3). The highest total PAH concentrations were measured between the spill site and 8.5 miles downstream (Figure 6.3). Furthermore, PAHs were detected in samples collected throughout the duration of the incident, including the samples collected by the Trustees, the split sample collected by Bridger in late March, and samples collected in the final sampling event in April (Figure 6.3). Similar to benzene, top/bottom samples also indicated that, while concentrations where higher at the top of the water column, PAH detections were also made at depth, indicating that PAHs were at least periodically mixed across the water column. PAH sampling was limited due to safety concerns that restricted access to the river because of the ice.

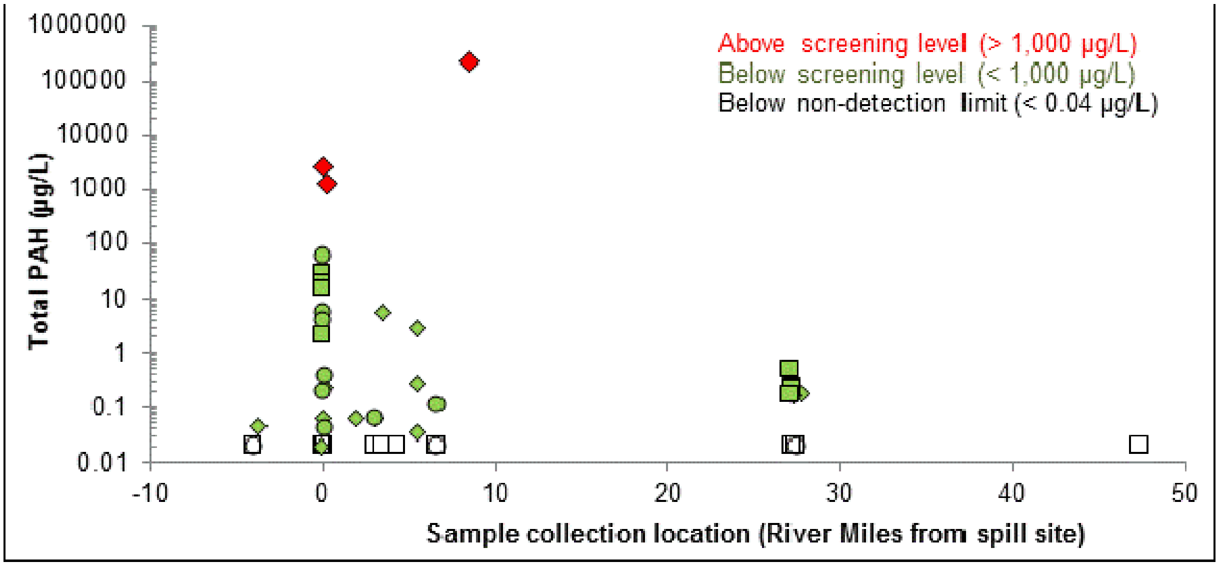
The total PAH concentration plotted in Figure 6.3 is the sum of all individual PAHs measured in a sample. While these plots show both Trustee and response crew data for completeness, the Trustee and response results are in fact not directly comparable, as the plotted PAH concentrations were measured using different analytical techniques.

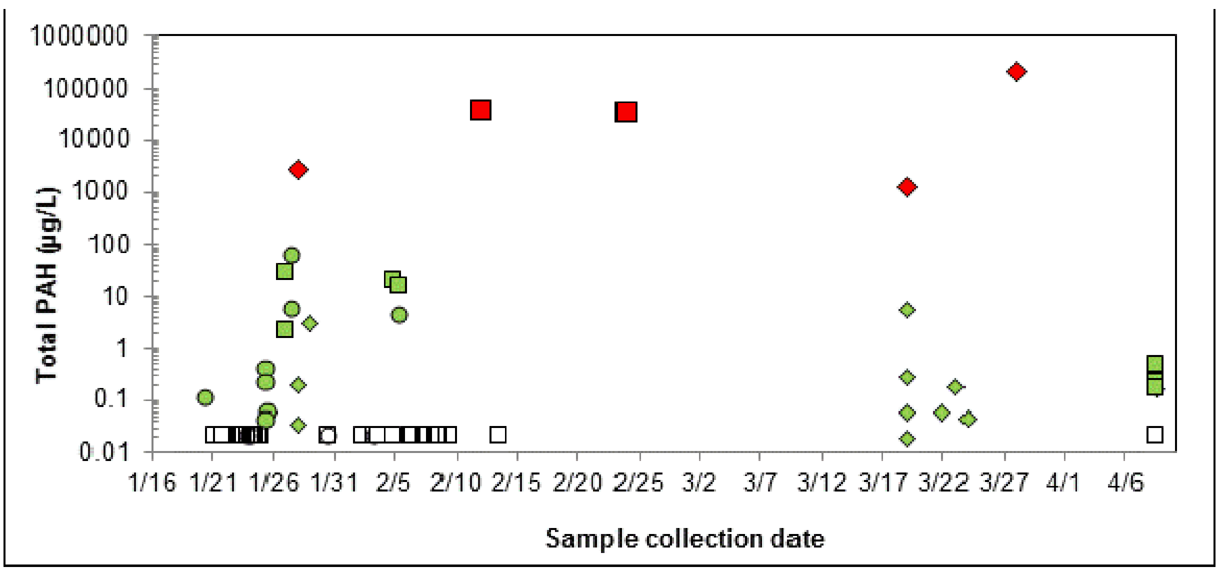
As noted above, the Trustees' samples were analyzed using EPA Method 8270, with extended alkylated PAHs by SIM, which measures 50 individual PAHs, including both parent and alkylated PAHs. By contrast, the samples collected by response crews were analyzed using EPA Method 8260, which only analyzes for 1 PAH (naphthalene); or by EPA Methods 8270/8270-SIM, which detect up to 16 PAHs. Therefore, the concentrations measured in samples collected by response crews likely under-represented the total PAH exposure, because they only measured a fraction of the total PAHs that could have been present.

This under-representation becomes even more striking with weathering. With weathering, the distribution of PAHs present in a water sample typically shifts to heavier PAHs, because the lighter PAHs preferentially weather away. Figure 6.4a shows the PAH profile of the Bakken crude oil, from a sample collected from the broken pipeline on January 20, 2015. As noted above, the product is dominated by lighter-end PAHs, including naphthalenes, phenanthrenes, anthracenes, and fluorenes, with a smaller amount of heavier PAHs, such as chrysene.

Figure 6.4b shows a weathered water sample collected by the Trustees on January 29, 2015, 12 days after the spill, approximately 5 miles downriver from the spill site. The PAH profile is relatively enriched in heavier PAHs, and depleted in the lighter-end PAHs compared to the crude oil. In this sample, naphthalene makes up less than 1% of the total PAHs. This means that for samples collected by response crews and analyzed using EPA Method 8260, where naphthalene is the only reported PAH, the reported total PAH concentration could be as much as 100 times less than the actual total PAH concentration if all 50 PAHs were measured. Figure 6.4d illustrates this for a sample collected by response crews on January 27, 2015 at the spill site using EPA Method 8260. Only naphthalene is measured by this method, and the "total" PAH concentration in this sample of 29 µg/L consists solely of naphthalene. Given the pattern shown in Figure 6.4b, PAHs in this response sample could be several times higher. Figure 6.4c shows the PAH profile for a sample collected by response crews on January 27, 2015 using EPA Method 8270. While more PAHs are detected, it still only reflects a fraction of the PAHs measured in the Trustee sample. Similarly, the total PAH concentrations measured in the response samples could have been many times higher than shown in Figures 6.1 and 6.2 (circle and square points on the graphs).

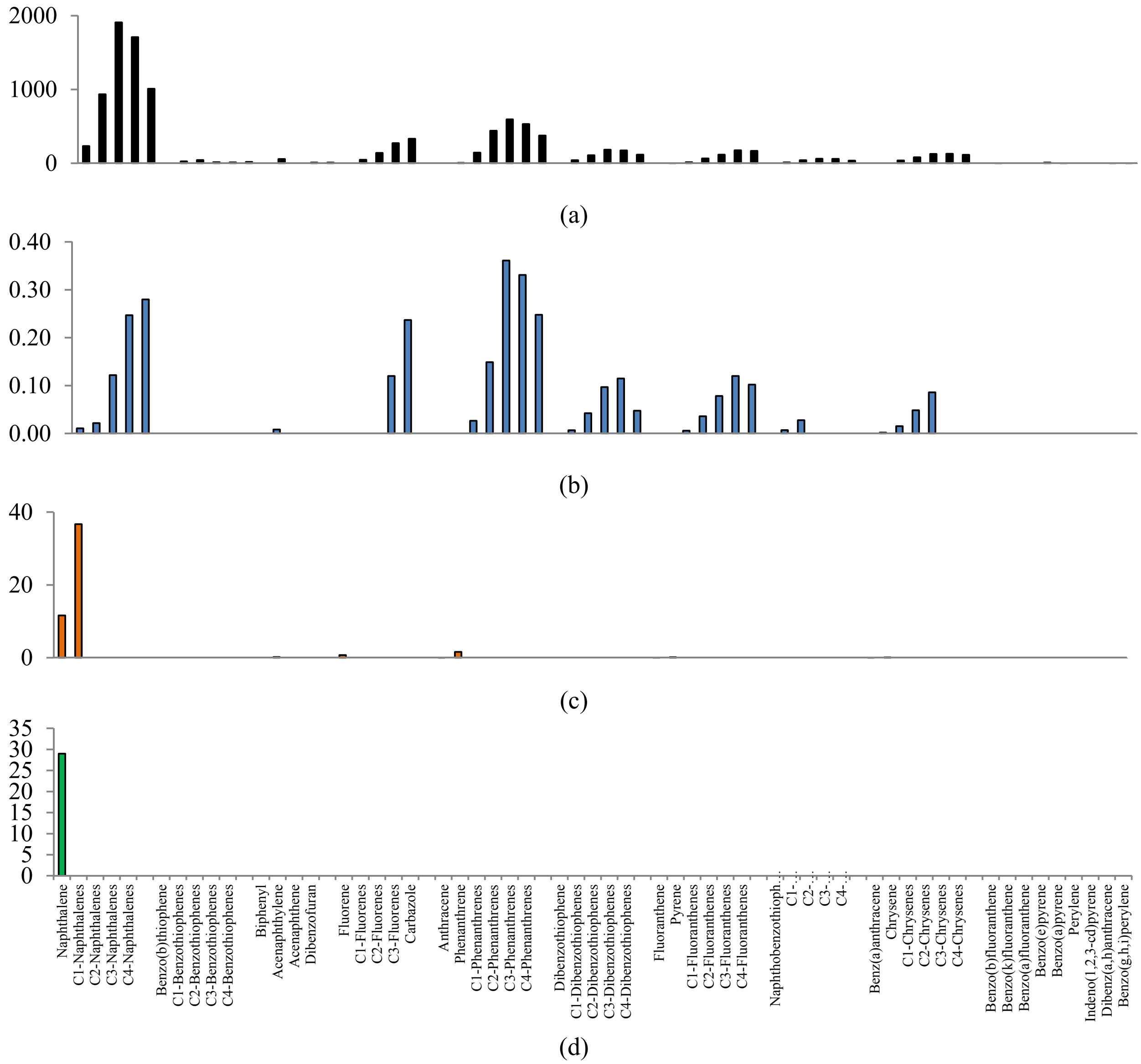
Figure 6.3. Total PAH water concentrations by river mile (top) and collection date (bottom). Diamonds = Trustee samples (analyzed for 50 PAHs), circles = response samples (analyzed for 16 PAHs), and squares = response samples (analyzed for naphthalene only). Note that the sample with the very high PAH concentration of 218,830 µg/L at river mile 8.5 was a split sample collected by Bridger at a heavily oiled site in a small side channel on March 28, 2015.





The elevated PAH concentrations confirm that surface water was exposed to PAHs, and information presented in Section 7 below shows that these levels exceeded injury criteria, pursuant to 990.51(b). Further, surface water likely acted as a PAH exposure pathway to biological resources, including fish and birds, which is discussed in more detail in Section 7.

Figure 6.4. PAH concentration profiles for (a) spilled Bakken crude oil analyzed by EPA Method 8270 with extended alkylated PAHs by SIM (mg/kg); (b) a water sample collected by the Trustees ~ 5 miles downriver from spill site on January 29 analyzed by the same method (µg/L); (c) a water sample collected by response crews on January 27 at the spill site, analyzed by EPA Method 8270 (µg/L); and (d) a water sample collected by response crews on January 27, 2015 at the spill site, analyzed by EPA Method 8260, which only detects one PAH, naphthalene (µg/L).



6.1.3 SPMD Samples

The SPMDs deployed by the Trustees also helped to confirm aquatic exposure to PAHs (see Figure 5.1 for deployment locations). The first set of six SPMDs were deployed on January 29, and retrieved on March 5, 2015. A second set of six SPMDs were deployed later on March 19 and retrieved on April 21, 2015. SPMDs were analyzed for 33 individual PAHs. PAHs were very low in the upstream sample, with elevated detections downstream of the spill site.

The most elevated measurements were in SPMDs deployed at the spill site and approximately three miles downriver from the spill site, in which naphthalenes, fluorenes, and phenanthrenes were the dominant PAHs detected. There were some complications with the deployment of the SPMDs. A number of the SPMDs were found either out of the water (due to lowered water levels) and thus were exposed to air (the SPMDs at the spill site and approximately three miles downstream), and/or were partially frozen (the last two SPMD sites downstream from Glendive). The length of time they were out of the water and the effects of freezing on the SPMDs are unknown. Therefore, it may not be appropriate to back-calculate water concentration data from the accumulated PAHs in the SPMDs, because the amount of contaminated water to which they were exposed is unclear. However, the detection of lighter-end PAHs does provide additional confirmation that surface water resources were exposed to PAHs in the water column downstream of the spill site.

6.1.4 Sediment Samples

The eight sediment samples collected by the Trustees were analyzed for PAHs. Concentrations of PAHs in the random grab samples collected by the Trustees ranged from 2.87 to 242 µg/kg. The four samples collected at visibly contaminated sites located between the spill site and approximately 7.5 miles downstream from the spill site on March 19 and April 16, 2015 contained total PAH concentrations ranging from 1,466 to 1,188,741 µg/kg. These contaminated sediments contained high concentrations of the same low molecular-weight PAHs that were found in the spilled oil. In addition to sediment samples, the Trustees also collected an oiled vegetation sample 27 miles downstream from the oil spill site on March 23, 2015. This sample contained the highest total PAH value measured in all non-product samples: 2,148,760 µg/L. Though only a small number of samples, these results confirm that sediments were exposed to oil constituents. In addition, these indicate that oil was present in the aquatic environmental as far as 27 miles downstream from the spill site, further helping to define the spatial extent of the oil spill.

Sediment samples were also collected by response crews in late January, and then again on April 8, 2015. The samples were analyzed for VOCs and semi-volatile organic compounds (SVOCs). Overall, the reported concentrations for these samples were low. For example, total extractable hydrocarbons measured in a sample collected at the spill site in January was only 5.1 mg/kg. The highest concentrations of oil constituents were measured 30 miles downstream of Glendive, on April 8, 2015, where benzene, naphthalene, and aromatic range C09–C10 were measured at detectable but low concentrations, and the total extractable hydrocarbon concentration was measured at 96 mg/kg. The response crews did not target oiled locations, but collected random grab samples of sediment, which likely explains the low measured concentrations.

6.2 Biological Resources

6.2.1 Fish

As described in Section 6.1, elevated benzene and PAH concentrations were found in the lower Yellowstone River downstream of the spill site, following the incident, thus establishing an exposure pathway for any organisms utilizing the affected reach of river. Based on the literature, many different fish species are known to inhabit the lower Yellowstone River, including state and federally listed species (e.g., burbot, pallid sturgeon). Furthermore, many of these species were observed in and around the affected reach of the river during preassessment activities conducted following the spill. For example, MT-FWP collected sturgeon, sauger, and catfish in late January 2015, during their FCA sampling event around Glendive. In addition, during two overflight surveys conducted on January 21 and 27, 2015, several tagged pallid sturgeon were located in the lower Yellowstone River (MT-FWP, 2016b). Additionally, on March 22, 2015, MT-FWP personnel caught a 2-foot juvenile pallid sturgeon between Glendive and the spill site during the Trustee-led fish health survey.

In addition to concentrations of oil constituents measured in the water column, BTEX and PAHs were also found in fish tissue samples from fish collected by MT-FWP downstream of the spill site. The fish tissue samples contained measurable concentrations of BTEX (mainly xylenes and toluene, with some benzene) and PAHs (dominated by naphthalene). The highest measured PAH concentration was 275 mg/kg of 1-methylnaphthalene, which was measured in a tissue sample from a shovelnose sturgeon collected 27 miles downriver from the spill site. The data from the fish tissue sampling prompted MT-FWP to extend the FCA on February 20, 2015.

