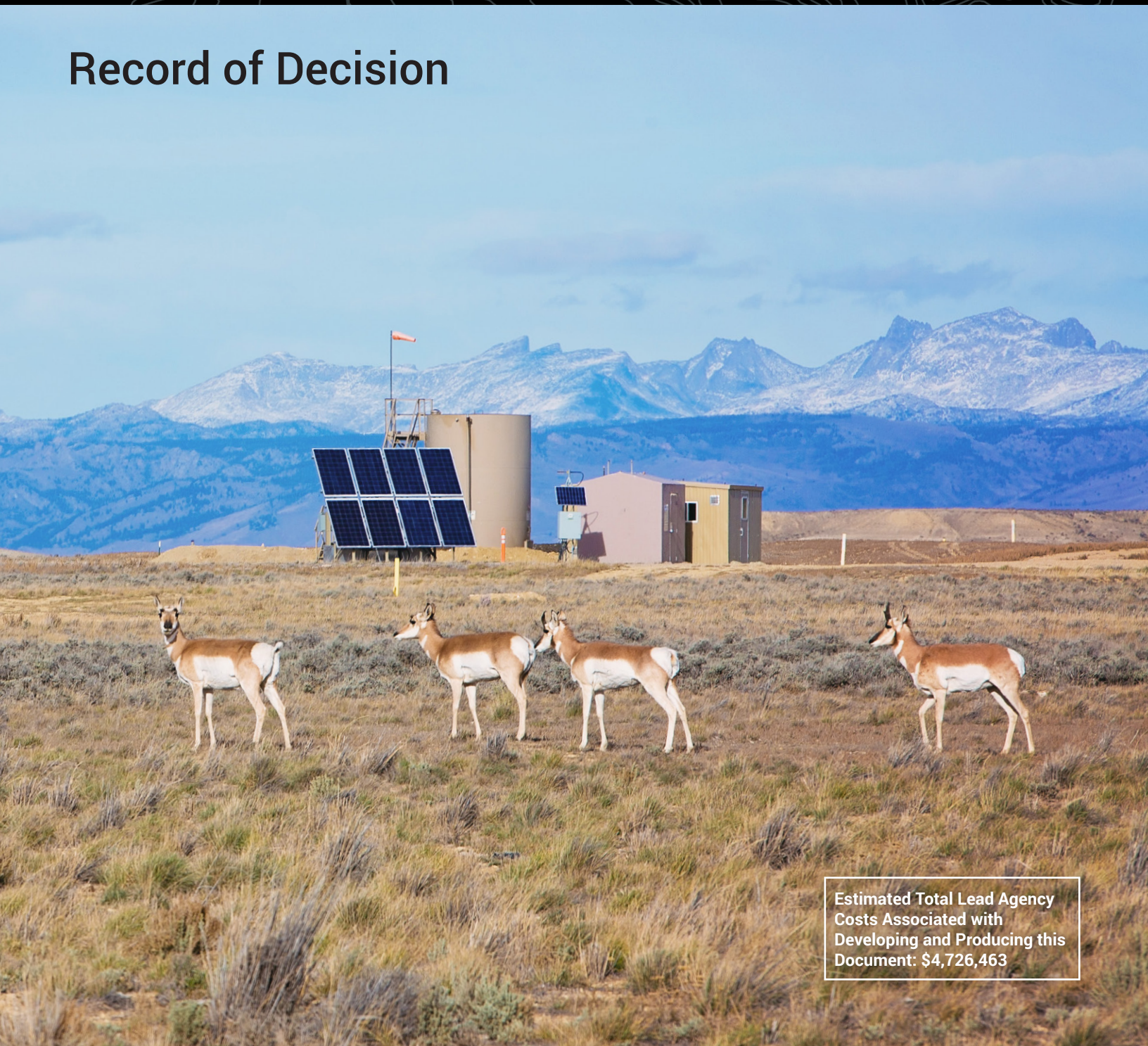
U.S. Department of the Interior
Bureau of Land Management

Normally Pressured Lance Natural Gas Development Project

Wyoming - Pinedale Field Office
August 2018

Record of Decision



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The Bureau of Land Management is responsible for the stewardship of our public lands. The BLM's mission is to sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations.

BLM/WY/PL-18/011+1310

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ACRONYMS & ABBREVIATIONS
Used in the ROD and Appendices

AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
AGWA	Automated Geospatial Watershed Assessment
AO	Authorized Officer
APD	Application for Permit to Drill
APLIC	Avian Power Line Interaction Committee
API	American Petroleum Institute
AQD	Air Quality Division
ARMPA	Approved Resource Management Plan Amendment
ASME	American Society of Mechanical Engineers
ATV	All-Terrain Vehicle
BACT	Best Available Control Technology
bbl	Barrel
BLM	Bureau of Land Management
BMP	Best Management Practice
CAA	Clean Air Act
CDP	Central Delivery Point
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CNG	Compressed Natural Gas
CO	Carbon Monoxide
COA	Condition of Approval
CSC	Central Service Center
DA	Development Area
dBA	Decibels
DDCT	Density Disturbance Calculation Tool
DOI	United States Department of the Interior
EIS	Environmental Impact Statement
EMS	Emergency Management Service
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESD	Ecological Site Description
FEIS	Final Environmental Impact Statement
FLPMA	Federal Land Policy and Management Act
FR	Federal Register
GHMA	General Habitat Management Area (Sage-Grouse)
GIS	Geographic Information System
GPS	Global Positioning System
HMA	Herd Management Area
HUC	Hydrologic Unit Code
I-80	Interstate 80
IBLA	Interior Board of Land Appeals
ID	Inter Disciplinary

IG	Implementation Group
IM	Instruction Memorandum
JIDPA	Jonah Infill Development Project Area
KINEROS2	Kinematic Runoff and Erosion Model
LOP	Life of Project
LRP	Limited Reclamation Potential
MOU	Memorandum of Understanding
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NHS	National Highway System
NHT	National Historic Trail
NOA	Notice of Availability
NOI	Notice of Intent
NO2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
NPDES	National Pollution Discharge Elimination System
NPL	Normally Pressurized Lance
NRCS	Natural Resource Conservation Service
NSR	New Source Review
NTL	Notice to Lessees/Operators
O3	Ozone
OCP	Operator Committed Practices
OHV	Off-highway Vehicle
OSHA	Occupational Safety and Health Administration
PAPA	Pinedale Anticline Project Area
PFC	Proper Functioning Conditions
PFO	Pinedale Field Office
PHMA	Priority Habitat Management Area
PM10	Particulate matter less than 10 microns in diameter
PM2.5	Particulate matter less than 2.5 microns in diameter
POD	Plan of Development
PUP	Pesticide Use Proposal
PUR	Pesticide Use Report
RCRA	Resource Conservation and Recovery Act of 1976
RGF	Regional Gathering Facility
RMP	Resource Management Plan
ROD	Record of Decision
ROW	Right-of-Way
RSFO	Rock Springs Field Office
SAR	Sodium Absorption Ratio
SARA	Superfund Amendments and Reauthorization Act
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Data Sheet
SEIS	Supplemental Environmental Impact Statement
SEO	State Engineer's Office
SHPO	State Historic Preservation Officer

SIP	State Implementation Plan
SO2	Sulfur Dioxide
SPCC	Spill Prevention Control Countermeasures
SPCCP	Spill Prevention, Control, and Countermeasure Plan
SSPS	Special Status Plant Species
STIP	State Transportation Improvement Plan
SUP	Surface Use Plan
SWPPP	Storm Water Pollution Prevention Plan
T&E	Threatened and Endangered
TPA	Transportation Planning Area
UGRB	Upper Green River Basin
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VOC	Volatile organic compound
WAQSR	Wyoming Air Quality Standards and Regulations
WDEQ	Wyoming Department of Environmental Quality
WFF	Workforce Facility
WGFD	Wyoming Game and Fish Department
WOGCC	Wyoming Oil and Gas Conservation Commission
WYDOT	Wyoming Department of Transportation
WYPDES	Wyoming Pollution Discharge Elimination System

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1.0 APPROVAL

I hereby approve the decision described in Section 3.0 (*The Decision).*

This decision may be appealed to the Interior Board of Land Appeals (IBLA), Office of Hearings and Appeals, U.S. Department of the Interior, in accordance with the regulations contained in 43 CFR 3165.4. The appeal must also be filed with the State Director, BLM, Wyoming State Office, P.O Box 1828, Cheyenne, WY 82003 or 5353 Yellowstone Road, Cheyenne, WY 82009.

If you wish to file a petition pursuant to 43 CFR 3165.4(c) for a stay (suspension) of the effectiveness of this decision during the time that your appeal is being reviewed by the Board, the petition for stay must accompany your notice of appeal. A petition for stay is required to show sufficient justification based on the standards listed in 43 CFR 3165.4(c), which include:

- The relative harm to the parties if the stay is granted or denied;
- The likelihood of the appellant's success on the merits;
- The likelihood of irreparable harm to the appellant or resource if the stay is not granted; and
- Whether the public interest favors granting the stay.

If a petition for stay is submitted with the notice of appeal, a copy of the notice of appeal and petition for stay must be served on each party named in the decision from which the appeal is taken, and with the IBLA at the same time it is filed with the State Director. A copy of the notice of appeal, statement of reasons and all pertinent documents, must be served on each adverse party named in the decision from which the appeal is taken and on the Office of the Regional Solicitor, U.S. Department of the Interior, 755 Parfet Street, Suite 151, Lakewood, CO 80215, no later than 15 days after filing the document with the State Director and/or the IBLA.

If you request a stay, you have the burden of proof to demonstrate that a stay should be granted.

This decision is effective upon the date it is signed by the Authorized Officer (AO).

Approved By:

Mary J. Rugwell, Wyoming State Director

Approval Date:

8/27/18

2.0 INTRODUCTION

Jonah Energy LLC (Jonah Energy) proposed to the U.S. Department of the Interior Bureau of Land Management (BLM) Pinedale Field Office (PFO) and Rock Springs Field Office (RSFO) to conduct full-field development of natural gas and condensate resources in Sublette County, Wyoming. The proposal is designated as the Normally Pressured Lance Natural Gas Development Project (NPL Project).

The NPL Project Area consists of approximately 140,859 acres located 35 miles south of Pinedale and immediately south and west of the existing Jonah Infill Development Project and south of the Pinedale Anticline Project. The Project Area is located on lands and minerals administered by the BLM (135,655 surface acres or 96.3 percent of the Project Area) and the State of Wyoming (5,123 surface acres or 3.6 percent of the Project Area), as well as private lands (81 acres or 0.06 percent of the Project Area) in Sublette County. The Project Area lies within the BLM Wyoming High Desert District and spans the PFO in the north and the RSFO to the south (Map 1).

Jonah Energy proposed drilling up to 3,500 directionally drilled wells during a 10-year development period. The rate of well development will be up to 350 new wells per year along with associated well pads, access roads, pipelines, regional gathering facilities (RGF), and other ancillary facilities. The life of the project is assumed to be 40 years. The precise locations of the proposed wells have not been identified, but will be proposed during site-specific permitting and subject to environmental review. The development of oil and gas resources within the Project Area, which currently contains approximately 55 producing natural gas wells, has proceeded at a slower pace than in surrounding fields. The Project Area, although substantially under valid existing fluid mineral leases, remains a largely rural and undeveloped expanse with occasional range improvements, roads, and oil and gas development facilities distributed across the landscape.

3.0 THE DECISION

The BLM has determined that the analysis contained within the NPL Final Environmental Impact Statement (FEIS) is adequate for the purposes of reaching an informed decision regarding the NPL Project. This Record of Decision (ROD) applies only to the BLM-administered public lands, including federal mineral estate, within the Project Area.

The BLM hereby selects and approves the FEIS Preferred Alternative, which was developed in response to comments received during scoping and on the Draft EIS, and was designed to allow for development under valid existing lease rights while conserving a broad range of resource values. The density of development and development limitations for the Preferred Alternative were based on a broad range of environmental concerns, including wildlife habitat, visual resources, paleontological resources, surface water features, identified lands with wilderness characteristics, and other resources.

The Preferred Alternative is approved in this ROD. Specific aspects of this approval (the decision) are outlined in subsequent portions of this ROD.

Under the decision, Jonah Energy LLC is approved to submit site-specific applications for natural gas drilling and related development on federal lands within the Project Area (Map 1) as described in the NPL Project FEIS under the BLM's Preferred Alternative, and in Section 3 (*The Decision)* of this ROD. Further, future exploration and development activities, applications for permits to drill (APDs) and Rights of Way (ROW) are subject to the required design features, Conditions of Approval (COAs), terms and conditions, and mitigation measures presented in Appendix A (*Resource Protection Measures),* which may be applied as COAs during site-specific permitting and authorization processes.

Prior to any project-related operations occurring on public lands other than casual use, required applications must be submitted to and considered by the BLM as part of the requirements set forth for APDs and ROW. No surface disturbance will be initiated on BLM-administered public land until the APD or other application for project related development is approved by the BLM, following site-specific environmental review and NEPA compliance during each appropriate process.

Under the decision, Jonah Energy can submit APDs and related ROW for as many as 3,500 natural gas wells, associated infrastructure and ancillary facilities, resulting in up to 350 wells site-specifically approved per year during the approximate 10-year development period. BLM hereby approves up to 5,874 acres of short-term disturbance and up to 1,741 acres of long-term disturbance during the anticipated 40-year life of the project as the result of site-specific proposals.

Development under the decision is subject to and will be implemented in accordance with laws, policies, and approved land use plans, including the Approved Pinedale RMP/ROD (2008), Approved Green River RMP/ROD (1997), and Approved Resource Management Plan Amendments (ARMPA) for the Rocky Mountain Region (BLM 2015a).

3.1 Description of Development

The Project Area is divided into three Development Areas (DAs) (Map 2). DA 1 will have an average of 1 disturbance location per 640 acres based on total acreage in DA 1 in consideration of

numerous resource values. DA 3 will have a density of development averaging no more than one disturbance location per 640 acres and not to exceed 32 acres (5 percent) surface disturbance per 640 acres, inclusive of existing disturbances, calculated using the Density Disturbance Calculation Tool (DDCT) process. DA 2, which has a higher degree of existing development, will have a higher density of development (an average of up to 4 disturbance locations per 640 acres). BLM authorizes development to occur in all DAs simultaneously (i.e., development in the DAs is not required to be sequential or phased over time).

3.1.1 Development Area 1

DA 1 covers approximately 38,384 acres (27 percent of the Project Area) and is located along the western and northern borders of the Project Area (Map 2). The boundaries of DA 1 and the density of development consider a range of resources in the area including VRM Class III areas, lands with wilderness characteristics, Alkali Creek and Alkali Draw surface water features and watersheds, portions of the Wasatch Formation with high potential for paleontological resources, Sage-Grouse Winter Concentration Areas (WCA), raptor nests and protective buffers, and big game habitats.

Within DA 1, BLM authorizes development at a density averaging one disturbance location per 640 acres.

The Decision is designed to incentivize development in less environmentally sensitive areas. Development in DA 1 will result in clusters of development in less sensitive areas of DA 1. This pattern of development will conserve larger areas of uninterrupted open space in DA 1 to benefit the range of resources present. The clustering of development will allow for development of valid existing leases to their fullest extent while still protecting WCAs and conforming to the restrictions imposed in DA 1.

Should DA 1 restrictions preclude full development of fluid mineral resources within DA 1, BLM will review the existing plan and complete appropriate analysis to consider further development in DA 1. Consistent with the intent of DA 1 restrictions, BLM will consider site-specific proposals in DA 1 that exceed the DA 1 restriction levels. Site-specific analysis will recognize the variety of resource concerns found within DA 1.

3.1.2 Development Area 2

DA 2 covers approximately 54,441 acres (39 percent of the Project Area) in the central portion of the Project Area, mostly adjacent to the Jonah Infill Development Project Area (JIDPA)(Map 2). Based on the identified resources in DA 2, and existing development and infrastructure already in place, this area will have a higher density of development compared to the other DAs.

Within DA 2, BLM authorizes development at a density averaging up to 4 disturbance locations per 640 acres.

3.1.3 Development Area 3

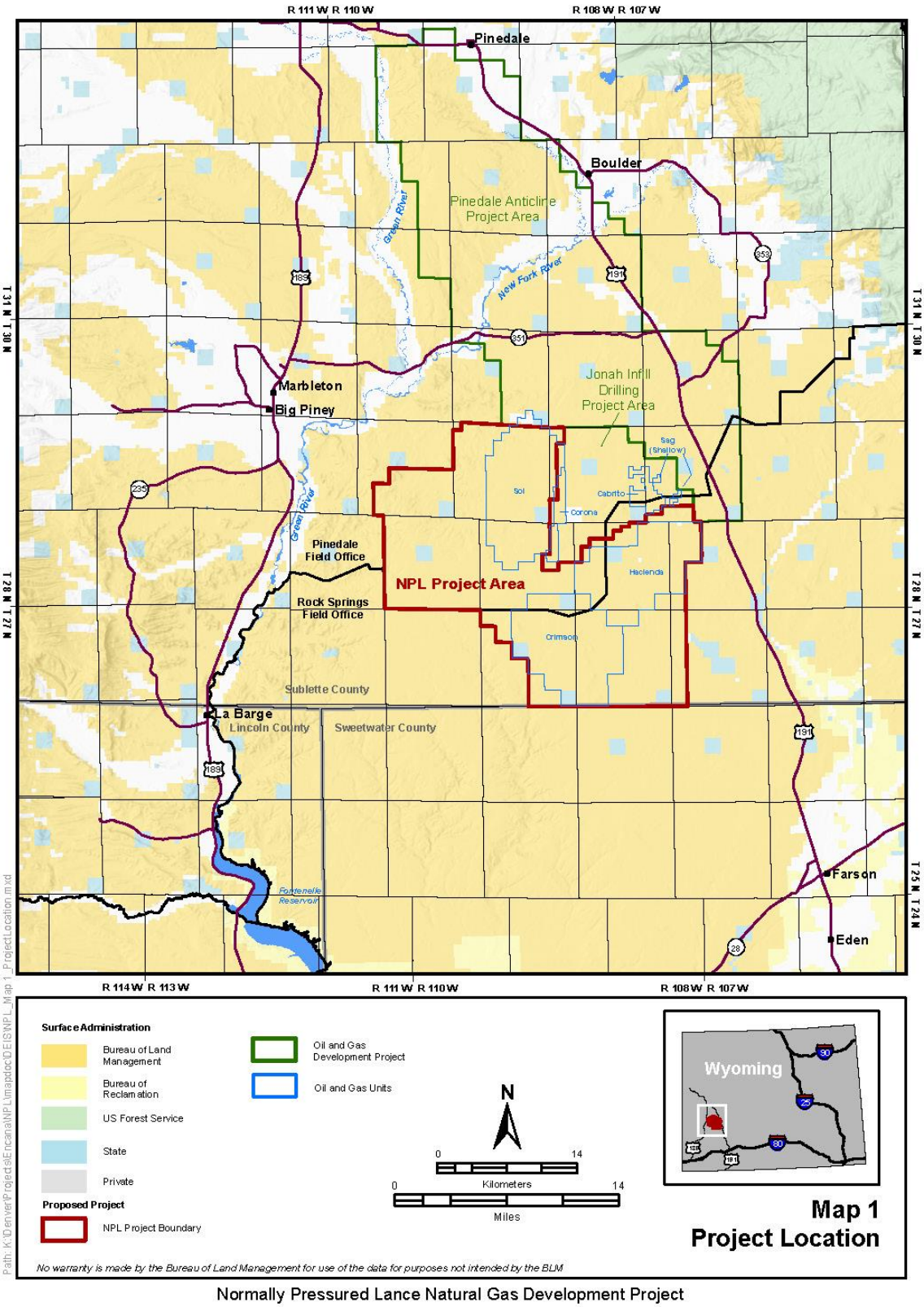
DA 3 covers approximately 48,034 acres (34 percent of the Project Area) in the southeastern portion of the Project Area and is defined by Sage-Grouse Priority Habitat Management Area (PHMA) (Map 2). DA 3 also contains the North Sublette Meadow Spring Variant of the Sublette

Cutoff and the associated three-mile viewshed, as well as raptor nests and protective buffers, prairie dog habitat, and mountain plover habitat.

Development in DA 3 will be consistent with State of Wyoming EO 2015-4 (State of Wyoming 2015) and the BLM Wyoming Sage-Grouse RMP Amendments (BLM 2015a).

Within DA3, BLM authorizes a density of development averaging no more than one disturbance location per 640 acres and not to exceed 32 acres (5 percent) surface disturbance per 640 acres, inclusive of existing disturbances, calculated using the Density Disturbance Calculation Tool (DDCT) process.

Map 1. NPL Project Area Location and Surface Ownership



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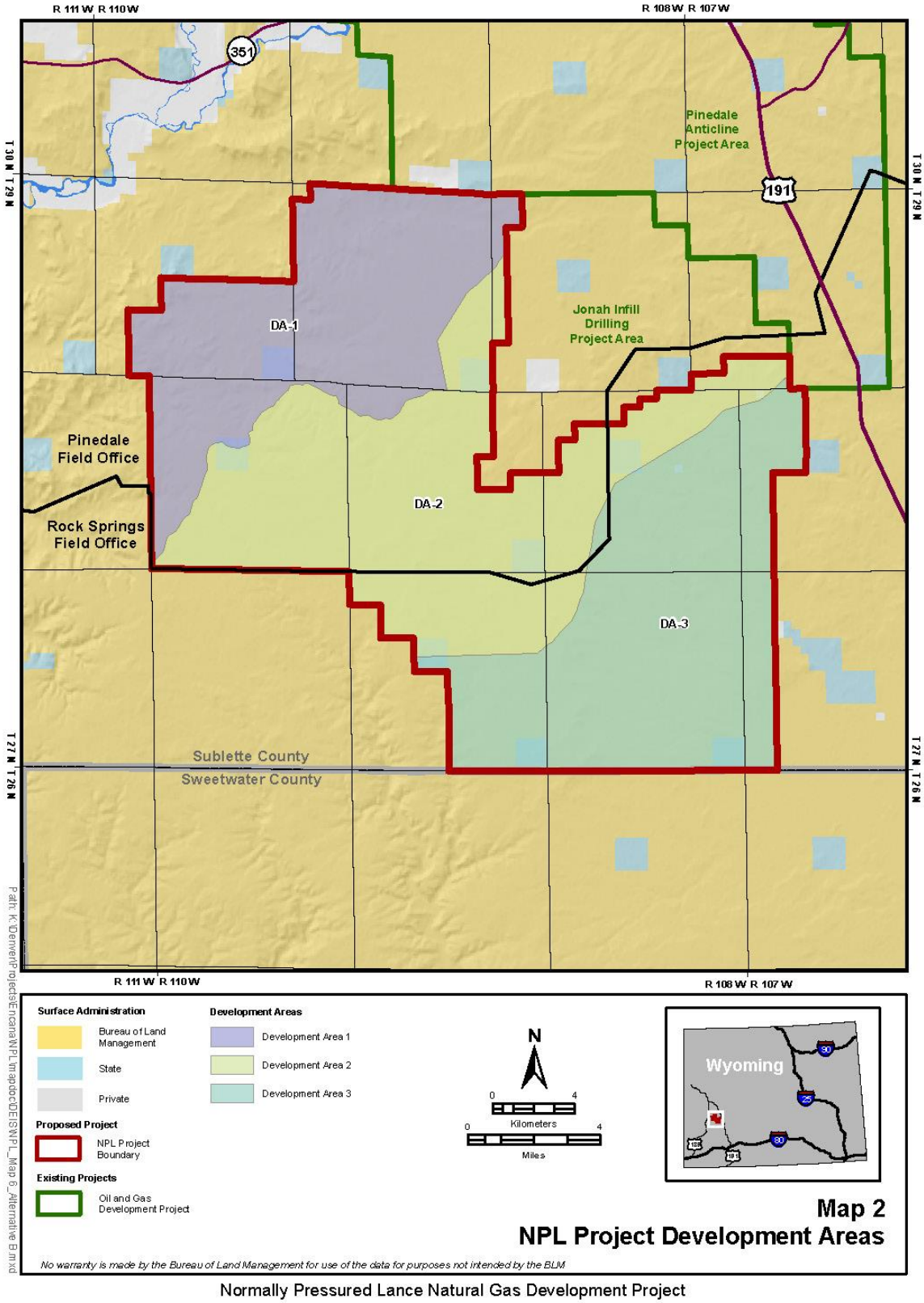
Map 2. NPL Project Selected Alternative Development Areas



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3.2 Development in Sage-Grouse Habitat

3.2.1 Development in Accordance with BLM Wyoming Sage-Grouse RMP Amendments

The terms of leases in the existing Crimson, Hacienda, and Sol oil and gas units in the Project Area (Map 1) pre-date the BLM Wyoming Sage-Grouse RMP Amendments; however, Jonah Energy has committed to applying Sage-Grouse protection measures and management in the Crimson, Hacienda, and Sol oil and gas units.

The following protection measures from the BLM Wyoming Sage-Grouse RMP Amendments (BLM 2015a) will be applied, unless more current guidance is adopted by the BLM, subject to valid existing lease rights. Refer to the BLM Wyoming Sage-Grouse RMP Amendments for additional information and descriptions of applicable management decisions, stipulations, and required design features (BLM 2015a). Protection measures that will be applied include, but are not limited to, the measures listed in this section.

Density and Disturbance

- In PHMA (Map 3), the density of disturbance of an energy or mining facility will be limited to an average of one site per square mile (640 acres). The one location and cumulative value of existing disturbances will not exceed 5 percent of suitable habitat in the DDCT area. Inside PHMA, suitable habitat disturbance will not exceed 5 percent within the DDCT area as determined by the DDCT process.

Timing and Distance Restrictions

- **Sage-Grouse Leks Inside PHMA:** Surface occupancy and surface-disturbing activities will be prohibited on or within a 0.6 mile radius of the perimeter of occupied Sage-Grouse lek.
- **Sage-Grouse Leks Outside PHMA:** Surface occupancy and surface-disturbing activities will be prohibited on or within a 0.25 mile radius of the perimeter of occupied Sage-Grouse lek.
- **Sage-grouse breeding, nesting, and early brood-rearing habitat inside PHMA:** Surface disturbing and/or disruptive activities will be prohibited from March 15 – June 30 to protect Sage-Grouse breeding, nesting, and early brood rearing habitat. This timing limitation will be applied throughout the PHMA. Activities in unsuitable habitats will be evaluated under the exception and modification criteria on a case by case basis.
- **Sage-Grouse Breeding, Nesting, and Early Brood-rearing Habitat Outside PHMA:** Surface disturbing and/or disruptive activities will be prohibited from March 15 – June 30 to protect Sage-Grouse nesting and early brood rearing habitats within 2 miles of the lek or lek perimeter of any occupied lek located outside PHMA.
- **Sage-Grouse Winter Concentration Areas:** Surface disturbing and/or disruptive activities in sage-grouse winter concentration areas will be prohibited from December 1 – March 14.

Noise

- New project noise levels, either individual or cumulative, will not exceed 10 dBA (as measured by L50) above baseline noise at the perimeter of the lek from 6:00 pm to 8:00 am during the breading season (March 1 – May 15). Specific noise protocols for measurement and implementation will be developed as additional research and information emerges. This restriction will apply to both development and production activities.

Co-location of Infrastructure

- New ROWs (e.g., powerlines, pipelines, access roads) will be co-located within or adjacent to existing ROWs where technically feasible.

Powerlines

- New electric distribution lines will be buried where technically and economically feasible. If not economically feasible, distribution lines may be authorized when effectively designed/mitigated to protect Sage-Grouse and the AO determines that overhead installation is the action alternative with the fewest adverse impacts while still meeting the project need.
- Power lines (distribution and transmission) will be designed to minimize wildlife related impacts and constructed to the latest Avian Power Line Interaction Committee (APLIC) standards.

Pipelines

- In PHMA, new pipelines constructed in RMP designated corridors or adjacent to existing utilities or roads will require completion of a DDCT analysis for baseline data collection, but the project is not required to meet the threshold of 5 percent. However, within 6 months of the completion of construction, the project proponent will provide the AO with as-built drawings so that total disturbance within core area can be calculated annually.

Access Roads

- New local or collector roads (as defined in BLM Manual 9113 [BLM 2015b]) will be avoided within 1.9 miles of the perimeter of occupied Sage-Grouse leks within PHMA. New roads will be prohibited within 0.6 miles of the perimeter of occupied Sage-Grouse leks within PHMA.
- Within PHMA, no upgrading of existing routes that will change route category or capacity will be allowed unless the upgrading will have minimal impact on Sage-Grouse in PHMA, is necessary for motorist safety, or eliminates the need to construct a new road.
- In PHMA, existing roads or realignments will be used to access valid existing rights that are not yet developed. If valid existing rights cannot be accessed via existing roads, any new road will be constructed to the absolute minimum standard necessary, and the surface disturbance will be added to the total disturbance in the PHMA.

Onsite and Offsite Mitigation

- In undertaking BLM management actions, and, consistent with valid existing rights and applicable law, in authorizing third-party actions that result in habitat loss and degradation in PHMA, the BLM will focus on other appropriate mitigation for the species, including accounting for any uncertainty associated with the effectiveness of such mitigation. This will be achieved by avoiding and minimizing impacts by applying beneficial mitigation actions, identified as needed, during the site specific application and subsequent review process. The BLM will implement actions to achieve goals consistent with the Wyoming Strategy (EO 2015-4) that includes additional appropriate mitigation as a strategy that should be used when avoidance and minimization are inadequate to protect Core Population Areas for Sage-Grouse (BLM 2015a).

Required Design Features

- The BLM will apply appropriate required design features identified in the BLM Wyoming Sage-Grouse RMP Amendments (BLM 2015a) as Stipulations/Conditions of Approval (COA)/Terms and Conditions within PHMAs for all program areas, as applicable. These features are included in the list of Resource Protection Measures found in Appendix A (*Resource Protection Measures*).

3.2.2 Development in Sage-Grouse Winter Concentration Areas

This decision authorizes limited development in Sage-Grouse Winter Concentration Areas (Map 3), acknowledging valid existing lease rights. Development will be conducted so as to provide for new information gathering to inform future site-specific application review.

A study will be conducted concurrently with limited development activities to better understand the impacts of development in Winter Concentration Areas. The objectives and details of the study will be coordinated with the BLM, WGFD, and other appropriate parties.

The results of the study, current information, and current guidance at the time of site-specific permitting will inform BLM understanding of impacts and subsequent development in Winter Concentration Areas, and analysis during subsequent site-specific NEPA reviews.

The decision authorizes two Winter Concentration Area development scenarios to allow appropriate decisions based on the results of the study and use of the most current guidance during site-specific application review. Under both scenarios, BLM authorizes development on a limited scale in Winter Concentration Areas.

Winter Concentration Area Development Scenario 1 reflects current guidance for Sage-Grouse Winter Concentration Areas in EO 2015-4 and the BLM Wyoming Sage-Grouse Amendments (BLM 2015a).

Winter Concentration Area Development Scenario 2 provides additional protection measures that could be applied if determined necessary based on study results and appropriate review of site-specific applications.

The BLM initially authorizes Winter Concentration Area Development Scenario 1. The decision allows for consideration of Winter Concentration Area Development Scenario 2 based on results of the study and appropriate review of site specific applications.

All other components of the ROD are common to both Development Scenarios where applicable.

The two Development Scenarios authorized for Sage-Grouse Winter Concentration Areas are summarized below and further described in Table 1:

1.) *Winter Concentration Area Development Scenario 1* applies a seasonal timing limitation on development during the wintering period as identified in the BLM Wyoming Sage-Grouse RMP Amendments (BLM 2015a).

2.) *Winter Concentration Area Development Scenario 2* applies the seasonal timing limitation as well as additional resource protection measures in Winter Concentration Areas, including a 5 percent disturbance threshold and other measures to reduce potential impacts (Table 1).

Table 1. Sage-Grouse Winter Concentration Area Development Scenarios

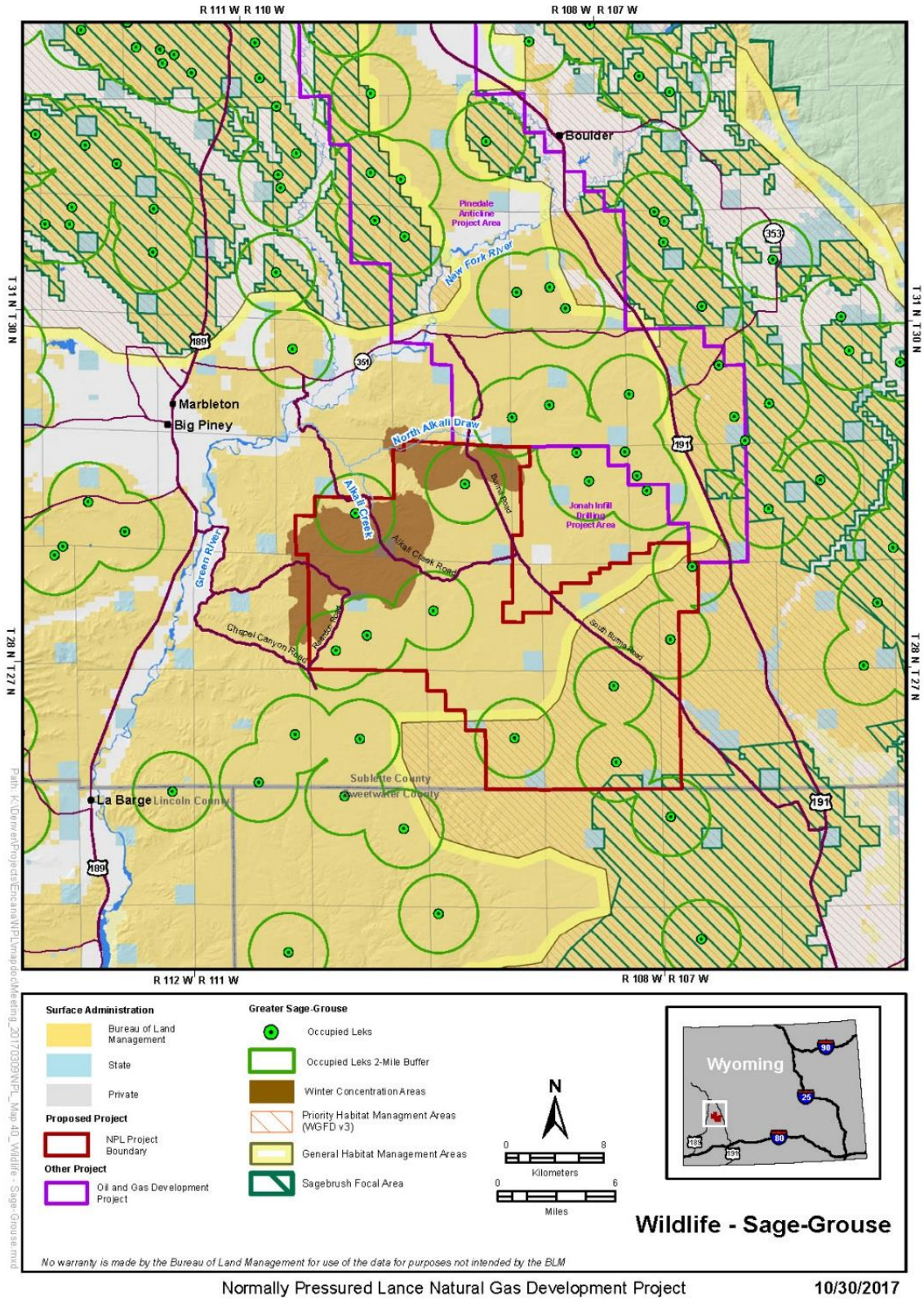
Winter Concentration Area Development Scenario 1	Winter Concentration Area Development Scenario 2
Surface disturbing and/or disruptive activities in Sage-Grouse Winter Concentration Areas are prohibited from December 1 – March 14 (BLM 2015a).	Surface disturbing and/or disruptive activities in Sage-Grouse Winter Concentration Areas are prohibited from December 1 – March 14 (BLM 2015a).
The DA 1 area (Map 2) will have a density of development averaging 1 disturbance location per 640 acres.	The DA 1 area (Map 2) will have a density of development averaging 1 disturbance location per 640 acres.
Not included in Winter Concentration Area Development Scenario 1	Within Winter Concentration Areas, surface disturbance will not exceed 32 acres (5 percent) per 640 acres, inclusive of existing disturbance.
Not included in Winter Concentration Area Development Scenario 1	Above-ground facilities will be centralized to locations outside of Winter Concentration Areas, where technically and economically feasible. Up to two RGFs may be centrally located in Winter Concentration Areas.
Not included in Winter Concentration Area Development Scenario 1	Within Winter Concentration Areas, development will initially proceed from east to west.
Not included in Winter Concentration Area Development Scenario 1	Buried pipelines will be constructed to transport produced water and condensate from RGFs within Sage-Grouse Winter

Table 1. Sage-Grouse Winter Concentration Area Development Scenarios

Winter Concentration Area Development Scenario 1	Winter Concentration Area Development Scenario 2
	Concentration Areas to RGFs outside of WCAs. Produced water that is not injected at RGF locations and condensate will be trucked or piped from RGFs outside of Winter Concentration Areas to treatment locations (produced water) and sales points (condensate).
Not included in Winter Concentration Area Development Scenario 1	Powerlines in Sage-Grouse Winter Concentration Areas will be buried, where feasible.

Note: Besides the differences in Sage-Grouse Winter Concentration Area development noted above, all other components of Alternative B development are the same under the two Winter Concentration Area development scenarios.

Map 3. NPL Project Area Sage-Grouse Habitat Features



3.3 Development in Accordance with General Conformity Requirements

Per the General Conformity regulations at 40 CFR 93.153(b), and Chapter 8, Section 3 of the Wyoming Air Quality Standards and Regulations (WAQSR) for current nonattainment areas, the BLM will not approve a level of development for the NPL Project that will exceed the *de minimis* emission limits of 100 tons/year for VOCs or NO_x in the Upper Green River Basin (UGRB) Ozone Non-Attainment Area. As a result, and as described in Appendix B (*Conformity Determination*), the BLM will only approve a level of development below the *de minimis* emission limits, which could result in a level of development less than 350 wells per year. The proposed 350 wells per year scenario was fully analyzed in the NPL Project Final EIS air quality impacts assessment modeling under the Proposed Action, based on the potential for technological improvements, regulatory changes, or other changes in the future that will allow for development of up to 350 wells per year during the life of the NPL Project.

A level of development that results in annual NO_x or VOC emissions at or below the 100 tons/year emissions limit will ensure compliance with the General Conformity regulations at 40 CFR 93.153(b), and Chapter 8, Section 3 of the WAQSR requirements.

In addition to potentially reducing the pace of development for the NPL field, provisions set forth by EPA New Source Performance Standard regulations (40 CFR Part 60) for oil and gas development sources could result in lower criteria pollutant emissions based on any future changes in the type of equipment used, the methodology for well completions (e.g., the use of "green" completions), and other emission limit and control requirements mandated by these updates. For example, the provisions require operators to conduct additional leak detection and monitoring activities and encourage them to use new technologies for leak detection. In addition to these requirements, Wyoming DEQ has also recently updated its guidance for the oil and gas development sector in its 8th update of Chapter 6, Section 2 of the *Oil and Gas Production Facilities Permitting Guidance* (WDEQ 2016). It is expected that the provisions contained in these recent guidance updates will result in less emissions from future oil and gas development sources in the NPL field.

To ensure that emissions levels will be below what is analyzed in the NPL EIS and the NPL Project Conformity Determination (Appendix B), Jonah Energy will submit annual emissions estimate data and emissions reports. The BLM will then use these annual emissions estimates to inform site-specific permitting and appropriate mitigation measures.

Refer to Appendix A (*Resource Protection Measures)* for measures that will be considered as COAs during site-specific permitting to reduce potential impacts to air quality.

3.4 Delineation Wells

Delineation wells will be drilled as needed to advance understanding of the location and extent of oil and gas resources in previously unexplored portions of the Project Area, typically using single-well pads. Findings of these initial delineation efforts will determine if further delineation efforts should be undertaken in the vicinity of the initial delineation wells. Development of delineation wells will be subject to the same resource protection measures, site-specific COAs, and terms and conditions as development wells.

Delineation wells will generally be located on up to 5-acre pads. Well pads constructed for delineation wells will have a limited number of wells (e.g., 1-5 wells) and will necessitate the use of small scale, temporary production facilities. Delineation wells that indicate potential for economic recovery of gas resources may be developed into multi-well pads. Delineation well pads that fail to identify recoverable oil and gas resources and are not successful will be plugged, abandoned, and reclaimed consistent with the reclamation and monitoring standards described in Appendix C (*Reclamation, Monitoring, and Weed Management Plan*). Delineation wells and associated surface disturbance are included in the well number and surface disturbance estimates described below.

3.5 Project Components

3.5.1 Wells and Well Pads

The decision allows for the development of up to 3,500 natural gas wells in the NPL Project Area, with development of up to 350 wells per year during the approximate 10.4-year development period. Disturbance for each multi-well pad location will range between 5 and 19 surface acres (on average). The size of well pads will depend on the number of wells needed to adequately recover the resources, well density limitations per section of land, and topographical, environmental, or other resource limitations. In general, delineation wells will be constructed on single-well pads of up to 5 acres and these may be expanded to multi-well pads to extract the resource depending on the drilling results.

3.5.2 Regional Gathering Facilities

The decision allows for up to eleven Regional Gathering Facilities (RGFs), which will be constructed in the most densely drilled portions of the Project Area, to separate and store liquids from the natural gas stream. In most cases, because of technical requirements, RGFs will need to be located within a three-mile radius of well pad clusters. The decision allows up to two RGFs in DA 1, seven in DA 2, and two in DA 3.

Each RGF will include liquids separation and gas dehydration equipment, temporary or long-term gas compression facilities, water injection wells and pumps, water and condensate storage tank batteries, liquids handling and offloading facilities, electrical transformers, and power control facilities. Up to two of the RGFs may be designated as Central Service Centers (CSC). To minimize air emissions, electric compression will be used at each RGF, powered by electrical distribution lines.

RGFs are long-term facilities used during the production period of the project. Therefore, Jonah Energy will not construct RGFs until after gas resources in a given DA have been delineated to the point where it can be determined that construction of RGFs is warranted. Well pads constructed for delineation wells will have a limited number of wells (e.g., 1-5 wells) and will necessitate the use of small scale, temporary production facilities. Jonah Energy may rely on these production facilities until the density of development supports the construction of RGFs. In cases where reduced line pressure will be required for production, compression facilities and overhead power will be installed during RGF construction. If permanent compression is not needed initially, installation of compression and power facilities will be deferred until later in the

production life of each RGF. In delineation areas of the Project Area, temporary compression may be constructed until the exploratory drilling demonstrates that the area is productive. Temporary compression facilities will be within existing disturbed areas and any emissions will be less than, and included within, the emissions for the proposed long-term facilities.

3.5.3 Powerlines and Substation

Overhead electrical distribution lines will be constructed within the Project Area to power RGFs and to facilitate certain emission-control technologies to be used at RGFs. Electricity may not be available for some components to operate during the initial years of the development, but will be implemented over time as powerlines and other equipment are brought online. An estimated 38.6 miles of new powerlines will be constructed for the NPL Project. The exact location of the powerlines will be determined by the final site location of each RGF. Powerline siting will be coordinated with existing or proposed transportation corridors whenever possible. Prior to construction of electrical distribution lines, the electric power company will apply for and, upon BLM approval, hold the powerline ROW. The authorized, but not yet constructed, Jonah Substation (#WYW-172154) that will be constructed in the JIDPA will step down the voltage from 230 kV to the proposed voltage for the NPL Project (25 kV).

Within Sage-Grouse PHMA, powerlines will be authorized in accordance with the BLM Wyoming Sage-Grouse RMP Amendments (BLM 2015a), including the authorization of electric distribution lines (less than 115 kV), as noted below:

- New electric distribution lines will be buried where technically and economically feasible. If not economically feasible, distribution lines may be authorized when effectively designed/mitigated to protect Sage-Grouse, and the AO determines that overhead installation is the action alternative with the fewest adverse impacts while still meeting the project need.
- Power lines (distribution and transmission) will be designed to minimize wildlife related impacts and constructed to the latest Avian Power Line Interaction Committee (APLIC) standards.

3.5.4 Pipelines

Products (natural gas, condensate, produced water) will be transported from well pads to RGFs via a three-phase pipeline gathering system. To transfer the natural gas to market, pipelines will also be constructed from RGFs to the nearest existing pipeline network connecting to the existing mid-stream pipeline system. The pipeline gathering system will require an estimated 205 miles of new pipelines in the Project Area.

Buried pipelines will have an average 75-foot-wide construction ROW and be buried at a depth of up to six feet to protect pipelines from surface freeze conditions. Whenever possible, pipelines will be located adjacent to new or existing access roads in a combined 100-foot wide construction corridor. Pipeline trenches will be excavated mechanically with trenching equipment, such as a backhoe or trencher. Trench dimensions will be between 18 and 24 inches wide.

For Winter Concentration Area development scenario 1, produced water and condensate will be transported from RGFs to treatment and sales points. For Winter Concentration Area development scenario 2, buried pipelines will be developed within a 75-foot wide construction corridor to transport produced water and condensate from RGFs within Sage-Grouse Winter Concentration Areas to RGFs outside of these areas. Produced water that is not injected at RGF locations, and condensate, will then be trucked from RGFs outside of Sage-Grouse Winter Concentration Areas to treatment locations (produced water) and sales points (condensate).

In PHMA, new pipelines constructed in RMP corridors or adjacent to existing utilities or roads will require completion of a DDCT analysis for baseline data collection, but the project is not required to meet the threshold of 5 percent. However, within 6 months of the completion of construction, the project proponent will provide the AO with as-built drawings so that total disturbance within core area can be calculated annually.

All new buried pipelines will be tested for hydrostatic integrity and structural soundness using approved testing procedures to ensure full compliance with the mandatory BLM pipeline requirements. All pipeline installations will be installed, inspected and tested in accordance with the applicable industry codes, such as American Society of Mechanical Engineers (ASME) B31.8 and American Petroleum Institute (API) 1104, as well as in accordance with standard engineering best practices, which will include the pressure testing of piping systems. Water from shallow groundwater wells will be used for testing pipeline integrity in the warmer months (April to November), and a freshwater/methanol mix kept in storage during colder months (December to March). The WDEQ regulates the discharge of hydrostatic test water to surface waters through the Wyoming Pollution Discharge Elimination System (WYPDES) program. Discharge of hydrostatic test water will require Jonah Energy to obtain a WYPDES permit prior to any discharge to surface waters.

3.5.5 Roads and Access

Regional access to the Project Area will be from U.S. Highway 191, generally via Luman Road to Burma and Crimson Roads. The exact location of internal access roads will depend on the location of the multi-well pads and RGFs. All new access roads will be constructed using standard equipment, with appropriate drainage and erosion control features and structures to include cut-and-fill slope and drainage stabilization, relief and drainage culverts, water bars, and wing ditches similar to those described in the Gold Book (BLM 2007).

Road maintenance will be performed on an as-needed basis over the course of the year. Road maintenance activities will be the responsibility of the lessee or authorized agent in accordance with approved Surface Use Plans in the case of APDs and under the terms and conditions of ROW grants. Gravelling and repair operations will be conducted during the spring and summer months. Plowing operations during the winter months will be required primarily to clear snow and ice from main access roads serving the RGFs, with secondary service to clear roads to well pad locations.

An estimated 35 miles of existing primary road will be maintained for year-round access to all RGFs. An estimated 205 miles of new access roads will be constructed in the Project Area. In general, roads and pipelines will share a common 100-foot wide ROW corridor, wherever possible.

Refer to Appendix D (*Transportation Plan*) for additional information on transportation management in the NPL Project Area.

3.6 Produced Water and Underground Injection

The decision provides for development which will result in an estimated 100,000 to 500,000 barrels of produced water during the life of each well. The primary factors that will affect the range of produced water per well include:

1. Total cumulative gas production for each well.
2. Geologic variation in water saturation conditions.

Most produced water will be disposed of in subsurface injection wells near each RGF. The location of injection wells is unknown at this time, since the location of RGFs has not been determined. The proposed injection wells to be located near RGFs in the Project Area will be similar to existing injection wells in the JIDPA and the Pinedale Anticline Project Area. Underground Injection Control permits for new wells will be approved by the Wyoming Oil and Gas Conservation Commission (WOGCC) for the injection of brines and other fluids associated with oil and gas production.

Smaller volumes of produced water will be transported to the JIDPA water treatment/disposal facility for treatment and reuse (an estimated 10 percent). Initially, produced water stored at the RGFs for treatment will be transported to the JIDPA water treatment/disposal facility. If additional facilities are needed in the future, additional environmental analysis will be completed.

3.7 Water Use and Water Supply Wells

Water for drilling operations, dust control, and hydrostatic testing will be obtained from existing shallow water wells in the JIDPA and NPL Project Area and will be used for drilling, cement production, casing surface aquifers, and hydrostatic testing of pipelines. If needed, new water wells may be drilled at appropriate locations in the Project Area, after all necessary permits are secured by Jonah Energy. Water used for well drilling will be trucked or transported via temporary surface pipeline from groundwater well locations to well pads and stored in water tanks on site. The primary factor driving the need for new water supply wells will be the distance from existing water supply wells to new development locations. As new areas are developed further away from existing water supply wells, the need for new water supply wells closer to these areas of development will increase. The new water supply wells could be located at the RGF locations servicing well clusters.

Water supply wells that are no longer needed will be plugged and abandoned in accordance with Wyoming State Engineers Office standards and other applicable guidelines and regulations, including notification of BLM prior to plugging and abandonment.

An estimated 35,000 bbls of water will be used for drilling and completions of each well. Water for drilling operations (29 percent of total water for drilling and completions, 10,000 bbls per well) will generally come from shallow groundwater wells in the top 1,000 feet of the Wasatch Aquifer. Once usable water is protected by the surface casing, Jonah Energy could potentially use recycled water from the base of the surface casing to total depth. All water for completions

operations (71 percent of total water for drilling and completions, 25,000 bbls per well) will be obtained from recycled sources (e.g., JIDPA Water Treatment Facility) and will be trucked or transported by temporary surface pipeline to well locations and stored onsite in tanks, if needed.

An estimated groundwater use of 3,531,431 bbls per year will occur during the 10.4 year development phase (455.2 acre-feet per year), for a total estimated groundwater use of 36,726,882 bbls during the approximate 10.4 year development phase (4,734.1 acre-feet).

In advance of development, Jonah Energy will work with appropriate federal, state and local agencies to implement an acceptable groundwater monitoring program for the NPL Project consistent with WOGCC rules to establish and monitor the quality of groundwater around sites prior to, during and after oil and gas development. This effort will consist of utilizing Jonah Energy's substantial historical data as baseline data, groundwater and surface water monitoring and installation of additional monitoring wells, as needed. The program will include routine sampling of monitoring wells as NPL development progresses with implementation of appropriate safeguards and BMPs during all phases of development.

3.8 Well Monitoring and Control

Jonah Energy will install supervisory control and data acquisition (SCADA) equipment on all well locations to remotely monitor well data. SCADA equipment will gather well data in real time from remote locations and will reduce traffic and human activity associated with well monitoring and control during production.

3.9 Reclamation and Monitoring

Reclamation, monitoring, and weed management for the NPL Project is described in Appendix C (*Reclamation, Monitoring, and Weed Management Plan*). If reclamation deficiencies are detected during BLM inspection and enforcement activities, Jonah Energy will take corrective actions to improve reclamation methods and reduce short- and long-term impacts to resources. Air quality monitoring will be conducted by the WDEQ Air Quality Division (AQD) in accordance with the findings of the *Air Quality Technical Support Document* (see Appendix L of NPL Project Final EIS), the *NPL Project Conformity Determination* (Appendix B) and the General Conformity requirements described above in Section 3.3 (*Development in Accordance with General Conformity Requirements*).

3.10 Exceptions, Modifications, and Waivers

In accordance with the applicable RMPs, the BLM will consider granting exceptions to oil and gas lease stipulations, COAs and terms and conditions for ROW grants and waivers and modifications for lease stipulations in accordance with the process and criteria for exceptions, modifications, and waivers described in the applicable RMP. Exceptions and waivers are not intended to be used to extend normal operations into the timing limitation period (BLM 2008). The BLM will consider exceptions to lease stipulations on a case-by-case basis based on current site-specific conditions. Modifications and waivers to lease stipulations will be considered based on site-specific analysis and will be processed by the BLM Wyoming State Office.

3.11 ROD Project Components and Surface Disturbance

Table 2 presents the project components and surface disturbance allowed under this ROD. Development beyond the levels indicated in Table 2 will require additional environmental analysis.

Table 2. NPL Record of Decision Components and Surface Disturbance

New Facility/Feature	Size or Number	Short-term Disturbance (acres)	Long-term Disturbance (acres)
Wells and Well Pads			
New Wells	3,500 wells	2,849	712
Surface Disturbance Subtotal		**2,849**	**712**
Construction and Production Facilities			
Regional Gathering Facilities or Compressor Stations	11 [1] 2 in DA 1, 7 in DA 2, 2 in DA 3	220	220
Surface Disturbance Subtotal		**220**	**220**
Linear Features			
Three-phase gathering pipelines	205 miles Pipelines and Roads share 100-foot ROW	1,864	0[2]
Access Roads	205 miles Pipelines and Roads share 100-foot ROW	621	621
Electric Powerlines	38.6 miles 40-foot ROW	188	188
Condensate and Produced Water Pipelines in Project Area (share same trench)	15 miles 75-foot ROW	132	0
Surface Disturbance Subtotal		**2,805**	**809**
Total Short-term Surface Disturbance		***5,874***	
Total Long-term Surface Disturbance			***1,741***

[1]Assumes 20 acres of short-term surface disturbance for RGFs that will persist for the life of the project (no interim reclamation).
[2]Assumes surface disturbance from pipelines will be fully reclaimed after interim reclamation.

4.0 NPL PROJECT RESOURCE PROTECTION MEASURES AND MITIGATION

This section describes resource protection measures and mitigation measures that were identified during the NPL Project EIS process to avoid, minimize, rectify, reduce, or mitigate potential resource impacts. This section also identifies potential additional mitigation that will be considered during site-specific permitting, if appropriate. The resource protection measures and mitigation identified in this section may be applied as COAs during site-specific permitting based on specific development proposals and potential site-specific impacts identified during APD permitting. Additional resource protection measures and mitigation may be imposed during site-specific permitting based on adaptive management, site-specific environmental review and identified impacts, and regulations/guidance current at the time of site-specific permitting.

4.1 Resource Protection Measures

In general, resource protection measures represent best management practices (BMPs), design features, Operator-Committed Practices (OCPs), and other measures that could reduce or eliminate potential adverse resource impacts. Appendix A (*Resource Protection Measures)* identifies the resource protection measures for the NPL Project.

Some resource protection measures will be included as COAs during permitting for site-specific development of the NPL Project, as applicable, while some measures may be treated as guidelines for voluntary compliance by Jonah Energy. COAs will apply to Jonah Energy and their contractors and will be binding in the event that the facilities or infrastructure are transferred or operated by another entity. Applicability of resource protection measures is subject to valid existing lease rights. Consistent with valid lease rights, Jonah Energy will implement the resource protection measures as listed in Appendix A (*Resource Protection Measures*), but will retain the flexibility to utilize new technologies that provide equal or better resource protections while facilitating Jonah Energy's exploration, development and production goals. It is important to note that many of the OCPs cannot be effectively or cost-effectively utilized until Jonah Energy completes exploration and delineation and is developing a particular Development Area.

4.2 Mitigation Measures

In addition to the resource protection measures identified in Appendix A (*Resource Protection Measures*), a variety of mitigation measures may be applied during site-specific permitting to mitigate the resource impacts described in Chapter 4 (*Environmental Consequences*) of the NPL Project Final EIS. The sections below identify mitigation measures by resource:

Air Quality

- Per the General Conformity regulations at 40 CFR 93.153(b), and Chapter 8, Section 3 of the WAQSR for current nonattainment areas, the BLM will not approve a level of development for the NPL Project that will exceed the *de minimis* emission limits as established by EPA for VOCs and NO_x in the Upper Green River Ozone Non-Attainment Area (see Section 3.3 of this ROD). Emission limits are driven by the WDEQ's State Implementation Plan. As a result, and as described in Appendix B (*Conformity*

Determination), the BLM will only approve a level of development below the *de minimis* emission limits, which could result in a level of development less than 350 wells per year

- To ensure that annual emissions remain below the Clean Air Act General Conformity *de minimis* thresholds for NOx or VOC in the UGRB Ozone Non-Attainment Area, Jonah Energy will submit annual emissions estimate data and emissions reports to the BLM. The BLM will use these annual emissions estimates to inform site-specific permitting and appropriate mitigation measures, as appropriate.

Cultural Resources

- During site-specific permitting, the BLM will assess the potential for installation/replacement of appropriate historic trail markers to clearly identify the location of the Sublette Cutoff and North Sublette Meadow Springs Variant to avoid unintentional damage to trails from construction, maintenance, and operation.
- If site-specific cultural surveys during the APD process indicate that adverse effects could occur, the BLM will consult with the Wyoming SHPO and other appropriate parties on resolution of adverse effects in accordance with the Wyoming State Protocol (BLM and SHPO 2014).

Noise

- **Use of heavy trucks is prohibited** within two-mile Sage-Grouse lek buffers between the hours of 6:00 p.m. to 8:00 a.m. during Sage-Grouse mating season (March 1 through May 15). This includes traffic on access roads.
- **Noise-reducing measures will be employed during construction** such that noise from construction activities does not exceed 10 dBA above baseline levels (in terms of L_{max} noise levels) at Sage-Grouse lek locations between the hours of 6:00 p.m. and 8:00 a.m. during Sage-Grouse breeding season. Measures to achieve these performance standards include but are not limited to:
    - Limit all noise-generating operational activity to the hours of 8:00 a.m. to 6:00 p.m. during Sage-Grouse mating season,
    - Prohibit all gasoline or diesel engines from having un-muffled exhaust,
    - Require that all construction equipment powered by gasoline or diesel engines have sound-control devices that are at least as effective as those originally provided by the manufacturer and that all equipment be operated and maintained to minimize noise generation,
    - Prevent excessive noise by shutting down idle vehicles or equipment, and
    - Change the location of stationary construction equipment to maximize the distance between equipment and residences where practical.
- **Noise-reducing measures will be employed during operation** of the NPL Project such that noise from operational activities does not exceed 10 dBA above baseline levels (in terms of L_{max} noise levels) at Sage-Grouse lek locations between the hours of 6:00 p.m. and 8:00 a.m. during Sage-Grouse breeding season. Measures to achieve these performance standards include but are not limited to:

  - Retain a qualified acoustical consultant to design acoustical treatments for compressors, well pads, and other sources of equipment noise where acoustical treatments are a feasible option,
  - Enclose noise-generating equipment in solid wall structures where practical,
  - Limit openings in enclosing structures and install acoustic ventilation louvers where ventilation openings are required,
  - Use low-noise motors, and
  - Install mufflers and silencers on exhaust stacks.

- **A noise monitoring program will be implemented to collect data from noise emissions due to construction and operation of the NPL Project.** Noise monitors will be installed on a case-by-case basis, where appropriate, for the duration of NPL construction and operation in areas of the NPL Project where Sage-Grouse leks are most likely to be affected by noise from construction or operation of the NPL Project, including heavy truck traffic on NPL access roads. Where possible, noise monitors will be installed along the line-of-sight between potentially impacted Sage-Grouse leks within the Project Area and the point of closest approach of a project access road or a construction site. In some cases, simultaneous continuous noise monitoring at a given lek may be necessary for data validation, depending on location of project elements relative to the lek.

Soil Resources

- The prescribed monitoring and mitigation will be determined by the initial model designations of plane or channel impacts and intensity of landscape disturbance, as described in Appendix J of the NPL Final EIS (AGWA Technical Report). The BLM will use new monitoring data collected by Jonah Energy during development of the NPL Project to re-parameterize the KINEROS2 model and re-run it as necessary, to aid in identifying significance thresholds, or action levels, for channel erosion and runoff/salinity increases.
- Because some individual planes in the Watershed Modeling Units exhibited a relatively substantial increase in surface runoff and discharge within the channels, Jonah Energy will implement monitoring and mitigation measures recommended in the Monitoring and Mitigation tables in Section 6.3 of Appendix J of the NPL Final EIS (AGWA Technical Report), or other approved measures that are as rigorous and protective.
- Jonah Energy will engineer all surface runoff control structures and treatments for higher levels of storm intensity and duration as indicated by the KINEROS2 modeling analysis (e.g., 25-year 24-hour event) described in Appendix J of the NPL Final EIS (AGWA Technical Report).
- Jonah Energy will be diligent in compliance monitoring of the condition of runoff control structures (e.g., after every precipitation event that resulted in any water movement off pads into detention ponds, off roads, and into wing ditches and catchments), and promptly repair any damage before the next precipitation event.
- Jonah Energy will develop Mitigation and Monitoring Plans and Storm Water Pollution Prevention Plans for the NPL Project, which incorporate the Technical Support Document for the Application of the Regional Framework for Water-Resources Monitoring Related to Energy Exploration and Development (BLM 2013) and the

recommended measures for monitoring and mitigation for each of the impact categories identified in Section 6.3 of Appendix J of the NPL Final EIS (AGWA Technical Report).

- To reduce challenges with achieving successful interim and final reclamation, Jonah Energy will avoid surface-disturbing activities in soils that have high risk characteristics, including but not limited to the limiting characteristics identified in Section 4.15 (*Soils*) of Chapter 4 (*Environmental Consequences*) of the NPL Final EIS. These will be identified and further assessed during onsite visits and site-specific permitting.

Visual Resources

- Based on site-specific analysis of potential visual and other impacts from solar panel arrays, the BLM will consider alternatives to solar panel arrays at well sites such as fuel cells, screening of panels, and other technology.

Water Resources

- Jonah Energy will work with appropriate federal, state and local agencies to implement an acceptable groundwater monitoring program for the NPL Project consistent with WOGCC rules to establish and monitor the quality of groundwater around sites prior to, during and after oil and gas development. This effort will consist of utilizing Jonah Energy's substantial historical data as baseline data, groundwater and surface water monitoring and installation of additional monitoring wells, as needed. The program will include routine sampling of monitoring wells as NPL development progresses with implementation of appropriate safeguards and BMPs during all phases of development. Jonah Energy will report the results to BLM on an annual basis or after each sampling cycle in a digital format to allow uploading into a database management system.
- To reduce potential impacts to springs, prior to the start of any surface disturbance activities, the source and contribution area of each spring will be determined and sensitive areas will be marked in the field to assist in development of mitigation measures to protect the spring resource.
- When the use of oil-based mud is planned, an intermediate casing string will be cemented in to isolate and protect any usable water zones prior to drilling with oil-based mud.
- Jonah Energy will cement the entire intermediate casing from the top of the Lance Formation to surface casing. Or, for casing with annular space that is not fully cemented, protect the casing from corrosion using a cathodic protection system.
- Jonah Energy will manage the drilling mud program to ensure that the proper balance of mud weight and filter cake properties is maintained to minimize fluid loss to the formations.
- Jonah Energy will locate new water supply wells (at surface and at depth) at sufficient distances from existing livestock water wells to reduce potential impacts to water quantity and quality for livestock well users.
- New water supply wells will be located in areas that will not have impacts to surface water (riparian areas, wetlands, seeps and springs).
- If a water supply well is to be drilled in an area where riparian vegetation is located, there may be a need to monitor groundwater levels. The potential to monitor groundwater levels will be considered in the NPL Project groundwater monitoring program and during site-specific permitting.

- In addition to meeting all SEO construction requirements, Jonah Energy LLC will cement wells to the surface without using bentonite grout, protect wells against unauthorized entry, and properly plug wells when no longer used.

Wildlife

- If equipment has been used in a high risk infested water [a water known to contain Dreissenid mussels (zebra/quagga mussels)], the equipment must be inspected by an authorized aquatic invasive species inspector recognized by the state of Wyoming prior to its use in any Wyoming water.
- Any equipment entering the state by land from March through November (regardless of where it was last used), must be inspected by an authorized aquatic invasive species inspector prior to its use in any Wyoming water. If aquatic invasive species are found, the equipment will need to be decontaminated by an authorized aquatic invasive species inspector.
- Any time equipment or surface water is moved from one 4th level (HUC-8) watershed to another within Wyoming, the following guidelines are recommended:
    - DRAIN: Drain all water from watercraft, gear, equipment, and tanks. Leave wet compartments open to dry.
    - CLEAN: Clean all plants, mud, and debris from vehicle, tanks, watercraft, and equipment.
    - DRY: Dry everything thoroughly. In Wyoming, WGFD recommends drying for 5 days in summer (June – August); 18 days in spring (March – May) and fall (September – November); or 3 days in winter (December – February) when temperatures are at or below freezing.

4.3 Additional Appropriate Mitigation

The BLM identified the following residual impacts that may warrant additional appropriate mitigation during site-specific permitting. The BLM also identified the associated mitigation standard for the potential residual impact warranting appropriate mitigation. The BLM will apply appropriate mitigation standards during site-specific permitting based on guidance and decisions current at that time.

- **Residual Effect: Decreased quantity and quality of Sage-Grouse habitat including habitat in PHMA and Winter Concentration Areas.** The NPL Project could result in decreased quantity and quality of suitable breeding, wintering, and foraging habitat for Greater Sage-Grouse, resulting from surface disturbance, vegetation clearing, and other project-related activity during the approximate 10.4-year development phase and from long-term facilities that will persist during the duration of the 30-year production phase (e.g., RGFs). These impacts could persist until interim and final reclamation are successful. Due to the prolonged time required to successfully reclaim and re-establish high quality, mature sagebrush habitat with vertical and horizontal structural diversity, these impacts could persist for up to 40 years, or for as long as it takes sagebrush communities in the Project Area to be restored to pre-disturbance conditions.

  - **Mitigation Standard:** When authorizing third-party actions that result in Sage-Grouse habitat loss and degradation in PHMA and Winter Concentration Areas, the BLM will require and ensure appropriate mitigation that complies with current policy and land use plans.

- **Residual Effect: Impacts to areas where Sage-Grouse have been observed during winter but are outside delineated Winter Concentration Areas.** Decrease in or degradation of seasonal habitats, including areas where Sage-Grouse have been observed during winter could result in local and regional impacts to Sage-Grouse as these areas are important to the life cycle of Sage-Grouse.
  - **Mitigation Standard:** No net loss of areas where Sage-Grouse have been observed during the winter but are outside of Winter Concentration Areas.
- **Residual Effect: Sage-Grouse impacts resulting from RGFs in PHMA and Winter Concentration Areas.** Due to the acreage of Sage-Grouse PHMA and Winter Concentration Areas in the Project Area (Map 3), RGFs may need to be located within PHMA and Winter Concentration Areas to effectively service well pads located in these areas. Locating RGFs within Sage-Grouse PHMA and Winter Concentration Areas could result in adverse impacts to Sage-Grouse resulting from noise impacts, direct mortality, surface disturbance, and other increased human and project-related activity associated with these facilities.
  - **Mitigation Standard:** When authorizing third-party actions that result in Sage-Grouse habitat loss and degradation in PHMA and Winter Concentration Areas, including RGFs in these areas, the BLM will require and ensure appropriate mitigation that complies with current policy and land use plans.

Potential appropriate mitigation for Sage-Grouse that could be applied during site-specific permitting to address these residual impacts will be consistent with the State of Wyoming's Revised Greater Sage-Grouse Compensatory Mitigation Framework (State of Wyoming 2017) and the Memorandum of Understanding (MOU) among the BLM, State of Wyoming, and other federal agencies on Promoting a Cohesive and Consistent Conservation Strategy for the Greater Sage-Grouse and its Habitat in Wyoming (DOI 2017), or more current guidance as it is adopted.

During the site-specific NEPA compliance process, if the BLM determines that the development proposal will result in residual effects warranting appropriate mitigation, the BLM, in coordination with Jonah Energy and other appropriate parties, will identify site-specific measurable objectives, mitigation standards, outcomes, and appropriate mitigation mechanisms for those impacts. During site-specific permitting, all disturbances in PHMA will be analyzed using the DDCT to determine compliance with the BLM Wyoming Sage-grouse RMP Amendments (BLM 2015a) and the State of Wyoming EO 2015-4 (State of Wyoming 2015). If DDCT analysis in PHMA, or other analysis in GHMA, indicate that permitted or approved actions exceed the thresholds in the approved BLM RMPs, appropriate mitigation will be calculated based on the State of Wyoming's Revised Greater Sage-Grouse Compensatory Mitigation Framework (State of Wyoming 2017).

Objectives and outcomes for appropriate mitigation, and mitigation measures at the site-specific level, will be tiered to the landscape-level objectives/outcomes and standards identified in the NPL Project ROD. Site-specific appropriate mitigation will be based on Jonah Energy's specific

development proposals submitted in APDs and ROW applications, quantified habitat impacts and surface disturbance for specific development proposals as identified during site-specific NEPA compliance, current science and resource understanding at the time of permitting, current regulatory frameworks for appropriate mitigation at the time of permitting, and an understanding of appropriate and available mitigation mechanisms at the time of site-specific permitting.

5.0 WHAT THE DECISION DOES NOT PROVIDE

Decisions contained within this document do not apply to non-federal lands; they apply only to BLM-administered federal lands, including federal minerals.

5.1 Site-Specific Authorizations

This ROD does not authorize site-specific construction, maintenance, or use of new wells, pads, pipelines, roads, transmission lines or other facilities on BLM-administered lands. Rather, Jonah Energy is required to submit APDs, Sundry Notices, and/or ROW applications for approval of wells, well pads, pipelines, roads, and other ancillary facilities associated with project development. The BLM will require site-specific environmental review and approval of such applications prior to initiation of surface-disturbing activities.