Detection of PAHs in fish tissues is typically quite rare because even if the fish are exposed to PAHs, the PAHs are generally metabolized quickly (Eisler, 1987; Johnson et al., 2008). However, little is known about PAH metabolic processes in cold climate conditions (Word, 2014) and slower metabolic rates in cold conditions might be one explanation for these observations. Regardless, the measured oil constituents in fish tissue confirm that this aquatic natural resource was exposed to oil and oil constituents as a result of the spill.

6.2.2 Birds

In addition to fish, many bird species utilize the lower Yellowstone River for food and shelter, including Montana State species of concern and federally listed threatened and endangered species. During Phase I of the response, Incident Command denied the request of the Wildlife Branch of the Operations Section for wildlife rescue support resources and, due to dangerous ice conditions on the river during Phase I (see Figures 2.1, 3.1), no organized oiled wildlife searches were conducted (CTEH, 2015a; Karen Nelson, personal communication). Despite the lack of organized wildlife searches, incidental observations of wildlife located in oil-impacted reaches of the river were made that include observations of common goldeneyes, common mergansers, geese and other waterfowl, and bald eagles (David Rouse, personal communication; Chris Boyer, personal communication; Karen Nelson, personal communication). Figure 6.5 shows three bald eagles using portions of the Yellowstone River on January 29, 2015, approximately nine miles below the spill location; and Figure 6.6 shows numerous unidentified waterfowl using the Yellowstone River within a mile downstream of the spill location on January 30, 2015. U.S. EPA (2015) reported an oil sheen at both of these locations during the response. During Phase I, birds were generally observed on the Yellowstone River in backwater and eddy habitats during morning hours (Chris Boyer, personal communication). In a data collection effort conducted 10 days prior to the spill as part of the FWS Central Flyway Mid-Winter Waterfowl Survey, more than 4,000 Canada geese and 150 mallards were counted within the reach of river between the spill location and Sidney, Montana (John Ensign, personal communication).

Figure 6.5. Three bald eagles on the Yellowstone River on January 29, 2015 approximately nine miles below the spill location (47.145695°, -104.693758°).

Photo credit: Kestrel Aerial.

Figure 6.6. Numerous unidentified waterfowl using the Yellowstone River on January 30, 2015 within one mile downstream of the spill release location (47.0422°, -104.75823°).

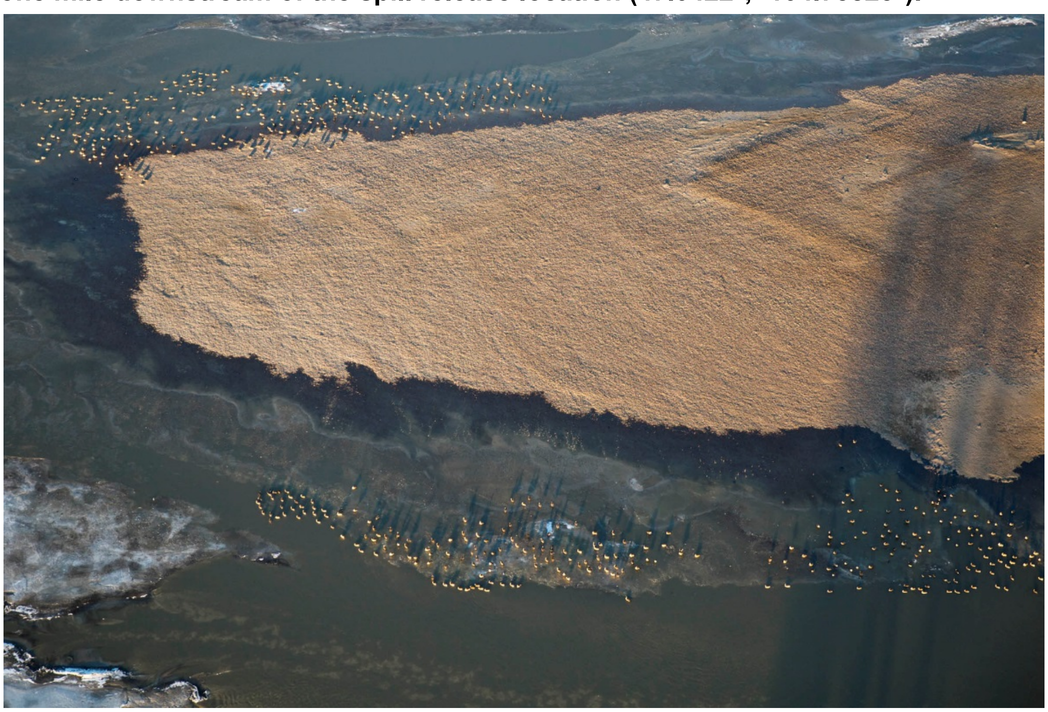


Photo credit: Kestrel Aerial.

During Phases II and III (as ice was breaking up and after it broke up), MT-FWP-managed Fishing Access Sites were monitored weekly for observations of bird use, ice conditions, and presence of oiled habitat (CTEH, 2015b). The number of sites visited every week varied and ranged from 3 to 8 locations along the roughly 70 miles of river between the spill location and Sidney, Montana (Brad Schmitz, personal communication). Although spatial coverage was limited, birds were observed using the Yellowstone River corridor during Phase II in areas with a reported sheen; and on February 12, 2015, counts of over 30,000 Canada geese and 10,000 ducks were reported (Brad Schmitz, personal communication). During Phase III, additional observations of birds using the Yellowstone River below the spill site include killdeer (*Charadrius vociferous*), common mergansers, and Canada geese (David Rouse, personal communication; Karen Nelson, personal communication).

While there were no reported observations of dead or oiled birds during preassessment activities, no wildlife surveys designed to quantify dead or oiled birds were conducted. Despite the lack of surveys, bird use of the Yellowstone River immediately below the spill location was confirmed by observations (Brad Schmitz, personal communication; David Rouse, personal communication; Karen Nelson, personal communication; Chris Boyer, personal communication) and other reports (Ensign, 2016; MTNHP, 2017). Many of these observations were made in areas where a sheen was reported, verifying the exposure pathway to various bird species (U.S. EPA, 2015).

7 Injury Determination under 15 CFR § 990.51

As described above, analyses of existing data have established that natural resources within the lower Yellowstone River, including surface waters, fish, and birds, have been exposed to oil constituents resulting from the discharge of oil due to the incident. In addition to establishing exposure, the "Trustees must determine whether an injury has occurred and, if so, identify the nature of the injury. Potential categories of injury include, but are not limited to, adverse changes in survival, growth, and reproduction; health, physiology and biological condition; behavior; community composition; ecological processes and functions; physical and chemical habitat quality or structure; and public services" (15 CFR § 990.51(c)). Under OPA, the definition of injury is "an observable or measurable adverse change in a natural resource or impairment of a natural resource service" (15 CFR § 990.30).

This section demonstrates injury to trust resources using data gathered and analyzed during preassessment activities. These injuries have been determined using the available assessment procedures described in 15 CFR § 990.27. For some resources, there is significant uncertainty in the data, which provides motivation for the assessment activities proposed in Section 7.2.

7.1 Confirmed Injuries

7.1.1 Surface Water Injury Based on Exceedance of Water Quality Standards

To determine injury to surface water resources, we compared the concentration of oil constituents measured in water samples collected from the river subsequent to the spill, to applicable water quality standards and screening levels.

Standards and screening levels used in the analysis. The MT-DEQ water-use classification for the Yellowstone River reach where the spill occurred is B-3 and must "be maintained suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming, and recreation, growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply" [Administrative Rules of Montana (ARM) § 17.30.625].

In addition, the B-3 classification specifies that "concentrations of carcinogenic, bioconcentrating, toxic, radioactive, nutrient, or harmful parameters may not exceed the applicable standards set forth in Department Circular DEQ-7" (ARM § 17.30.625). Also, "State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges" that will create a "visible oil film" (ARM § 17.30.637).

According to MT-DEQ guidance, if a contaminant does not have a Circular DEQ-7 Montana Numeric Water Quality Standard or a risk-based screening level (RBSL) from the *Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases* (RBCA; MT-DEQ, 2009), then the EPA tapwater regional screening level contained in the most recent Regional Screening Level (RSL) tables (U.S. EPA, 2016) can be used for water quality assessments. We recognize that these are values developed for drinking water. Given that the affected reach is a source of drinking water for the Town of Glendive, we believe it is appropriate to use them in this analysis. Accordingly, for constituents lacking a Circular DEQ-7 standard, we obtained values from MT-DEQ (2009) or U.S. EPA (2016).

Exceedances. The oil constituents that exceeded standards and screening levels include benzene, total PAHs (C11–C22 Aromatics), naphthalene, chrysene, benzo(a)anthracene, 1-methylnaphthalene, 2-methylnaphthalene, 1,3,5-trimethylbenzene, and aliphatics (Table 7.1). Here we discuss benzene and total PAHs in further detail, because they exceeded their respective standards most frequently.

Benzene. As shown in Figure 6.1, there were numerous exceedances of the 5-µg/L standard for benzene (the red shaded symbols in the figure represent samples that exceeded the benzene water standard of 5 µg/L). The highest benzene concentrations measured in the river were from samples collected at the spill site on January 27 (298 and 285 µg/L), followed by February 5, 2015 (132 µg/L). These concentrations range from 60 to 25 times over the 5 µg/L standard, and were collected as far as 6.5 miles downstream from the spill site (Figure 6.1) and 2 and 3 weeks after the spill (see Figure 6.2).

Total PAHs. We evaluated PAH data using the C11–C22 Aromatics screening level of 1,000 µg/L. According to RBCA (MT-DEQ, 2009), the concentration of C11–C22 Aromatics is to be determined based on the Massachusetts Method for Extractable Petroleum Hydrocarbons (EPH). The C11–C22 aromatic range measured using this method is analogous to total PAHs. We previously established this fact through discussions with the analytical laboratory that conducts these analyses for MT-DEQ (Stratus Consulting, 2011). Because only one sample was actually analyzed using this method, for all other samples we instead compared our calculated sums of total PAHs to the C11–C22 Aromatic screening level of 1,000 µg/L. For Trustee samples, this was the sum of 50 PAHs. For samples collected by response crews, this was either just naphthalene, or the sum of 16 PAHs (depending upon the analytical method used on a sample – see Section 6.1.2).

Table 7.1. Summary of water quality standards and screening levels (SLs) that were exceeded in surface water samples collected by response crews and Trustees after and downriver from the spill site

Date	Location	Analyte	Measured result (µg/L)	Standard/SL (µg/L)	Standard/SL basis
January 18 to 23, 2015					
	At Glendive WTP (river mile 6.5)				
		Benzene	14 and 40	5.0	MT-DEQ DEQ-7 Human Health Standard
January 27, 2015					
	At spill site (river mile 0)				
		Benzene	285 and 298	5.0	MT-DEQ DEQ-7 Human Health Standard
		1-Methylnaphthalene	1.7 to 16	1.1	EPA RSL Carcinogenic Tap Water SL
		Benzo(a)anthracene	0.065	0.038	MT-DEQ DEQ-7 Human Health Standard
		Chrysene	0.11	0.038	MT-DEQ DEQ-7 Human Health Standard
		Aliphatic (C05–C08)	3,190	700	MT RBCA Tier 1 RBSL
		Aliphatic (C09–C12)	1,140	1,000	MT RBCA Tier 1 RBSL
		Aliphatic (C19–C36)	1,060	1,000	MT RBCA Tier 1 RBSL
January 28, 2015					
	At spill site (river mile 0)				
		1-Methylnaphthalene	122	1.1	EPA RSL Carcinogenic Tapwater SL
		2-Methylnaphthalene	154	36	EPA RSL Non-carcinogenic Tapwater SL
		Chrysene	10	0.038	MT-DEQ DEQ-7 Human Health Standard

Table 7.1. Summary of water quality standards and screening levels (SLs) that were exceeded in surface water samples collected by response crews and Trustees after and downriver from the spill site

Date	Location	Analyte	Measured result (µg/L)	Standard/SL (µg/L)	Standard/SL basis
		C11–C22 Aromatics	3,429	1,000	MT RBCA Tier 1 RBSL
February 5, 2015					
	At spill site (river mile 0)				
		Benzene	5.51 to 132	5.0	MT-DEQ DEQ-7 Human Health Standard
		1-Methylnaphthalene	1.5 to 5.7	1.1	EPA RSL Carcinogenic Tapwater SL
		Aliphatic (C05–C08)	1,680	700	MT RBCA Tier 1 RBSL
February 12, 2015					
	At spill site (river mile 0)				
		Naphthalene	40,300	100	MT-DEQ DEQ-7 Human Health Standard
		1,3,5-Trimethylbenzene	17,500	120	MT RBCA Tier 1 RBSL
		C11–C22 Aromatics	40,300	1,000	MT RBCA Tier 1 RBSL
February 24, 2015					
	At spill site (river mile 0)				
		Naphthalene	35,200	100	MT-DEQ DEQ-7 Human Health Standard
		1,3,5-Trimethylbenzene	5,900	120	MT RBCA Tier 1 RBSL
		C11–C22 Aromatics	35,200	1,000	MT RBCA Tier 1 RBSL
March 19, 2015					
	Melting crude contaminated ice near spill location (river mile 0)				
		1-Methylnaphthalene	44	1.1	EPA RSL Carcinogenic Tapwater SL
		Chrysene	4.2	0.038	MT-DEQ DEQ-7 Human Health Standard
		C11–C22 Aromatics	1,226	1,000	MT RBCA Tier 1 RBSL
March 28, 2015					
	Pooled water just downriver from highway 95 bridge in Glendive (river mile 8.5)				
		1-Methylnaphthalene	715	1.1	EPA RSL Carcinogenic Tapwater SL
		2-Methylnaphthalene	522	36	EPA RSL Non-Carcinogenic Tapwater SL
		Chrysene	1,180	0.038	MT-DEQ DEQ-7 Human Health Standard
		C11–C22 Aromatics	218,830	1,000	MT RBCA Tier 1 RBSL

There were five exceedances of the C11–C22 Aromatics screening level of 1,000 µg/L. The exceedances of the 1,000-µg/L screening level predominantly occurred near the spill site, but as noted above, extended as far as 8.5 miles downstream of the spill (Figure 7.1). Furthermore, as described in Section 6.1.2, the samples collected by response crews are likely to significantly under-represent the total PAH concentration that was actually present at the time of sampling, because the samples were only analyzed for a small fraction of the PAHs. Many more of the samples that were collected by response crews likely exceeded the 1,000-µg/L screening level.

Spatial and vertical extent of the exceedances. Most of the exceedances were in water samples collected at the spill site, though exceedances also occurred farther downstream. As noted above, there were elevated concentrations in samples collected from the Glendive WTP (6.5 miles downstream from the spill site), and in samples collected as far as 8.5 miles downriver from the spill site (the sample collected on March 28, 2015 in a side channel of the river). Further, top-bottom samples and the analyses of water collected from the Glendive WTP (which pulls from the bottom of the river) confirm that the contamination was mixed across the water column at least for periods of time, and not restricted to the top of the water column.

Temporal extent of the exceedances. Multiple exceedances were measured in the days after the spill, and oil constituents continued to exceed standards and screening levels in February, and after ice-out in March 2015. A sample collected by the Trustees on March 19, 2015 confirmed there were pockets of oil remaining in the system after ice-out. This sample was collected from the last of the remaining ice near the oil spill. Total PAHs measured at 1,226 µg/L were above the PAH (C11–C22 Aromatics) screening level of 1,000 µg/L. The last water quality exceedances were measured in the water sample collected on March 28, 2015, approximately 2½ months after the spill.

Further, it is possible there were additional exceedances that occurred without being detected. As noted above, VOCs > 200 µg/L were measured at the Glendive WTP plant on March 14, 2015, when the ice melted off the river in the spill area. These elevated VOC concentrations were likely associated with oil that was trapped in pockets and fissures, and was released as the ice melted. It is possible that similar releases may have occurred at injurious levels, associated with "mini thaws" that occurred in late January and February. These events could have occurred undetected, given that the ice was unstable at these times, and samples could not be collected.

Additional evidence of surface water injury. Following the incident, benzene concentrations in the drinking water supply were exceeding the MCL of 5 µg/L by several times, which led to a "do not consume" water advisory being issued for City of Glendive residents on January 18, 2015. This advisory was not lifted until January 23, 2015. High VOCs were again detected at the Glendive WTP on March 14, 2015, at the time of the final ice breakup and melting, which prompted the Glendive WTP to switch its water supply from the river to water storage tanks.