5.2 Existing and Historical Authorizations

This ROD in no way replaces any stipulations, COAs, or terms and conditions of any previously authorized and constructed APD, ROW, or ancillary facility permits in the NPL Project Area. Unless otherwise provided for in a future BLM decision (with accompanying NEPA compliance), future authorizations within NPL Project Area will comply with the required design features of the Selected Alternative, and the COAs, terms and conditions, and mitigation measures described in this ROD, as well as other site-specific measures as identified and decided upon by the BLM.

5.3 Mitigation Measures Not Carried Forward

After analysis of impacts, several mitigation measures proposed for Alternative A in the NPL Final EIS were not carried forward into the NPL ROD. Measures not carried forward in the ROD and the rationale for not carrying them forward are described below.

Jonah Energy will include mulching as a dust reduction technique for use when appropriate (e.g., sandy areas).

> Rationale: The measure as written was an optional action which may still be considered based on site-specific conditions and therefore is not required at the EIS level.

No traffic would be allowed on North Burma Road north of the Project Area boundary.

> Rationale: Removing the potential for traffic on the North Burma Road arbitrarily prohibits future transportation management considerations which could prove beneficial.

Within DA 1, development would be prohibited in areas containing greater than 5 percent sagebrush canopy cover, except where technically and economically infeasible.

> Rationale: Development in DA 1 must retain adequate flexibility to allow for site specific proposals, that would also in many cases incorporate results of the study of limited

development in WCAs. This measure could unintentionally result in limitations of beneficial management considerations.

Where practicable, well heads would not be located within the visible line of site of delineated mountain plover habitat in DA 3 and DA 6.

Rationale: Consideration of site specific proposals will best allow for resolution of issues related to delineated mountain plover habitat. This measure could unintentionally result in limitations of beneficial management considerations.

Development of any kind, throughout the Project Area, will avoid entirely cutting off or bisecting tall/dense habitat features (primarily ephemeral drainages) so that dispersal between each half of bisected feature can no longer be maintained.

- Throughout the Project Area, oversized, bottomless culverts will be used under roadways where roadways cross tall dense habitat features.
- Throughout the project area, pipelines will be bored under ephemeral drainages where tall/dense sage brush occurs if the pipeline disturbance exceeds 30 feet wide.

Rationale: The measure contains general guidance that can best be addressed during site-specific permitting to achieve the same goals. This type of consideration would occur during evaluation of site-specific applications.

Jonah Energy will install oversized, bottomless culverts under roadways. Strategic placement will be pursued so that connectivity can be maintained by small mammals and herpetological species between habitats situated on either side of the roadway. Acceptable placement of these culverts will be demonstrated by Jonah Energy to the acceptance of the AO.

Rationale: The measure contains guidance that if required would best be addressed during site-specific permitting to achieve the same goals.

6.0 SUMMARY OF ALTERNATIVES

6.1 Overview

Four alternatives were considered in detail in the NPL Project Final EIS, including the Proposed Action. For a complete description of the alternatives, refer to Chapter 2 of the Final EIS (*Proposed Action and Alternatives*). Sections 2.10 (*Comparison of Alternatives*) and 2.11 (*Summary of Impacts*) of the Final EIS contain tables comparing the alternatives and their potential impacts. Nine additional alternatives were considered and eliminated from detailed study in the Final EIS, as explained in Section 2.9 (*Alternatives Considered but Eliminated from Further Analysis)* of the Final EIS and summarized in Section 6.4 of this document.

6.2 Alternatives Analyzed

The four alternatives analyzed in detail in the Final EIS and summarized in the sections below are:

- No Action Alternative

- Proposed Action
- Alternative A
- Alternative B (Preferred Alternative)

6.2.1 No Action Alternative

Consideration of the No Action Alternative provides a baseline for analyzing impacts (including cumulative impacts) resulting from implementation of the Proposed Action and other action alternatives, and is required under Council on Environmental Quality (CEQ) Regulations (Section 1502.14(d)). Under the No Action Alternative, the BLM Authorized Officer would not approve the Proposed Action and associated land-use applications. However, existing federal oil and gas leases within the Project Area would remain valid unless they are not otherwise in compliance with applicable laws and regulatory requirements. Federal oil and gas resources could continue to be developed and produced on an individual-lease or unit-area basis. For the purpose of analysis, the BLM assumes that development and production would continue at the rate that has been seen in the Project Area since 1997: drilling and completion of approximately three new wells per year from single or multi-well pads, for a 10-year development period, along with construction and maintenance of ancillary facilities associated with productive wells.

6.2.2 The Proposed Action

The Proposed Action is Jonah Energy's development proposal for the NPL Project and includes a maximum of 3,500 directionally drilled wells during a 10-year development period within the 140,859-acre Project Area. The rate of well development would be up to 350 new wells per year along with associated well pads, access roads, pipelines, regional gathering facilities, and other ancillary facilities. The life of the project is assumed to be 40 years. Directionally drilled wells would be drilled from multi-well pads, with an average of up to four multi-well pads per 640-acre section of land in areas outside designated Sage-Grouse PHMA. Inside Sage-Grouse PHMA, Jonah Energy would construct an average of up to one multi-well pad per 640-acre section, consistent with state of Wyoming EO 2015-4, *Greater Sage-Grouse Core Area Protection*, and the BLM Wyoming Sage-Grouse RMP Amendments.

6.2.3 Alternative A

This alternative was developed primarily to address sensitive wildlife resources identified during scoping and the alternatives development process. For Alternative A, the maximum number of wells would be the same as the Proposed Action, but the location, timing, and pattern of development would be different than the Proposed Action, with the timing of development occurring sequentially in three geographically defined Phases. The maximum allowable density of development within seven identified DAs would be largely driven by the presence or absence of delineated wildlife habitats in a given DA, and the expanse of those habitats, if present. The BLM would apply additional resource protection measures for wildlife species within delineated habitats of DAs where species are considered a focus species. Focus species are species with existing delineated habitats that warrant additional management focus due to species status, quantity and quality of habitat, issues identified during scoping, or other factors. The development period would be slightly longer than that of the Proposed Action, resulting in

slightly fewer new wells drilled per year, on average. Development under Alternative A would occur sequentially within the DAs identified for the three phases starting with Phase 1, adjacent to the Jonah Infill Drilling Project Area. Development in Sage-Grouse PHMA would be phased during the development period, with the PHMA divided into three DAs, with one DA occurring in each phase.

6.2.4 Alternative B (Preferred Alternative)

Alternative B is the BLM Preferred Alternative and was developed to address concerns expressed during scoping associated with conserving a broad range of resource values and focusing development in the least environmentally sensitive areas. In contrast to Alternative A, where the density of development and development limitations would be based primarily on wildlife habitat for focus species, development for Alternative B is based on a broader range of resources including visual resources, paleontological resources, surface water features, identified lands with wilderness characteristics, and other resources (including wildlife habitat). Under Alternative B, the maximum number of wells is the same as for the Proposed Action, but the DA 1 area (Map 2) will have a reduced density of development, reduced surface disturbance, and more clustering of disturbance locations to reduce impacts to a range of sensitive resources in this area. For Alternative B, the development period will be slightly longer than that of the Proposed Action, resulting in slightly fewer new wells drilled per year (on average).

In addition to the Alternative B development prescriptions in the identified DAs (e.g., an average of 1 disturbance location per 640 acres in DA 1), Alternative B includes two potential development scenarios for Sage-Grouse Winter Concentration Areas:

1.) Winter Concentration Area Development Scenario 1 applies a seasonal timing limitation on development during the wintering period as identified in the BLM Wyoming Sage-Grouse RMP Amendments.

2.) Winter Concentration Area Development Scenario 2 applies the seasonal timing limitation as well as additional resource protection measures in Winter Concentration Areas, including a disturbance threshold and other measures to reduce potential impacts.

Under both scenarios, development will be allowed on a limited scale in Winter Concentration Areas. A study will be conducted concurrently with development activities to better understand the impacts of developing in Winter Concentration Areas. The results of the study, current information available at the time of site-specific permitting, and current guidance at the time of site-specific permitting will inform BLM's understanding of impacts and subsequent development in Winter Concentration Areas, which will inform analysis during site-specific NEPA reviews.

6.3 Environmentally Preferable Alternative

In accordance with CEQ regulations (40 CFR 1505.2(b)), one or more environmentally preferable alternatives must be identified in the ROD. An environmentally preferable alternative is one that will cause the least damage to the biological and physical environment, and will best protect, preserve, and enhance historic, cultural, and natural resources. The BLM has determined that the No Action Alternative is the environmentally preferable alternative. Under the No Action Alternative, the relatively low level of development (an estimated average of 3 new wells

per year for the No Action Alternative versus 350 wells per year for the action alternatives) would result in the least impact to the environment of the alternatives analyzed in detail.

6.4 Alternatives Considered, but Eliminated from Further Analysis

During the NPL Project EIS process, the BLM considered several alternatives and alternative components that were eventually eliminated from detailed analysis, including the following:

- A **wildlife and resource protection** alternative that would guide development in response to sensitive wildlife resources as well as other issues identified during scoping. This alternative was eliminated from further detailed analysis because it would be substantially similar to, and result in similar effects as, other action alternatives being analyzed.
- A **paced development** alternative that would analyze a range of development paces to respond to public and agency concerns related to project-related air emissions and impacts on air quality. This alternative was eliminated from further detailed analysis because lower paces of development may not be technically or economically feasible and because project-related emissions will be addressed by General Conformity regulations.
- A **no net increase in emissions** alternative that would address the EPA's designation of marginal ozone nonattainment for the UGRB through the use of emission offsets or credits. This alternative was eliminated from detailed analysis due to the lack of remaining offsets and credits available in UGRB that would be required to implement the alternative.
- A **Project Area-wide low density of development** alternative that would limit the density of development to one well pad per 640 acres across the entire Project Area, which would reduce surface disturbance compared to the Proposed Action and other action alternatives. This alternative was eliminated because other alternatives limit development density, it did not respond to localized issues identified during scoping, and concerns about its economic viability.
- An alternative requiring **use of surface pipelines** instead of buried pipelines to reduce surface disturbance. This alternative was eliminated from further detailed analysis because the BLM determined that, based on past and current technology and practice, surface pipelines would be technically or economically infeasible and could increase potential impacts.
- An alternative requiring onsite **evaporation ponds** to store and treat wastewater to reduce the number of vehicle trips and to reduce the need for water disposal and injection in other areas. This alternative was eliminated from detailed analysis because the BLM determined that approved operations in the Project Area may not produce enough water to make evaporation ponds technically or economically feasible, and that evaporation ponds could result in more impacts to wildlife and other resources than water disposal and injection.
- An alternative **prohibiting development in lands with wilderness characteristics** in the Project Area. This alternative was eliminated from detailed analysis for not meeting the purpose and need and not honoring valid and existing lease rights.
- A **No Action Alternative with an increased level of development**, consisting of 61 new wells per year, in the Project Area. This alternative was eliminated from detailed analysis because the BLM determined that the No Action Alternative of three new wells per year

represents the reasonably foreseeable development in the Project Area and provides a useful baseline for comparison of environmental effects resulting from the action alternatives.

- An alternative with **additional protection measures for development in Sage-Grouse Winter Concentration Areas**, including shutting in wells during the wintering period; prohibiting RGFs and powerlines; requiring all powerlines be buried; a longer seasonal timing limitation period; and other measures. This alternative was eliminated from detailed analysis because the BLM determined that these additional protection measures would not be technically or economically feasible.

7.0 MANAGEMENT CONSIDERATIONS AND RATIONALE FOR DECISION

The BLM developed the NPL EIS to consider Jonah Energy's project proposal and to decide whether to deny the proposal or, upon the submittal of site-specific permit applications, approve all project components as proposed, or approve some or all proposed project components with modifications. Based on the Final EIS analysis, the Authorized Officer has determined that Alternative B will best avoid or reduce impacts to sensitive resources while still allowing for recovery of natural gas and condensate resources, as described in Section 3 (*The Decision)* of this ROD. This alternative will allow development on valid existing leases throughout the NPL Project Area and will best meet the purpose and need of the project.

Implementation of this ROD will result in production of nationally significant natural gas resources consistent with the National Energy Policy (May 2001), the National Energy Policy Act of 2005, Executive Order 13783 on *Promoting Energy Independence and Economic Growth*, and other applicable guidance and regulations.

The sections below outline additional considerations that contributed to the BLM's approval of the Selected Alternative.

7.1 Purpose and Need for the Project

The BLM's purpose is to respond to the proposal by Jonah Energy to develop and extract hydrocarbon resources underlying Jonah Energy's federal oil and gas leases within the Project Area. The need for the action is to facilitate exploration and development of Federal oil and gas leases, within the constraints of lease terms and conditions, allowing the lessee(s) or their designated operators to drill for, extract, remove, and market federal hydrocarbon resources. This need is established by the BLM's responsibility under applicable mineral leasing and development statutes, regulations, and policies.

7.2 Analysis in the NPL Project Final EIS

The NPL Project Final EIS includes a reasonable range of alternatives that were developed based on issues identified during scoping, public comments received on draft versions of the EIS, and input from cooperating agencies and other parties during alternatives development and throughout the NPL EIS process. The NPL Project Final EIS provides an adequate analysis of potential impacts to resources that could result from the range of alternatives. The analysis in the

NPL Final EIS provides for an informed understanding of potential impacts, disclosure of these potential impacts to the public, and sufficient information to allow for an informed decision.

7.3 Multiple-Use and Resource Impacts

The decision implements the Preferred Alternative in the NPL Final EIS which provides the best balance of multiple uses within the Project Area and is best suited to sustain the long-term yield of resources while promoting stability of local and regional economies, environmental integrity, and conservation of resources for future generations (NEPA Section 101 and FLPMA, Section 302). The decision provides for the management of the Project Area in a manner that allows for natural gas exploration and development while also addressing impacts on key resources including air quality, wildlife, water, and other resources.

7.4 Conformance with BLM Land Use Plans

7.4.1 Pinedale and Green River Resource Management Plans

Policies and guidelines for development within the Project Area are contained in the BLM Approved Pinedale RMP and ROD (BLM 2008) and the BLM Approved Green River RMP and ROD (BLM 1997), including maintenance actions and amendments. Both RMPs allocate lands and/or federal minerals for leasing and provide development guidelines. The RODs associated with each RMP indicate that federal minerals will be made available for orderly and efficient development, and they require all minerals actions to comply with goals, objectives, and resource restrictions (mitigations) to protect other resource values.

The proposed development of natural gas within the Project Area is in conformance with the BLM Green River and Pinedale Approved RMPs. This decision incorporates decisions, terms, and conditions of use described in the BLM Pinedale and Green River Approved RMPs.

7.4.2 BLM Wyoming Greater Sage-Grouse Resource Management Plan Amendments

In September 2015, the BLM finalized the Greater Sage-Grouse Approved Resource Management Plan Amendments for the BLM Wyoming Casper, Kemmerer, Newcastle, Pinedale, Rawlins, and Rock Springs field offices (BLM Wyoming Sage-Grouse RMP Amendments). The BLM Wyoming Sage-Grouse RMP Amendments amended the BLM Pinedale Approved RMP and the BLM Approved Green River RMP in response to the U.S. Fish and Wildlife Service's (USFWS) March 2010 "warranted, but precluded" Endangered Species Act (ESA) listing petition decision for the Sage-Grouse. The BLM Wyoming Sage-Grouse RMP Amendment provides management of Sage-Grouse in BLM Wyoming's High Desert District.

The proposed development of natural gas within the Project Area is in conformance with the BLM Wyoming Sage-Grouse RMP Amendments. This decision incorporates goals, objectives, management decisions, and required design features from the BLM Wyoming Sage-Grouse RMP Amendments, as applicable to the NPL Project (BLM 2015a).

8.0 CONSULTATION, COORDINATION, AND PUBLIC INVOLVEMENT

The NPL Project EIS and this decision considered input from cooperating agencies, the public, potentially affected Tribes, and other stakeholders.

8.1 Cooperating Agencies

The BLM signed memoranda of understanding (MOUs) with nine agencies that worked as cooperating agencies during the preparation of the NPL Project EIS. Cooperating agencies were given opportunities to review internal drafts, attend internal meetings, and provide feedback during the development of the EIS. The nine cooperating agencies included:

- U.S. Environmental Protection Agency
- Lincoln County
- Lincoln County Conservation District
- State of Wyoming (including all appropriate state agencies)
- Sublette County
- Sublette County Conservation District
- Sweetwater County
- Sweetwater County Conservation District
- Town of Pinedale

8.2 National Historic Preservation Act Section 106 Consultation

The NPL Project EIS is a programmatic level EIS and this ROD does not authorize surface-disturbing activities. Site-specific environmental review and NEPA compliance conducted as part of the APD process will include National Historic Preservation Act (NHPA) Section 106 consultation and compliance. Class III cultural resource inventories (conducted by a qualified entity) will be required for all proposed areas of disturbance associated with each APD or other proposed project activity in accordance with Section 106 of the NHPA and the BLM Wyoming and Wyoming State Historic Preservation Officer (SHPO) State Protocol. The inventory will identify cultural resources and make recommendations regarding site eligibility, which will assist BLM with determining if those cultural resources are either eligible or ineligible for inclusion on the NRHP and whether any of the NRHP-eligible sites will be adversely affected and require mitigation.

The future delineation project proposed by Jonah Energy in the viewshed of the North Sublette Meadow Spring Variant of the Sublette Cutoff of the California National Historic Trail (NHT) will be handled according to Section 106 of the NHPA. If a delineation project is determined to be an adverse effect, a Memorandum of Agreement and mitigation for that project will be developed. This process will be used until the delineation phase is complete. Once the delineation phase is complete, if Jonah Energy decides to pursue additional development within the viewshed of the NHTs, a Programmatic Agreement will be necessary to mitigate all adverse impacts to the NHT from the proposed development prior to approving the development.

As part of the NPL Project, undertakings within the viewshed of the Sublette Cutoff and the North Sublette Meadow Springs Variant have the potential to cause adverse effects (as defined in 36 CFR §800.5(a)) to contributing segments of the NHTs. Each undertaking proposed by Jonah Energy within the NHT viewshed portion of the NPL Project Area will be analyzed according to 36 CFR 800. Should a determination of adverse effect to the NHT be made by the BLM and concurred by the Wyoming SHPO, the adverse effect will require the development of appropriate mitigation, which will be codified into an agreement document with the involvement of consulting parties (36 CFR §800.6(a)(2)). Within the viewshed of the NHT, only delineation wells and related facilities (e.g., powerlines, pipelines, and access roads) will be processed under the current State Protocol Agreement between the BLM Wyoming State Director and the Wyoming SHPO in the absence of a Programmatic Agreement.

As part of the NPL Project, project-related development and activity in the Teakettle Dune Field has the potential to result in adverse impacts to cultural resources in the Teakettle Dune Field. If development is proposed in the Teakettle Dune Field, prior to surface disturbance being authorized within the Dune Field, the BLM will further consider an appropriate management plan for development within the Teakettle Dune Field, including consideration of the Dune Field as an archaeological district.

8.3 Tribal Government-to-Government Consultation

The U.S. has a special legal relationship with Indian Tribal governments as set forth in the U.S. Constitution, treaties, statutes, regulations, EOs, and court decisions. In recognition of this unique relationship, the BLM consults with Tribes on a government-to-government basis regarding NHPA, NEPA, treaty rights, sacred sites, and broader Trust responsibilities. Prior to the scoping period, the BLM mailed Tribal consultation letters to potentially affected Tribes, formally initiating government-to-government consultation regarding the NPL Project. The BLM contacted the following Tribes through mailing consultation letters and subsequent phone calls:

- Eastern Shoshone Tribe;
- Northern Arapaho Tribe;
- Shoshone-Bannock Tribes of Fort Hall; and
- Ute Tribe of the Uinta and Ouray Reservation.

During EIS development, the BLM also invited Tribes to participate in the alternatives development workshops, the cumulative effects workshop, and other meetings. Consultations with Tribes that have an interest in the NPL Project continued throughout the EIS process, consistent with applicable regulations and guidance, including the NHPA. In accordance with the NHPA, consultations with the Wyoming SHPO were also coordinated with Tribal consultation, as appropriate. Coordination with Tribes and other appropriate parties helped identify potential cultural-resource related issues and appropriate scale of analysis for the EIS, and provided other information that was utilized for the NPL Project EIS process.

8.4 Endangered Species Act Section 7 Consultation

The BLM conducted programmatic consultation with the USFWS under Section 7 of the Endangered Species Act (ESA) as part of the NPL Project EIS process. In December 2015, the

USFWS provided the official list of federally-threatened and endangered species that may occur in the NPL Project Area and/or may be affected by the NPL Project. The USFWS species list was used as the basis for the federally-listed species included and analyzed in Chapter 4 (*Environmental Consequences*) of the NPL Project EIS. Based on the potential for impacts to the Colorado River endangered fish species, the BLM requested formal consultation with the USFWS for the NPL Project. The BLM received the draft Biological Opinion for review on May 24, 2017 and completed a review of the document on May 30, 2017. The USFWS provided the final Biological Opinion on June 13, 2017, which is included as Appendix E (*Biological Opinion)* of this ROD. All reasonable and prudent measures and terms and conditions from the final Biological Opinion have been carried forward as COAs for this ROD and can be found in Appendix A (*Resource Protection Measures).*

8.5 Public Involvement

8.5.1 Public Scoping

The formal scoping process for the NPL Project began with publication of a notice of intent (NOI) in the *Federal Register* on April 12, 2011 (76 FR 20370). The NPL Project scoping period ran from April 12 to May 12, 2011. The BLM hosted three scoping meetings held May 2–4, 2011 in Pinedale, Marbleton, and Rock Springs, Wyoming. The scoping meetings gave agencies, organizations, the public, and other interested parties an opportunity to learn and ask questions about the NPL Project and to share issues and concerns with the BLM.

A total of 48 individuals (not including Jonah Energy, BLM, or consultants working on the NPL Project) filled out registration cards at the three public scoping meetings. The BLM received 150 comment documents (scoping meeting comment forms, written comments, and email transmittals) as of May 19, 2011 (15 days after the last scoping meeting). From these comment documents, the BLM identified 1,238 individual scoping comments covering a broad range of issue categories. The greatest number of comments within the scope of the EIS were associated with wildlife (180), social and economic (150), air quality (104), and water (93). The issues of concern raised during scoping are summarized in Section 1.7 (*Public and Agency Scoping*) of the NPL Final EIS and detailed in the *NPL Natural Gas Development Project Scoping Report* (BLM 2011).

8.5.2 Draft Environmental Impact Statement

A notice of availability (NOA) was published in the Federal Register (82 FR 31628) on July 7, 2017, announcing the availability of the Draft EIS for public review and comment. The 45-day comment period closed on August 21, 2017. Following release of the Draft EIS, the BLM held public meetings at the PFO on July 25, 2017 and RSFO on July 26, 2017 to provide the public with opportunities to learn more about the project. The BLM received 3,357 comment letters (including all electronic formats and hard copies) during the public comment period for the Draft EIS. Of these, 3,134 were email letters containing the exact same—or very similar—verbiage (i.e., form letters). The BLM bracketed 1,024 individual comments from the comment letters received during the Draft EIS comment period. Appendix P (*Draft EIS Comment Summaries and Responses*) of the NPL Final EIS contains a description of the comment analysis and response process, as well as a summary of substantive comments and associated responses.

Draft EIS comments were received from 3 federal government entities, 12 State of Wyoming government entities, 2 local government entities, 80 interest groups or businesses, 1 news agency, and 125 private individuals with no identified affiliation. Key issues and concerns identified during the Draft EIS comment period included:

- Inconsistencies between Greater Sage-Grouse compensatory mitigation requirements in the NPL Draft EIS and Wyoming's Sage-Grouse Compensatory Mitigation Framework
- Inconsistencies between development restrictions in the NPL EIS and the BLM Pinedale RMP, the BLM Green River RMP, the BLM Wyoming Sage-Grouse RMP Amendments, and Wyoming EO 2015-4
- Inconsistencies between development restrictions for Sage-Grouse Winter Concentration Areas in the NPL Draft EIS and existing federal and State policies, and questions regarding the technical and economic feasibility of such development restrictions
- Concerns regarding identification of Sage-Grouse wintering areas outside of delineated Winter Concentration Areas
- Concerns regarding inclusion of compensatory mitigation requirements for pronghorn
- Requests to clarify use of the terms "migration corridors" and "migration routes"
- Failure to demonstrate NPL Project conformance with the General Conformity under the Clean Air Act and analyze an alternative that meets General Conformity requirements
- Failure to fully analyze the impacts of reducing the number of wells drilled per year to meet the Clean Air Act General Conformity requirements
- Requests to clarify parameters for delineation drilling activities in the Project Area

Substantive comments received during the Draft EIS comment period were used to refine the BLM's Preferred Alternative and to modify, clarify, and correct the EIS, as appropriate.

8.5.3 Final Environmental Impact Statement

The NOA for the Final EIS was published in the *Federal Register* on June 22, 2018, announcing the availability of the NPL Project Final EIS. The BLM received 9 comment letters during the 30-day availability period for the NPL FEIS and one comment letter shortly after the end of the availability period. Comments were received from 1 federal government entity, 3 State of Wyoming government entities, 2 local government entities, and 4 interest groups or businesses.

Comments received during the Final EIS availability period covered a range of topics including recommendations for the density of development under the Preferred Alternative, input on development in Sage-Grouse Winter Concentration Areas, concerns about how development could affect big game and Sage-Grouse, identification of new data sources, recommendations for air emissions inventories, recommendations for air and water monitoring to be considered in the ROD, clarifications on transportation routes, and clarifications on terminology in the Final EIS. The BLM considered comments received during preparation of the Record of Decision.

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Normally Pressured Lance Natural Gas Development Project

Record of Decision

Appendix A

Resource Protection Measures

APPENDIX A
RESOURCE PROTECTION MEASURES

This appendix identifies the resource protection measures that will be considered for Conditions of Approval (COAs) during site-specific permitting. During site-specific environmental review, the BLM will determine which resource protection measures to apply as COAs based on site-specific development proposals, potential impacts to resources associated with site-specific proposals, and the environmental review process during site-specific permitting.

In general, this appendix does not include measures that are policy or regulation (e.g., obtaining air quality permits or consistency with Wyoming Oil and Gas Conservation Commission regulations) or standard practice (e.g. conducting Class III cultural resource surveys prior to development). Some resource protection measures will be included as COAs during permitting for site-specific development of the NPL Project, as applicable, while some measures will be treated as guidelines for voluntary compliance by Jonah Energy. COAs apply to Jonah Energy and their contractors and are binding in the event that the facilities or infrastructure are transferred or operated by another entity. Applicability of resource protection measures is subject to valid existing lease rights. Jonah Energy will endeavor to implement the resource protection measures, but will retain the flexibility to utilize new technologies that provide equal or better resource protections while facilitating Jonah Energy's exploration, development and production goals. It is important to note that many of the OCPs cannot be effectively or cost-effectively utilized until Jonah Energy completes exploration and delineation and is developing a particular Development Area.

AIR QUALITY

Jonah Energy will install state-of-the-art air monitoring stations as required to comply with any potential WDEQ requirements. The preferred location of these air monitoring stations will be determined by WDEQ, BLM, and EPA.

Jonah Energy will utilize remote telemetry and automated wellhead equipment to reduce vehicle trips.

Jonah Energy will maintain NOX and VOC emissions below de-minimus levels through continual monitoring and taking corrective actions as appropriate.

In coordination with appropriate entities (BLM, counties, etc.), Jonah Energy will treat primary access roads, and heavily used resource roads as necessary during high use periods with BLM approved dust suppressants or gravel. Jonah Energy will water construction sites and well pad access roads as necessary to control fugitive dust during the summer. In some cases, Jonah Energy will pave roads at the discretion of BLM AO to control dust, provide all-weather access, and reduce road maintenance.

Jonah Energy will include mulching as a dust reduction technique for use when appropriate (e.g., sandy areas).

Jonah Energy will control fugitive dust associated with surface disturbing activities with the use of water or mulch during the reclamation phase.

Jonah Energy will utilize air actuated or electrically actuated controllers, or other technology with comparable emission profiles, at RGFs to eliminate VOC venting associated with gas actuated controllers. In addition, Jonah Energy will install gas capture and recovery systems (VRU technology) at RGFs to return waste gas from process equipment (dehydrators and storage tanks) to sales and limit the amount of waste gas that is sent to a combustor.

Jonah Energy will maintain combustors that meet or exceed the 98 percent destruction level required in the UGRB and in the Project Area. Venting from control and process equipment (dehydrators and storage tanks) will be captured and not vented, and will either be sent to sales utilizing vapor recovery unit technology or combusted.

Jonah Energy will use electric or air driven pneumatic pumps at the RGFs to eliminate vented emissions from these devices.

Jonah Energy will use electric compression, eliminating essentially all emissions from gas-driven compressors.

Jonah Energy will not locate any compressor facility closer than 4 miles to a dwelling or residence. Additional NEPA analysis will be required prior to the final selection of the site and authorization to construct.

Jonah Energy will not locate a well closer than 0.25 mile from a dwelling or residence.

Jonah Energy will capture and recover all production waste gas from tanks, and dehydration units. The associated pumps will be either air driven or electrically driven, eliminating emissions from these sources.

Jonah Energy will use solar powered equipment and processes whenever practicable for the NPL Project.

Jonah Energy will address transportation-related air quality concerns through implementation of a variety of strategies including multi-well pads using directional drilling, simultaneous completions operations, a small number of Regional Gathering Facilities with consolidated tank batteries for water and condensate to minimize truck traffic, dust control measures during construction and dry periods, speed limitations, and reclamation of roads and other disturbance as soon as possible.

Jonah Energy will use non-road mobile heavy construction equipment engines (rated tier 3 or better) whenever available during construction.

Jonah Energy will use drill rigs for the NPL project that are compliant with Jonah Energy's drill rig permit and meet Tier 3 equivalent emission factors or better. Jonah Energy's drill rig permit

allows the use of both natural gas powered drill rigs and diesel powered drill rigs and establishes stringent emissions requirements for both types.

Jonah Energy will enforce a "no-idle" policy for trucks except where prohibited by safety or operating conditions.

Jonah Energy will reduce emissions related to rig mobilization, de-mobilization, and construction by minimizing the number of well pads and consolidating production facilities into RGFs.

CULTURAL RESOURCES

Equipment operators must be notified that a cultural resource could be found anywhere; and if they uncover a site during construction, surface disturbing activities at the site must be halted immediately and the BLM notified.

Jonah Energy must notify their employees, contractors, and subcontractors about relevant federal regulations intended to protect archaeological and cultural resources. All personnel will be informed that collecting artifacts (including arrowheads) is a violation of federal law and that employees engaged in this activity will be subject to disciplinary action, which could include dismissal. They will also be subject to an assessment of penalties under Federal laws which may include fines and other prosecution.

Jonah Energy will participate in the creation of educational materials for cultural resources similar to Jonah Energy's role in the development of the booklet "Archaeology of the Jonah Field: 9000 Years of Human History".

Jonah Energy will collaborate with local government stakeholders and local historic preservation groups to enhance public awareness of the rich history of the Sublette Cutoff.

Jonah Energy will provide detailed information and orientation training to contractors and staff on cultural regulations in the NPL Project Area during orientation.

If Jonah Energy discovers cultural resources in culturally sensitive soils or sediments that are frozen and the condition precludes the ability to adequately record or evaluate the find by a qualified archeologist, construction work will cease and the site will be protected for the duration of frozen soil conditions. Following natural thaw, recordation, evaluation, and recommendations concerning further management will be made to the BLM AO, who will consult with affected parties. Construction will not resume until a Notice to Proceed is issued by the BLM.

- Construction in frozen ground may be done using a roto-mill. Use the narrowest of cuts possible for the first 2 feet of soil removal. Use of scrapers and backhoes is not acceptable.

Jonah Energy will avoid surface disturbing activities within one-quarter mile of a historic trail unless such disturbance will not be visible from the trail or will occur in an existing visual

intrusion area. Jonah Energy will not use historic trails as haul roads. Location of facilities outside one-quarter mile that are within view of the Sublette Cutoff and the North Meadow Spring Variant of the Sublette Cutoff will be sited by Jonah Energy to blend in with the site and the corresponding background.

Jonah Energy will educate all project-related workers on the location and development guidelines for the Sublette Cutoff and North Sublette Meadow Springs Variant to minimize potential for unintentional damage.

Jonah Energy will preserve the integrity of livestock trails. The Green River Drift Programmatic Agreement will be followed in regards to actions near this NRHP listed stock trail.

Jonah Energy will immediately halt construction activities at a site of previously undetected cultural resources where cultural resources have been discovered. The BLM will be notified and will coordinate consultation with SHPO, Native American tribes, and if necessary, the Advisory Council, to determine proper mitigation hierarchy measures pursuant to 36 CFR 800.11 or other treatment plans, programmatic agreements, or discovery plans that may direct such efforts such as the discovery plan in the BLM Wyoming and Wyoming SHPO State Protocol (BLM and SHPO 2014). Construction will not resume until a Notice to Proceed is issued by the BLM.

The BLM will consult with Native American tribes should future work impact any eligible cultural sites, sacred or religious sites, or plant/mineral gathering areas to resolve conflicts. This consultation will occur on a case-by-case basis or in conformance with an approved Native American Concerns Agreement Document.

GEOLOGY AND MINERAL RESOURCES

Jonah Energy will reclaim well locations and associated disturbances that are dry holes or abandoned producers during the first appropriate growing season.

Jonah Energy must consult with the BLM prior to proposing single-well pad locations in order to minimize surface disturbance.

HAZARDOUS MATERIALS AND SOLID WASTE

Streams, cultural sites, and paleontological locales at pipeline crossings will be protected from contamination by pipeline shutoff valves or other systems capable of minimizing accidental discharge.

Jonah Energy will keep a SDS on file in their field office for every chemical or hazardous material brought on-site per 29 CFR 1910.1200.

SPCC Plans and SWPPP will be developed and maintained by Jonah Energy during drilling and production operations as needed by WYPDES permit requirements.

- The SPCC Plan will outline methods to contain a hydrocarbon spill and strategies to facilitate rapid clean-up of any hydrocarbon spill prior to potential contamination of surface and subsurface water.
- The SWPPP plan will cover runoff from the well pad area and waters intercepted from ephemeral drainages, and will specify methods and locations of storm water discharge.
- If reserve pit leakage is detected, operations at the site will be curtailed, as directed by the BLM, until the leakage is corrected.

Jonah Energy will inventory and report on chemical and hazardous materials in accordance with the SARA Title III (40 CFR 335). If quantities exceeding 10,000 pounds or the threshold planning quantity are to be produced or stored, the appropriate Section 311 and 312 forms will be submitted at the required times to the State and County Emergency Management Coordinators and the local fire departments.

LIVESTOCK GRAZING

Jonah Energy will construct fencing where necessary (as determined by BLM range personnel and livestock grazing permittees) in order to mitigate impacts to grazing management. All fences will comply with BLM fence construction regulations. This mitigation will apply to both large scale and site-specific fences as deemed necessary by the BLM and permittees.

Jonah Energy will completely fence the perimeter of all well pads. All new fences will adhere to standards provided by BLM Handbook H-1741-1. Jonah Energy will maintain their fences. Location of fences, how long they will remain in place, and the conditions under which fences will be removed will be discussed and included during site-specific permitting.

Jonah Energy will mitigate impacts to grazing permittees and management activities as determined by permittees, the BLM, and Sublette County.

Jonah Energy will conduct two annual meetings with grazing permittees to discuss project-specific impacts and required mitigation. Jonah Energy will notify affected parties of proposed drilling and maintenance schedules during these meetings.

Throughout the life of the project, if there are any substantial changes in the Plan of Development for the NPL Project, Jonah Energy will hold additional meetings with grazing permittees.

Jonah Energy will designate a grazing contact person to act as liaison with, and single point of contact for, livestock grazing permittees and Jonah Energy. This individual will facilitate proactive communication and also coordinate and initiate regularly scheduled meetings and other forms of communication with permittees.

Jonah Energy will communicate with permittees to minimize development-related impacts to grazing operations in the NPL.

Jonah Energy will provide grazing permittees a map showing the location of new well pads and access roads when APDs are filed with the BLM.

Jonah Energy will share development plans, as they are created, with permittees.

Jonah Energy will communicate with permittees regarding pipeline construction operations through joint discussions between Jonah Energy, permittees, and the BLM.

Jonah Energy will coordinate with grazing permittees to develop aquifer and water well data.

There will be no project-related activity in the vicinity of the North Sublette Meadow Spring without consultation with the permittee from May 1 to July 1 to avoid impacts to the permittee's lambing operation.

Jonah Energy will work to control noise near lambing/calving operations.

Oil and gas or other operations will be conducted so as to retain access to cattle movement corridors (trails) so that livestock can be managed.

Jonah Energy will provide compensation for cattle lost to oil and gas activities (includes deaths from pits and animals struck on roads). This will be addressed in the same manner as a road maintenance agreement, with Jonah Energy making payment based on their level of activity and site-specific considerations, not on the proximity to the dead animal.

Pipeline projects will be conducted to allow natural movement of livestock through the field. Jonah Energy will provide gaps in the trenching process to allow livestock to move, or complete pipeline projects while cattle are not on the allotment.

Jonah Energy and other approved operators will repair any damage to the function of range improvements (e.g., fence damage, cattle guard cleaning, livestock loss) immediately.

Jonah Energy will avoid all range improvements (stock water tanks, pipelines, corrals, etc.) by 500 feet unless no other alternative is available and impacts can be mitigated as determined by the BLM AO.

Operators will mitigate all energy development related impacts to agricultural operations, in order to maintain the viability of working landscapes.

Jonah Energy will mitigate any impacts to existing livestock water such that there are no adverse impacts to livestock management, water availability, or water quality.

If project activities cause impacts to wells, springs, or surface water improvements, new water well development may be required to mitigate these impacts. Jonah Energy will be responsible for drilling, maintaining, and monitoring new stock water wells and/or improving existing water wells as determined by grazing permittees and the BLM AO.

Jonah Energy will communicate with permittees at regularly scheduled meetings to develop and adapt reclamation fencing practices to on-going circumstances as appropriate.

MONITORING AND REPORTING

Jonah Energy will continue the Jonah Enhanced Directed Inspector & Maintenance program in the NPL by inspecting and reporting on every well annually. Jonah Energy will work with WDEQ and other agencies to provide appropriate access to this information.

NOISE

To avoid potentially significant noise impacts, Jonah Energy will locate compressor engines 2,500 feet or more from a dwelling or residence.

PALEONTOLOGY

If Jonah Energy discovers paleontological resources during surface-disturbing activities, Jonah Energy will immediately suspend operations at the site and contact the BLM AO. BLM will arrange for a qualified paleontologist to determine if the resources have historic or scientific value and if necessary, recommend a recovery or avoidance plan. Mitigation of impacts to paleontological resources will be conducted on a case-by-case basis, and Jonah Energy will either avoid or protect paleontological resources.

If there is potential to encounter bedrock in areas that are underlain by either the Wasatch or Green River Formations, these areas shall be surveyed by a qualified paleontologist prior to surface disturbing activities being authorized. Based upon the findings of these surveys additional monitoring and/or mitigations may be required.

All major pipelines (> 12" in diameter) shall have an open trench inspection in areas where bedrock is encountered.

All pits and pads require a spot check if bedrock is encountered.

Monitoring, spot checks and OTI's will be done by a qualified paleontologist.

RECREATION

Jonah Energy will limit ATV use to surveying, wildlife monitoring, and vegetation management contractors.

Operators will restrict OHV activity by employees and contract workers to the immediate area of authorized activity or existing roads and trails.

SOCIOECONOMICS

Jonah Energy will conduct outreach to new business people through work with community colleges and through the Community Investment Program.

Jonah Energy will host one or more “contractor awareness” seminars to help enhance awareness of Jonah Energy’s contractor hiring practices and requirements. Jonah Energy will also work with local communities to raise awareness of how to do business with industry and Jonah Energy in particular.

Jonah Energy will continue to update the NPL website to address new issues as development commences as well as communication requirements with permittees, and other stakeholders.

Jonah Energy will support organizations faced with addressing energy development impacts in their local communities by sharing lessons learned in Sublette County and other areas.

Jonah Energy will work on economic development efforts with many of the communities in Sublette, Sweetwater, and Lincoln counties.

Jonah Energy will work with the local communities to raise awareness of how to do business with industry and Jonah Energy in particular. Per OCP recommendations, Jonah Energy commits to hosting one or more "contractor awareness" seminars to help enhance awareness of Jonah Energy's contractor hiring practices and requirements.

Jonah Energy will invite local Emergency Service entities to participate in safety meetings, as appropriate.

Jonah Energy will work with local EMS authorities during NPL development to determine appropriate siting and construction of additional helipads as needed.

Jonah Energy will work with local EMS authorities during NPL development to develop detailed maps to assist local emergency response jurisdictions with EMS planning.

Jonah Energy will ensure adequate emergency response coverage for NPL Project workers.

Jonah Energy will mark roads with reflector poles to allow EMS vehicles to better navigate roads at night or in bad weather.

Jonah Energy will post GPS coordinates and location information at each well site.

Jonah Energy will work with local EMS authorities to support volunteer recruitment of fire fighters, wherever needed.

Jonah Energy will route all emergency calls to Sublette County for dispatch to appropriate responders.

Jonah Energy will provide flexible work scheduling for employees involved in volunteer efforts and other community service such as fighting fires and EMS training.

SOIL RESOURCES

On existing well pads that are not fully developed by the second winter following construction, all bare ground will have at least a 75-percent protective cover that may include but not be limited to organic mulch, herbaceous vegetation, jute matting, or other erosion-preventive fabric. Protective cover may be excluded on active work sites (up to the wellhead with production equipment) if justified by the operator and with BLM concurrence. Refer to Appendix C (Reclamation, Monitoring, and Weed Management Plan) for more information on reclamation.

Jonah Energy will document reclamation success through a number of factors and use that information for future reclamation planning.

Jonah Energy will employ a Reclamation Specialist to continuously monitor reclamation for the NPL Project.

Jonah Energy will include the use of the Lawson Aerator in the "tool box" of available reclamation techniques.

Jonah Energy will include the use of spreader dikes in the "tool box" of available reclamation techniques.

Jonah Energy will include the use of wood chips, mulch and microbes in the "tool box" of available reclamation techniques.

Jonah Energy will revegetate exposed soils on portions of the disturbance no longer needed for operations (e.g., cut and fill slopes, portions of well pads not needed for production operations) within one growing season of the time the disturbance is no longer needed for operations. Interim reclamation (i.e., site stabilization/soil retention seeding) shall be conducted on disturbed areas that are needed for future planned operations but will not be occupied for one or more growing seasons.

Jonah Energy will reclaim each disturbed location as soon as possible. Ideally, re-seeding will occur prior to the next growing season.

Abandoned sites must be satisfactorily rehabilitated by Jonah Energy in accordance with a plan approved by the BLM. Soil samples may be analyzed to determine reclamation potential, appropriate reseeding species, and nutrient deficits. Tests may include pH, mechanical analysis, electrical conductivity, and sodium content. Terraces or elongated water breaks will be constructed after slope reduction.

Jonah Energy will salvage 6 to 12 inches of surface soil in ditches exceeding 24 inches in width where possible for the entire right-of-way.

- When Jonah Energy buries pipelines and communication lines, at least 30 inches of backfill will be on top of the pipe. Backfill should not extend above the original ground level after the fill has settled.
- Guides for construction and water bar placement are found in "Surface Operating Standards for Oil and Gas Exploration and Development" (USDA 1978).
- Jonah Energy will re-spread surface materials on the cleared route once construction is completed.
- Disturbed areas that have been reclaimed may need to be fenced by Jonah Energy when the route is near livestock watering areas.

Jonah Energy will return all disturbances to the approximate predisturbance contour of the land. Jonah Energy will consult with BLM on the need to immediately stabilize a disturbed site based off a site-specific soil analysis. To determine base line conditions and conditions after topsoil has been redistributed, the site-specific soil analysis must include biological, chemical, and physical conditions of soils as well as weather, slope, etc.

Jonah Energy will implement soil retention measures such as silt fencing, contour furrows, or hydromulching, on erosive soils at the time of disturbance.

Any mulch and mineral material (sand and gravel) used by Jonah Energy will be certified weed free and free from mold or fungi. Mulch may include native hay, small grain straw, wood fiber, live mulch, cotton, jute, synthetic netting, and rock. Straw mulch should contain fibers long enough to facilitate crimping and provide the greatest cover.

On producing locations, Jonah Energy will be required to reduce slopes to original contours (not to exceed 3:1 slopes). Areas not used for production purposes will be backfilled and blended into the surrounding terrain, reseeded, and erosion control measures installed by Jonah Energy. Erosion control measures will be required after slope reduction. Facilities will be required to approach zero runoff from the location to avoid contamination and water quality degradation downstream. Jonah Energy may be required to mulch, apply erosion control measures, and fertilize to achieve acceptable stabilization.

Jonah Energy will compact backfill over a trench to promote soil stability (not to extend above the original ground level after the fill has settled). Wheel or other method of compacting the pipeline trench backfill will be required at two levels to reduce trench settling and water channeling; once after 3 feet of fill has been replaced and once within 6 to 12 inches of the surface.

- Jonah Energy will install water bars, mulching, and terracing as determined in consultation with BLM, to minimize erosion.
- Jonah Energy will install in-stream protection structures (e.g., drop structures) as determined in consultation with BLM for drainages crossed by a pipeline to prevent erosion.

Access road(s) leading to the temporarily stabilized well pad will have protective cover to the same levels required on the well pad.

Jonah Energy will pay careful attention to the proposed road location and design to significantly minimize environmental harm. For example, shorter roads constructed on steep slopes may cost more to construct, maintain, and reclaim and can also result in greater environmental impacts than will longer roads constructed along the contours of the lands or constructed in flatter terrain.

Jonah Energy will avoid re-work and re-disturbance of pipeline segments.

Temporary disturbances that do not require major excavation (e.g., small pipelines and communication lines) will be stripped of vegetation to ground level by Jonah Energy using mechanical treatment, leaving topsoil intact and root mass relatively undisturbed.

Jonah Energy will consult with BLM in regard to the benefits of utilizing techniques such as limiting soil removal and mowing in place of blading vegetation for site development and increasing the success of reclamation.

To reduce erosion and soil loss, Jonah Energy will divert storm water away from the well location with ditches, berms, or waterbars above the cut slopes and will trap well location runoff on or near the location through the use of sediment fences or water retention ponds.

Jonah Energy will keep roads, pipelines, and pads to a minimum to reduce surface disturbance, where appropriate.

Jonah Energy will not cause any new surface disturbance in any of the following areas or conditions:

a) Slopes in excess of 25 percent.

b) Within important scenic areas (Class I and II Visual Resource Management Areas).

c) Within 500 feet of surface water and/or riparian areas.

d) Within either one-quarter mile or the visual horizon (whichever is closer) of historic trails.

e) Construction with frozen material or during periods when the soil material is saturated or when watershed damage is likely to occur. Exception, waiver, or modification of this limitation may be approved in writing, including documented supporting analysis, by the AO.

Jonah Energy will avoid adverse impacts to soils by:

- Minimizing disturbance, avoiding construction with frozen soil material
- Avoiding areas with high erosion potential (e.g., unstable soil, dunal areas, slopes greater than 25 percent, floodplains), where possible
- Salvaging and selectively handling topsoil from disturbed areas
- Adequately protecting stockpiled topsoil and replacing it on the surface during reclamation

- Leaving the soil intact (scalping only) during pipeline construction, where possible
- Using appropriate erosion and sedimentation control techniques, including, but not limited to, diversion terraces, riprap, and matting
- Promptly revegetating disturbed areas using adapted species
- Applying temporary erosion control measures (e.g., temporary vegetation cover)
- Applying biodegradable mulch, netting, or soil stabilizers
- Constructing barriers as appropriate in certain areas to minimize wind and water erosion and sedimentation prior to vegetation establishment.

Jonah Energy will limit development on slopes greater than 10 percent and with south-facing aspects with sensitive or highly erosive soils and areas with biological crusts.

Jonah Energy will limit development in areas with slopes from 15 to 25 percent and highly erodible lands with erosion ratings between 41 and 51.

Jonah Energy will use existing soil inventory and range inventory data as baseline information. A detailed site-specific inventory will be conducted prior to disturbance.

Jonah Energy will avoid upland soils classified as highly erodible in the order three soil survey. Refer to Chapter 3 and Chapter 4 soils sections of the NPL Project EIS for soils with high risk for erosion.

Jonah Energy will locate pipeline ROWs to minimize soil disturbance. Mitigation will include locating pipeline ROWs adjacent to access roads to minimize ROW disturbance widths, or routing pipeline ROWs directly to minimize disturbance lengths. In some cases, it may be appropriate to place pipelines directly on the surface.

Jonah Energy will design reclamation plans to restore the affected lands to predisturbance land uses once a project is completed. While surface-disturbing or disruptive activities continue, land uses will be mitigated using revegetation, stabilization, erosion control, and habitat enhancement. Refer to Appendix C (NPL Project Reclamation, Monitoring, and Weed Management Plan) for more information on reclamation for the NPL Project.

During saturated soil conditions, Jonah Energy will confine vehicle activity to roads designed and constructed for all-weather access (e.g., paved, graveled, and "mag-water" surfaced roads).

Jonah Energy must consult with the BLM on using mat pads or similar methods to reduce surface disturbance where applicable and feasible. Mat pads should be considered anywhere single well pads are proposed for exploratory drilling, to minimize surface disturbance.

Jonah Energy will educate the public about reclamation timeframes via tours, presentations, articles, and other venues. Jonah Energy will post signs at selected areas in the NPL area to help build public awareness of reclamation efforts.

SURFACE DISTURBANCE – SITE STABILIZATION

Jonah Energy will begin reclamation activities on disturbed wetland areas immediately after completion of project activities.

TRANSPORTATION AND ACCESS

Jonah Energy will recommend and BLM will select initial road alignments and road classes based on the potential for upgrade if the wells are completed for production.

In areas of high environmental sensitivity as determined by BLM, special road location, design, and construction and maintenance techniques will be required of Jonah Energy, as well as seasonal vehicular closures to the general public.

Jonah Energy will install supervisory control and data acquisition (SCADA) equipment on all well locations. SCADA equipment will gather well data in real time from remote locations, reducing traffic associated with well monitoring and control and allowing for identification of and rapid response to any downhole issue encountered.

Proper road location can significantly reduce or eliminate impacts to cultural, scenic, biological, and other environmental resources. Jonah Energy will contact the BLM or private surface owner to evaluate possible route locations before surveying and staking a preferred route.

When selecting a location for new roads, Jonah Energy will follow topographic contours. While laying out roads in a point-to-point approach minimizes the length of road, it often increases soil erosion, maintenance costs, long-term loss of vegetation, and visual contrast. Following natural topographic contours preserves natural drainage patterns and usually makes it possible to design a more aesthetically pleasing road with lower construction, maintenance, and reclamation costs and less impact on the environment.

Jonah Energy will submit individual road design plans for new and/or improved roads for approval as components of APDs or ROW permits. Plans must be approved prior to initiation of work. Jonah Energy will schedule a review of plans with sufficient time to obtain BLM approval prior to commencement of work.

Jonah Energy will locate roads and pipelines adjacent to existing linear facilities wherever practical.

Jonah Energy will use existing crowned and ditched roads for access where possible to minimize surface disturbance.

Clearing of pipeline and communication line rights-of-way will be accomplished with the least degree of disturbance to topsoil. Where topsoil removal is necessary, Jonah Energy will stockpile (windrow) and re-spread the topsoil over the disturbance after construction and backfilling are completed.

Vegetation removed from the ROW will be re-spread by Jonah Energy to provide protection, nutrient recycling, and a seed source.

Jonah Energy's application of produced water on roads for use in dust suppression activities on BLM-administered public lands will not be allowed unless TDS are proved to be less than 400 mg/l (state standard for the Colorado River drainage), the water does not contain hazardous material, and prior approval is obtained from BLM and WDEQ.

Roads constructed for the NPL Project that are not required for routine operation and maintenance of producing wells, ancillary facilities, livestock grazing administration, or necessary recreation access will be reclaimed by Jonah Energy as directed by the BLM. These roads will be permanently blocked, recontoured, reclaimed, and revegetated, as will disturbed areas associated with permanently plugged and abandoned wells.

Jonah Energy's reclamation of abandoned roads will include requirements for reshaping, recontouring, resurfacing with topsoil, installation of water bars, and seeding on the contour. Road beds, well pads, and other compacted areas will be ripped to a 2-foot depth on 1.5-foot centers by Jonah Energy to reduce compaction prior to spreading the topsoil across the disturbed area. Stripped vegetation will be spread over the disturbance for nutrient recycling, where practical.

Jonah Energy will provide additional erosion control measures (e.g., fiber matting) and road barriers at the discretion of BLM to discourage travel. As deemed necessary by the BLM AO, Jonah Energy will strip usable gravel from graveled roads, well pads, and other sites and haul material to new construction sites prior to ripping. Jonah Energy will remove structures such as bridges, culverts, cattleguards, and signs as required by BLM.

Jonah Energy will construct all new roads to meet the design requirements of BLM Manual 9113 (BLM 1985a). Jonah Energy will design new main artery roads to reduce sediment, salt, and phosphate loading to the Green and New Fork Rivers. Where necessary, Jonah Energy will gravel the running surfaces of roads if the base does not already contain sufficient aggregate.

At the discretion of the BLM AO, Jonah Energy will be required to monitor road construction with a qualified individual agreed to by the BLM AO and the operator. A certified civil engineer is to submit a statement that the road was built as designed within 15 days after the road has been constructed. Compaction of the subgrade with water and heavy equipment to a density higher than the surrounding subsurface is required during construction.

On newly constructed roads and permanent roads, Jonah Energy will be required to place topsoil, seeding, and stabilization material on all cut and fill slopes unless conditions prohibit this (e.g., rock). No unnecessary sidecasting of material (e.g., maintenance) by Jonah Energy on steep slopes will be allowed. Jonah Energy's snow removal plans may be required at the discretion of BLM to assure that snow removal does not adversely affect reclamation efforts or resources adjacent to the road.

Jonah Energy will regularly maintain all lease roads in a safe, usable condition. A regular maintenance program will include, but not be limited to, blading, ditching, culvert installation, drainage installation, surfacing, and cattle guards, as needed. Jonah Energy's design,

construction, and maintenance of the road will be in compliance with the standards contained in BLM Manual, Section 9113 (Roads) (BLM 1985a), and in the latest version of the "Gold Book," Oil and Gas Surface Operating Standards for Oil and Gas Exploration and Development.

As deemed necessary by the BLM AO, Jonah Energy and/or their contractors will post appropriate warning signs and require project vehicles to adhere to appropriate speed limits on project-required roads and support local law enforcement officials in enforcing speed limits to reduce fugitive dust concerns and protect human health and safety.

Jonah Energy will use the content and recommendations in the NPL transportation plan that was developed as part of the NPL Project EIS process to guide safe and efficient transportation for the NPL Project.

Jonah Energy is committed to safe travel in the NPL Project Area and will work closely with BLM to enforce speed limits and other road regulations.

Jonah Energy will utilize or upgrade existing roads instead of constructing new roads, to the extent feasible.

Jonah Energy will avoid the creation of new two-track roads. The use of existing two-track and unconstructed roads will be encouraged where such roads would withstand the proposed access activity, would provide a safe route for ingress and egress, would not result in offsite sediment discharge, could be effectively reclaimed, and would result in minimal, if any, new surface disturbance.

Jonah Energy will be required to follow transportation plans to maintain the largest undisturbed blocks of habitat possible and to minimize the acres of disturbance from roads, pipelines, power lines and other facilities within and/or associated with the NPL project area.

VEGETATION

Jonah Energy will implement the NPL weed management plan (Appendix C) during development and production.

Jonah Energy will use a variety of techniques to accelerate revegetation of reclamation and for weed prevention.

Jonah Energy, grantee, or lessee will be responsible for the control of all noxious weed infestations on surface disturbances. Prior to any treatment, Jonah Energy, grantee, or lessee will be responsible for submission of Pesticide Use Proposals and subsequent Pesticide Use Reports. Control measures will adhere to those allowed in the Final Vegetation Treatments Using Herbicides on BLM in 17 Western States Programmatic EIS (BLM 2007b) and ROD (BLM 2007c), Rock Springs District Noxious Weed Control EA (BLM 1982), the Regional Northwest Area Noxious Weed Control Program EIS (BLM 1987), and the Decision Record for Invasive Plant Management (IPM)-Kemmerer, Pinedale and Rock Springs field offices (BLM 2010). Herbicide approvals and treatments will be monitored by the BLM AO. Herbicide applications

by Jonah Energy will be kept at least 500 feet from known SSPS populations. Aerial application of chemicals by Jonah Energy is prohibited within one-quarter mile of special status plant locations, or other distance deemed safe by the BLM AO.

Jonah Energy will require equipment moving into the Project Area to be power washed.

Weed control will be conducted through an approved weed control plan and any supporting PUP and PUR. Weed monitoring and reclamation measures will be continued on an annual basis (or as frequently as the BLM determines) throughout the LOP.

Jonah Energy will monitor noxious weed and invasive non-native species of concern occurrence and implement a noxious weed/non-native species of concern control plan in cooperation with the BLM and Sublette County to ensure noxious weed and nonnative species of concern invasion does not become a problem. Weed-free certification by county extension agents will be required for grain or straw used for mulching revegetated areas. Gravel and other surfacing materials used for the project will also be certified weed-free.

Jonah Energy will seed in the fall and re-evaluate the need for remediation every three years. If needed, Jonah Energy will conduct re-seeding during the fall of the third year. Refer to Appendix C (Reclamation, Monitoring, and Weed Management Plan) for more information on reclamation for the NPL Project.

All reclamation will be accomplished by Jonah Energy as soon as possible after the disturbance occurs, with efforts continuing until a satisfactory revegetation cover is established and the site is stabilized (3 to 5 years). Only areas needed for construction will be disturbed.

Jonah Energy will revegetate road ditches and cut and fill slopes to stabilize exposed soils and reduce sediment loss, reduce the growth of noxious weeds, reduce maintenance costs, maintain scenic quality and forage, and protect habitat.

All disturbed land will be reclaimed by Jonah Energy and will utilize a diverse mix of noninvasive, certified weed free seed demonstrated effective for post-disturbance land uses and approved by the AO. In designated crucial and important wildlife habitats, this seed mix should be designed to restore predisturbance wildlife use. Refer to Appendix C (Reclamation, Monitoring, and Weed Management Plan) for more information on reclamation for the NPL Project.

On all areas Jonah Energy will reclaim, seed mixtures will be required to be site specific and composed of native species. Seed mixtures also will be required to include species promoting soil stability. A predisturbance species composition list must be developed for each site if the project encompasses an area in which several different plant communities are present. Livestock palatability and wildlife habitat needs will be given consideration in seed mix formulation. BLM guidance for native seed use is BLM Manual 1745 (Introduction, Transplant, Augmentation, and Reestablishment of Fish, Wildlife, and Plants; BLM 1985b), and Executive Order No. 11987 (Exotic Organisms).

Interseeding, secondary seeding, or staggered seeding may be required of Jonah Energy to accomplish revegetation objectives. During rehabilitation of areas in important wildlife habitat, Jonah Energy will make provisions for the establishment of native browse and forb species, if determined to be beneficial for the habitat affected.

Follow-up seeding or corrective erosion control measures may be required on areas of surface disturbance which experience reclamation failure.

Jonah Energy will finance site-specific surveys for special status plant species prior to any surface disturbance in areas determined by the BLM to contain potential habitat for such species (Directive USDI-BLM 6840). These surveys will be completed by a qualified botanist as authorized by the BLM, and this botanist will be subject to BLM's special status plant survey policy requirements. Data from these surveys will be provided to the BLM, and if any special status plant species or habitats are found, BLM recommendations for avoidance or mitigation will be implemented.

Known locations of special status plant species communities will be protected and closed to: 1) surface disturbing activities or any disruptive activity that could adversely affect the plants or their habitat; 2) the location of new mining claims (withdrawal from mineral location and entry under the land laws will be pursued); 3) mineral material sales; 4) all off-road vehicular use, including those vehicles used for geophysical exploration activities, surveying, etc.; and 5) the use of explosives and blasting.

Jonah Energy will work with BLM and other agencies to minimize the disturbance of Gardner's saltbush (Atriplex gardneri), winterfat (Krascheninnikovia lanata), and bud sagebrush (Artemisia spinescens).

Jonah Energy will protect trees, shrubs, and ground cover (not to be cleared from rights-of-way) from construction damage. Jonah Energy will be required to backfill to preconstruction condition (in a similar sequence and density) and restore normal surface drainage.

VISUAL RESOURCES

During the site-specific environmental analysis during the APD process, the BLM will consider appropriate mitigation measures and COAs to reduce adverse visual impacts from the use of solar panels.

Jonah Energy will install low profile tanks wherever visual sensitivity is an issue and/or wherever deemed the appropriate mitigation to help maintain the visual integrity and basic characteristics of the landscape.

Jonah Energy will minimize or eliminate effects to viewsheds and visibility within the NPL Project area when feasible.

In visually sensitive areas, Jonah Energy will select locations that provide for vegetative and topographic screening.

Well sites will be designed by Jonah Energy to fit the landscape and minimize construction needs. In many cases, this means designing a well site that has an irregular shape, not rectangular.

Visual contrast ratings will be required for all major projects proposed for VRM Class I, II, and III areas that have high sensitivity levels.

WATER RESOURCES

Surface Water

Jonah Energy will restore streams, wetlands, and riparian areas disturbed during project construction to as near pre-project conditions as practical, and if impermeable soils contributed to wetland formation, soils will be compacted to reestablish impermeability.

Jonah Energy will construct channel crossings by pipelines so that the pipe is buried at a depth sufficient to ensure the pipeline does not become exposed.

Jonah Energy will construct channel crossings by roads and pipelines perpendicular to flow. Streams/channels crossed by roads will have culverts installed at all appropriate locations as specified in the BLM Manual 9112-Bridges and Major Culverts (USDI, BLM 1990) and Manual 9113-Roads (BLM 1985a). All stream crossing structures will be designed to carry the 100-year discharge event or other capacities as directed by the BLM.

Jonah Energy will be restricted from crossing ephemeral, intermittent, and perennial streams associated with road and utility line construction until after spring runoff, when normal flows (e.g., no flow for ephemeral or intermittent streams; low flow or baseflow for perennial streams) are established.

If a perennial stream is proposed to be crossed, the BLM, WGFD, and Jonah Energy will meet to discuss the stream crossing and additional protections/mitigation will be developed during site-specific permitting to minimize the impacts of the stream crossing.

Jonah Energy will design and implement approved surface disturbing management actions in stream corridors (within the "high bank" of any ephemeral or intermittent stream course, or within the high bank plus 50 feet of any perennial stream) to protect fish spawning, fry, and other important fish life stages and habitats within the stream or connected streams and to maintain fish passage.

All disturbances occurring within the high bank +50 feet shall be reclaimed by Jonah Energy to meet Proper Functioning Condition (PFC) standards.

Jonah Energy or pipeline contractors will comply with state and federal regulations for water discharged into an established drainage channel. The rate of discharge will not exceed the capacity of the channel to convey the increased flow without creating alterations to the channel that could create a trend towards failing Wyoming Land Health Standards.

Waters that do not meet applicable state or federal standards will be treated or disposed of at approved facilities. The disposal of all water (hydrostatic test water, stormwater, produced water) will be conducted in conformance with WDEQ-WQD, BLM Onshore Oil and Gas Order No. 7, and WOGCC rules and regulations.

Prior to any discharge, Jonah Energy will obtain a WYPDES permit and comply with the requirements of that permit to ensure that the water meets local, State or Federal water quality standards. Jonah Energy will submit testing results and WDEQ permit to the authorized officer.

Prior to discharge of hydrostatic testing water from the pipeline, Jonah Energy will design and install a suitable energy dissipater at the outlets, and design and install suitable channel protection structures necessary to ensure that there will be no erosion or scouring of natural channels within the affected watershed as a result of such discharge. Jonah Energy will be held responsible for any erosion or scouring resulting from such discharge. Jonah Energy shall remove sandbags, rock, or other materials or objects installed from the site upon completion of hydrostatic testing.

Proposals by Jonah Energy for linear crossings (e.g., roads) within 100-year floodplains, or within 100-feet of the edge of the inner gorge of intermittent and large ephemeral drainages) will be considered by the BLM AO on a case-by-case basis.

Jonah Energy will not allow surface disturbance to occur and will not construct new permanent facilities within 100-year floodplains, wetlands, or riparian areas, except those designed and implemented to enhance wetland or riparian area condition or function. Floodplains will have no permanent structures constructed within their boundaries unless it can be demonstrated on a case-by-case basis that there is no physically practical alternative. In cases in which floodplain construction is approved, additional constraints will be applied, as appropriate, through the APD approval process.

All of Jonah Energy's surface disturbance, permanent facilities, etc., will remain a minimum of 500 feet away from the edge of surface waters, riparian areas, wetlands, and 100-year floodplains unless it is determined through site specific analysis, and approved in writing by the BLM AO, that no practicable alternative to the proposed action exists. If such a circumstance exists, then all practicable measures to mitigate possible harm to these areas be employed. These mitigating measures will be determined on a case-by-case basis and may include, but are not limited to, diking, lining, screening, mulching, terracing, and diversions. Avoidance of these features will be assessed during site-specific permitting.

All of Jonah Energy's surface disturbance will be prohibited within a 500-foot buffer from standing or flowing water, floodplains, and/or riparian/wetland areas, unless impacts to soils, watershed, water quality, and fisheries can be mitigated. No surface disturbance is allowed within 100 feet of the edge of the inner gorge of intermittent and large ephemeral drainages, without an approved plan to mitigate impacts to water quality. Linear crossings in these areas will be considered on a case-by-case basis. Avoidance of these features will be assessed during site-specific permitting.

Jonah Energy will be permitted to cross wetland areas during dry conditions (i.e., late summer, fall, or dry winters); winter construction activities will occur only prior to soil freezing or after soils have thawed.

During the period when an existing well pad is not being fully developed, there will be no sediment discharge from the existing pad. Jonah Energy will modify all existing well pads to achieve zero sediment discharge for a 25-year storm or snowmelt event.

Jonah Energy must control upland erosion from surface disturbing activities effectively and not allow sediment transport to stream systems.

Disturbances must be reclaimed or managed by Jonah Energy for zero sediment discharge. All excavations and pits must be closed by backfilling and contouring to conform to surrounding terrain. On well pads and larger locations, Jonah Energy's surface use plan will include objectives for successful reclamation such as soil stabilization, plant community composition, and desired vegetation density and diversity.

Jonah Energy will implement silt fences, straw wattles, earthen water bars, diversion ditches and other BMPs to control surface runoff; and protect natural drainages, along with any other ephemeral or permanent bodies of water.

Groundwater

Jonah Energy will work closely with livestock grazing permittees to determine the best location for new water wells using best available information.

Jonah Energy will case and cement all natural gas wells to protect subsurface mineral and freshwater zones. Jonah Energy will properly abandon and plug unproductive wells and wells that have completed their intended purpose using procedures identified by the Office of State Oil and Gas Supervisor, Rules and Regulations of WOGCC and the BLM, including Oil and Gas Onshore Order #2.

Jonah Energy will set all surface casing in accordance with WOGCC rules and regulations. All production zones will be isolated by cementing, and the top of the cement will be at least 1,000 feet above any production zone. No unprotected sections of the wellbore will exist.

All water Jonah Energy uses for the drilling of the surface casing must comply with all requirements concerning water quality as set forth by WOGCC Regulations.

Jonah Energy will disclose contents of all drilling muds, drilling additives, and completions constituents prior to drilling or completions operations as required by WOGCC. Jonah Energy will self-report all hydraulic fracturing constituents on the FracFocus clearinghouse.

In advance of development, Jonah Energy will work with appropriate federal, state and local agencies to implement an acceptable groundwater monitoring program for the NPL Project consistent with WOGCC rules to establish and monitor the quality of groundwater around sites

prior to, during and after oil and gas development. This effort will consist of utilizing Jonah Energy's substantial historical data as baseline data, groundwater and surface water monitoring and installation of additional monitoring wells, as needed. The program will include routine sampling of monitoring wells as NPL development progresses with implementation of appropriate safeguards and BMPs during all phases of development.

Jonah Energy must construct and operate all water supply wells according to all requirements of the Wyoming State Engineer's Office. Wells shall be equipped with measures and equipment to prevent backflow and/or siphoning into the well.

Jonah Energy will provide check valves, backflow preventers, or other devices for any industrial water wells and any tanks, pumps, hoses, pipes, or other associated connections that secure the well against discharge of fluids into the well.

Jonah Energy will work with livestock grazing permittees, and other stakeholder communities, to disseminate aquifer and water well data and sampling results.

Jonah Energy will recycle and reuse all produced water in the field combined with in-field injection of all waters in excess of drilling and completion needs. The injection zone will be >10,000 ppm TDS.

WILD HORSES

The appropriate mitigation to reduce impacts to wild horses and grazing will be implemented by Jonah Energy in the Little Colorado HMA.

WILDLIFE AND FISHERIES RESOURCES

General

ROW fencing associated with this project will be kept to a minimum as determined by the BLM AO. Fences will consist of four-strand barbed wire meeting WGFD approval and BLM Fencing Handbook 1741-1 standards for facilitating wildlife movement.

Jonah Energy will work closely with livestock grazing permittees and BLM to identify appropriate wildlife-friendly fencing initiatives through joint discussions between Jonah Energy, permittees, and the BLM.

Jonah Energy will use wildlife-proof fencing on reclaimed areas, in accordance with standards specified in BLM Fencing Handbook 1741-1, if it is determined by BLM that wildlife species are impeding successful vegetation establishment.

- All fences should be wildlife friendly. Fencing of reclamation to exclude wildlife should be done only after documented evidence is provided to demonstrate wildlife is impeding successful vegetation establishment following WGFD consultation.

Wildlife habitat mitigation will be carried out by Jonah Energy as quickly as possible or at the same time as the disturbance.

Well locations and associated road and pipeline routes will be selected and designed by Jonah Energy to avoid disturbances to areas of high wildlife value (e.g., raptor nest sites, wetland areas).

Jonah Energy will proactively coordinate with local government stakeholders and local historic interests to identify and resolve issues, whenever possible.

Jonah Energy will work with members of the OCP Committee, and other groups, to better understand and implement, as appropriate, components of a landscape approach to land management.

Big Game

To protect important big game winter habitat, Jonah Energy's activities or surface use will not be allowed from November 15 to April 30 within certain areas encompassed by the authorization. The same criteria apply to defined big game birthing areas from May 1 to June 30.

Jonah Energy will work with BLM, WGFD, and other stakeholders to better understand, and if possible preserve, migration routes in the Project Area.

Jonah Energy will avoid activities and facilities that create barriers to the seasonal movements of big game and livestock.

Activities by Jonah Energy in crucial habitats will be avoided when practicable.

Education and Outreach

The Jonah Energy Community Relations group will commit to coordinating with the USFWS to host "global" bird counts in specific areas of the Project Area.

Jonah Energy will provide to BLM, as appropriate, access to NPL water and wildlife information.

Jonah Energy will ensure that the message "Jonah Energy cares about wildlife" continues to be communicated to the public.

Greater Sage-Grouse

For all alternatives, development will be consistent with the BLM Wyoming Sage-Grouse RMP Amendments (BLM 2015) or more current guidance as it is adopted.

In PHMA, the density of disturbance of energy or mining facilities will be limited to an average of one site per square mile (640 acres) within the DDCT, subject to valid existing rights. The one location and cumulative value of existing disturbances will not exceed 5 percent of suitable habitat of the DDCT area. Inside PHMA, all suitable habitat disturbed (any program area) will not exceed 5 percent within the DDCT area using the DDCT process.

Sage-Grouse Leks Inside PHMA: Surface occupancy and surface-disturbing activities will be prohibited on or within a 0.6 mile radius of the perimeter of occupied sage-grouse leks.

Sage-Grouse Leks Outside PHMA: Surface occupancy and surface-disturbing activities will be prohibited on or within a 0.25 mile radius of the perimeter of occupied sage-grouse leks.

Sage-grouse breeding, nesting, and early brood-rearing habitat inside PHMA: Surface disturbing and/or disruptive activities will be prohibited from March 15 – June 30 to protect sage-grouse breeding, nesting, and early brood rearing habitat. This timing limitation will be applied throughout the PHMA. Activities in unsuitable habitats will be evaluated under the exception and modification criteria and shall be allowed on a case-by-case basis.

Sage-Grouse Breeding, Nesting, and Early Brood-rearing Habitat Outside PHMA: Surface disturbing and/or disruptive activities will be prohibited from March 15 – June 30 to protect sage-grouse nesting and early brood rearing habitats within 2 miles of the lek or lek perimeter of any occupied lek located outside PHMA.

Sage-Grouse Winter Concentration Areas: Surface disturbing and/or disruptive activities in sage-grouse winter concentration areas will be prohibited from December 1 – March 14. Protection of additional mapped winter concentration areas in GHMA will be implemented only where winter concentration areas are identified as supporting biologically significant numbers of sage-grouse nesting in PHMA and/or attending leks within PHMA. "Biologically significant numbers will be based on site-specific data collected when identifying new winter concentration areas, usually from collaring data. Any new winter concentration areas will be identified through WGFD and BLM coordination, with involvement by other appropriate parties (e.g., Sage-Grouse Implementation Team). Appropriate seasonal timing restrictions and habitat protection measures will be considered and evaluated in consultation with the WGFD in all identified winter concentration areas.

New project noise levels, either individual or cumulative, should not exceed 10 dBA (as measured by L50) above baseline noise at the perimeter of the lek from 6:00 p.m. to 8:00 a.m. during the breeding season (March 1 – May 15). Specific noise protocols for measurement and implementation will be developed as additional research and information emerges. This stipulation will apply to both development and production activities.

New ROWs (e.g., powerlines, pipelines, access roads) will be co-located within or adjacent to existing ROWs where technically feasible.

New electric distribution lines will be buried where technically and economically feasible. If not economically feasible, distribution lines may be authorized when effectively designed/mitigated to protect Sage-Grouse, and the AO determines that overhead installation is the action alternative with the fewest adverse impacts while still meeting the project need.

Power lines (distribution and transmission) will be designed to minimize wildlife related impacts and constructed to the latest APLIC standards.

New pipelines through PHMA will be allowed: (1) within an RMP corridor currently authorized for that use or designated through future RMP amendments; or (2) constructed in or adjacent to existing utilities (buried and above-ground) or roads. Pipelines constructed in RMP corridors or adjacent to existing utilities or roads will require completion of a DDCT analysis for baseline data collection but the project is not required to meet the threshold of 5 percent. However, within 6 months of the completion of construction, the project proponent will provide the AO with as-built drawings so that total disturbance within core area can be calculated annually.

New local or collector roads (as defined in BLM Manual 9113 [BLM 1985]) will be avoided within 1.9 miles of the perimeter of occupied Sage-Grouse leks within PHMAs. All new roads will be prohibited within 0.6 miles of the perimeter of occupied Sage-Grouse leks within PHMA.

Within PHMA, no upgrading of existing routes that will change route category or capacity will be allowed unless the upgrading will have minimal impact on Sage-Grouse in PHMA, is necessary for motorist safety, or eliminates the need to construct a new road.

In PHMA, existing roads or realignments will be used to access valid existing rights that are not yet developed. If valid existing rights cannot be accessed via existing roads, any new road will be constructed to the absolute minimum standard necessary, and the surface disturbance will be added to the total disturbance in the PHMA.

The BLM Wyoming Greater Sage-Grouse RMP Amendments (BLM 2015) adaptive management plan provides a means of addressing and responding to unintended negative impacts to sage-grouse and its habitat before consequences become severe or irreversible. The BLM Wyoming Greater Sage-Grouse RMP Amendments (BLM 2015) include the requirement for projects requiring an EIS to develop adaptive management strategies in support of the population management objectives for sage-grouse set by the State of Wyoming.

The BLM will apply additional appropriate mitigation consistent with Wyoming Executive Order 2015-4, the Wyoming State Mitigation Framework, the BLM MOU with the State of Wyoming and other agencies on promoting a consistent conservation strategy for Sage-Grouse, and the BLM's Approved Sage-Grouse RMP Amendments (or more current guidance as it is adopted).

The BLM will apply appropriate required design features identified in the BLM Wyoming Sage-Grouse RMP Amendments (BLM 2015) as Stipulations/ COAs/Terms and Conditions within PHMA for all program areas, as applicable.

Jonah Energy will fund studies and projects, as appropriate, to help better understand Sage Grouse winter concentrations and lek locations.

Migratory Birds

For all breeding birds observed, additional surveys will be conducted by Jonah Energy immediately prior to construction activities to search for active nest sites.

For the protection of migratory bird nests, in accordance with the Migratory Bird Treaty Act, a nest survey must be conducted prior to construction from March 15 to August 15. If a nest is present and active, monitoring will be done by Jonah Energy until the young have fledged, and Jonah Energy will not conduct any activities or surface use from March 15 to August 15, or until the young have fledged. Jonah Energy will contact a BLM wildlife biologist prior to conducting nest surveys.

Mountain Plover

For surface disturbing activities, Jonah Energy will conduct surveys within suitable plover habitat with a qualified biologist in accordance with USFWS 1999 guidelines. (A copy of the guidelines may be obtained from the USFWS, BLM, or WGFD). Two types of surveys may be conducted: 1) surveys to determine the presence/absence of breeding plovers (i.e., displaying males and foraging adults), or 2) surveys to determine nest density.

Raptors

Within Sage-Grouse PHMA, Jonah Energy will equip tanks and other above-ground facilities with structures or devices that discourage nesting and perching of raptors and corvids.

Within Sage-Grouse GHMA, Jonah Energy will equip tanks and other above-ground facilities with structures or devices that discourage nesting of raptors and corvids.

Permanent (life of the project) and high profile structures such as well locations, roads, buildings, storage tanks, overhead power lines, etc., and other structures requiring repeated human presence will not be constructed by Jonah Energy within 1,000 feet (1,400 feet for ferruginous hawks; 2,600 feet for bald eagles) of active raptor nests. Jonah Energy's wells that must be located closer than 2,600 feet (but will not be allowed closer than 2,000 feet) of a bald eagle nest will be out of the direct line of sight of the nest; will have no human activity at the well site from February 1 through August 15 except in the case of an emergency; and will locate production facilities off-site or at a central production facility location at a distance of 2,600 feet or more from the nest. In these cases, the USFWS will be contacted by Jonah Energy to ensure compliance under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. - Pinedale

All of Jonah Energy's surface-disturbing activity (e.g., road, pipeline, well pad construction, drilling, completion, workover operations) will be seasonally restricted from February 1 through July 31 within a 0.5-mile radius of all active raptor nests, except that the seasonal buffer for ferruginous hawk nests will be 1.0 mile Activities will be restricted within 1.0 mile of bald eagle nests from February 1 through August 15. An active raptor nest is defined as a nest that has been occupied within the past 3 years. Raptor nest surveys will be conducted by Jonah Energy for active nests within a 0.5- to 1.0-mile radius of proposed surface use or activity areas if such activities are proposed to be conducted between February 1 and July 31, or as required in the Pinedale Field Office raptor survey protocol. - Pinedale

To minimize impacts on raptors, actions by Jonah Energy that prohibit raptors from successfully fledging offspring are prohibited. - Pinedale

All new production facilities that have open-vent exhaust stacks will be equipped to prevent bird and bat entry or perching on the stack. - Pinedale

Surface disturbing and disruptive activities will be prohibited within ½ mile of burrowing owl nesting habitat from April 1 through August 15. - Pinedale

To protect important raptor and/or sage and sharp-tailed grouse nesting habitat, Jonah Energy's activities or surface use will not be allowed from February 1 to July 31 within certain areas encompassed by the authorization. The same criteria apply to defined raptor and game bird winter concentration areas from November 15 to April 30. March 1 to May 15 for greater sage-grouse leks and March 15 to July 15 for nesting areas are the dates applied for greater sage-grouse lek and nesting area use in the Rock Springs Field Office. – Rock Springs

Surface disturbing and disruptive activities will be prohibited from April 1 to September 10 within ½ mile of burrowing owl nest sites. – Rock Springs

Jonah Energy's surface disturbing and disruptive activities will be prohibited within 1-mile of ferruginous hawk nests from February 1 through July 31. The same restrictions apply within ½-mile of burrowing owl, coopers hawk, golden eagle, merlin, osprey, and Swainson's hawk nesting habitats. – Rock Springs

Fish

During onsite visits and site-specific permitting, the operator and BLM will assess the potential for erosion and sedimentation loading to Wyoming State Wildlife Action Plan (SWAP) Tier 1 fish species habitat in the Green River and Big Sandy River. If impacts to Tier 1 fish species are identified, the operator will work with the BLM and WGFD to identify and apply appropriate BMP's that reduce sedimentation and loss of habitat function in Tier 1 fish species habitat in the Green River and Big Sandy River.

Amphibians and Reptiles

During site-specific wildlife surveys during the APD process, Jonah Energy or their wildlife contractor will record incidental observations of amphibian and reptile species encountered. Species, geographic coordinates (preferably decimal degrees or UTM), date, age class (adult, juvenile, larval, or egg), general vegetation type, and general comments are requested for each observation. If special status species reptiles or amphibians are identified through incidental observations, the operator, BLM, and WGFD will coordinate on appropriate protection measures and monitoring during site-specific permitting during the APD process.

During site-specific permitting, if amphibian habitat cannot be avoided, the operator will work with the BLM and WGFD to determine reasonable measures to minimize impacts.

Special Status Species

Jonah Energy will characterize special status species habitat and populations within the Project Area and include appropriate avoidance and minimization measures (e.g., disturbance buffers).

While Jonah Energy is conducting operations, if substantial unanticipated environmental effects to listed, proposed, or candidate species are observed (whether effects are direct or indirect), Jonah Energy will notify BLM and BLM will initiate formal consultation with USFWS immediately in addition to cessation of all such operations.

USFWS and WGFD consultation and coordination will be conducted by BLM for all mitigation activities relating to raptors and T&E species and their habitats. All permits required for movement, removal, and/or establishment of raptor nests will be pursued by Jonah Energy if they meet USFWS migratory bird office requirements.

Jonah Energy will implement surveys for T&E and candidate wildlife species by a qualified biologist in areas of potential habitat prior to disturbance. Findings will be reviewed by the BLM prior to or as components of ROW applications and APD review processes. If T&E and/or candidate species are found in the area, consultation with the USFWS will be initiated, and construction activities will be curtailed until there is concurrence between BLM and USFWS, on what activities can be authorized.

The USFWS has determined that any withdrawal of water from the Colorado River System (surface or groundwater) will jeopardize the endangered Colorado pikeminnow, humpback chub, bonytail, and razorback sucker. The USFWS Colorado River Endangered Fish Recovery Program requires a depletion fee be paid by Jonah Energy to help support the recovery program. The fee is required for each acre-foot of water depletion where the depletion of water is in excess of 100 acre-feet from the Colorado River system.

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Normally Pressured Lance Natural Gas Development Project

Record of Decision

Appendix B

General Conformity Determination

NORMALLY PRESSURED LANCE NATURAL GAS DEVELOPMENT PROJECT

GENERAL CONFORMITY DETERMINATION

Prepared by:
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Bureau of Land Management, Wyoming State Office

July 2016

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List of Tables

Attachments

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APPENDIX B

NPL PROJECT CONFORMITY DETERMINATION

1.0 INTRODUCTION

Section 176(c)(1) of the Clean Air Act (CAA) requires any entity of the federal government that engages in, supports, or in any way provides financial support for, licenses, or permits, or approves any activity, to demonstrate that the action conforms to the applicable State Implementation Plan (SIP) for achieving and maintaining the National Ambient Air Quality Standards (NAAQS) for criteria pollutants before the action is otherwise approved (General Conformity Rule). Section 176(c)(1) also assigns primary oversight responsibility for conformity assurance to the agencies themselves, not to the United States Environmental Protection Agency (U.S. EPA) or the states. Specifically, for there to be conformity, a federal action must not contribute to new violations of standards for ambient air quality, increase the frequency or severity of existing violations, or delay timely attainment of standards in the area of concern. A General Conformity evaluation is required for project-related direct and indirect net emissions of criteria pollutants and their precursors in nonattainment or maintenance areas. The CAA defines nonattainment areas as geographic regions designated as not meeting one or more of the NAAQS.

A SIP is a state's compilation of its air quality control plans and rules that will be implemented to achieve compliance with the NAAQS. Criteria pollutants are six major air pollutants for which the U.S. EPA has established NAAQS. These pollutants are ozone (O3), particulate matter (particulate matter less than 10 microns in diameter [PM10] and particulate matter less than 2.5 microns in diameter [PM2.5]), carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), and lead.

As a result of the 2012 ozone nonattainment designation of Wyoming's Upper Green River Basin, the BLM and other federal agencies within the area must comply with the General Conformity regulations in 40 CFR 93 Subpart B and Chapter 8, Section 3 of the Wyoming Air Quality Standards and Regulations (WAQSR). Per these regulations, federal agencies must demonstrate that new actions occurring within the nonattainment area will conform with the Wyoming SIP either through an applicability analysis to demonstrate that the total of direct and indirect emissions from the proposed federal action do not exceed the de minimis emission levels specified in WAQSR Chapter 8, Section 3, or through a conformity determination if approval of the federal action will exceed the de minimis emission levels of 100 tons/year of nitrogen oxides (NOx) or volatile organic compounds (VOC), the precursor pollutants that form ozone in the atmosphere. Federal actions estimated to have an annual net emissions increase less than the de minimis levels are not required to demonstrate conformity under the General Conformity regulations. In addition, any portion of the project or action that is permitted under the State of Wyoming's New Source Review (NSR) program are excluded from the agency's general conformity analysis per Chapter 8, Section 3 of the WAQSR.

The EPA issued a Final Rule on May 4, 2016, effective June 3, 2016, that included a Determination of Attainment for the UGRB by the attainment date of July 20, 2015 for marginal nonattainment areas. This Determination of Attainment does not constitute a re-designation of

attainment. BLM and other federal agencies within the area must continue to comply with General Conformity regulations while the WDEQ meets a number of additional statutory criteria for the UGRB to be re-designated in attainment.

The proposed Normally Pressured Lance (NPL) project is located on BLM-managed land within the Upper Green River Basin ozone nonattainment area. The Project is considered a major federal action that, under the National Environmental Policy Act (NEPA), requires an Environmental Impact Statement (EIS) and a conformity analysis before the project can be authorized by the agency. The BLM has estimated the annual project emissions that would be subject to General Conformity in order to determine if the net emissions of these pollutants are above the General Conformity de minimis thresholds, and thus subject to the General Conformity Rule. This draft General Conformity Determination for the NPL project provides the BLM's analysis of the proposed action emissions as well as the BLM's Conformity analysis for the project.

2.0 GENERAL CONFORMITY RULE

The General Conformity regulations establish certain procedural requirements that must be followed when preparing a General Conformity Determination. This section addresses the regulatory background, requirements, and processes of the General Conformity Rule.

2.1 GENERAL CONFORMITY REGULATORY BACKGROUND

The U.S. EPA promulgated the General Conformity Rule on November 30, 1993 to implement the conformity provision of Title I, Section 176(c) of the federal CAA (42 U.S.C. § 7506(c)). Section 176(c)(1) requires that the federal government not engage, support, or provide financial assistance for permit or license, or approve any activity that fails to conform to an approved SIP.

The General Conformity Rule is codified in 40 Code of Federal Regulations (CFR) Part 93 (40 CFR 93), Subpart B, "*Determining Conformity of General Federal Actions to State or Federal Implementation Plans*". The General Conformity Rule applies to all federal actions, except programs and projects that require funds or approval from the U.S. Department of Transportation (U.S. DOT), the Federal Highway Administration (FHWA), or the Federal Transit Administration (FTA). In lieu of a General Conformity analysis, these latter types of programs and projects must comply with the Transportation Conformity Rule promulgated by U.S. DOT on November 24, 1993 (58 FR 62197). The federal General Conformity Rule is often incorporated into the state regulations. The State of Wyoming has incorporated the federal regulation into the WAQSR Chapter 8, Section 3: *Conformity of general federal actions to state implementation plans,* and therefore, the state has primacy and authority to enforce the General Conformity regulations.

2.2 GENERAL CONFORMITY REQUIREMENTS

As defined in the CAA, conformity means to uphold air quality goals through reduction or elimination of NAAQS violations. Accordingly, the Federal agency must demonstrate that the proposed action or activity achieves conformity by demonstrating that the associated emissions will not:

- Cause or contribute to new violations of any NAAQS in any area;
- Increase the frequency or severity of any existing violation of any NAAQS; or
- Delay timely attainment of any NAAQS or interim emission reductions.

The General Conformity Rule allows for conformity analysis in coordination with and as part of the NEPA environmental review process. The General Conformity Rule affects air pollutant emissions associated with actions that are federally-funded, licensed, permitted, or approved; and ensures the net emissions do not contribute to air quality degradation, or prevent the achievement of state and federal air quality goals. In short, General Conformity, if applicable, refers to the process to evaluate plans, programs, and projects to determine and demonstrate that they satisfy the requirements of the CAA and the SIP.

2.3 GENERAL CONFORMITY PROCESSES

The process to evaluate General Conformity for a proposed federal action involves the General Conformity applicability review and analysis, the General Conformity evaluation and determination process, and the General Conformity Determination draft review process. The applicability review process and analysis is required for any federal action (if it is not exempt) that would contribute pollutant emissions within the nonattainment area. A Conformity Determination is required for each criteria pollutant and its precursors where the total of direct and indirect net annual emissions in a nonattainment or maintenance area would equal or exceed the General Conformity de minimis thresholds. The de minimis thresholds are based on the severity of the nonattainment status. The Upper Green River Basin was designated as marginal nonattainment for ozone (2008 standard) by the U.S. EPA, thus the applicable de minimis thresholds for the ozone precursors of NOx and VOC are 100 tons per year for any Federal action. The Federal agency must prepare a draft Conformity determination which must be made publicly available for review and comment before the agency issues the final determination and decision for the Federal action.

Based on the regulatory definitions, direct emissions are caused by the action itself, such as the emissions from the construction of a facility. Indirect emissions are also caused by the action, but are removed from the action in either time or space. For example, emissions from employees commuting to a facility are indirect emissions. The General Conformity analysis for the NPL project is based on the total direct and indirect net emissions from the proposed action excluding emission sources that are permitted through WDEQ's NSR Permit Program. Since the NPL project spans many years, the year during which the emissions for the proposed action are projected to be the greatest on an annual basis was calculated and evaluated for the General Conformity analysis.

3.0 NPL PROJECT EMISSIONS

Ozone precursor emissions of NOx and VOC were calculated for each year of the project development and the year of maximum emissions for the NPL project was evaluated for General Conformity. Emissions from construction, drilling, and the operational phase of the project are included in the BLM's Conformity analysis excluding emission sources that are permitted through WDEQ's NSR Permit Program. Since Jonah Energy has a federally-enforceable drill rig permit (Air Quality Permit CT-8122A2) issued by the WDEQ through the New Source

Review program, drill rig emissions from the proposed action are presumed to conform and were also excluded from the BLM's Conformity analysis.

The original proposed drilling schedule of up to 350 wells per year resulted in estimated NO_x emissions that exceeded the 100 tpy de minimis emission threshold even after the exclusion of permitted sources. The primary emission source causing the exceedance of the de minimis threshold are the completion rigs (based on drilling 350 wells per year).

The following emission sources are permitted by the WDEQ under the authority of Chapter 6, Section 2 of the WAQSR, and were excluded from the BLM's Conformity analysis per Chapter 8, Section 3: *Conformity of general federal actions to state implementation plans:*

- Storage tanks
- Dehydration units
- Pneumatic equipment
- Separation vessels
- Truck loading
- Fugitives
- Process heaters
- Green completions
- Blowdowns

4.0 GENERAL CONFORMITY ANALYSIS

The General Conformity regulation provides options available for a Federal agency to demonstrate conformity for a Federal action, such as fully offsetting new emissions resulting in a no-net increase or the State regulatory authority for air quality can develop an emissions budget for a nonattainment area and/or incorporate Federal agency actions into the SIP. However, the requirements for Marginal nonattainment areas do not require preparation of an emissions budget or nonattainment SIP. The BLM and WDEQ have worked cooperatively to address General Conformity requirements in the UGRB for several years utilizing the annual de minimis emissions thresholds for NOx and VOCs. The only option available at this time to demonstrate conformity for the NPL project is for the BLM to reduce and limit the pace of development in order to not exceed the annual *de-minimis* emissions thresholds for NOx and VOCs.

In order to accomplish this and determine what level of development can be authorized in the Record of Decision, the BLM conducted an analysis to determine the allowable number of wells that could be drilled in the NPL project area while still meeting the NO_x and VOC emission threshold of 100 tons per year (tpy) for each pollutant. For the purposes of the BLM's General Conformity analysis, the following emission sources were quantified since these sources are <u>not</u> permitted through WDEQ's NSR Permit Program:

- Construction Mobile Equipment
- Drill Rig Mobile Equipment
- Completion Rigs
- Completion Mobile Equipment
- Workovers
- Production Mobile Equipment

- Employee and Workforce Commuting Traffic for all Phases of Development

For the Conformity emission inventory (see Attachment A), proposed well and pad counts were reduced in the proposed action inventory until the de minimis emission threshold was reached. The reduced schedule includes drilling up to 160 wells per year and construction of 10 well pads per year. This reduces the estimated NO_x emissions to 97.7 tons/year in the maximum year. Annual emission totals for the Conformity emission inventory are provided in Table 1. The complete emissions inventory developed for the Conformity determination is included as Attachment A. In modifying the original proposed action emission inventory to estimate the annual number of wells for the conformity threshold comparison, the following assumptions and modifications were made:

- The original proposed action inventory was modified to allow for the computation of the number of pads needed per year to accommodate the proposed number of wells. Based on the configuration of 16 wells per pad, 10 pads per year would be allowed.
- The ramp-up period for well drilling was changed from the original proposed values of 60, 180, and 240 wells per year for the first 3 years and 350 wells per year for all remaining years, to 60 wells per year in Year 1 and 160 wells per year in Years 2-10.
- The number of facilities and the construction schedule for facilities and other infrastructure (roads, pipelines, etc.) were analyzed at the same emissions levels as the original proposed action. However, emissions for these activities are likely to decrease as well due to the reduction in well pads and wells drilled annually.
- Although production rates and throughput would be expected to decrease with the decreased schedule of well development, production rates, traffic, and other indirect emission sources were also held at the same emission levels as the proposed action for the purposes of this analysis to ensure a conservative estimate.

Table 1. ANNUAL EMISSION TOTALS FOR GENERAL CONFORMITY DEVELOPMENT SCENARIO

Year	CO	NOx	PM10	PM2.5	SO2	VOC
1	42.8	49.5	234.2	33.9	1.7	58.9
2	51.0	97.7	461.2	66.3	3.9	58.5
3	49.0	96.7	444.8	64.4	3.9	55.7
4	48.1	97.5	461.1	66.2	3.9	58.5
5	45.8	95.5	428.4	62.6	3.8	52.6
6	45.2	96.4	444.7	64.4	3.9	55.5
7	44.3	96.3	444.7	64.4	3.9	55.4
8	43.0	95.4	428.3	62.6	3.8	52.6
9	42.6	96.2	444.7	64.4	3.9	55.3

Year	CO	NOx	PM10	PM2.5	SO2	VOC
10	41.5	95.3	428.3	62.6	3.8	52.6

Source: Refer to Attachment A (*General Conformity Emissions Inventory)*

5.0 GENERAL CONFORMITY DETERMINATION

Based on the BLM's General Conformity Development Scenario of 160 wells/years, the NPL project can be authorized at a reduced pace of development and demonstrate Conformity with the Wyoming SIP. This Conformity Determination can be revised in the future if the operator can demonstrate additional reductions in NOx emissions from the project or the State of Wyoming develops an emissions budget for the nonattainment area that is inclusive of the NPL project emissions. Either case will require the BLM to prepare a new Draft Conformity Determination for the project and require a public notice and comment period.

6.0 REFERENCES

URS Corporation. (October 2012). *CALNEV PIPELINE EXPANSION PROJECT*: *DRAFT CONFORMITY DETERMINATION*. La Jolla, CA.

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ATTACHMENT A. NPL PROJECT GENERAL CONFORMITY EMISSIONS CALCULATIONS

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NPL Natural Gas Development Field - Sublette County, Wyoming Updated 11/16/2017

Emission inventory reflects the maximum number of wells that can be drilled annually to meet the General Conformity limits of 100 tpy for NOx and VOC

Well Pad	2	2
pads/yr	10	10
pad/section	4	4
pad spacing (acre)	160	160
acres/pad	18	18
well/pad	16	16
wells/yr	160	160
development years	10	10
Construction		
days/pad	5	5
days/road seg	3	3
days/pipe seg	3	3
resource road/pad (ft)	2640	2640
resource road acre/pad	4.55	4.55
lateral pipe/pad (ft)	2640	2640
resource road ROW (ft)	75	75
PAD ROW Pipe (ft)	0	0
local road (ft)	574	574
local road ROW (ft)	60	60
Gathering Pipe (mile)	280	280
Gathering ROW (acre)	1229	1229
Gathering ROW Pipe (ft)	36	36

Notes: Resource ROW includes road and pipeline

Assumes 60 wells drilled in Year 1 and 160 wells/year drilled in Years 2-10

Pad, Road and Gas Gathering Pipeline Disturbance

Year	Pads (acres)	New Pads (number)	Local Roads (miles)	Local Roads (acres)	Resource Roads (Miles)	Resource Roads (acres)	Pipelines (miles)	Pipelines (acres)	Annual Total (acres)
Existing		0							
New	1800	100			50	454.54545	330	0	2254.5455

Well Pad Construction/Expansion - Per Acre

Project: **NPL**
Scenario: **4 Pad/Section**
Activity: **Well Pad Construction**
Emissions: **Fugitive Particulate Emissions from Well Pad Construction**

Well Pad Area (Expansion)	Worst-Case Construction Activity PM_{10} Emission Factor[1]	$PM_{2.5}$/PM10 Ratio for Fugitive Dust from Construction [2]	Construction Activity Duration[3]	Construction Activity Duration	Emission Control Efficiency	PM_{10} Emissions (controlled)	$PM_{2.5}$ Emissions (controlled)
(acre)	(tons/acre-month)		(days/acre)	(hours/day)	(%)	(lb/acre)	(lb/acre)
18	0.42	0.1	0.28	10	50	70.00	7.00

[1] Countess Environmental, 2006. WRAP Fugitive Dust Handbook. WGA Contract No. 30204-111.

[2] Countess Environmental, 2006. WRAP Fugitive Dust Handbook. WGA Contract No. 30204-111, Section 3.3.1

[3] Construction Activity Duration taken from an average of durations provided by Shell, Ultra and Questar.

Monthly emissions converted to daily and hourly emissions based on 30-day month.

Local Road Construction - Per Mile

Project: **NPL**
Scenario: **4 Pad/Section**
Activity: **Access Road Construction per Pad**
Emissions: **Fugitive Particulate Emissions from Local Road Construction**

Road Length	Local Road Area[1]	Worst-Case Construction Activity PM_{10} Emission Factor[2]	$PM_{2.5}/PM_{10}$ Ratio for Fugitive Dust from Construction [3]	Construction Activity Duration[3]	Construction Activity Duration	Emission Control Efficiency	PM_{10} Emissions (controlled)	$PM_{2.5}$ Emissions (controlled)
(mi)	(acres)	(tons/acre-month)		(days/mi)	(hours/day)	(%)	(lb/mi)	(lb/mi)
0.11	1	0.42	0.1	3	12	50	33.21	3.32

[1] Construction Area taken from average of current field activity of 4.51 acres/mile for Local Roads.

[2] Countess Environmental, 2006. WRAP Fugitive Dust Handbook. WGA Contract No. 30204-111, Section 3.3.1

[3] Construction Activity Duration taken from an average of durations provided by Shell, Ultra and Questar.

Monthly emissions converted to daily and hourly emissions based on 30-day month.

Resource Road Construction - Per Mile

Project: **NPL**
Scenario: **4 Pad/Section**
Activity: **Access Road Construction per Pad**
Emissions: **Fugitive Particulate Emissions from Resource Road Construction**

Road Length	Resource Road Area	Worst-Case Construction Activity PM_{10} Emission Factor[1]	$PM_{2.5}/PM_{10}$ Ratio for Fugitive Dust from Construction [2]	Construction Activity Duration	Construction Activity Duration	Emission Control Efficiency	PM_{10} Emissions (controlled)	$PM_{2.5}$ Emissions (controlled)
(mi)	(acres)	(tons/acre-month)		(days/mi)	(hours/day)	(%)	(lb/mi)	(lb/mi)
0.5	4.55	0.42	0.1	3	10	50	45.45	4.55

[1] Countess Environmental, 2006. WRAP Fugitive Dust Handbook. WGA Contract No. 30204-111, Section 3.3.1

[2] Construction Activity Duration taken from an average of durations provided by Shell, Ultra and Questar.

Monthly emissions converted to daily and hourly emissions based on 30-day month.

Pipeline Construction - Per Mile

Accounted for under road construction

Project: NPL
Scenario: 4 Pad/Section
Activity: Pipeline Construction per Pad
Emissions: Fugitive Particulate Emissions from Pipeline Construction

Pipeline Length	Pipeline Area[1]	Worst-Case Construction Activity PM_{10} Emission Factor[2]	$PM_{2.5}/PM_{10}$ Ratio for Fugitive Dust from Construction [3]	Construction Activity Duration[4]	Construction Activity Duration	Emission Control Efficiency	PM_{10} Emissions (controlled)	$PM_{2.5}$ Emissions (controlled)
(mi)	(acres)	(tons/acre-month)		(days/mi)	(hours/day)	(%)	(lb/mi)	(lb/mi)
2.80	12.3	0.42	0.1	14	10	50	1.20	0.12

[1] Includes both laterals and trunks.
[2] Countess Environmental, 2006. WRAP Fugitive Dust Handbook. WGA Contract No. 30204-111, Section 3.3.1
[3] Construction Activity Duration taken from an average of durations provided by Shell, Ultra and Questar.

[4]Monthly emissions converted to daily and hourly emissions based on 30-day month.
Construction Activity Duration assumed to be similar to road construction.

Other Construction Activities

Project: **NPL**
Scenario: **4 Pad/Section**
Activity: **Facility Construction**
Emissions: **Fugitive Particulate Emissions from Const. Activities**

Construction Activity	Construction Area[1] (acres)	Worst-Case Construction Activity PM_{10} Emission Factor[2] (tons/acre-month)	$PM_{2.5}/PM_{10}$ Ratio for Fugitive Dust from Construction [3]	Construction Activity Duration[4] (days)	Construction Activity Duration (hours/day)	Emission Control Efficiency (%)	PM_{10} Emissions (controlled) (lbs)	PM_{10} Emissions (controlled) (tpy)	$PM_{2.5}$ Emissions (controlled) (lbs)	$PM_{2.5}$ Emissions (controlled) (tpy)
Central Facility 1	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Central Facility 2	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Central Facility 3	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Central Facility 4	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Central Facility 5	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Central Facility 6	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Central Facility 7	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Central Facility 8	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Central Facility 9	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Central Facility 10	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Central Facility 11	15.00	0.42	0.1	4.17	10	50	875.00	0.44	87.50	0.04
Total Other Construction:	165.00	0.42	0.1	45.83	10	50	9625.00	4.81	962.50	0.48

[1] Estimated.
[2] Countess Environmental, 2006. WRAP Fugitive Dust Handbook. WGA Contract No. 30204-111, Section 3.3.1
[3] Construction Activity Duration taken from an average of durations provided by Shell, Ultra and Questar.

[4]Monthly emissions converted to daily and hourly emissions based on 30-day month.
y Duration assumed to be similar to pad construction and pipeline construction for stabilizer facility/compressor station and gathering system, respectively
Construction Activit

Construction Wind Erosion - Per Acre of Disturbance

Project: NPL
Scenario: 4 Pad/Section
Activity: Well Pad, Resource Road, Pipeline Construction
Emissions: Wind Erosion

Emission Factor (PM_{10})[1] : 0.0611 lb/hr-acre 24 hr/day
Emission Factor ($PM_{2.5}$)[1] : 0.0092 lb/hr-acre

Control Efficiency[2]: 50 %

Disturbed Area:
Well Pad Construction/Exp.: 18 acres

Access Road Construction: 5.34 acres

Pipeline Construction 12 acres

Central Facility Construction 15 acres

Emissions Calculations:

	PM_{10} Emission Factor	$PM_{2.5}$ Emission Factor	Area	Control Efficiency	Construction Hours	Controlled PM_{10} Emissions	Controlled $PM_{2.5}$ Emissions	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(lb/hr-acre)	(lb/hr-acre)	(acre)	(%)	hr per pad or facility	(lb/hr)	(lb/hr)	(ton/pad)	(ton/pad)
Well Pad Construction (per pad)	0.0611	0.0092	18.00	50	120.0	0.55	0.08	0.03	0.00
Road Construction (per pad)	0.0611	0.0092	5.34	50	151.3	0.16	0.02	0.01	0.00
Pipeline Construction (per pad)	0.0611	0.0092	12.29	50	672.0	0.38	0.06	0.13	0.02
Central Facilty Construction (per facility)	0.0611	0.0092	15.00	50	240.0	0.46	0.07	0.06	0.01

[1] See 'WindErosion Data' sheet for details.

[2] Based on AP-42 Chapter 13.2.5 (EPA 2004) Industrial Wind Erosion using Area meteorological data.
AP-42 (EPA 2004), Section 13.2.3, "Heavy Construction Operations".

Well Pad Construction Traffic

Project: NPL
Scenario: 4 Pad/Section
Activity: Pad Const. Traffic
Emissions: Fugitive Particulate Emissions from Traffic on Unpaved Roads

Vehicle Type	Road Type	Dust Control Method[1]	Average Vehicle Weight (lb)	Average Vehicle Speed (mph)	Silt Content[2] (%)	Moisture Content[3] (%)	Vehicle Count	Round Trips (RTs) (RT/pad)	RT Distance (miles)	Vehicle Miles Traveled (VMT)[4] (VMT/pad)	Emission Control Efficiency[5] (%)	PM_{10} Emission Factor[6] (lb/VMT)	$PM_{2.5}$ Emission Factor[6] (lb/VMT)	PM_{10} Emissions[7] (controlled) (lb/pad)	$PM_{2.5}$ Emissions[7] (controlled) (lb/pad)	
3/4 ton Pickup	Local	Chemical + Restriction	5,800	25	5.1	2.4	5	11	34	1870	85	0.51	0.05	143.01	14.21	1b
	Resource	Water + Restriction	5,800	20	5.1	2.4	5	11	1	55	50	0.68	0.07	18.81	1.88	1a
1 ton Roustabout w/ trailer	Local	Chemical + Restriction	7,500	25	5.1	2.4	1	2	34	68	85	0.51	0.05	5.20	0.52	1b
	Resource	Water + Restriction	7,500	20	5.1	2.4	1	2	1	2	50	0.77	0.08	0.77	0.08	1a
Semi w/ bellydump	Local	Chemical + Restriction	70,000	25	5.1	2.4	1	10	34	340	85	0.51	0.05	26.00	2.58	1b
	Resource	Water + Restriction	70,000	20	5.1	2.4	1	10	1	10	50	2.10	0.21	10.49	1.05	1a
Semi w/ lowboy trailer	Local	Chemical + Restriction	75,000	25	5.1	2.4	2	2	34	136	85	0.51	0.05	10.40	1.03	1b
	Resource	Water + Restriction	75,000	20	5.1	2.4	2	2	1	4	50	2.16	0.22	4.33	0.43	1a
Bulk fuel truck	Local	Chemical + Restriction	35,000	25	5.1	2.4	1	1	34	34	85	0.51	0.05	2.60	0.26	1b
	Resource	Water + Restriction	35,000	20	5.1	2.4	1	1	1	1	50	1.54	0.15	0.77	0.08	1a
Water Truck	Local	Chemical + Restriction	35,000	25	5.1	2.4	1	5	34	170	85	0.51	0.05	13.00	1.29	1b
	Resource	Water + Restriction	35,000	20	5.1	2.4	1	5	1	5	50	1.54	0.15	3.84	0.38	1a
													Total Unpaved Road Traffic Emissions (lb/pad)	167.78	16.69	

[1] Dust control methods include using water (resource road) or chemical (loacal road) as a dust suppressants along with vehicle restriction speed limit of 25 mph.

[2] AP-42 (EPA 2004), Table 13.2.2-1, Western surface coal mining - plant road, "Typical Silt Content Values of Surface Material on Industrial and Rural Unpaved Roads."

[3] AP-42 (EPA 2004), Table 11.9-3, "Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations."

[4] Calculated as Round Trips per Vehicle Type x Round Trip Distance.

[5] Fugitive Dust Handbook (WRAP 2006) Chapter 6.

[6] AP-42 (EPA 2004), Figure 13.2.2-2, "Watering control effectiveness for unpaved travel surfaces.", AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b.

[7] Calculated as lb/VMT x VMT/pad x control efficiency.

Road Construction Traffic - All Operators

Most Accounted for under Pad Construction

Project: NPL
Scenario: 4 Pad/Section
Activity: Resource Road Const. Traffic
Emissions: Fugitive Particulate Emissions from Traffic on Unpaved Roads

Vehicle Type	Road Type	Dust Control Method[1]	Average Vehicle Weight	Average Vehicle Speed	Silt Content[2]	Moisture Content[3]	Vehicle Count	Round Trips (RTs)	RT Distance	Vehicle Miles Traveled (VMT)[4]	Emission Control Efficiency[5]	PM_{10} Emission Factor[6]	$PM_{2.5}$ Emission Factor[6]	PM_{10} Emissions[7] (controlled)	$PM_{2.5}$ Emissions[7] (controlled)
			(lb)	(mph)	(%)	(%)		(RT/pad)	(miles)	(VMT/pad)	(%)	(lb/VMT)	(lb/VMT)	(lb/pad)	(lb/pad)
3/4 ton Pickup	Local	Chemical + Restriction	5,800	25	5.1	2.4	5	6	34	1020	85	0.51	0.05	78.00	7.75
	Resource	Water + Restriction	5,800	20	5.1	2.4	5	6	1	30	50	0.68	0.07	10.26	1.03
1 ton Roustabout w/ trailer	Local	Chemical + Restriction	7,500	25	5.1	2.4	1	2	0	0	85	0.51	0.05	0.00	0.00
	Resource	Water + Restriction	7,500	20	5.1	2.4	1	2	0	0	50	0.77	0.08	0.00	0.00
Semi w/ bellydump	Local	Chemical + Restriction	70,000	25	5.1	2.4	1	10	0	0	85	0.51	0.05	0.00	0.00
	Resource	Water + Restriction	70,000	20	5.1	2.4	1	10	0	0	50	2.10	0.21	0.00	0.00
Semi w/ lowboy trailer	Local	Chemical + Restriction	75,000	25	5.1	2.4	2	2	0	0	85	0.51	0.05	0.00	0.00
	Resource	Water + Restriction	75,000	20	5.1	2.4	2	2	0	0	50	2.16	0.22	0.00	0.00
Bulk fuel truck	Local	Chemical + Restriction	35,000	25	5.1	2.4	1	1	0	0	85	0.51	0.05	0.00	0.00
	Resource	Water + Restriction	35,000	20	5.1	2.4	1	1	0	0	50	1.54	0.15	0.00	0.00
Water Truck	Local	Chemical + Restriction	35,000	25	5.1	2.4	1	5	0	0	85	0.51	0.05	0.00	0.00
	Resource	Water + Restriction	35,000	20	5.1	2.4	1	5	0	0	50	1.54	0.15	0.00	0.00
													Total Unpaved Road Traffic Emissions (lb/pad)	88.26	8.78

[1] Dust control methods include using water (resource road) or chemical (loacal road) as a dust suppressants along with vehicle restriction speed limit of 25 mph.

[2] AP-42 (EPA 2004), Table 13.2.2-1, Western surface coal mining - plant road, "Typical Silt Content Values of Surface Material on Industrial and Rural Unpaved Roads."

[3] AP-42 (EPA 2004), Table 11.9-3, "Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations."

[4] Calculated as Round Trips per Vehicle Type x Round Trip Distance.

[5] Fugitive Dust Handbook (WRAP 2006) Chapter 6.
AP-42 (EPA 2004), Figure 13.2.2-2, "Watering control effectiveness for unpaved travel surfaces.",

[6] AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b.

[7] Calculated as lb/VMT x VMT/pad x control efficiency.

Pipeline Construction Traffic

Project: NPL
Scenario: 4 Pad/Section
Activity: Pipeline Construction
Emissions: Fugitive Particulate Emissions from Unpaved Road Traffic

Vehicle Type	Road Type	Dust Control Method[1]	Average Vehicle Weight[2] (lb)	Average Vehicle Speed (mph)	Silt Content[3] (%)	Moisture Content[4] (%)	Vehicle Count	RTs per mile	RT Distance (miles)	VMT[5] (VMT/pad)	Emission Control Efficiency[6] (%)	PM_{10} Emission Factor[7] (lb/VMT)	$PM_{2.5}$ Emission Factor[7] (lb/VMT)	PM_{10} Emissions[8] (controlled) (lb/pad)	$PM_{2.5}$ Emissions[8] (controlled) (lb/pad)
Light truck/pick-ups	Local	Chemical + Restriction	5,800	25	5.1	2.4	10	28	34	9520	85	0.51	0.05	728.03	72.36
	Resource	Water + Restriction	5,800	20	5.1	2.4	10	28	1	280	50	0.68	0.07	95.75	9.58
Sideboom	Local	Chemical + Restriction	70,000	25	5.1	2.4	3	0.1	34	10.2	85	0.51	0.05	0.78	0.08
	Resource	Water + Restriction	70,000	20	5.1	2.4	3	0.1	1	0.3	50	2.10	0.21	0.31	0.03
Trencher	Local	Chemical + Restriction	43,000	25	5.1	2.4	1	0.1	34	3.4	85	0.51	0.05	0.26	0.03
	Resource	Water + Restriction	43,000	20	5.1	2.4	1	0.1	1	0.1	50	1.68	0.17	0.08	0.01
Track Hoe	Local	Chemical + Restriction	45,000	25	5.1	2.4	3	0.1	34	10.2	85	0.51	0.05	0.78	0.08
	Resource	Water + Restriction	45,000	20	5.1	2.4	3	0.1	1	0.3	50	1.72	0.17	0.26	0.03
Dozer	Local	Chemical + Restriction	28,500	25	5.1	2.4	1	0.1	34	3.4	85	0.51	0.05	0.26	0.03
	Resource	Water + Restriction	28,500	20	5.1	2.4	1	0.1	1	0.1	50	1.40	0.14	0.07	0.01
Grader	Local	Chemical + Restriction	51,000	25	5.1	2.4	1	0.1	34	3.4	85	0.51	0.05	0.26	0.03
	Resource	Water + Restriction	51,000	20	5.1	2.4	1	0.1	1	0.1	50	1.82	0.18	0.09	0.01
													Total Unpaved Road Traffic Emissions (lb/pad)	826.59	82.21

[1] Dust control methods include using water (resource road) or chemical (loacal road) as a dust suppressants along with vehicle restriction speed limit of 25 mph.

[2] Semi vehicle weight range is 28,000-60,000 lbs; average weight of 44,000 lbs used for calculations.

[3] AP-42 (EPA 2004), Table 13.2.2-1, Western surface coal mining - plant road, "Typical Silt Content Values of Surface Material on Industrial and Rural Unpaved Roads."

[4] AP-42 (EPA 2004), Table 11.9-3, "Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations."

[5] Calculated as Round Trips per Vehicle Type x Round Trip Distance.

[6] Fugitive Dust Handbook (WRAP 2006) Chapter 6.

[7] AP-42 (EPA 2004), Figure 13.2.2-2, "Watering control effectiveness for unpaved travel surfaces.", AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b.

[8] Calculated as lb/VMT x VMT/pad x control efficiency.

Well Pad Construction - Heavy Equipment Tailpipe

Project: NPL
Scenario: 4 Pad/Section
Activity: Pad Construction Heavy Equip.
Emissions: Diesel Combustion Emissions from Heavy Equipment Tailpipes

Heavy Equipment	Engine Horsepower (hp)	Number Required	Operating Load Factor[1]	Pollutant Emission Factor[2] (g/hp-hr)																Construction Activity Duration	
				CO	NO_x	SO_2	VOC	PM_{10}	$PM_{2.5}$	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4[3]	CO_2	N_2O[3]	(days/pad)	(hrs/day)
Cat 430D Backhoe	94	1	0.43	7.36	6.61	0.15	1.59	1.14	1.1								0.10226601	692	6.82E-03	1.5	8
Cat D8R Dozer	350	1	0.43	1.26	3.91	0.12	0.3	0.25	0.24								0.079270936	536.4	5.28E-03	5	9
Cat 627F Scraper	350	2.5	0.43	1.26	3.94	0.12	0.3	0.25	0.25								0.079270936	536.4	5.28E-03	4	9
Cat 14H Grader	220	1	0.43	1.47	4.08	0.12	0.33	0.32	0.31								0.079256158	536.3	5.28E-03	5	9

Pollutant Emissions (lb/pad)

CO	NO_x	SO_2	VOC	PM_{10}	$PM_{2.5}$	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
7.9	7.1	0.2	1.7	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	740.0	0.0
18.8	58.4	1.8	4.5	3.7	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	8008.8	0.1
37.6	117.7	3.6	9.0	7.5	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	16017.5	0.2
13.8	38.3	1.1	3.1	3.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	5033.1	0.0

HD Vehicle traffic Emissions[4]

	miles/pad	g/mile														
		CO	NO_x	SO_2	VOC	PM_{10}	$PM_{2.5}$	Benzene	Ethylbe	Formal	H_2S	n-Hexa	Toluene	Xylenes	CH_4[3]	CO_2	N_2O[3]
1 ton Roustabout w/ trailer	70	2.25E+00	9.64E+00	1.47E-02	3.76E-01	5.02E-01	4.44E-01	4.07E-03		3.03E-02					2.67E-02	1.94E+03	1.76E-03
Semi w/ bellydump	350	2.25E+00	9.64E+00	1.47E-02	3.76E-01	5.02E-01	4.44E-01	4.07E-03		3.03E-02					2.67E-02	1.94E+03	1.76E-03
Semi w/ lowboy trailer	140	2.25E+00	9.64E+00	1.47E-02	3.76E-01	5.02E-01	4.44E-01	4.07E-03		3.03E-02					2.67E-02	1.94E+03	1.76E-03
Bulk fuel truck	35	2.16E+00	8.64E+00	1.15E-02	4.00E-01	4.74E-01	4.12E-01	4.33E-03		3.23E-02					2.76E-02	1.52E+03	1.88E-03
Water Truck	175	2.16E+00	8.64E+00	1.15E-02	4.00E-01	4.74E-01	4.12E-01	4.33E-03		3.23E-02					2.76E-02	1.52E+03	1.88E-03
		lb/pad															
1 ton Roustabout w/ trailer		3.47E-01	1.49E+00	2.26E-03	5.80E-02	7.74E-02	6.86E-02	6.28E-04		4.68E-03					4.12E-03	3.00E+02	2.72E-04
Semi w/ bellydump		1.74E+00	7.44E+00	1.13E-02	2.90E-01	3.87E-01	3.43E-01	3.14E-03		2.34E-02					2.06E-02	1.50E+03	1.36E-03
Semi w/ lowboy trailer		6.94E-01	2.98E+00	4.52E-03	1.16E-01	1.55E-01	1.37E-01	1.26E-03		9.36E-03					8.25E-03	6.00E+02	5.44E-04
Bulk fuel truck		1.66E-01	6.67E-01	8.87E-04	3.09E-02	3.66E-02	3.18E-02	3.34E-04		2.49E-03					2.13E-03	1.18E+02	1.45E-04
Water Truck		8.32E-01	3.33E+00	4.44E-03	1.54E-01	1.83E-01	1.59E-01	1.67E-03		1.25E-02					1.07E-02	5.88E+02	7.24E-04
Total Heavy Equipment Tailpipe Emissions		81.9	237.3	6.7	18.9	16.3	15.9	0.0	0.0	0.1	0.0	0.0	0.0	0.0	4.4	32906.3	0.3

[1] Taken from "Median Life Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, Table 9, 7-cycle average (7/2010)

[2] Emission factors from NONROADS 2008, run for 2009.
Fuel Oxygen 2.440 wt%;Dsl Sulfur 0.0351 %

[3] CO_2 = 10.15 kg CO2 / gal diesel fuel. CO2 value provided in NOANROADs 2008 run for 2009. NO2 and CHR are not. CH4=0.0015 kg/gal diesel fuel, NO2 = 0.001 kg/gal diesel fuel
Factor for CH4 = 0.0015/10.15, factor for NO2 = 0.0001/10.15

[4] MOVES 2013

Road Construction - Heavy Equipment Tailpipe

Project: NPL
Scenario: 4 Pad/Section
Activity: Road Construction Heavy Equip.
Emissions: Diesel Combustion Emissions from Heavy Equipment Tailpipes

Heavy Equipment	Engine Horsepower	Number Required	Operating Load Factor[1]	Pollutant Emission Factor[2] (g/hp-hr)																Construction Activity Duration	
	(hp)			CO	NO_x	SO_2	VOC	PM_{10}	$PM_{2.5}$	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4[3]	CO_2	N_2O[3]	(days/pad)	(hrs/day)
Cat 430D Backhoe	94	1	0.43	7.36	6.61	0.15	1.59	1.14	1.1								0.102	692	6.82E-03	0.9	8
Cat D8R Dozer	350	1	0.43	1.26	3.91	0.12	0.3	0.25	0.24								0.079	536.4	5.28E-03	3	9
Cat 627F Scraper	350	2.5	0.43	1.26	3.94	0.12	0.3	0.25	0.25								0.079	536.4	5.28E-03	2.4	9
Cat 14H Grader	220	1	0.43	1.47	4.08	0.12	0.33	0.32	0.31								0.079	536.3	5.28E-03	3	9

Pollutant Emissions (lb/pad)

	CO	NO_x	SO_2	VOC	PM_{10}	$PM_{2.5}$	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
	4.7	4.2	0.1	1.0	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	444.0	0.0
Cat 430D Backhoe	11.3	35.0	1.1	2.7	2.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	4805.3	0.0
Cat D8R Dozer	22.6	70.6	2.2	5.4	4.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	9610.5	0.1
Cat 627F Scraper	8.3	23.0	0.7	1.9	1.8	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	3019.9	0.0
Cat 14H Grader																
Total Heavy Equipment Tailpipe Emissions	46.9	132.8	4.0	10.9	9.3	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	17879.6	0.2

[1] Taken from "Median Life Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, Table 9, 7-cycle average (7/2010)

[2] Emission factors from NONROADS 2008, run for 2009.
Fuel Oxygen 2.440 wt%;Dsl Sulfur 0.0351 %

[3] CO_2 = 10.15 kg CO2 / gal diesel fuel. CO2 value provided in NOANROADs 2008 run for 2009. NO2 and CHR are not. CH4=0.0015 kg/gal diesel fuel, NO2 = 0.001 kg/gal diesel fuel
Factor for CH4 = 0.0015/10.15, factor for NO2 = 0.0001/10.15

Pipeline Heavy Equipment Tailpipe

Project: NPL
Scenario: 4 Pad/Section
Activity: Pipeline Construction
Emissions: Diesel Combustion Emissions from Heavy Equipment Tailpipes

Heavy Equipment	Engine Horsepower	Number Required	Operating Load Factor[1]	Pollutant Emission Factor[2] (g/hp-hr)																Construction Activity Duration	
	(hp)																			(days/mile)	(hrs/day)
				CO	NO_x	SO_2	VOC	PM_{10}	$PM_{2.5}$	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4[3]	CO_2	N_2O[3]		
Sideboom	240	3	0.43	1.06	4.6	0.11	0.35	0.25	0.25								0.078	530.5	5.23E-03	10	10
Trencher	215	1	0.43	1.57	4.61	0.12	0.35	0.3	0.29								0.079	536.3	5.28E-03	10	10
Track Hoe	150	3	0.43	7.77	6.69	0.15	1.59	1.19	1.16								0.102	691.9	6.82E-03	10	10
Dozer	125	1	0.43	3.92	4.69	0.13	0.47	0.54	0.52								0.088	595.3	5.87E-03	10	10
Grader	185	1	0.43	1.47	4.08	0.12	0.33	0.32	0.31								0.079	536.3	5.28E-03	10	10

Pollutant Emissions (lb/pad) << these are per mile when summing multiply by miles/pad

	CO	NO_x	SO_2	VOC	PM_{10}	$PM_{2.5}$	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
Sideboom	72.3	314.0	7.5	23.9	17.1	17.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	36208.7	0.4
Trencher	32.0	94.0	2.4	7.1	6.1	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	10930.5	0.1
Track Hoe	331.5	285.4	6.4	67.8	50.8	49.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	29515.6	0.3
Dozer	46.5	55.6	1.5	5.6	6.4	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	7054.1	0.1
Grader	25.8	71.6	2.1	5.8	5.6	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	9405.3	0.1
Total Emissions from Heavy Equipment Tailpipes	508	820	20	110	86	84	0	0	0	0	0	0	0	14	93114	1

appears to be per mile

[1] Taken from "Median Life Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, Table 9, 7-cycle average (7/2010)

[2] Emission factors from NONROADS 2008, run for 2009.
Fuel Oxygen 2.440 wt%;Dsl Sulfur 0.0351 %

[3] CO_2 = 10.15 kg CO2 / gal diesel fuel. CO2 value provided in NOANROADs 2008 run for 2009. NO2 and CHR are not. CH4=0.0015 kg/gal diesel fuel, NO2 = 0.001 kg/gal diesel fuel
Factor for CH4 = 0.0015/10.15, factor for NO2 = 0.0001/10.15

Compressor Station Construction - Heavy Equipment Tailpipe

Project: NPL
Scenario: 4 Pad/Section
Activity: Compressor Station Construction Heavy Equip.
Emissions: Diesel Combustion Emissions from Heavy Equipment Tailpipes

Heavy Equipment	Engine Horsepower	Number Required	Operating Load Factor[1]	Pollutant Emission Factor[2] (g/hp-hr)																Construction Activity Duration	
	(hp)			CO	NO_x	SO_2	VOC	PM_{10}	$PM_{2.5}$	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4[3]	CO_2	N_2O[3]	(days/pad)	(hrs/day)
Cat 430D Backhoe	94	1	0.43	7.36	6.61	0.15	1.59	1.14	1.1								0.102	692	6.82E-03	1.5	8
Cat D8R Dozer	350	1	0.43	1.26	3.91	0.12	0.3	0.25	0.24								0.079	536.4	5.28E-03	5	9
Cat 627F Scraper	350	2.5	0.43	1.26	3.94	0.12	0.3	0.25	0.25								0.079	536.4	5.28E-03	4	9
Cat 14H Grader	220	1	0.43	1.47	4.08	0.12	0.33	0.32	0.31								0.079	536.3	5.28E-03	5	9

Pollutant Emissions (lb/pad)

	CO	NO_x	SO_2	VOC	PM_{10}	$PM_{2.5}$	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
Cat 430D Backhoe	7.9	7.1	0.2	1.7	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	740.0	0.0
Cat D8R Dozer	18.8	58.4	1.8	4.5	3.7	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	8008.8	0.1
Cat 627F Scraper	37.6	117.7	3.6	9.0	7.5	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	16017.5	0.2
Cat 14H Grader	13.8	38.3	1.1	3.1	3.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	5033.1	0.0
Total Heavy Equipment Tailpipe Emissions	78.1	221.4	6.7	18.2	15.4	15.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	29799.3	0.3

[1] Taken from "Median Life Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, Table 9, 7-cycle average (7/2010)

[2] Emission factors from NONROADS 2008, run for 2009.

Fuel Oxygen 2.440 wt%;Dsl Sulfur 0.0351 %

[3] CO_2 = 10.15 kg CO2 / gal diesel fuel. CO2 value provided in NOANROADs 2008 run for 2009. NO2 and CHR are not. CH4=0.0015 kg/gal diesel fuel, NO2 = 0.001 kg/gal diesel fuel

Factor for CH4 = 0.0015/10.15, factor for NO2 = 0.0001/10.15

Drilling Traffic

Project: NPL
Scenario: 4 Pad/Section
Activity: Drilling
Emissions: Fugitive Particulate Emissions from Traffic on Unpaved Roads

Vehicle Type	Road Type	Dust Control Method[1]	Average Vehicle Weight (lb)	Average Vehicle Speed (mph)	Silt Content[2] (%)	Moisture Content[3] (%)	Vehicle Count	RTs per Well	RT Distance (miles)	VMT [4] (VMT/Well)	Emission Control Efficiency[5] (%)	PM_{10} Emission Factor[6] (lb/VMT)	$PM_{2.5}$ Emission Factor[6] (lb/VMT)	PM_{10} Emissions[6] (controlled) (lb/pad)	$PM_{2.5}$ Emissions[6] (controlled) (lb/pad)
Light truck/pick-ups	Local Road	Chemical + Restriction	5,800	25	5.1	2.4	1	40	6	240	85	0.51	0.05	293.66	29.19
	Resource Road	Water + Restriction	5,800	20	5.1	2.4	1	40	10	400	50	0.68	0.07	2,188.60	218.86
Tandem Tractor Drilling muds	Local Road	Chemical + Restriction	60,000	20	5.1	2.4	1	2	34	68	85	0.46	0.05	74.41	7.39
	Resource Road	Water + Restriction	60,000	15	5.1	2.4	1	2	10	20	50	1.96	0.20	313.16	31.32
Tandem Tractor Fresh Water	Local Road	Chemical + Restriction	60,000	20	5.1	2.4	1	15	8	120	85	0.46	0.05	131.31	13.04
	Resource Road	Water + Restriction	60,000	15	5.1	2.4	1	15	10	150	50	1.96	0.20	2,348.67	234.87
Tandem Tractor Processed Water	Local Road	Chemical + Restriction	60,000	20	5.1	2.4	1	50	10	500	85	0.46	0.05	547.14	54.34
	Resource Road	Water + Restriction	60,000	15	5.1	2.4	1	50	10	500	50	1.96	0.20	7,828.91	782.89
Tandem Tractor Casing	Local Road	Chemical + Restriction	60,000	20	5.1	2.4	1	2	34	68	85	0.46	0.05	74.41	7.39
	Resource Road	Water + Restriction	60,000	15	5.1	2.4	1	2	10	20	50	1.96	0.20	313.16	31.32
Tandem Tractor Cement	Local Road	Chemical + Restriction	60,000	20	5.1	2.4	1	2	34	68	85	0.46	0.05	74.41	7.39
	Resource Road	Water + Restriction	60,000	15	5.1	2.4	1	2	10	20	50	1.96	0.20	313.16	31.32
Light Duty Misc	Local Road	Chemical + Restriction	5,000	20	5.1	2.4	1	20	34	680	85	0.46	0.05	744.12	73.90
	Resource Road	Water + Restriction	5,000	15	5.1	2.4	1	20	10	200	50	0.64	0.06	1,023.60	102.36
Company Man	Local Road	Chemical + Restriction	5,800	25	5.1	2.4	1	10	6	60	85	0.51	0.05	73.42	7.30
	Resource Road	Water + Restriction	5,800	20	5.1	2.4	1	10	10	100	50	0.68	0.07	547.15	54.71
													Total Unpaved Road Traffic Emissions (lb/pad)	16,889.28	1,687.57

[1] Dust control methods include using water (resource road) or chemical (loacal road) as a dust suppressants along with vehicle restriction speed limit of 25 mph.

[2] AP-42 (EPA 2004), Table 13.2.2-1, "Typical Silt Content Values of Surface Material on Industrial and Rural Unpaved Roads."

[3] AP-42 (EPA 2004), Table 11.9-3, "Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations."

[4] Calculated as Round Trips per Vehicle Type x Round Trip Distance.

[5] Fugitive Dust Handbook (WRAP 2006) Chapter 6.

[6] AP-42 (EPA 2004), Figure 13.2.2-2, "Watering control effectiveness for unpaved travel surfaces.", AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b.

[7] Calculated as lb/VMT x VMT/pad x control efficiency.

Rig Move Traffic

Project: NPL
Scenario: 4 Pad/Section
Activity: Rig Move
Emissions: Fugitive Particulate Emissions from Traffic on Unpaved Roads

Vehicle Type	Road Type	Dust Control Method[1]	Average Vehicle Weight (lb)	Average Vehicle Speed (mph)	Silt Content[2] (%)	Moisture Content[3] (%)	Vehicle Count	RTs per Pad	RT Distance (miles)	VMT [4] (VMT/pad)	Emission Control Efficiency[5] (%)	PM_{10} Emission Factor[6] (lb/VMT)	$PM_{2.5}$ Emission Factor[6] (lb/VMT)	PM_{10} Emissions[7] (controlled) (lb/pad)	$PM_{2.5}$ Emissions[7] (controlled) (lb/pad)	
Rig Haul Trucks	Local Road	Chemical + Restriction	80,000	25	5.1	2.4	10	3	6	180	85	0.51	0.05	13.77	1.37	1b
	Resource Road	Water + Restriction	80,000	20	5.1	2.4	10	3	14	420	50	2.23	0.22	467.82	46.78	1a
Light Trucks	Local Road	Chemical + Restriction	5,800	25	5.1	2.4	2	3	6	36	85	0.51	0.05	2.75	0.27	1b
	Resource Road	Water + Restriction	5,800	20	5.1	2.4	2	3	14	84	50	0.68	0.10	28.73	4.40	1a
											Total Unpaved Road Traffic Emissions (lb/pad)			513.07	52.83	

[1] Dust control methods include using water (resource road) or chemical (loacal road) as a dust suppressants along with vehicle restriction speed limit of 25 mph.

[2] AP-42 (EPA 2004), Table 13.2.2-1, "Typical Silt Content Values of Surface Material on Industrial and Rural Unpaved Roads."

[3] AP-42 (EPA 2004), Table 11.9-3, "Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations."

[4] Calculated as Round Trips per Vehicle Type x Round Trip Distance.

[5] Fugitive Dust Handbook (WRAP 2006) Chapter 6.

[6] AP-42 (EPA 2004), Figure 13.2.2-2, "Watering control effectiveness for unpaved travel surfaces.", AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b.

[7] Calculated as lb/VMT x VMT/well x control efficiency.

Drilling Haul Truck Tailpipe

Project: NPL
Scenario: 4 Pad/Section
Activity: Drilling Traffic
Emissions: Diesel Combustion Emissions from Heavy Equipment Tailpipes

Vehicle Type	Pollutant	Pollutant Emission Factor[1] (g/mile)	Total Haul Truck RTs (RTs/well)	RT Distance Avg. (miles/RT)	Total Haul Truck Miles Traveled (miles/well)	Haul Activity Duration[3] (days/well)	Haul Activity Duration (hours/day)	Emissions (lb/pad)
Heavy Duty	CO	1.25	71	22	1,534	17	24	67
	NO_x	3.18	71	22	1,534	17	24	172
	PM_{10}	0.21	71	22	1,534	17	24	11
	$PM_{2.5}$	0.17	71	22	1,534	17	24	9
	SO_2	0.01	71	22	1,534	17	24	0
	VOC	0.32	71	22	1,534	17	24	17
	Benzene	3.45E-03	71	22	1,534	17	24	0
	Ethylbenzene		71	22	1,534	17	24	0
	Formaldehyde	2.57E-02	71	22	1,534	17	24	1
	H_2S		71	22	1,534	17	24	0
	n-Hexane		71	22	1,534	17	24	0
	Toluene		71	22	1,534	17	24	0
	Xylenes		71	22	1,534	17	24	0
	CH_4	3.73E-02	71	22	1,534	17	24	2
	CO_2[2]	854.68	71	22	1,534	17	24	46246
	N_2O	1.88E-03	71	22	1,534	17	24	0

[1] MOVES, 2013 heavy duty short haul truck

[2] CO2 from CO2(eq) {CO2(eq)-21*CH4-320*N20}

[3] Based on average spud to release date for Jonah wells.