In addition, on January 18, 2015, the MT-FWP preemptively issued an FCA for the area near Glendive, which was extended on February 20, 2015, based on results from a fish tissue survey, and in place until April 13, 2015.

7.1.2 Fish Injury Based on PAH Adverse Effects Levels

It is well-established that PAHs from crude oil can be toxic to fish. To evaluate whether fish may have been adversely affected by PAHs subsequent to the spill, we compared the total PAH concentrations measured in water samples collected by response crews and the Trustees to literature-based adverse effect levels for fish.

Literature-based adverse effects levels for fish. Table 7.2 provides a list of adverse effects levels for different life stages of fish and endpoints that we compiled from the literature. Early life stages of fish (e.g., embryos, larvae) are typically most sensitive to oil, followed by juveniles and adults (Boufadel et al., 2015; DWH NRDA Trustees, 2016). Exposure to PAHs interferes with the sequence of gene regulation needed for normal embryo development, and the upregulation of detoxification enzymes during PAH metabolism creates reactive oxygen species that can cause oxidative stress and damage developing cells. In embryos and larvae, the outcomes of exposure range from death, to craniofacial deformities, to reduced cardiac function. Embryos that survive exposure as juveniles or adults may exhibit reduced survivability, stamina/fitness, and reproductive potential. Adults and juveniles have been less extensively studied; however, effects can occur at different levels of biological organization resulting in adverse responses in individuals, like reduced fecundity and reduced swim performance. In the wild, these endpoints can have significant and severe impacts for fish. For example, reduced swim performance may result in a reduced ability to evade predators or capture prey, and may therefore contribute to increased mortality. Concentration ranges for these adverse effects and their respective references are provided in Table 7.2.

Table 7.2. Adverse effects levels for total polycyclic aromatic hydrocarbon (TPAH) exposure in fish. EC50 and EC20 is the modeled concentration in which 50% and 20% of individuals are affected, respectively. The lowest-observed-effect concentration (LOEC) is the lowest exposure concentration with a statistically significant different response than the control. Ucrit = the maximum swimming speed a fish can maintain for a given period of time (a swim performance metric).

	Species	Toxicant	Exposure duration	Endpoint	Effect metric	TPAH (µg/L)	Source
Embryo exposures (lethality)							
	Yellowfin tuna	GoM sweet crude	24 hours	Decreased survival	EC20	0.70	DWH NRDA Trustees, 2016
	Mahi-mahi	GoM sweet crude	48 hours	Decreased survival	EC20	0.95–40.2	DWH NRDA Trustees, 2016
	Bay anchovy	GoM sweet crude	48 hours	Decreased survival	EC20	1.3–3.3	DWH NRDA Trustees, 2016
	Speckled sea trout	GoM sweet crude	72 hours	Decreased survival	EC20	6.2–25.6	DWH NRDA Trustees, 2016
	Red drum	GoM sweet crude	60–72 hours	Decreased survival	EC20	7.0–21.7	DWH NRDA Trustees, 2016
	Pink salmon	Weathered ANSC crude	83 days	Mortality	EC20	7.8–16.4	Brannon et al., 2006
	Pink salmon	Weathered ANSC crude	6 month	Mortality	LOEC	< 16.5	Carls et al., 2005
	Cobia	GoM sweet crude	48 hours	Decreased survival	EC20	17.3–27.5	DWH NRDA Trustees, 2016
Embryo exposures (sublethal effects)							
	Pacific herring	More-weathered ANSC crude	16 days	Cranio-facial deformity	EC50	0.33	Carls et al., 1999
	Pacific herring	More-weathered ANSC crude	16 days	Edema	LOEC	0.41	Carls et al., 1999
	Yellowfin tuna	GoM sweet crude	48 hours	Cardio-toxicity	EC20	0.5–4.1	DWH NRDA Trustees, 2016
	Southern bluefin tuna	GoM sweet crude	48 hours	Cardio-toxicity	EC20	0.6–3.3	DWH NRDA Trustees, 2016
	Red drum	GoM sweet crude	48 hours	Cardio-toxicity	EC20	1.0–15.7	DWH NRDA Trustees, 2016
	Mahi-mahi	GOM sweet crude	48 hours	Swim performance	Ucrit	1.2	Mager et al., 2014
	Mahi-mahi	GOM sweet crude	48 hours	Cardio-toxicity	EC20	1.3–8.7	DWH NRDA Trustees, 2016
	Rainbow trout	SCOT and MESA crude	22 days	Deformities	EC50	2.1	Wu et al., 2012
	Rainbow trout	FED crude	22 days	Deformities	EC50	2.7	Wu et al., 2012
	Greater amberjack	GoM sweet crude	48 hours	Cardio-toxicity	EC20	2.8–8.3	DWH NRDA Trustees, 2016
	Rainbow trout	ANSC crude	22 days	Deformities	EC50	3.4	Wu et al., 2012

Table 7.2. Adverse effects levels for total polycyclic aromatic hydrocarbon (TPAH) exposure in fish. EC50 and EC20 is the modeled concentration in which 50% and 20% of individuals are affected, respectively. The lowest-observed-effect concentration (LOEC) is the lowest exposure concentration with a statistically significant different response than the control. Ucrit = the maximum swimming speed a fish can maintain for a given period of time (a swim performance metric).

	Species	Toxicant	Exposure duration	Endpoint	Effect metric	TPAH (µg/L)	Source
	Pink salmon	Weathered Prudhoe Bay crude	18 days	Development	LOEC	4.4	Marty et al., 1997
	Pacific herring	Less-weathered ANSC crude	16 days	Edema	LOEC	9.1	Carls et al., 1999
	Zebrafish	ANSC crude	2 days	Cardio-toxicity	EC50	25.0	Carls et al., 2008
Larval effects observed in fish exposed as embryos							
	Pacific herring	More-weathered ANSC crude	16 days	Swimming ability	EC50	2.44	Carls et al., 1999
	Pink salmon	Weathered ANSC	8 months	Returning adults	LOEC	5.4	Heintz et al., 2000
	Pacific herring	Less-weathered ANSC	16 days	Swimming ability	EC50	18.4	Carls et al., 1999
Juvenile and adult							
	Zebrafish	Benzo(a)pyrene	49 days	Reduced fecundity	LOEC	1.63	Hoffmann and Oris, 2006
	Zebrafish	Benzo(a)pyrene	49 days	Reduced GSI	LOEC	3.35	Hoffmann and Oris, 2006
	Mahi-mahi	GoM sweet crude	24 hours	Adult swim performance	Ucrit	8.4	DWH NRDA Trustees, 2016
	Mahi-mahi	GoM sweet crude	24 hours	Juv. swim performance	Ucrit	30	DWH NRDA Trustees, 2016

ANSC = Alaska North Slope crude, FED = federated crude, GoM = Gulf of Mexico sweet crude, GSI = gonadosomatic index, MESA = medium South American crude, SCOT = Scotian light crude.

Literature-based adverse effects level for pallid sturgeon. As part of the *Deepwater Horizon* (DWH) oil spill NRDA, injury to the federally listed threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*) was assessed. In addition to field tagging and assessment work on Gulf sturgeon, laboratory toxicity testing was conducted to characterize oil toxicity in a surrogate species, juvenile shovelnose sturgeon (*Scaphirhynchus platorynchus*), a closely related species to the federally listed endangered pallid sturgeon. The FWS (2015) characterized potential adverse effects on DNA, blood cells, and immune function associated with crude oil exposure. They found that 5–10 µg/L total PAHs resulted in damaged red blood cell DNA and they observed enlarged spleens, which is consistent with blood cell damage. They also observed lower white blood cells and neutrophils numbers in the exposed fish, indicating reduced immune capacity (FWS, 2015).

Comparison of water concentrations to adverse effects levels. As described in Section 4.3.2, many juvenile and adult fish were observed and known to be present during the spill. In particular, sturgeon, sauger, catfish, and a burbot were collected by MT-FWP from the river near Glendive during their FCA sampling event in late January 2015. For most fish species in the lower Yellowstone River, adults and juveniles are the only life stages expected to be present during the winter months that coincide with the time of the spill. However, the burbot is a unique species in that it spawns in the winter in the Yellowstone River. Given the burbot lifecycle and that burbot were found in the affected area, it is likely that burbot embryos and larvae were exposed to oil as a result of the spill. As such, we compared PAH concentrations measured in samples collected in the Yellowstone River downstream of the spill site to levels predicted to cause adverse effects to both embryos and to juvenile and adult fish.

Figure 7.1 provides a graphical description of the range of PAH concentrations that are associated with adverse effects in embryos, based on the literature presented in Table 7.2. It shows that concentrations of PAHs sufficiently high to cause adverse effects in embryos were measured in water samples collected at the spill site, and as far as almost 30 miles downriver of the spill site. Figure 7.2 shows the PAH levels predicted to cause adverse effects in adults and juvenile fish. Although juveniles and adults are less sensitive to PAHs than early life stages, PAH concentrations were measured above levels predicted to cause adverse effects in these older life stages as well. The concentrations were also within the range observed to cause adverse effects to sturgeon (FWS, 2015). Furthermore, many of the PAH concentrations reported in samples collected by response crews likely under-represent the actual PAH exposure, because many of the samples were only analyzed for a limited number of PAHs (see Section 6.1.2).

Figure 7.1. Total PAH concentrations measured in oil spill response crew- and Trustee-collected samples, compared to the concentration range (shown by solid lines) that could cause adverse effects in fish embryos exposed to PAHs. Samples within the shaded area are above adverse effects levels. Black lines represent lower and upper range of literature-reported adverse effects levels for fish embryos presented in Table 7.2.

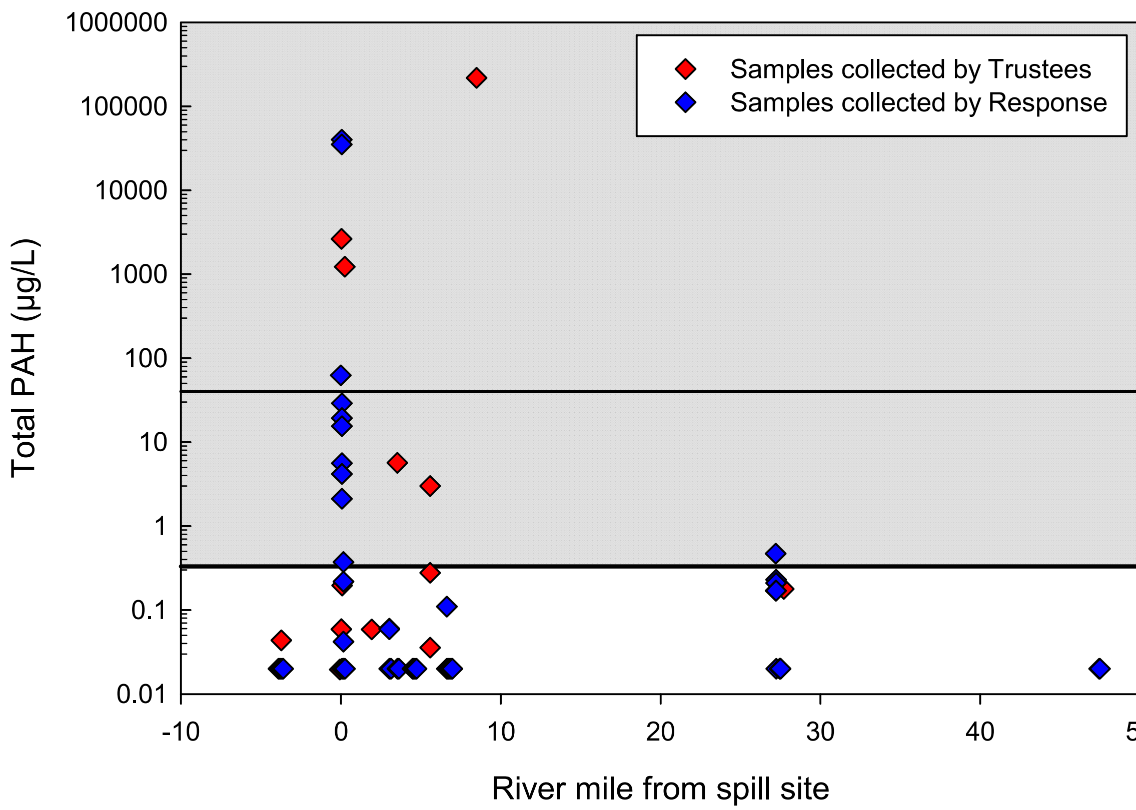
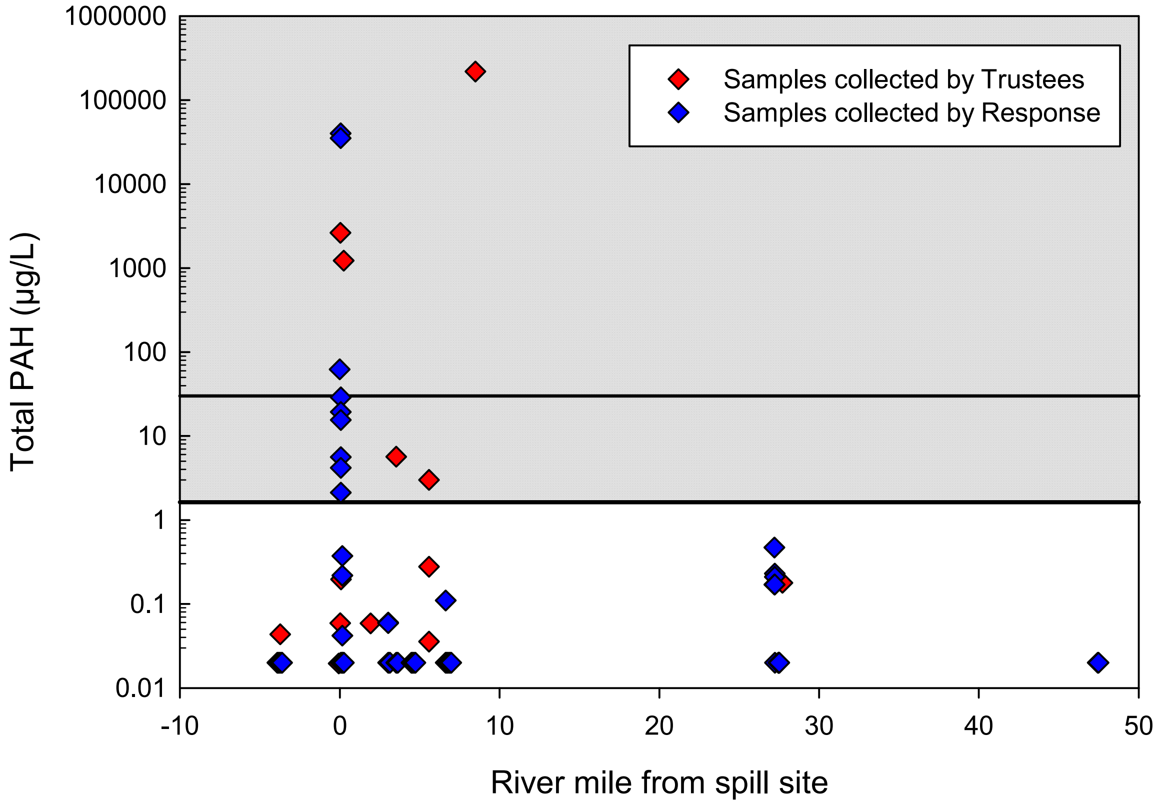


Figure 7.2. Total PAH concentrations measured in oil spill response crew- and Trustee-collected samples compared to the concentration range (shown by solid lines) that could cause adverse effects in juvenile and adult fish exposed to PAHs. Samples within the shaded area are above adverse effects levels. Black lines represent the lower and upper range of literature-reported adverse effects levels for juvenile and adult fish presented in Table 7.2.



There are uncertainties with this analysis. For example, few studies have been conducted with fish species that inhabit the lower warm-water reach of the Yellowstone River, or with Bakken crude oil. Literature-based adverse effects values from toxicity tests on a range of species using a range of types of crude oils, including both fresh and weathered oils, are presented in Table 7.2. However, the adverse effects levels across these different studies vary by orders of magnitude and we do not know for sure the sensitivity of particular species found in the lower Yellowstone River to the specific oil that was spilled, Bakken crude. Furthermore, there are few studies that have examined the effect of cold water temperatures on the adverse impacts of PAHs to fish and very few, if any, that have investigated oil toxicity under ice-over conditions. The results of the few studies that have been conducted on oil toxicity and decreased water temperatures are inconclusive. Some study results have suggested changes in sensitivity to PAHs under cold conditions (e.g., Korn et al., 1979), possibly associated with changes in PAH degradation and loss under colder conditions. Other studies have shown increased sensitivity to oil when below and above optimum water temperatures (e.g., Linden et al., 1979).