Rig Move Haul Truck Tailpipe

Project: NPL
Scenario: 4 Pad/Section
Activity: Rig Move
Emissions: Diesel Combustion Emissions from Haul Truck Tailpipes

Pollutant	Pollutant Emission Factor[1] (g/mile)	Total Haul Truck RTs (RTs/pad)	RT Distance (miles/RT)	Total Haul Truck Miles Traveled (miles/pad)	Haul Activity Duration (days/move)	Haul Activity Duration (hours/day)	Emissions (lb/pad)
CO	1.25	3	20	600	3	24	1.65
NO_x	3.18	3	20	600	3	24	4.20
PM_{10}	0.21	3	20	600	3	24	0.28
$PM_{2.5}$	0.17	3	20	600	3	24	0.22
SO_2[2]	0.01	3	20	600	3	24	0.01
VOC	0.32	3	20	600	3	24	0.42
Benzene	3.45E-03	3	20	600	3	24	4.56E-03
Ethylbenzene		3	20	600	3	24	0.00
Formaldehyde	2.57E-02	3	20	600	3	24	3.40E-02
H_2S		3	20	600	3	24	0.00
n-Hexane		3	20	600	3	24	0.00
Toluene		3	20	600	3	24	0.00
Xylenes		3	20	600	3	24	0.00
CH_4	3.73E-02	3	20	600	3	24	4.94E-02
CO_2[2]	854.68	3	20	600	3	24	1130.53
N_2O	1.88E-03	3	20	600	3	24	2.49E-03

[1] MOVES, 2013 heavy duty short haul truck

[2] CO2 from CO2(eq) {CO2(eq)-21*CH4-320*N20}

Gas Composition

	MW (g/mol)	Carbons	mol %	mol%*MW	Wt %	C%	Wt-C
Carbon Dioxide	44	1	0.54	23.61	1.28	27.27	34.95
Hydrogen Sulfide		0	0	0.00	0		
Nitrogen		0	0.21	0.00	0		
Methane	16.04	1	89.82	1440.67	78.19	74.81	5849.30
Ethane	30.07	2	5.59	167.97	9.12	79.81	727.57
Propane	44.09	3	2.14	94.45	5.13	81.65	418.51
Isobutane	58.12	4	0.518	30.09	1.63	82.59	134.86
n-Butane	58.12	4	0.520	30.23	1.64	82.59	135.50
Isopentane	72.15	5	0.204	14.73	0.80	83.16	66.48
n-Pentane	72.15	5	0.144	10.38	0.56	83.16	46.87
Cyclopentane	70.13	5	0	0.00	0	85.56	0
n-hexane	86.18	6	0.049	4.24	0.23	83.55	19.22
Cyclohexane	84.16	6	0.028	2.36	0.13	85.55	10.97
Other Hexanes	86.18	6	0.085	7.35	0.40	83.55	33.34
Heptanes	100.21	7	0.063	6.34	0.34	83.82	28.84
Methylcyclohexane	98.19	7	0.037	3.62	0.20	85.55	16.81
2,2,4-Trimethylpentane	114.23	8	0.005	0.53	0.029	84.04	2.43
Benzene	78.11	6	0.012	0.94	0.051	92.18	4.71
Toluene	92.14	7	0.015	1.39	0.076	91.17	6.90
Ethylbenzene	106.17	8	0.001	0.057	0.003	90.42	0.28
Xylenes	106.17	8	0.005	0.517	0.028	90.42	2.54
C8+Heavies	128.26	9	0.024	3.134	0.17	84.20	14.32
Total			*100.00*	*1842.63*	*100.00*	*1635.05*	*7554.40*
					11.42		

MW Fuel	18.43	lb fuel/lb-mol fuel
Wt% Fuel	98.72	fuel
Wt% C	0.77	lb C/lb fuel
CO 2 Factor	6.18E-05	tonne/scf
	122.25	lb/MMbtu
	0.14	lb/scf

Dehy - Post condenser gas composition

	MW (g/mol)	Carbons	mol %	mol%*MW	Wt %	C%	Wt-C
H2O		0	18.6	0.00	0.00		
Oxygen		0	0	0.00	0.00		
CO2	44	1	4.63	203.72	5.18	27.27	141.40
N2		0	0.0671	0.00	0.00		
Methane	16.04	1	31.1	498.84	12.70	74.81	949.79
Ethane	30.07	2	7.42	223.12	5.68	79.81	453.21
Propane	44.09	3	7.95	350.52	8.92	81.65	728.38
Isobutane	58.12	4	3.02	175.52	4.47	82.59	368.92
n-Butane	58.12	4	4.26	247.59	6.30	82.59	520.40
Isopentane	72.15	5	1.35	97.40	2.48	83.16	206.15
n-Pentane	72.15	5	1.15	82.97	2.11	83.16	175.61
Hexane+	100.21	7	20.4529	2049.59	52.16	83.82	4372.42
Total			*100.00*	*3929.27*	*100.00*	*678.87*	*7916.28*

MW Fuel	39.29	lb fuel/lb-mol fuel
Wt% Fuel	100.00	fuel
Wt% C	0.79	lb C/lb fuel
CO 2 Factor	1.36E-04	tonne/scf
	144.98	lb/MMbtu
	0.30	lb/scf

Dehy - Flash tank off gas composition

	MW (g/mol)	Carbons	mol %	mol%*MW	Wt %	C%	Wt-C
H2O		0	1.07	0.00	0.00		
Oxygen		0	0	0.00	0.00		
CO2	44	1	1.21	53.24	2.52	27.27	68.64
N2		0	0.189	0.00	0.00		
Methane	16.04	1	81.7	1310.47	61.95	74.81	4634.92
Ethane	30.07	2	6.59	198.16	9.37	79.81	747.71
Propane	44.09	3	3.39	149.47	7.07	81.65	576.95
I-Butane	58.12	4	1.05	61.03	2.89	82.59	238.27
N-Butane	58.12	4	2.6	151.11	7.14	82.59	590.00
I-Pentane	72.15	5	0.561	40.48	1.91	83.16	159.13
N-Pentane	72.15	5	0.465	33.55	1.59	83.16	131.90
Hexane+	100.21	7	1.175	117.75	5.57	83.82	466.61
Total			*100.00*	*2115.25*	*100.00*	*678.87*	*7614.15*

MW Fuel	21.15	lb fuel/lb-mol fuel
Wt% Fuel	100.00	fuel
Wt% C	0.76	lb C/lb fuel
CO 2 Factor	7.06E-05	tonne/scf
	124.56	lb/MMbtu
	0.16	lb/scf

Condensate Composition

	MW (g/mol)	Carbons	mol %	mol%*MW	Wt %	C%	Wt-C
Methane	16.04	1	5.19	83.24	0.81	74.81	60.36
Ethane	30.07	2	2.65	79.73	0.77	79.81	61.68
Propane	44.09	3	3.67	161.90	1.57	81.65	128.14
i-Butane	58.12	4	2.18	126.47	1.23	82.59	101.25
n-Butane	58.12	4	3.15	183.06	1.77	82.59	146.56
neoPentane	72.15	5	0.07	5.01	0.05	83.16	4.04
i-Pentane	72.15	5	2.84	204.77	1.99	83.16	165.08
n-Pentane	72.15	5	2.79	201.15	1.95	83.16	162.16
2,2-DMB	86.18	6	0.16	13.82	0.13	83.55	11.19
2,3-DMB	86.18	6	0.61	52.98	0.51	83.55	42.91
2-MP	86.18	6	1.90	163.43	1.58	83.55	132.36
3-MP	86.18	6	1.06	91.21	0.88	83.55	73.87
n-Hexane	86.18	6	1.86	159.94	1.55	83.55	129.53
Heptane	100.21	7	16.91	1694.30	16.42	83.82	1376.76
Octanes	114.23	8	7.39	844.06	8.18	84.04	687.65
Nonanes	128.26	9	12.85	1648.13	15.98	84.20	1345.32
Decanes+	156.31	11	20.29	3171.74	30.75	84.45	2596.47
N2		0	0.00	0.00	0.00		
CO2	44	1	0.09	3.81	0.04	27.27	1.01
Benzene	78.11	6	1.15	89.90	0.87	92.18	80.33
Toluene	92.14	7	5.59	515.09	4.99	91.17	455.21
E-Benzene	106.17	8	0.66	70.35	0.68	90.42	61.67
m&p Xylenes	106.17	8	5.22	554.67	5.38	90.42	486.19
o Xylene	106.17	8	1.00	106.06	1.03	90.42	92.96
2,2,4-TMP	114.23	8	0.80	90.91	0.88	84.04	74.06
Total			*100.07*	*10315.74*	*100.00*	*1971.10*	*8476.78*
					98.42		

MW Fuel	103.16	lb fuel/lb-mol fuel
Wt% Fuel	14.80	fuel
Wt% C	0.82	lb C/lb fuel
CO 2 Factor	3.73E-04	tonne/scf
	657.18	lb/MMbtu
	0.82	lb/scf

Condensate Storage Tank - Flash gas composition

	MW (g/mol)	Carbons	mol %	mol%*MW	Wt %	C%	Wt-C
CO2	44	1	0.77	33.88	1.10	27.27	29.96
Methane	16.04	1	48.32	775.05	25.13	74.81	1879.96
Ethane	30.07	2	20.10	604.41	19.60	79.81	1564.04
Propane	44.09	3	16.19	713.82	23.14	81.65	1889.69
Isobutane	58.12	4	4.80	278.98	9.04	82.59	747.00
n-Butane	58.12	4	4.97	288.86	9.37	82.59	773.46
Isopentane	72.15	5	1.64	118.33	3.84	83.16	319.03
n-Pentane	72.15	5	1.25	90.19	2.92	83.16	243.17
n-Hexane	86.18	6	0.22	18.96	0.61	83.55	51.36
other Hexanes	86.18	6	0.76	65.50	2.12	83.55	177.41
Heptanes	100.21	7	0.54	54.11	1.75	83.82	147.07
Benzene	78.11	6	0.12	9.37	0.30	92.18	28.01
Toluene	92.14	7	0.16	14.74	0.48	91.17	43.58
Ethylbenzene	106.17	8	0.01	1.06	0.03	90.42	3.11
Xylenes	106.17	8	0.04	4.25	0.14	90.42	12.45
C8+ Heavies	128.26	9	0.10	12.83	0.42	84.20	35.02
Total			*99.99*	*3084.32*	*100.00*	*1294.35*	*7944.30*
					54.18		

MW Fuel	30.84	lb fuel/lb-mol fuel
Wt% Fuel	98.90	fuel
Wt% C	0.80	lb C/lb fuel
CO 2 Factor	1.09E-04	tonne/scf
	134.55	lb/MMbtu
	0.24	lb/scf

Drill Rigs

Project: NPL
Scenario: 4 Pad/Section
Effective Dates: 2009
Emissions: Combustion Emissions from Drilling Engines

Engine	Pollutant	EPA Tier Certification	Pollutant Emission Factor	Emission Factor Reference	Fuel Heating Value[2]	Fuel Consumption Rate[3]	Drilling Activity Duration	Drilling Activity Duration	Emissions	Emissions per Well	Emissions per Pad
			(lb/MMbtu)		(btu/scf) or (btu/gal)	(mcf/hr) or (gal/hr)	(days/well)	(hours/day)	(lb/hr)	(lb)	(tons)
Cat 3516G	CO	Tier 3+	1.04	1	1115	10.11	10.5	24	11.77	2,965.70	23.73
(Main)	NOx	Tier 3+	0.44	1	1115	10.11	10.5	24	5.01	1,261.27	10.09
	SO_2	Tier 3+	5.88E-05	6	1115	10.11	10.5	24	0.00	0.17	0.00
	VOC	Tier 3+	0.05	1	1115	10.11	10.5	24	0.51	127.83	1.02
	PM_{10}	Tier 3+	0.01	1	1115	10.11	10.5	24	0.07	17.04	0.14
	$PM_{2.5}$		7.71E-05	4	1115	10.11	10.5	24	0.00	0.22	0.00
	Benzene		4.40E-04	4	1115	10.11	10.5	24	0.00	1.25	0.01
	Ethylbenzene		3.97E-05	4	1115	10.11	10.5	24	0.00	0.11	0.00
	Formaldehyde		0.07	1	1115	10.11	10.5	24	0.79	198.85	1.59
	H_2S		0.00E+00	6	1115	10.11	10.5	24	0.00	0.00	0.00
	n-Hexane		1.11E-03	4	1115	10.11	10.5	24	0.01	3.15	0.03
	Toluene		4.08E-04	4	1115	10.11	10.5	24	0.00	1.16	0.01
	Xylenes		1.84E-04	4	1115	10.11	10.5	24	0.00	0.52	0.00
	CH_4		1.52	7	1115	10.11	10.5	24	17.12	4,315.04	34.52
	CO_2		122.25	8	1115	10.11	10.5	24	1378.08	347,277	2,778.21
	N_2O		2.28E-04	9	1115	10.11	10.5	24	0.00	0.65	0.01
	Acetaldehyde		3.31E-03	11	1115	10.11	10.5	24	3.73E-02	9.40	0.08
	Acrolein		2.03E-03	11	1115	10.11	10.5	24	2.29E-02	5.77	0.05
	Methanol		9.89E-04	11	1115	10.11	10.5	24	1.11E-02	2.81	0.02
Cat C27/	CO	Tier 1+	0.34	1	137030	4.29	10.5	24	0.20	50.37	0.40
Det R1237M36	NOx	Tier 1+	1.78	1	137030	4.29	10.5	24	1.04	262.95	2.10
(Cold Start)	SO_2	Tier 1+	6.30E-02	1	137030	4.29	10.5	24	0.04	9.33	0.07
	VOC	Tier 1+	0.32	1	137030	4.29	10.5	24	0.19	46.66	0.37
	PM_{10}	Tier 1+	0.09	1	137030	4.29	10.5	24	0.05	13.33	0.11
	$PM_{2.5}$		0.09		137030	4.29	10.5	24	0.05	13.33	0.11
	Benzene		9.33E-04	5	137030	4.29	10.5	24	0.00	0.14	0.00
	Ethylbenzene				137030	4.29	10.5	24	0.00	0.00	0.00
	Formaldehyde		1.18E-03	5	137030	4.29	10.5	24	0.00	0.17	0.00
	H_2S				137030	4.29	10.5	24	0.00	0.00	0.00
	n-Hexane				137030	4.29	10.5	24	0.00	0.00	0.00
	Toluene		4.09E-04	5	137030	4.29	10.5	24	0.00	0.06	0.00
	Xylenes		2.85E-04	5	137030	4.29	10.5	24	0.00	0.04	0.00
	CH_4		1.60E-04	7	137030	4.29	10.5	24	0.00	0.02	0.00
	CO_2		164	10	137030	4.29	10.5	24	96.41	24,295.02	194.36
	N_2O		1.32E-03	9	137030	4.29	10.5	24	0.00	0.20	0.00
	Acetaldehyde		7.67E-04	11	137030	4.29	10.5	24	4.51E-04	0.11	0.00
	Acrolein		9.25E-05	11	137030	4.29	10.5	24	5.44E-05	0.01	0.00
	Methanol		0.00	11	137030	4.29	10.5	24	0.00E+00	0.00	0.00
William & Davis	CO	Tier 3+	0.08	1	1115	0.43	10.5	24	0.04	9.91	0.08
(Boiler)	NOx	Tier 3+	0.10	1	1115	0.43	10.5	24	0.05	11.84	0.09
	SO_2	Tier 3+	0.00	6	1115	0.43	10.5	24	0.00	0.07	0.00
	VOC	Tier 3+	0.01	1	1115	0.43	10.5	24	0.00	0.65	0.01
	PM_{10}	Tier 3+	7.50E-03	1	1115	0.43	10.5	24	0.00	0.91	0.01
	$PM_{2.5}$		7.71E-05	4	1115	0.43	10.5	24	0.00	0.01	0.00
	Benzene		4.40E-04	4	1115	0.43	10.5	24	0.00	0.05	0.00
	Ethylbenzene		3.97E-05	4	1115	0.43	10.5	24	0.00	0.00	0.00
	Formaldehyde		0.07	1	1115	0.43	10.5	24	0.03	8.46	0.07
	H_2S		0.00E+00	6	1115	0.43	10.5	24	0.00	0.00	0.00
	n-Hexane		1.11E-03	4	1115	0.43	10.5	24	0.00	0.13	0.00
	Toluene		4.08E-04	4	1115	0.43	10.5	24	0.00	0.05	0.00
	Xylenes		1.84E-04	4	1115	0.43	10.5	24	0.00	0.02	0.00
	CH_4		2.30E-03	7	1115	0.43	10.5	24	0.00	0.28	0.00
	CO_2		117.60	8	1115	0.43	10.5	24	56.38	14,209	113.67
	N_2O		2.16E-03	9	1115	0.43	10.5	24	0.00	0.26	0.00
	Acetaldehyde		8.36E-03	11	1115	0.43	10.5	24	0.00	1	0.01
	Acrolein		5.14E-03	11	1115	0.43	10.5	24	0.00	0.62	0.00
	Methanol		2.50E-03	11	1115	0.43	10.5	24	0.00	0	0.00
Total	CO							CO	12.01	3025.97	24.21
	NOx							NOx	6.10	1536.06	12.29
	SO_2							SO_2	0.04	9.57	0.08
	VOC							VOC	0.70	175.15	1.40
	PM_{10}							PM_{10}	0.12	31.28	0.25
	$PM_{2.5}$							$PM_{2.5}$	0.05	13.56	0.11
	Benzene							Benzene	0.01	1.44	0.01
	Ethylbenzene							Ethylbenzene	0.00	0.12	0.00
	Formaldehyde							Formaldehyde	0.82	207.48	1.66
	H_2S							H_2S	0.00	0.00	0.00
	n-Hexane							n-Hexane	0.01	3.29	0.03
	Toluene							Toluene	0.01	1.27	0.01
	Xylenes							Xylenes	0.00	0.59	0.00
	CH_4							CH_4	17.12	4315.34	34.52
	CO_2							CO_2	1530.87	385,780	3086.24
	N_2O							N_2O	0.00	1.10	0.01
	Acetaldehyde							Acetaldehyde	0.04	10.53	0.08
	Acrolein							Acrolein	0.03	6.40	0.05
	Methanol							Methanol	0.01	3.11	0.02

[1] Encana Drill Rig Permit (WDEQ 2010) and fuel usage (averaged from 2008-2009 reports submitted to BLM).
[2] Fuel heating value of natural gas based on average of 2008-2009 analysis in Jonah Infill. Diesel heating value from API 2004 Greenhouse Compendium, Table 3-5.
[3] Fuel consumption rate based on average of actual usage during 2009-2010 in Jonah Infill.
[4] AP-42 (EPA 2004) "Natural Gas-fired Reciprocating Engines" Table 3.2-2.
[5] AP-42 (EPA 2004) Section 3.3 "Gasoline and Diesel Industrial Engines" Table 3.3-2. Emission factor in units of lb/MMbtu.
[6] All SO_2 emissions based on S-balance equation in Section 3.4 and 1200 ppm diesel fuel.
[7] Greenhouse Gas Compendium (API 2009) Table 4-9. Natural gas fired engines have adjusted for fuel heating value.
[8] Greenhouse Gas Compendium (API 2009) Section 4-3. See 'Material Balance' sheet for calculation.
[9] Greenhouse Gas Compendium (API 2009) Table 4-5.
[10] Greenhouse Gas Compendium (API 2009) Table 4-3.
[11] HAP EF originally provided by Encana

Frac/Other Completion Engine Emissions

Project: NPL
Scenario: 4 Pad/Section
Effective Dates: All
Emissions: Diesel Combustion Emissions from Frac/Other Completion Engines

Engine	Pollutant	EPA Tier Certification	Pollutant Emission Factor (g/hp-hr)	Emission Factor Reference	Engine Count	Horsepower[1] (hp)	Overall Load Factor[2]	Activity Duration (days/well)	Activity Duration (hours/day)	Emissions per Well (lb/well)	Emissions per Hour (lb/hr)	Emissions per Pad (tons)
Cat 5EN2368	CO	Tier 2	0.87	3	1	170	0.30	2	24	4.68	0.10	3.74E-02
	NOx	Tier 2	4.10	3	1	170	0.30	2	24	22.13	0.46	1.77E-01
	SO_2	Tier 2	0.20	3	1	170	0.30	2	24	1.08	0.02	8.64E-03
	VOC	Tier 2	0.34	3	1	170	0.30	2	24	1.83	0.04	1.46E-02
	PM_{10}	Tier 2	0.18	3	1	170	0.30	2	24	0.97	0.02	7.77E-03
	$PM_{2.5}$		0.18		1	170	0.30	2	24	0.97	0.02	7.77E-03
	Benzene		2.96E-03	4, 8	1	170	0.30	2	24	0.02	0.00	1.28E-04
	Ethylbenzene				1	170	0.30	2	24	0.00	0.00	0.00E+00
	Formaldehyde		3.75E-03	4, 8	1	170	0.30	2	24	0.02	0.00	1.62E-04
	H_2S				1	170	0.30	2	24	0.00	0.00	0.00E+00
	n-Hexane				1	170	0.30	2	24	0.00	0.00	0.00E+00
	Toluene		1.30E-03	4, 8	1	170	0.30	2	24	0.01	0.00	5.61E-05
	Xylenes		9.05E-04	4, 8	1	170	0.30	2	24	0.00	0.00	3.91E-05
	CH_4		5.08E-04	5, 8	1	170	0.30	2	24	0.00	0.00	2.19E-05
	CO_2		521	6, 8	1	170	0.30	2	24	2,810.37	58.55	2.25E+01
	N_2O		4.19E-03	7, 8	1	170	0.30	2	24	0.02	0.00	1.81E-04
	Acetaldehyde		2.44E-03	4,8	1	170	0.30	2	24	1.31E-02	2.74E-04	1.05E-04
	Acrolein		2.94E-04	4,8	1	170	0.30	2	24	1.59E-03	3.30E-05	1.27E-05
Cat BCX00314	CO	Tier 2	0.84	3	1	425	0.30	2	24	11.37	0.24	9.09E-02
	NOx	Tier 2	4.34	3	1	425	0.30	2	24	58.49	1.22	4.68E-01
	SO_2	Tier 2	0.20	3	1	425	0.30	2	24	2.70	0.06	2.16E-02
	VOC	Tier 2	0.17	3	1	425	0.30	2	24	2.25	0.05	1.80E-02
	PM_{10}	Tier 2	0.13	3	1	425	0.30	2	24	1.78	0.04	1.42E-02
	$PM_{2.5}$		0.13		1	425	0.30	2	24	1.78	0.04	1.42E-02
	Benzene		2.96E-03	4, 8	1	425	0.30	2	24	0.04	0.00	3.20E-04
	Ethylbenzene				1	425	0.30	2	24	0.00	0.00	0.00E+00
	Formaldehyde		3.75E-03	4, 8	1	425	0.30	2	24	0.05	0.00	4.04E-04
	H_2S				1	425	0.30	2	24	0.00	0.00	0.00E+00
	n-Hexane				1	425	0.30	2	24	0.00	0.00	0.00E+00
	Toluene		1.30E-03	4, 8	1	425	0.30	2	24	0.02	0.00	1.40E-04
	Xylenes		9.05E-04	4, 8	1	425	0.30	2	24	0.01	0.00	9.77E-05
	CH_4		5.08E-04	5, 8	1	425	0.30	2	24	0.01	0.00	5.48E-05
	CO_2		521	6, 8	1	425	0.30	2	24	7,025.91	146.37	5.62E+01
	N_2O		4.19E-03	7, 8	1	425	0.30	2	24	0.06	0.00	4.52E-04
	Acetaldehyde		2.44E-03	4,8	1	425	0.30	2	24	3.29E-02	6.85E-04	2.63E-04
	Acrolein		2.94E-04	4,8	1	425	0.30	2	24	3.96E-03	8.26E-05	3.17E-05
Cat 2AF00204	CO	Tier 2	0.76	3	2	2,250	0.30	2	24	109.17	2.27	8.73E-01
	NOx	Tier 2	4.10	3	2	2,250	0.30	2	24	585.73	12.20	4.69E+00
	SO_2	Tier 2	0.20	3	2	2,250	0.30	2	24	28.57	0.60	2.29E-01
	VOC	Tier 2	0.17	3	2	2,250	0.30	2	24	23.84	0.50	1.91E-01
	PM_{10}	Tier 2	0.13	3	2	2,250	0.30	2	24	18.80	0.39	1.50E-01
	$PM_{2.5}$		0.13		2	2,250	0.30	2	24	18.80	0.39	1.50E-01
	Benzene		2.96E-03	4, 8	2	2,250	0.30	2	24	0.42	0.01	3.39E-03
	Ethylbenzene				2	2,250	0.30	2	24	0.00	0.00	0.00E+00
	Formaldehyde		3.75E-03	4, 8	2	2,250	0.30	2	24	0.54	0.01	4.28E-03
	H_2S				2	2,250	0.30	2	24	0.00	0.00	0.00E+00
	n-Hexane				2	2,250	0.30	2	24	0.00	0.00	0.00E+00
	Toluene		1.30E-03	4, 8	2	2,250	0.30	2	24	0.19	0.00	1.48E-03
	Xylenes		9.05E-04	4, 8	2	2,250	0.30	2	24	0.13	0.00	1.03E-03
	CH_4		5.08E-04	5, 8	2	2,250	0.30	2	24	0.07	0.00	5.81E-04
	CO_2		521	6, 8	2	2,250	0.30	2	24	74,392.04	1,549.83	5.95E+02
	N_2O		4.19E-03	7, 8	2	2,250	0.30	2	24	0.60	0.01	4.79E-03
	Acetaldehyde		2.44E-03	4,8	2	2,250	0.30	2	24	3.48E-01	7.25E-03	2.78E-03
	Acrolein		2.94E-04	4,8	2	2,250	0.30	2	24	4.20E-02	8.74E-04	3.36E-04
DDC 12VF014134	CO	Tier 2	0.76	3	1	750	0.30	2	24	18.20	0.38	1.46E-01
	NOx	Tier 2	4.10	3	1	750	0.30	2	24	97.62	2.03	7.81E-01
	SO_2	Tier 2	0.20	3	1	750	0.30	2	24	4.76	0.10	3.81E-02
	VOC	Tier 2	0.17	3	1	750	0.30	2	24	3.97	0.08	3.18E-02
	PM_{10}	Tier 2	0.13	3	1	750	0.30	2	24	3.13	0.07	2.51E-02
	$PM_{2.5}$		0.13		1	750	0.30	2	24	3.13	0.07	2.51E-02
	Benzene		2.96E-03	4, 8	1	750	0.30	2	24	0.07	0.00	5.64E-04
	Ethylbenzene				1	750	0.30	2	24	0.00	0.00	0.00E+00
	Formaldehyde		3.75E-03	4, 8	1	750	0.30	2	24	0.09	0.00	7.14E-04
	H_2S				1	750	0.30	2	24	0.00	0.00	0.00E+00
	n-Hexane				1	750	0.30	2	24	0.00	0.00	0.00E+00
	Toluene		1.30E-03	4, 8	1	750	0.30	2	24	0.03	0.00	2.47E-04
	Xylenes		9.05E-04	4, 8	1	750	0.30	2	24	0.02	0.00	1.72E-04
	CH_4		5.08E-04	5, 8	1	750	0.30	2	24	0.01	0.00	9.68E-05
	CO_2		521	6, 8	1	750	0.30	2	24	12,398.67	258.31	9.92E+01
	N_2O		4.19E-03	7, 8	1	750	0.30	2	24	0.10	0.00	7.98E-04
	Acetaldehyde		2.44E-03	4,8	1	750	0.30	2	24	5.80E-02	1.21E-03	4.64E-04
	Acrolein		2.94E-04	4,8	1	750	0.30	2	24	6.99E-03	1.46E-04	5.59E-05
CUM 10723297	CO	Tier 2	0.84	3	1	600	0.30	2	24	16.05	0.33	1.28E-01
	NOx	Tier 2	4.34	3	1	600	0.30	2	24	82.58	1.72	6.61E-01
	SO_2	Tier 2	0.20	3	1	600	0.30	2	24	3.81	0.08	3.05E-02
	VOC	Tier 2	0.17	3	1	600	0.30	2	24	3.18	0.07	2.54E-02
	PM_{10}	Tier 2	0.13	3	1	600	0.30	2	24	2.51	0.05	2.01E-02
	$PM_{2.5}$		0.13		1	600	0.30	2	24	2.51	0.05	2.01E-02
	Benzene		2.96E-03	4, 8	1	600	0.30	2	24	0.06	0.00	4.51E-04
	Ethylbenzene				1	600	0.30	2	24	0.00	0.00	0.00E+00
	Formaldehyde		3.75E-03	4, 8	1	600	0.30	2	24	0.07	0.00	5.71E-04
	H_2S				1	600	0.30	2	24	0.00	0.00	0.00E+00
	n-Hexane				1	600	0.30	2	24	0.00	0.00	0.00E+00
	Toluene		1.30E-03	4, 8	1	600	0.30	2	24	0.02	0.00	1.98E-04
	Xylenes		9.05E-04	4, 8	1	600	0.30	2	24	0.02	0.00	1.38E-04
	CH_4		5.08E-04	5, 8	1	600	0.30	2	24	0.01	0.00	7.74E-05
	CO_2		521	6, 8	1	600	0.30	2	24	9,918.94	206.64	7.94E+01
	N_2O		4.19E-03	7, 8	1	600	0.30	2	24	0.08	0.00	6.39E-04
	Acetaldehyde		2.44E-03	4,8	1	600	0.30	2	24	4.64E-02	9.66E-04	3.71E-04
	Acrolein		2.94E-04	4,8	1	600	0.30	2	24	5.59E-03	1.17E-04	4.48E-05
Backhoe	CO	Tier 1	2.37	3	1	100	0.40	2	6	2.50	0.21	2.00E-02
	NOx	Tier 1	5.60	3	1	100	0.40	2	6	5.92	0.49	4.74E-02
	SO_2	Tier 1	0.20	3	1	100	0.40	2	6	0.21	0.02	1.69E-03
	VOC	Tier 1	0.52	3	1	100	0.40	2	6	0.55	0.05	4.41E-03
	PM_{10}	Tier 1	0.47	3	1	100	0.40	2	6	0.50	0.04	4.00E-03
	$PM_{2.5}$		0.47		1	100	0.40	2	6	0.50	0.04	4.00E-03
	Benzene		2.96E-03	4, 8	1	100	0.40	2	6	0.00	0.00	2.51E-05
	Ethylbenzene				1	100	0.40	2	6	0.00	0.00	0.00E+00
	Formaldehyde		3.75E-03	4, 8	1	100	0.40	2	6	0.00	0.00	3.17E-05
	H_2S				1	100	0.40	2	6	0.00	0.00	0.00E+00
	n-Hexane				1	100	0.40	2	6	0.00	0.00	0.00E+00
	Toluene		1.30E-03	4, 8	1	100	0.40	2	6	0.00	0.00	1.10E-05
	Xylenes		9.05E-04	4, 8	1	100	0.40	2	6	0.00	0.00	7.66E-06
	CH_4		5.08E-04	5, 8	1	100	0.40	2	6	0.00	0.00	4.30E-06
	CO_2		521	6, 8	1	100	0.40	2	6	551.05	45.92	4.41E+00
	N_2O		4.19E-03	7, 8	1	100	0.40	2	6	0.00	0.00	3.55E-05
	Acetaldehyde		2.44E-03	4,8	1	100	0.40	2	6	2.58E-03	2.15E-04	2.06E-05
	Acrolein		2.94E-04	4,8	1	100	0.40	2	6	3.11E-04	2.59E-05	2.49E-06
Bulldozer	CO	Tier 1	0.75	3	1	200	0.40	1.5	6	1.19	0.13	9.49E-03
	NOx	Tier 1	5.58	3	1	200	0.40	1.5	6	8.85	0.98	7.08E-02
	SO_2	Tier 1	0.20	3	1	200	0.40	1.5	6	0.32	0.04	2.54E-03
	VOC	Tier 1	0.31	3	1	200	0.40	1.5	6	0.49	0.05	3.92E-03
	PM_{10}	Tier 1	0.25	3	1	200	0.40	1.5	6	0.40	0.04	3.20E-03
	$PM_{2.5}$		0.25		1	200	0.40	1.5	6	0.40	0.04	3.20E-03
	Benzene		2.96E-03	4, 8	1	200	0.40	1.5	6	0.00	0.00	3.76E-05
	Ethylbenzene				1	200	0.40	1.5	6	0.00	0.00	0.00E+00
	Formaldehyde		3.75E-03	4, 8	1	200	0.40	1.5	6	0.01	0.00	4.76E-05
	H_2S				1	200	0.40	1.5	6	0.00	0.00	0.00E+00
	n-Hexane				1	200	0.40	1.5	6	0.00	0.00	0.00E+00
	Toluene		1.30E-03	4, 8	1	200	0.40	1.5	6	0.00	0.00	1.65E-05
	Xylenes		9.05E-04	4, 8	1	200	0.40	1.5	6	0.00	0.00	1.15E-05
	CH_4		5.08E-04	5, 8	1	200	0.40	1.5	6	0.00	0.00	6.45E-06
	CO_2		521	6, 8	1	200	0.40	1.5	6	826.58	91.84	6.61E+00
	N_2O		4.19E-03	7, 8	1	200	0.40	1.5	6	0.01	0.00	5.32E-05
	Acetaldehyde		2.44E-03	4,8	1	200	0.40	1.5	6	3.87E-03	4.30E-04	3.09E-05
	Acrolein		2.94E-04	4,8	1	200	0.40	1.5	6	4.66E-04	5.18E-05	3.73E-06
Wireline	CO	Tier 1	2.37	3	1	100	0.40	2.5	7.5	3.91	0.21	3.13E-02
	NOx	Tier 1	5.60	3	1	100	0.40	2.5	7.5	9.26	0.49	7.41E-02
	SO_2	Tier 1	0.20	3	1	100	0.40	2.5	7.5	0.33	0.02	2.65E-03
	VOC	Tier 1	0.52	3	1	100	0.40	2.5	7.5	0.86	0.05	6.90E-03
	PM_{10}	Tier 1	0.47	3	1	100	0.40	2.5	7.5	0.78	0.04	6.26E-03
	$PM_{2.5}$		0.47		1	100	0.40	2.5	7.5	0.78	0.04	6.26E-03
	Benzene		2.96E-03	4, 8	1	100	0.40	2.5	7.5	0.00	0.00	3.92E-05
	Ethylbenzene				1	100	0.40	2.5	7.5	0.00	0.00	0.00E+00
	Formaldehyde		3.75E-03	4, 8	1	100	0.40	2.5	7.5	0.01	0.00	4.96E-05
	H_2S				1	100	0.40	2.5	7.5	0.00	0.00	0.00E+00
	n-Hexane				1	100	0.40	2.5	7.5	0.00	0.00	0.00E+00
	Toluene		1.30E-03	4, 8	1	100	0.40	2.5	7.5	0.00	0.00	1.72E-05
	Xylenes		9.05E-04	4, 8	1	100	0.40	2.5	7.5	0.00	0.00	1.20E-05
	CH_4		5.08E-04	5, 8	1	100	0.40	2.5	7.5	0.00	0.00	6.72E-06
	CO_2		521	6, 8	1	100	0.40	2.5	7.5	861.02	45.92	6.89E+00
	N_2O		4.19E-03	7, 8	1	100	0.40	2.5	7.5	0.01	0.00	5.54E-05
	Acetaldehyde		2.44E-03	4,8	1	100	0.40	2.5	7.5	4.03E-03	2.15E-04	3.22E-05
	Acrolein		2.94E-04	4,8	1	100	0.40	2.5	7.5	4.86E-04	2.59E-05	3.89E-06
Crane	CO	Tier 1	1.53	3	1	30	0.40	2.5	1	0.10	0.04	8.11E-04
	NOx	Tier 1	4.73	3	1	30	0.40	2.5	1	0.31	0.13	2.50E-03
	SO_2	Tier 1	0.20	3	1	30	0.40	2.5	1	0.01	0.01	1.06E-04
	VOC	Tier 1	0.28	3	1	30	0.40	2.5	1	0.02	0.01	1.48E-04
	PM_{10}	Tier 1	0.34	3	1	30	0.40	2.5	1	0.02	0.01	1.79E-04
	$PM_{2.5}$		0.34		1	30	0.40	2.5	1	0.02	0.01	1.79E-04
	Benzene		2.96E-03	4, 8	1	30	0.40	2.5	1	0.00	0.00	1.57E-06
	Ethylbenzene				1	30	0.40	2.5	1	0.00	0.00	0.00E+00
	Formaldehyde		3.75E-03	4, 8	1	30	0.40	2.5	1	0.00	0.00	1.98E-06
	H_2S				1	30	0.40	2.5	1	0.00	0.00	0.00E+00
	n-Hexane				1	30	0.40	2.5	1	0.00	0.00	0.00E+00
	Toluene		1.30E-03	4, 8	1	30	0.40	2.5	1	0.00	0.00	6.87E-07
	Xylenes		9.05E-04	4, 8	1	30	0.40	2.5	1	0.00	0.00	4.79E-07
	CH_4		5.08E-04	5, 8	1	30	0.40	2.5	1	0.00	0.00	2.69E-07
	CO_2		521	6, 8	1	30	0.40	2.5	1	34.44	13.78	2.76E-01
	N_2O		4.19E-03	7, 8	1	30	0.40	2.5	1	0.00	0.00	2.22E-06
	Acetaldehyde		2.44E-03	4,8	1	30	0.40	2.5	1	1.61E-04	6.44E-05	1.29E-06
	Acrolein		2.94E-04	4,8	1	30	0.40	2.5	1	1.94E-05	7.77E-06	1.55E-07
Wellhead Heater	CO	Tier 1	2.37	3	5	170	0.40	2	6.5	23.05	1.77	1.84E-01
	NOx	Tier 1	5.60	3	5	170	0.40	2	6.5	54.56	4.20	4.36E-01
	SO_2	Tier 1	0.20	3	5	170	0.40	2	6.5	1.95	0.15	1.56E-02
	VOC	Tier 1	0.52	3	5	170	0.40	2	6.5	5.08	0.39	4.06E-02
	PM_{10}	Tier 1	0.47	3	5	170	0.40	2	6.5	4.61	0.35	3.69E-02
	$PM_{2.5}$		0.47		5	170	0.40	2	6.5	4.61	0.35	3.69E-02
	Benzene		2.96E-03	4, 8	5	170	0.40	2	6.5	0.03	0.00	2.31E-04
	Ethylbenzene				5	170	0.40	2	6.5	0.00	0.00	0.00E+00
	Formaldehyde		3.75E-03	4, 8	5	170	0.40	2	6.5	0.04	0.00	2.92E-04
	H_2S				5	170	0.40	2	6.5	0.00	0.00	0.00E+00
	n-Hexane				5	170	0.40	2	6.5	0.00	0.00	0.00E+00
	Toluene		1.30E-03	4, 8	5	170	0.40	2	6.5	0.01	0.00	1.01E-04
	Xylenes		9.05E-04	4, 8	5	170	0.40	2	6.5	0.01	0.00	7.05E-05
	CH_4		5.08E-04	5, 8	5	170	0.40	2	6.5	0.00	0.00	3.96E-05
	CO_2		521	6, 8	5	170	0.40	2	6.5	5,074.27	390.33	4.06E+01
	N_2O		4.19E-03	7, 8	5	170	0.40	2	6.5	0.04	0.00	3.27E-04
	Acetaldehyde		2.44E-03	4,8	5	170	0.40	2	6.5	2.37E-02	1.83E-03	1.90E-04
	Acrolein		2.94E-04	4,8	5	170	0.40	2	6.5	2.86E-03	2.20E-04	2.29E-05
Total	CO					6,445.00				190.22	5.68	1.52E+00
	NOx									925.45	23.93	7.40E+00
	SO_2									43.74	1.08	3.50E-01
	VOC									42.08	1.28	3.37E-01
	PM_{10}									33.50	1.06	2.68E-01
	$PM_{2.5}$									33.50	1.06	2.68E-01
	Benzene									0.65	0.02	5.18E-03
	Ethylbenzene									0.00	0.00	0.00E+00
	Formaldehyde									0.82	0.02	6.56E-03
	H_2S									0.00	0.00	0.00E+00
	n-Hexane									0.00	0.00	0.00E+00
	Toluene									0.28	0.01	2.27E-03
	Xylenes									0.20	0.00	1.58E-03
	CH_4									0.11	0.00	8.89E-04
	CO_2									113,893.29	2,807.50	9.11E+02
	N_2O									0.92	0.02	7.33E-03
	Acetaldehyde									5.33E-01	1.31E-02	4.26E-03
	Acrolein									6.42E-02	1.58E-03	5.14E-04

[1] Horsepower based on current contractor equipment.
[2] Load factor based on weighted average of full load and idle conditions during frac operations.
[3] Emission factors from Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling--Compression-Ignition, Table A-2; (EPA 420-P-04-009 April 2004).
[4] AP-42 (EPA 1996) Section 3.3 "Gasoline and Diesel Industrial Engines" Table 3.3-2.
[5] Greenhouse Gas Compendium (API 2009) Table 4-9.
[6] Greenhouse Gas Compendium (API 2009) Table 4-3.
[7] Greenhouse Gas Compendium (API 2009) Table 4-5.
[8] Emission factor converted from lb/Mmbtu to g/hp-hr assuming an average BSFC of 7,000 btu/hp-hr (AP-42 Table 3.3-1).

grams/lb	**453.6**	Acetaldehyde	7.67E-04 lb/MMBtu	2.44E-03 g/hp-hr
		Acrolein	< 9.25E-05 lb/MMBtu	2.94E-04 g/hp-hr

Well Completion Emissions

Project: NPL
Scenario: 4 Pad/Section
Effective Dates: All
Emissions: Well completion emissions

Activity	Average Gas Volume[1]	Event Duration[2]	Wells	Pollutant	Weight Fraction[3]	Emission Factor[4]	Emissions per Well	Emissions per Pad
	(mcf/well)	(day/well)				(lb/MMbtu)	(lb/yr)	(tons/yr)
Completions	77	60	160	CO		0.37	2.56	0.02
				NOx		0.14	0.97	7.75E-03
				SO_2		0.00	0.00	0.00
	Molecular Weight	18.43		VOC	0.11		8.54	0.07
	Fuel Heating Value (actual)	1,124	Btu/scf	PM_{10}		0.007	4.85E-02	3.88E-04
	Gas Volume to Flare[5]	8	%	$PM_{2.5}$		0.007	4.85E-02	3.88E-04
	Gas Volume Vented[5]	2	%	Benzene	5.12E-04		3.83E-02	3.06E-04
				Ethylbenzene	3.07E-05		2.30E-03	1.84E-05
				Formaldehyde		8.10E-05	5.61E-04	4.49E-06
				H_2S	0.00		0.00	0.00
				n-Hexane	2.30E-03		1.72E-01	1.38E-03
				Toluene	7.57E-04		5.66E-02	4.53E-04
				Xylenes	2.80E-04		2.10E-02	1.68E-04
				CH_4	0.78		58.49	4.68E-01
				CO_2[6]	0.013	122.252	847.41	6.78
				N_2O[7]		1.04E-07	7.20E-07	5.76E-09

[1] Data from Jonah Infill well completions 2008-2010.
[2] Data from Jonah Infill well completions 2008-2010.
[3] Weight fraction based on gas composition. See 'Material Balance' sheet.
[4] Emission factors taken from WDEQ "Oil and Gas Production Facilities - Chapter 6, Section 2 Permitting Guidance" and AP-42, Table 1.4-2.
[5] Encana originally committed to capturing 90% of the hydrocarbons through flareless completions in the 2006 Infill ROD and proposes to continue this in the NPL.
[6] See 'Material Balance' sheet.
[7] Greenhouse Gas Compendium (API 2009) Table 4-5

Completion/Testing Traffic

Project: NPL
Scenario: 4 Pad/Section
Activity: Completion/Testing Traffic
Emissions: Fugitive Particulate Emissions from Traffic on Unpaved Roads

Vehicle Type	Road Type	Dust Control Method[1]	Average Vehicle Weight (lb)	Average Vehicle Speed (mph)	Silt Content[2] (%)	Moisture Content[3] (%)	RTs per Well	RT Distance (miles)	VMT[4] (VMT/well)	Emission Control Efficiency[5] (%)	PM_{10} Emissions[6] (lb/VMT)	$PM_{2.5}$ Emissions[6] (lb/VMT)	PM_{10} Emissions[7] (controlled) (lb/pad)	$PM_{2.5}$ Emissions[7] (controlled) (lb/pad)	
Light Trucks/ Pickups	Local	Chemical + Restriction	5,800	25	5.1	2.4	60	10	600	85	0.51	0.05	734	73	1b
	Resource	Water + Restriction	5,800	20	5.1	2.4	60	1	60	50	0.68	0.07	328	33	1a
Water Truck	Local	Chemical + Restriction	60,000	20	5.1	2.4	240	8	1,920	85	0.46	0.05	2,101	209	1b
	Resource	Water + Restriction	60,000	15	5.1	2.4	240	10	2,400	50	1.96	0.30	37,579	5,762	1a
Sand Truck	Local	Chemical + Restriction	60,000	20	5.1	2.4	40	34	1,360	85	0.46	0.05	1,488	148	1b
	Resource	Water + Restriction	60,000	15	5.1	2.4	40	10	400	50	1.96	0.30	6,263	960	1a
Winch Truck	Local	Chemical + Restriction	60,000	20	5.1	2.4	36	6	216	85	0.46	0.05	236	23	1b
	Resource	Water + Restriction	60,000	15	5.1	2.4	36	10	360	50	1.96	0.30	5,637	864	1a
										Total Unpaved Road Traffic Emissions (lb/pad)			54,367	8,072	

[1] Dust control methods include using water (resource road) or chemical (loacal road) as a dust suppressants along with vehicle restriction speed limit of 25 mph.

[2] AP-42 (EPA 2004), Table 13.2.2-1, "Typical Silt Content Values of Surface Material on Industrial and Rural Unpaved Roads."

[3] AP-42 (EPA 2004), Table 11.9-3, "Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations."

[4] Calculated as Round Trips per Vehicle Type x Round Trip Distance.

[5] Fugitive Dust Handbook (WRAP 2006) Chapter 6.

[6] AP-42 (EPA 2004), Figure 13.2.2-2, "Watering control effectiveness for unpaved travel surfaces.", AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b.

[7] Calculated as lb/VMT x VMT/well x control efficiency.

Completion/Testing Haul Truck Tailpipe

Project: NPL
Scenario: 4 Pad/Section
Activity: Completion/Testing
Emissions: Diesel Combustion Emissions from Heavy Equipment Tailpipes

Pollutant	Pollutant Emission Factor[1] (g/mile)	Total Haul Truck RTs (RTs/well)	RT Distance (miles/RT)	Total Haul Truck Miles Traveled (miles/well)	Haul Activity Duration[3] (days/well)	Haul Activity Duration[3] (hours/day)	Emissions (lb/well)	Emissions (lb/pad)
CO	1.25	316	21	6,656	10	18	18.29	293
NO_x	3.18	316	21	6,656	10	18	46.60	746
PM_{10}	0.21	316	21	6,656	10	18	3.08	49
$PM_{2.5}$	0.17	316	21	6,656	10	18	2.43	39
SO_2[2]	0.01	316	21	6,656	10	18	0.09	1.48E+00
VOC	0.32	316	21	6,656	10	18	4.67	75
Benzene	3.45E-03	316	21	6,656	10	18	0.05	8.10E-01
Ethylbenzene		316	21	6,656	10	18	0.00	0
Formaldehyde	2.57E-02	316	21	6,656	10	18	0.38	6.03E+00
H_2S		316	21	6,656	10	18	0.00	0
n-Hexane		316	21	6,656	10	18	0.00	0
Toluene		316	21	6,656	10	18	0.00	0
Xylenes		316	21	6,656	10	18	0.00	0
CH_4	3.73E-02	316	21	6,656	10	18	0.55	8.76E+00
CO_2[2]	854.68	316	21	6,656	10	18	12541.34	200661
N_2O	1.88E-03	316	21	6,656	10	18	0.03	4.41E-01

[1] MOVES, 2013 heavy duty short haul truck

[2] CO2 from CO2(eq) {CO2(eq)-21*CH4-320*N20}

[3] Haul Activity Duration for completion activities based on an average of 10 days per well and an average of 24 hr/day for 5 days and 12 hr/day for 5 days.

Workover Traffic

Project: NPL
Scenario: 4 Pad/Section
Activity: Workover Traffic
Emissions: Fugitive Particulate Emissions from Traffic on Unpaved Roads

Vehicle Type	Road Type	Dust Control Method[1]	Average Vehicle Weight (lb)	Average Vehicle Speed (mph)	Silt Content[2] (%)	Moisture Content[3] (%)	RTs per Well	RT Distance (miles)	VMT[4] (VMT/well)	Emission Control Efficiency[5] (%)	PM_{10} Emissions[6] (lb/VMT)	$PM_{2.5}$ Emissions[6] (lb/VMT)	PM_{10} Emissions[7] (controlled) (lb/pad)	$PM_{2.5}$ Emissions[7] (controlled) (lb/pad)	
Light Trucks/ Pickups	Local	Chemical + Restriction	5,800	25	5.1	2.4	6	10	60	85	0.51	0.05	73	7	1b
	Resource	Water + Restriction	5,800	20	5.1	2.4	6	1	6	50	0.68	0.07	33	3	1a
Water Truck	Local	Chemical + Restriction	60,000	20	5.1	2.4	24	8	192	85	0.46	0.05	210	21	1b
	Resource	Water + Restriction	60,000	15	5.1	2.4	24	10	240	50	1.96	0.20	3,758	376	1a
Sand Truck	Local	Chemical + Restriction	60,000	20	5.1	2.4	4	34	136	85	0.46	0.05	149	15	1b
	Resource	Water + Restriction	60,000	15	5.1	2.4	4	10	40	50	1.96	0.20	626	63	1a
Winch Truck	Local	Chemical + Restriction	60,000	20	5.1	2.4	4	6	24	85	0.46	0.05	26	3	1b
	Resource	Water + Restriction	60,000	15	5.1	2.4	4	10	40	50	1.96	0.20	626	63	1a
												Total Unpaved Road Traffic Emissions (lb/pad)	5,502	550	

[1] Dust control methods include using water (resource road) or chemical (loacal road) as a dust suppressants along with vehicle restriction speed limit of 25 mph.

[2] AP-42 (EPA 2004), Table 13.2.2-1, "Typical Silt Content Values of Surface Material on Industrial and Rural Unpaved Roads."

[3] AP-42 (EPA 2004), Table 11.9-3, "Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations."

[4] Calculated as Round Trips per Vehicle Type x Round Trip Distance.

[5] Fugitive Dust Handbook (WRAP 2006) Chapter 6.

[6] AP-42 (EPA 2004), Figure 13.2.2-2, "Watering control effectiveness for unpaved travel surfaces.", AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b.

[7] Calculated as lb/VMT x VMT/well x control efficiency.

Workover Tailpipe

Project: NPL
Scenario: 4 Pad/Section
Activity: Well Workover
Emissions: Diesel Combustion Emissions from Heavy Equipment Tailpipes

Pollutant	Pollutant Emission Factor[1] (g/mile)	Total Haul Truck RTs (RTs/well)	RT Distance (miles/RT)	Total Haul Truck Miles Traveled (miles/well)	Haul Activity Duration[3] (days/well)	Haul Activity Duration[3] (hours/day)	Emissions (lb/well)	Emissions (lb/pad)
CO	1.25	32	21	664	10	18	1.82	29
NO_x	3.18	32	21	664	10	18	4.65	74
PM_{10}	0.21	32	21	664	10	18	0.31	4.91E+00
$PM_{2.5}$	0.17	32	21	664	10	18	0.24	3.87E+00
SO_2[2]	0.01	32	21	664	10	18	0.01	0
VOC	0.32	32	21	664	10	18	0.47	7.45E+00
Benzene	3.45E-03	32	21	664	10	18	0.01	8.07E-02
Ethylbenzene		32	21	664	10	18	0.00	0
Formaldehyde	2.57E-02	32	21	664	10	18	0.04	6.01E-01
H_2S		32	21	664	10	18	0.00	0
n-Hexane		32	21	664	10	18	0.00	0
Toluene		32	21	664	10	18	0.00	0
Xylenes		32	21	664	10	18	0.00	0
CH_4	3.73E-02	32	21	664	10	18	0.05	8.74E-01
CO_2[2]	854.68	32	21	664	10	18	1250.37	20006
N_2O	1.88E-03	32	21	664	10	18	0.00	4.40E-02

[1] MOVES, 2013 heavy duty short haul truck

[2] CO2 from CO2(eq) {CO2(eq)-21*CH4-320*N20}

[3] Haul Activity Duration for completion activities based on an average of 10 days per well and an average of 24 hr/day for 5 days and 12 hr/day for 5 days.

Well Workover and Blowdown Emissions

Project: NPL
Scenario: 4 Pad/Section
Effective Dates: All
Emissions: Well workover and blowdown emissions

Activity	Volume Gas Vented[1] (mcf/well)	Event Duration[2] (hour/well)	Events (well/year)	Wells	Control Efficiency[3] (%)	Pollutant	Weight Fraction[4]	Emissions per Well (lb/well-yr)	Emissions per Pad (tons/yr)
Venting	53.6	0.15	0.5	160	0	CO	0.00		
						NOx	0.00		
						SO_2	0.00		
	Molecular Weight	18.43				VOC	0.11	133.78	1.07
	Fuel Heating Value (actual)	1,124	Btu/scf			PM_{10}	0.00		
						$PM_{2.5}$	0.00		
						Benzene	5.12E-04	0.60	0.00
						Ethylbenzene	3.07E-05	0.04	0.00
						Formaldehyde	0.00		
						H_2S	0.00		
						n-Hexane	2.30E-03	2.70	0.02
						Toluene	7.57E-04	0.89	0.01
						Xylenes	2.80E-04	0.33	0.00
						CH_4	0.78	916.14	7.33
						CO_2	0.013	15.01	0.12
						N_2O	0.00		

[1] Based on volume of gas vented from NPL wells during 2010 and proposed operations for the NPL development.
[2] Operator knowledge of actual vent time for NPL wells.
[3] None
[4] Weight fraction based on gas composition. See 'Material Balance' sheet.

Production Facility Development

Project: NPL
Scenario: Gas Throughput (MMscfd)
Activity: Production Facility Development
Emissions:

Date:

Facility	Year									
	1	2	3	4	5	6	7	8	9	10
1	75	75	75	75	75	75	75	75	75	70
2	45	50	50	50	50	50	50	50	50	45
3	43	65	65	65	75	75	75	75	75	70
4		26	50	50	50	50	50	50	50	45
5		27	48	50	50	50	50	50	50	45
6			17	29	41	51	61	69	75	75
7				20	28	28	40	40	40	35
8				15	30	44	44	50	50	50
9						15	18	31	40	40
10							12	17	25	25
11									10	10
Totals	163	243	305	354	399	438	475	507	540	510

Project: Jonah NPL
Scenario: Horsepower
Activity: Production Facility Development
Emissions:

Date:

Facility	Year									
	1	2	3	4	5	6	7	8	9	10
1	10118	10118	10118	10118	10118	10118	10118	10118	10118	10118
2	6475	6475	6475	6475	6475	6475	6475	6475	6475	6475
3	6475	10118	6475	10118	10118	10118	10118	10118	10118	10118
4		3373	6475	6475	6475	6475	6475	6475	6475	6475
5		3373	6475	6475	6475	6475	6475	6475	6475	6475
6			3373	6475	6475	10118	10118	10118	10118	10118
7				3373	6475	6475	6475	6475	6475	6475
8				3373	6475	6475	6475	6475	6475	6475
9						3373	3373	6475	6475	6475
10							3373	3373	3373	3373
11									3373	3373
Totals	23068	33457	39391	52882	59086	66102	69475	72577	75950	75950

Production Traffic – Per Round Trip

Project: NPL
Scenario: 4 Pad/Section
Activity: Production Traffic
Emissions: Fugitive Particulate Emissions from Traffic on Unpaved Roads

Vehicle Type	Road Type	Dust Control Method[1]	Average Vehicle Weight	Average Vehicle Speed	Silt Content[2]	Moisture Content[3]	RTs	RT Distance	VMT[4]	Emission Control Efficiency[5]	PM_{10} Emission Factor[6]	$PM_{2.5}$ Emission Factor[6]	PM_{10} Emissions[7] (controlled)	$PM_{2.5}$ Emissions[7] (controlled)	
			(lb)	(mph)	(%)	(%)	(RTs)	(miles\pad)	(VMT)	(%)	(lb/VMT)	(lb/VMT)	(lb/pad)	(lb/pad)	
Light Truck	Local	Chemical + Restriction	5,800	25	5.1	2.4	365	9	3,285	85	0.51	0.05	251.22	24.97	1b
	Resource	Water + Restriction	5,800	20	5.1	2.4	365	1	365	50	0.68	0.07	124.82	12.48	1a
												Total Access and Unimproved Road Emissions (lb/pad)	376.04	37.45	

[1] Dust control methods include using water (resource road) or chemical (loacal road) as a dust suppressants along with vehicle restriction speed limit of 25 mph.

[2]

[3] AP-42 (EPA 2004), Table 13.2.2-1, "Typical Silt Content Values of Surface Material on Industrial and Rural Unpaved Roads."

AP-42 (EPA 2004), Table 11.9-3, "Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations."

[4]

[5] Calculated as Round Trips per Vehicle Type x Round Trip Distance

[6] AP-42 (EPA 2004), Figure 13.2.2-2, "Watering control effectiveness for unpaved travel surfaces.", Fugitive Dust Handbook (WRAP 2006) Chapter 6.

[7] AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b.
Calculated as lb/VMT x VMT/RT x control efficiency.

Liquids Gathering Traffic - Per Round Trip

Project: **NPL**
Scenario: **4 Pad/Section**
Activity: **Production Traffic**
Emissions: **Fugitive Particulate Emissions from Traffic on Unpaved Roads**

Vehicle Type	Road Type	Dust Control Method[1]	Average Vehicle Weight	Average Vehicle Speed	Silt Content[2]	Moisture Content[3]	RTs	RT Distance	VMT[4]	Emission Control Efficiency[5]	PM_{10} Emission Factor[6]	$PM_{2.5}$ Emission Factor[6]	PM_{10} Emissions[7] (controlled)	$PM_{2.5}$ Emissions[7] (controlled)
			(lb)	(mph)	(%)	(%)	(RT)	(miles)	(VMT/RT)	(%)	(lb/VMT)	(lb/VMT)	(lb/yr)	(lb/yr)
Haul Truck	Local	Chemical + Restriction	54,000	25	5.1	2.4	4,149	34	141,082	85	0.51	0.05	10,789.11	1,072.29
	Resource	Water + Restriction	54,000	20	5.1	2.4	4,149	2	8,299	50	1.87	0.19	7,745.39	774.54
												Total Access and Unimproved Road Emissions (lb/RT)	18,534.50	1,846.83

[1] Dust control methods include using water (resource road) or chemical (loacal road) as a dust suppressants along with vehicle restriction speed limit of 25 mph.

[2]

[3] AP-42 (EPA 2004), Table 13.2.2-1, "Typical Silt Content Values of Surface Material on Industrial and Rural Unpaved Roads."

AP-42 (EPA 2004), Table 11.9-3, "Typical Values for Correction Factors Applicable to the Predictive Emission Factor Equations."

[4]

[5] Calculated as Round Trips per Vehicle Type x Round Trip Distance

[6] AP-42 (EPA 2004), Figure 13.2.2-2, "Watering control effectiveness for unpaved travel surfaces.", Fugitive Dust Handbook (WRAP 2006) Chapter 6.

[7] AP-42 (EPA 2004), Section 13.2.2 "Unpaved Roads", equations 1a and 1b.
Calculated as lb/VMT x VMT/RT x control efficiency.

Tanker Traffic Tailpipe - Per Round Trip

Project: NPL
Scenario: 4 Pad/Section
Activity: Production Tailpipe
Emissions: Diesel Combustion Emissions from Heavy Equipment Tailpipes

Pollutant	Pollutant Emission Factor[1] (g/mi)	RT (RT)	Single Round Trip Distance (mi/RT)	Yearly VMT (mi)	Central Facility Emissions (lb/yr)
CO	1.25	365	10	3650	10.03
NO_x	3.18	365	10	3650	25.55
PM_{10}	0.21	365	10	3650	1.69
$PM_{2.5}$	0.17	365	10	3650	1.33
SO_2[2]	0.01	365	10	3650	0.05
VOC	0.32	365	10	3650	2.56
Benzene	3.45E-03	365	10	3650	2.77E-02
Ethylbenzene		365	10	3650	0.00
Formaldehyde	2.57E-02	365	10	3650	2.07E-01
H_2S		365	10	3650	0.00
n-Hexane		365	10	3650	0.00
Toluene		365	10	3650	0.00
Xylenes		365	10	3650	0.00
CH_4	3.73E-02	365	10	3650	3.00E-01
CO_2[2]	854.68	365	10	3650	6877.54
N_2O	1.88E-03	365	10	3650	1.51E-02

[1] MOVES, 2013 heavy duty short haul truck
[2] CO2 from CO2(eq) {CO2(eq)-21*CH4-320*N20}

Tanker Traffic Tailpipe - Per Round Trip

Project: NPL
Scenario: 4 Pad/Section
Activity: Tanker Tailpipe
Emissions: Diesel Combustion Emissions from Heavy Equipment Tailpipes

Pollutant	Pollutant Emission Factor[1]	RT	Single Round Trip Distance	Yearly VMT	Central Facility Emissions
	(g/mi)	(RT)	(mi/RT)	(mi)	(lb/yr)
CO	1.25	4,149	36	149381	410.44
NO_x	3.18	4,149	36	149381	1045.87
PM_{10}	0.21	4,149	36	149381	69.05
$PM_{2.5}$	0.17	4,149	36	149381	54.48
SO_2[2]	0.01	4,149	36	149381	2.07
VOC	0.32	4,149	36	149381	104.77
Benzene	3.45E-03	4,149	36	149381	1.14
Ethylbenzene		4,149	36	149381	0.00
Formaldehyde	2.57E-02	4,149	36	149381	8.46
H_2S		4,149	36	149381	0.00
n-Hexane		4,149	36	149381	0.00
Toluene		4,149	36	149381	0.00
Xylenes		4,149	36	149381	0.00
CH_4	3.73E-02	4,149	36	149381	12.29
CO_2[2]	854.68	4,149	36	149381	281472.42
N_2O	1.88E-03	4,149	36	149381	6.19E-01

[1] MOVES, 2013 heavy duty short haul truck
[2] CO2 from CO2(eq) {CO2(eq)-21*CH4-320*N20}

Wind Erosion Data

Year	Month	Day	Peak Wind Speed (mph)	Peak Wind Speed u^+_{10} (m/s)[1]	Friction Velocity u* (m/s)[2]	Threshold Friction Velocity u^*_t[3]	Exceed Threshold Friction Velocity	P (g/m²)[4]	ΣP (g/m²-yr)
2008	1	1	7	3.13	0.17	1.02	No		
2008	1	2	7	3.13	0.17	1.02	No		
2008	1	3	6	2.68	0.14	1.02	No		
2008	1	4	7	3.13	0.17	1.02	No		
2008	1	5	31	13.86	0.73	1.02	No		
2008	1	6	10	4.47	0.24	1.02	No		
2008	1	7	9	4.02	0.21	1.02	No		
2008	1	8	9	4.02	0.21	1.02	No		
2008	1	9	12	5.36	0.28	1.02	No		
2008	1	10	8	3.58	0.19	1.02	No		
2008	1	11	21	9.39	0.50	1.02	No		
2008	1	12	8	3.58	0.19	1.02	No		
2008	1	13	14	6.26	0.33	1.02	No		
2008	1	14	10	4.47	0.24	1.02	No		
2008	1	15	33	14.75	0.78	1.02	No		
2008	1	16	13	5.81	0.31	1.02	No		
2008	1	17	22	9.83	0.52	1.02	No		
2008	1	18	14	6.26	0.33	1.02	No		
2008	1	19	8	3.58	0.19	1.02	No		
2008	1	20	14	6.26	0.33	1.02	No		
2008	1	21	14	6.26	0.33	1.02	No		
2008	1	22	7	3.13	0.17	1.02	No		
2008	1	23	10	4.47	0.24	1.02	No		
2008	1	24	9	4.02	0.21	1.02	No		
2008	1	25	9	4.02	0.21	1.02	No		
2008	1	26	10	4.47	0.24	1.02	No		
2008	1	27	16	7.15	0.38	1.02	No		
2008	1	28	37	16.54	0.88	1.02	No		
2008	1	29	13	5.81	0.31	1.02	No		
2008	1	30	22	9.83	0.52	1.02	No		
2008	1	31	7	3.13	0.17	1.02	No		
2008	2	1	12	5.36	0.28	1.02	No		
2008	2	2	7	3.13	0.17	1.02	No		
2008	2	3	7	3.13	0.17	1.02	No		
2008	2	4	12	5.36	0.28	1.02	No		
2008	2	5	13	5.81	0.31	1.02	No		
2008	2	6	20	8.94	0.47	1.02	No		
2008	2	7	38	16.99	0.90	1.02	No		
2008	2	8	21	9.39	0.50	1.02	No		
2008	2	9	16	7.15	0.38	1.02	No		
2008	2	10	10	4.47	0.24	1.02	No		
2008	2	11	21	9.39	0.50	1.02	No		
2008	2	12	17	7.60	0.40	1.02	No		
2008	2	13	23	10.28	0.54	1.02	No		
2008	2	14	13	5.81	0.31	1.02	No		
2008	2	15	6	2.68	0.14	1.02	No		
2008	2	16	22	9.83	0.52	1.02	No		
2008	2	17	18	8.05	0.43	1.02	No		
2008	2	18	17	7.60	0.40	1.02	No		
2008	2	19	10	4.47	0.24	1.02	No		
2008	2	20	6	2.68	0.14	1.02	No		
2008	2	21	6	2.68	0.14	1.02	No		
2008	2	22	9	4.02	0.21	1.02	No		
2008	2	23	8	3.58	0.19	1.02	No		
2008	2	24	10	4.47	0.24	1.02	No		
2008	2	25	10	4.47	0.24	1.02	No		
2008	2	26	15	6.71	0.36	1.02	No		
2008	2	27	8	3.58	0.19	1.02	No		
2008	2	28	16	7.15	0.38	1.02	No		
2008	2	29	9	4.02	0.21	1.02	No		
2008	3	1	23	10.28	0.54	1.02	No		
2008	3	2	21	9.39	0.50	1.02	No		
2008	3	3	10	4.47	0.24	1.02	No		
2008	3	4	21	9.39	0.50	1.02	No		
2008	3	5	21	9.39	0.50	1.02	No		
2008	3	6	17	7.60	0.40	1.02	No		
2008	3	7	16	7.15	0.38	1.02	No		
2008	3	8	12	5.36	0.28	1.02	No		
2008	3	9	8	3.58	0.19	1.02	No		
2008	3	10	9	4.02	0.21	1.02	No		
2008	3	11	23	10.28	0.54	1.02	No		
2008	3	12	15	6.71	0.36	1.02	No		
2008	3	13	17	7.60	0.40	1.02	No		
2008	3	14	18	8.05	0.43	1.02	No		
2008	3	15	13	5.81	0.31	1.02	No		
2008	3	16	14	6.26	0.33	1.02	No		
2008	3	17	15	6.71	0.36	1.02	No		
2008	3	18	13	5.81	0.31	1.02	No		
2008	3	19	18	8.05	0.43	1.02	No		
2008	3	20	25	11.18	0.59	1.02	No		
2008	3	21	29	12.96	0.69	1.02	No		
2008	3	22	13	5.81	0.31	1.02	No		
2008	3	23	8	3.58	0.19	1.02	No		
2008	3	24	30	13.41	0.71	1.02	No		
2008	3	25	18	8.05	0.43	1.02	No		
2008	3	26	49	21.90	1.16	1.02	Yes	4.68	
2008	3	27	31	13.86	0.73	1.02	No		
2008	3	28	18	8.05	0.43	1.02	No		
2008	3	29	29	12.96	0.69	1.02	No		
2008	3	30	9	4.02	0.21	1.02	No		
2008	3	31	35	15.65	0.83	1.02	No		
2008	4	1	15	6.71	0.36	1.02	No		
2008	4	2	15	6.71	0.36	1.02	No		
2008	4	3	20	8.94	0.47	1.02	No		
2008	4	4	20	8.94	0.47	1.02	No		
2008	4	5	35	15.65	0.83	1.02	No		
2008	4	6	15	6.71	0.36	1.02	No		
2008	4	7	30	13.41	0.71	1.02	No		
2008	4	8	20	8.94	0.47	1.02	No		
2008	4	9	21	9.39	0.50	1.02	No		
2008	4	10	23	10.28	0.54	1.02	No		
2008	4	11	26	11.62	0.62	1.02	No		
2008	4	12	22	9.83	0.52	1.02	No		
2008	4	13	17	7.60	0.40	1.02	No		
2008	4	14	30	13.41	0.71	1.02	No		
2008	4	15	29	12.96	0.69	1.02	No		
2008	4	16	18	8.05	0.43	1.02	No		
2008	4	17	20	8.94	0.47	1.02	No		
2008	4	18	39	17.43	0.92	1.02	No		
2008	4	19	31	13.86	0.73	1.02	No		
2008	4	20	44	19.67	1.04	1.02	Yes	0.59	
2008	4	21	32	14.31	0.76	1.02	No		
2008	4	22	23	10.28	0.54	1.02	No		
2008	4	23	31	13.86	0.73	1.02	No		
2008	4	24	29	12.96	0.69	1.02	No		
2008	4	25	41	18.33	0.97	1.02	No		
2008	4	26	22	9.83	0.52	1.02	No		
2008	4	27	17	7.60	0.40	1.02	No		
2008	4	28	32	14.31	0.76	1.02	No		
2008	4	29	41	18.33	0.97	1.02	No		
2008	4	30	24	10.73	0.57	1.02	No		
2008	5	1	26	11.62	0.62	1.02	No		
2008	5	2	25	11.18	0.59	1.02	No		
2008	5	3	14	6.26	0.33	1.02	No		
2008	5	4	21	9.39	0.50	1.02	No		
2008	5	5	28	12.52	0.66	1.02	No		
2008	5	6	24	10.73	0.57	1.02	No		
2008	5	7	18	8.05	0.43	1.02	No		
2008	5	8	28	12.52	0.66	1.02	No		
2008	5	9	30	13.41	0.71	1.02	No		
2008	5	10	23	10.28	0.54	1.02	No		
2008	5	11	36	16.09	0.85	1.02	No		
2008	5	12	23	10.28	0.54	1.02	No		
2008	5	13	21	9.39	0.50	1.02	No		
2008	5	14	23	10.28	0.54	1.02	No		
2008	5	15	16	7.15	0.38	1.02	No		
2008	5	16	22	9.83	0.52	1.02	No		
2008	5	17	24	10.73	0.57	1.02	No		
2008	5	18	37	16.54	0.88	1.02	No		
2008	5	19	29	12.96	0.69	1.02	No		
2008	5	20	68	30.40	1.61	1.02	Yes	35.05	
2008	5	21	24	10.73	0.57	1.02	No		
2008	5	22	14	6.26	0.33	1.02	No		
2008	5	23	21	9.39	0.50	1.02	No		
2008	5	24	32	14.31	0.76	1.02	No		
2008	5	25	15	6.71	0.36	1.02	No		
2008	5	26	35	15.65	0.83	1.02	No		
2008	5	27	25	11.18	0.59	1.02	No		
2008	5	28	32	14.31	0.76	1.02	No		
2008	5	29	36	16.09	0.85	1.02	No		
2008	5	30	23	10.28	0.54	1.02	No		
2008	5	31	18	8.05	0.43	1.02	No		
2008	6	1	26	11.62	0.62	1.02	No		
2008	6	2	35	15.65	0.83	1.02	No		
2008	6	3	26	11.62	0.62	1.02	No		
2008	6	4	23	10.28	0.54	1.02	No		
2008	6	5	31	13.86	0.73	1.02	No		
2008	6	6	43	19.22	1.02	1.02	No		
2008	6	7	32	14.31	0.76	1.02	No		
2008	6	8	30	13.41	0.71	1.02	No		
2008	6	9	31	13.86	0.73	1.02	No		
2008	6	10	32	14.31	0.76	1.02	No		
2008	6	11	31	13.86	0.73	1.02	No		
2008	6	12	32	14.31	0.76	1.02	No		
2008	6	13	30	13.41	0.71	1.02	No		
2008	6	14	32	14.31	0.76	1.02	No		
2008	6	15	31	13.86	0.73	1.02	No		
2008	6	16	28	12.52	0.66	1.02	No		
2008	6	17	37	16.54	0.88	1.02	No		
2008	6	18	26	11.62	0.62	1.02	No		
2008	6	19	26	11.62	0.62	1.02	No		
2008	6	20	28	12.52	0.66	1.02	No		
2008	6	21	28	12.52	0.66	1.02	No		
2008	6	22	36	16.09	0.85	1.02	No		
2008	6	23	36	16.09	0.85	1.02	No		
2008	6	24	32	14.31	0.76	1.02	No		
2008	6	25	26	11.62	0.62	1.02	No		
2008	6	26	66	29.50	1.56	1.02	Yes	30.74	
2008	6	27	29	12.96	0.69	1.02	No		
2008	6	28	28	12.52	0.66	1.02	No		
2008	6	29	16	7.15	0.38	1.02	No		
2008	6	30	56	25.03	1.33	1.02	Yes	13.13	
2008	7	1	35	15.65	0.83	1.02	No		
2008	7	2	30	13.41	0.71	1.02	No		
2008	7	3	29	12.96	0.69	1.02	No		
2008	7	4	36	16.09	0.85	1.02	No		
2008	7	5	26	11.62	0.62	1.02	No		
2008	7	6	31	13.86	0.73	1.02	No		
2008	7	7	25	11.18	0.59	1.02	No		
2008	7	8	30	13.41	0.71	1.02	No		
2008	7	9	26	11.62	0.62	1.02	No		
2008	7	10	30	13.41	0.71	1.02	No		
2008	7	11	28	12.52	0.66	1.02	No		
2008	7	12	23	10.28	0.54	1.02	No		
2008	7	13	24	10.73	0.57	1.02	No		
2008	7	14	31	13.86	0.73	1.02	No		
2008	7	15	26	11.62	0.62	1.02	No		
2008	7	16	25	11.18	0.59	1.02	No		
2008	7	17	24	10.73	0.57	1.02	No		
2008	7	18	36	16.09	0.85	1.02	No		
2008	7	19	32	14.31	0.76	1.02	No		
2008	7	20	24	10.73	0.57	1.02	No		
2008	7	21	26	11.62	0.62	1.02	No		
2008	7	22	37	16.54	0.88	1.02	No		
2008	7	23	28	12.52	0.66	1.02	No		
2008	7	24	32	14.31	0.76	1.02	No		
2008	7	25	21	9.39	0.50	1.02	No		
2008	7	26	31	13.86	0.73	1.02	No		
2008	7	27	28	12.52	0.66	1.02	No		
2008	7	28	28	12.52	0.66	1.02	No		
2008	7	29	29	12.96	0.69	1.02	No		
2008	7	30	36	16.09	0.85	1.02	No		
2008	7	31	29	12.96	0.69	1.02	No		
2008	8	1	31	13.86	0.73	1.02	No		
2008	8	2	31	13.86	0.73	1.02	No		
2008	8	3	33	14.75	0.78	1.02	No		
2008	8	4	31	13.86	0.73	1.02	No		
2008	8	5	30	13.41	0.71	1.02	No		
2008	8	6	28	12.52	0.66	1.02	No		
2008	8	7	32	14.31	0.76	1.02	No		
2008	8	8	31	13.86	0.73	1.02	No		
2008	8	9	37	16.54	0.88	1.02	No		
2008	8	10	48	21.46	1.14	1.02	Yes	3.73	
2008	8	11	30	13.41	0.71	1.02	No		
2008	8	12	25	11.18	0.59	1.02	No		
2008	8	13	33	14.75	0.78	1.02	No		
2008	8	14	33	14.75	0.78	1.02	No		
2008	8	15	24	10.73	0.57	1.02	No		
2008	8	16	17	7.60	0.40	1.02	No		
2008	8	17	17	7.60	0.40	1.02	No		
2008	8	18	15	6.71	0.36	1.02	No		
2008	8	19	21	9.39	0.50	1.02	No		
2008	8	20	33	14.75	0.78	1.02	No		
2008	8	21	43	19.22	1.02	1.02	No		
2008	8	22	23	10.28	0.54	1.02	No		
2008	8	23	20	8.94	0.47	1.02	No		
2008	8	24	21	9.39	0.50	1.02	No		
2008	8	25	43	19.22	1.02	1.02	No		
2008	8	26	33	14.75	0.78	1.02	No		
2008	8	27	39	17.43	0.92	1.02	No		
2008	8	28	28	12.52	0.66	1.02	No		
2008	8	29	17	7.60	0.40	1.02	No		
2008	8	30	25	11.18	0.59	1.02	No		
2008	8	31	44	19.67	1.04	1.02	Yes	0.59	
2008	9	1	32	14.31	0.76	1.02	No		
2008	9	2	15	6.71	0.36	1.02	No		
2008	9	3	30	13.41	0.71	1.02	No		
2008	9	4	39	17.43	0.92	1.02	No		
2008	9	5	26	11.62	0.62	1.02	No		
2008	9	6	26	11.62	0.62	1.02	No		
2008	9	7	28	12.52	0.66	1.02	No		
2008	9	8	15	6.71	0.36	1.02	No		
2008	9	9	36	16.09	0.85	1.02	No		
2008	9	10	35	15.65	0.83	1.02	No		
2008	9	11	23	10.28	0.54	1.02	No		
2008	9	12	26	11.62	0.62	1.02	No		
2008	9	13	28	12.52	0.66	1.02	No		
2008	9	14	22	9.83	0.52	1.02	No		
2008	9	15	12	5.36	0.28	1.02	No		
2008	9	16	14	6.26	0.33	1.02	No		
2008	9	17	23	10.28	0.54	1.02	No		
2008	9	18	35	15.65	0.83	1.02	No		
2008	9	19	17	7.60	0.40	1.02	No		
2008	9	20	29	12.96	0.69	1.02	No		
2008	9	21	26	11.62	0.62	1.02	No		
2008	9	22	26	11.62	0.62	1.02	No		
2008	9	23	24	10.73	0.57	1.02	No		
2008	9	24	28	12.52	0.66	1.02	No		
2008	9	25	30	13.41	0.71	1.02	No		
2008	9	26	25	11.18	0.59	1.02	No		
2008	9	27	30	13.41	0.71	1.02	No		
2008	9	28	22	9.83	0.52	1.02	No		
2008	9	29	14	6.26	0.33	1.02	No		
2008	9	30		0.00	0.00	1.02	No		
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2008	10	2	25	11.18	0.59	1.02	No		
2008	10	3	23	10.28	0.54	1.02	No		
2008	10	4	21	9.39	0.50	1.02	No		
2008	10	5	26	11.62	0.62	1.02	No		
2008	10	6	23	10.28	0.54	1.02	No		
2008	10	7	26	11.62	0.62	1.02	No		
2008	10	8	41	18.33	0.97	1.02	No		
2008	10	9	38	16.99	0.90	1.02	No		
2008	10	10	21	9.39	0.50	1.02	No		
2008	10	11	31	13.86	0.73	1.02	No		
2008	10	12	18	8.05	0.43	1.02	No		
2008	10	13	15	6.71	0.36	1.02	No		
2008	10	14	24	10.73	0.57	1.02	No		
2008	10	15	10	4.47	0.24	1.02	No		
2008	10	16	18	8.05	0.43	1.02	No		
2008	10	17	12	5.36	0.28	1.02	No		
2008	10	18	23	10.28	0.54	1.02	No		
2008	10	19	13	5.81	0.31	1.02	No		
2008	10	20		0.00	0.00	1.02	No		
2008	10	21	41	18.33	0.97	1.02	No		
2008	10	22		0.00	0.00	1.02	No		
2008	10	23	27	12.07	0.64	1.02	No		
2008	10	24	24	10.73	0.57	1.02	No		
2008	10	25	35	15.65	0.83	1.02	No		
2008	10	26	17	7.60	0.40	1.02	No		
2008	10	27	14	6.26	0.33	1.02	No		
2008	10	28	12	5.36	0.28	1.02	No		
2008	10	29	26	11.62	0.62	1.02	No		
2008	10	30	14	6.26	0.33	1.02	No		
2008	10	31	8	3.58	0.19	1.02	No		
2008	11	1	20	8.94	0.47	1.02	No		
2008	11	2	31	13.86	0.73	1.02	No		
2008	11	3	22	9.83	0.52	1.02	No		
2008	11	4	26	11.62	0.62	1.02	No		
2008	11	5	37	16.54	0.88	1.02	No		
2008	11	6	37	16.54	0.88	1.02	No		
2008	11	7	24	10.73	0.57	1.02	No		
2008	11	8	16	7.15	0.38	1.02	No		
2008	11	9	14	6.26	0.33	1.02	No		
2008	11	10	25	11.18	0.59	1.02	No		
2008	11	11	21	9.39	0.50	1.02	No		
2008	11	12	29	12.96	0.69	1.02	No		
2008	11	13	44	19.67	1.04	1.02	Yes	0.59	
2008	11	14	24	10.73	0.57	1.02	No		
2008	11	15	33	14.75	0.78	1.02	No		
2008	11	16	13	5.81	0.31	1.02	No		
2008	11	17	15	6.71	0.36	1.02	No		
2008	11	18	17	7.60	0.40	1.02	No		
2008	11	19	13	5.81	0.31	1.02	No		
2008	11	20	22	9.83	0.52	1.02	No		
2008	11	21	30	13.41	0.71	1.02	No		
2008	11	22	13	5.81	0.31	1.02	No		
2008	11	23	26	11.62	0.62	1.02	No		
2008	11	24	13	5.81	0.31	1.02	No		
2008	11	25	10	4.47	0.24	1.02	No		
2008	11	26	12	5.36	0.28	1.02	No		
2008	11	27	12	5.36	0.28	1.02	No		
2008	11	28	38	16.99	0.90	1.02	No		
2008	11	29	51	22.80	1.21	1.02	Yes	6.77	
2008	11	30	47	21.01	1.11	1.02	Yes	2.85	
2008	12	1	25	11.18	0.59	1.02	No		
2008	12	2	35	15.65	0.83	1.02	No		
2008	12	3	25	11.18	0.59	1.02	No		
2008	12	4	16	7.15	0.38	1.02	No		
2008	12	5	29	12.96	0.69	1.02	No		
2008	12	6	20	8.94	0.47	1.02	No		
2008	12	7	20	8.94	0.47	1.02	No		
2008	12	8	26	11.62	0.62	1.02	No		
2008	12	9	20	8.94	0.47	1.02	No		
2008	12	10	30	13.41	0.71	1.02	No		
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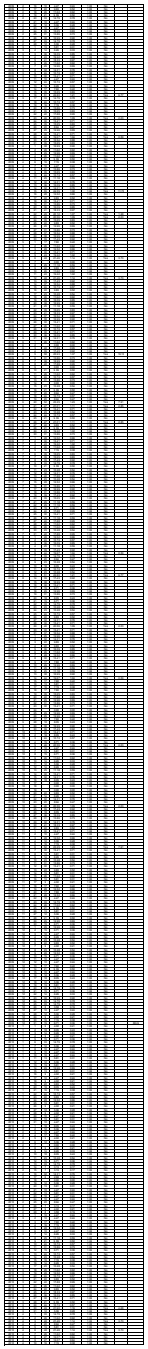