Additional evidence of fish injury. Starting March 22, 2015, soon after the river ice melt and breakup, the Trustees conducted a fish health study (Figure 7.3). For this study they investigated the occurrence of abnormalities associated with oil exposure including external lesions and abnormalities; gill clumping or fusion of the secondary lamellae (Nero et al., 2006; Santos et al., 2011; Khan, 2013); and kidney abnormalities (Pacheco and Santos, 2002; Camargo and Martinez, 2007; Kakkar et al., 2011) and blood markers for anemia and tissue damage (Albers, 2003; Jee et al., 2004). The pathology findings were summarized by Headwaters Fish Pathology (2015). In general, fish from the upriver reference site were in better overall condition compared to fish collected in downriver reaches, and the following observations were made (Headwaters Fish Pathology, 2015):

- Gill changes associated with responses to irritants, including petroleum exposure, were observed at higher rates in fish collected downriver from the spill site. This included observations of gill clumping (e.g., Figure 7.4).
- Degeneration of kidney tubule epithelium was more prevalent and of greater severity in fish collected in the first two sampling reaches downriver from the spill site. In freshwater fish, kidney tubules are involved in the active reabsorption of salts from urine to blood (Jobling, 1996). Crude oil exposure can damage the kidney tubules and reduce the ability of the fish to maintain its ion gradient with the environment (Gabriel et al., 2007b; Kakkar et al., 2011).
- Blood smears from river carpsucker, shovelnose sturgeon, and shorthead redhorse collected in the reach downriver from the spill site had 80–95% more pre-erythrocytes than reference area fish. Pre-erythrocytes are immature red blood cells that are rare in healthy fish (Clauss et al., 2008). Immature red blood cells are produced to replace damaged red blood cells (Curby et al., 1976), and oil exposure has been associated with damage to blood cells (Prasad et al., 1987; Gabriel et al., 2007a; Ezike et al., 2015).

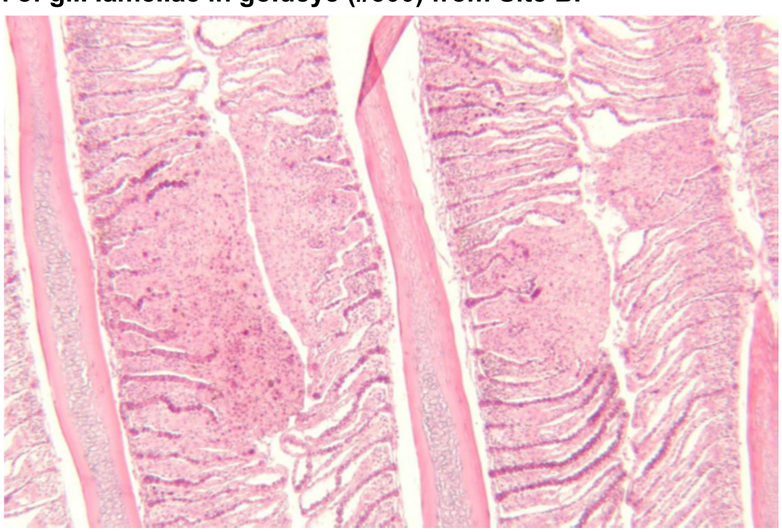
7.1.3 Bird Injury Based on Observed Sheen on River

As noted previously, Incident Command denied the request of the Wildlife Branch of the Operations Section for wildlife rescue support resources and, due to dangerous ice conditions on the river during Phase I (see Figures 2.1, 3.1), no organized oiled wildlife searches were conducted (CTEH, 2015a; Karen Nelson, personal communication). Despite the lack of organized wildlife searches, incidental observations of wildlife located in oil-impacted reaches of the river were made that include observations of common goldeneyes, common mergansers, Canada geese and other waterfowl, and bald eagles (David Rouse, personal communication; Chris Boyer, personal communication; Karen Nelson, personal communication).

Birds can become oiled while floating, wading, and feeding in open-water areas along the river where a sheen is present. Many of the birds documented using the Yellowstone River during the winter spend time roosting or feeding in open-water areas. Mallards are excellent swimmers and divers when necessary. In winter, mallards are able to withstand cold temperatures, require only small areas of open water for roosting, and spend some time in the water each day between trips to the numerous agricultural fields in the area where they feed (Drilling et al., 2002). Common mergansers were seen on the river where a sheen was present. Mergansers are generally found on the water; tend to sleep on open water; and feed by probing sediments and underwater stones for prey, or swim with their head underwater searching for or chasing prey (Pearce et al., 2015).

Figure 7.3. Examples of fish species collected during the fish health assessment on March 21, 2015, including (A) river carpsucker, (B) shovelnose sturgeon, (C) goldeye, (D) shorthead redhorse, and (E) channel catfish.

Figure 7.4. Fusion of gill lamellae in goldeye (#500) from Site B.



Source: Headwaters Fish Pathology, 2015.

Therefore, mergansers likely came into contact with the oil sheen. Common goldeneye, another standard waterfowl species on the Yellowstone River during the winter, was also at risk of coming into contact with the sheen. Goldeneyes are strong swimmers and divers, and spend most of their time on the water, diving frequently (Eadie et al., 1995). Canada geese were present in the largest number during the spill. During the winter, Canada geese generally fly from roosting sites on the water in the morning and evening to feed in agricultural fields. Primary activities include feeding and alert behaviors at foraging sites, and loafing and sleeping at midday and at night-time roost sites (Mowbray et al., 2002). Killdeer were seen when the ice came off the river along the shoreline within an area containing a sheen from melting, oiled ice chunks. These birds often inhabit and feed along the shoreline and could become oiled while trying to feed.

Avian injury resulting from a spill may include mortality, changes in reproductive success, and other sub-lethal effects. In this spill, the most likely injury was mortality due to direct oil exposure. Oil interferes with the structure of feathers and reduces water repellency and insulation. The numerous birds documented along the Yellowstone River in the area of the spill were likely using open water for roosting sites. Any birds using areas containing a sheen would have been oiled. Once a bird is oiled, its ability to search for food, swim, float, and thermoregulate is diminished, all of which can lead to mortality. Birds may also ingest oil while preening (cleaning their feathers), by consuming contaminated vegetation or prey, or through the incidental ingestion of contaminated sediment. Oil ingestion may result in direct mortality or lead to long-term physiological, metabolic, and behavioral effects. These long-term effects may ultimately reduce survival.

Because of the cold temperatures at the time of the spill [the average high temperature in January and February 2015 was 31.6°F and 36°F, respectively; and the average low temperature in January and February was 13°F and 12.3°F, respectively (U.S. Climate Data, 2017)], the effects of oiled feathers will be the focus of our injury claim. In birds, the physical structure of feathers is critical for thermoregulation. The microscopic interlocking of barbules and barbicels in feathers creates a waterproof barrier that traps air next to the skin, allowing birds to maintain high body temperatures (103–106°F) as well as buoyancy when in the water (Albers, 1995; Jessup and Leighton, 1996). Once a bird is exposed to oil, the microstructure of feathers can collapse (Hartung, 1967; Clark and Kennedy, 1968; Jenssen and Ekker, 1988), which can allow water to penetrate deeply into this insulative air layer (Stephenson and Andrews, 1997; Newman et al., 2000; O'Hara and Morandin, 2010). Bird feathers exposed to a barely visible sheen (0.04-µm thick) and a trace color sheen (0.1-µm thick) caused barbules to clump; and in sheens 0.1-µm thick or greater, measurable oil transfer to feathers was documented (O'Hara and Morandin, 2010). The result of exposure to an oil sheen and water penetration is increased heat loss from the skin and, for a bird on the Yellowstone River in the winter and spring, a much greater tendency to become hypothermic. The decreased insulation also increases vulnerability to starvation as oiling increases the rate at which stored body fat is exhausted (Hartung, 1967; Fry and Lowenstine, 1985). Because of the cold temperatures present during the spill, most birds would have died before starvation. Finally, the removal of this insulative air layer due to oiling can also cause birds to lose the capacity to swim or float (McEwan and Koelink, 1973; Vermeer and Vermeer, 1975), leading to an inability to forage or escape predators, or drown.

While there were no reported observations of dead or oiled birds during preassessment activities, this does not necessarily indicate a lack of exposure. Structured wildlife surveys were not conducted during this incident and when searches are actually conducted, locating dead or injured wildlife is difficult. Many of the reasons bird carcasses are unaccounted for in coastal spills are also applicable to riverine freshwater spills. Oiled birds may be become ill and/or disturbed by response actions, leading them to hide or move away from the area. Exposed birds may succumb; be unable to fly; or may be trapped in the water, sink, and be washed out of the area where searches occur. Searchers' abilities to systematically search for and observe dead birds, particularly songbirds and other small birds, in the dense vegetation that occurs in riverine habitats may be limited. Also, scavenging by natural predators as well as domestic animals may reduce the number of carcasses available to be found by search teams. Oil on birds is also difficult to see, and can easily be missed, especially when the oiling is minimal. During the DWH spill, birds were captured to evaluate the effects of oil to birds. Captured birds were classified as to their degree of oiling and there were frequent instances of a bird being visually noted as not oiled but subsequently identified as trace oiled when ultraviolet (UV) fluorescence was used (Peter Tuttle, the FWS, personal communication). This observation on captured birds indicates the difficulty in observing small quantities of oil on birds. On the Yellowstone River, open-water areas where birds were located were surrounded by unstable ice, creating unsafe conditions for anyone trying to get close enough to observe the birds, so any oiling on birds using these areas would be difficult to document. Yet, studies have shown that a small amount of external oiling on birds can cause adverse effects (O'Hara and Morandin, 2010; Dean and Bursian, 2017; Maggini et al., 2017a, 2017b; Perez et al., 2017a, 2017b, 2017c).

7.2 Injury Assessment Studies

Below we describe the two injury assessment activities proposed by the Trustees.

7.2.1 Laboratory-Based Fish Toxicity Studies

As described above, the range of PAHs in the water column during and after the spill encompasses the range of adverse effects levels reported in the literature for marine and freshwater fish (see Figures 7.1 and 7.2). These effects range from mortality in early life stages to compromised immune function and swim performance in adult/juvenile life stages. However, as described in Section 6, the cold water temperatures and ice cover during the spill in the Yellowstone River are somewhat unique and, therefore, less well-studied than the toxicity of oil under warmer water temperatures with open atmospheric conditions. Additionally, the toxicity of oil to many of the fish species that the Trustees have confirmed were present in the river and were likely exposed to Bakken crude oil during the incident, including the federally listed endangered pallid sturgeon and the burbot, a Montana State potential species of concern, has not been studied in detail. Of particular importance are species like the burbot, because they spawn and rear in the river during the winter months (i.e., January/February), and thus sensitive early life stages would have been present when the oil was discharged.

Therefore, the Trustees have proposed to conduct laboratory-based toxicity tests on early life stage burbot and juvenile pallid sturgeon, under conditions that emulate the environmental conditions during and after the spill, including cold water temperatures and closed atmospheric conditions, in order to assess injury to these species. The laboratory methods employed in the study will be based on proven methods employed in the field of oil toxicology, such as Morris et al. (2015b); and methods that have been rigorously tested by a consortium of scientists funded by the American Petroleum Institute, including for closed-atmosphere exposure systems (e.g., Aurand and Coelho, 2005). Further details on the fish toxicity study, and the peer-reviewed scientific methodologies upon which it is based, are provided in Appendix B.

Finally, this study is not only needed to confirm whether these important species of fish were injured as a result of the spill, but also to inform the nature of restoration that may be required to compensate for injury and service losses resulting from the spill. For example, pallid sturgeon are a long-lived species that requires very long, unencumbered river reaches to spawn, and thus unique/specific restoration may be needed to compensate for any injury to this federally listed species.

Pursuant to 15 CFR § 990.27, the Trustees determined the proposed laboratory injury assessment activities for fish will be reliable and valid to determine injury for this specific incident. As discussed in greater detail in Appendix B, the toxicity testing methods will emulate the conditions in the river during the incident by exposing test organisms to oil/water mixtures under cold temperatures and closed atmospheric conditions. The researchers will be able to simulate the types of exposures and oil/water mixtures that existed during the incident based on the Trustees' direct measures of oil constituent concentrations, including PAHs, benzene, and other analytes, in surface water samples collected from the river during and after the incident. These samples were collected at different depths and distances downstream from the spill, and over several days and weeks following the spill. Despite the challenging sampling conditions, dozens of samples were collected and analyzed for benzene, PAHs, and oil constituents during response efforts to the spill (MT-MDEQ, 2015a, 2015b). Therefore, the Trustees have direct information on exposure levels as they were measured at the time of the incident.

Further, as described in Appendix B, the Trustees will conduct experiments with a water accommodated fraction in a chemical and physical state similar to the mixture likely present during and after the spill. This will likely result in the testing of both non-weathered and weathered oil. The Trustees intend to conduct cold water, closed-system (capped) water accommodated fraction (WAF) characterization prior to conducting any bioassays for this project, to confirm and determine relevant mixing and exposure procedures. This will require collecting water samples during testing at different time points during the exposures, and analyzing the samples for a full suite of up to 50 PAHs (e.g., EPA Method 8270SIM; Forth et al., 2015, 2017), as well as for volatile compounds such as BTEX (e.g., EPA Method 8260C). As described in Morris et al. (2015a), while non-weathered oil contains more soluble constituents than weathered oil, weathered oil can, in fact, be more toxic on a mass basis, as some of the heavier, slower-to-weather PAHs are also more toxic.

Although the effect of cold water temperatures and ice cover is not well-studied, the studies proposed in this plan will be based on reliable and valid methods. Phase 1, Task 2 of the fish study (Appendix B) specifies that bioassay exposure methods will be developed to emulate conditions during the oil spill. These will be based on proven methods employed in the field of oil toxicology, including those utilized and developed for the DWH oil spill NRDA (e.g., Morris et al., 2015a), which were followed to conduct over 650 bioassays and chemical characterizations on over 30 species of fish and invertebrates. The bioassay systems that will be developed for this project will be based on methods that have been rigorously tested by a consortium of scientists funded by the American Petroleum Institute, including closed-atmosphere exposure systems (e.g., Aurand and Coelho, 2005).

Pursuant to 15 CFR § 990.27(a)(2), the additional cost of the fish study is reasonably related to the expected increase in quantity and quality of relevant information for this assessment. While there is an extensive body of literature on the effects of oil on aquatic species, most studies have been conducted in warmer temperatures and open atmospheric conditions, which do not reflect conditions during this spill. Furthermore, there are few if any studies in the literature that address the toxicity of oil to embryonic/larval burbot or juvenile pallid sturgeon, which are species and life stages of particular interest in this assessment. Therefore, the Trustees propose this study because of the unique cold, under-ice conditions of the spill; and the specific species and life stages that were exposed under these conditions. The study is needed to understand the magnitude and extent of the injuries. Only once this is better understood can appropriate restoration be identified and scaled to understand the amount of restoration needed to make the public whole.

Since 2011, a large body of literature has been published on the adverse effects of PAHs on aquatic species. This literature has demonstrated that early life stages are particularly sensitive to oil and identified endpoints (survival, growth, development) that are more conducive to a laboratory- than a field-based study (see, for example, Boufadel et al., 2015; DWH NRDA Trustees, 2016).

7.2.2 Model-Based Bird Assessment

The effects of oil on avian health and survival have been well-documented. One particular aspect of oil exposure in birds is the effect that oil has on the microstructure of the feather. The microscopic interlocking of barbules and barbicels in feathers creates a waterproof barrier that traps air next to the skin, allowing birds to maintain high body temperatures (103–106°F) as well as buoyancy when in the water (Albers, 1995; Jessup and Leighton, 1996). Oil can coat and cause structural changes in bird feathers by collapsing the interlocking structure of barbs, barbules, and hooks (Hartung, 1967; O'Hara and Morandin, 2010). Since the physical structure of the feather is critical for thermoregulation, increased metabolic rates have consistently been reported as an effect in birds in response to external oiling (Hartung, 1967; Lambert et al., 1982; Jenssen and Ekker, 1991; Stephenson and Andrews, 1997; Morandin and O'Hara, 2016). During spill response activities, the average high temperature in January and February 2015 was 31.6°F and 36°F, respectively; and the average low was 13°F and 12.3°F, respectively. Even light oiling of a bird's exterior or exposure to thin oil sheens can affect feather microstructure and increase the energetic demand of a bird to levels that affect behavior, growth, and survival (Hartung, 1967; Stephenson and Andrews, 1997; O'Hara and Morandin, 2010; Morandin and O'Hara, 2016; Maggini et al., 2017b). Compromised feather structure due to oiling can also result in a reduced capacity to swim or float, and impair flight performance (McEwan and Koelink 1973; Vermeer and Vermeer, 1975; Maggini et al., 2017b).