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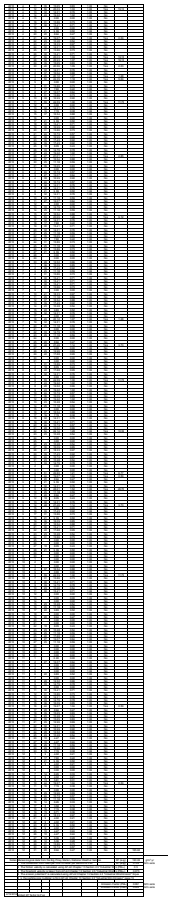

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2010	10	3		0.00	0.00	1.00	No			
2010	10	4	37	16.54	0.88	1.00	No			
2010	10	5		0.00	0.00	1.00	No			
2010	10	6	55	24.59	1.30	1.00	Yes	11.73		
2010	10	7	31	13.86	0.73	1.00	No			
2010	10	8	30	13.41	0.71	1.00	No			
2010	10	9	33	14.75	0.78	1.00	No			
2010	10	10	23	10.28	0.54	1.00	No			
2010	10	11	30	13.41	0.71	1.00	No			
2010	10	12		0.00	0.00	1.00	No			
2010	10	13		0.00	0.00	1.00	No			
2010	10	14		0.00	0.00	1.00	No			
2010	10	15	23	10.28	0.54	1.00	No			
2010	10	16	25	11.18	0.59	1.00	No			
2010	10	17	22	9.83	0.52	1.00	No			
2010	10	18		0.00	0.00	1.00	No			
2010	10	19	20	8.94	0.47	1.00	No			
2010	10	20		0.00	0.00	1.00	No			
2010	10	21		0.00	0.00	1.00	No			
2010	10	22	18	8.05	0.43	1.00	No			
2010	10	23	23	10.28	0.54	1.00	No			
2010	10	24	25	11.18	0.59	1.00	No			
2010	10	25	40	17.88	0.95	1.00	No			
2010	10	26	27	12.07	0.64	1.00	No			
2010	10	27	25	11.18	0.59	1.00	No			
2010	10	28		0.00	0.00	1.00	No			
2010	10	29		0.00	0.00	1.00	No			
2010	10	30		0.00	0.00	1.00	No			
2010	10	31		0.00	0.00	1.00	No			
2010	11	1		0.00	0.00	1.00	No			
2010	11	2	27	12.07	0.64	1.00	No			
2010	11	3		0.00	0.00	1.00	No			
2010	11	4		0.00	0.00	1.00	No			
2010	11	5		0.00	0.00	1.00	No			
2010	11	6	22	9.83	0.52	1.00	No			
2010	11	7		0.00	0.00	1.00	No			
2010	11	8	28	12.52	0.66	1.00	No			
2010	11	9	33	14.75	0.78	1.00	No			
2010	11	10		0.00	0.00	1.00	No			
2010	11	11	30	13.41	0.71	1.00	No			
2010	11	12	31	13.86	0.73	1.00	No			
2010	11	13	32	14.31	0.76	1.00	No			
2010	11	14	33	14.75	0.78	1.00	No			
2010	11	15	36	16.09	0.85	1.00	No			
2010	11	16	44	19.67	1.04	1.00	Yes	0.59		
2010	11	17	20	8.94	0.47	1.00	No			
2010	11	18	35	15.65	0.83	1.00	No			
2010	11	19	23	10.28	0.54	1.00	No			
2010	11	20	35	15.65	0.83	1.00	No			
2010	11	21	29	12.96	0.69	1.00	No			
2010	11	22	32	14.31	0.76	1.00	No			
2010	11	23	38	16.99	0.90	1.00	No			
2010	11	24	28	12.52	0.66	1.00	No			
2010	11	25	23	10.28	0.54	1.00	No			
2010	11	26	10	4.47	0.24	1.00	No			
2010	11	27	10	4.47	0.24	1.00	No			
2010	11	28	25	11.18	0.59	1.00	No			
2010	11	29	29	12.96	0.69	1.00	No			
2010	11	30	16	7.15	0.38	1.00	No			
2010	12	1	9	4.02	0.21	1.00	No			
2010	12	2	17	7.60	0.40	1.00	No			
2010	12	3	21	9.39	0.50	1.00	No			
2010	12	4	9	4.02	0.21	1.00	No			
2010	12	5		0.00	0.00	1.00	No			
2010	12	6		0.00	0.00	1.00	No			
2010	12	7	14	6.26	0.33	1.00	No			
2010	12	8	9	4.02	0.21	1.00	No			
2010	12	9	13	5.81	0.31	1.00	No			
2010	12	10	44	19.67	1.04	1.00	Yes	0.59		
2010	12	11	16	7.15	0.38	1.00	No			
2010	12	12		0.00	0.00	1.00	No			
2010	12	13	29	12.96	0.69	1.00	No			
2010	12	14	24	10.73	0.57	1.00	No			
2010	12	15	25	11.18	0.59	1.00	No			
2010	12	16	14	6.26	0.33	1.00	No			
2010	12	17	8	3.58	0.19	1.00	No			
2010	12	18	16	7.15	0.38	1.00	No			
2010	12	19	15	6.71	0.35	1.00	No			
2010	12	20	41	18.33	0.97	1.00	No			
2010	12	21	9	4.02	0.21	1.00	No			
2010	12	22	9	4.02	0.21	1.00	No			
2010	12	23	21	9.39	0.50	1.00	No			
2010	12	24	9	4.02	0.21	1.00	No			
2010	12	25	10	4.47	0.24	1.00	No			
2010	12	26	10	4.47	0.24	1.00	No			
2010	12	27	12	5.36	0.28	1.00	No			
2010	12	28	12	5.36	0.28	1.00	No			
2010	12	29	31	13.86	0.73	1.00	No			
2010	12	30	24	10.73	0.57	1.00	No			
2010	12	31	20	8.94	0.47	1.00	No		185.82	
Notes:	Meteorological data from the Big Piney Station, National Weather Service.							ΣP (avg)	120.02	g/m²-yr
	1. The conversion from miles per hour to meter per second is 0.44							ΣP (avg)	0.123	lb/hr-acre
	2. The friction velocity is calculated using AP-42 Chapter 13 Section 2.5 "Industrial Wi							k (PM10)⁵	0.5	
	3. The threshold velocity is taken from AP-42 Chapter 13 Section 2.5 "Industrial Wind							k (PM2.5)⁵	0.075	
	4. The erosion potential P is calculated using AP-42 Chapter 13 Section 2.5 "Industrial Wind Erosion" Equa									
	5. k, the particle size multiplier is from AP-42 Chapter 13 Section 2.5 "Industrial Wind Erosion" page 13									
							Emission Factor (PM10)		0.061	lb/hr-acre
							Emission Factor (PM2.5)		0.009	lb/hr-acre
4/15/201	added 25" factor to P ec									

Production Wind Erosion - Per Acre of Disturbance

Project: **NPL**
Scenario: **4 Pad/Section**
Activity: **Production Wind Erosion**

Emissions: **Wind Erosion**

Emission Factor (PM_{10})[1] : 0.0611 lb/hr-acre
Emission Factor ($PM_{2.5}$)[1] : 0.0092 lb/hr-acre

Control Efficiency[2]: 50 %

Disturbed Area:

Well Pad and Road: 18 acres assume 30% of pads/facility will have equipment on it

Central Facility: 11 acres assume 30% of pads/facility will have equipment on it

Emissions Calculations:

	PM_{10} Emission Factor	$PM_{2.5}$ Emission Factor	Area	Control Efficiency	PM_{10} Emissions	$PM_{2.5}$ Emissions	Controlled PM_{10} Emissions	Controlled $PM_{2.5}$ Emissions
	(lb/hr-acre)	(lb/hr-acre)	(acre)	(%)	(lb/hr)	(lb/hr)	(tons/yr)	(tons/yr)
Well Pad and Road	0.0611	0.0092	17.94	50	0.55	0.08	2.40	0.36
Compressor Station	0.0611	0.0092	10.50	50	0.32	0.05	1.41	0.21
Total							3.81	0.57

[1] Based on AP-42 Chapter 13.2.5 (EPA 2004), Industrial Wind Erosion using Area meteorological data. See 'WindErosion Data' sheet for details.
[2] AP-42 (EPA 2004), Section 13.2.3, "Heavy Construction Operations".

Compressor Engine Emissions

Project: NPL
Scenario: Option 3 - Electric Engines
Effective Dates: All
Emissions: Combustion Emissions from Compressor Engines

0.17073171

Engine	Pollutant	EPA Tier Certification	Pollutant Emission Factor[1] (g/hp-hr)	Engine Count	Horse-power[2] (hp)	Overall Load Factor[3]	Annual Activity (days/yr)	Daily Ops (hrs/day)	Emissions per Facility (lb/facility)	Emissions per Hour (lb/hr)	Emissions per Facility (tons)
Cat 3612 w/SCO AFRC Combustion	CO	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	NOx	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	SO_2	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	VOC	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	PM_{10}	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	$PM_{2.5}$	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	Benzene	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	Ethylbenzene	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	Formaldehyde	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	H_2S	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	n-Hexane	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	Toluene	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	Xylenes	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	CH_4	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	CO_2	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00
	N_2O	Electric	0.00	1	3,500	0.90	365	24	0.00	0.00	0.00

		Compressor Volume (scf)[4]	Events per Year	MW Gas	Weight Fraction			lb/compressor-y	lb/hr	v/compressor-yr
Cat 3612 w/SCO AFRC Blowdown	CO									
	NOx									
	SO_2									
	VOC	650	24	18.53	0.12			91.45	0.01	0.05
	PM_{10}									
	$PM_{2.5}$									
	Benzene	650	24	18.53	5.12E-04			0.39	0.00	0.00
	Ethylbenzene	650	24	18.53	3.07E-05			0.02	0.00	0.00
	Formaldehyde									
	H_2S									
	n-Hexane	650	24	18.53	2.30E-03			1.75	0.00	0.00
	Toluene	650	24	18.53	7.57E-04			0.58	0.00	0.00
	Xylenes	650	24	18.53	2.80E-04			0.21	0.00	0.00
	CH_4	650	24	18.53	0.782			595.86	0.07	0.30
	CO_2	650	24	18.53	1.28E-02			9.77	0.00	0.00
	N_2O									
Total	CO							0.00	0.00	0.00
	NOx							0.00	0.00	0.00
	SO_2							0.00	0.00	0.00
	VOC							91.45	0.01	0.05
	PM_{10}							0.00	0.00	0.00
	$PM_{2.5}$							0.00	0.00	0.00
	Benzene							0.39	0.00	0.00
	Ethylbenzene							0.02	0.00	0.00
	Formaldehyde							0.00	0.00	0.00
	H_2S							0.00	0.00	0.00
	n-Hexane							1.75	0.00	0.00
	Toluene							0.58	0.00	0.00
	Xylenes							0.21	0.00	0.00
	CH_4							595.86	0.07	0.30
	CO_2							9.77	0.00	0.00
	N_2O							0.00	0.00	0.00

ton/yr

Facility	Year	HP	Engine Count	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzen	ormaldehyd	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
1	9	10118	3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.01	0.00
2	9	6475	2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.01	0.00
3	9	10118	3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.01	0.00
4	9	6475	2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.01	0.00
5	9	6475	2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.01	0.00
6	9	10118	3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.01	0.00
7	9	6475	2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.01	0.00
8	9	6475	2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.01	0.00
9	9	6475	2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.01	0.00
10	9	3373	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00
11	9	3373	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00
									1.05										

[1] Emissions factors taken from EMIT quotes for emissions control devices and used for previously permitted engines.
[2] Justin Barberio - assume 140hp/MMscfd.
[3] Justin Barberio.
[4] API Greenhouse Gas Compendium Table 5-21 (2004). Includes both start-ups and blowdow

Project: Jonah NPL
Scenario: Horsepower
Activity: Production Facility Development
Emissions:

Date:

Facility	Year									
	1	2	3	4	5	6	7	8	9	10
1	10118	10118	10118	10118	10118	10118	10118	10118	10118	10118
2	6475	6475	6475	6475	6475	6475	6475	6475	6475	6475
3	6475	10118	6475	10118	10118	10118	10118	10118	10118	10118
4		3373	6475	6475	6475	6475	6475	6475	6475	6475
5		3373	6475	6475	6475	6475	6475	6475	6475	6475
6			3373	6475	6475	10118	10118	10118	10118	10118
7				3373	6475	6475	6475	6475	6475	6475
8				3373	6475	6475	6475	6475	6475	6475
9						3373	3373	6475	6475	6475
10							3373	3373	3373	3373
11									3373	3373
Totals	23068	33457	39391	52882	59086	66102	69475	72577	75950	75950

Compressor Engine Emissions

Project: NPL
Scenario: Option 3 - Electric Engines
Effective Dates: All
Emissions: Natural Gas Combustion Emissions from Misc Engines

Engine	Pollutant	EPA Tier Certification	Pollutant Emission Factor	Engine Count	Horse power	Overall Load Factor	Annual Activity	Daily Ops	Emissions per Hour	Emissions per Year
			(g/hp-hr)		(hp)		(days/yr)	(hrs/day)	(lb/hr)	(tons/yr)
Generac GS140	CO	Electric	0.00	3	175	0.90	365	24	0.00	0.00
Generator	NOx	Electric	0.00	3	175	0.90	365	24	0.00	0.00
Water Mng Facilities	SO_2	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	VOC	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	PM_{10}	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	$PM_{2.5}$	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	Benzene	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	Ethylbenzene	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	Formaldehyde	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	H_2S	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	n-Hexane	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	Toluene	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	Xylenes	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	CH_4	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	CO_2	Electric	0.00	3	175	0.90	365	24	0.00	0.00
	N_2O	Electric	0.00	3	175	0.90	365	24	0.00	0.00
Caterpillar 3512	CO	Electric	0.00	3	950	0.90	365	24	0.00	0.00
Water Injection	NOx	Electric	0.00	3	950	0.90	365	24	0.00	0.00
Water Mng Facilities	SO_2	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	VOC	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	PM_{10}	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	$PM_{2.5}$	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	Benzene	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	Ethylbenzene	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	Formaldehyde	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	H_2S	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	n-Hexane	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	Toluene	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	Xylenes	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	CH_4	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	CO_2	Electric	0.00	3	950	0.90	365	24	0.00	0.00
	N_2O	Electric	0.00	3	950	0.90	365	24	0.00	0.00
VRU Compression	CO	Electric	0.00							
	NOx	Electric	0.00							
	SO_2	Electric	0.00							
	VOC	Electric	0.00							
	PM_{10}	Electric	0.00							
	$PM_{2.5}$	Electric	0.00							
	Benzene	Electric	0.00							
	Ethylbenzene	Electric	0.00							
	Formaldehyde	Electric	0.00							
	H_2S	Electric	0.00							
	n-Hexane	Electric	0.00							
	Toluene	Electric	0.00							
	Xylenes	Electric	0.00							
	CH_4	Electric	0.00							
	CO_2	Electric	0.00							
	N_2O	Electric	0.00							

Facility (VRU)		HP	Hours	Load	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	ton/yr Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
	1	240	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	160	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3	240	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	160	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	160	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6	240	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	130	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	8	160	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9	130	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	80	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	35	8585	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Separator/Indirect Line Heaters

Electric therefore emissions are set to zero

Project: NPL
Scenario: All
Activity: Production
Emissions: Separator/Line Heaters

Fuel Combustion Source:

Unit Description	Separator/Line Heaters	
Average Design Firing Rate	0.33	MMBTU/hr

Operating Parameters:

Annual Operating hours	4380	
	Total Hours	% Operating
Winter (Nov. - Apr.)	4344	85
Summer (May - Oct.)	4416	15.6

Actual Fuel Combustion for the Year for Unit:

Average Natural Gas Combusted	1.29	MMscf/yr
Fuel Heating Value (actual)	1,124	Btu/scf
Fuel Heating Value (Em. Factor)	1,020	Btu/scf

Potential Emission Data:

	Emission Factor (lb/MMscf)	(lb/hr) Winter	(lb/hr) Summer	(lb/facility) Total
Total PM	0.0	0.00000	0.00000	0.000
SO_2	0.0	0.00000	0.00000	0.000
NO_x	0.0	0.00000	0.00000	0.000
CO	0.0	0.00000	0.00000	0.000
VOC	0.0	0.00000	0.00000	0.000

	Emission Factor (lb/MMscf)	(lb/hr) Winter	(lb/hr) Summer	(lb/facility) Total
Benzene	0.0	0.00000	0.00000	0.000
Ethylbenzene	0.0	0.00000	0.00000	0.000
Formaldehyde	0.0	0.00000	0.00000	0.000
H_2S	0.0	0.00000	0.00000	0.000
n-Hexane	0.0	0.00000	0.00000	0.000

	Emission Factor[2] (lb/MMscf)	(lb/hr) Winter	(lb/hr) Summer	(lb/facility) Total
Toluene	0.00E+00	0.00000	0.00000	0.000
Xylenes	0.0	0.00000	0.00000	0.000
CH_4	0.00	0.00000	0.00000	0.000
CO_2	0.00E+00	0.00000	0.00000	0.000
N_2O	0.00	0.00000	0.00000	0.000

		ton/yr															
Facility	MMbtu/hr	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzen	Formaldehyd	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
1	0.5	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
2	0.35	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
3	0.5	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
4	0.35	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
5	0.35	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
6	0.5	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
7	0.25	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
8	0.35	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
9	0.25	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
10	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
11	0.1	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00

Dehy Reboiler Heater

Electric therefore emissions are set to zero

Project: NPL
Scenario: All
Activity: Production
Emissions: Dehy Reboiler Heater

Fuel Combustion Source:

Unit Description	Dehy Reboiler Heater	
Average Design Firing Rate	1.47	MMBTU/hr

Operating Parameters:

Annual Operating hours	6570	
	Total Hours	Operation %
Winter (Nov. - Apr.)	4344	100
Summer (May - Oct.)	4416	50.5

Actual Fuel Combustion for the Year for Unit:

Average Natural Gas Combusted	8.59	MMscf/yr
Fuel Heating Value (actual)	1,124	Btu/scf
Fuel Heating Value (Em. Factor)	1,020	Btu/scf

Potential Emission Data:

	Emission Factor	(lb/hr)		(lb/facility)		Emission Factor	(lb/hr)		(lb/facility)		Emission Factor[2]	(lb/hr)		(lb/facility)
	(lb/MMscf)	Winter	Summer	Total		(lb/MMscf)	Winter	Summer	Total		(lb/MMscf)	Winter	Summer	Total
Total PM	0.0	0.00000	0.00000	0.000	Benzene	0.0E+00	0.00000	0.00000	0.000	Toluene	0.00E+00	0.00000	0.00000	0.000
SO_2	0.0	0.00000	0.00000	0.000	Ethylbenzene	0.0	0.00000	0.00000	0.000	Xylenes	0.0	0.00000	0.00000	0.000
NO_x	0.0	0.00000	0.00000	0.000	Formaldehyde	0.0E+00	0.00000	0.00000	0.000	CH_4	0.00	0.00000	0.00000	0.000
CO	0.0	0.00000	0.00000	0.000	H_2S	0.0	0.00000	0.00000	0.000	CO_2	0.00E+00	0.00000	0.00000	0.000
VOC	0.0	0.00000	0.00000	0.000	n-Hexane	0.0	0.00000	0.00000	0.000	N_2O	0.00	0.00000	0.00000	0.000

ton/yr

Facility	MMbtu/hr	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzen	Formaldehyd	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
1	2.25	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
2	1.5	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
3	2.25	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
4	1.5	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
5	1.5	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
6	2.25	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
7	1.2	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
8	1.5	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
9	1.2	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
10	0.75	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
11	0.3	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00

Dehy Flash Tank Heater

Electric therefore emissions are set to zero

Project: NPL
Scenario: All
Activity: Production
Emissions: Dehy Flash Tank Heater

Fuel Combustion Source:

Unit Description	Flash Tank Heaters	
Average Design Firing Rate	0.12	MMBTU/hr

Operating Parameters:

Annual Operating hours	4380	

	Total Hours	Operation %
Winter (Nov. - Apr.)	4344	85
Summer (May - Oct.)	4416	15.6

Actual Fuel Combustion for the Year for Unit:

Average Natural Gas Combusted	0.47	MMscf/yr
Fuel Heating Value (actual)	1,124	Btu/scf
Fuel Heating Value (Em. Factor)	1,020	Btu/scf

Potential Emission Data:

	Emission Factor	(lb/hr)		(lb/facility)
	(lb/MMscf)	Winter	Summer	Total
Total PM	0.0	0.00000	0.00000	0.000
SO_2	0.0	0.00000	0.00000	0.000
NO_x	0.0	0.00000	0.00000	0.000
CO	0.0	0.00000	0.00000	0.000
VOC	0.0	0.00000	0.00000	0.000

	Emission Factor	(lb/hr)		(lb/facility)
	(lb/MMscf)	Winter	Summer	Total
Benzene	0.0E+00	0.00000	0.00000	0.000
Ethylbenzene	0.0	0.00000	0.00000	0.000
Formaldehyde	0.0E+00	0.00000	0.00000	0.000
H_2S	0.0	0.00000	0.00000	0.000
n-Hexane	0.0	0.00000	0.00000	0.000

	Emission Factor[2]	(lb/hr)		(lb/facility)
	(lb/MMscf)	Winter	Summer	Total
Toluene	0.00E+00	0.00000	0.00000	0.000
Xylenes	0.0	0.00000	0.00000	0.000
CH_4	0.00	0.00000	0.00000	0.000
CO_2	0.00E+00	0.00000	0.00000	0.000
N_2O	0.00	0.00000	0.00000	0.000

								ton/yr								
Facility	MMbtu/hr	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzen	ormaldehyd	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
1	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
2	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
3	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
4	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
5	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
6	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
7	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
8	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
9	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
10	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
11	0.12	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00

Condensate Tank Heater

Electric therefore emissions are set to zero

Project: NPL
Scenario: All
Activity: Production
Emissions: Condensate Tank Heater

Fuel Combustion Source:

Unit Description	Condensate Tank Heaters	
Average Design Firing Rate	0.16	MMBTU/hr

Operating Parameters:

Annual Operating hours	6570	

	Total Hours	Operation %
Winter (Nov. - Apr.)	4344	100
Summer (May - Oct.)	4416	34

Actual Fuel Combustion for the Year for Unit:

Average Natural Gas Combusted	0.94	MMscf/yr
Fuel Heating Value (actual)	1,124	Btu/scf
Fuel Heating Value (Em. Factor)	1,020	Btu/scf

Potential Emission Data:

	Emission Factor	(lb/hr)		(lb/facility)
	(lb/MMscf)	Winter	Summer	Total
Total PM	0.0	0.00000	0.00000	0.000
SO_2	0.0	0.00000	0.00000	0.000
NO_x	0.0	0.00000	0.00000	0.000
CO	0.0	0.00000	0.00000	0.000
VOC	0.0	0.00000	0.00000	0.000

	Emission Factor	(lb/hr)		(lb/facility)
	(lb/MMscf)	Winter	Summer	Total
Benzene	0.0E+00	0.00000	0.00000	0.000
Ethylbenzene		0.00000	0.00000	0.000
Formaldehyde	0.0E+00	0.00000	0.00000	0.000
H_2S		0.00000	0.00000	0.000
n-Hexane	0.0	0.00000	0.00000	0.000

	Emission Factor[2]	(lb/hr)		(lb/facility)
	(lb/MMscf)	Winter	Summer	Total
Toluene	0.00E+00	0.00000	0.00000	0.000
Xylenes	0.0	0.00000	0.00000	0.000
CH_4	0.00	0.00000	0.00000	0.000
CO_2	0.00E+00	0.00000	0.00000	0.000
N_2O	0.00	0.00000	0.00000	0.000

		ton/yr															
Facility	MMbtu/hr	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzen	ormaldehyd	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
1	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
2	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
3	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
4	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
5	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
6	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
7	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
8	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
9	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
10	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00
11	0.16	0.00	0.00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00

Dehydrator Flashing

Project: NPL
Scenario: Option 3 - Electric Engines and VRU Control/Combustor backup
Activity: Production
Emissions: TEG Dehydrator Emissions

Pollutant	Uncontrolled[1] (tpy)	Uncontrolled[1] (lb/hr)	Controlled[2] (tpy)	Controlled[2] (lb/hr)
VOC	171.47	39.15	0.07	0.02
HAP	101.95	23.28	0.04	0.01
Benzene	16.63	3.80	0.01	0.00
Ethylbenzene	2.76	0.63	0.00	0.00
Formaldehyde	0.00			
H_2S	0.00			
n-Hexane	2.00	0.46	0.00	0.00
Toluene	41.64	9.51	0.02	0.00
Xylenes	38.67	8.83	0.02	0.00
CH_4	74.06	16.91	0.03	0.01
CO_2	3.74	0.86	0.00	0.00

Throughput (MMscf/day)	49
Regenerator Flow (scf/day)	802
Regenerator HV (btu/scf)	2074
Flash Tank Flow (scf/day)	107448
Flash Tank HV (btu/scf)	1250
Combustor Control Efficiency	0.98
Fraction Combustor Operation	0.02
VRU Control Efficiency	1
Fraction VRU Operation	0.98

Combustion Emission Factor[3]

CO	0.37	lb/MMbtu	
CO_2[4]	0.30	lb/scf	Regenator
CO_2[4]	0.16	lb/scf	Flash Tank
Formaldehyde	8.10E-05	lb/MMbtu	
NOx	0.14	lb/MMbtu	
PM_{10}	0.007	lb/MMbtu	
$PM_{2.5}$	0.007	lb/MMbtu	
N_2O[5]	1.04E-07	lb/MMbtu	
SO_2	0	lb/MMbtu	

		From Combustor					ton/yr									From Combustor	
Facility	Throughput (MMscf/day)	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
1	75	0.28	0.11	0.005	0.005	0	0.10	1.02E-02	1.69E-03	6.16E-05	0	0.00	0.03	0.02	0.05	94.81	7.90E-08
2	50	0.19	0.07	0.004	0.004	0	0.07	6.79E-03	1.12E-03	4.10E-05	0	0.00	0.02	0.02	0.03	63.21	5.27E-08
3	75	0.28	0.11	0.005	0.005	0	0.10	1.02E-02	1.69E-03	6.16E-05	0	0.00	0.03	0.02	0.05	94.81	7.90E-08
4	50	0.19	0.07	0.004	0.004	0	0.07	6.79E-03	1.12E-03	4.10E-05	0	0.00	0.02	0.02	0.03	63.21	5.27E-08
5	50	0.19	0.07	0.004	0.004	0	0.07	6.79E-03	1.12E-03	4.10E-05	0	0.00	0.02	0.02	0.03	63.21	5.27E-08
6	75	0.28	0.11	0.005	0.005	0	0.10	1.02E-02	1.69E-03	6.16E-05	0	0.00	0.03	0.02	0.05	94.81	7.90E-08
7	40	0.15	0.06	0.003	0.003	0	0.06	5.43E-03	9.00E-04	3.28E-05	0	0.00	0.01	0.01	0.02	50.56	4.21E-08
8	50	0.19	0.07	0.004	0.004	0	0.07	6.79E-03	1.12E-03	4.10E-05	0	0.00	0.02	0.02	0.03	63.21	5.27E-08
9	40	0.15	0.06	0.003	0.003	0	0.06	5.43E-03	9.00E-04	3.28E-05	0	0.00	0.01	0.01	0.02	50.56	4.21E-08
10	25	0.09	0.04	0.002	0.002	0	0.03	3.39E-03	5.62E-04	2.05E-05	0	0.00	0.01	0.01	0.02	31.60	2.63E-08
11	10	0.04	0.01	0.001	0.001	0	0.01	1.36E-03	2.25E-04	8.21E-06	0	0.00	0.00	0.00	0.01	12.64	1.05E-08

[1] Data based on GRI-GLYCalc V. 4.0, 49 MMSCFD, max glycol flow rate, average representative gas analysis. See supporting documentation for details.
[2] 100% VRU control efficienc y 98% of the operational time and 98% combustor control efficiency 2% of the operational time
[3] Emission factors taken from WDEQ "Oil and Gas Production Facilities - Chapter 6, Section 2 Permitting Guidance", AP-42 (EPA 1998) Table 1.4-2, and (API 2009)
[4] For composition of vented streams, see 'Material Balance' sheet.
[5] Greenhouse Gas Compendium (API 2009) Table 4-5.

Pneumatic Venting

Air or Electric, so no emissions

Project: NPL
Scenario: Option 3 - Electric Engines and VRU Control/Combustor backup
Activity: Production
Emissions: Pneumatic Emissions

Pollutant	Weight Fractions	Uncontrolled (tpy)	Uncontrolled (lb/hr)	Controlled (tpy)	Controlled (lb/hr)
VOC	0.00	0.00	0.00	0.00	0.00
HAP	0	0.00	0.00	0.00	0.00
Benzene	0.00E+00	0.00	0.00	0.00	0.00
Ethylbenzene	0.00E+00	0.00	0.00	0.00	0.00
Formaldehyde	0.00E+00				
H_2S	0.00E+00				
n-Hexane	0.00E+00	0.00	0.00	0.00	0.00
Toluene	0.00E+00	0.00	0.00	0.00	0.00
Xylenes	0.00E+00	0.00	0.00	0.00	0.00
CH_4	0.00	0.00	0.00	0.00	0.00
CO_2	0.000	0.00	0.00	0.00	0.00

Model	Flow (scf/hr)	Count	Op Hours
Textsteam 5000 Methai	50	2	4380
Husky-Wilden 1040 Gly	600	5	4380

Gas Molecular Weight	18.426	lb/lb-mol
Fuel Heating Value (actual)	0	Btu/scf
Fuel Heating Value (Em. Factor)[1]	1,020	Btu/scf
Combustor Control Efficiency	0.98	
Fraction Combustor Operation	0.02	
VRU Control Efficiency	1	
Fraction VRU Operation	0.98	

Combustor Emission Factor[3]		
CO	0.37	lb/MMbtu
CO_2	0.00	lb/scf
Formaldehyde	8.10E-05	lb/MMbtu
NOx	0.14	lb/MMbtu
PM_{10}	0.007	lb/MMbtu
$PM_{2.5}$	0.007	lb/MMbtu
N_2O	1.04E-07	lb/MMbtu
SO_2	0	lb/MMbtu

ton/yr

Facility	From Combustor CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzen	ormaldehyd	H_2S	n-Hexane	Toluene	Xylenes	CH_4	From Combustor CO_2	N_2O
1	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00
2	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00
3	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00
4	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00
5	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00
6	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00
7	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00
8	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00
9	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00
10	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00
11	0.00	0.00	0.00E+00	0.00E+00	0	0.00	0.00E+00	0.00E+00	0.00E+00	0	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00E+00

Air or Electric, so no emissions

Fugitive Emissions - Per Facility

Project: NPL
Scenario: All
Activity: Production
Emissions: Fugitive VOC/HAP Emissions

Gas Analysis Weight Fraction[1]		Condensate Analysis Weight Fraction[1]		Water Analysis Weight Fraction[2]		DI&M Control Efficiency
VOC	0.11417	VOC	0.98420	VOC	0.29200	75.0%
Benzene	0.00051	Benzene	0.00871	Benzene	0.00052	
Toluene	0.00076	Toluene	0.04993	Toluene	0.00091	
Ethlybenzene	0.00003	Ethlybenzene	0.00682	Ethlybenzer	0.00003	
Xylene	0.00028	Xylene	0.05377	Xylene	0.00036	
n-hexane	0.00230	n-hexane	0.01550	n-hexane	0.00131	
CH_4	0.78186	CH_4	0.00807	CH_4	0.00239	
CO_2	0.01281	CO_2	0.00037	CO_2	0.00011	

Source	Service	Quantity	Emission Factor[2] (lb/hr/component)	Non-methane Hydrocarbons[3] (lb/hr)	Non-methane Hydrocarbons (tpy)	Benzene[3] (lb/hr)	Benzene (tpy)	Toluene[3] (lb/hr)	Toluene (tpy)	Ethlybenzene[3] (lb/hr)	Ethlybenzene (tpy)	Xylenes[3] (lb/hr)	Xylenes (tpy)	n-Hexane[3] (lb/hr)	n-Hexane (tpy)	CH_4[3] (lb/hr)	CH_4 (tpy)	CO_2[3] (lb/hr)	CO_2 (tpy)
Valves	Gas	577	0.01	0.1647	0.721	0.00074	0.00323	0.00109	0.00478	0.000044	0.000194	0.00040	0.00177	0.00332	0.0145	1.1278	4.9399	0.0185	0.0810
Flanges	Gas	407	0.000875	0.0102	0.045	0.00005	0.00020	0.00007	0.00030	0.000003	0.000012	0.00002	0.00011	0.00020	0.0009	0.0696	0.3049	0.0011	0.0050
Connections	Gas	5386	0.000458	0.0704	0.308	0.00032	0.00138	0.00047	0.00204	0.000019	0.000083	0.00017	0.00076	0.00142	0.0062	0.4822	2.1119	0.0079	0.0346
Pump seals	Gas	2	0.00542	0.0003	0.001	0.00000	0.00001	0.00000	0.00001	0.000000	0.000000	0.00000	0.00000	0.00001	0.0000	0.0021	0.0093	0.0000	0.0002
Open ended lines	Gas	80	0.004583	0.0105	0.046	0.00005	0.00021	0.00007	0.00030	0.000003	0.000012	0.00003	0.00011	0.00021	0.0009	0.0717	0.3139	0.0012	0.0051
Other	Gas	522	0.01958	0.2917	1.278	0.00131	0.00572	0.00193	0.00847	0.000079	0.000344	0.00072	0.00314	0.00588	0.0258	1.9978	8.7503	0.0327	0.1434
Valves	Light Liquids	40	0.00542	0.0062	0.027	0.00003	0.00012	0.00004	0.00018	0.000002	0.000007	0.00002	0.00007	0.00012	0.0005	0.0424	0.1855	0.0007	0.0030
Flanges	Light Liquids	0	0.00024	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Connections	Light Liquids	1084	0.00046	0.0142	0.062	0.00006	0.00028	0.00009	0.00041	0.000004	0.000017	0.00003	0.00015	0.00029	0.0013	0.0970	0.4250	0.0016	0.0070
Pump seals	Light Liquids	0	0.02875	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Open ended lines	Light Liquids	0	0.00310	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	Light Liquids	0	0.01667	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Valves	Water-Oil	108	0.00022	0.0007	0.003	0.00000	0.00001	0.00000	0.00002	0.000000	0.000001	0.00000	0.00001	0.00001	0.0001	0.0046	0.0201	0.0001	0.0003
Flanges	Water-Oil	0	0.00001	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Connections	Water-Oil	1488	0.00024	0.0103	0.045	0.00005	0.00020	0.00007	0.00030	0.000003	0.000012	0.00003	0.00011	0.00021	0.0009	0.0704	0.3083	0.0012	0.0051
Pump seals	Water-Oil	6	0.00005	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0001	0.0003	0.0000	0.0000
Open ended lines	Water-Oil	0	0.00054	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	Water-Oil	16	0.03083	0.0141	0.062	0.00006	0.00028	0.00009	0.00041	0.000004	0.000017	0.00003	0.00015	0.00028	0.0012	0.0964	0.4224	0.0016	0.0069
			Total Emissions/Facility	0.5932	2.5980	0.0027	0.0116	0.0039	0.0172	0.0002	0.0007	0.0015	0.0064	0.0120	0.0524	4.0620	17.7917	0.0666	0.2916

[1] See 'Material Balance' sheet.
[1] "Oil and Gas Production Facilities Chapter 6, Section 2 Permitting Guidance" (WDEQ 2010).

Fugitive HAPs and VOC - Per Wellhead

Project: NPL
Scenario: All
Activity: Production
Emissions: Fugitive VOC/HAP Emissions

Gas Analysis Weight Fraction		**Condensate Analysis Weight Fraction**		**Water Analysis Weight Fraction**	
VOC	0.11417	VOC	0.98420	VOC	0.29200
Benzene	0.00051	Benzene	0.00871	Benzene	0.00052
Toluene	0.00076	Toluene	0.04993	Toluene	0.00091
Ethlybenzene	0.00003	Ethlybenzene	0.00682	Ethlybenze	0.00003
Xylene	0.00028	Xylene	0.05377	Xylene	0.00036
n-hexane	0.00230	n-hexane	0.01550	n-hexane	0.00131
CH_4	0.78186	CH_4	0.00807	CH_4	0.00239
CO_2	0.01281	CO_2	0.00037	CO_2	0.00011

Source	Service	Quantity	Emission Factor[1] (lb/hr/component)	Non-methane Hydrocarbons[2] (lb/hr)	Non-methane Hydrocarbons (tpy)	Benzene[2] (lb/hr)	Benzene (tpy)	Toluene[2] (lb/hr)	Toluene (tpy)	Ethlybenzene[2] (lb/hr)	Ethlybenzene (tpy)	Xylene[2] (lb/hr)	Xylene (tpy)	n-Hexane[2] (lb/hr)	n-Hexane (tpy)	CH_4[3] (lb/hr)	CH_4 (tpy)	CO_2[3] (lb/hr)	CO_2 (tpy)
Valves	Gas	22	0.01	0.0251	0.110	0.00011	0.00049	0.00017	0.00073	0.000007	0.000030	0.00006	0.00027	0.00051	0.0022	0.1720	0.7534	0.0028	0.0123
Flanges	Gas	15	0.000875	0.0015	0.007	0.00001	0.00003	0.00001	0.00004	0.000000	0.000002	0.00000	0.00002	0.00003	0.0001	0.0103	0.0449	0.0002	0.0007
Connections	Gas	6	0.000458	0.0003	0.001	0.00000	0.00001	0.00000	0.00001	0.000000	0.000000	0.00000	0.00000	0.00001	0.0000	0.0021	0.0094	0.0000	0.0002
Pump seals	Gas	0	0.00542	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Open ended lines	Gas	2	0.004583	0.0010	0.005	0.00000	0.00002	0.00001	0.00003	0.000000	0.000001	0.00000	0.00001	0.00002	0.0001	0.0072	0.0314	0.0001	0.0005
Other	Gas	2	0.01958	0.0045	0.020	0.00002	0.00009	0.00003	0.00013	0.000001	0.000005	0.00001	0.00005	0.00009	0.0004	0.0306	0.1341	0.0005	0.0022
Valves	Light Liquids	0	0.00542	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Flanges	Light Liquids	0	0.00024	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Connections	Light Liquids	0	0.00046	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Pump seals	Light Liquids	0	0.02875	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Open ended lines	Light Liquids	0	0.00310	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	Light Liquids	0	0.01667	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Valves	Water-Oil	0	0.00022	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Flanges	Water-Oil	0	0.00001	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Connections	Water-Oil	0	0.00024	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Pump seals	Water-Oil	0	0.00005	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Open ended lines	Water-Oil	0	0.00054	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	Water-Oil	0	0.03083	0.0000	0.000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000
			Total Emissions/Facility	0.0324	0.1421	0.0001	0.0006	0.0002	0.0009	0.0000	0.0000	0.0001	0.0003	0.0007	0.0029	0.2222			
																0.9732	0.0036	0.0160	

[1] Taken from the WDEQ (2010) "Oil and Gas Production Facilities Chapter 6, Section 2 Permitting Guidance".
[2] Calculated as weight fraction * emissions factor * quantity of source.

Condensate Storage Emissions - Per Facility

Project: NPL
Scenario: Option 3 - Electric Engines and VRU Control/Combustor bac
Activity: Production
Emissions: Condensate Storage Tanks

	Tank Flash[1]				Working Breathing[2]		Total
	Uncontrolled		Controlled[3]		Uncontrolled	Controlled[3]	Controlled[3]
Pollutant	(tpy)	(lb/hr)	(tpy)	(lb/hr)	(tpy)	(tpy)	(tpy)
HC	442.60	101.05	0.18	0.04			0.18
VOC	239.30	54.63	0.10	0.02	5.30	0.00	0.10
HAP	7.30	1.67	0.00	0.00			0.00
Benzene	1.40	0.32	0.00	0.00			0.00
Ethylbenzene	0.08	0.02	0.00	0.00			0.00
Formaldehyde	0.00	0.00	0.00	0.00			0.00
H_2S	0.00	0.00	0.00	0.00			0.00
n-Hexane	2.70	0.62	0.00	0.00			0.00
Toluene	2.07	0.47	0.00	0.00			0.00
Xylenes	0.60	0.14	0.00	0.00			0.00
CH_4	111.20	25.39	0.04	0.01			0.04
CO_2	4.90	1.12	0.00	0.00			0.00

Average Condensate Production	294	bbl/day
Flash Gas Flow Rate	1243.33	scf/hr
Flash Gas Heating Value	1780	btu/scf
Oil to Gas Ratio	6	bbl/MMscf
Combustor Control Efficiency	0.98	
Fraction Combustor Operation	0.02	
VRU Control Efficiency	1	
Fraction VRU Operation	0.98	

Combustor Emission Factor[2]		
CO	0.37	lb/MMbtu
CO_2[4]	0.24	lb/scf
Formaldehyde	8.10E-05	lb/MMbtu
NOx	0.14	lb/MMbtu
PM_{10}	0.007	lb/MMbtu
$PM_{2.5}$	0.007	lb/MMbtu
N_2O[5]	1.04E-07	lb/MMbtu
SO_2	0	lb/MMbtu

		From Combustor						ton/yr								From Combustor	
Facility	Throughput (MMscf/day)	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzen	Formaldehyd	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
1	75	0.11	0.04	2.08E-03	2.08E-03	0	0.15	8.56E-04	4.72E-05	2.40E-05	0	1.65E-03	1.27E-03	3.67E-04	0.07	0.00	3.09E-08
2	50	0.00	0.00	1.38E-03	1.38E-03	0	0.10	5.70E-04	3.15E-05	1.60E-05	0	1.10E-03	8.47E-04	2.45E-04	0.05	0.00	2.06E-08
3	75	0.00	0.00	2.08E-03	2.08E-03	0	0.15	8.56E-04	4.72E-05	2.40E-05	0	1.65E-03	1.27E-03	3.67E-04	0.07	0.00	3.09E-08
4	50	0.00	0.00	1.38E-03	1.38E-03	0	0.10	5.70E-04	3.15E-05	1.60E-05	0	1.10E-03	8.47E-04	2.45E-04	0.05	0.00	2.06E-08
5	50	0.00	0.00	1.38E-03	1.38E-03	0	0.10	5.70E-04	3.15E-05	1.60E-05	0	1.10E-03	8.47E-04	2.45E-04	0.05	0.00	2.06E-08
6	75	0.00	0.00	2.08E-03	2.08E-03	0	0.15	8.56E-04	4.72E-05	2.40E-05	0	1.65E-03	1.27E-03	3.67E-04	0.07	0.00	3.09E-08
7	40	0.00	0.00	1.11E-03	1.11E-03	0	0.08	4.56E-04	2.52E-05	1.28E-05	0	8.82E-04	6.77E-04	1.96E-04	0.04	0.00	1.65E-08
8	50	0.00	0.00	1.38E-03	1.38E-03	0	0.10	5.70E-04	3.15E-05	1.60E-05	0	1.10E-03	8.47E-04	2.45E-04	0.05	0.00	2.06E-08
9	40	0.00	0.00	1.11E-03	1.11E-03	0	0.08	4.56E-04	2.52E-05	1.28E-05	0	8.82E-04	6.77E-04	1.96E-04	0.04	0.00	1.65E-08
10	25	0.00	0.00	6.92E-04	6.92E-04	0	0.05	2.85E-04	1.57E-05	8.01E-06	0	5.51E-04	4.23E-04	1.22E-04	0.02	0.00	1.03E-08
11	10	0.00	0.00	2.77E-04	2.77E-04	0	0.02	1.14E-04	6.29E-06	3.21E-06	0	2.20E-04	1.69E-04	4.90E-05	0.01	0.00	4.11E-09

[1] HYSYS output based on average of 294 bbl/day. See 'Material Balance' sheet.

[2] Emission factors taken from WDEQ "Oil and Gas Production Facilities - Chapter 6, Section 2 Permitting Guidance" and AP-42, Table 1.4-2.

[3]

[4] 100% VRU control efficiency 98% of the operational time and 98% combustor control efficiency 2% of the operational time. For flash gas composition, see 'Material Balance' sheet.

[5] Greenhouse Gas Compendium (API 2009) Table 4-5.

Condensate Loading Emissions - Per Facility

Project: NPL
Scenario: Option 3 - Electric Engines and VRU Control/Combustor backup
Activity: Production
Emissions: Condensate Loading

Average Condensate Loadout Emissions

Uncontrolled Emissions[1]			Controlled Emissions[2]		
CO	0	ton/facility	CO	4.54E-04	ton/facility
NOx	0	ton/facility	NOx	1.72E-04	ton/facility
PM_{10}	0	ton/facility	PM_{10}	8.58E-06	ton/facility
$PM_{2.5}$	0	ton/facility	$PM_{2.5}$	8.58E-06	ton/facility
SO_2	0	ton/facility	SO_2	0.0000	ton/facility
VOC	4.54	ton/facility	VOC	0.0081	ton/facility
Benzene	0.0265	ton/facility	Benzene	2.76E-07	ton/facility
Ethylbenzene	0.0015	ton/facility	Ethylbenzene	8.38E-10	ton/facility
Formaldehyde	0		Formaldehyde	0	ton/facility
H_2S	0		H_2S	0	ton/facility
n-Hexane	0.0512		n-Hexane	1.03E-06	ton/facility
Toluene	0.0394		Toluene	6.07E-07	ton/facility
Xylenes	0.0114		Xylenes	5.08E-08	ton/facility
CH_4	2.1097		CH_4	1.74E-03	ton/facility
CO_2	0		CO_2	0.16	ton/facility
N_2O	0		N_2O	1.28E-10	ton/facility

Average Condensate Production	294	bbl/day	
Oil to Gas Ratio	6	bbl/MMscf	
Vapor Molecular Weight	50	lb/lb-mol	
Vapor Heating Value	1780	btu/scf	
Combustor Control Efficiency	0.98		
Fraction Combustor Operation	0.02		
VRU Control Efficiency	1		
Fraction VRU Operation	0.98		

Combustor Emission Factor[3]

CO	0.37	lb/MMbtu
CO_2[4]	0.24	lb/scf
Formaldehyde	8.10E-05	lb/MMbtu
NOx	0.14	lb/MMbtu
PM_{10}	0.007	lb/MMbtu
$PM_{2.5}$	0.007	lb/MMbtu
N_2O[5]	1.04E-07	lb/MMbtu
SO_2	0	lb/MMbtu

LL= 12.46 * S P M /T

LL = Loading loss (Lb/1,000 gal.), of liquid loaded
S = Saturation factor (from AP-42 Table 5.2-1)
P = True vapor pressure of liquid loaded (psia), (from AP-42 Table 7.1-2)
M = Molecular weight of vapors (Lb/Lb-mole)
T = Temperature of liquid loaded (0R = 460 + 0F)

S= 0.6 (For dedicated Hydrocarbon service)
P= 2.8 True Vapor Pressure (psia) @ T=60 for a RVP=10 fluid
M= 50 Lb/Lb-mole (from composition of vapor phase as per Tanl
T= 60 0F or 520 0R

181.6
1377.618
2452159

LL= 2.0128 Lb/1,000 gal. Loaded

-For a facility making: 0 bbl/yr or 294 bbl/day

LL (TPY) = LL (Lb/1,000 gal) * annual production (bbl/yr) * 42 gal/bbl * 1ton/

Truck Loadout Emissions = 0.0 TPY of VOC

LL (lb/hr) = LL (Lb/1,000 gal) * 240 bbl tank truck * 42 gal/bbl * 1 hr loadout

Truck Loadout Emissions = 20.29 lb/hr of VOC

Truck Loadout Emissions = 0.1 TPY of HAP

Truck Loadout Emissions = 0.60 lb/hr of HAP

		From Combustor					ton/yr									From Combustor	
Facility	Throughput (MMscf/day)	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzen	ormaldehyd	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O
1	75	6.94E-04	2.63E-04	1.31E-05	1.31E-05	0	0.012367	4.22E-07	1.28E-09	1.52E-07	0	1.57E-06	9.30E-07	7.77E-08	2.67E-03	0.252503	1.95E-10
2	50	4.63E-04	1.75E-04	8.76E-06	8.76E-06	0	0.008245	2.81E-07	8.56E-10	1.01E-07	0	1.05E-06	6.20E-07	5.18E-08	1.78E-03	0.168336	1.30E-10
3	75	6.94E-04	2.63E-04	1.31E-05	1.31E-05	0	0.012367	4.22E-07	1.28E-09	1.52E-07	0	1.57E-06	9.30E-07	7.77E-08	2.67E-03	0.252503	1.95E-10
4	50	4.63E-04	1.75E-04	8.76E-06	8.76E-06	0	0.008245	2.81E-07	8.56E-10	1.01E-07	0	1.05E-06	6.20E-07	5.18E-08	1.78E-03	0.168336	1.30E-10
5	50	4.63E-04	1.75E-04	8.76E-06	8.76E-06	0	0.008245	2.81E-07	8.56E-10	1.01E-07	0	1.05E-06	6.20E-07	5.18E-08	1.78E-03	0.168336	1.30E-10
6	75	6.94E-04	2.63E-04	1.31E-05	1.31E-05	0	0.012367	4.22E-07	1.28E-09	1.52E-07	0	1.57E-06	9.30E-07	7.77E-08	2.67E-03	0.252503	1.95E-10
7	40	3.70E-04	1.40E-04	7.01E-06	7.01E-06	0	0.006596	2.25E-07	6.84E-10	8.11E-08	0	8.40E-07	4.96E-07	4.15E-08	1.42E-03	0.134668	1.04E-10
8	50	4.63E-04	1.75E-04	8.76E-06	8.76E-06	0	0.008245	2.81E-07	8.56E-10	1.01E-07	0	1.05E-06	6.20E-07	5.18E-08	1.78E-03	0.168336	1.30E-10
9	40	3.70E-04	1.40E-04	7.01E-06	7.01E-06	0	0.006596	2.25E-07	6.84E-10	8.11E-08	0	8.40E-07	4.96E-07	4.15E-08	1.42E-03	0.134668	1.04E-10
10	25	2.31E-04	8.76E-05	4.38E-06	4.38E-06	0	0.004122	1.41E-07	4.28E-10	5.07E-08	0	5.25E-07	3.10E-07	2.59E-08	8.90E-04	0.084168	6.51E-11
11	10	9.26E-05	3.50E-05	1.75E-06	1.75E-06	0	0.001649	5.62E-08	1.71E-10	2.03E-08	0	2.10E-07	1.24E-07	1.04E-08	3.56E-04	0.033667	2.60E-11
Total in 2024 (all Facilities operating)		5.00E-03	1.89E-03	9.46E-05	9.46E-05	0.00E+00	8.90E-02										

[1]
[2] Based on average of 294 bbl/day production and AP-42 (EPA 1995) Section 5.2 Loadout emissions calculation.
[3] 100% VRU control efficiency 98% of the operational time and 98% combustor control efficiency 2% of the operational time.
Emission factors taken from WDEQ "Oil and Gas Production Facilities - Chapter 6, Section 2 Permitting Guidance" and AP-42 (EPA 2008), Section 5.2.
[4] For flash gas composition, see 'Material Balance' sheet.
[5] Greenhouse Gas Compendium (API 2009) Table 4-5.