Due to decisions made by Incident Command during response activities, unsafe river conditions that include ice and snow, and limited shoreline access, wildlife surveys were not conducted during Phase I of the spill and minimal monitoring was conducted in Phase II due to time and limited access locations. However, annual mid-winter waterfowl surveys that are completed on the lower Yellowstone River, including a survey done 10 days before the spill, provided evidence that the open-water areas in the impacted reach of water are routinely used by overwintering waterfowl. This was confirmed by observations made during Phase I of response activities of various bird species within impacted reaches of the river (see Section 6.2).

Observations of bird use on impacted reaches of the river continued into Phases II and III of response activities, and included many of the spring migrants returning to or stopping at this location that is made up of thousands of ducks and geese (Brad Schmitz, personal communication). Comprehensive wildlife surveys were not completed during the response activities, but birds were confirmed using reaches of the river where a visible sheening was reported or observed during the response. Therefore, a risk assessment approach to estimate bird mortality will be used to quantify bird injury.

While no searches were authorized under the Wildlife Operations Branch for response activities during the Bridger oil spill, even when searches are allowed, the actual number of birds injured generally exceeds the actual number of bird carcasses collected. Oiled birds may be become ill and/or disturbed by response actions, leading them to hide or move away from the area. Exposed birds may succumb; be unable to fly; or may be trapped in the water, sink, and be washed out of the area where searches occur. Searchers' abilities to systematically search and observe dead birds, particularly songbirds and other small birds, in the dense vegetation that occurs in many riparian habitats may be limited. Also, scavenging by natural predators as well as domestic dogs and cats may reduce the number of carcasses available to be found by search teams. Because birds were observed in the area and the limited open-water area below the spill site contained an oil sheen, it is very likely that birds were oiled and died. Because the Wildlife Branch of the Operations Section was denied the opportunity to search for dead birds, we will use a risk assessment approach to bird mortality. A risk assessment approach uses estimates of the bird populations at risk and an estimate of the percent of the bird populations oiled. Those data are then augmented with avian toxicity data to estimate the total number of birds that were likely oiled and killed. This type of approach was used on the Chalk Point oil spill (NOAA et al., 2002) and more recently for estimating the number of pelagic birds killed during the DWH oil spill (IEc, 2015a, 2015b).

Appendix C contains a detailed work plan for the model-based bird assessment. The following parameters will be considered to quantify bird injury:

1. Extent and degree of oiling
2. Effects of oil on birds
3. Bird density estimates
4. Bird mortality estimates
5. Lost productivity.

Maps, databases, and all other locational or geographic data sources associated with the Bridger Pipeline oil spill will be used to document the extent of oiling downstream from the pipeline break within the Yellowstone River. Two exposure periods will also be considered based on areas of the river where birds would have been exposed to oil when ice covered the river, and areas where birds would have been exposed to oil during and immediately after the ice breakup. Using existing scientific, agency, Trustee, and other source reports and information, the adverse effects of oil to birds will be described to estimate the mortality of birds based on various categories of oiling, and will consider the potential differences in air and water temperatures during the two exposure periods. Bird density estimates will be developed in cooperation with the FWS and MT-FWP using literature and seasonally appropriate, site-specific data and surveys (conducted during and prior to the spill, including historical data and surveys). Based on these factors, the number of total birds oiled will be estimated using the following equation:

$$\textbf{Average density of birds in open area}\left(\frac{birds}{km^2}\right) \times \textbf{Area oiling within open area}\,(km^2) = \textbf{Number of birds oiled.}$$

Once the total number of birds oiled is quantified, the number of oiled birds by species will be calculated using the following equation:

$$\textbf{Number of birds oiled} \times \textbf{Proportion of birds}_i = \textbf{Number of birds oiled}_i.$$

Having calculated the number of birds oiled by species, the number of birds killed by species and category of oiling will be calculated using the following equation:

$$\textbf{Number of birds oiled}_i \times \textbf{Proportion of birds oiled}_j \times \textbf{Fate}\,(\%\ \textbf{expected mortality})_j = \textbf{Number of birds killed}_{i,j,}$$

where i = species of bird and j = category of oiling.

Finally, the total number of birds killed by species will be calculated by summing the estimated number of birds killed by oiling category for each species. As part of our bird injury quantification, we will also estimate the lost productivity for the birds killed. Lost productivity will be determined using life history parameters for each species. The lost productivity for each species will be added to the number of birds killed for that species to quantify the total bird injury. Once injury has been quantified, the Trustees may develop a Resource Equivalency Analysis (REA) for birds in order to help determine the amount of restoration required to offset the losses.

8 Injury Quantification under 15 CFR § 990.52

8.1 Quantification Approaches

To quantify natural resource injuries the Trustees will evaluate the spatial extent, the temporal extent, and the degree of injuries throughout the affected reach of the Yellowstone River (15 CFR § 990.52). The spatial and temporal extent of injuries will be evaluated by establishing the spatial and temporal extent of oil contamination in the river based on available environmental data, and considering the presence and abundance of natural resources in the affected area. The degree of injuries will be evaluated by considering the degree of exceedance of criteria or other thresholds that are protective of natural resources.

As an example, for surface water resources we could quantify the number of river miles adversely affected by the incident by determining how far downstream there were water quality standard or screening level exceedances. Likewise, we could quantify the injury to fish and bird resources by determining adverse effects levels for different biologically relevant endpoints (e.g., growth, reproduction, survival), and determining the degree and extent in which contaminant concentrations likely exceeded these levels in the river.

8.2 Natural Recovery

To quantify injury, we will estimate, quantitatively or qualitatively, the time for natural recovery without restoration, but including any response actions. In our analysis we will consider the following factors: (1) the nature, degree, and spatial and temporal extent of injury; (2) the sensitivity and vulnerability of the injured natural resource and/or service; (3) the reproductive and recruitment potential; (4) the resistance and resilience (stability) of the affected environment; (5) the natural variability; and (6) the physical/chemical processes of the affected environment (15 CFR § 990.52(c)).

8.3 Restoration Scaling Approaches

8.3.1 Habitat Equivalency Analysis

A habitat equivalency analysis (HEA) may be used to scale restoration alternatives to compensate for injuries. An HEA quantifies habitat injuries in terms of discounted service-acre years (DSAYs) to represent the geographic scope and severity of ecological services lost, modified by the duration of injury and discounted over time. Similarly, HEA computes the value of a habitat restoration project in terms of DSAYs to represent the geographic scope and duration of the services it provides, modified by the time the project requires to reach full function and discounted over time.

8.3.2 Resource Equivalency Analysis

An REA may be used for specific resources that recover at a significantly different rate than their habitat, or that may have had injuries that are not well-represented by the level of injury to habitat. The Trustees anticipate using this approach for birds and fish.

9 Restoration Selection under 15 CFR §§ 990.53 though 990.56

The evaluation and development of alternatives and development of the Restoration Plan is not included in the approximately 18-month timeline covered by this Partial Claim, but the Trustees' actions during the year will result in progress toward the Restoration Plan. Any claim for development of the Restoration Plan will be presented separately from this current Partial Claim, once associated costs have been developed. Similarly, the costs of implementing the Restoration Plan are also not included in the current Partial Claim.

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A. Total Polycyclic Aromatic Hydrocarbon Analyte List

Table A.1. List of PAHs analyzed in samples collected by response crews and the Trustees

Analyte or analyte class name	Response water samples (analyzed by EPA methods 8270/8270 SIM)	Trustee water samples (analyzed by EPA Method 8270 with extended alkylated hydrocarbons by SIM)
1-Methylnaphthalene[a]	X	
2-Methylnaphthalene[a]	X	
Acenaphthene	X	X
Acenaphthylene	X	X
Anthracene	X	X
Benz(a)anthracene	X	X
Benzo(a)fluoranthene		X
Benzo(a)pyrene	X	X
Benzo(b)fluoranthene	X	X
Benzo(b)fluorene		X
Benzo(e)pyrene		X
Benzo(g,h,i)perylene	X	X
Benzo(k)fluoranthene	X	X
Biphenyl		X
C1-Chrysenes		X
C1-Dibenzothiophenes		X
C1-Fluoranthenes/Pyrenes		X
C1-Fluorenes		X
C1-Naphthalenes		X
C1-Naphthobenzothiophenes		X
C1-Phenanthrenes/Anthracenes		X
C2-Chrysenes		X
C2-Dibenzothiophenes		X
C2-Fluoranthenes/Pyrenes		X
C2-Fluorenes		X
C2-Naphthalenes		X
C2-Naphthobenzothiophenes		X
C2-Phenanthrenes/Anthracenes		X
C3-Chrysenes		X
C3-Dibenzothiophenes		X
C3-Fluoranthenes/Pyrenes		X
C3-Fluorenes		X
C3-Naphthalenes		X
C3-Naphthobenzothiophenes		X
C3-Phenanthrenes/Anthracenes		X
C4-Chrysenes		X
C4-Dibenzothiophenes		X
C4-Fluoranthenes/Pyrenes		X
C4-Naphthalenes		X
C4-Naphthobenzothiophenes		X

Table A.1. List of PAHs analyzed in samples collected by response crews and the Trustees

Analyte or analyte class name	Response water samples (analyzed by EPA methods 8270/8270 SIM)	Trustee water samples (analyzed by EPA Method 8270 with extended alkylated hydrocarbons by SIM)
C4-Phenanthrenes/Anthracenes		X
Chrysene	X	X
Dibenz(a,h)anthracene	X	X
Dibenzofuran		X
Dibenzothiophene		X
Fluoranthene	X	X
Fluorene	X	X
Indeno(1,2,3-cd)pyrene	X	X
Naphthalene	X	X
Naphthobenzothiophene		X
Phenanthrene	X	X
Pyrene	X	X

a. Note: these two analytes that were analyzed in samples collected by response crews are incorporated into the C1-Naphthalenes and C2-Naphthalenes analyte classes analyzed in samples collected by the Trustees.

B. Fish Laboratory Toxicity Study Simulating Cold (under Ice) Exposure to Bakken Crude Oil

B.1 Introduction

Bridger's Poplar Pipeline ruptured on January 17, 2015, near Glendive, Montana, spilling more than 30,000 gallons of Bakken crude oil into the Yellowstone River (MT-DEQ, 2015). The spill occurred when ice covered much of the river.

This created challenges for the recovery of the spilled oil and for characterizing the nature and extent of contamination. Despite these challenges, water samples with elevated concentrations of oil constituents, including benzene and PAHs, were collected for several miles downstream, with exceedances of water quality standards and screening levels recorded as far as 8.5 miles downstream of the spill site (see Figure 7.1 in the main document); as well as in the City of Glendive's water intake, 6.5 miles from the spill site. SPMDs deployed downstream from the spill site also contained elevated PAH residues at all downstream sites for both deployments. The ice-covered river conditions at the time of the spill appear to have trapped volatile constituents in the water. The Trustees are concerned that natural resources present in the river under the ice, including fish, were exposed to and adversely affected by the oil.

PAHs and other oil constituents are toxic to fish (e.g., Wu et al., 2012; Bornstein et al., 2014; Brown-Peterson et al., 2015; Lee et al., 2015a, 2015b; Morris et al., 2015b; DWH NRDA Trustees, 2016; Esbaugh et al., 2016). However, very few oil toxicity studies have examined the toxicity of oil:

- On fish species that inhabit the lower Yellowstone River
- Using Bakken crude oil
- In very cold water with limited exposure to the atmosphere (i.e., capped with ice).

The few studies that tested oil toxicity under colder water conditions are inconclusive. Some study results have suggested changes in sensitivity to PAHs under cold conditions (e.g., Korn et al., 1979), possibly associated with changes in PAH degradation and loss under colder conditions. Other studies have shown increased sensitivity to oil when water temperatures are either above or below optimum levels (e.g., Linden et al., 1979).

This appendix summarizes a cold-water, laboratory-based toxicity study that will provide injury determination information on fish species exposed to oil under the ice. Additionally, this appendix provides a general description of the goals of the studies and the general approach. A more detailed work plan would be developed once the study is approved.

This study is needed to inform the nature of restoration that may be required to compensate for injury and service losses resulting from the spill. For example, pallid sturgeon, one of the species that may have been adversely affected by the spill, are a long-lived species that requires very long, unencumbered river reaches for successful recruitment, and thus unique/specific restoration may be needed to compensate for any injury to this federally listed species.

This appendix is organized as follows:

- Section B.2 provides background information on the toxicological effects of oil on fish; and the purpose, need, and goals of the laboratory toxicity testing study.
- Section B.3 provides the proposed overall laboratory toxicity testing study approach.
- Section B.4 provides an estimate of costs to prepare a full work plan and implement the study.
- The last section includes references cited in this appendix.

B.2 Purpose, Need, and Study Goals

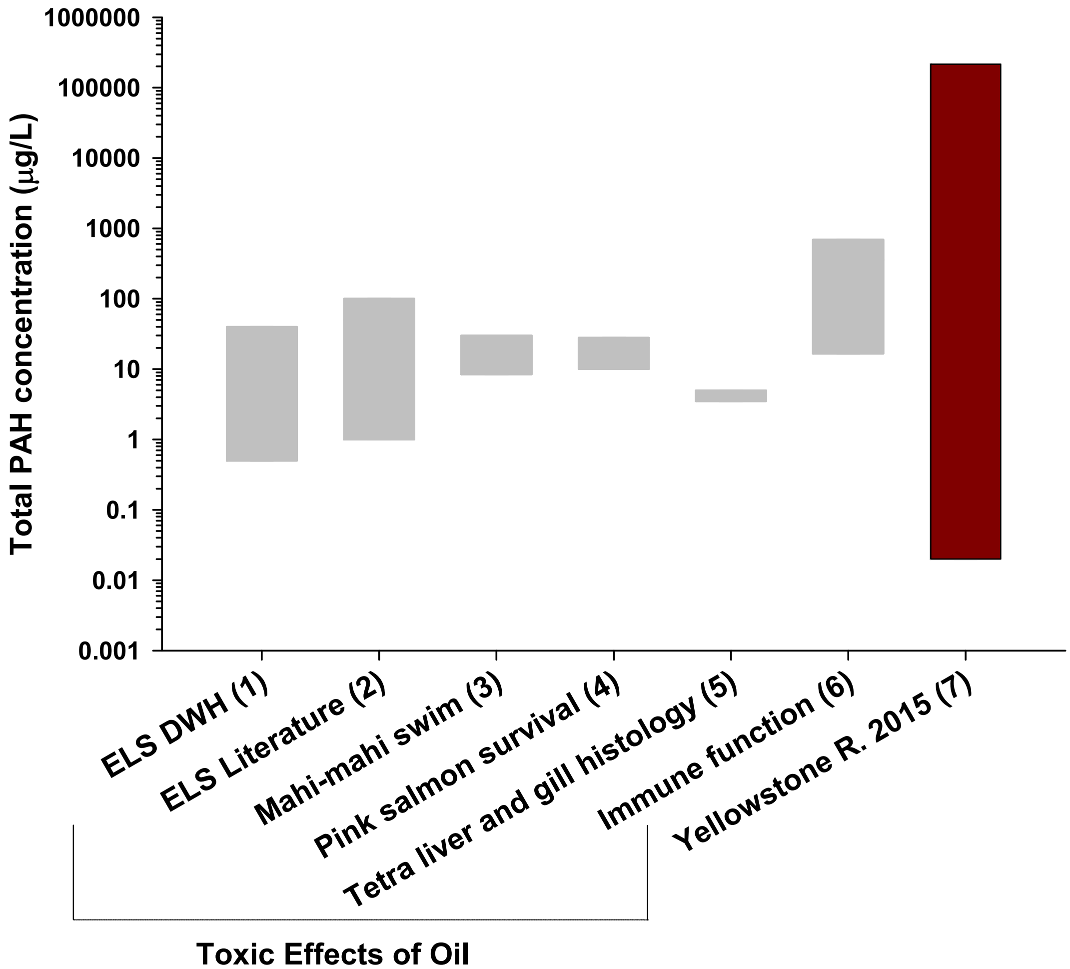
Many previous studies have shown that oil (and PAHs within oil) is toxic to fish, causing many different adverse effects (e.g., Wu et al., 2012; Bornstein et al., 2014; Brown-Peterson et al., 2015; Lee et al., 2015a, 2015b; Morris et al., 2015b; DWH NRDA Trustees, 2016; Esbaugh et al., 2016). PAH concentrations in the Yellowstone River downstream from the spill site exceeded toxic concentrations reported in the literature and measured during the DWH NRDA toxicity testing program (Figure B.1). However, as noted previously, few if any studies have examined the toxicity of Bakken crude oil on Yellowstone River species, particularly in cold water and under ice.