	Construction[1] (mile/pad)	Drilling-Completion[2] (mile/well)	Production (mile/operator)
	12775	1,646	3,650
	Pads (per year)	Wells (per year)	Operators (per year)
	10	160	28
Total mile/year	127750	263360	102200

Commuters

	one-way (miles)	round trip (miles)	no. people	trips/year	total miles/year
Contractors	35	70	60	52	218400
Employees	35	70	28	300	588000

Assume contractors are 50/50 diesel/gas
Assume workers are CNG
[1] Includes Pad, Road, Pipeline
[2] Includes Tabs 16,17,24&26 (added company man 4/9/2014)

	NOx	PM10	PM2.5	T/year SO2	CO	VOC	CO2	CH4	N_2O[a]	Benzene	Formaldehyde
2013											
Pad											
Gas	0.07	0.00	0.00	0.00	0.35	0.01	30.91	5.11E-04	3.07E-04	3.64E-04	1.35E-04
Diesel	0.15	0.01	0.01	0.00	0.09	0.02	44.33	1.11E-03	1.06E-04	2.05E-04	1.53E-03
Well											
Gas	0.14	0.00	0.00	0.00	0.73	0.02	63.72	1.05E-03	6.32E-04	7.50E-04	2.79E-04
Diesel	0.31	0.02	0.02	0.00	0.19	0.04	91.40	2.28E-03	2.19E-04	4.23E-04	3.15E-03
CNG											
Operators	0.40	0.01	0.00	0.00	4.21	0.00	104.02	2.49E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.11	0.00	0.00	0.00	0.60	0.02	52.84	8.74E-04	5.24E-04	6.22E-04	2.31E-04
Diesel	0.26	0.02	0.02	0.00	0.16	0.03	75.79	1.89E-03	1.82E-04	3.51E-04	2.61E-03
Employees - CNG	2.30	0.03	0.01	0.00	24.23	0.00	598.47	1.43E-02	2.58E-02	0.00E+00	0.00E+00
Total:	3.73	0.10	0.06	0.00	30.57	0.14	1061.47	2.45E-02	3.23E-02	2.72E-03	7.94E-03
2014											
Pad											
Gas	0.06	0.00	0.00	0.00	0.33	0.01	30.36	4.78E-04	2.76E-04	3.29E-04	1.23E-04
Diesel	0.14	0.01	0.01	0.00	0.09	0.02	44.16	1.19E-03	1.06E-04	1.79E-04	1.33E-03
Well											
Gas	0.12	0.00	0.00	0.00	0.69	0.02	62.59	9.86E-04	5.68E-04	6.78E-04	2.53E-04
Diesel	0.28	0.02	0.02	0.00	0.18	0.03	91.03	2.45E-03	2.19E-04	3.69E-04	2.75E-03
CNG											
Operators	0.39	0.01	0.00	0.00	3.93	0.00	104.02	2.30E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.10	0.00	0.00	0.00	0.57	0.02	51.91	8.18E-04	4.71E-04	5.62E-04	2.09E-04
Diesel	0.23	0.02	0.01	0.00	0.15	0.03	75.49	2.03E-03	1.82E-04	3.06E-04	2.28E-03
Employees - CNG	2.27	0.03	0.01	0.00	22.59	0.00	598.47	1.32E-02	2.58E-02	0.00E+00	0.00E+00
Total:	3.60	0.09	0.06	0.00	28.52	0.12	1058.01	2.35E-02	3.21E-02	2.42E-03	6.94E-03
2015											
Pad											
Gas	0.06	0.00	0.00	0.00	0.32	0.01	29.79	4.45E-04	2.48E-04	2.97E-04	1.11E-04
Diesel	0.12	0.01	0.01	0.00	0.08	0.01	43.96	1.26E-03	1.06E-04	1.56E-04	1.16E-03
Well											
Gas	0.11	0.00	0.00	0.00	0.65	0.02	61.42	9.18E-04	5.12E-04	6.12E-04	2.29E-04
Diesel	0.25	0.02	0.01	0.00	0.16	0.03	90.63	2.60E-03	2.19E-04	3.21E-04	2.39E-03
CNG											
Operators	0.39	0.01	0.00	0.00	3.66	0.00	104.02	2.12E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.09	0.00	0.00	0.00	0.54	0.01	50.94	7.61E-04	4.25E-04	5.08E-04	1.90E-04
Diesel	0.21	0.01	0.01	0.00	0.13	0.02	75.16	2.16E-03	1.82E-04	2.66E-04	1.98E-03
Employees - CNG	2.23	0.03	0.01	0.00	21.05	0.00	598.47	1.22E-02	2.58E-02	0.00E+00	0.00E+00
Total:	3.47	0.08	0.05	0.00	26.59	0.11	1054.39	2.25E-02	3.20E-02	2.16E-03	6.07E-03
2016											
Pad											
Gas	0.05	0.00	0.00	0.00	0.30	0.01	29.16	4.04E-04	2.25E-04	2.63E-04	1.01E-03
Diesel	0.11	0.01	0.01	0.00	0.07	0.01	43.73	1.33E-03	1.06E-04	1.36E-04	1.01E-03
Well											
Gas	0.10	0.00	0.00	0.00	0.61	0.02	60.12	8.33E-04	4.63E-04	5.43E-04	2.09E-03
Diesel	0.23	0.01	0.01	0.00	0.15	0.03	90.15	2.75E-03	2.19E-04	2.80E-04	2.09E-03
CNG											
Operators	0.38	0.01	0.00	0.00	3.41	0.00	104.02	1.97E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.09	0.00	0.00	0.00	0.51	0.01	49.86	6.91E-04	3.84E-04	4.50E-04	1.73E-03
Diesel	0.19	0.01	0.01	0.00	0.12	0.02	74.76	2.28E-03	1.82E-04	2.32E-04	1.73E-03
Employees - CNG	2.20	0.03	0.01	0.00	19.64	0.00	598.47	1.13E-02	2.58E-02	0.00E+00	0.00E+00
Total:	3.36	0.08	0.05	0.00	24.82	0.10	1050.27	2.16E-02	3.19E-02	1.90E-03	9.66E-03
2017											
Pad											
Gas	0.05	0.00	0.00	0.00	0.28	0.01	28.58	3.73E-04	2.04E-04	2.38E-04	8.95E-05
Diesel	0.10	0.01	0.01	0.00	0.07	0.01	43.53	1.40E-03	1.06E-04	1.18E-04	8.81E-04
Well											
Gas	0.10	0.00	0.00	0.00	0.59	0.01	58.92	7.70E-04	4.20E-04	4.90E-04	1.85E-04
Diesel	0.21	0.01	0.01	0.00	0.14	0.02	89.75	2.88E-03	2.19E-04	2.44E-04	1.82E-03
CNG											
Operators	0.38	0.01	0.00	0.00	3.20	0.00	104.02	1.85E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.08	0.00	0.00	0.00	0.49	0.01	48.86	6.38E-04	3.49E-04	4.06E-04	1.53E-04
Diesel	0.17	0.01	0.01	0.00	0.12	0.02	74.43	2.39E-03	1.82E-04	2.02E-04	1.51E-03
Employees - CNG	2.18	0.03	0.01	0.00	18.39	0.00	598.47	1.06E-02	2.58E-02	0.00E+00	0.00E+00
Total:	3.26	0.08	0.04	0.00	23.26	0.09	1046.55	2.09E-02	3.18E-02	1.70E-03	4.63E-03
2018											
Pad											
Gas	0.04	0.00	0.00	0.00	0.27	0.01	28.02	3.47E-04	1.86E-04	2.16E-04	8.17E-05
Diesel	0.09	0.01	0.00	0.00	0.06	0.01	43.33	1.45E-03	1.06E-04	1.03E-04	7.70E-04
Well											
Gas	0.09	0.00	0.00	0.00	0.56	0.01	57.76	7.15E-04	3.83E-04	4.46E-04	1.69E-04
Diesel	0.19	0.01	0.01	0.00	0.13	0.02	89.33	3.00E-03	2.19E-04	2.13E-04	1.59E-03
CNG											
Operators	0.37	0.01	0.00	0.00	3.00	0.00	104.02	1.74E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.07	0.00	0.00	0.00	0.46	0.01	47.90	5.93E-04	3.18E-04	3.70E-04	1.40E-04
Diesel	0.16	0.01	0.01	0.00	0.11	0.02	74.08	2.48E-03	1.82E-04	1.77E-04	1.32E-03
Employees - CNG	2.15	0.03	0.01	0.00	17.28	0.00	598.47	1.00E-02	2.58E-02	0.00E+00	0.00E+00
Total:	3.17	0.07	0.04	0.00	21.89	0.08	1042.90	2.04E-02	3.17E-02	1.52E-03	4.06E-03
2019											
Pad											
Gas	0.04	0.00	0.00	0.00	0.26	0.01	27.49	3.21E-04	1.70E-04	1.97E-04	7.49E-05
Diesel	0.09	0.01	0.00	0.00	0.06	0.01	43.13	1.50E-03	1.06E-04	9.07E-05	6.75E-04
Well											
Gas	0.08	0.00	0.00	0.00	0.54	0.01	56.68	6.63E-04	3.50E-04	4.07E-04	1.54E-04
Diesel	0.18	0.01	0.01	0.00	0.13	0.02	88.91	3.10E-03	2.19E-04	1.87E-04	1.39E-03
CNG											
Operators	0.37	0.01	0.00	0.00	2.83	0.00	104.02	1.60E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.07	0.00	0.00	0.00	0.45	0.01	47.00	5.50E-04	2.90E-04	3.37E-04	1.28E-04
Diesel	0.15	0.01	0.01	0.00	0.11	0.01	73.73	2.57E-03	1.82E-04	1.55E-04	1.15E-03
Employees - CNG	2.13	0.03	0.01	0.00	16.30	0.00	598.46	9.23E-03	2.58E-02	0.00E+00	0.00E+00
Total:	3.10	0.07	0.04	0.00	20.67	0.07	1039.43	1.95E-02	3.16E-02	1.37E-03	3.58E-03
2020											
Pad											
Gas	0.04	0.00	0.00	0.00	0.25	0.01	27.01	3.00E-04	1.56E-04	1.81E-04	6.89E-05
Diesel	0.08	0.00	0.00	0.00	0.06	0.01	42.94	1.55E-03	1.06E-04	7.97E-05	5.94E-04
Well											
Gas	0.08	0.00	0.00	0.00	0.52	0.01	55.68	6.18E-04	3.22E-04	3.73E-04	1.42E-04
Diesel	0.16	0.01	0.01	0.00	0.12	0.02	88.52	3.20E-03	2.19E-04	1.64E-04	1.22E-03
CNG											
Operators	0.37	0.01	0.00	0.00	2.68	0.00	104.02	1.49E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.06	0.00	0.00	0.00	0.43	0.01	46.18	5.12E-04	2.67E-04	3.09E-04	1.18E-04
Diesel	0.13	0.01	0.01	0.00	0.10	0.01	73.41	2.65E-03	1.82E-04	1.36E-04	1.01E-03
Employees - CNG	2.11	0.03	0.01	0.00	15.45	0.00	598.47	8.56E-03	2.58E-02	0.00E+00	0.00E+00
Total:	3.03	0.07	0.03	0.00	19.62	0.06	1036.22	1.89E-02	3.15E-02	1.24E-03	3.16E-03
2021											
Pad											
Gas	0.03	0.00	0.00	0.00	0.24	0.01	26.56	2.84E-04	1.44E-04	1.67E-04	6.37E-05
Diesel	0.07	0.00	0.00	0.00	0.06	0.01	42.76	1.59E-03	1.06E-04	7.02E-05	5.23E-04
Well											
Gas	0.07	0.00	0.00	0.00	0.50	0.01	54.76	5.86E-04	2.97E-04	3.43E-04	1.31E-04
Diesel	0.15	0.01	0.01	0.00	0.12	0.01	88.16	3.28E-03	2.19E-04	1.45E-04	1.08E-03
CNG											
Operators	0.36	0.01	0.00	0.00	2.55	0.00	104.02	1.42E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.06	0.00	0.00	0.00	0.42	0.01	45.41	4.86E-04	2.46E-04	2.85E-04	1.09E-04
Diesel	0.13	0.01	0.01	0.00	0.10	0.01	73.11	2.72E-03	1.82E-04	1.20E-04	8.93E-04
Employees - CNG	2.10	0.03	0.01	0.00	14.69	0.00	598.47	8.16E-03	2.58E-02	0.00E+00	0.00E+00
Total:	2.98	0.07	0.03	0.00	18.69	0.05	1033.24	1.85E-02	3.15E-02	1.13E-03	2.80E-03
2022											
Pad											
Gas	0.03	0.00	0.00	0.00	0.24	0.00	26.16	2.72E-04	1.34E-04	1.54E-04	5.93E-05
Diesel	0.07	0.00	0.00	0.00	0.06	0.01	42.60	1.63E-03	1.06E-04	6.18E-05	4.60E-04
Well											
Gas	0.07	0.00	0.00	0.00	0.49	0.01	53.92	5.62E-04	2.76E-04	3.18E-04	1.22E-04
Diesel	0.14	0.01	0.01	0.00	0.12	0.01	87.83	3.36E-03	2.19E-04	1.27E-04	9.48E-04
CNG											
Operators	0.36	0.01	0.00	0.00	2.44	0.00	104.02	1.36E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.05	0.00	0.00	0.00	0.41	0.01	44.72	4.66E-04	2.29E-04	2.64E-04	1.01E-04
Diesel	0.12	0.01	0.00	0.00	0.10	0.01	72.83	2.79E-03	1.82E-04	1.06E-04	7.86E-04
Employees - CNG	2.09	0.03	0.01	0.00	14.03	0.00	598.47	7.82E-03	2.58E-02	0.00E+00	0.00E+00
Total:	2.92	0.06	0.03	0.00	17.88	0.05	1030.55	1.83E-02	3.14E-02	1.03E-03	2.48E-03
2023											
Pad											
Gas	0.03	0.00	0.00	0.00	0.23	0.00	25.79	2.59E-04	1.25E-04	1.43E-04	5.54E-05
Diesel	0.06	0.00	0.00	0.00	0.06	0.01	42.45	1.66E-03	1.06E-04	5.45E-05	4.06E-04
Well											
Gas	0.06	0.00	0.00	0.00	0.48	0.01	53.16	5.33E-04	2.57E-04	2.96E-04	1.14E-04
Diesel	0.13	0.01	0.01	0.00	0.12	0.01	87.52	3.42E-03	2.19E-04	1.12E-04	8.36E-04
CNG											
Operators	0.36	0.01	0.00	0.00	2.33	0.00	104.02	1.28E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.05	0.00	0.00	0.00	0.39	0.01	44.09	4.42E-04	2.13E-04	2.45E-04	9.47E-05
Diesel	0.11	0.01	0.00	0.00	0.10	0.01	72.58	2.84E-03	1.82E-04	9.31E-05	6.94E-04
Employees - CNG	2.07	0.03	0.01	0.00	13.41	0.00	598.47	7.36E-03	2.58E-02	0.00E+00	0.00E+00
Total:	2.88	0.06	0.03	0.00	17.10	0.04	1028.07	1.78E-02	3.14E-02	9.44E-04	2.20E-03
2024											
Pad											
Gas	0.03	0.00	0.00	0.00	0.22	0.00	25.45	2.42E-04	1.16E-04	1.33E-04	5.16E-05
Diesel	0.06	0.00	0.00	0.00	0.06	0.00	42.33	1.68E-03	1.06E-04	4.80E-05	3.58E-04
Well											
Gas	0.06	0.00	0.00	0.00	0.46	0.01	52.46	4.98E-04	2.40E-04	2.74E-04	1.06E-04
Diesel	0.12	0.01	0.00	0.00	0.11	0.01	87.26	3.47E-03	2.19E-04	9.90E-05	7.37E-04
CNG											
Operators	0.36	0.01	0.00	0.00	2.22	0.00	104.02	1.18E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.05	0.00	0.00	0.00	0.38	0.01	43.51	4.13E-04	1.99E-04	2.27E-04	8.82E-05
Diesel	0.10	0.01	0.00	0.00	0.09	0.01	72.36	2.88E-03	1.82E-04	8.21E-05	6.11E-04
Employees - CNG	2.06	0.03	0.01	0.00	12.78	0.00	598.47	6.77E-03	2.58E-02	0.00E+00	0.00E+00
Total:	2.84	0.06	0.03	0.00	16.34	0.04	1025.85	1.71E-02	3.14E-02	8.64E-04	1.95E-03
2025											
Pad											
Gas	0.03	0.00	0.00	0.00	0.22	0.00	25.14	2.28E-04	1.09E-04	1.23E-04	4.81E-05
Diesel	0.06	0.00	0.00	0.00	0.05	0.00	42.20	1.71E-03	1.06E-04	4.26E-05	3.17E-04
Well											
Gas	0.05	0.00	0.00	0.00	0.45	0.01	51.83	4.70E-04	2.24E-04	2.55E-04	9.92E-05
Diesel	0.12	0.01	0.00	0.00	0.11	0.01	86.99	3.52E-03	2.19E-04	8.77E-05	6.53E-04
CNG											
Operators	0.36	0.01	0.00	0.00	2.14	0.00	104.02	1.10E-03	4.49E-03	0.00E+00	0.00E+00
Contractors											
Gas	0.05	0.00	0.00	0.00	0.37	0.01	42.98	3.89E-04	1.86E-04	2.11E-04	8.23E-05
Diesel	0.10	0.01	0.00	0.00	0.09	0.01	72.14	2.92E-03	1.82E-04	7.28E-05	5.42E-04
Employees - CNG	2.05	0.03	0.01	0.00	12.29	0.00	598.47	6.32E-03	2.58E-02	0.00E+00	0.00E+00
Total:	2.80	0.06	0.03	0.00	15.73	0.04	1023.78	1.67E-02	3.13E-02	7.92E-04	1.74E-03

Notes: Fuel - assume construction, drilling and completion vehicles will be 50% gasoline and 50% diesel. Production vehicles will be compressed natural gas.

Mobile Source - Moves run for 2013-2005, WY
Emission factors for Commuting Vehicles Exhaust

Emission Factors for Commuting Vehicles											
Emission Factors (gm/mile)											
Project Year	NOx	PM10	PM2.5	SO2	CO	VOC	CO2	CH_4	N_2O[a]	Benzene	Form
2013											
LDGT2	0.94	0.03	0.02	0.01	5.01	0.15	438.97	0.01	0.00	0.01	0.00
LDDT	2.14	0.15	0.13	0.00	1.32	0.27	629.66	0.02	0.00	0.00	0.02
CNG (transit bus)	3.55	0.05	0.02	0.00	37.38	0.00	923.35	0.02	0.04	0.00	0.00
2014											
LDGT2	0.86	0.03	0.02	0.01	4.74	0.14	431.22	0.01	0.00	0.00	0.00
LDDT	1.93	0.13	0.11	0.00	1.21	0.23	627.13	0.02	0.00	0.00	0.02
CNG (transit bus)	3.50	0.05	0.02	0.00	34.86	0.00	923.35	0.02	0.04	0.00	0.00
2015											
LDGT2	0.79	0.03	0.02	0.01	4.48	0.12	423.17	0.01	0.00	0.00	0.00
LDDT	1.74	0.11	0.10	0.00	1.11	0.20	624.38	0.02	0.00	0.00	0.02
CNG (transit bus)	3.45	0.05	0.02	0.00	32.48	0.00	923.35	0.02	0.04	0.00	0.00
2016											
LDGT2	0.72	0.03	0.02	0.01	4.23	0.11	414.22	0.01	0.00	0.00	0.01
LDDT	1.58	0.10	0.09	0.00	1.04	0.18	621.07	0.02	0.00	0.00	0.01
CNG (transit bus)	3.40	0.05	0.02	0.00	30.30	0.00	923.35	0.02	0.04	0.00	0.00
2017											
LDGT2	0.66	0.03	0.02	0.01	4.03	0.10	405.89	0.01	0.00	0.00	0.00
LDDT	1.44	0.09	0.07	0.00	0.97	0.15	618.31	0.02	0.00	0.00	0.01
CNG (transit bus)	3.36	0.05	0.02	0.00	28.37	0.00	923.35	0.02	0.04	0.00	0.00
2018											
LDGT2	0.61	0.03	0.02	0.01	3.86	0.09	397.90	0.00	0.00	0.00	0.00
LDDT	1.32	0.08	0.06	0.00	0.92	0.14	615.46	0.02	0.00	0.00	0.01
CNG (transit bus)	3.32	0.05	0.02	0.00	26.66	0.00	923.35	0.02	0.04	0.00	0.00
2019											
LDGT2	0.56	0.03	0.02	0.01	3.70	0.08	390.47	0.00	0.00	0.00	0.00
LDDT	1.21	0.07	0.06	0.00	0.88	0.12	612.55	0.02	0.00	0.00	0.01
CNG (transit bus)	3.29	0.05	0.02	0.00	25.14	0.00	923.34	0.01	0.04	0.00	0.00
2020											
LDGT2	0.52	0.03	0.02	0.01	3.57	0.08	383.62	0.00	0.00	0.00	0.00
LDDT	1.12	0.07	0.05	0.00	0.86	0.10	609.84	0.02	0.00	0.00	0.01
CNG (transit bus)	3.26	0.05	0.02	0.00	23.83	0.00	923.35	0.01	0.04	0.00	0.00
2021											
LDGT2	0.48	0.03	0.02	0.01	3.46	0.07	377.25	0.00	0.00	0.00	0.00
LDDT	1.04	0.06	0.05	0.00	0.84	0.09	607.35	0.02	0.00	0.00	0.01
CNG	3.24	0.05	0.02	0.00	22.67	0.00	923.35	0.01	0.04	0.00	0.00
2022											
LDGT2	0.45	0.03	0.02	0.01	3.37	0.07	371.51	0.00	0.00	0.00	0.00
LDDT	0.97	0.05	0.04	0.00	0.82	0.08	605.08	0.02	0.00	0.00	0.01
CNG	3.22	0.05	0.02	0.00	21.65	0.00	923.35	0.01	0.04	0.00	0.00
2023											
LDGT2	0.43	0.03	0.02	0.01	3.27	0.06	366.25	0.00	0.00	0.00	0.00
LDDT	0.90	0.05	0.04	0.00	0.80	0.07	602.95	0.02	0.00	0.00	0.01
CNG	3.20	0.05	0.02	0.00	20.68	0.00	923.35	0.01	0.04	0.00	0.00
2024											
LDGT2	0.40	0.03	0.02	0.01	3.18	0.06	361.45	0.00	0.00	0.00	0.00
LDDT	0.85	0.05	0.03	0.00	0.79	0.06	601.15	0.02	0.00	0.00	0.01
CNG	3.18	0.05	0.02	0.00	19.73	0.00	923.35	0.01	0.04	0.00	0.00
2025											
LDGT2	0.37	0.03	0.02	0.01	3.10	0.05	357.10	0.00	0.00	0.00	0.00
LDDT	0.80	0.04	0.03	0.00	0.78	0.06	599.33	0.02	0.00	0.00	0.00
CNG	3.16	0.05	0.01	0.00	18.97	0.00	923.35	0.01	0.04	0.00	0.00

Construction Emission Summary

								ton								
per	**CO**	**NOx**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**	**Benzene**	**Ethylbenzene**	**Formaldehyde**	**H_2S**	**n-Hexane**	**Toluene**	**Xylenes**	**CH_4**	**CO_2**	**N_2O**	Pads per year
Pad/Road/Pipeline	0.78	1.33	1.49	0.42	0.03	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	155.75	0.00	10
Facility	0.04	0.11	0.50	0.06	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.90	0.00	

								ton									Facility
Year	**CO**	**NOx**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**	**Benzene**	**Ethylbenzene**	**Formaldehyde**	**H_2S**	**n-Hexane**	**Toluene**	**Xylenes**	**CH_4**	**CO_2**	**N_2O**	**CO2e**	
1	7.87	13.67	16.41	4.38	0.34	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1602.23	0.02	1,613	3
2	7.83	13.56	15.91	4.32	0.34	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1587.33	0.02	1,598	2
3	7.80	13.45	15.41	4.26	0.34	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1572.43	0.02	1,583	1
4	7.83	13.56	15.91	4.32	0.34	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1587.33	0.02	1,598	2
5	7.76	13.34	14.91	4.20	0.33	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1557.53	0.02	1,568	0
6	7.80	13.45	15.41	4.26	0.34	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1572.43	0.02	1,583	1
7	7.80	13.45	15.41	4.26	0.34	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1572.43	0.02	1,583	1
8	7.76	13.34	14.91	4.20	0.33	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1557.53	0.02	1,568	0
9	7.80	13.45	15.41	4.26	0.34	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1572.43	0.02	1,583	1
10	7.76	13.34	14.91	4.20	0.33	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1557.53	0.02	1,568	0

Wells/Pad 16

Total Drilling Summary

Combined

	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	Pads	Acetaldehyde	Acrolein
									ton										
Per Pad	25.9	20.2	39.2	5.6	0.4	1.9	0.0	0.0	1.7	0.0	0.0	0.0	0.0	35.0	4138.2	0.0	22.0	0.1	0.1
						per pad													

Drilling

	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	Pads	Acetaldehyde	Acrolein
									ton										
Per Pad	24.24	12.38	8.96	0.98	0.08	1.41	0.01	0.00	1.66	0.00	0.03	0.01	0.00	34.52	3109.93	0.01	22.0	0.08	0.05
						yes, per pad													

Completion

	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	Pads	Acetaldehyde	Acrolein
									ton										
Per Pad	1.7	7.8	30.2	4.6	0.4	0.4	5.93E-03	0.0	9.88E-03	0.0	0.0	0.0	0.0	0.5	1028.3	0.0	22.0	4.3E-03	5.1E-04
						per pad													

Commuter

1	26.59	3.47	0.08	0.05	0.00	0.11	2.16E-03		6.07E-03					0.02	1054.39	0.03			
2	24.82	3.36	0.08	0.05	0.00	0.10	1.90E-03		9.66E-03					0.02	1050.27	0.03			
3	23.26	3.26	0.08	0.04	0.00	0.09	1.70E-03		4.63E-03					0.02	1046.55	0.03			
4	21.89	3.17	0.07	0.04	0.00	0.08	1.52E-03		4.06E-03					0.02	1042.90	0.03			
5	20.67	3.10	0.07	0.04	0.00	0.07	1.37E-03		3.58E-03					0.02	1039.43	0.03			
6	19.62	3.03	0.07	0.03	0.00	0.06	1.24E-03		3.16E-03					0.02	1036.22	0.03			
7	18.69	2.98	0.07	0.03	0.00	0.05	1.13E-03		2.80E-03					0.02	1033.24	0.03			
8	17.88	2.92	0.06	0.03	0.00	0.05	1.03E-03		2.48E-03					0.02	1030.55	0.03			
9	17.10	2.88	0.06	0.03	0.00	0.04	9.44E-04		2.20E-03					0.02	1028.07	0.03			
10	16.34	2.84	0.06	0.03	0.00	0.04	8.64E-04		1.95E-03					0.02	1025.85	0.03			

									ton												
Year	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	CO2e	Acetaldehyde	Acrolein	Pads	Wells
1	123.9	79.21	147.0	21.0	1.6	7.07	0.1	0.0	6.3	0.0	0.1	0.0	0.0	131.3	16572.6	0.1	20,276	0.3	0.2		60
2	284.3	205.34	392.0	55.9	4.3	18.66	0.2	0.0	16.7	0.0	0.3	0.1	0.1	350.0	42432.2	0.2	52,291	0.9	0.5		160
3	282.7	205.24	391.9	55.9	4.3	18.65	0.2	0.0	16.7	0.0	0.3	0.1	0.1	350.0	42428.4	0.2	52,287	0.9	0.5		160
4	281.3	205.15	391.9	55.9	4.3	18.64	0.2	0.0	16.7	0.0	0.3	0.1	0.1	350.0	42424.8	0.2	52,283	0.9	0.5		160
5	280.1	205.08	391.9	55.9	4.3	18.63	0.2	0.0	16.7	0.0	0.3	0.1	0.1	350.0	42421.3	0.2	52,280	0.9	0.5		160
6	279.1	205.01	391.9	55.9	4.3	18.62	0.2	0.0	16.7	0.0	0.3	0.1	0.1	350.0	42418.1	0.2	52,276	0.9	0.5		160
7	278.1	204.95	391.9	55.9	4.3	18.61	0.2	0.0	16.7	0.0	0.3	0.1	0.1	350.0	42415.1	0.2	52,273	0.9	0.5		160
8	277.3	204.90	391.9	55.9	4.3	18.61	0.2	0.0	16.7	0.0	0.3	0.1	0.1	350.0	42412.4	0.2	52,271	0.9	0.5		160
9	276.6	204.86	391.9	55.9	4.3	18.60	0.2	0.0	16.7	0.0	0.3	0.1	0.1	350.0	42410.0	0.2	52,268	0.9	0.5		160
10	275.8	204.81	391.9	55.9	4.3	18.60	0.2	0.0	16.7	0.0	0.3	0.1	0.1	350.0	42407.7	0.2	52,266	0.9	0.5		160

Wells/Pad 16

Drilling Summary for Conformity

Combined

	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	Pads	Acetaldehyde	Acrolein
						ton													
Per Pad	1.7	7.9	38.9	5.5	0.4	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1051.9	0.0	22.0	0.0	0.0
						per pad													

Drilling

	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	Pads	Acetaldehyde	Acrolein
						ton													
Per Pad	0.03	0.09	8.71	0.87	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.69	0.00	22.0		
						per pad													

Completion

	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	Pads	Acetaldehyde	Acrolein
						ton													
Per Pad	1.7	7.8	30.2	4.6	0.4	0.4	5.93E-03	0.0	9.88E-03	0.0	0.0	0.0	0.0	0.5	1028.3	0.0	22.0	4.3E-03	5.1E-04
						per pad													

Commuter

1	26.59	3.47	0.08	0.05	0.00	0.11	2.16E-03		6.07E-03					0.02	1054.39	0.03			
2	24.82	3.36	0.08	0.05	0.00	0.10	1.90E-03		9.66E-03					0.02	1050.27	0.03			
3	23.26	3.26	0.08	0.04	0.00	0.09	1.70E-03		4.63E-03					0.02	1046.55	0.03			
4	21.89	3.17	0.07	0.04	0.00	0.08	1.52E-03		4.06E-03					0.02	1042.90	0.03			
5	20.67	3.10	0.07	0.04	0.00	0.07	1.37E-03		3.58E-03					0.02	1039.43	0.03			
6	19.62	3.03	0.07	0.03	0.00	0.06	1.24E-03		3.16E-03					0.02	1036.22	0.03			
7	18.69	2.98	0.07	0.03	0.00	0.05	1.13E-03		2.80E-03					0.02	1033.24	0.03			
8	17.88	2.92	0.06	0.03	0.00	0.05	1.03E-03		2.48E-03					0.02	1030.55	0.03			
9	17.10	2.88	0.06	0.03	0.00	0.04	9.44E-04		2.20E-03					0.02	1028.07	0.03			
10	16.34	2.84	0.06	0.03	0.00	0.04	8.64E-04		1.95E-03					0.02	1025.85	0.03			

						ton															
Year	**CO**	**NOx**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**	**Benzene**	**Ethylbenzene**	**Formaldehyde**	**H_2S**	**n-Hexane**	**Toluene**	**Xylenes**	**CH_4**	**CO_2**	**N_2O**	**CO2e**	Acetaldehyde	Acrolein	Pads	Wells
1	33.1	33.13	146.1	20.6	1.3	1.82	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	4999.2	0.1	5,068	0.0	0.0		60
2	42.2	82.45	389.4	54.8	3.5	4.65	0.1	0.0	0.1	0.0	0.0	0.0	0.0	4.8	11569.7	0.1	11,735	0.1	0.0		160
3	40.6	82.35	389.4	54.8	3.5	4.63	0.1	0.0	0.1	0.0	0.0	0.0	0.0	4.8	11566.0	0.1	11,732	0.0	0.0		160
4	39.3	82.27	389.4	54.8	3.5	4.62	0.1	0.0	0.1	0.0	0.0	0.0	0.0	4.8	11562.4	0.1	11,728	0.0	0.0		160
5	38.0	82.19	389.4	54.8	3.5	4.62	0.1	0.0	0.1	0.0	0.0	0.0	0.0	4.8	11558.9	0.1	11,725	0.0	0.0		160
6	37.0	82.13	389.4	54.8	3.5	4.61	0.1	0.0	0.1	0.0	0.0	0.0	0.0	4.8	11555.7	0.1	11,721	0.0	0.0		160
7	36.1	82.07	389.4	54.8	3.5	4.60	0.1	0.0	0.1	0.0	0.0	0.0	0.0	4.8	11552.7	0.1	11,718	0.0	0.0		160
8	35.3	82.02	389.4	54.8	3.5	4.60	0.1	0.0	0.1	0.0	0.0	0.0	0.0	4.8	11550.0	0.1	11,716	0.0	0.0		160
9	34.5	81.97	389.4	54.8	3.5	4.59	0.1	0.0	0.1	0.0	0.0	0.0	0.0	4.8	11547.5	0.1	11,713	0.0	0.0		160
10	33.7	81.93	389.4	54.8	3.5	4.59	0.1	0.0	0.1	0.0	0.0	0.0	0.0	4.8	11545.3	0.1	11,711	0.0	0.0		160

Wells/Pad 16

Drill Rig Engines Only

Drilling

tons

	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	Pads	Acetaldehyde	Acrolein
Per Pad	24.21	12.29	0.25	0.11	0.08	1.40	0.01	0.00	1.66	0.00	0.03	0.01	0.00	34.52	3086.24	0.01	22.0	0.03	0.01
						per pad													

tons/year

Year	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	CO2e	Acetaldehyde	Acrolein	Pads	Wells
1	90.8	46.08	0.9	0.4	0.3	5.25	0.0	0.0	6.2	0.0	0.1	0.0	0.0	129.5	11573.4	0.0	15,208	0.1	0.0		60
2	242.1	122.89	2.5	1.1	0.8	14.01	0.1	0.0	16.6	0.0	0.3	0.1	0.0	345.2	30862.4	0.1	40,555	0.3	0.1		160
3	242.1	122.89	2.5	1.1	0.8	14.01	0.1	0.0	16.6	0.0	0.3	0.1	0.0	345.2	30862.4	0.1	40,555	0.3	0.1		160
4	242.1	122.89	2.5	1.1	0.8	14.01	0.1	0.0	16.6	0.0	0.3	0.1	0.0	345.2	30862.4	0.1	40,555	0.3	0.1		160
5	242.1	122.89	2.5	1.1	0.8	14.01	0.1	0.0	16.6	0.0	0.3	0.1	0.0	345.2	30862.4	0.1	40,555	0.3	0.1		160
6	242.1	122.89	2.5	1.1	0.8	14.01	0.1	0.0	16.6	0.0	0.3	0.1	0.0	345.2	30862.4	0.1	40,555	0.3	0.1		160
7	242.1	122.89	2.5	1.1	0.8	14.01	0.1	0.0	16.6	0.0	0.3	0.1	0.0	345.2	30862.4	0.1	40,555	0.3	0.1		160
8	242.1	122.89	2.5	1.1	0.8	14.01	0.1	0.0	16.6	0.0	0.3	0.1	0.0	345.2	30862.4	0.1	40,555	0.3	0.1		160
9	242.1	122.89	2.5	1.1	0.8	14.01	0.1	0.0	16.6	0.0	0.3	0.1	0.0	345.2	30862.4	0.1	40,555	0.3	0.1		160
10	242.1	122.89	2.5	1.1	0.8	14.01	0.1	0.0	16.6	0.0	0.3	0.1	0.0	345.2	30862.4	0.1	40,555	0.3	0.1		160

Production Emission Summary - (Cummulative)

									tons							
Facility	**CO**	**NOx**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**	**Benzene**	**Ethylbenzene**	**Formaldehyde**	**H_2S**	**n-Hexane**	**Toluene**	**Xylenes**	**CH_4**	**CO_2**	**N_2O**	**Year Comes Online**
1	0.7	0.9	14.5	1.6	0.0	3.1	0.02	0.002	0.006	0.000	0.058	0.045	0.031	18.81	304.9	0.000	1
2	0.5	0.8	14.5	1.6	0.0	2.9	0.02	0.002	0.006	0.000	0.056	0.036	0.023	18.47	273.2	0.000	1
3	0.6	0.9	14.5	1.6	0.0	3.1	0.02	0.002	0.006	0.000	0.058	0.045	0.031	18.81	304.9	0.000	1
4	0.5	0.8	14.5	1.6	0.0	2.9	0.02	0.002	0.006	0.000	0.056	0.036	0.023	18.47	273.2	0.000	2
5	0.5	0.8	14.5	1.6	0.0	2.9	0.02	0.002	0.006	0.000	0.056	0.036	0.023	18.47	273.2	0.000	2
6	0.6	0.9	14.5	1.6	0.0	3.1	0.02	0.002	0.006	0.000	0.058	0.045	0.031	18.81	304.9	0.000	3
7	0.5	0.8	14.5	1.6	0.0	2.9	0.02	0.002	0.006	0.000	0.056	0.032	0.019	18.46	260.5	0.000	4
8	0.5	0.8	14.5	1.6	0.0	2.9	0.02	0.002	0.006	0.000	0.056	0.036	0.023	18.47	273.2	0.000	4
9	0.5	0.8	14.5	1.6	0.0	2.9	0.02	0.002	0.006	0.000	0.056	0.032	0.019	18.46	260.5	0.000	6
10	0.4	0.8	14.5	1.6	0.0	2.8	0.02	0.001	0.006	0.000	0.054	0.026	0.015	18.14	241.5	0.000	7
11	0.3	0.8	14.5	1.6	0.0	2.8	0.01	0.001	0.006	0.000	0.054	0.021	0.010	18.11	222.5	0.000	9
Blowdown Per Well/Y	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.01	0.00	

Wind Erosion Production

Year	**PM_{10}**	**$PM_{2.5}$**	Facility cummulative	pads
1	28.22	4.23	3	10
2	55.04	8.26	5	20
3	80.45	12.07	6	30
4	107.27	16.09	8	40
5	131.27	19.69	8	50
6	156.68	23.50	9	60
7	182.09	27.31	10	70
8	206.10	30.92	10	80
9	231.51	34.73	11	90
10	255.52	38.33	11	100

									tons										
Year	**CO**	**NOx**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**	**Benzene**	**Ethylbenzene**	**Formaldehyde**	**H_2S**	**n-Hexane**	**Toluene**	**Xylenes**	**CH_4**	**CO_2**	**N_2O**	**CO2e**	**wells/year**	**#wells total**
1	1.8	2.7	71.7	8.9	0.0	21.6	0.1	0.0	0.0	0.0	0.4	0.2	0.1	142.0	884.4	1.38E-03	4,860	60	60
2	2.8	4.4	127.5	16.0	0.0	61.0	0.3	0.0	0.0	0.0	1.2	0.5	0.2	407.9	1434.5	2.31E-03	12,857	160	220
3	3.4	5.2	167.4	21.4	0.0	97.5	0.5	0.0	0.0	0.0	1.9	0.8	0.4	655.8	1743.1	2.77E-03	20,105	160	380
4	4.3	6.9	223.2	28.5	0.0	136.8	0.7	0.0	0.1	0.0	2.7	1.1	0.5	921.7	2280.6	3.69E-03	28,089	160	540
5	4.3	6.9	247.2	32.1	0.0	170.2	0.8	0.1	0.1	0.0	3.4	1.3	0.6	1150.7	2284.3	3.69E-03	34,505	160	700
6	4.8	7.8	287.1	37.5	0.0	206.6	1.0	0.1	0.1	0.0	4.1	1.5	0.7	1398.2	2548.6	4.15E-03	41,699	160	860
7	5.2	8.6	327.0	42.9	0.0	242.8	1.2	0.1	0.1	0.0	4.9	1.8	0.8	1645.3	2793.8	4.61E-03	48,864	160	1020
8	5.2	8.6	351.0	46.5	0.0	276.3	1.3	0.1	0.1	0.0	5.5	2.0	0.8	1874.3	2797.6	4.61E-03	55,280	160	1180
9	5.5	9.4	390.9	51.8	0.0	312.5	1.5	0.1	0.1	0.0	6.3	2.2	0.9	2121.5	3023.8	5.07E-03	62,426	160	1340
10	5.5	9.4	414.9	55.4	0.0	345.9	1.6	0.1	0.1	0.0	6.9	2.5	1.0	2350.5	3027.6	5.07E-03	68,842	160	1500

Well fugitives - add to production above

Year	Pad	#wells										
						Tons						
1	10	60	8.5	0.0	0.0	0.2	0.1	0.0	58.4	1.0		
2	20	220	31.3	0.1	0.0	0.6	0.2	0.1	214.1	3.5		
3	30	380	54.0	0.2	0.0	1.1	0.4	0.1	369.8	6.1		
4	40	540	76.7	0.3	0.0	1.5	0.5	0.2	525.6	8.6		
5	50	700	99.5	0.4	0.0	2.0	0.7	0.2	681.3	11.2		
6	60	860	122.2	0.5	0.0	2.5	0.8	0.3	837.0	13.7		
7	70	1020	145.0	0.6	0.0	2.9	1.0	0.4	992.7	16.3		
8	80	1180	167.7	0.8	0.0	3.4	1.1	0.4	1148.4	18.8		
9	90	1340	190.4	0.9	0.1	3.8	1.3	0.5	1304.2	21.4		
10	100	1500	213.2	1.0	0.1	4.3	1.4	0.5	1459.9	23.9		

Production Comformity Emission Summary

Year	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	tons Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	CO2e
1	1.8	2.7	71.7	8.9	0.0	21.6	1.25E-01	1.02E-02	1.91E-02	0.00E+00	4.25E-01	2.08E-01	1.15E-01	142.0	884.4	1.38E-03	4,860
2	1.0	1.7	55.8	7.1	0.0	39.3	1.90E-01	1.28E-02	1.27E-02	0.00E+00	7.86E-01	2.93E-01	1.27E-01	266.0	550.1	9.22E-04	7,997
3	0.6	0.9	39.9	5.4	0.0	36.5	1.74E-01	1.15E-02	6.38E-03	0.00E+00	7.32E-01	2.67E-01	1.13E-01	247.8	308.6	4.61E-04	7,248
4	0.9	1.7	55.8	7.1	0.0	39.3	1.89E-01	1.25E-02	1.27E-02	0.00E+00	7.86E-01	2.89E-01	1.24E-01	265.9	537.5	9.22E-04	7,984
5	0.0	0.0	24.0	3.6	0.0	33.4	1.50E-01	9.00E-03	0.00E+00	0.00E+00	6.74E-01	2.22E-01	8.21E-02	229.0	3.8	0.00E+00	6,416
6	0.5	0.8	39.9	5.4	0.0	36.3	1.69E-01	1.06E-02	6.34E-03	0.00E+00	7.30E-01	2.54E-01	1.02E-01	247.5	264.3	4.61E-04	7,194
7	0.4	0.8	39.9	5.4	0.0	36.3	1.66E-01	1.03E-02	6.32E-03	0.00E+00	7.28E-01	2.48E-01	9.66E-02	247.1	245.2	4.61E-04	7,166
8	0.0	0.0	24.0	3.6	0.0	33.4	1.50E-01	9.00E-03	0.00E+00	0.00E+00	6.74E-01	2.22E-01	8.21E-02	229.0	3.8	0.00E+00	6,416
9	0.3	0.8	39.9	5.4	0.0	36.2	1.64E-01	9.94E-03	6.31E-03	0.00E+00	7.28E-01	2.43E-01	9.18E-02	247.1	226.2	4.61E-04	7,146
10	0.0	0.0	24.0	3.6	0.0	33.4	1.50E-01	9.00E-03	0.00E+00	0.00E+00	6.74E-01	2.22E-01	8.21E-02	229.0	3.8	0.00E+00	6,416

Total Emission Summary

Year	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	Benzene	Ethylbenzene	Formaldehyde	H_2S	n-Hexane	Toluene	Xylenes	CH_4	CO_2	N_2O	CO2e	Acetaldehyde	Acrolein
	tons																		
1	133.5	95.54	235.1	34.3	2.0	30.43	0.2	0.0	6.3	0.0	0.5	0.3	0.1	273	19059	0.1	26,749	0.3	0.2
2	294.9	223.26	535.3	76.2	4.6	81.33	0.5	0.0	16.7	0.0	1.5	0.6	0.3	758	45454	0.2	66,746	0.9	0.5
3	293.9	223.93	574.7	81.5	4.6	117.83	0.7	0.0	16.7	0.0	2.2	0.9	0.4	1006	45744	0.2	73,975	0.9	0.5
4	293.5	225.64	631.0	88.7	4.6	157.12	0.9	0.1	16.8	0.0	3.0	1.2	0.5	1272	46293	0.2	81,971	0.9	0.5
5	292.2	225.34	654.0	92.2	4.6	190.54	1.0	0.1	16.8	0.0	3.7	1.4	0.6	1501	46263	0.2	88,353	0.9	0.5
6	291.6	226.23	694.4	97.6	4.6	226.89	1.2	0.1	16.8	0.0	4.4	1.7	0.7	1748	46539	0.2	95,559	0.9	0.5
7	291.1	226.98	734.3	103.0	4.6	263.14	1.3	0.1	16.8	0.0	5.1	1.9	0.8	1996	46781	0.2	102,721	0.9	0.5
8	290.2	226.82	757.8	106.5	4.6	296.56	1.5	0.1	16.8	0.0	5.8	2.1	0.9	2225	46768	0.2	109,119	0.9	0.5
9	289.9	227.68	798.2	112.0	4.6	332.76	1.7	0.1	16.8	0.0	6.5	2.4	1.0	2472	47006	0.2	116,278	0.9	0.5
10	289.0	227.52	821.7	115.5	4.6	366.19	1.8	0.1	16.8	0.0	7.2	2.6	1.1	2701	46993	0.2	122,677	0.9	0.5

Overall Confomity Emission Summary

								tons											
Year	**CO**	**NOx**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**	**Benzene**	**Ethylbenzene**	**Formaldehyde**	**H_2S**	**n-Hexane**	**Toluene**	**Xylenes**	**CH_4**	**CO_2**	**N_2O**	**CO2e**	Acetaldehyde	Acrolein	Wells (Con
1	42.8	49.5	234.2	33.9	1.7	25.2	0.1	0.0	0.1	0.0	0.4	0.2	0.1	144.0	7485.8	0.1	11,109	0.0	0.0	60
2	51.0	97.7	461.2	66.3	3.9	45.7	0.3	0.0	0.1	0.0	0.8	0.3	0.1	271.0	13707.2	0.1	20,518	0.1	0.0	160
3	49.0	96.7	444.8	64.4	3.9	42.9	0.2	0.0	0.1	0.0	0.7	0.3	0.1	252.8	13447.1	0.1	19,804	0.0	0.0	160
4	48.1	97.5	461.1	66.2	3.9	45.6	0.3	0.0	0.1	0.0	0.8	0.3	0.1	270.9	13687.2	0.1	20,498	0.0	0.0	160
5	45.8	95.5	428.4	62.6	3.8	39.7	0.2	0.0	0.1	0.0	0.7	0.2	0.1	234.0	13120.2	0.1	19,007	0.0	0.0	160
6	45.2	96.4	444.7	64.4	3.9	42.7	0.2	0.0	0.1	0.0	0.7	0.3	0.1	252.5	13392.4	0.1	19,741	0.0	0.0	160
7	44.3	96.3	444.7	64.4	3.9	42.6	0.2	0.0	0.1	0.0	0.7	0.3	0.1	252.1	13370.4	0.1	19,711	0.0	0.0	160
8	43.0	95.4	428.3	62.6	3.8	39.7	0.2	0.0	0.1	0.0	0.7	0.2	0.1	234.0	13111.3	0.1	18,998	0.0	0.0	160
9	42.6	96.2	444.7	64.4	3.9	42.5	0.2	0.0	0.1	0.0	0.7	0.3	0.1	252.1	13346.2	0.1	19,686	0.0	0.0	160
10	41.5	95.3	428.3	62.6	3.8	39.7	0.2	0.0	0.1	0.0	0.7	0.2	0.1	234.0	13106.6	0.1	18,993	0.0	0.0	160

Conformity Plot Data

CO (tons)

Year	1	2	3	4	5	6	7	8	9	10
Constructic	7.87	7.83	7.80	7.83	7.76	7.80	7.80	7.76	7.80	7.76
Drilling	33.11	42.20	40.64	39.27	38.05	36.99	36.07	35.25	34.48	33.71
Production	1.78	0.99	0.59	0.95	0.00	0.46	0.40	0.00	0.34	0.00

NOx (tons)

Year	1	2	3	4	5	6	7	8	9	10
Constructic	13.67	13.56	13.45	13.56	13.34	13.45	13.45	13.34	13.45	13.34
Drilling	33.13	82.45	82.35	82.27	82.19	82.13	82.07	82.02	81.97	81.93
Production	2.66	1.70	0.89	1.68	0.00	0.84	0.81	0.00	0.79	0.00

PM10 (tons)

Year	1	2	3	4	5	6	7	8	9	10
Constructic	16.41	15.91	15.41	15.91	14.91	15.41	15.41	14.91	15.41	14.91
Drilling	146.10	389.45	389.44	389.44	389.44	389.44	389.43	389.43	389.43	389.43
Production	71.69	55.80	39.90	55.79	24.01	39.90	39.90	24.01	39.90	24.01

PM2.5 (tons)

	1	2	3	4	5	6	7	8	9	10
Year	2015	2015	2016	2017	2018	2019	2020	2021	2022	2023
Constructic	4.38	4.32	4.26	4.32	4.20	4.26	4.26	4.20	4.26	4.20
Drilling	20.58	54.80	54.80	54.80	54.79	54.79	54.79	54.79	54.79	54.79
Production	8.90	7.13	5.37	7.13	3.60	5.36	5.36	3.60	5.36	3.60

VOC (tons)

Year	1	2	3	4	5	6	7	8	9	10
Constructic	1.72	1.71	1.70	1.71	1.69	1.70	1.70	1.69	1.70	1.69
Drilling	1.82	4.65	4.63	4.62	4.62	4.61	4.60	4.60	4.59	4.59
Production	21.64	39.33	36.52	39.29	33.44	36.35	36.25	33.44	36.20	33.44

CH4 (tons)

Year	1	2	3	4	5	6	7	8	9	10
Constructic	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Drilling	1.80	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.76	4.76
Production	141.97	265.96	247.82	265.94	229.01	247.47	247.15	229.01	247.12	229.01

CO2 (tons)

Year	1	2	3	4	5	6	7	8	9	10
Constructic	1602.23	1587.33	1572.43	1587.33	1557.53	1572.43	1572.43	1557.53	1572.43	1557.53
Drilling	4999.19	11569.75	11566.03	11562.38	11558.90	11555.69	11552.72	11550.03	11547.55	11545.33
Production	884.35	550.13	308.63	537.45	3.75	264.27	245.25	3.75	226.24	3.75

N2O (tons)

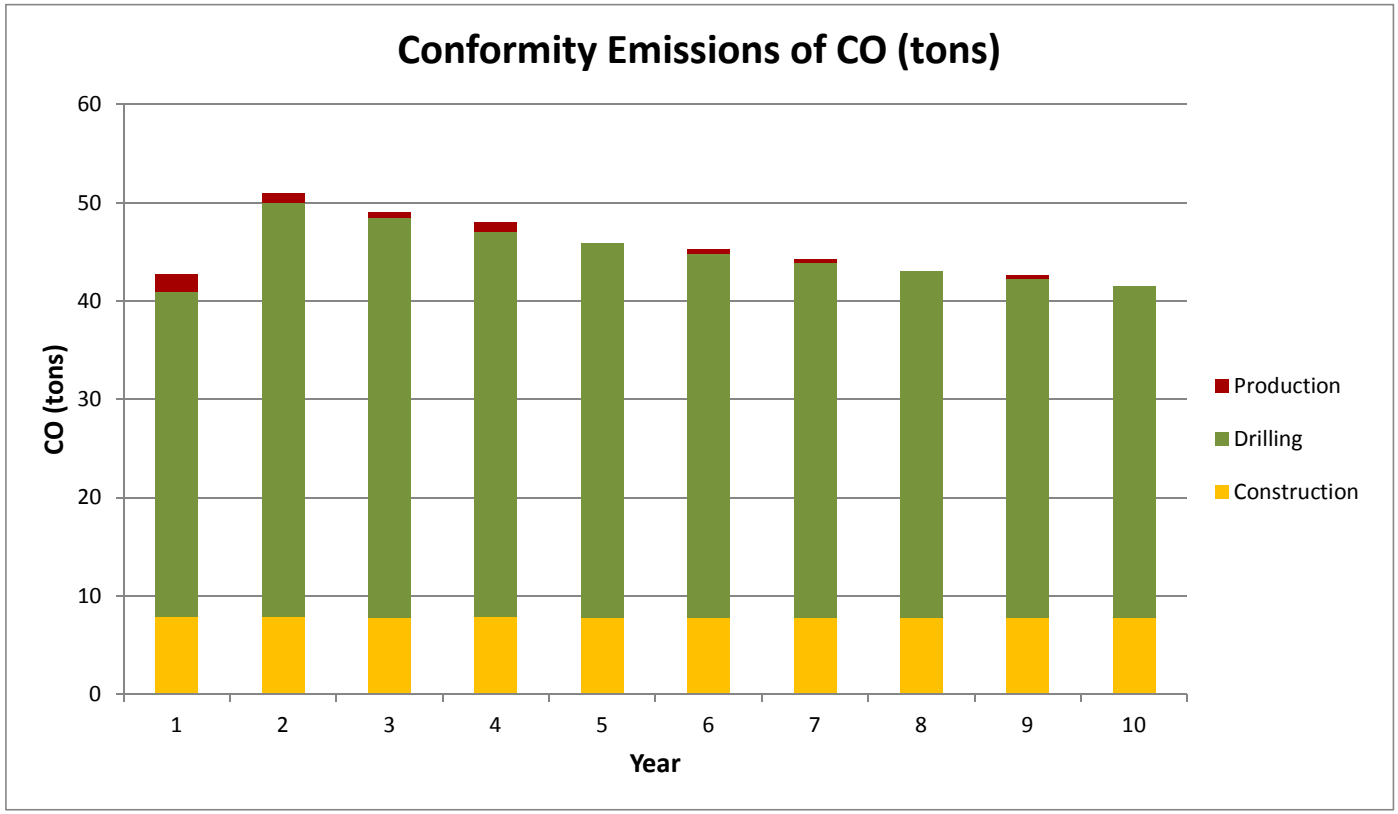
Year	1	2	3	4	5	6	7	8	9	10
Constructic	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Drilling	0.06	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

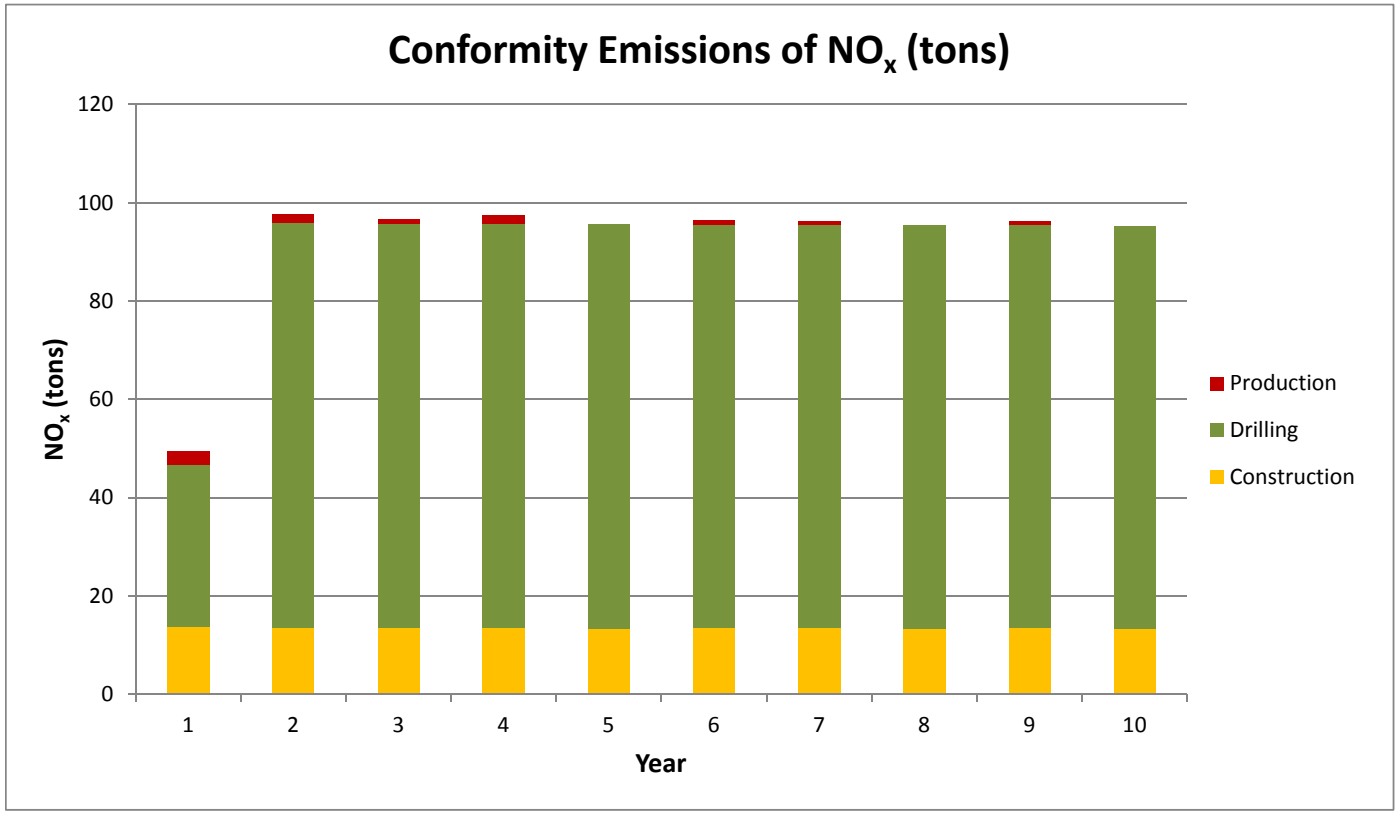
SO2 (tons)

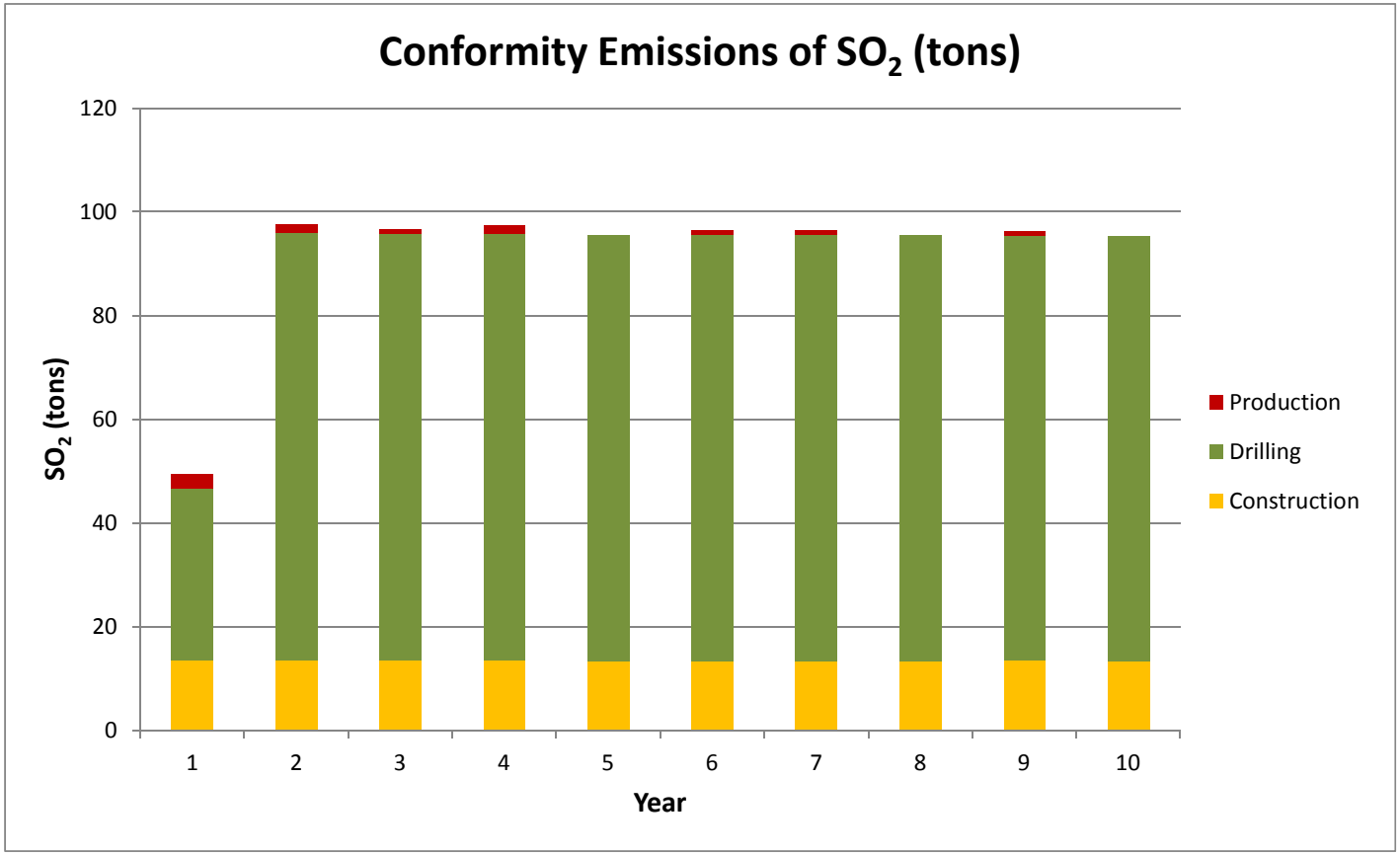
Year	1	2	3	4	5	6	7	8	9	10
Constructic	0.34	0.34	0.34	0.34	0.33	0.34	0.34	0.33	0.34	0.33
Drilling	1.32	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51	3.51
Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

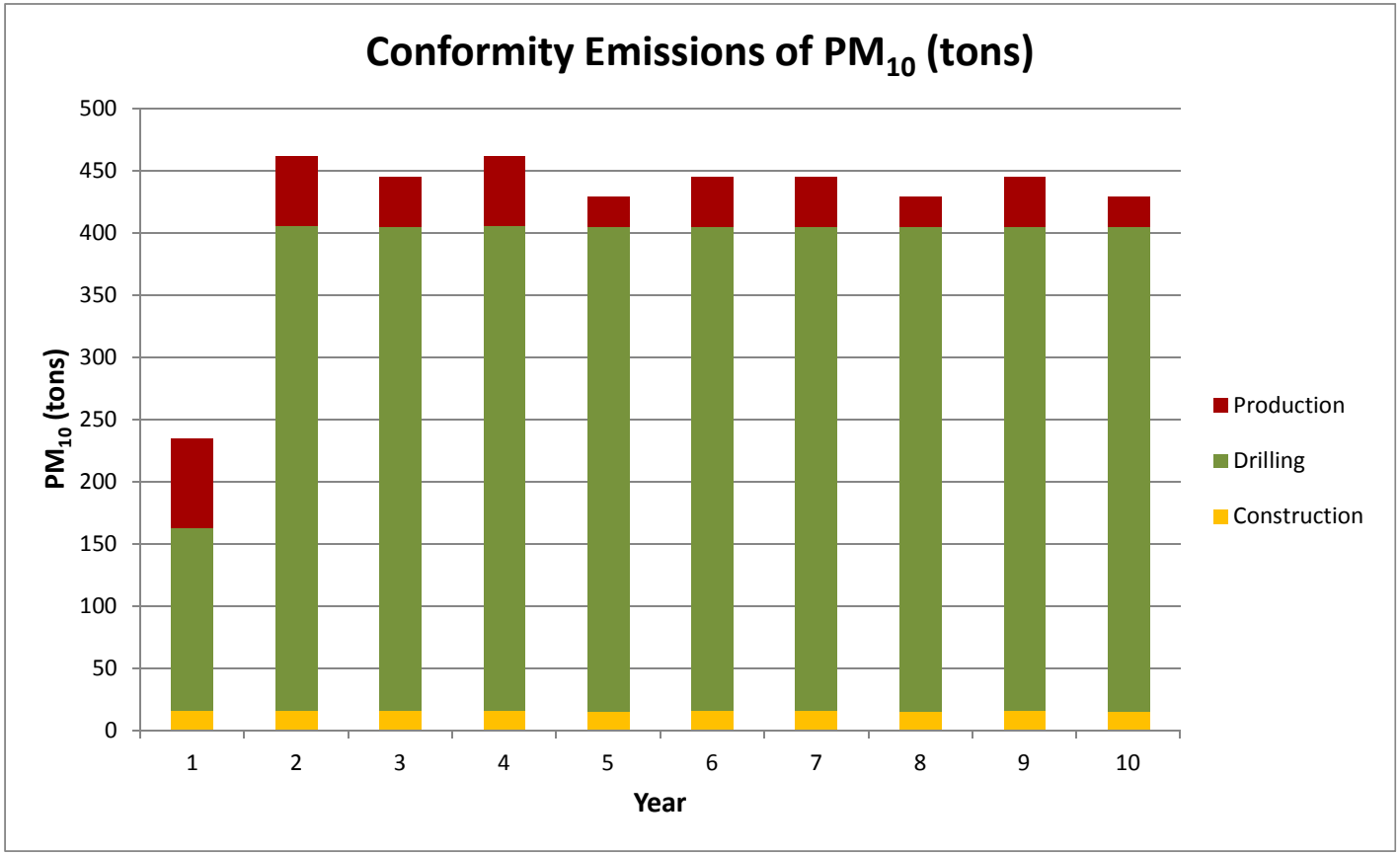
CO2eq (tons)

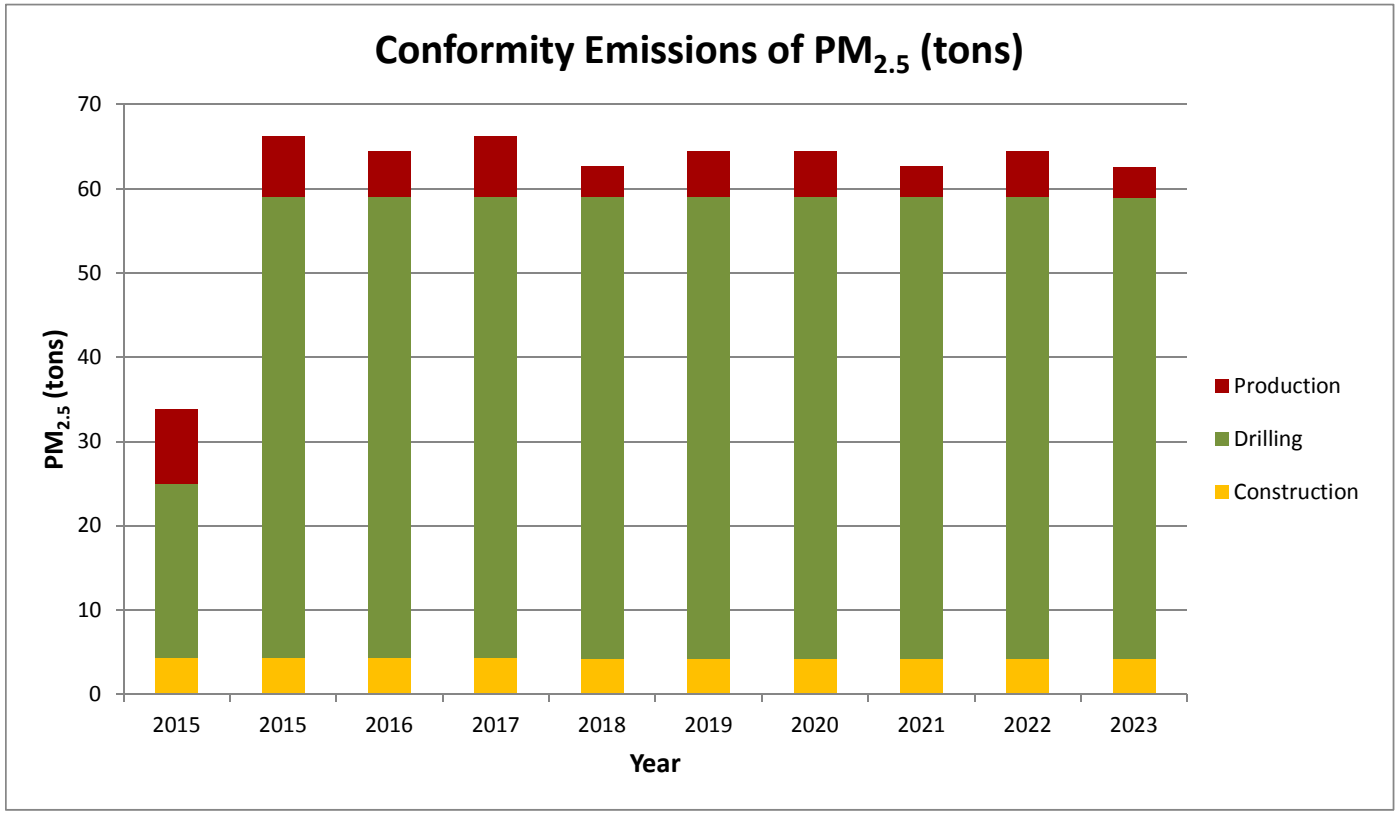
Year	1	2	3	4	5	6	7	8	9	10
Constructic	1613.46	1598.46	1583.45	1598.46	1568.45	1583.45	1583.45	1568.45	1583.45	1568.45
Drilling	5067.72	11735.49	11731.73	11728.04	11724.51	11721.27	11718.27	11715.55	11713.05	11710.80
Production	4860.05	7997.25	7247.77	7984.14	6416.05	7193.54	7165.53	6416.05	7145.87	6416.05

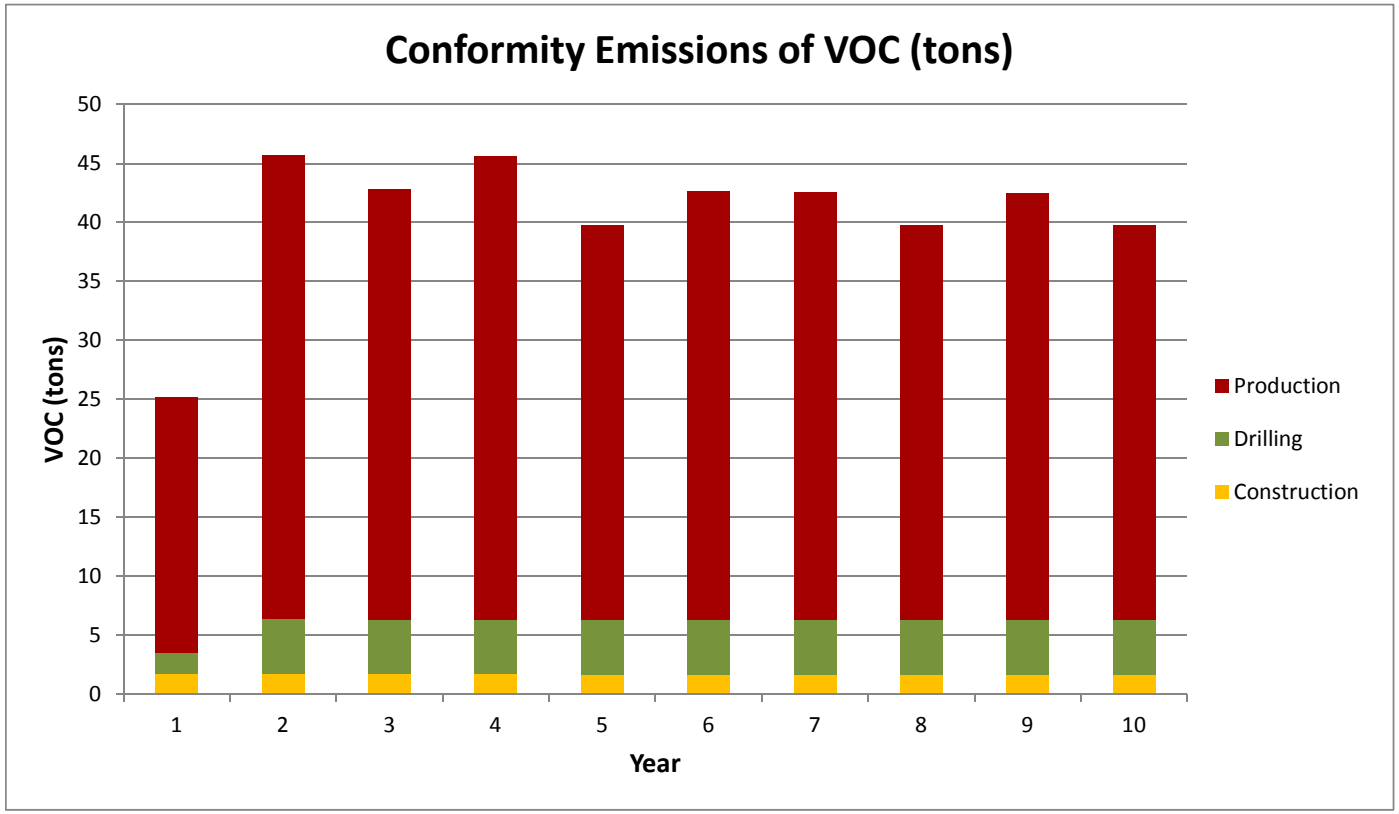

Conformity Emissions of CO (tons)
CO (tons)
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
Year
Production
Drilling
Construction

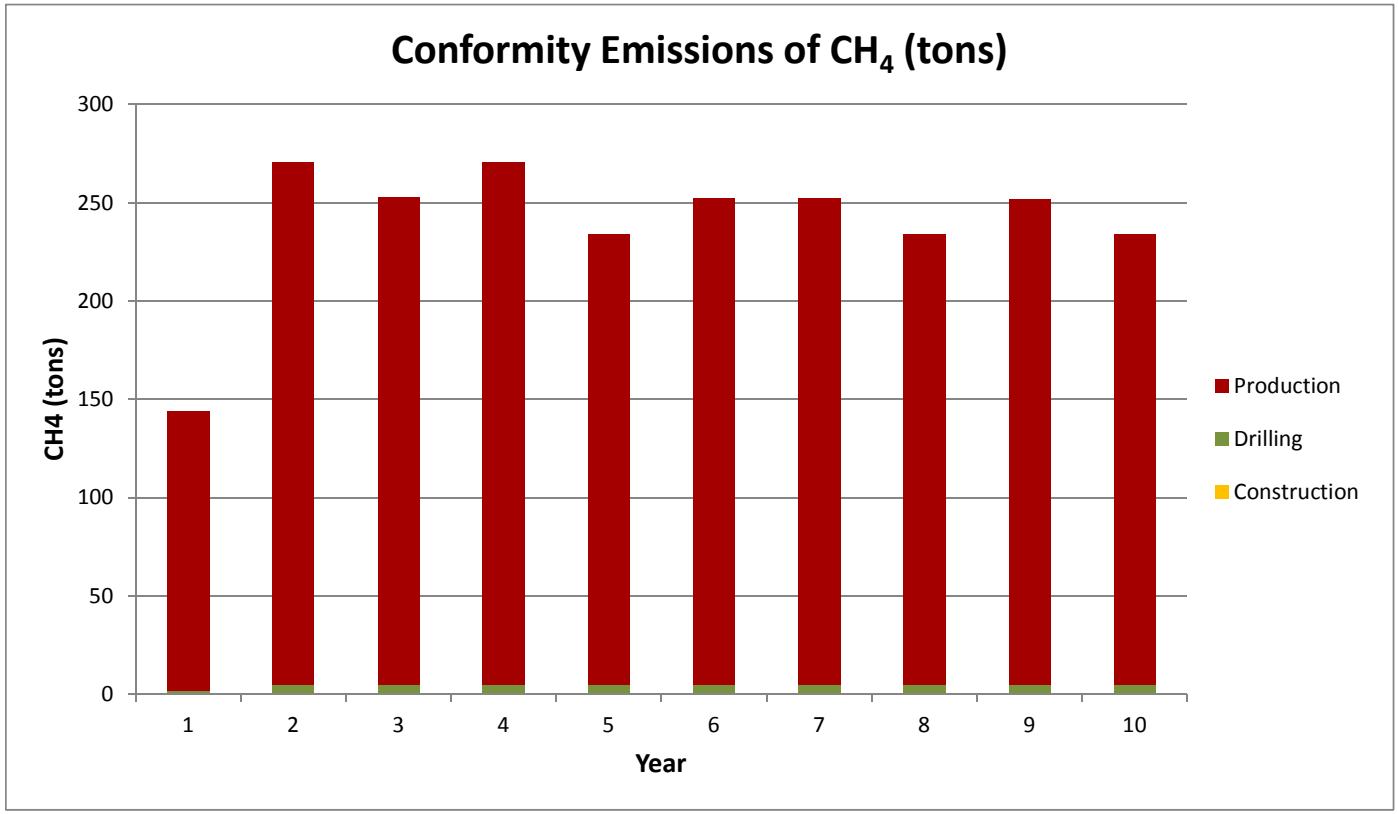

Conformity Emissions of NOx (tons)
120
100
80
60
40
20
0
NOx (tons)
1
2
3
4
5
6
7
8
9
10
Year
Production
Drilling
Construction