When the spill occurred, the Yellowstone River was mostly frozen. The ice may have served as a cap; volatile compounds like benzene that normally evaporate quickly after a spill were present in elevated concentrations downstream of the spill site. These volatile compounds can cause narcotic toxic effects (narcosis) that reduce activity and can lead to acute mortality.

In addition to volatile compounds like benzene, PAH concentrations were also elevated in the river after the spill. PAHs are lipophilic compounds that readily absorb into fatty tissues and lipid-rich cell membranes in all organisms. This can occur in aquatic environments through dermal exposure or ingestion of these contaminants. In vertebrates such as fish, the body recognizes PAHs as toxicants, triggering a physiological PAH detoxification process. Cellular enzymatic activity (cytochrome P4501A or CYP1A enzyme) driving this detoxification produces reactive oxygen species (ROS) and other toxic metabolites that cause tissue and cell damage (e.g., Timme-Laragy et al., 2009; Jung and Di Giulio, 2010; Van Tiem and Di Giulio, 2011). The resulting oxidative stress can result in tissue and DNA damage, craniofacial and skeletal malformations, and cardiovascular deformities. In addition, PAH exposure can cause reduced cardiac function (e.g., Incardona et al., 2009, 2014, 2015; Hicken et al., 2011; Brette et al., 2014; Sørhus et al., 2016; Khursigara et al., 2017), altered immune function (e.g., Bayha et al., 2017; Jones et al., 2017), and reduced swim performance (e.g., Mager et al., 2014; Stieglitz et al., 2016).

PAH exposure under cold-water conditions presents a situation where the fish's metabolism and subsequent detoxification capacities could be reduced, which would result in an accumulation of PAHs in the tissues and a delayed toxicological response (Chapman, 2015). Once water temperatures began to rise in the spring and fish metabolism increases, it is possible that PAH detoxification processes in fish would increase, resulting in toxic concentrations of ROS and other metabolites as stored PAHs are acted upon physiologically by the fish.

Figure B.1. Effects ranges for oil toxicity for early life stage (ELS) and older life stage fish and concentrations of PAHs detected following the Yellowstone River oil spill near Glendive in 2015.



Sources: (1) Morris et al., 2015b; (2) Lee et al., 2015a, 2015b; (3) Mager et al., 2014; Morris et al., 2015b; DWH NRDA Trustees, 2016; (4) Birtwell et al., 1999; (5) Akaishi et al., 2004; (6) Carls et al., 1998; Ortell et al., 2015; DWH NRDA Trustees, 2016; and (7) PAH concentration ranges measured following Yellowstone River oil spill near Glendive, Montana in 2015.

On the other hand, some fish acclimating to seasonal cold-water conditions increase their mitochondrial density, similar to many resident Arctic or polar fish species (e.g., Regoli et al., 2005; O'Brien, 2011), through a process called mitochondrial biogenesis. Mitochondria in fish and other animals can produce CYP1A in response to hydrocarbon exposure (e.g., Jung and Di Giulio, 2010). Fish with increased mitochondrial density may increase CYP1A-induced PAH detoxification. While this would help to detoxify the PAHs, it could also lead to increased toxic ROS and other metabolites that are byproducts of the detoxification process. Existing literature has not adequately addressed the mechanisms of PAH toxicity in near-freezing waters, nor is the literature sufficient to determine whether the cold water might increase or decrease PAH toxicity compared to ambient water temperatures in most toxicity tests.

Whether cold-water PAH exposure results in increased PAH concentrations in the tissue or an enhanced detoxification response due to cold-water-induced mitochondrial biogenesis, either situation could potentially increase the toxicity of PAHs to certain fish species under winter conditions. However, these theories, along with species-specific PAH sensitivity, are topics that should be further investigated through targeted laboratory testing under cold-water conditions.

Accordingly, the goals of the Trustees' laboratory toxicity-testing studies are to:

- Test the toxicity of Bakken crude oil on a subset of the particular species and life stages that were likely exposed at the time of the spill.
- Test and evaluate the toxicity of Bakken crude oil under environmental conditions present during the spill, including:
  - Toxicity under cold conditions
  - Toxicity under closed atmospheric conditions (as existed when ice capped the river)
  - Toxicity after prolonged exposures of several weeks.

B.3 Approach

This section provides a general overview of the laboratory toxicity-testing studies that can address some of these unanswered questions. It first describes preliminary oil chemistry characterization that will form the underlying basis for the toxicity tests. It then discusses the selection of species and life stages for the study, followed by a general description of the anticipated laboratory setup, the types of tests to be run, the exposure duration, endpoints, and the subsequent utilization of field and laboratory data for injury assessment. The bioassay exposure methods described below will be based on proven methods employed in the field of oil toxicology, such as Morris et al. (2015b), and methods that have been rigorously tested by a consortium of scientists funded by the American Petroleum Institute, including closed-atmosphere exposure systems (e.g., Aurand and Coelho, 2005).

Conducting a rigorous toxicity testing program in support of an NRDA that includes site-specific species/life stages, spill-specific petroleum, incident-specific exposure conditions, and the requisite development of new testing methods is not unprecedented. For example, in close collaboration with the National Oceanic and Atmospheric Administration (NOAA), Abt Associates led the Trustees' toxicity testing program for the DWH NRDA, which included several hundred successful bioassays utilizing a multitude of fish and invertebrate species/life stages from the Gulf of Mexico and innovative testing methods that had not been utilized prior to the injury assessment (e.g., Morris et al., 2015b; DWH NRDA Trustees, 2016).

B.3.1 Oil Exposure and Chemistry

To design a laboratory study addressing the toxic effects of oil in water, the first step is to characterize the oil when mixed with water. This requires creating water-oil mixtures, or WAFs, with Bakken crude oil to simulate the chemistry of the oil- water mixture to which fish were likely exposed. We will employ methods published in the peer-reviewed scientific literature (including, for example, Marty et al., 1997; Heintz et al., 1999; Incardona et al., 2005; Brannon et al., 2006; Morris et al., 2015b; and Forth et al., 2017a, 2017b), to reproduce the actual PAH concentrations that were measured in the field subsequent to the spill, and to reflect the different weathering states and mixing conditions.

The constituent composition of non-weathered DWH and Bakken crude oil are similar (Figure B.2), so much of the DWH data will likely be relevant to the oil characterization of Bakken crude. However, the DWH spill occurred in the deep sea, and the oil surfaced in the open ocean. Volatile compounds such as BTEX quickly evaporated in the Gulf of Mexico. This contrasts with the spill in the Yellowstone River, which occurred in very cold water capped with ice. Therefore, additional cold water, closed-system (i.e., capped) WAF characterization should be conducted prior to conducting any bioassays for this project, to confirm and determine relevant mixing and exposure procedures. This requires collecting water samples during testing at different time points during the exposures, and analyzing the samples for a full suite of up to 50 PAHs (e.g., EPA Method 8270D; Forth et al., 2015), as well as for volatile compounds such as BTEX (e.g., EPA Method 8260C). Additionally, as described in Morris et al. (2015a), although non-weathered oil contains more soluble constituents than weathered oil, weathered oil can be more toxic on a mass basis. Therefore, describing weathered oil as less toxic is misleading as the toxicity is a function of exposure concentration, among other things. The exposure concentration is a function of the solubility of the oil and the mixing method/energy used to generate the exposure solution, which also introduces oil droplets that can contribute to toxicity. Therefore, the weathering state of the oil used to generate the exposure solutions should also be matched as closely as possible to the weathering state of the oil in the river during the spill over time to accurately reflect exposure chemistry and subsequent toxicity.

B.3.2 Cold Water Bioassays

Species and Life Stages

A list of all fish species found in this reach is provided in Tables B.1 and B.2. The species listed in Table B.1 were collected by MT-FWP during the NRDA preassessment phase in January 2015, coincident with the time period during which elevated oil constituents were measured in the same reach of the river. Elevated PAH concentrations were measured in sampled fish tissue at this time, confirming that fish were both present and exposed to oil constituents at the time of the incident. Early life stages are typically more sensitive to contaminants than juvenile or adult life stages. Therefore, this testing program will include the youngest life stages likely to have been exposed to the oil for each species tested. The list of test species will be a subset of the complete list of species present. Species of most concern that may potentially be tested include the federally listed endangered pallid sturgeon (*Scaphirhynchus albus*; or appropriate surrogate species), and burbot (*Lota lota*). Pallid sturgeon and burbot are also both Montana State species of concern. The life stages that would be tested for pallid sturgeon and burbot include juvenile (1–2 years old) and embryo/larvae, respectively. Additional species that could also be tested include goldeye (*Hiodon alosoides*), channel catfish (*Ictalurus punctatus*), shorthead redhorse (*Moxostoma macrolepidotum*), river carpsucker (*Carpiodes carpio*), and shovelnose sturgeon (*Scaphirhynchus platorynchus*). Most of these species have not been tested for PAH sensitivity. In some cases, unique aquaculture systems may be required to facilitate rearing, holding, and toxicity testing.

Figure B.2. BTEX and PAH concentrations in un-weathered Macondo MC252 (Forth et al., 2017a) and Bakken (Etkin and Moore, 2015, Tables 45–46) crude oils.

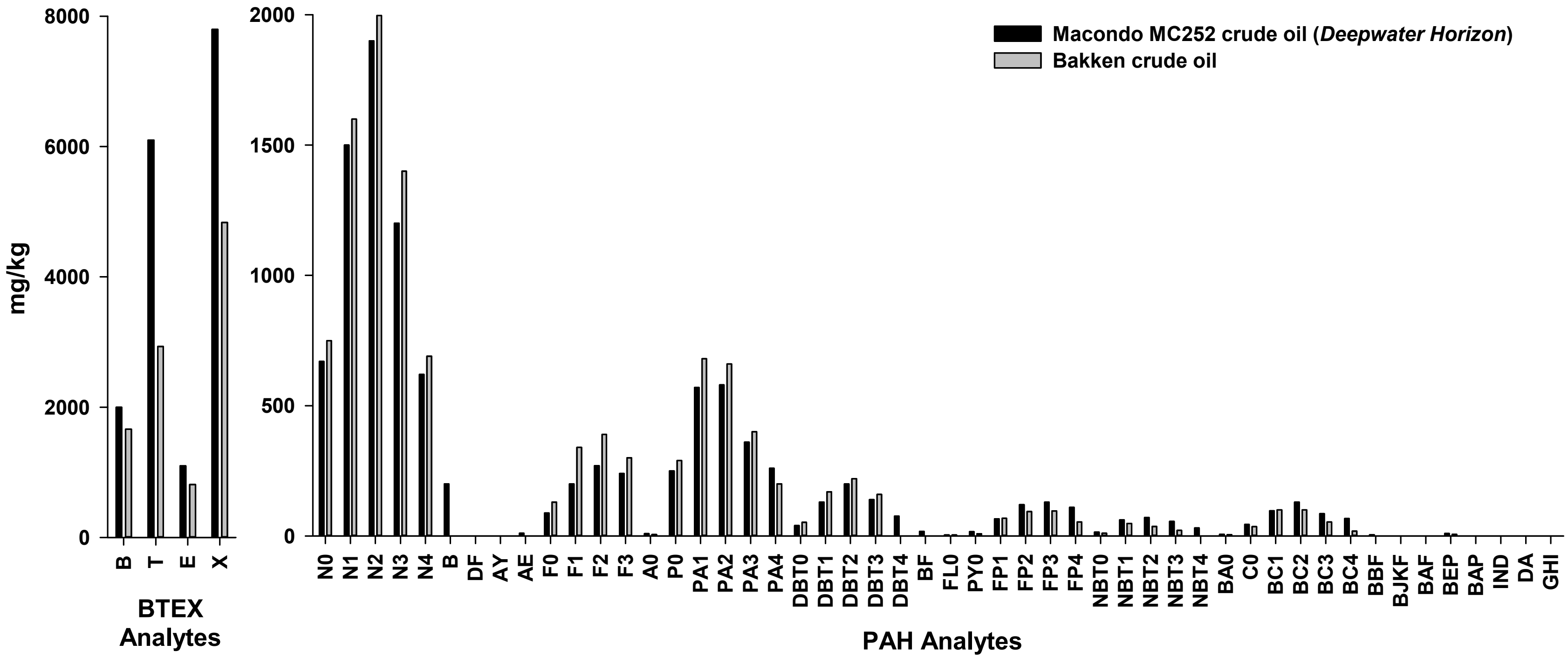


Table B.1. Lower Yellowstone River fish species that MT-FWP personnel collected during spill assessment activities

Common name	Scientific name
Bigmouth buffalo	*Ictiobus cyprinellus*
Black bullhead	*Ameiurus melas*
Blue sucker[a]	*Cycleptus elongates*
Brook stickleback[b]	*Culaea inconstans*
Burbot[b]	*Lota lota*
Channel catfish	*Ictalurus punctatus*
Common carp	*Cyprinus carpio*
Crappie spp.	*Pomoxis spp.*
Emerald shiner	*Notropis atherinoides*
Fathead minnow	*Pimephales promelas*
Flathead chub	*Platygobio gracilis*
Freshwater drum	*Aplodinotus grunniens*
Goldeye	*Hiodon alosoides*
Largemouth bass	*Micropterus salmoides*
Longnose dace	*Rhinichthys cataractae*
Longnose sucker	*Catostomus catostomus*
Mountain sucker	*Catostomus platyrhynchus*
Paddlefish[a]	*Polyodon spathula*
Pallid sturgeon[c]	*Scaphirhynchus albus*
River carpsucker	*Carpiodes carpio*
Sauger[a]	*Sander Canadensis*
Shorthead redhorse	*Moxostoma macrolepidotum*
Shortnose gar[a]	*Lepisosteus platostomus*
Shovelnose sturgeon	*Scaphirhynchus platorynchus*
Smallmouth bass	*Micropterus dolomieu*
Smallmouth buffalo	*Ictiobus bubalus*
Stonecat	*Noturus flavus*
Sunfish spp.	*Lepomis spp.*
Walleye	*Sander vitreus*
Western silvery minnow/plains minnow	*Hybognathus argyritis*
White sucker	*Catostomus commersonii*
Yellow bullhead	*Ameiurus natalis*
Yellow perch	*Perca flavescens*

a. Montana State species of concern.

b. Montana State potential species of concern.

c. Montana State species of concern and federally listed endangered species.

Table B.2. Additional lower Yellowstone River fish species that Holton and Johnson (2003) identified as occurring in this reach in *A Field Guide to Montana Fishes*

Common name	Scientific name
Brassy minnow	*Hybognathus hakinsoni*
Creek chub[b]	*Semotilus atromaculatus*
Golden shiner	*Notemigonus crysoleucas*
Green sunfish	*Lepomis cyanellus*
Lake chub	*Couesius plumbeus*
Northern pike	*Esox Lucius*
Northern redbelly dace[a]	*Phoxinus eos*
Plains killifish	*Fundulus zebrinus*
Rainbow smelt	*Osmerus mordax*
Sand shiner	*Notropis stramineus*
Sturgeon chub[a]	*Macrhybopsis gelida*
Western mosquitofish	*Gambusia affinis*

a. Montana State species of concern.

b. Montana State potential species of concern.

Exposure System

Investigating potential toxicological effects of the spill will require an exposure system design that will emulate the environmental and chemical conditions present during the spill. These include nearly freezing water temperatures and a system closed to the atmosphere, which will prevent evaporation of volatile constituents, such as BTEX. The methods used to conduct these bioassays will be based on proven methods employed in the field of oil toxicology, including those utilized and developed for the DWH oil spill NRDA (e.g., Morris et al., 2015b), which were followed to conduct over 650 bioassays and chemical characterizations on over 30 species of fish and invertebrates. The bioassay systems that will be developed for this project will be based on methods that have been rigorously tested by a consortium of scientists funded by the American Petroleum Institute, including closed-atmosphere exposure systems (e.g., Aurand and Coelho, 2005) with water circulating through modified freezers or cold rooms that can maintain near-freezing water temperatures. The water in these chambers will also be under constant recirculation and receive periodic renewal from freshly formulated WAF preparations. It is also possible to set up exposure systems that simulate the flow conditions of a dynamic river system to evaluate swim performance and metabolic condition under flowing conditions (see, for example, Mager et al., 2014 and Stieglitz et al., 2016). However, simulating flow conditions is not necessary to emulate PAH and BTEX exposure levels in the river at the time of the spill, as we have direct measures of these oil constituent concentrations in surface water samples collected from the river subsequent to the incident, and these concentrations and compositions can be matched using existing WAF preparation techniques.