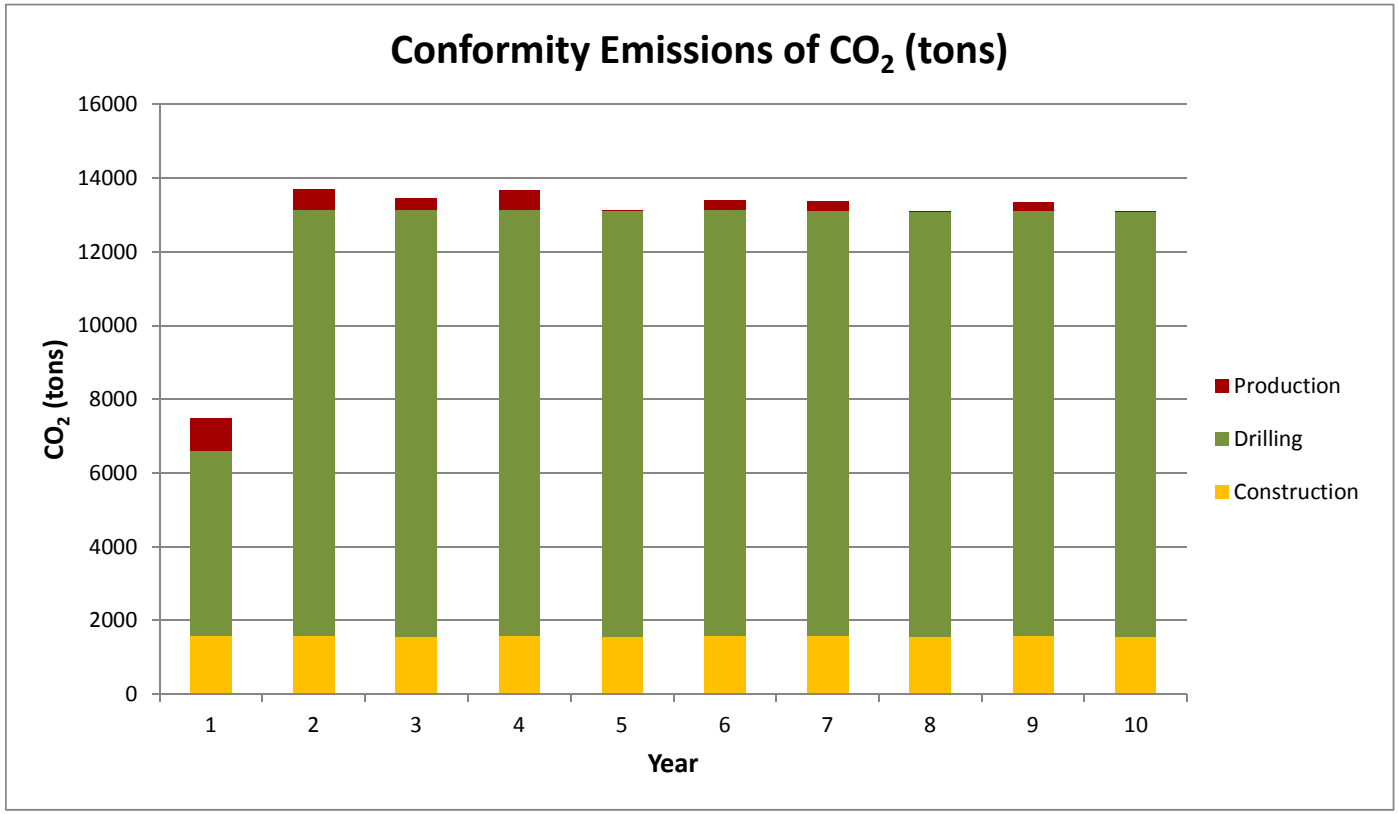

Conformity Emissions of SO2 (tons)
120
100
80
60
40
20
0
SO2 (tons)
1
2
3
4
5
6
7
8
9
10
Year
Production
Drilling
Construction

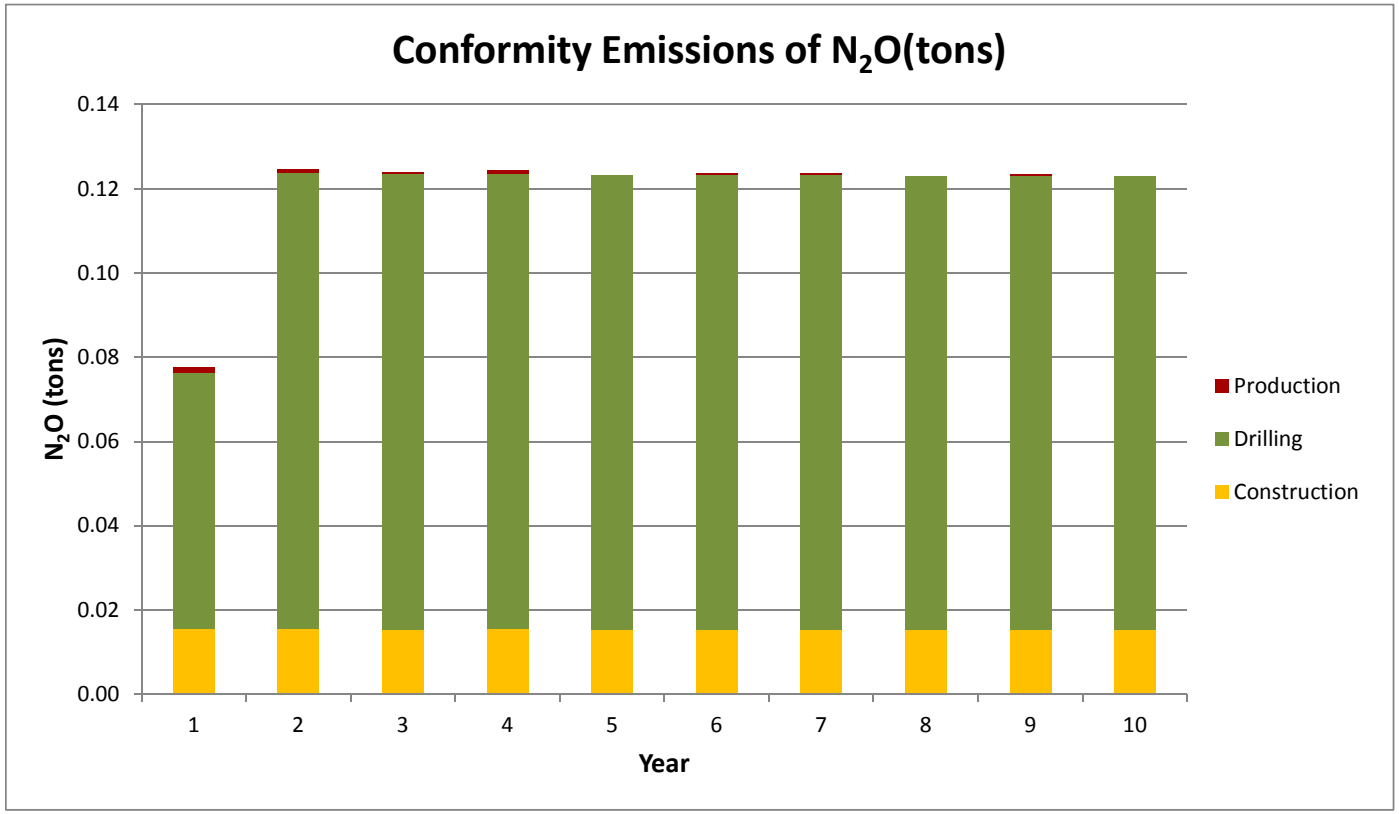

Conformity Emissions of PM10 (tons)
PM10 (tons)
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
Year
Production
Drilling
Construction

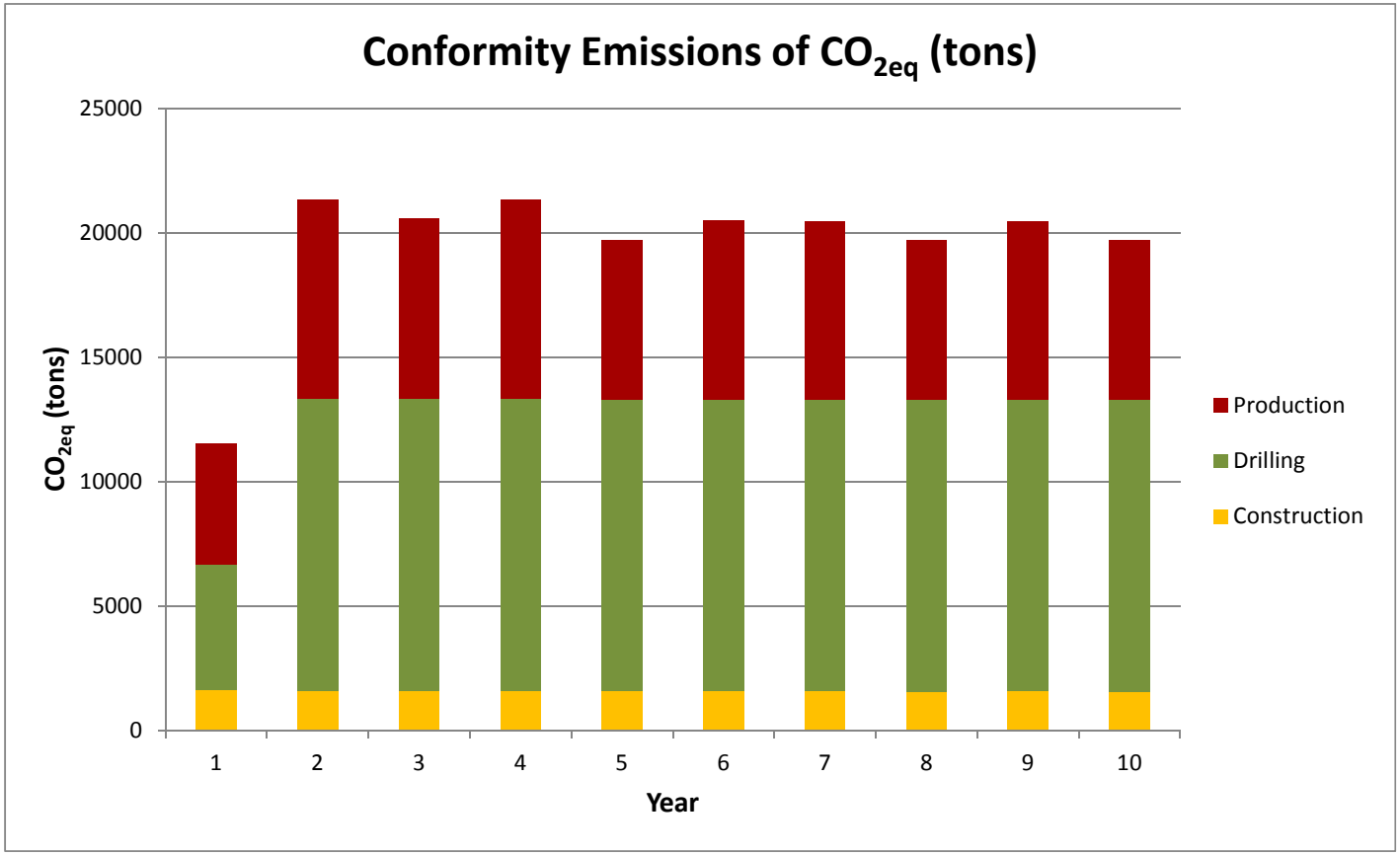

Conformity Emissions of PM2.5 (tons)
70
60
50
40
30
20
10
0
PM2.5 (tons)
2015
2015
2016
2017
2018
2019
2020
2021
2022
2023
Year
Production
Drilling
Construction

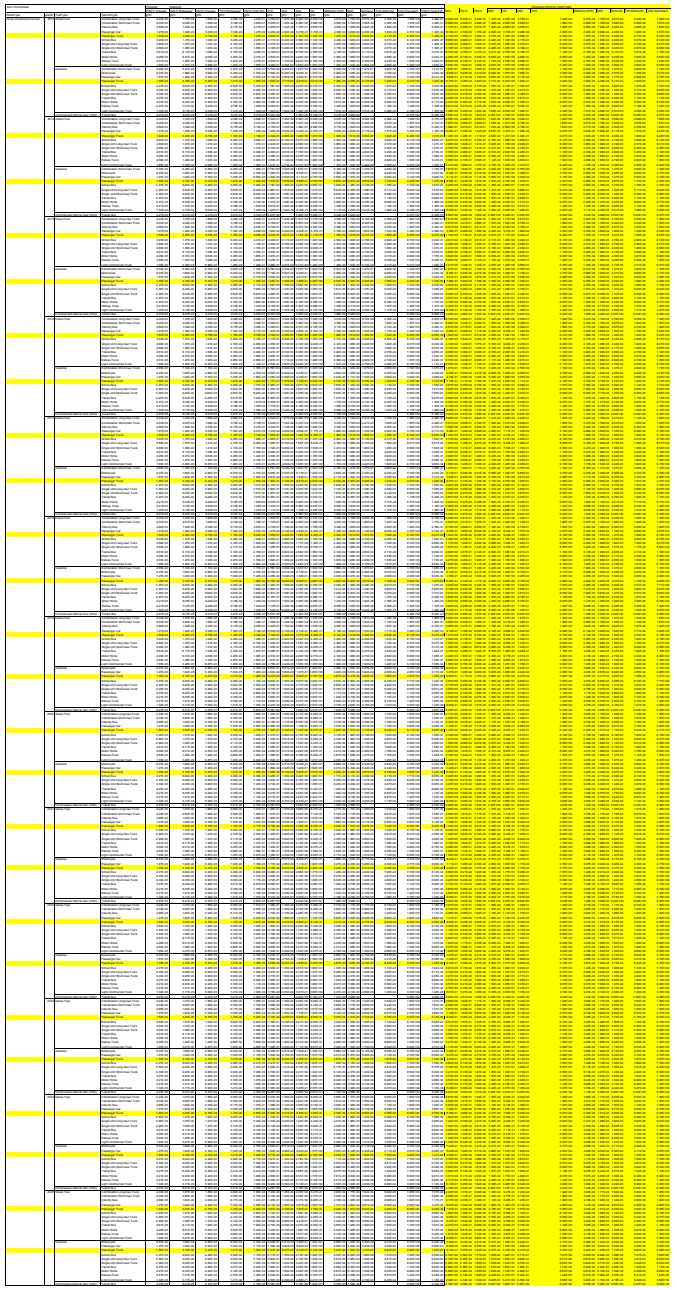

Conformity Emissions of VOC (tons)
VOC (tons)
50
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
Year
Production
Drilling
Construction


Conformity Emissions of CH_4 (tons)
CH4 (tons)
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
Year
Production
Drilling
Construction


Conformity Emissions of CO_2 (tons)
16000
14000
12000
10000
8000
6000
4000
2000
0
CO_2 (tons)
1
2
3
4
5
6
7
8
9
10
Year
Production
Drilling
Construction


Conformity Emissions of N_2O(tons)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
N_2O (tons)
1
2
3
4
5
6
7
8
9
10
Year
Production
Drilling
Construction


Conformity Emissions of CO_{2eq} (tons)
25000
20000
15000
10000
5000
0
CO_{2eq} (tons)
1
2
3
4
5
6
7
8
9
10
Year
Production
Drilling
Construction



Sum of emisRate				Pollutant	RateUnit										
				PM2.5 Tirewear	PM2.5 Brakewear	PM10 Tirewear	PM10 Brakewear	PM10 Total Exh	VOC	SO2	NOx	CO	Methane (CH4)	N2O	Benzene
RoadType	yearID	FuelType	SourceType	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi
Rural Unrestricted Access	2013	Diesel Fuel	Combination Long-haul Truck	4.44E-03	1.07E-02	1.85E-02	4.09E-02	4.42E-01	3.76E-01	1.47E-02	9.64E+00	2.25E+00	2.67E-02	1.76E-03	4.07E-03
			Combination Short-haul Truck	4.04E-03	9.93E-03	1.69E-02	3.79E-02	3.96E-01	3.65E-01	1.40E-02	8.98E+00	2.06E+00	2.80E-02	1.76E-03	3.96E-03
			Intercity Bus	4.86E-03	1.62E-02	2.03E-02	6.17E-02	5.77E-01	4.55E-01	1.24E-02	1.17E+01	2.80E+00	2.56E-02	1.96E-03	4.94E-03
			Passenger Car	1.27E-03	1.92E-03	5.30E-03	7.33E-03	1.47E-02	2.26E-02	2.62E-03	5.73E-01	3.73E-01	2.29E-03	3.82E-04	2.45E-04
			Passenger Truck	1.62E-03	3.03E-03	6.75E-03	1.16E-02	1.27E-01	2.69E-01	4.75E-03	2.14E+00	1.32E+00	1.57E-02	1.51E-03	2.92E-03
			School Bus	3.93E-03	1.37E-02	1.64E-02	5.25E-02	2.97E-01	4.17E-01	6.22E-03	5.56E+00	1.72E+00	2.20E-02	1.96E-03	4.52E-03
			Single Unit Long-haul Truck	2.89E-03	1.07E-02	1.21E-02	4.10E-02	1.53E-01	3.37E-01	5.91E-03	3.03E+00	1.29E+00	3.67E-02	1.88E-03	3.65E-03
			Single Unit Short-haul Truck	2.89E-03	1.08E-02	1.21E-02	4.11E-02	1.56E-01	3.18E-01	6.28E-03	3.18E+00	1.25E+00	3.73E-02	1.88E-03	3.45E-03
			Transit Bus	2.61E-03	8.11E-03	1.09E-02	3.10E-02	4.34E-01	4.72E-01	9.01E-03	8.75E+00	2.79E+00	2.12E-02	1.96E-03	5.11E-03
			Motor Home	2.28E-03	8.51E-03	9.53E-03	3.25E-02	2.31E-01	4.82E-01	6.65E-03	4.46E+00	1.63E+00	3.26E-02	1.88E-03	5.23E-03
			Refuse Truck	4.57E-03	1.26E-02	1.90E-02	4.81E-02	4.07E-01	4.00E-01	1.15E-02	8.64E+00	2.16E+00	2.76E-02	1.88E-03	4.33E-03
			Light Commercial Truck	1.65E-03	3.31E-03	6.88E-03	1.27E-02	1.65E-01	3.58E-01	4.80E-03	2.63E+00	1.67E+00	1.23E-02	1.54E-03	3.89E-03
		Gasoline	Combination Short-haul Truck	2.29E-03	6.47E-03	9.55E-03	2.47E-02	1.31E-01	3.75E+00	3.02E-02	1.67E+01	1.34E+02	9.24E-02	1.17E-02	1.27E-01
			Motorcycle	6.37E-04	1.66E-04	2.66E-03	6.33E-04	4.70E-02	7.62E-01	6.49E-03	8.50E-01	1.57E+01	2.90E-02	1.95E-03	2.57E-02
			Passenger Car	1.27E-03	1.92E-03	5.30E-03	7.33E-03	9.03E-03	5.17E-02	5.56E-03	3.69E-01	2.31E+00	4.85E-03	1.56E-03	1.77E-03
			Passenger Truck	1.30E-03	3.16E-03	5.42E-03	1.21E-02	1.52E-02	1.52E-01	7.71E-03	9.37E-01	5.01E+00	7.26E-03	4.35E-03	5.17E-03
			School Bus	2.27E-03	8.84E-03	9.46E-03	3.38E-02	3.30E-02	1.18E+00	1.35E-02	4.42E+00	3.12E+01	5.54E-02	1.45E-02	3.99E-02
			Single Unit Long-haul Truck	2.30E-03	9.22E-03	9.60E-03	3.52E-02	8.28E-03	3.91E-01	1.41E-02	3.32E+00	1.43E+01	8.55E-03	1.05E-02	1.32E-02
			Single Unit Short-haul Truck	2.30E-03	9.23E-03	9.60E-03	3.53E-02	9.81E-03	4.38E-01	1.50E-02	3.51E+00	1.58E+01	1.06E-02	1.01E-02	1.48E-02
			Transit Bus	2.27E-03	8.40E-03	9.46E-03	3.21E-02	1.05E-02	8.81E-01	1.97E-02	4.09E+00	2.90E+01	1.55E-02	1.34E-02	2.98E-02
			Motor Home	2.21E-03	8.33E-03	9.22E-03	3.18E-02	2.30E-02	7.36E-01	1.52E-02	4.47E+00	2.52E+01	2.51E-02	1.46E-02	2.49E-02
			Refuse Truck	2.21E-03	7.31E-03	9.22E-03	2.79E-02	1.56E-02	9.05E-01	2.49E-02	5.61E+00	3.79E+01	1.49E-02	1.20E-02	3.06E-02
			Light Commercial Truck	1.33E-03	3.17E-03	5.53E-03	1.21E-02	1.49E-02	1.62E-01	7.62E-03	1.02E+00	5.23E+00	7.61E-03	4.84E-03	5.51E-03
		Compressed Natural Gas (CNG)	Transit Bus	2.27E-03	8.41E-03	9.47E-03	3.21E-02	5.37E-03	0.00E+00		3.55E+00	3.74E+01	2.21E-02	3.98E-02	
	2014	Diesel Fuel	Combination Long-haul Truck	4.44E-03	1.07E-02	1.85E-02	4.09E-02	3.89E-01	3.32E-01	1.45E-02	8.58E+00	2.00E+00	2.87E-02	1.76E-03	3.59E-03
			Combination Short-haul Truck	4.04E-03	9.93E-03	1.69E-02	3.79E-02	3.41E-01	3.18E-01	1.38E-02	7.87E+00	1.81E+00	3.01E-02	1.76E-03	3.45E-03
			Intercity Bus	4.86E-03	1.62E-02	2.03E-02	6.17E-02	5.15E-01	4.15E-01	1.23E-02	1.06E+01	2.56E+00	2.77E-02	1.96E-03	4.50E-03
			Passenger Car	1.27E-03	1.92E-03	5.30E-03	7.33E-03	1.22E-02	1.95E-02	2.53E-03	5.00E-01	4.57E-01	2.83E-03	3.82E-04	2.11E-04

						=CO2(eq)-(CH4*21)-(NO2*320)					
NOx	PM10	PM2.5	SO2	CO	VOC	CO2	Methane (CH4)	N2O	Benzene	Formaldehyde	CO2 Equivalent

Normally Pressured Lance Natural Gas Development Project

Record of Decision

Appendix C

Reclamation, Monitoring, and Weed Management Plan

NORMALLY PRESSURED LANCE

NATURAL GAS DEVELOPMENT PROJECT

Reclamation, Monitoring, and Weed Management Plan

U.S. Department of the Interior
Bureau of Land Management

BLM Pinedale Field Office
P.O. Box 768
1625 West Pine Street
Pinedale, Wyoming 82941

The Bureau of Land Management is responsible for the stewardship of our public lands. The Bureau of Land Management's mission is to sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations.

TABLE OF CONTENTS

LIST OF TABLES

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1.0 INTRODUCTION

This Reclamation, Monitoring, and Weed Management Plan was designed to define reclamation objectives and monitoring criteria for surface disturbance resulting from the development of the Normally Pressured Lance (NPL) Natural Gas Development Project. The Reclamation, Monitoring, and Weed Management Plan uses current information based on third-order soil data (NRCS 2012),Ecological Site Descriptions (ESDs) from the Natural Resource Conservation Service (NRCS) online database and local expertise. Any future modifications to the ESDs will be incorporated into this Reclamation Monitoring and Weed Management Plan.

The Bureau of Land Management (BLM) considered and incorporated information from the following sources for this Reclamation, Monitoring, and Weed Management Plan:

- Bureau of Land Management (BLM) Proposed Lander Resource Management Plan (RMP) and Final Environmental Impact Statement (FEIS) (BLM 2013a)
- BLM Green River RMP (BLM 1997)
- BLM Pinedale RMP (BLM 2008a)
- BLM Pinedale Anticline Project Area (PAPA) Supplemental Environmental Impact Statement (SEIS) – Reclamation Plan (BLM 2008b)
- BLM Jonah Infill Drilling Project FEIS (BLM 2006)
- BLM Instruction Memorandum (IM) WY-2012-032 – *Wyoming BLM Reclamation Policy* (BLM 2012a)
- BLM IM WYD-2012-005 – *High Desert District Policy for Reclamation of Disturbed* Lands – (BLM 2012b) and
- Approved Resource Management Plan Amendments for the Rocky Mountain Region Greater Sage-Grouse (GRSG) sub-regions of Lewistown, North Dakota, Northwest Colorado, and Wyoming (ARMPAs) (BLM 2015).

The BLM encourages the use of new technology for achieving successful reclamation as it becomes available.

Other information considered and incorporated in this Reclamation, Monitoring, and Weed Management Plan includes federal, state (Wyoming) and county (Sublette and Sweetwater) policies concerning Greater Sage-Grouse habitat, big game crucial winter ranges, other wildlife habitat, and livestock grazing, as well as input from Jonah Energy, BLM, and other cooperating agencies.

Interim and final reclamation implementation are critical following disturbance. Reclamation will be conducted in compliance with all applicable federal, state, county, and local regulations. The sub-sections below further describe guidance and policies that are particularly relevant to reclamation and monitoring for the NPL Project.

Three phases of reclamation are described in this document; temporary, interim and final reclamation. Temporary reclamation is referred to as site-stabilization. Site-stabilization is using measures including but not limited to seeding and erosion control measures to maintain topsoil viability and reduce erosion from the topsoil pile and disturbed area. Interim reclamation includes recontouring all or most of the disturbed area, redistributing all or most of the topsoil,

and reseeding/re-vegetating (using established plants) over all or most of the disturbed area, where there are no remaining production facilities. Final reclamation includes but is not limited to: removing all of the facilities, recontouring and redistributing topsoil and reseeding/re-vegetating the entire disturbed area.

1.1 Wildlife

For wildlife, BLM reviewed the following for guidance in developing this Reclamation, Monitoring, and Weed Management Plan:

- *Approved Resource Management Plan Amendments for the Rocky Mountain Region Greater Sage-Grouse (GRSG) sub-regions of Lewistown, North Dakota, Northwest Colorado, and Wyoming (ARMPAs)* (BLM 2015);
- State of Wyoming Executive Order 2015-4 – Greater Sage-Grouse Core Area Protection (State of Wyoming 2015);
- 10-Year Sublette Mule Deer Mitigation Plan (BLM 2012c) and other sensitive wildlife species (i.e., mountain plover and pygmy rabbits).

1.2 Livestock Grazing

The BLM currently uses ESDs to monitor and manage livestock grazing allotments. Each ESD has an associated Reference Sheet which NRCS provides online as a tool for assessing rangeland health. The BLM will continue to consult, cooperate, and coordinate with the Wyoming Department of Agriculture (WDA), Sublette and Sweetwater County Conservation Districts and grazing permittees as necessary.

1.3 Wyoming BLM Reclamation Policy

The Wyoming BLM Reclamation Policy Instruction Memorandum No. WY-2012-032 (BLM 2012a) identifies the minimum requirements for federal actions requiring a reclamation plan. This policy provides short-term (stabilize disturbance) and long-term goals (establish a desired native plant community and ecological function), and provides reclamation requirements: (summarized and subject to change with any updates to this policy):

- manage all waste materials;
- ensure subsurface integrity and eliminate sources of ground and surface water contamination;
- re-establish slope stability, surface stability, and desired topography;
- reconstruct and stabilize water courses and drainage features;
- maintain the biological, chemical, and physical integrity of the topsoil and subsoil (where appropriate);
- prepare site for revegetation;
- establish desired self-perpetuating native plant community;
- reestablish a complementary visual composition;
- manage invasive plants, and;

- develop and implement a reclamation monitoring and reporting strategy.

1.4 Other Requirements

Implementation of this Reclamation, Monitoring and Weed Management Plan will also meet the objectives and standards from the following:

- Applicable RMPs including revisions and amendments
- Onshore Oil and Gas Orders;
- Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (BLM 2007), and;
- Applicable local, county, state, and federal regulations.

2.0 PREDISTURBANCE AND SITE PLANNING

Predisturbance planning minimizes the amount of reclamation at a site by reducing land disturbance. Preparing the site for construction while concurrently planning for reclamation with practices such as salvaging, separating, and stockpiling topsoil and spoil, locating facilities away from cut-and-fill slopes, and minimizing the area occupied by facilities will advance the goal of achieving reclamation success.

2.1 Predisturbance Planning

During selection of well pads, access roads, pipelines, and ancillary facility locations, the operator will avoid developing in the following areas, unless acceptable mitigation can be achieved as described below:

- areas with high erosion potential (e.g., rugged topography, steep slopes [>25 percent], stabilized sand dunes, floodplains);
- areas with saturated soils;
- areas within 500 feet of wetland or riparian areas (e.g., playas and open water areas);
- areas within 100 feet of ephemeral and intermittent channels; and,
- areas with limited reclamation potential (includes areas with limited reclamation potential as defined by the NRCS Soil Web Survey database).

The operator will conduct site-specific preconstruction inspections with the BLM and cooperating agencies for each proposed surface disturbance. The site-specific preconstruction inspections will determine the suitability of the proposed production facility locations and/or access road, pipeline and utility disturbances regarding the above-listed avoidance areas, as well as other areas. The operator will submit Surface Use Plans (SUPs) and/or Plans of Development (PODs) for each proposed surface disturbance area or for BLM approval. These plans will include the following components:

- project administration, timeframes, and responsible individuals;
- commitment to adhere to this reclamation plan and its success standards;

- detailed descriptions of all deviations from this plan required due to site-specific conditions and the rationale for changes.

The operator will submit a plan each year projecting what will be disturbed or reclaimed that year. Each Application for Permit to Drill (APD) submitted by the operator will discuss reclamation in number 10 of the 12-point surface use plan including but not limited to: filling in cellars, drill cuttings and cuttings pit reclamation, how much of pad will be in interim reclamation, soil amendments used, proposed seed mix, cover crops if needed, fencing if needed, weed control and a shapefile, showing actual disturbance.

The operator will follow the initiating and conducting baseline inventory in Table M-1 of the BLM *Approved Resource Management Plan Amendments for the Rocky Mountain Region Greater Sage-Grouse (GRSG) sub-regions of Lewistown, North Dakota, Northwest Colorado, and Wyoming (ARMPAs)* (BLM 2015) presented here.

Table C-1. Description of Baseline Inventory

Activity	Critical Components
Initiating baseline inventory	• Identify site location • Contact land manager/owner or agency • Consult soil survey maps • Determine ESD • Consult Wyoming Geographic Information Center (WyGISC) to access aerial photography in color, grayscale, or color infrared (CIR) • Identify wildlife presence or use • If state lands, contact Wyoming Department of Environmental Quality, Land Quality Division for guidelines and or permits.
Conducting baseline inventory	• Travel to site • Verify ESD and soil types • Record vegetation types and distribution on the site using an accepted method for collecting the data • Record topographical landforms and surface hydrological features • Take photographs to provide a visual reference • Document data gathering and photos with GPS coordinates.

2.2 Site Preparation

Locations will be built to maximize reclaimed area by reducing the amount of disturbance to develop and operate the wells.

The BLM recommends the operator plan to the extent feasible, to avoid sharply contrasting soil types (loamy versus saline for example) within the same location. This strategy will increase the reclamation potential for each location by reducing the potential for mixing of different soil types.

2.2.1 Trash and Spills

Trash removal will routinely occur throughout field development and operation. Trash will be picked up by field personnel and disposed of in on-site trash receptacles. These receptacles will be serviced by a licensed solid waste contractor.

Spills will be handled in accordance with operator-specific Spill Prevention, Control, and Countermeasure Plans (SPCCPs) for the field.

Removal of trash or spill materials will be included in the operation plan rather than in the reclamation plan because these types of disposals will occur routinely during project operations.

Topsoil will not be placed on contaminated materials. The absence of contaminated materials at or near the ground surface is a reclamation requirement and a criterion of reclamation success.

2.2.2 Topsoil and Spoil Handling

The operator will design well pads to minimize bare soil and maximize reclamation per location.

Topsoil will be salvaged from all proposed disturbance areas and stockpiled unless the BLM deems that leaving topsoil in place, where mat pads or other methods could be used, will facilitate better reclamation. Vegetation will be salvaged and stockpiled with topsoil to incorporate native seeds and organic matter. The operator may consider the use of a grinding machine to salvage topsoil and vegetation in one pass rather than having heavy machinery make multiple passes over the site.

The volume of topsoil, other suitable plant growth material to be salvaged, proposed topsoil replacement depth, and topsoil storage areas will be specified in the SUP or POD. With BLM approval, if less than two inches of topsoil is available, the topsoil can be mixed with suitable spoil so that a minimum of two inches of plant growth material is available for use during reclamation. Spoil to be mixed with topsoil will be amended as needed to meet suitability criteria for topsoil (see Table C-2 below); no unsuitable materials will be used. This will only be done if the location's integrity is not compromised and if topsoil and spoil (subsoil) have similar physical and chemical properties.

For example, topsoil from an alkali location will not be mixed with topsoil from a non-alkali location. Alternatively, the operator will identify other topsoil stockpile(s) from which topsoil will be obtained for reclamation. If Location A has less than 2 inches of topsoil but 24 inches were salvaged from neighboring Location B, the operator may identify the neighboring location as the source of additional surface soil material. The SUP or POD for both locations will note that a specific volume of topsoil from Location B is slated for use at Location A, subject to BLM approval.

To minimize the volume of spoil stockpiled, the operator will balance the volumes of cut versus fill material where applicable and to the extent feasible. Spoil will be salvaged and stockpiled separately from topsoil.

Topsoil will be salvaged from all areas to be disturbed and stockpiled. For pipelines and access roads constructed on slopes of less than 15 percent, topsoil will be stored in windrows within the construction right-of-way (ROW). Where pipelines and roads are to be constructed on slopes greater than 15 percent, topsoil will be transported to more level terrain for storage.

When the ground is frozen, construction will be pre-approved by BLM with the conditions of approval.

Criteria to establish suitability of topsoil substitute (spoil) are described below in Table C-2.

Table C-2. Criteria to Establish Suitability of Topsoil (or topsoil substitutes)†

Parameter	Suitable	Marginal‡	Unsuitable
pH	5.5-8.5	5.0-5.5;8.5-9.0	<5.0; >9.0
Electrical Conductivity (EC) mmhos/cm	0-8	8-12	>12
Saturation percentage	25-80	<25; >80	
Texture		Clay, silty clay, sand	
Sodium Absorption Ratio (SAR)£	0-10	10-12¥;10-15	>12¥;>15
Selenium	<0.3 ppm	>0.3-0.8 ppm	
Boron	<5.0 ppm		>5.0 ppm
Coarse Fragments (% vol.)	<25	25-35	>35

†Adapted from Wyoming Department of Environmental Quality Land Quality Division Rules Update (WDEQ 2015).
‡ Evaluated on an individual basis for suitability
£ As an alternative to sodium absorption ration (SAR) calculations, exchangeable sodium percentage (ESP) can be determined. ESP should be determined if suitable SAR value is exceeded.
¥ For fine textured soils (clay >40%)

Storage and handling of topsoil will include but will not be limited to:

- a maximum soil stockpile height of 15 feet;
- avoiding the stripping of topsoil or redistributing topsoil when it is wet or frozen;
- using BLM's procedures for constructing during frozen soil conditions;
- reclaiming the disturbed locations during the first appropriate growing season after well drilling and completion;
- fencing of all or portions of the topsoil stock pile with wildlife friendly fence could be considered as an aid to vegetation establishment and improving soil organic matter content;
- seeding topsoil pile with sterile and non-competitive cover crop (or alternative approved by the BLM) in accordance with BLM Manual 1745, to avoid aggressive or invasive species that may succeed so well in a particular situation that other species suffer. These well adapted competitors spread fast, crowding out less aggressive native plants, competing for water, light and nutrients. They have the potential to out-compete other plant species and create a monoculture. This could harm native plant communities and leave the persistent species or monoculture vulnerable to destruction by species-specific pests or pathogens, and;
- The use of non-native species must comply with BLM Wyoming State Policy.

Topsoil and spoil stockpiles will be designed to minimize the surface disturbance needed for oil and gas development, as practically allowed and will be constructed to remain stable until they

are used for reclamation. Stockpiles may be used in the interim to screen activities on the well pads.

Topsoil and spoil stockpiles must be clearly marked and noted on site maps and may be identified with signs. oil and spoil stockpiles should be placed separately to avoid contamination between stockpiles.

If a topsoil stockpile will be located on or adjacent to ground that slopes from 15 to 25 percent, runoff will be diverted around the stockpile via interceptor ditches. Interceptor ditches will be rounded V-shaped—one foot deep and four feet wide—with a minimum longitudinal gradient of at least 0.5 percent (BLM Road Manual Section 9113) and will empty onto native, undisturbed vegetation. Alternatively, energy dispersing devices (e.g., rock aprons) will be placed at each end of the interceptor ditch. All stockpiles will be located to not affect existing drainages.

Topsoil will be spread after all wells on a location are producing, when the ground is not frozen, and when moisture is not greater than field capacity to prevent soil compaction and rutting.

2.2.3 Additional Procedures for Wetlands or Riparian Areas

Wetland construction will follow guidelines within the applicable RMPs. Well pads will not be located in wetlands or riparian areas. Where roads and pipelines must cross wetlands or riparian areas, construction will occur during the appropriate season when the area is at its driest. In work areas that will not be excavated but will be driven on (e.g., scalped pipeline disturbances adjacent to pipeline trenches), vegetation will be cut to ground level leaving existing root systems intact; these areas will not be graded.

All of the topsoil will be salvaged and replaced from wetland or riparian areas except in areas with standing water, saturated soils, and/or where no topsoil will be salvaged. If standing water or saturated soils are present, either wide-track/balloon-tire construction equipment or typical construction equipment operated on equipment pads will be used. Equipment pads will be removed immediately upon completion of construction.

2.3 Reclamation Timing

Topsoil re-spreading can occur anytime during the year after the ground thaws and is not saturated, or after excess compaction and rutting will occur in the spring until the ground refreezes in the fall. Seeding for site-stabilization, interim reclamation, and final reclamation should occur during the first fall after topsoil re-spreading, so long as wet and frozen soils can be avoided. If the operator cannot seed during the fall, the BLM will consider an alternative seeding time in the spring or defer to the next fall. See Section 3.2 of for details on seeding.

2.4 Site-Stabilization

Site-stabilization will occur on areas that will be re-disturbed (e.g., topsoil pile and/or pad surface, including cut and fill slopes) before project abandonment. For example, if the topsoil pile will not be respread for more than a year, the operator will stabilize the location, including topsoil. Site-stabilization will prevent erosion and minimize the population of undesirable weeds

such as Russian thistle and halogeton. Site-stabilization will not be used as a means to delay interim or final reclamation on areas that will not be re-disturbed.

Site-stabilization areas will be graded to the original contours where possible and practical. Graded surfaces will be ripped if necessary to eliminate soil compaction. Surfaces will then be disced at the operator's discretion to loosen surface material.

Topsoil will not be replaced on site-stabilized areas to minimize topsoil handing. Replacing and then re-disturbing topsoil on site-stabilized areas will increase the potential for topsoil loss while it is being handled, stockpiled, and replaced a second time.

Disturbed areas will be seeded using the seed mixture (Table C-3) for site-stabilization. Light discing might be used to improve soil and seed contact and moisture capture and reduce compaction. The operator will determine which mixture to use based on seed availability, cost, or other operational considerations. The BLM will consider alternative seed mixtures in addition to the one shown in Table C-3.

Table C-3. Seed Mixture for Site-Stabilization†

Species	Approximate Seeding Rate (PLS/acre)‡
Western wheatgrass (*Elymus smithii*)	2.0
Thickspike wheatgrass (*Elymus lanceolatus spp lanceolatus*)	2.0
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	2.0
Winter wheat (*Triticum aestivum*)¥	5.0
TOTAL	**11.0**

† It is anticipated that this seed mixture primarily will be used on topsoil and subsoil stockpiles designated for long-term storage.
‡ Pure Live Seed (PLS)/acre = pounds of pure live seed per acre; alternate seeding rates may be applied in some areas as deemed appropriately by BLM and specified in approved SUPs and/or PODs.
¥ A sterile hybrid will be seeded as a cover crop; cover crops will be used only in areas where rapid site stabilization is desired and where further disturbance and reseeding efforts will be likely.

2.4.1 Site-Stabilization Standards

Erosion will not be permitted to exceed what is natural per tolerable soil loss data for each soil series (tolerable soil loss information can be found on each soil map unit description produced by NRCS) and applicable ESD Reference Sheet. Site-specific authorizations for site-stabilization will be followed.

3.0 INTERIM AND FINAL RECLAMATION OBJECTIVES AND STANDARDS

This section describes interim and final reclamation objectives and standards for the NPL Project. Reclamation will begin as soon as practicable on areas not needed for well production. Reclamation objectives and standards are based on lessons learned and measures adopted from relevant sources (e.g., Jonah Infill Drilling Project, Pinedale Anticline, BLM Wyoming Sage-

Grouse RMP Amendments, Green River, Lander, and Pinedale RMPs, BLM BMPs) and site-specific characteristics of the Project Area. In some cases, interim and final reclamation standards were adopted from the Jonah Infill Drilling Project FEIS Appendix DP-B – Reclamation Plan (BLM 2006), PAPA SEIS Appendix C – Reclamation Plan (BLM 2008b).

Interim and final reclamation for the NPL Project will be based on ESDs where applicable. The ESD concept is defined based on reference conditions representing disturbed and undisturbed reference states. For more information, see the Interagency Ecological Site Handbook for Rangelands (NRCS 2013) available online at: http://www.ars.usda.gov/SP2UserFiles/Place/62351500/InteragencyEcolSiteHandbook.pdf.

Another method for determining reclamation success is to use reference sites. This process, which references existing plant communities, has been used in the past to represent benchmarks for success. Reference plant communities represent plant communities in their current state under existing management, which may not represent the desirable plant communities for the area. The quality and density of plant communities within reclaimed areas should be similar to information found within the ESD for the site (or a reference site). Reclaimed sites could represent either successional communities (trending toward communities described in the ESD) or the original plant community (pre-disturbance/reference site).

Some rangeland forbs (such as hoods phlox and prickly pear) become more abundant over time, either through natural causes or in response to management. In some cases, these forbs may compete with more desirable species and skew baseline measurements. ESDs are one way to represent what can occur on a given site and provide a benchmark for desired reclamation outcomes. These outcomes are partially dependent upon management of the resource(s). Even under theoretically "perfect" management, these less desirable forbs will increase in accordance with time since disturbance is a natural process and part of the functioning ecosystem.

The following sections describe surface preparation procedures that will be implemented as necessary to achieve successful interim and final reclamation.

3.1.1 Backfilling and Grading

Backfilling will occur before fine grading. Areas to be backfilled include cuttings pits, cut slopes, pipeline trenches, borrow ditches, and facility foundations. Pipeline trenches will be backfilled so there is enough soil to avoid subsidence and gullying (to be determined by operator). Spoil for backfill will be obtained from fill material and spoil stockpiles.

Areas to be reclaimed will be graded to approximate original contours to blend in with adjacent topography. Area-wide drainage will be restored so that surface runoff flows and gradients are returned to the conditions present before development. Graded surfaces will be made suitable for replacement of topsoil at a uniform depth, will promote cohesion between subsoil and topsoil layers, reduce wind erosion, and facilitate moisture capture.

Specialized grading techniques will be applied at the operator's discretion and may include slope rounding, bench grading, and/or contour furrowing.

Dozers, loaders, scrapers, and motor graders are typically used for backfilling and grading of subsoil.

3.1.2 Ripping and Discing

Compacted areas such as roads and well pads will be ripped (before topsoil is spread) to a depth determined by the operator to improve soil aeration, water infiltration, and root penetration. Ripped areas will be disced if necessary to fill in deep furrows where topsoil will be lost and to break up large clods. The topsoil should be rough enough to allow moisture capture and reduce runoff without minimizing soil/seed contact.

Motor graders or tractors equipped with ripping shanks are typically used for ripping. Ripper shanks will be set about two feet apart. Discing is typically accomplished using a tractor-drawn disc set two to six inches deep. Discing and ripping are optional methods. However, if reclamation fails and the BLM determines soil compaction was an issue, BLM will have the authority to require these methods.

3.2 Seedbed Preparation

Seedbed preparation maximizes seeding efficiency and improves reclamation success. It includes topsoil replacement with amendments where appropriate and discing, if necessary. Surface roughening procedures (e.g., pitting, gouging) may be applied at the discretion of the operator.

3.2.1 Topsoil Replacement

Where necessary and before topsoil is replaced, waterbars and other erosion control devices will be installed on reclaimed areas to control topsoil erosion.

Stockpiled topsoil will be redistributed uniformly on areas to be reclaimed. Topsoil could be mixed with suitable spoil or imported from another area where conditions warrant the application and approved by the BLM. The operator should use caution to avoid mixing subsoil with topsoil when using a disc or harrow to prepare soils for seeding. Topsoil will not be replaced on contaminated material; all contaminated material will be removed or otherwise handled in accordance with the SPCCPs and applicable Wyoming Oil and Gas Conservation Commission (WOGCC) or Wyoming Department of Environmental Quality (WDEQ) soil cleanup guidelines.

Topsoil is typically replaced using scrapers, dozers, and/or motorgraders. Excavators may also be used to redistribute topsoil in sensitive or confined areas when compaction or shifting subsoil is a concern.

After topsoil is replaced, seeding will typically occur in the fall, when soil is not frozen, when soil is less than field moisture capacity, and when soil moisture (relative to soil texture) is below the point at which soils are prone to compaction and/or rutting. Seeding will be delayed until moisture falls below saturated conditions, to prevent rutting and compaction, and soils have thawed and become friable. An early frost will not be used to delay seeding until the following spring if subsequent fall conditions are appropriate for seeding. If the operator cannot seed during the fall, the BLM will consider an alternative seeding time in the spring or defer to the next fall. Requirements for replacing topsoil could include, but will not be not limited to:

- recontouring – refer to Handbook of Western Reclamation Techniques (OSMRE 1996);
- not mixing topsoil & subsoil if not approved by the BLM;

- not planting on compacted soil (rip or disc first, if necessary). Compacted soil is soil that has an increased bulk density, decreased infiltration rate and an increased restriction for root penetration;
- not planting on powdery soil. Add moisture, mulch or bonding agents;
- stabilizing slopes (e.g., no types of active erosion, sloughing or land sliding and/or erosion control measures are in place to prevent these from happening) before planting;
- planting along contours, not up/down slopes;
- ensuring good soil-seed contact to:
    - Prevent seed or root desiccation
    - Reduce chance of seedling death soon after germination
    - Reduce seed exposure to wind, birds, rodents, disease and micro-organisms;
- roughening soil before seeding to improve seed/soil contact, create depressions that trap moisture and reduce removal of seed by wind;
- using appropriate equipment to break up soil and cover seeds, and;
- covering seed to appropriate depth for each species (check seeding depth and calibrate/adjust drill seeding equipment).

3.3 Revegetation

If a pad expansion is necessary, previously reclaimed areas will be redisturbed rather than undisturbed areas. However, if it appears that the plant community within the reclaimed area is providing more forage and better habitat than the surrounding plant community, the BLM will consider that the operator not disturb the reclaimed area; thus requiring new surface disturbance.

Reclaimed areas will be seeded using the BLM approved seed mixtures. These mixtures will be developed based on the following criteria:

- general conditions within the analysis area;
- species adaptations to site conditions;
- usefulness of the species for rapid site stabilization, species success in past re-vegetation efforts;
- availability, and;
- compliance with *Executive Order* 13112 and its amendment *Executive Order 13751* and *BLM Manual 1745* (i.e., use of native species) and ESDs.

Alternative species and seeding rates may be used at operator discretion, with approval of the BLM Authorized Officer (AO), if warranted by site-specific conditions or seed-availability provided that the alternative species/seeding rates facilitate achieving reclamation success and all modifications are documented.

The operator will utilize seed mixes based on current guidelines and procedures during site-specific permitting in consultation with the BLM, state, and local agencies, and other appropriate entities. For example, for mountain plover habitat, the seed mix may not include woody plant species. The operator may also elect to use inter-seeding techniques. Inter-seeding is not required for the first-time attempt at interim and final reclamation but may be required at a later

date by BLM if reclamation success is not achieved. Noxious and invasive weeds, undesirable weeds (if present), and erosion will be monitored and controlled annually and more often when conditions warrant.

The operator has discretion to inoculate selected seed mixtures with soil microorganisms to facilitate germination and growth. It is not required for the first-time attempt at interim or final reclamation but may be required at a later date by BLM if reclamation success is not achieved.

Broadcasting of seeds, and seeding in general, will be determined during site-specific permitting based on procedures and guidance in place at the time of site-specific permitting.

3.3.1 Limited Reclamation Potential (LRP)

Areas possessing unique landscape characteristics such as sensitive geologic formations, extremely limiting soil conditions, biological soil crusts, badlands, rock-outcrops, etc., often make reclamation success impractical and/or unrealistic due to physical, biological, and/or chemical challenges. When disturbed, these areas may require unconventional reclamation strategies to address the ten requirements established by the Wyoming Reclamation Policy and applicable RMPs. As part of subsequent NEPA analysis during APD processing, the BLM will further analyze potential LRP areas on a site-specific basis.

3.4 Erosion Control

3.4.1 Construction-and Operation-Phase Erosion Control

Erosion control will follow guidelines set forth in the applicable RMPs.

The operator will adhere to the following additional erosion control measures during construction and operation:

- construction will be avoided on slopes greater than 25 percent;
- culverts, road ditches, and roads will be designed in accordance with Gold Book standards and typical engineering practices to minimize erosion along active roads;
- culverts will be sized to pass expected 100-year flows without causing erosion above, below, or around the culvert and will be annually inspected and maintained;
- culvert inlets and outlets will be protected with energy dissipaters such as riprap or rock aprons as necessary;
- road ditches will be sized to collect runoff from roads and surrounding areas;
- energy dissipating structures will be used to prevent ditch erosion;
- roads will be designed to enable head-on traffic to pass without leaving the surfaced travel-way;
- if turnouts are built to accommodate passing vehicles, the operator will instruct field personnel to use turnouts to avoid traveling on roadside ditches;
- water discharged from culverts, roadside ditches, and turnouts will be directed either into undisturbed vegetation or natural drainages;

- interceptor ditches will be installed, as appropriate, above all cut slopes, as determined by the BLM AO. Interceptor ditches will be rounded V-shaped, sized appropriately for anticipated flows, with gently sloping sides, and will empty onto native, undisturbed vegetation. Alternatively, energy-dissipating devices (e.g., rock aprons) will be placed at each end of the interceptor ditch;
- re-vegetating ditches along roads will be required to dissipate energy of water flow and to prevent erosion;
- where appropriate, sediment control devices will be installed at the base of all slopes and stockpiles prone to erosion and will be annually inspected and maintained;
- where road or pipeline construction occurs on slopes greater than 15 percent, temporary sediment barriers such as silt fences and/or staked weed-free straw bales will be installed along the contour downhill from the access road, pipeline and utility disturbances;
- silt fences or other sediment filtering devices will be installed wherever road or pipeline construction occurs within 100 feet of a drainage;
- temporary sediment barriers will remain in place until the surfaces are stable and reclamation success standards are met. Sediment filtering devices will be cleaned out and maintained in functional condition throughout the life of the project;
- soft plugs will be installed during pipeline construction every one-quarter mile with a gated access (opening) for wildlife and livestock;
- where roads and pipelines cross a water body (i.e., wetlands or drainages), topsoil and spoil will be placed at least ten feet from the edge of the water body, and sediment control structures will be placed between the topsoil/spoil and the water body, and;
- soil and brush riprap will not be used; rock, vegetation mats, or another BLM approved alternative will be used to stabilize the ROWs at water body crossings.

3.4.2 Reclamation-Phase Erosion Control

Reclamation-phase erosion control measures will be identified in the operator's SWPPP submitted with each APD/SUP. Erosion and sediment control structures will be installed on reclaimed areas on slopes greater than 15 percent and where monitoring demonstrates that erosion control structures are needed.

Runoff from reclaimed areas where slopes exceed 15 percent (and/or where experience and/or monitoring suggests that it is warranted) will be controlled using structures including but not limited to waterbars, silt fences, geotextile, and energy dissipaters.

All disturbed areas will be subject to reclamation efforts that address cumulative runoff regardless of slope. Waterbars will be installed in accordance with standard BLM specifications and will drain into undisturbed vegetation. Waterbars generally will be 12 to 18 inches high with a two percent grade. Waterbars will be installed after ripping and before topsoil placement. Silt fences will be placed downhill from reclaimed areas where erosion may impact a water body and will be installed according to manufacturers' instructions. Energy dissipaters will be used to slow flows wherever water is channelized (e.g., by a waterbar or an interceptor ditch).

All runoff and erosion control structures will be inspected, maintained, and cleaned-out by the operator whenever necessary throughout the life of the project. Inspections will occur after

runoff events such as spring runoff and storm events. Sites and sources of soil movement will be addressed in a timely manner and recorded in a way that will allow for erosion pattern tracking. These reports will be provided to BLM annually by March 1, from the previous year's data.

3.5 Weed Control

The operator will be responsible for the annual inventory and control of noxious, non-native, invasive, and undesirable weeds (or when directed by BLM in urgent cases) for all NPL project activities, and shall prepare an annual project-wide plan specifying what remedies (mechanical, chemical, biological), will be used. As site-specific conditions arise, the BLM will consider alternative methods with cooperating agencies. If use of herbicides is deemed necessary by the operator, a Pesticide Use Proposal will be submitted for approval to the BLM. All herbicides will be used only in the season or growth stage during which they are most effective.

Weed management must also be performed in accordance with any additional guidelines set forth in the applicable RMPs.

3.6 Interim Reclamation

3.6.1 Site-Stabilization Objectives

The objectives of site-stabilization are to prevent erosion, increase moisture capture, maintain site/topsoil-productivity and minimize weeds.

3.6.2 Interim Reclamation Objectives

The objectives of interim reclamation are to:

- maintain healthy and biologically active topsoil;
- control erosion; and
- restore habitat, visual, and forage function on those portions of the disturbed area not needed for production operations for the life of the well(s) and facilities or until final reclamation is initiated.

The BLM will consider interim reclamation successful when disturbed areas not needed for long-term production operations or vehicle travel are re-contoured, protected from erosion, and re-vegetated. Successful re-vegetation will occur when plant communities are self-sustaining, vigorous, diverse, and sufficient to minimize visual impacts, provide wildlife habitat and forage suitable for wildlife and livestock, stabilize soils, and impede the invasion of undesirable and noxious and invasive weeds.

The BLM will consider alternative reclamation criteria for plant communities, cover percentage, and density in soils that are difficult to reclaim on a case-by-case basis if no feasible alternative locations can be identified for development.

3.6.3 Interim Reclamation Standards

Interim reclamation standards will be based on site-specific authorizations and subject to the inspection and enforcement process.

3.7 Final Reclamation

3.7.1 Final Reclamation Objectives

The objective of final reclamation is to achieve an established desired plant community that provides site-stability, habitat, forage, and hydrologic functions. This will include (but not limited to) all development activities completed and all facilities removed and restoration of the original landform or creating a landform that approximates and blends with the surrounding landform. Final reclamation involves having the following trend toward long-term goals: re-establishing natural vegetation, hydrologic systems, visual resources, agricultural values, and wildlife habitats.

Final reclamation standards will be based on site-specific authorizations and subject to the BLM inspection and enforcement process.

4.0 RECLAMATION PLAN AND ANNUAL REPORT

Annual reporting for reclamation will be based on existing guidance and procedures for reporting during site-specific permitting.

The operator will provide the BLM with an annual report for all sites disturbed.

Copies of the completed individual site review forms (operator onsite forms) or a BLM-approved electronic report. A summary of monitoring data and results, including but not limited to:

- Individual site reclamation monitoring reporting data
- Identification of sites successfully reclaimed by reclamation years (starting with the first growing season)
- Identification of sites needing additional work or more reclamation activities (adaptive management) by reclamation year
- Sites proposed for meeting interim and final reclamation

The BLM's useable shapefile(s) or geographic information system (GIS) layer(s) that details location, name, type, and extent of:

- Original surface disturbance and new surface disturbance (new surface disturbance can be re-disturbed reclamation on an existing pad or access road, pipeline and utility disturbances, new pad expansion, etc.)
- New reclamation
- Successful interim reclamation
- Successful final reclamation
- Failed or unsuccessful reclamation
- Locations of noxious/invasive weed infestation (this can be included with the pesticide use proposal or pesticide annual report

- Further vegetation treatments planned (e.g., mulching, matting, and weed control).

On these shapefiles or GIS layers, *location* shall be given as the legal location and geo-referenced location of the site; *name*, as appears on the BLM's APD, lease, or other BLM file name for the site; *extent*, as the appropriate component boundary.

5.0 BEST MANAGEMENT PRACTICES

This section identifies Best Management Practices (BMPs) that could be suggested as recommendations during interim and final reclamation based on BLM specialist local expertise.

- "Live-hauling" topsoil from one location to another location may aid in reclamation success, but should only be considered on a "case-by-case basis" because the ESD for topsoil from one location could be different from its destination. Timing problems could also occur when stripping topsoil from one location and hauling to another location. The quantity of topsoil could likely vary from one location to another location.

The BLM AO may direct the use of containerized plants in not more than gallon-sized pots and germinated from a local seed source. These plants will be planted in clusters to catch snow, retain moisture, and provide a seed source. This will mostly apply to native shrubs such as sagebrush and saltbush with the purpose of quickly establishing the shrub component. Some or all of the following practices may be implemented to expedite reclamation:

- planting bare-root seedlings (shrubs such as sagebrush);
- importing topsoil to add to spots where it is absent or not productive;
- erecting fences (wildlife friendly) around reclaimed areas to allow for enhanced establishment of vegetation;
- using snow fences or an alternate snow-capture device to capture moisture, and;
- irrigating reclamation (enough to simulate typical spring and summer moisture) to establish roots.

Irrigating reclamation could be repeated for the first two years but not more than three. A pause in irrigation after three years provides a period for the vegetation to demonstrate persistence before the reclamation can be accepted as complete.

6.0 SEED MIXES

Jonah Energy will utilize seed mixes based on current guidelines and procedures during site-specific permitting, in consultation with the BLM, state, county and local agencies, and other appropriate entities.

7.0 WEED MANAGEMENT PLAN FOR THE NPL PROJECT AREA

Weed management during site-specific permitting will be based on procedures and guidance at the time of site-specific permitting.

8.0

Alkali soil: Soils with pH above 8.5.

Avoid: Paraphrasing the Council on Environmental Quality (CEQ) Regulations (40 CFR 1508.20), avoidance means to circumvent, or bypass, an impact altogether by not taking a certain action, or parts or an action. Therefore, the term "avoid" does not necessarily prohibit a proposed activity, but it may require the relocation of the action, or the total redesign of an action to eliminate any potential impacts resulting from it.

Avoidance Areas: Areas to be avoided which may be available for location of ROWs and Section 302 permits, leases, and easements with special stipulations or mitigation measures. For such authorizations, the area's environmental sensitivity and other feasible alternatives will be strongly considered.

Reference sites: Plant communities in their current state.

Benchmarks: Goals.

Compacted soil: Soil with an increased bulk density (g/cm3), decreased pore space limiting water infiltration, percolation, and storage; plant growth; and nutrient cycling.

Desired plant community: A plant community that meets the land uses for a given area.

Ecological Site Description: Framework for classifying and describing rangeland and forestland soils and vegetation.

Field moisture capacity: The percentage of water remaining in the soil two or three days after having been saturated and after free drainage has practically ceased.

Natural landscape: A landscape unaltered by human activities such as but not limited to agricultural, industrial, recreational and transportation use.

Non-alkali soil: Soil with pH less than 8.5.

Noxious and invasive weed: A county, state or federally listed weed.

Reclamation: The act of reclaiming disturbed areas by recontouring back to the original topography as much as possible and practical and establishing desired plant communities that provide site-stability, hydrologic function and biotic integrity.

Powdery soil: Soil lacking structure and moisture, most likely due to the soil particles being dispersed by salts.

Saturated soil: All pores in the soil filled with water.

Soft Plugs: Barriers across an open pipeline trench that typically consist of compacted soils or sandbags. They serve to reduce erosion and to provide access across the trench for livestock and wildlife.

Spoil: Soil beneath the topsoil not meeting reclamation standards.

Suitable plant growth material or suitable soil: Soil that meets reclamation standards due to its chemical and physical properties set forth in the Wyoming Department of Environmental Quality regulations.

Temporary reclamation: Reclamation used for site-stabilization to reduce erosion and maintain site/topsoil productivity.

Topsoil: Soil used for reclamation, typically the O and/or A horizons.

Third order soil data: Soil mapping based on landform scale.

Undesirable weed: An undesirable plant not listed as a noxious and invasive weed.

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Normally Pressured Lance Natural Gas Development Project

Record of Decision

Appendix D

Transportation Plan

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APPENDIX D

TRANSPORTATION PLAN

1.0 Introduction

1.1 Objectives

This Transportation Plan (TP) assesses future road development and use in and around the NPL Project Area, and potential impacts to the existing transportation system within the first year of development. Additionally, this TP provides a basis for future transportation planning associated with the oil- and gas-related exploration, development, and production within the Project Area, and surrounding area.

The transportation planning area (TPA) includes the Project Area plus adjacent areas that include roads that may be used to access the Project Area (Figure D-1). The TPA includes the following main routes: United States (U.S.) Highway 189 located west of the Project Area, Wyoming State Highway 351 located north of the Project Area, and U.S. Highway 191 located east of the Project Area.

Localized planning for each new well location will be necessary, and this document and applicable transportation codes and standards will be used in localized planning efforts. Operational updates will be made during project development to detail specific localized transportation networks, if deemed necessary, as determined by the BLM, working in coordination with local counties and other appropriate entities. All new or upgraded roads in the TPA will incorporate the general provisions of this planning document.

The objectives and content of this TP are listed and discussed below:

- Describe existing roads and primary routes (i.e., project-required collector and local roads) in the Project Area; high-traffic-volume roads (i.e., local or collector roads) and resource, two-track, and other unimproved roads are also discussed;
- Identify existing roads and road corridors that may be used as collector or local roads for the NPL Project;
- Identify existing pipelines and pipeline corridors that may be used for the NPL Project;
- Provide estimates on vehicle trips and vehicle use associated with the NPL Project;
- Identify natural transportation obstacles (e.g., steep terrain, drainages) and environmentally sensitive areas (e.g., Sage-Grouse leks, raptor nests); these areas will be avoided when determining the location of future high-traffic-volume transportation routes;
- Identify environmental constraints (e.g., soils) in the Project Area and discuss their limitations for project operations;
- Identify road types by functional classification; standard road surface, construction-related disturbance, and right-of-way (ROW) widths are provided in the EIS;
- Describe the annual operational update process, including scheduling and responsibilities;
- Discuss maintenance and other agreements; and

- Discuss, on a periodic basis, roadway impacts and mitigation measures with cooperating agencies including Lincoln, Sublette, and Sweetwater counties.

1.2 Scope

The scope of this TP includes a description of the existing road network, the general locations of high-traffic-volume roads and corridors, and definitions of the road types. Relevant requirements for road construction or upgrading are identified. A working plan is outlined to help determine the procedures for planning a road to serve a proposed well, or group of wells, and the development of agreements for use and maintenance are outlined.

This TP also applies to the transportation of natural gas, condensate, or water via pipelines within the area. Pipelines generally will be located adjacent to roads to reduce the total amount of new surface disturbance. However, this design may complicate route selection and, in some instances, lead to increased environmental impacts. If this occurs, pipelines will be located along alternative routes.

Existing and improved access roads to the Project Area are under the jurisdiction of the BLM, which approves the road designs and requires that roads are maintained. Most roads within the Project Area also are under the jurisdiction of the BLM, and maintenance of these roads is conducted by Jonah Energy and other operators. This document describes the responsibility for road maintenance; the type of maintenance is discussed generically. Jonah Energy will provide the BLM with copies of road maintenance agreements that include the name of a designated contact person. Non-oil and gas roads will be maintained by the BLM or other ROW permit holders. If Jonah Energy proposes the use and access on private or county roads, Jonah Energy will coordinate appropriate agreements with counties, private landowners, and other appropriate parties in accordance with existing guidance and standards.

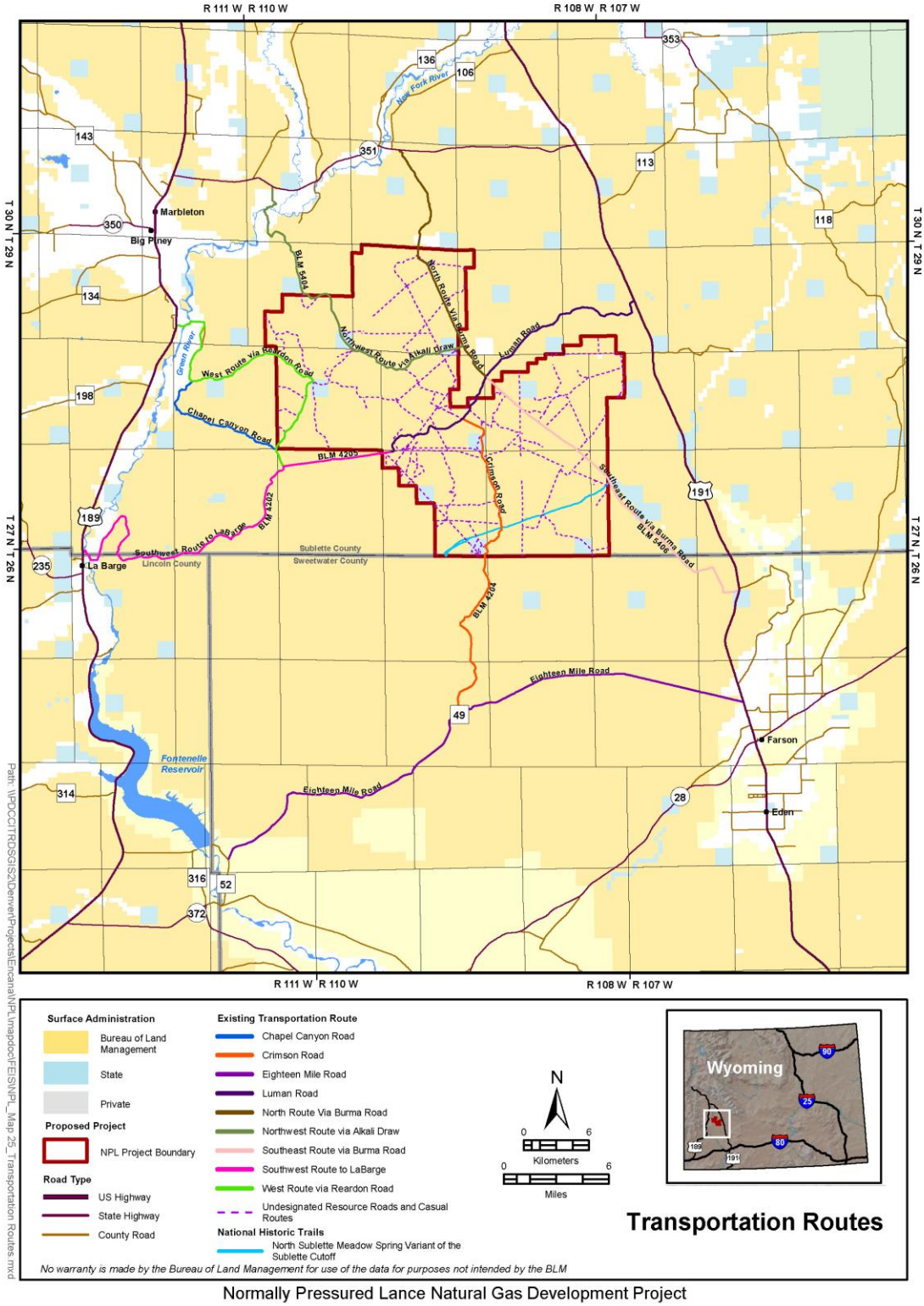
1.3 Limitations

The condition (e.g., road design, upgrading requirements) and maintenance status (e.g., plowed) of existing roads and casual routes in the transportation network are identified on detailed maps available at the BLM Pinedale Field Office (PFO) and Rock Springs Field Office (RSFO). Many existing roads may not be usable during inclement weather or during winter months. All roads developed for the NPL Project will require upgrading, maintenance, and winter snow removal. Specific road upgrading and maintenance responsibilities will be identified annually under the direction of the BLM.

Due to the sensitivity of paleontological and historic/cultural resources, the known locations of these resources on and adjacent to the Project Area are not provided. Further detail on paleontological and historic/cultural resources will be collected prior to road development as a component of the Application for Permit to Drill (APD) and/or ROW application process.

The transportation network described in this document is focused on local and collector roads and potential road corridors; however, existing low-traffic-volume resource roads and unimproved roads also are identified on the detailed maps available for review at the PFO and RSFO. Figure D-1 depicts new and existing routes associated with development activities within the first year of the NPL Project and where these transportation routes connect to the Sublette and Sweetwater County transportation network.

Figure D-1. Transportation Routes Associated with the NPL Project



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2.0 Transportation Planning Stakeholder and Public Involvement

2.1 Scoping

In compliance with the National Environmental Policy Act (NEPA), as amended, the BLM published a Notice of Intent (NOI) to prepare an EIS for the NPL Project in the *Federal Register* on April 12, 2011. Publication of the NOI initiated a 30-day formal public and agency scoping period (end date of May 12, 2011), during which the BLM solicited comments regarding the NPL Project and its potential impacts. During the scoping period the BLM received 35 separate comments related to transportation and traffic.

Commenters requested that the EIS clearly define the NPL Project's associated road system, including all proposed new or improved roads, and its effects on county roads. Comments regarding the NPL Project's effects on county roads raised issues related to usage, condition, dust abatement, maintenance, and traffic safety. One commenter requested that the EIS include a level of service study for affected county roads; another suggested using the most direct travel routes for the NPL Project. A number of commenters requested that the EIS include a transportation plan; they asked for close coordination with local governments in this plan's development to address road maintenance, closure, construction, traffic, and mitigation measures for roads affected by project-related usage. Other transportation issues raised by commenters included:

- access route alternatives for the NPL Project;
- the effect of seasonal restrictions on traffic during tourism season;
- preference for no new net road increases (i.e., close old roads if new roads are to be constructed);
- avoiding off-road travel; and
- coordinating with the Wyoming Department of Transportation and counties for permitting, project access routes, and oversize loads.

Other commenters suggested that the EIS analyze an alternative that minimizes surface disturbance by building roads to the minimum standard for production operations, that directs the proponent to bus workers to construction locations, and that establishes speed limits on access roads.