Exposure Duration

Fish downstream of the spill were potentially exposed to oil constituents in the water column for several weeks following the spill, because of dissolution and periodic release of oil trapped in pockets under the river ice and near the riverbanks. Therefore, relevant bioassay exposure durations were likely longer than the typical 96-hour exposures in acute tests. Additionally, delayed effects of oil exposure may have occurred after the water temperature increased. These tests should include long-term monitoring of organism survival and development following oil exposure. Water temperatures should be increased slowly over this time to increase fish metabolism and simulate warming spring conditions. This metabolic increase may be a critically dangerous time for exposed organisms that accumulated PAHs during cold-water exposure and began increasing detoxification rates as metabolic rates increased, which would potentially create high concentrations of ROS and other toxic metabolites.

Endpoints

Multiple endpoints can be quantified in these bioassays, depending on the species, life stage, and exposure duration for each test. At a minimum, the tests will include typical toxicity endpoints, such as survival, growth, and development. Additional endpoints that may be quantified include reproductive effects (e.g., gamete development and fecundity on a model test organism like a fathead minnow), immunotoxicity (e.g., immune system suppression on juvenile pallid sturgeon), cardiovascular toxicity (e.g., developmental cardio-toxicity on early life stage burbot), and general behavior.

Modeling

Laboratory bioassay data and field data have been utilized to inform modeling efforts associated with injury assessment conducting NRDAs and other environmental investigations (e.g., DWH NRDA Trustees, 2016). Data from the 2015 Yellowstone oil spill include elevated PAH and BTEX concentrations downstream of the spill for an extended period of time, as well as elevated PAH concentrations in fish tissues collected downstream of the spill. Additionally, several different fish species were collected downstream of the spill, including potential toxicity testing species such as burbot and pallid sturgeon. Therefore, the preassessment data confirm there was oil exposure to fish downstream of the spill. The next step in assessing injury is modeling the potential effects of this exposure based on existing relevant toxicology literature and new data generated by conducting bioassays described herein. Literature data and any new data will be used to estimate PAH and/or BTEX concentrations and exposure durations where adverse effects might occur, and model potential injury to aquatic resources downstream from the spill site.

B.4 Estimated Costs and Timeline

The Trustees will employ a lead contractor to provide overall project management as well as expert technical support, oversight, and data analysis and interpretation for this toxicity work. The lead contractor will vet, hire, and form a close collaboration with the laboratories and scientists conducting the bioassays, as well as the laboratories and chemists performing analytical chemistry and data validation. The following sections describe the three phases of the study, followed by estimated costs.

B.4.1 Phase 1

This phase includes two tasks: (1) project initiation, and (2) methods development and preliminary toxicity testing.

Task 1 – Project Initiation

Task 1 will include the lead contractor identifying and contracting all collaborating laboratories and consultants. This task will also include initial work plan and Quality Assurance Project Plan (QAPP) development. Further, the availability of the proposed test species will be assessed during this task and will include any necessary permitting associated with the use of the species, as may be warranted for species like the pallid sturgeon.

Task 2 – Methods Development and Preliminary Testing

Under Task 2, the lead contractor will work closely with the testing laboratories to develop bioassay exposure methods that emulate conditions present during the spill. This will generally include an exposure system that can deliver a WAF in a chemical and physical state similar to the mixture likely present during and after the spill. This requires maintaining cold temperatures and closed or partially closed atmospheric conditions. Once the exposure system is functional, the lead contractor and laboratory team will begin preliminary pilot testing, first using model species, such as fathead minnow (*Pimephales promelas*); and then target species, such as burbot, at multiple life stages. The goal will be to ensure that the exposure system functions properly and generates preliminary toxicity data that will inform Phase 2.

B.4.2 Phase 2

Once method development is completed in Phase 1, definitive Phase 2 testing will begin with a resident species and life stage (such as embryonic/larval burbot) present during the spill, involving extended exposure durations.

B.4.3 Phase 3

Phase 3 work will be a continuation of the definitive testing conducted under Phase 2, with a different target species and life stage. For example, bioassays under this phase may be conducted using juvenile pallid sturgeon or a suitable surrogate species.

B.4.4 Estimated Costs

The estimated cost for this toxicity testing project is $871,000. Below are the different cost components and assumptions.

Project Management and Oversight. As noted above, the lead contractor will be responsible for identifying, contracting, and managing all laboratories and consultants participating in this project through all three phases. In addition to the initial project setup, the lead contractor will also provide ongoing project management, visit and audit testing facilities, participate in bioassay testing, and conduct data processing and preliminary data analysis.

Work Plan and Procedures Development. In collaboration with the testing laboratories, the lead contractor will produce a detailed study plan for each phase of the study, including bioassay testing plans, standard operating procedures, and a QAPP. All of these plans will ensure reliable testing, and a reliable and high-quality product that is appropriate for assessing certain ecological injuries (e.g., Morris et al., 2015b).

Laboratory Toxicity Testing. As described above, the lead contractor/testing laboratory team will likely conduct bioassays on multiple life stages of a model test species, such as fathead minnow; as well as bioassays with target species, such as early life stage (embryo and larval) burbot and juvenile (1-2 years old) pallid sturgeon, or a suitable surrogate species. This work will most likely be conducted in collaboration with a university partner with environmental toxicology and aquaculture expertise, preferably including NRDA experience. This study would likely require supporting a post-doctoral candidate full-time, plus additional laboratory technical support; hours for a Principal Investigator; and a budget for equipment and supplies needed to conduct these tests.

Analytical Chemistry and Data Validation. The final number of water and tissues samples analyzed during the three phases of the study will depend on the study design and the results of the preliminary laboratory trials (Phase 1). The testing laboratory will likely analyze a subset of samples as part of real-time project monitoring and methods development. A commercial analytical laboratory with experience producing complex and reliable analytical data will analyze the remaining samples, collected at key points during the bioassays. The results from these definitive analytical samples will be sent to a third-party data validator to ensure compliance with the QAPP.

Report Writing. The lead contractor will produce interim and final reports for all three phases of this aquatic toxicity program. Additional data analysis and interpretation will be included as part of the report writing.

B.4.5 Project Timeline

Once all contracting and subcontracting activities are finalized, Phase 1 of this project will likely last approximately six to eight months. Phases 2 and 3 will likely last an additional six months each. These overall timeframes depend on the start dates, as certain test species and life stages (e.g., burbot) may only be available as early life stage organisms during one short period each year. Therefore, if necessary, the six-month period during which Phase 2 work is conducted on early life stage burbot may be conducted over two, three-month periods when the species/life stage is available (i.e., January–March during Year 1 of Phase 2 and January–March during Year 2 of Phase 2).

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C. Detailed Work Plan for Estimating Bird Mortality from the Bridger Oil Spill

Objective

Collect spill data and bird population data suitable for estimating bird injury and restoration needs resulting from the Bridger Pipeline oil spill in the Yellowstone River in Montana.

C.1 Introduction

On January 17, 2015, the Poplar Pipeline, which is owned and operated by Bridger of Casper, Wyoming, discharged at least 30,000 gallons of Bakken crude oil into the Yellowstone River just upstream of Glendive, Montana. At the time of the release, the Yellowstone River and its floodplain were experiencing winter conditions and were covered in ice and snow, and the river was ice-covered along large extents of its length. Despite the winter conditions on the river, areas of open water existed in the Yellowstone River downstream of the spill site for more than a month prior to the ice breaking up around March 14, 2015 and many of these open-water areas exhibited an oil sheen. When the ice broke up, most of the oil trapped under the ice at the spill location moved downstream; however, several large chunks of ice released oil into the river for approximately another week. Small oil/sheen areas were located adjacent to and below the melting oiled ice chunks.

The Unified Command was established on January 19, 2015 at the Dawson County Disaster and Emergency Service Center in Glendive, Montana. The Unified Command was responsible for directing response activities including cleanup of oil from the Yellowstone River. The EPA entered into a Unified Command with Bridger and the MT-DEQ. Dawson County, Montana Disaster and Emergency Services, MT-FWP, the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration, and the FWS were supporting agencies. Initial cleanup activities occurred on the south side of the river, about six miles upstream of Glendive and near the site of the pipeline break. However, because of weather and river ice conditions, cleanup was difficult.

Natural Resource Trustees are authorized under the OPA (33 USC 2701 et seq.) to assess injury caused to natural resources by discharges of oil as part of an NRDA. On January 20, 2015, the FWS began coordinating natural resource damage pre-assessment activities with co-Trustees. The Trustees are concerned that migratory and other birds were exposed to oil and died during the spill. Several open-water areas below the spill site contained oil sheens that posed a risk to migratory birds. As part of Incident Command, a Wildlife Branch was identified within the Environmental Unit (CTEH, 2015a). During Phase I, the Wildlife Branch requested that a permitted wildlife rehabilitation organization that could provide oiled wildlife collection, rehabilitation, and documentation services be brought onsite. The Unified Command denied the request and no reason was provided (Karen Nelson, personal communication). Also, due to dangerous ice conditions on the river during Phase I and limited staff resources, no organized oiled wildlife searches were conducted (CTEH, 2015a). During Phases II and III (as ice was breaking up and after the ice broke up), MT-FWP-managed fishing access sites were monitored weekly for observations of bird use, ice conditions, and presence of oiled habitat (CTEH, 2015b). This was typically done by one observer and no shoreline searches were performed. While the goal of conducting these site visits was weekly, they occurred as MT-FWP staff could work the monitoring into their schedules.

C.2 Yellowstone River Bird Usage

Throughout the year, the lower Yellowstone River supports a wide-array of migratory birds, protected by the Migratory Bird Treaty Act, including bald eagles (*Haliaeetus leucocephalus*), which are also protected by the Bald and Golden Eagle Protection Act. Because of the known bird use that the lower Yellowstone River receives, this stretch of river is routinely monitored as part of the FWS Central Flyway Mid-Winter Waterfowl surveys. Beginning in 1935, mid-winter waterfowl surveys have been conducted across the Central Flyway typically in January to track overwintering waterfowl population trends. Wintering grounds with major concentrations of waterfowl are selected for surveys within the flyway and the lower Yellowstone River is one of three Montana areas surveyed. The other two survey locations in Montana include the upper Yellowstone River and the Fort Peck Reservoir.

In 2015, the mid-winter waterfowl survey for the lower Yellowstone River was conducted on January 7, 2015, 10 days before the Bridger Pipeline oil spill, and observations of greater than 29,000 Canada geese (*Branta Canadensis*) and 1,400 mallards (*Anas platyrhynchos*) were reported (James Dubovsky, personal communication). Of these, more than 4,000 Canada geese and 150 mallards were counted within the reach of river between the spill location and Sidney, Montana (John Ensign, personal communication). These surveys provide a snapshot of waterfowl using the waterbodies as an overwintering habitat during a single point in time and may not account for all of the species that use a location during the season. Other species that are commonly observed during mid-winter waterfowl surveys for the lower Yellowstone River include common goldeneyes (*Bucephala clangula*) and common mergansers (*Mergus merganser*) (John Ensign, personal communication). The Glendive area is rich in food resources and waterfowl remain in the Glendive area until the photoperiod and temperatures increase, after which they move farther north (Brad Schmitz, personal communication).

Despite the lack of organized wildlife searches, incidental observations of wildlife located in oil-impacted reaches of the river were made that include observations of common goldeneyes, Canada geese, other waterfowl, and bald eagles (David Rouse, personal communication; Chris Boyer, personal communication). Figure C.1 shows three bald eagles using portions of the Yellowstone River on January 29, 2015, approximately nine miles below the spill location; and Figure C.2 shows numerous unidentified waterfowl using the Yellowstone River within a mile downstream of the spill location on January 30, 2015. U.S. EPA (2015) reported oil sheens at both of these locations during the response activities. During Phase I, the Trustees contracted a flight to be completed downstream of the spill. The pilot noted on January 30, 2015 that "ducks and geese everywhere in open eddies and backwaters when I flew early Friday morning" but he did not see much during the day (Chris Boyer, personal communication).

Figure C.1. Three bald eagles on the Yellowstone River on January 29, 2015 approximately nine miles below the spill location (47.145695°, -104.693758°).

Photo credit: Kestrel Aerial.

Figure C.2. Numerous unidentified waterfowl using the Yellowstone River on January 30, 20157 within one mile downstream of the spill release location (47.0422°, -104.75823°).

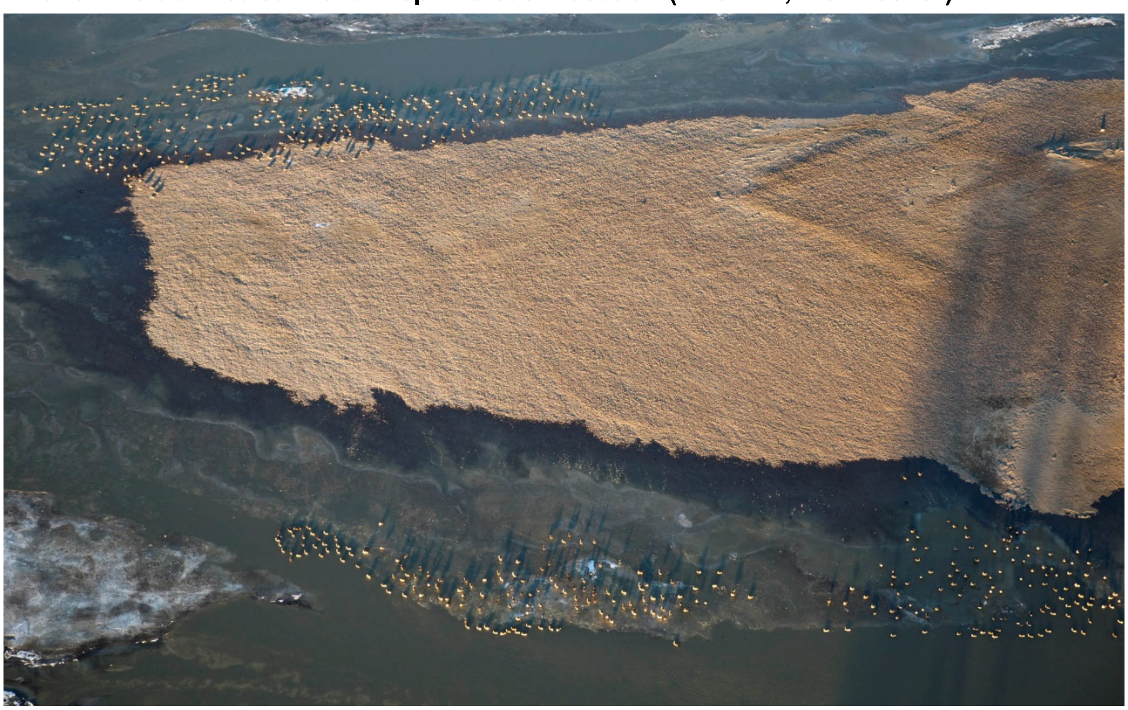

Photo credit: Kestrel Aerial.

During Phases II and III (as ice was breaking up and after the ice broke up), MT-FWP-managed fishing access sites were monitored weekly for observations of bird use, ice conditions, and presence of oiled habitat (CTEH, 2015b). The number of sites visited every week varied and ranged from 3 to 8 locations along the roughly 70 miles of river between the spill location and Sidney, Montana (Brad Schmitz, personal communication). Although spatial coverage was limited, birds were observed using the Yellowstone River corridor during Phase II in areas with a reported sheen and on February 12, 2015, counts of over 30,000 Canada geese and 10,000 ducks were reported (Brad Schmitz, personal communication). During Phase III, additional observations of birds using the Yellowstone River below the spill site include killdeer *(Charadrius vociferous*), common mergansers, and Canada geese (David Rouse, personal communication; Karen Nelson, personal communication).

C.3 Bird Exposure to Oil

Birds can become oiled while floating, wading, and feeding in open-water areas along the river where an oil sheen is present. Many of the birds that winter in the Yellowstone River corridor use open-water areas. Mallards, for example, are excellent swimmers, and spend some time in the water each day between trips to the numerous agricultural fields in the area where they feed (Drilling et al., 2002). Common mergansers were seen on the river where the oil sheen was present. Mergansers are generally found on the water, tend to sleep on open water, and feed by probing sediments and underwater stones for prey; or swim with their head underwater searching for or chasing prey (Pearce et al., 2015). Therefore mergansers likely came into contact with the oil sheen as well. Common goldeneye, another common waterfowl species on the Yellowstone River during the winter, was also at risk of coming into contact with the sheen. Goldeneyes are strong swimmers and divers, and spend most of their time on the water diving frequently (Eadie et al., 1995). More Canada geese were observed than another other species during the spill. During the winter, Canada geese generally fly from roosting sites on the water in the morning and evening to feed in agricultural fields. Primary activities include feeding and alert behaviors at foraging sites, and loafing and sleeping at midday and at night-time roost sites (Mowbray et al., 2002). Killdeer were seen when the ice came off the river along the shoreline within an area containing a sheen from melting, oiled ice chunks. These birds often inhabit and feed along the shoreline and could become oiled while trying to feed.

Avian injury resulting from a spill may result in mortality, changes in reproductive success, and other sub-lethal effects. In this spill, the most likely injury was mortality due to direct oil exposure. The numerous birds documented along the Yellowstone River in the area of the spill were likely using open water for roosting sites. Because of the cold temperatures at the time of the spill (the average high temperature in January and February 2015 was 31.6°F and 36°F, respectively; and the average low was 13°F and 12.3°F, respectively; U.S. Climate Data, 2017), the effects of oiled feathers will be the focus of our injury claim. In birds, the physical structure of feathers is critical for thermoregulation. The microscopic interlocking of barbules and barbicels in feathers creates a waterproof barrier that traps air next to the skin, allowing birds to maintain high body temperatures (103–106°F) as well as buoyancy when in the water (Albers, 1995; Jessup and Leighton, 1996). Once a bird is exposed to oil, the microstructure of feathers can collapse (Hartung, 1967; Clark and Kennedy, 1968; Jenssen and Ekker, 1988), which can allow water to penetrate deeply into this insulative air layer (Stephenson and Andrews, 1997; Newman et al., 2000; O’Hara and Morandin, 2010). Birds exposed to barely visible sheen (0.04-µm thick) and trace color sheen (0.1-µm thick) caused barbules to clump; and in sheens of

0.1-µm thick or greater, measurable oil transfer to feathers was documented (O'Hara and Morandin, 2010). The result of exposure to oil sheen and water penetration is increased heat loss from the skin, and for a bird on the Yellowstone River, a much greater tendency to become hypothermic. The decreased insulation also increases vulnerability to starvation as oiling increases the rate at which stored body fat is exhausted (Hartung, 1967; Fry and Lowenstine, 1985). Because of the cold temperatures present during the spill, most birds would have died before starvation. Finally, the removal of this air layer from oiling can also cause birds to lose the capacity to swim or float (McEwan and Koelink, 1973; Vermeer and Vermeer, 1975), leading to an inability to forage or to escape predators.

While there were no reported observations of dead or oiled birds during preassessment activities, this does not necessarily indicate a lack of exposure. Structured wildlife surveys were not conducted during this incident and when searches are actually conducted, locating dead or injured wildlife is difficult. Many of the reasons bird carcasses are unaccounted for in coastal spills are also applicable to riverine freshwater spills. Oiled birds may be become ill and/or disturbed by response actions, leading them to hide or move away from the area. Exposed birds may succumb; be unable to fly; or may be trapped in the water, sink, and be washed out of the area where searches occur. Searchers' abilities to systematically search for and observe dead birds, particularly songbirds and other small birds, in the dense vegetation that occurs in riverine habitats may be limited. Also, scavenging by natural predators as well as domestic animals may reduce the number of carcasses available to be found by search teams. Oil on birds is also difficult to see, and can easily be missed, especially when the oiling is minimal. During the DWH spill, birds were captured to evaluate the effects of oil to birds. Captured birds were classified as to their degree of oiling, and there were frequent instances of a bird being visually noted as not oiled but subsequently identified as trace oiled when UV fluorescence was used (P. Tuttle, the FWS, personal communication). This observation on captured birds indicates the difficulty in observing small quantities of oil on birds. On the Yellowstone River, any open-water areas where birds were located were surrounded by unstable ice, creating unsafe conditions for anyone trying to get close enough to observe birds, so any oiling on birds using these areas would be difficult to document. Yet, studies have shown that a small amount of external oiling on birds can cause adverse effects (O'Hara and Morandin, 2010; Dean and Bursian, 2017; Maggini et al., 2017a, 2017b; Perez et al., 2017a, 2017b, 2017c).

The technical literature evaluated by the Trustees supports that some portion of birds present in the area when the oil sheen was present were likely exposed to oil from the Bridger pipeline break. Estimating the actual number of birds killed or injured has been a concern in other cases besides Bridger, including pesticide application projects; wind turbine operations; Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) natural resource injury estimates; and oil spill injury estimates. In all these events, it is generally recognized that the actual number of birds injured exceeds the number of bird carcasses collected for several reasons, including, but not limited to, movement by oiled birds away from the area; transport of dead birds by winds and current; sinking of dead birds; frequency of searches; searchers' ability to locate birds (searcher efficiency); and the length of time a bird carcass is available to be observed by searchers (carcass persistence). Estimates of the actual number of birds injured during a spill event have been developed for numerous spills, including, but not limited to, the Athos spill (Bird and Wildlife Technical Working Group, 2007) and the Chalk Point spill (NOAA et al., 2002).

Many of the reasons bird carcasses are unaccounted for in coastal spills are also applicable to riverine freshwater spills. Oiled birds may be become ill and/or disturbed by response actions, leading them to hide or move away from the area. Exposed birds may succumb; be unable to fly; or may be trapped in the water, sink, and be washed out of the area where searches occur. In this spill, no organized searches were performed, but even when they are conducted, searchers' abilities to systematically search and observe dead birds, particularly songbirds and other small birds, in the dense vegetation that occurs in riverine habitats may be limited. Also, scavenging by natural predators as well as domestic animals may reduce the number of carcasses available to be found by search teams.

To estimate the total number of birds affected by an oil spill, it is customary to use wildlife searches for dead and dying birds close to the date of discovery of the spill, and with significant searcher effort. For example, during the recent DWH oil spill, teams walked sandy beaches to specifically look for dead birds. The ability of searchers to find dead birds (searcher efficiency) ranged from 79 to 93% (IEc, 2015b). Weekly monitoring may be too infrequent due to the disappearance of dead birds by scavenging (carcass persistence). Carcass persistence after seven days from the DWH oil spill ranged from 29 to 53% for carcasses on beaches and only 4 to 26% for carcasses in marsh habitat (IEc, 2015b). River riparian habitat is likely more similar to marsh habitat, and hence it is unlikely that a carcass remained along the river for seven days to be found during weekly searches. Moreover, carcass persistence rates can vary between seasons and winter carcass persistence rates have been reported to be lower than those rates of other seasons like the spring and summer (Smallwood, 2007; Flint et al., 2010).

Because of safety concerns during Phase I, no organized search efforts for dead and dying birds occurred. Also during Phases II and III, only weekly observations for birds at specific locations occurred. Therefore, the search effort for dead and dying birds was inadequate for quantifying bird injury using models that utilize collected birds and, as such, the Trustees must use other approaches. The objective of activities described in the injury quantification part of this work plan include collecting spill data (extent and degree of oiling) and winter bird population data suitable for estimating bird mortality. A similar approach has been previously used in other coastal spills [e.g., T/V Puerto Rican (PRBO, 1985) and DWH (IEc, 2015a)]. Once injuries have been quantified, the activities described in the restoration planning part of this work plan include identification of suitable restoration approaches. Restoration approaches will be identified for key avian species, and scaling restoration approaches will be determined to adequately restore for the birds killed by the Bridger pipeline oil spill.

C.4 Injury Quantification

C.4.1 Extent and Degree of Oiling

Maps, databases, and all other locational or geographic data sources associated with the Bridger Pipeline oil spill will be used to document the extent of oiling downstream from the pipeline break within the Yellowstone River. As was the case for response actions, this effort will have two parts:

- The first part will utilize data associated with Phase I and Phase II response efforts.
- The second part will utilize data associated with Phase III response efforts.

The information from both of these efforts will be used to estimate (1) the areas of the river where birds would have been exposed to oil when ice covered the river (Bird Exposure Area 1 – BEA1), and (2) the areas where birds would have been exposed to oil during and immediately after ice breakup (Bird Exposure Area 2 – BEA2). The ice began to break up around March 14 and river operations were postponed until March 20, 2015. These two time periods have different extents of oiling. During BEA1, bird oil exposure was primarily confined to open pools of water. During BEA2, bird oil exposure was primarily associated with oil leaching from large chunks of ice or other accumulations.

BEA1 is the geographic extent of the oil downstream from the pipeline break during the time period when ice covered the river (i.e., BEA1 has both geographic and seasonal components). Using all available locational or geographic data (including, but not limited to, maps, overflights, drone flights, and oil sampling databases), a comprehensive description of river conditions including the open-water areas (number and size) as well as the observed or sampled oil conditions of those open waters will be developed. This description will include the farthest distance downstream where oil was observed from the pipeline break. Within BEA1, the number of open-water areas will be enumerated as well as the size of each of the open-water areas. Additionally, using data when available, or a reasonable worst-case approach, the extent of oiling (percent area covered) for each open-water area will be estimated for BEA1. This will result in a site map identifying open-water areas and observed and/or measured oiled open areas.

BEA2 is the geographic extent of the oil downstream during the time period when ice was breaking up and after the ice broke up (i.e., BEA2 has both geographic and seasonal components). Using all available locational or geographic data (including, but not limited to, maps, overflights, drone flights, and oil sampling databases), a comprehensive description of river conditions during and immediately after the ice breakup (about March 14), as well as the observed or sampled oil conditions for the river, will be developed (hereafter referred to as BEA2). This description will include the farthest distance downstream where oil was observed from the pipeline break and the extent of oiling (percent area covered) for the river within BEA2. In addition to the description, a site map identifying BEA2 and known (observed and/or measured) oiled areas will be produced.

C.4.2 Effects of Oil on Birds

The adverse effects of oil to birds will be described. This effort is anticipated to be a general overview of the oil effects to birds using existing scientific, agency, Trustee, and other source reports and information. The overview will consider the physical effects of oil on feathers and the likely effect to birds from oil on feathers in cold weather (BEA1) and in slightly warmer weather (BEA2). The physiological effects of oil on birds will also be described.

Using this information, the estimated mortality of birds will be determined for each of the following four categories of oiling: trace (less than 5% of the body surface), light (5 to 20%), moderate (21 to 40%), and heavy (greater than 40%). These oiling categories have been used in other oiled bird assessments [e.g., Athos 1 (Nixon et al., 2008) and DWH (Haney, 2011)]. In the absence of data, we will distribute the number of oiled birds evenly across the four oiling levels. For example, if 100 birds were estimated to be oiled, 25 would be considered trace oiled, 25 would be lightly oiled, 25 would be moderately oiled, and 25 would be heavily oiled. Since the number of oiled birds will vary by species, we will distribute the oiling categories as a percentage. Therefore, each oiling category will be 25% of the total estimated number of oiled birds. The mortality estimates for each oiling category will be determined for birds exposed during BEA1 river conditions and BEA2 river conditions, and will evaluate potential differences in air and water temperature at those times.

C.4.3 Bird Density Estimates

Bird density estimates will be developed in cooperation with the FWS and MT-FWP using literature and seasonally appropriate site-specific data and surveys (conducted during and prior to the spill, including historical data and surveys). This effort will include a description of the species and populations of migratory and other birds that use and live within the Yellowstone River during BEA1 and BEA2. This effort will also include a review of Bridger spill overflights and drone flights conducted during response efforts in Phases I, II, and III of the spill. The goal of this effort is to estimate the species and number of birds likely exposed to oil within BEA1 and BEA2. From this effort, the list of impacted species will be determined and the density of each species will be estimated for BEA1 and BEA2. As data are reviewed, bird species of special concern including, but not limited to, federally and state-listed threatened and endangered species and species of conservation concern will be recognized in the analysis.

It would be preferable to determine the number of each bird species using an area of oiled water. However, with the available data, it is more likely that a total number of birds using an area will be determined, and that the relative proportion of each species exposed to oil will need to be estimated based on surveys and best professional judgment. This assumption will be used in estimating bird mortalities described in Section C.4.4.

C.4.4 Bird Mortality Estimates

Using the four oiling categories described previously (trace, light, moderate, and heavy), the Trustees will assume an equal proportion of birds were oiled for each category (i.e., 25% of birds were oiled in each trace, light, moderate, and heavy oiling category) for the reasons described previously. A table illustrating the expected fate of birds in each oiling category will then be developed, including the mortality estimates for each species and the oiling category combination within BEA1 and BEA2.

An example of a complete calculation for trace-oiled hypothetical "species Y" within BEA1 follows:

Estimating number of "species Y" birds oiled:

Average density of birds in open area (birds/km^2)	X	Area of oiling within open area (km^2)	=	Number of birds oiled
Number of birds oiled	X	"Species Y" proportion of total birds	=	Number of "species Y" birds oiled

Number of trace oiled "species Y" birds that died:

Number of "species Y" birds oiled	X	Proportion of birds oiled (25% for trace oiling category)	X	Fate (% expected mortality for trace oiling category)	=	Estimated number of "species Y" birds killed in trace oiling category

For "species Y" within BEA1, this same calculation is then conducted for each additional oiling category (light, moderate, and heavy) and the number of "species Y" birds killed within BEA1 is equal to the sum of birds killed within each oiling category. The same approach is then used for BEA2. The "species Y" results for BEA1 and BEA2 are then summed to obtain a total mortality for "species Y." This same estimation is conducted for each species exposed to oil during the spill. In addition, due to the transitory nature of birds, birds will move from area to area, and new birds may have arrived in the area, thereby increasing the opportunity for additional birds to be killed. An evaluation will be conducted to determine the approaches for estimating the number of additional birds that were killed due to the presence of the oil over time.

C.4.5 Lost Productivity

Birds killed during the spill were mature birds and most species were likely of reproducing age. Therefore, the loss of these birds would reduce the number of young birds produced during the next breeding season. As part of our bird injury quantification, we will also estimate the lost productivity for the birds killed. Lost productivity will be determined using life history parameters for each species. The lost productivity for each species will be added to the number of birds killed for that species to quantify the total bird injury.

A report will be provided, which (1) will describe the primary data used in bird injury quantification, (2) describe the equations used for estimating bird injury, and (3) summarize the injury quantification. The summary will include a table that identifies the species and number of birds for each species killed by the spill.

C.5 Restoration Planning

Upon completion of the injury quantification, key avian species for which injuries have been quantified and require restoration will be identified by the Trustees. Upon identification of those species, appropriate restoration approaches will be determined. Restoration approaches will include actions that benefit the injured species and likely will include several different types of restoration actions, including, but not limited to, increasing/enhancing nesting habitat, reducing predators at existing nesting areas, providing or enhancing overwinter or migratory stopover areas, or improving foraging habitat. After identifying appropriate restoration approaches, the restoration will be scaled to address both the species and number of birds that were injured for each species. For some species, it may be best to identify a mix of restoration approaches (e.g., increasing nesting habitat *and* providing predator control). In addition to determining various restoration approaches, the cost for restoration actions will be estimated, and potential general geographic areas for where the restoration may be implemented will be identified. These estimates will include costs for drafting a restoration plan, revising the plan after public review and comment, implementing the restoration actions, and monitoring the restoration and providing any corrective actions needed in light of adaptive management principles.

A report will be provided that will include a description of the suite of identified restoration approaches, the appropriate scale of restoration to compensate for the injured birds, the potential location for implementing the restoration actions, and the estimated costs for restoration. The report will also include descriptions of the sources that identified the restoration approaches, the sources for the scaling approaches that restore the quantified injured birds, and sources for the cost estimates of the various restoration actions.

C.6 Data Management

C.6.1 Injury Quantification

This effort does not include any primary data collection. Existing data will be utilized, including, but not limited to, copies of field datasheets, electronic databases, photographs, overflights, drone flights, shoreline surveys, meeting notes, response plans, and any other data or information collected during the spill. Historical bird population information either gathered by natural resource management agencies (e.g., the FWS, MT-FWP) or available in scientific reports or literature will also be relied upon. Further, scientific reports and literature will be used for determine the effect of oil to birds. Life history parameters will be obtained from the literature and from appropriate experts. Additionally, all data calculations (e.g., Excel files) will be provided.

C.6.2 Restoration Planning

Federal and state agencies as well as nongovernmental organizations (e.g., Ducks Unlimited) will be consulted to identify existing successful restoration approaches and restoration plans. Additionally, all restoration scaling (e.g., Excel files) will be provided.

C.7 Schedule

C.7.1 Injury Quantification

It will likely take an estimated 45 days to gather all data, maps, field notes, overflights, shoreline surveys, and other existing site-specific data. These activities will be conducted cooperatively with the Trustees and the contractor, and may require significant Trustee participation. The contractor will then have 60 days to compile the data, conduct the analysis, and generate a first draft report. The Trustees will have 30 days to review the draft report and provide comments to the contractor. The contractor will then have 15 days to address the comments and produce a final draft report.

C.7.2 Restoration Planning

After injury quantification occurs, it will likely take an estimated 45 days to contact agencies and nongovernmental organizations, gather all restoration approaches, scale the restoration approaches, and compile costs. These activities will be conducted cooperatively with the Trustees and the contractor, and may require significant Trustee participation. The contractor will then have 60 days to compile the information, scale the restoration approaches, and generate a first draft report. The Trustees will have 30 days to review the draft report and provide comments to the contractor. The contractor will then have 15 days to address the comments and produce a final draft report.

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