2.2 Alternatives Development

During development of alternatives for the NPL Project, the BLM hosted an alternatives development workshop on July 13 and July 14, 2011, attended by cooperating agencies, tribes, the BLM, and the contractor preparing the NPL Project EIS. During the alternatives development workshop, cooperating agencies confirmed their preference for the development of a transportation plan for the NPL Project. During the alternatives workshop, cooperators provided specific transportation comments, including:

- concern about impacts on existing county roads;
- inquiring about the potential need for adding additional county roads;

- clarification on the number of heavy vehicle trips and light vehicle trips associated with the NPL Project;
- general recommendations to try and limit truck traffic for the NPL Project; and
- recommendations to include monitoring and maintenance in the transportation plan.

2.3 Additional Transportation Planning with Cooperators

On November 9, 2011, the BLM met with county representatives from Sublette, Sweetwater, and Lincoln Counties to discuss transportation planning for the NPL Project. The BLM's goals for the meeting were to solicit input from the counties on the Draft TP, and to discuss the proposed routes in the Draft TP to determine if they are reasonable, if the counties had interest in discussing the design standards for the proposed routes, and if the vehicle counts in the TP are accurate and realistic. The Draft TP was revised based on the meeting, and counties were also provided a subsequent opportunity to review and comment on it. During the meeting, the BLM and counties discussed several items, including:

- biological and other issues associated with transportation routes;
- routes and vehicle trips associated with heavy trucks;
- routes and travel associated with workers for the NPL Project;
- county road standards, maintenance, and improvements for new and improved routes;
- connection of the NPL Transportation Network to Sweetwater County routes; and
- lessons learned from the Pinedale Anticline Project.

3.0 Road Route Descriptions

The following sections briefly describe the location and status of the road routes in the TPA used to access the Project Area and in-field development sites. Any new roads or necessary improvements and realignments to existing routes will be developed in accordance with BLM standards. In addition, all new routes will be selected to ensure safety, maximize transportation efficiency, avoid sensitive environmental resources, and minimize road densities.

Three existing paved all-weather roads provide access to the Project Area: U.S. Highway 191, U.S. Highway 189, and State Highway 351. The remaining eight routes are unpaved. The portions of the routes currently used to service existing locations in the Project Area have been surfaced (e.g., gravel, aggregate) to be passable when wet and during the winter. Improvements and maintenance, including snow removal, are regularly performed on these segments only. Some realignment of the existing routes may be required to minimize impacts on sensitive resources, ensure safety, and maximize traffic flow efficiency. Figure D-1 shows the location of the NPL Project transportation routes, including collector and local road routes, with the highest traffic volumes on the TPA.

3.1 U.S. Highway 191

U.S. Highway 191 is the primary transportation corridor currently linking the Project Area (via the Luman Road intersection) to the communities of Pinedale and Rock Springs. Between Pinedale and Rock Springs, U.S. Highway 191 is a two-lane highway with an occasional third passing lane. In 2000, average daily traffic (ADT) along U.S. Highway 191 between the Sublette/Sweetwater County Line and the State Highway 351 intersection ranged between approximately 1,300 vehicles (including 160 trucks)[1] and 1,500 vehicles (including 240 trucks),[2] respectively. This volume increased to an ADT of 2,299 vehicles (including 219 trucks) and 2,603 vehicles (including 497 trucks), respectively, in 2010. Traffic volumes then decreased in 2014, to an ADT of 1,949 vehicles (including 187 trucks) and 2,268 vehicles (including 402 trucks), respectively (Wyoming Department of Transportation [WYDOT] 2014).

WYDOT classifies U.S. Highway 191 as a National Highway System (NHS) Arterial (Non-Interstate) roadway. NHS Arterials are functionally classified as Principal Arterials because this system type provides for high levels of mobility and access control by (1) substantial trip lengths including regional, statewide, and interstate travel; (2) connected travel movements between major urban areas; and (3) partial control of access to maintain the primary function of mobility while providing access from adjacent land uses (WYDOT 2008). In general, NHS Arterials include lane widths of 12 feet, with varying shoulder widths depending on whether a given segment of the roadway is located in a rural or urban section and exists as a two-lane undivided roadway or multi-lane divided roadway, as well as the estimated average daily trips of the given segment. The Project Area is located in a setting that is largely rural.

U.S. Highway 191 was recently improved over much of its length between Interstate 80 (I-80) and State Highway 351, and a turnout at the Luman Road intersection, which is also a primary access point for the Jonah Infill Drilling Project Area (JIDPA), has been developed. The majority of the access to the Project Area from U.S. Highway 191 will occur via Luman Road. However, some traffic will access the Project from U.S. Highway 191 via Sweetwater County Road 4-49 (Eighteen Mile Road) and the BLM Crimson Road.

Any new access road junctions will be developed in consideration of sight distances and may require turnout lanes. These actions will be coordinated with WYDOT, and special arrangements will be made with WYDOT to place road signs along this road to increase awareness of potential driving hazards and increase employee and public safety. These signs may include, but will not be restricted to, school bus stops, upcoming turn markers (i.e., Luman Road), animal crossings, etc. U.S. Highway 191 is one of many roadways listed in Wyoming's State Transportation Improvement Plan (STIP). The State of Wyoming STIP was developed through an extensive public involvement process, input from engineering studies, and the collective judgment of the Transportation Commission and WYDOT. Capital improvement projects are incorporated into the STIP. The STIP is not meant to serve as an accounting document. Rather, it is a snapshot of expected projects and their schedules (WYDOT 2011). Planned improvements for U.S. Highway 191 include lane widening projects throughout the majority of its extent in Sublette County.

[1] Data for this segment of U.S. Highway 91 was generated from the Junction Route 1801 Monitoring Station.

[2] Data for this segment of U.S. Highway 91 was generated from the Junction Speedway Road Monitoring Station.

3.2 U.S. Highway 189

U.S. Highway 189 is a north-south two-lane highway located west of the Project Area, connecting the communities of Marbleton, Big Piney, La Barge, and Kemmerer. In 2000, ADT along U.S. Highway 189 near the community of Big Piney, west of the Project Area, was approximately 4,200 vehicles (including 280 trucks).[3] The ADT increased to 4,748 vehicles (including 680 trucks) in 2010, then decreased to 3,701 vehicles (including 461 trucks) in 2014 (WYDOT 2014).

WYDOT classifies U.S. Highway 189 as a Non-NHS State Highway. Non-NHS State Highways include those with functional classifications as Principal and Minor Arterials, Collector Roads and Streets, and Local Roads and Streets. These highways are designed to provide (1) trip lengths to accommodate regional and intra county travel, (2) connected travel movements between urban areas and other traffic generators, and (3) access from adjacent land use. The segment of U.S. Highway 189 associated with the Project Area is specifically classified as a Principal Arterial. In general, Non-NHS State Highways include lane widths of 12 feet, with varying shoulder widths depending on whether a given segment of the roadway is located in a rural or urban section and exists as a 2-lane undivided roadway or multi-lane divided roadway, as well as the estimated average daily trips of the given segment. The Project Area is located in a setting that is largely rural. U.S. Highway 189 is included in the State of Wyoming STIP. Planned improvements include lane widening and wildlife connectivity projects throughout its extent in Sublette County.

3.3 State Highway 351

State Highway 351 is a two-lane east-west highway that passes north of the Project Area. ADT along State Highway 351 has also increased over the past several years. In 2000, ADT was approximately 640 vehicles (including 100 trucks).[4] The ADT along this route increased to 1,341 vehicles (including 673 trucks) in 2010, then decreased to 947 vehicles (including 205 trucks) in 20143 (WYDOT 2014). Special arrangements will be made with WYDOT to place signs along this road to increase awareness of potential driving hazards and increase employee and public safety. These signs may include, but will not be restricted to, school bus stops, up-coming turn markers (i.e., Burma Road and Jonah North Road), animal crossings, etc.

Similar to U.S. Highway 189, WYDOT classifies State Highway 351 as a Non-NHS State Highway. However, the segment of U.S. Highway 189 associated with the Project Area is specifically classified as a Minor Arterial. Minor Arterials also include lane widths of 12 feet. State Highway 351 is included in the State of Wyoming STIP. Planned improvements include a bridge replacement project near its eastern terminus with U.S. Highway 191 (WYDOT 2011).

3.4 Luman Road

The existing unpaved Luman Road (BLM Road 5409) links the Project Area to U.S. Highway 191 and is the primary field access route (Figure D-1). This road is a local/collector road, is gravel/aggregate surfaced, and is regularly treated with magnesium chloride from its junction

[3] Data for this segment of U.S. Highway 89 was generated from the Big Piney North Corp Limits Monitoring Station.

[4] Data for this segment of State Highway 352 was generated from the Junction Route 11 (U.S. 289) Monitoring Station.

with U.S. Highway 191 to the Project Area. Luman Road has been improved through the JIDPA and continues southwesterly to its junction with the existing North Boundary Road. Luman Road is heavily travelled year-round by all types of oil and gas traffic, as well as seasonal hunters and recreationists. Luman Road heading east from U.S. Highway 191 is primarily used for oil- and gas-related industry traffic and experiences approximately 503 vehicle trips per day, of which 161 are truck trips (JIO 2010).

Additional improvement and maintenance work on Luman Road will be performed by operators under the jurisdiction of the BLM. It is anticipated that, at field abandonment, Luman Road will remain in an upgraded condition. Multiple subsurface gas sales pipelines currently exist along Luman Road, which may be replaced with larger pipelines; additional pipelines also may be constructed.

3.5 Southwest Route to La Barge

This route will provide southwest access to the Project Area for workers and equipment coming in from La Barge (Figure D-1). This is a dirt road that is periodically maintained by BLM. It is lightly travelled year-round by oil- and gas-related commuter vehicles as well as grazing permittees, hunters, and recreationists depending on the season and weather conditions. Although this route is mostly outside the Project Area, it is classified as a local/collector road because it provides essentially year round access to the southern and western portions of the area and provides connectivity to Luman Road for the communities west of the Project Area.

The route begins at roughly NW NE Sec. 6, T. 27N., R. 109W., where Luman Road turns into North Boundary Road (BLM Road 4205). The route continues west for approximately seven miles to SE SW Sec. 6, T. 27N., R. 110W., where North Boundary Road terminates, and continues south along CCC Road (BLM 5402) for about 1/2 mile. The route continues south at this point along County Line Road (BLM 4203) for about five miles where it connects to Figure Four Road (BLM Road 4203). Figure Four Road proceeds westerly for about 14 miles where it crosses the Green River via Whelan Bridge and terminates at State Highway 189 on the north end of the town of La Barge.

3.6 North Route via North Burma Road (BLM Road 5406)

North Burma Road (BLM Road 5406) begins at the junction with Luman Road and extends northwest for approximately three miles where it leaves the JIDPA and enters the Project Area (Figure D-1). The route continues for about six miles through the northeastern flank of the Project Area. The route exits the Project Area just south of North Alkali Draw near some stock pens and continues for another seven miles where it connects with State Highway 351 just east of the New Fork River.

Within the JIDPA boundary this route is moderately travelled year-round by all types of oil and gas traffic, as well as seasonal hunters and recreationists. Outside the JIDPA boundary the road is lightly travelled by only by grazing permittees, hunters, and recreationists depending on the season and weather conditions. At this time, oil and gas traffic is prohibited on the North Route outside of the JIDPA. This road will be a local/collector road within the Project Area providing access to the north portion of the Project Area and connectivity to the JIDPA road network. Numerous collector roads currently branch off of the segment of North Burma Road that falls

within the JIDPA. The route will be used to access well sites within the Project Area. No traffic will be allowed on North Burma Road north of the Project Area boundary. This route is maintained for year-round access up to the JIDPA boundary and turns to a recreational dirt road north of the JIDPA boundary.

3.7 Southeast Route via South Burma Road (BLM Road 4206)

South Burma Road (BLM Road 4206) extends southeast for about four miles from its junction with Luman Road to service wells in the Hacienda Unit (Figure D-1). The road becomes a two-track road at the edge of the Hacienda 12-21 well pad and continues southeasterly for about eight miles, passing just south of Teakettle Butte and terminating near North Sublette Meadow Springs.

This road is maintained for year round access to the Hacienda 12-21 well pad and is travelled routinely by well servicing vehicles up to the well pad. Past this point it is only used occasionally by grazing permittees, hunters, and recreationists depending on the season and weather conditions. The entire length of this road will potentially become a local/collector road used during future drilling operations in the south and east portions of the Project Area. No traffic will be allowed on South Burma Road east of the Project Area boundary.

3.8 South Route via Crimson and Eighteen Mile Roads (Sweetwater County Road 4-49)

Crimson Road (BLM Road 4204) is a resource road that extends north to south through the Crimson Unit in the south-central portion of the Project Area (Figure D-1). The road begins at an intersection with Luman Road in NE NW Sec. 26, T. 28N, R. 109W., and proceeds southeasterly for about 1.5 miles. The road then turns south into the Crimson Unit in the Project Area and intersects several service roads that branch off to the existing well locations in the area. Crimson Road terminates at the intersection with Sweetwater County Eighteen Mile Road (4-49) in T. 25N. R. 109W. Above this intersection, the Crimson Road also intersects several more east-west service roads in the NPL Project Area as well as the Sublette Cutoff of the California National Historic Trail and the North Meadow Springs Variant. From the intersection of Crimson Road, Sweetwater County Road 4-49 continues to the west to Sweetwater County Line Road (4-52) near Fontenelle Dam and continues to the east to U.S. Highway 191.

The northern section of the route is travelled routinely by well servicing vehicles south to the turnoff going west toward the Sugarloaf 3-36, 11-36, and 12-34 well pads and functions as a local/collector road providing connectivity to other main routes in the Project Area, including Luman Road. About 3/4 of a mile south of the Project Area, Crimson Road crosses the Sublette Cutoff of the Emigrant Trail. The 18 Mile Road (Sweetwater County 4-49) passes near Eighteen Mile Canyon and Buckhorn Canyon. This section of the route is only used occasionally by grazing permittees, hunters, and recreationists depending on the season and weather conditions. For the next eight miles or so, the route passes through a section of the LaBarge Platform oil field and eventually crosses the Green River via a light duty, one-lane bridge, three miles south of the Fontenelle Reservoir Dam. From there the route continues for about two miles along the old Fontenelle Townsite Road and terminates at the intersection with State Highway 189.

3.9 Northwest Route via Alkali Draw

The Northwest Route starts out on Alkali Draw Road (BLM Road 5404) from the point of beginning at Burma Road near NW SW Sec. 31, T. 29N., R. 108W., and continues westerly for about three miles, passing through the Sol and Corona Units of the Project Area (Figure D-1). This section of the route is maintained for year-round access up to the point where an access road heads south to the Corona 2-9 and Corona 6-9 well pads. West of this junction, the route is only used occasionally by oil- and gas-related commuter vehicles as well as grazing permittees, hunters, and recreationists depending on the season and weather conditions. West of this point the route is maintained by the BLM. Proceeding west another five miles the route turns north at a junction of Reardon Road. From this junction, Alkali Draw Road continues northerly for approximately three miles where it leaves the Project Area. Up to this point, the route will function as a local/collector road. Proceeding north from the Project Area boundary, the route continues another five miles where it briefly turns west onto Red Hill Road (BLM Road 5405) for about one mile. From there, the route continues along an unnamed road roughly paralleling Alkali Creek and the Wardell Ditch where it crosses the Green River via a private bridge. From there the route eventually connects with State Highway 351 to the north. This portion of the route could potentially provide external access to the northwest portion of the Project Area. However, access rights will need to be obtained from the landowner, and improvements will need to be made to the bridge and roads to accommodate heavy equipment traffic.

3.10 West Route via Reardon Road

The West Route starts out following Reardon Road (BLM Road 5401) from the point of beginning at an intersection with Alkali Draw Road near NE NW Sec. 2, T. 28W., R. 110W. From there the route proceeds southwesterly for about four miles up the crest of a steep ridge leading out of Alkali Draw onto a mesa-like plateau to the intersection with CCC Road (BLM Road 5402) at roughly NW Sec. 16, T. 28N., R. 110N. Note that CCC Road provides a western connection between the West Route and the Southwest Route by proceeding southwesterly for approximately five miles, leaving the Project Area, and then continuing another mile to the ending point at the junction with North Boundary Road. The West Route continues from the CCC Road intersection for about three miles where it leaves the Project Area. The route continues another ten miles where it crosses the Green River via Five Mile Bridge and connects to US 189 just north of McDonald Draw.

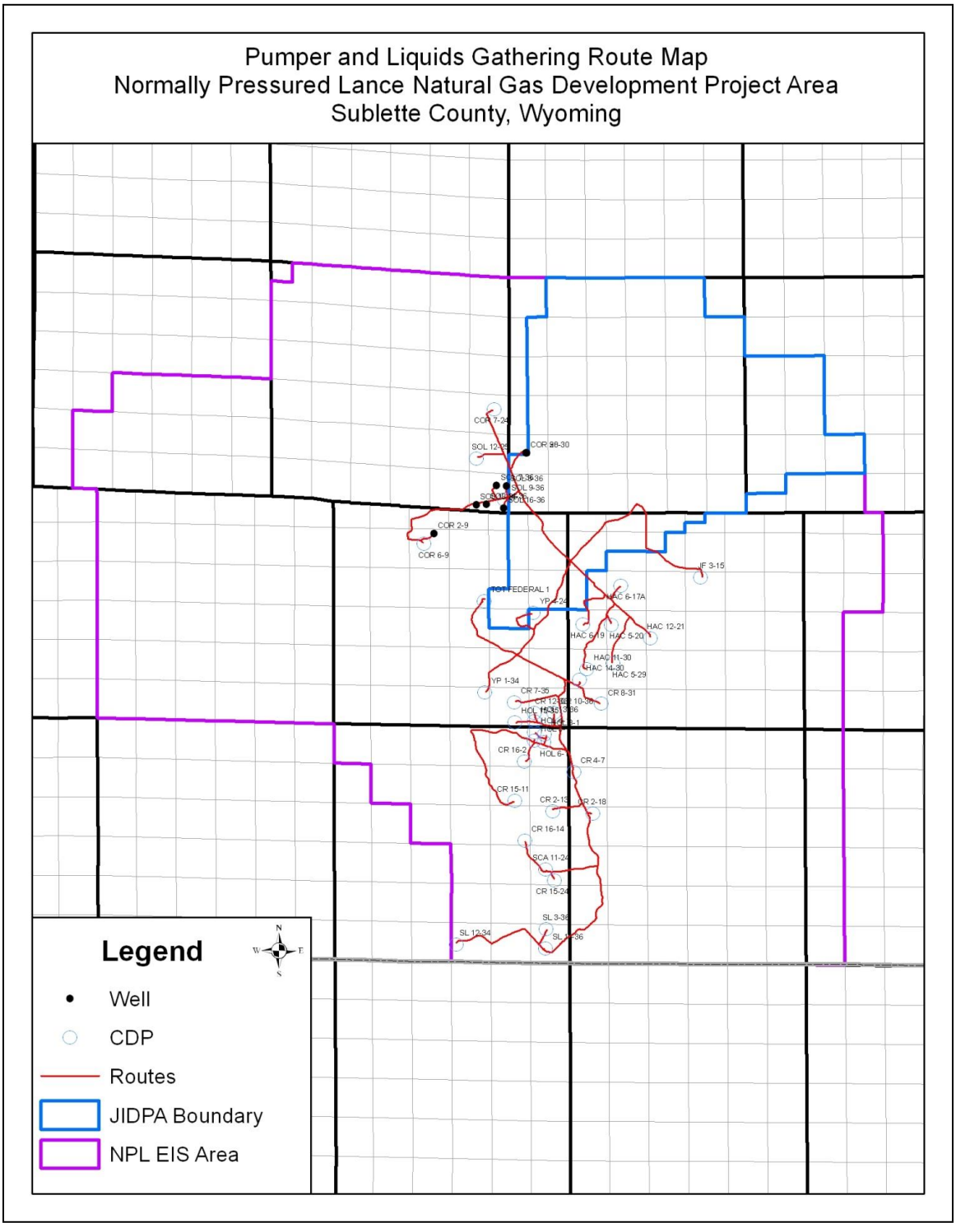
This route is not maintained for year-round access and is a dirt road occasionally used by oil- and gas-related commuter vehicles as well as grazing permittees, hunters, and recreationists depending on the season and weather conditions. The portion of this route and CCC Road that fall within the Project Area will be local/collector roads. Outside of the Project Area, the West Route will provide additional access to the western portion of the Project Area for workers and equipment. However, the route will need to be improved to support this type of sustained heavy usage.

4.0 Additional Local and Resource Roads and Gathering Pipelines

Additional local and resource roads and gathering pipelines will be constructed in the Project Area to accommodate new wells, and these routes will be specified in annual operational updates. Existing and proposed routes associated with the first year of development are identified in the following section of this TP. Where any new roads are shown to duplicate existing two-track roads, the existing two-track will be reclaimed unless it is deemed necessary for other area activities (e.g., livestock operations).

At field abandonment, it is anticipated that most, if not all, newly constructed local and resource roads will be reclaimed unless there is an identified need for the road by other area users. Existing infrastructure of pipelines and flowlines will be utilized to the greatest extent possible. The existing and proposed pipelines in the Project Area and adjacent JIDPA are depicted in Figure D-2. Pipelines and/or flowlines will be installed within the road easement and/or within pipeline corridors. In instances where parallel roads and lines lead to increased environmental and/or safety impacts, pipelines may be located along alternative routes. These alternative routes will be evaluated and sited to minimize impacts. The operator will coordinate with the BLM Authorized Officer (AO) to determine the most suitable routes.

Figure D-2. Pumper and Liquids Gathering Route Map



5.0 Existing Transportation Needs

5.1 The Existing Network

The existing transportation network in the TPA is shown on Figure D-1. This system includes the following primary access routes: Luman Road, North Route via North Burma Road within the JIDPA, the South Route via Crimson and 18 Mile Roads to the southern Project Area boundary, the eastern portion of the Northwest Route via Alkali Draw up to turnoff to the Corona wells in section 9, and the Southeast Route via South Burma Road up to the Hacienda 12-21 well pad. Historic use of the roads has been limited primarily to livestock operators and recreationists (e.g., hunters, off-road vehicle users). The principal current use of these and other roads in the area is for oil- and gas-related traffic, particularly traffic associated with the JIDPA and existing NPL wells. The existing transportation system is generally suitable for all current users.

Luman Road is used by all user groups, receives more use by large vehicles than any other road in the area, and is the most heavily used road in the area (BLM 2006). Most use of Luman Road occurs in the JIDPA and eastward to U.S. Highway 191; however, access via the Southwest Route and West Route (via the CCC cutoff) is suited for traffic during drier weather. Most of the heavy vehicle traffic associated with the JIDPA travels Luman Road to U.S. Highway 191. Establishment of the Jonah Energy workforce facility has greatly reduced travel along Luman Road to U.S. Highway 191. This camp houses workers associated with drilling and completion phases, all of whom are currently working on drilling and completion activities associated with the JIDPA.

North Burma Road is traversed by all users but is currently not well suited for all-weather travel or large vehicles. The road receives less traffic use than Luman Road; however, there is a moderate amount of heavy truck use during dry weather. Recent oil and gas development activities associated with the JIDPA have increased the level of vehicular activity along this road. Activities associated with the NPL Project will be limited to driving that portion of North Burma Road that falls within the Project Area boundary.

The South Route will provide primary access to existing wells in the south-central portion of the Project Area. Pumper trucks and liquids hauler traffic occurs regularly on this road (see Figure D-2). The South Route ties into Sublette and Lincoln Counties via the following roads, U. S. Highways 189 and 191, Wyoming State Highways 372, 316, and 28 and Sweetwater County Roads 49 and 52.

Portions of the West, Southwest, and Southeast Routes as well as North Burma Road could be used to access well sites over the course of development. Undesignated two-track roads could also be converted to access roads. Several of these roads are associated with existing access roads. During development, new roads will need to be constructed to extend the road network from the nearest access to proposed well sites. Some of the existing routes are used primarily by grazing permittees and recreationists, and may be prohibited for use by operators except in emergencies. Grazing permittees primarily use the two-track roads to access stock watering facilities.

Existing vehicle traffic along secondary and local/collector roads includes energy exploration and development activities, residential and business travel, livestock operations, and recreational

activities. Table D-1 provides the ADT recorded along highways, secondary, and local/collector roads associated with the NPL Project.

Table D-1. Average Daily Traffic along Major Highways, and Secondary and Local/Collector Roads near the Project Area

Transportation Route	Daily Vehicle Trips (2000)	Daily Vehicle Trips (2010)	Daily Vehicle Trips (2014)
U.S. Highway 191 (Junction Route 1801)	1,300 (160)[1]	2,229 (219)[1]	1,949 (187) [1]
U.S. Highway 191 (Junction Speedway Road)	1,500 (240)[1]	2,603 (497)[1]	2,268 (402) [1]
U.S. Highway 189 (Big Piney North Corporate Limits)	4,200 (280)[1]	4,748 (680)[1]	3,701 (461) [1]
State Highway 351 (Junction Route 11)	640 (110)[1]	1,341 (673)[1]	947 (205) [1]
Luman Road	No data available Heavy industry traffic (JIDPA only)	503 (161)[2]	–[5]
Southwest Road to LaBarge	No data available Very light commuter, grazing, and recreational traffic	20 (0)[3]	–[5]
North Route via Burma Road	No data available Minimal industry traffic	2 (0)[3] (outside JIDPA only)	–[5]
Southeast Route via South Burma Road	No data available Grazing, recreational only	1 (1)[4] (to Hacienda 12-21 well pad only)	–[5]
South Route via Crimson Road	No data available Crimson Road did not exist at this time. All traffic was for grazing, recreational uses only via 18 Mile Road	2 (2)[4]	–[5]
Northwest Route via Alkali Draw Road	No data available Grazing, recreational only	1 (1)[4] (to Corona 2-9,6-9 turnoff only)	–[5]
West Route via Reardon Road	No data available Grazing, recreational only	3 (0)[3]	–[5]

[1]Source: WYDOT 2014
[2]Source: JIO 2010
[3]Source: Estimates from Jonah Energy based on field observations
[4]Source: Jonah Energy-estimated pumper traffic only
[5]Daily vehicle trip data has not been collected for this route since 2010

Note: Numbers in parentheses correspond to the total number of truck trips.

JIDPA Jonah Infill Development Project Area

Existing vehicle traffic in the Project Area is related to 45 locations including 36 Central Delivery Points (CDPs) and nine satellite wells. These locations are serviced by pumper trucks (pickups) and liquids haulers (semi tankers) at various intervals. The pumper trucks and liquids

haulers operate seven days a week. A total of 48.11 miles of road provides access to these locations.

Pumper trucks travel to the CDPs and satellite wells at the intervals listed below:

- 23 CDPs on a daily basis;
- 8 CDPs every two days;
- 2 CDPs every three days;
- 3 CDPs every two weeks; and
- 9 satellite wells once per month.

The liquids haulers only travel to the CDPs, not the satellite wells. Approximately 15 liquid loads (water or condensate) are hauled from the Project Area each week (an average of 2.14 loads each day). These loads may or may not be full loads, and one or more CDPs may be visited on each trip depending on many factors. The 36 CDPs receive essentially all of the pumper truck and liquids haulers traffic. The CDPs are evenly distributed over the entire area (i.e., they are not clustered) so that all road segments are used to access the CDPs.

6.0 Proposed Network Use or Modification

The typical stages of a trip necessary for use of the Project Area transportation system are listed below:

- main movement (i.e., United States and state highway lanes for workers with destinations terminating in the Project Area);
- transition (i.e., turnout lanes, where there is a change in travel speed);
- distribution/collection (i.e., oil/gas field unit or ranch access roads, collector and local roads); and
- terminal access (i.e., well location access roads and resource roads).

It is anticipated that construction of the first Regional Gathering Facility (RGF) and development of NPL Project wells will commence in close proximity to existing wells located near the JIDPA boundary to facilitate the use of existing locations wherever possible. As areas of higher resource potential are identified, additional wells will be drilled from those existing locations. This will initially impact portions of the road network in proximity to the JIDPA and then expand to more distant portions of the Project Area.

When planning transportation facilities, all of the described traffic stages can be identified within the system, but any stage could be eliminated if not needed (e.g., intermediate stages may not be necessary). Each movement stage is handled by a separate facility designed specifically for its function. Identifying the stages helps to plan traffic flows.

The TPA transportation network may experience problems at traffic stage changes due to the increase in expected traffic in addition to the existing traffic levels associated with the JIDPA. However, worker and vehicle activities associated with the NPL Project will not contribute additional vehicles to the existing transportation infrastructure (i.e., all vehicles associated with the NPL Project are currently operating within the JIDPA).

Localized construction and drilling activity will temporarily place heavy demands on road servicing. Traffic demands will be high in areas where drilling and completion activities are occurring throughout the development period, but will be reduced within other areas of the Project Area once development is completed. Once all wells have been developed, traffic requirements will remain high for the remainder of the life of the project. Roads will be used continually until all wells in the area are abandoned and disturbed areas reclaimed.

Construction of each RGF will involve grading and preparation of the site. Dehydration units, storage tanks, and other processing equipment will then be installed at each RGF. Later in the life of the field, overhead electrical lines and compression facilities will be installed at each RGF as needed. Pipelines and roads will also be constructed prior to construction of the multi-well pad sites to facilitate transport of gas and liquids to the nearest RGF. Construction traffic will be heavy at first and decrease as each new well pad is connected to the RGF. Construction traffic will increase each time another well site is constructed. This pattern will continue for each phase of the NPL Project where drilling will be in progress.

6.1 Transportation Network Use under the Proposed Action

6.1.1 NPL Project-Related Transportation and Vehicle Trips

Traffic and transportation associated with the NPL Project will occur throughout all phases including drilling, completion, and production. Table D-2 summarizes the heavy and light vehicle trips per day for drilling, completion, and production activities associated with the NPL Project. Detailed traffic and transportation information for each phase of the NPL Project is presented below.

Table D-2. Type and Number of Vehicle Trips by Project Activity (per 24-hour day)

Project Activity	Heavy Vehicle Trips	Light Vehicle Trips	Total Vehicle Trips
Drilling	20	306	326
Completion	165	18	183
Production	121	1,163	1,284

Source: Vehicle trip numbers derived from Jonah Interagency Office Traffic Study (JIO 2010)

Jonah Energy Workforce Facility

During the development phase of the project, drilling, completions, and other field workers will be assigned 12-hour shifts over a "two weeks on, one week off" schedule cycle. These workers will reside at the Jonah Energy workforce facility (WFF) during their "days on." For each 12-hour shift the workers will drive or be transported to and from the assigned work location. Workers will only be allowed to take personal vehicles offsite while leaving for, or returning from, their "days off." This practice will greatly reduce traffic and improve safety within the Project Area, as well as on the surrounding highways.

Occupancy figures for July 2010 showed an average occupancy at the Jonah Energy WFF of 231 occupants per day. This annualizes to approximately 86,000 occupants per year. In the absence of the Jonah Energy WFF, these residents will have had to drive to and from an offsite residence each day. In many cases this residence will have been more than 30 miles away. Using these figures, the Jonah Energy WFF can be estimated to have reduced traffic on Luman Road and U.S. Highway 191 and connecting arterials by at least 172,000 trips per year.

Compressed Natural Gas Field Vehicles

Jonah Energy has begun converting all field vehicles to bi-fuel gasoline/compressed natural gas (CNG) operation. Once completed, this fleet conversion project will result in a dramatic reduction of nitrogen oxide (NO_X) and volatile organic compound (VOC) emissions generated by in-field transportation and hauling efforts.

Drilling Phase

An estimated 326 vehicle trips per day will be required for drilling operations. For each rig, initial rig-up activities will involve transportation of the drill rig, drill pipe, drilling fluid products, living quarters, and ancillary facilities requiring approximately 19 heavy truck vehicle trips between the new site and previous site. The rig-up process can take between three to five days to complete. Drilling operations will occur 24-hours a day, in 12-hour shifts at each drilling site. While drilling is in progress, workers will drive or be transported up to 17 miles to and from well sites and the workforce facility once per 12-hour shift. An estimated 30 vehicle trips per day for a period of 10.5 days is expected to drill one well, totaling 302 light vehicle trips per day during the 10-year drilling phase. Occasional visits from product vendors will be required to resupply the operation (e.g., fuel and drilling fluid additives). Table D-3 summarizes the type and amount of daily vehicle trips associated with each drilling phase.

Table D-3. Type and Number of Vehicle Trips during Drilling (per 24-hour day)

Vehicle Type	Rig-Up Trips	Vendor and Supply Trips	Worker Trips	Total Trips
Heavy Vehicle	19	1	0	20
Light Vehicle	0	4	302	306
TOTAL	**19**	**5**	**302[1]**	**326**

Source: Vehicle trip numbers derived from Jonah Interagency Office Traffic Study (JIO 2010)

[1]Assumes drill time at each well of 10.5 days and 30 vehicle trips per day, equating to 302 trips per day over 10 years (10.5 days X 30 trips = 315 trips per well. 315 trips per well * 3,500 wells = 1,102,500 vehicle trips over 10 years. 1,102,500 vehicle trips / 3,650 days = 302 vehicle trips per day).

Note: One or two rigs may operate at once at each multi-well pad.
Note: Vehicle trip estimates are based on available current information. These estimates are subject to revision based on changing conditions.

Completions

Completions operations will occur at the same time as drilling operations at each multi-well pad location, and will occur 24-hours a day in 12-hour shifts at each completions site. Initial setup of completions equipment at each new multi-well pad will occur as soon as drilling of the first well is completed. During setup, approximately 34 water tanks, two sand-containment vessels (Sand Chiefs), six pump trucks, two mixing vehicles, and one equipment van will be driven or transported to the site, resulting in approximately 45 vehicle trips between the new site and previous site each day.

Completion of each well will involve an average of five stages and an estimated total of 120 vehicle trips per day. At each of the five stages, 21 vehicle trips will be needed to load approximately 4,400 barrels (bbls) of water into the water tanks, totaling approximately 105 round trips per day. Prior to the completion of each of the five stages, approximately 2.5 vehicle trips will be required to load approximately 155,000 pounds of sand into the Sand Chiefs, totaling approximately 13 round trips per day. Completions staff will be transported to the wells by van from the Jonah Energy workforce facility every 12 hours, resulting in approximately two vehicle round trips per day. The distance from the workforce facility to the well sites is estimated to range up to 17 miles.

After stimulation of each well is completed, a coil tubing rig will visit the site and drill out the bridge plugs in the well, requiring one trip from the Jonah Energy work force facility per day. Flow-back will require a crew of three flow testers to monitor the well and conduct measurements and adjustments to flow-back equipment, requiring a total of 15 vehicle trips per day. Flow-back will require five pieces of equipment to be moved to the multi-well pad site, and it is anticipated that flow back-equipment will stay at the site until all wells are completed.

One completions crew will operate at each completions site regardless of the number of drill rigs on site. It is anticipated that water tanks and Sand Chiefs will remain at the site until all wells are completed. Water and sand trucks will be moved from site to site to supply all active completions sites in the development area. Table D-4 identifies vehicle trips per day during completions.

Table D-4. Type and Number of Vehicle Trips during Completions (per 24-hour day)

Vehicle Type	Completions Setup	Completions (5 stages)	Coil Tubing Rig	Flow Back Staff	Flow Back Equipment	Total Trips
Heavy Vehicle	44	118	1	--	2	165
Light Vehicle	1	2	--	15	--	18
TOTAL	**45**	**120[1]**	**1**	**15**	**2[2]**	**183[3]**

Source: Vehicle trip numbers derived from Jonah Interagency Office Traffic Study (JIO 2010).
[1]Assumes 1.25 days to complete one well to determine completions staff vehicle trips (1 trip every 12 hours = approximately 2 vehicle trips).
[2]Represents trips per multi-well pad location. These five pieces of equipment are moved onto the multi-well pad when flow-back begins on the first well. The equipment is not moved until the last well is completed.
[3]Completions setup only occurs once per multi-well pad location. As a result, these vehicle trips are not included in the total per day.

Note: Vehicle trip estimates are based on available current information. These estimates are subject to revision based on changing conditions.

Production

Production-related staff will travel to and from their assigned CSC and various RGFs, wells, and other sites each day. During production, morning and evening travel to/from the CSCs will result in a maximum of 228 round trips per day between either the Jonah Energy workforce facility or homes outside the Project Area during each 24-hour period. Staff shuttles and carpooling could reduce these trips. The one or two CSCs and the existing Jonah Energy workforce facility will provide the base of operations for production staff and allow the Project Area to be divided into three service areas (i.e., western, central, and southern regions). Using existing road distances and the expected RGF location scenario, estimated production trips within each region will vary from 0 to 10 miles in length.

Facility Operators will be responsible for maintenance of production equipment and operation of the liquids load-out facilities at one or more RGFs. Travel will be between the base CSC and the RGF assignment for the day. This will equate to a total of 11 (0- to 10-mile) trips per day for the Project Area.

Pumpers will travel each day between CSCs, well sites, and RGFs to perform well maintenance tasks. Estimates indicate that each pumper will visit three sites per day with a variable travel distance of 0 to 10 miles per trip. This will equate to a total of 450 (0- to 10-mile) trips per day within the Project Area.

Production Supervisors could be housed both at the CSCs and at the Jonah Energy workforce facility. Estimates indicate that each supervisor will visit 15 sites per day with a variable travel distance of 0 to 20 miles per trip, depending on the number and location of sites visited in the Project Area. This will equate to a total of 450 (0- to 20-mile) trips per day for the Project Area.

Environmental Specialists will travel each day between the base CSC and well sites, RGFs, and other areas to perform forward-looking infrared camera emission scans, leak tests, and other environmental compliance tasks. Estimates indicate each Environmental Specialist will visit six sites per day with a variable travel distance of 0 to 10 miles per trip. This will equate to a total of 24 (0- to 10-mile) trips per day within the Project Area.

Liquids Haulers will use semi-tractor trailer tankers to haul condensate from each RGF to existing condensate sales points in Rock Springs, or to haul produced water from each RGF to the JIDPA water treatment facility. Estimates indicate that each RGF (11) will require seven condensate runs per day to sales points in Rock Springs[5] to service each RGF, at 70 to 90 miles each way (up to 180 miles round trip), for a total of 77 external vehicle trips. Each RGF (11) will also require an average of four water treatment runs per day, at 5 to 15 miles each way (up to 30 miles round trip) to the JIDPA water treatment facility, for a total of 44 in-field vehicle trips. This will equate to a total of 121 liquids-related trucking runs per day to service all 11 RGFs in the Project Area. Table D-5 summarizes the type and amount of vehicle trips associated with the production phase for each well that will be developed.

[5]*Depending on a variety of unknown factors, condensate runs may occur to sales points that are closer to the Project Area than Rock Springs. This analysis assumes all condensate runs will be to sales points in Rock Springs.*

Table D-5. Type and Number of Vehicle Trips During Production for the Proposed Action (per 24-hour day)

	External Trips[1]			In-Field Trips						Total
	Workforce Travel to Project Area	*Liquid Haulers*	*Total*	*Facility Operators*	*Pumpers*	*Production Supervisors*	*Environmental Specialists*	*Liquid Haulers*	*Total*	
Heavy Vehicle Trips	-	77	77	-	-	-	-	44	44	121
Light Vehicle Trips	228	-	228	11	450	450	24	-	935	1,163
Total	**228**	**77**	**305**	**11**	**450**	**450**	**24**	**44**	**979**	**1,284**

[1]External trips include workforce driving to and from their worksite to their home/lodging. This number represents a high-end scenario, as there may be vans or carpools for transportation to worksites. It is assumed that all staff will operate from a CSC or the workforce facility as their home worksite and conduct in-field trips from there.
Note: Vehicle trips per day calculated based on the number of wells per year and the vehicle trips per well reported in Appendix E (*Transportation Plan*.
Note: Vehicle trip estimates are based on available current information and are subject to revision based on changing conditions.

6.1.2 NPL Project-Related Vehicle Trips in the Transportation Network under the Proposed Action

Table D-6 identifies estimated annual vehicle trips on routes in the transportation network during drilling and production under the Proposed Action.

Table D-6. Estimated Annual NPL Project-Related Vehicle Trips under the Proposed Action

Transportation Route/Location	Baseline Year	Estimated Annual Proposed Action-related Vehicle Trips (Years 1-10)[1]			
	2014[2]	*Drilling*[2]	*Production*[2]	*Total Trips*	*Increase (percent)*
U.S. Highway 191 (Junction State Highway 351 [Route 1801 Monitoring Station])	711,385 (68,255)[3]	7,609	34,529	42,138	5.92
U.S. Highway 191 (Junction Speedway Road)	827,820 (146,730)[3]	14,490	78,475	90,698	10.96
U.S. Highway 189 (Big Piney North Corporate Limits)	1,350,865 (168,265)[3]	938	4,964	5,902	0.44
State Highway 351 (Junction	345,655	1,876	9,125	11,001	3.18

Table D-6. Estimated Annual NPL Project-Related Vehicle Trips under the Proposed Action

Transportation Route/Location	Baseline Year	Estimated Annual Proposed Action-related Vehicle Trips (Years 1-10)[1]			
	2014[2]	*Drilling*[2]	*Production*[2]	*Total Trips*	*Increase (percent)*
Route 11)	(74,825)[3]				
Luman Road	183,595 (58,765)[4]	96,550	468,660	565,210	307.85
Southwest Road to LaBarge	7,300 (0)[5]	208	208	416	5.70
North Route via Burma Road (outside JIDPA only)	730 (0)[5]	49,754	234,593	284,347	38,851.64
Southeast Route via South Burma Road (to Hacienda 12-21 only)	365 (365)[6]	16,974	80,417	97,391	26,582.47
South Route via Crimson Road (to turnoff to Sugarloaf wells only)	730 (730)[6]	16,974	80,417	97,391	13,241.23
Northwest Route via Alkali Draw Road (to Corona 2-9,6-9 turnoff only)	365 (365)[6]	33,364	157,505	190,869	52,192.87
West Route via Reardon Road	1,095 (0)[5]	16,974	80,417	97,391	8,794.16

Notes: Numbers in parentheses correspond to the total number of truck trips. Vehicle trip estimates are based on available current information and are subject to revision based on changing conditions.

[1]Vehicle trips for the Proposed Action were provided by Jonah Energy and were estimated using section aggregations combined with the 80/20 rubric used for estimating disturbance (JIO 2010).
[2] Vehicle trip data for year 2014 was available for certain routes through the Wyoming Department of Transportation, as identified in the footnotes below. All other routes vehicle trip estimates are based on data collected by Jonah Energy in 2010, which represents the most recent data available for these routes.
[3]Source: Wyoming Department of Transportation 2014
[4]Source: Derived from Jonah Interagency Office Traffic Study (JIO 2010)
[5]Source: Estimates from Jonah Energy based on field observations in 2010
[6]Source: Estimates from Jonah Energy based on field observations in 2010, pumper truck traffic only

6.2 Ultimate Road Disposition

When the field is ready for abandonment (estimated to be approximately 40 years from authorization of drilling activities), the transportation network within the TPA will be reclaimed to appear much as it did prior to development. Roads identified as necessary or desirable for other area users (e.g., grazing permittees, recreationists) may be retained with improvements.

Resource roads that may be retained after the life of the project will be those that were identified during transportation planning as duplicating an existing two-track or other low-traffic-volume road, for which these two-track or other roads were reclaimed. In addition, resource roads that are deemed necessary by the BLM for other area uses may also be retained.

Luman and Burma Roads may be retained after project completion in an upgraded status, depending on the alternative selected. All other project-required roads are anticipated to be entirely reclaimed or returned to conditions similar to those that existed prior to development.

Road use following project completion will likely be limited to two of the three existing uses (i.e., grazing management and recreation), and responsibility for maintenance of roads will revert back to the BLM. A determination regarding the extent of post-project road maintenance (e.g., winter snow removal) cannot be determined at this time because the level of future area use is unknown. Decisions will be made during the later years of the NPL Project. Jonah Energy and BLM will coordinate with local counties and governments on road disposition at the end of the project, as appropriate.

7.0 Road Classifications

7.1 Functional Road Classification, General

The general functional road classification used in this document classifies roads according to a hierarchy of traffic movement within a traffic system. This classification is described in BLM Manual Section 9113 (BLM 1985) and does not necessarily depend on road condition.

7.2 Functional Road Classification

The road classification system used in this document is based on the system currently used by the BLM. The special attributes of the roads within the TPA require the use of multiple collector roads. The road classification described below is derived from the BLM Manual Section 9113 (BLM 2015, 1991).

- Collector Roads: These roads normally provide primary access to large blocks of land, and connect with or are extensions of a public road system. Collector roads accommodate mixed traffic and serve many uses. They generally receive the highest volume of traffic of all the roads in the Bureau system. User cost, safety, comfort, and travel time are primary road management considerations. Collector roads usually require application of the highest standards used by the Bureau. As a result, they have the potential for creating substantial environmental impacts and often require complex mitigation procedures.
- Local Roads: These roads normally serve a smaller area than collectors, and connect to collectors or public road systems. Local roads receive lower volumes, carry fewer traffic types, and generally serve fewer uses. User cost, comfort, and travel time are secondary to construction and maintenance cost considerations. Low volume local roads in mountainous terrain, where operating speed is reduced by effect of terrain, may be single lane roads with turnouts. Environmental impacts are reduced as steeper grades, sharper curves, and lower design speeds than will be permissible on collector roads are allowable.

The public local and collector roads in the Project Area include Luman Road, North Route, Southeast Route, South Route, Northwest Route, and West Route (includes the CCC Road cutoff) (see Figures D-1 and D-2).

Numerous undesignated resource roads (see Figure D-1) currently provide access to existing well sites including the Sol and Corona wells in the north-central area; Holmes, Crimson, Yellowpoint, and Sugarload wells in the south area; Hacienda wells in the southeast area; and the Tot, Ferry Island Unit area, and Cutlass Unit wells in the southwest area. Additional resource roads will be constructed as needed to extend access to new well sites and facilities.

A variety of undesignated resource routes (unimproved/two-track roads) also provide access to water wells, grazing allotments, and recreational sites within the Project Area (see Figure D-1). These are never used for heavy industrial traffic and have been used occasionally for wildlife inventories, archaeology studies, and various types of geodetic and seismic surveys. Some of the existing resource routes may be upgraded and used as resource or local roads for natural gas development activities. Future resource roads (i.e., low-traffic-volume roads) are not specifically identified in this document due to the lack of site-specific details for the NPL Project. Resource roads and future local roads will be identified during localized area transportation planning and will be specified in annual operational updates. If Jonah Energy proposes the use and access on private or county roads, to ensure proper utilization of private and county roads, prior to NPL Project commencement, Jonah Energy will coordinate appropriate roadway agreements with counties, private landowners, and other appropriate parties in accordance local, state and federal policies, guidance and standards.

8.0 Environmental Constraints

There are many natural obstacles (e.g., steep slopes, poor soils for road construction, sensitive resources) throughout the TPA that could pose potential conflicts for road construction and development. This section discusses several of the more formidable obstacles. Additional areas of concern may be identified during transportation planning and APD or ROW application review processes. Although roads could be constructed through many of the obstacles, these areas will be avoided to mitigate resource conflicts and augmented construction costs.

8.1 Topographic Constraints

In addition to the topographic obstacles listed below, there are many small, dry lake beds and low-lying areas, small drainage channels, rock outcroppings, steep slopes, etc., that will be considered when choosing transportation routes within and adjacent to the TPA.

8.1.1 Steep Slope Areas

Steep slope areas occur throughout the TPA, and these areas will be avoided to minimize potential erosion, visual resource, and biological resource impacts.

8.1.2 Large Drainages

Crossing drainages is expensive and can cause adverse impacts if crossings are not appropriately designed and constructed. When it is necessary to cross a large drainage, an appropriate bridge, culvert, or low-water crossing will be selected and designed to handle at least a 10-year flood event.

The number of drainage crossings will be scrupulously limited. Drainages within the TPA include Sand Draw, Granite Wash, North Alkali Creek, and Upper Alkali Creek, which flow generally west into Alkali Creek; the East Buckhorn watershed, which flows south into Eighteen Mile Canyon; and Long Draw, which flows southeast into the Big Sandy River.

8.2 Soil Constraints

Site investigations and soil evaluations provide valuable information on soil types and limitations of the materials encountered on a road project. The extent of sampling and testing work required depends on the type and size of the road and soils characteristics. Lower standard roads (e.g., some resource roads) generally will not require soil investigations. Visual examination is generally sufficient for low-traffic-volume roads that will not carry frequent heavy loadings, and for roads that appear to have soil types well suited to road construction. Soils that generally present conflicts are loose windblown sand, silt, and clay (fine-grained materials without the presence of gravel or rocky material). Fine-grained silts or clays are particularly troublesome when saturated. Sands typically cause problems when dry for extensive periods of time.

Sands, silts, and clays may be difficult to distinguish when in combination, and intermediate silts possess some characteristics of both sands and clays. Roads constructed on poor soils may perform well immediately after construction, but may lose stability by bearing failure (sand) or becoming too slippery or unable to support loads (clay) when wet. Road surfacing (e.g., gravel, pavement, etc.) can mitigate road placement on poor soils. Classifying soil types at proposed construction sites is valuable in predicting potential surface damage and in determining the need for and type of surfacing material. Laboratory testing to determine the structural values of the soil may be advisable on roads requiring high traffic volumes and/or repeated heavy loads. Soils will be classified prior to road construction and specified with appropriate construction criteria in operational updates and/or APDs and ROW applications.

Most soils within the TPA have limitations for road construction, shallow excavations associated with pipeline construction, pond/reservoir areas (reserve pits), and reclamation. Limitations can be identified using criteria obtained from the *U.S. Soil Conservation Service National Soils Handbook*, 603.15 (Soil Survey Staff 1983).

Most of the soil in the Project Area has developed from residuum, or direct weathering, of the underlying formation sediments. The primary process of sediment movement across this landscape is slopewash, although other alluvial and colluvial processes have transported sediments in portions of the surrounding area. The soils most sensitive to disturbance are those developed from bedrock or glaciated bedrock and occurring on areas of steep slopes. Steep slopes may limit development and reclamation potential in localized areas, but most soils are typically located on gently sloping, undulating uplands.

8.3 Biological Constraints

Known sensitive biological resources present in the TPA include Greater Sage-Grouse leks and nesting areas, raptor nests, pronghorn antelope migration corridors, and various habitats suitable for threatened, endangered, and other sensitive species. As with other environmental constraints, these resource locations and their associated buffers will be avoided to minimize disturbance. In

addition, inventorying and monitoring of these resources will be conducted as specified in annual wildlife monitoring reports.

8.4 Other Environmental Constraints

Numerous paleontology and cultural resource sites are known to exist within the Project Area. These sites will be avoided during road improvement and construction activities. In addition, surveys for these resources will be conducted prior to construction, and monitoring of construction sites will be implemented as appropriate during development to avoid unnecessary disturbance. If avoidance of a cultural site during construction is not feasible, adverse impacts will be appropriately mitigated.

Neither the Sublette Cutoff of the California Trail nor the North Meadow Springs Variant of the Sublette Cutoff will not be used for access to or from the Project Area. Water developments (i.e., reservoirs, wells, and pipelines) occur throughout the surrounding area, and these locations are important for livestock and wildlife. Roads developed and/or improved for the NPL Project will avoid these locations to minimize adverse impacts on livestock and wildlife resources.

9.0 Road Specifications, Plans, and Maintenance

9.1 General Requirements

In general, all new, improved, or rebuilt roads within the TPA will be developed according to the standards stated below for designed roads. Roads on state or private land within the Project Area will be planned and built according to these same standards unless otherwise specified by the state or private landowner. Where roads are not developed in accordance with BLM standards, the potential for adverse impacts on health and safety and sensitive environmental resources is increased.

Newly designed roads on Federal lands or those requiring a Federal undertaking will comply with the requirements of the BLM District Engineer. The District Engineer requirements draw on the BLM Manual Section 9113 – Roads (BLM 1985) and the associated Wyoming State Supplement (BLM 1991), as well as other BLM manual sections. Design elements of the roads also will draw on the current American Association of State Highway and Transportation Officials, *Manual on Uniform Traffic Control Devices* (U.S. Department of Transportation Federal Highway Administration 1988), American Society for Testing Materials, and Wyoming State and Sublette County design criteria, where appropriate.

In March 1992, the Wyoming BLM adopted the Wyoming State *Supplement to the BLM Manual 9113* (BLM 1991). This supplement amplifies several parts of the BLM Section 9113 (BLM 1985). Some of the information contained within this document is emphasized in the following section.

In Wyoming, BLM roads are designed, constructed, and/or upgraded for long-term use and are to be located, designed, and constructed to provide safety to the user and to require the minimum amount of maintenance. Adequate design and construction of drainage structures, cut-and-fill slopes, and the travel-way will minimize future maintenance needs. The BLM will not accept

roads that are constructed by others that require excessive maintenance expenditures by the BLM.

A standard below the Resource Road classification may only be constructed for short-duration use (30 to 60 days) and should not service traffic during the winter and spring months. In most cases, flat-bladed roads develop into canals, are a hazard to the user, and create environmental problems. Flat-bladed roads will not be authorized in Wyoming. The exception to this rule will be for the lowest-class resource road where upgrading of short segments of an existing route is planned (i.e., excavating a hump for better site distance, widening a curve, etc.).

Where information in the BLM manual that addresses roads and bridges seems inappropriate, the BLM PFO or RSFO District Engineer will be consulted for clarification. The standards discussed below are the minimum standards for all roads constructed on BLM lands in Wyoming (BLM 1985). These standards are values established to ensure adequate uniformity and quality of all roads constructed on lands administered by the BLM. ADT, vehicle types, and design speed determine the geometric standards to be applied.

9.2 Technical Requirements for Roads

Because each road is unique, it is not the purpose of this document to give all of the technical data that may be necessary for every road. Each road construction project will be evaluated with its own requirements and appropriate technical information obtained during the transportation planning processes and subsequently processed APDs and ROW applications. BLM Manual Section 9113 (BLM 1985) and its Wyoming State Supplement (BLM 1991) contain the comprehensive technical requirements necessary for the design of roads on Wyoming BLM lands. A copy of applicable BLM manual sections can be obtained from the RSFO.

9.3 Road Surface Material

Road-surfacing material sources in the area are known to be available from three locations: two sand pits and one gravel quarry. Potential surface material sources on and adjacent to the area are shown on the maps available for review at the PFO and RSFO. The need for additional surface aggregate sources is not anticipated for the NPL Project. Many roads within the TPA are or will be built across sandy or clayey soils and will require surfacing material. Both sandy and clayey soils are subject to special stability problems, which can be remedied by applying an aggregate surface. When surfacing aggregate is required for roads, it will consist of appropriate material and gradations. Surface material will be applied to the minimum compacted depths that meet current BLM standards. Given the long-term traffic volumes associated with the NPL Project, the BLM may require the paving of selected primary access roads (e.g., Luman Road, Burma Road) and/or the use of magnesium chloride or other dust suppressants on more in-field collector, local, and resource roads.

9.4 Drainage Crossings

Bridge, culvert, and low-water crossing designs will conform to the BLM Manual Section 9112 (BLM 1990), Wyoming state law, and standard engineering practices. Drainage structures can be placed on most of the drainages within the TPA using a U.S. Army Corps of Engineers (USACE) Nationwide 404 Permit 14 (Road Crossings Sections 10 and 404). The USACE will

be consulted to obtain permits for crossing drainages, and it is anticipated that nationwide permit stipulations will be met under most circumstances. If the stipulations in Permit 14 cannot be met, a full standard Clean Water Act Section 404 Permit will be required. The USACE will be notified when construction of a road involves a drainage, even if all provisions of Permit 14 are met or flow in the drainage is intermittent. Usually, a simple letter to, and a reply from, the USACE will satisfy the requirement on small drainages. If there is any question about the need to obtain a USACE permit or the type of permit necessary, contact with the Wyoming USACE will be initiated.

Culverts, bridges, or low-water crossings will be installed wherever a road is constructed across a defined drainage or natural channel. Culverts will be designed to pass no less than a 10-year flood event without developing static head at the entrance, as identified by a BLM hydrologist, engineer, or other similarly qualified individual. Calculations will be based on local soil types and other pertinent environmental data. The size and gradient of the culvert will be designed to avoid damage from a 25-year flood. Culverts smaller than 18 inches in diameter will not be used due to problems with cleaning and maintenance.

In addition to installing culverts in defined drainages to provide adequate cross drainage and minimize erosion, cross culverts will be installed at appropriate spacing for lateral drainage. There are three major factors to consider when determining culvert spacing: gradient, soil type, and rainfall intensity. Other factors that affect drainage are frost and frozen ground, snow depth, groundwater depth, soil permeability, and evaporation rate. Recommended spacings of cross culverts for various gradients and soil types are provided in the BLM Manual Section 9113 (BLM 1985). This applies to most situations and will be used unless local experience dictates otherwise.

In some relatively flat areas with permeable well-drained soils, a culvert may fill with sand and silt annually, providing no drainage. Culverts in areas with highly erosive soils have a tendency to wash out, leaving an impassable barrier. When past experience or soil and gradient conditions indicate potential problems with culverts, the best option may be to construct the road without cross-drain culverts, except on defined drainages, and to evaluate the drainage performance of the road and adjacent area. Raised roads with flat-bottomed ditches may be useful in poorly drained areas. If unacceptable amounts of water accumulate and do not dissipate within a reasonable period of time, corrective action will be taken. Such action may include installing a dip or low-water crossing or installing a culvert and evaluating its performance.

9.4.1 Culverts

Culverts are to be aligned with the natural drainage and will comply with BLM Manual Sections 9112 (BLM 1990) and 9113 (BLM 1985) and the Wyoming State Supplement (BLM 1991). Culverts will be installed as needed at all road intersections except when an intersection occurs at the crest of a ridge. The minimum allowable culvert diameter is 18 inches. Culverts and structures will be strong enough to support a minimum of HS-20 loading (American Association of State Highway and Transportation Officials [AASHTO] specification) as required by BLM (1985).

9.4.2 Low-Water Crossings

Low-water crossings may be used with BLM approval, when necessary, as a type of drainage crossing where a 10-year runoff design produces more runoff than can be reasonably handled with a drainage structure or when the cost of a structure is unreasonable. Cost analysis, terrain and drainage features, structure stability, and necessary drainage diversions must be considered when determining the best alternative for drainage crossings.

Environmental disturbance must also be considered. Drainage structures may not be the best environmental choice; and low-water crossings, if constructed properly, may cause less short- and long-term environmental damage than a large structure with road approach fills, water backup, and downstream bed scouring. However, low-water crossings require continued maintenance to minimize erosion and to allow vehicles to cross, and they should not be considered when there is a fishery or a water flow for more than just runoff periods. Low-water crossings in drainages with flow tend to become impassable during winter months due to freeze and thaw cycles. Trucks attempting to cross ice crusts over water may break through and may high-center on the ice.

9.4.3 Bridges or Structures

Bridges and major culverts constructed on public lands must conform to standards as outlined in BLM Manual Section 9112 (BLM 1990), including design by or under the direction of a qualified registered professional engineer. These structures are special and will be developed site-specifically.

Some structures, such as bridges, may need to be designed to carry heavier loads and will be considered individually at the time of construction. All bridges must have a minimum curb-to-curb or rail-to-rail width (whichever is less) of 14 feet for single-lane roads and 24 feet for double-lane roads but, in all cases, not less than the nominal width of the adjacent travelway as measured at right angles to the travelway centerline. All structures will be designed for a minimum of HS-20 loading.

9.5 Road Layout and Construction Inspection

Surveying and staking necessary for road construction or improvement will be conducted by or under the direction of proper Wyoming registered professionals (e.g., surveyors, engineers). The complexity of the NPL Project will govern the amount of work, design, and inspection necessary.

9.5.1 Centerline Staking

Surveyors use many methods to lay out roads. At a minimum, the BLM requires that stakes be placed on the centerline of the road at a maximum distance of 100 feet, at all fence or utility crossings, and at all abrupt breaks in ground profile of vertical change of 1 foot or more. Stakes will be placed on the centerline of the road at a maximum distance of 50 feet around curves of 4 degrees or sharper. The station or stake number will be written clearly on each stake. Section corner ties will be made and shown on all road design plans, as presented in applications. The BLM may require additional construction staking criteria as determined on an individual basis.

9.5.2 Construction Monitoring

Many access roads can be constructed without major inspection efforts. Roads without unusual construction requirements may, in some cases, be monitored by Jonah Energy. The extent and type of construction monitoring will be determined by the BLM for roads that travel on lands administered by the BLM. Construction inspection ensures the following:

- the route approved for construction is followed with as little environmental disturbance as practical;
- all sensitive environmental, paleontological, or cultural/historic sites are adequately protected;
- construction methods properly remove organic matter from roadfill areas or fill material;
- topsoil removal, stockpiling, and replacement and, in some instances, reseeding are conducted commensurate with approved design;
- embankments meet proper width, slope, and compaction criteria (this may involve the use of water);
- frost in the ground is not so excessive that it precludes proper construction;
- reasonable efforts are made to walk equipment on the overall road surface to help with compaction;
- drainage structure installation includes adequate compaction, riprap placement, drainage bowl installation, cover depths, wing ditch slopes and lengths, etc.; and
- proper sign placement is used.

In some cases, the inspector may be required to certify that the construction was completed according the design parameters and standards specified in ROW applications. In this case, a Wyoming registered professional will provide to the BLM and relevant operators a seal and signature on an affidavit of completion, according to the approved plans and specifications.

9.6 Other Design Guidelines

The BLM Manual Section 9113 – Roads (BLM 1985) and its Wyoming Supplement (BLM 1991), as well as other applicable manual sections, will be the guides for design elements such as horizontal and vertical alignment, curve super elevation, cross-section elements, earthwork design, drainage elements, cattle guards, signs and markers, sight distances, and staking.

The roadway structure that includes the sub-grade, the sub-base course (in some cases), and the base course (or the base course used as a surface course in the case of graded earth roads) must be strong enough to support HS-20 loadings (AASHTO specification) as required by BLM specifications or by engineer design where design exceeds BLM minimum requirements.

The special qualities of the particular road and its location govern how the structure is designed and built. In general, road surfacing varies in thickness according to various design factors. All cattle guards or other structures are to have a minimum curb-to-curb or rail-to-rail width (whichever is less) of 14 feet for single-lane roads and 24 feet for double-lane roads but, in all cases, not less than the nominal width of the adjacent travelway as measured at right angles to the travelway centerline. All structures will be designed for a minimum of HS-20 loading.

9.7 Maintenance

All roads in the Project Area will be maintained to BLM Manual 9113 specifications (BLM 1985, 1991) and the latest edition of the Gold Book (*Surface Operating Standards for Oil and Gas Exploration and Development*) (BLM 2007). Maintenance on collector roads is anticipated to occur at least twice per year, whereas local and resource road maintenance may be required only once annually. To foster a cooperative road planning process, when determined necessary by the BLM, Jonah Energy will enter into road agreements with the appropriate governing entity to ensure proper road use, planning, and maintenance. All roads required for the NPL Project will be maintained as necessary to provide all-weather access (e.g., grading, surface material application, snow plowing), and the operators will be responsible for these maintenance actions. Maintenance agreements developed among operators will be provided to the BLM. Where roads become impassable, the BLM may deny access until the roads are repaired and/or the potential for resource damage is otherwise alleviated.

9.8 Maintenance Agreements

Maintenance agreements are usually binding contracts between companies that handle road maintenance. The BLM generally does not enter into maintenance agreements with companies. The preferred approach is for companies to work together and adjudicate maintenance agreements amongst themselves or with other governing entities. Jonah Energy will provide the BLM with copies of all road maintenance agreements, including the name of a designated contact person. Non-project roads will be maintained by the BLM or other ROW holder. To foster a cooperative road planning process, when determined necessary by the BLM, Jonah Energy will enter into road agreements with the appropriate governing entity to ensure proper road use, planning, and maintenance.

Problems may occur with new operators in an area. Maintenance agreements must be revised to include new users. If a company is the first to drill in an area, that company may be the sole road maintainer until other companies begin to access the area. Agreements will be reviewed and budgets for maintenance prepared where new operators or users are identified. Meetings may be held with operators and other road users to review maintenance agreements. If a company only has a few roads, review may be made over the telephone with other participants, and then the contract can be mailed and notarized signatures obtained. When operators or other area users propose new activity that will use part or all of an existing road, maintenance agreements for existing roads must be restructured to include the new users.

Maintenance agreements will contain grading, surfacing, and other maintenance schedules; participant responsibilities; and cost allocation. Agreements will describe response methods and primary and secondary emergency contacts for hazard maintenance.

Operator responsibilities for road maintenance can be divided into at least three types of agreements. The principal maintenance agreement type weighs the maintenance cost share of each operator according to the amount of projected use of the road. The projected use can be based on past use, number of producing wells and facilities down-road, and wet weather access needs. The maintenance contract will have each operator's tallied amounts and commitments for the upcoming year. This agreement type will be the one most commonly used within the Project Area. Other types of agreements involve operators taking care of road maintenance on alternate

time intervals or dividing a road into segments of near equal maintenance amounts and assigning each operator maintenance responsibility for their segment of the road.

Snow removal is often considered as a separate item. Some operators may not need access to sites during the winter months and may not participate in costs associated with snow removal. In some cases, roads may only need maintenance once or twice per year or at some other time interval.

10.0 Operational Updates

Operational updates will be made to the BLM during project development to detail specific localized transportation networks, if deemed necessary by the BLM, in coordination with local counties and other appropriate entities. Updates will be provided on at least an annual basis by the operator. Operational update meetings will be initiated by the BLM if necessary. The operational meeting will include appropriate stakeholder representatives, as determined by the BLM, in joint conversations with local counties and other appropriate entities. Operational update meetings will be used to determine road design parameters for new and upgraded roads, road maintenance protocols and responsibilities, and solutions for other similar transportation issues. Design parameters for the road types proposed for the NPL Project will be commensurate with BLM Manual 9113 specifications (BLM 1985, 1991) and other applicable standards for road resign, repair, or maintenance determined by the governing jurisdiction.

11.0 References

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Normally Pressured Lance Natural Gas Development Project

Record of Decision

Appendix E

Biological Opinion

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
5353 Yellowstone Road, Suite 308A
Cheyenne, Wyoming 82009

JUN 1 3 2017

In Reply Refer To:
06E13000-2017-F-0260

Memorandum

To: District Manager, Bureau of Wildlife Management, High Desert District, Rock Springs Field Office, Rock Springs, Wyoming

From: Field Supervisor, U.S. Fish and Wildlife Service, Wyoming Field Office, Cheyenne, Wyoming

Subject: Jonah Energy, Normally-Pressured Lance Natural Gas Development Project: Colorado River Depletions

In accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*), and the Interagency Cooperation Regulations (50 CFR 402), this document transmits the U.S. Fish and Wildlife Service's (Service) biological opinion based on our review of the proposed Normally-Pressured Lance Natural Gas Development project (Project) located in Sublette County, Wyoming, and its effects on the endangered Colorado pikeminnow (*Ptychocheilus lucius*), humpback chub (*Gila cypha*), bonytail (*Gila elegans*), and razorback sucker (*Xyrauchen texanus*) and their designated critical habitat. This biological opinion is in response to the Bureau of Land Management's (BLM) March 23, 2017, request to initiate formal consultation for the Project.

The BLM intends to issue applications for permits to drill (APDs) for Jonah Energy to construct, drill, and complete up to 3,500 natural gas wells and issue a right of way grant (ROW) for the associated pipeline that crosses BLM land. Water from the Project will come from existing and new shallow groundwater wells within the top 1,000 feet of the Wasatch aquifer, and it is assumed these wells are hydrologically connected to the Colorado River Basin. The Service concurs that the proposed Project may adversely affect the endangered Colorado pikeminnow, humpback chub, bonytail, and razorback sucker, and their designated critical habitat.

We appreciate your efforts to ensure the conservation of endangered, threatened, and candidate species. If you have questions regarding this letter or your responsibilities under the ESA, please contact Lynn Gemlo of my office at the letterhead address or phone (307) 772-2374, ext. 228.

Attachment (Biological Opinion)

cc: BLM, Supervisory Wildlife Biologist, Rock Springs, WY (M. Snyder) (msnyder@blm.gov)
BLM, Threatened and Endangered Species Program Lead, Cheyenne, WY (C. Keefe) (ckeefe@blm.gov)
FWS, Assistant Director Colorado River Recovery Program, Lakewood, CO (A. Kantola) (angela_kantola@fws.gov)
WGFD, Statewide Nongame Bird and Mammal Program Supervisor, Lander, WY (Z. Walker) (zack.walker@wyo.gov)
WGFD, Statewide Habitat Protection Program, Cheyenne, WY (wgfd.hpp@wyo.gov)

BIOLOGICAL OPINION

FOR BUREAU OF LAND MANAGEMENT'S

NORMALLY-PRESSURED LANCE NATURAL GAS DEVELOPMENT

PROJECT

06E13000-2017-F-0260

Tyler A. Abbott, Field Supervisor

U.S. Fish and Wildlife Service
Wyoming Ecological Services Office
Cheyenne, Wyoming

June 13, 2017

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CONSULTATION HISTORY

On January 21-22, 1988, the Secretary of the Department of the Interior; the Governors of Wyoming, Colorado, and Utah; and the Administrator of the Western Area Power Administration signed a Cooperative Agreement to implement the "Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin" (USFWS 1987). In 2009, the Recovery Program was extended until September 30, 2023. The objective of the Recovery Program is to recover the listed species while water development continues in accordance with federal and state laws and interstate compacts.

In order to further define and clarify processes outlined in sections 4.1.5, 4.1.6, and 5.3.4 of the Recovery Program, a section 7 Agreement (Agreement) and a Recovery Implementation Program Recovery Action Plan (RIPRAP) was developed (USFWS 1993). The Agreement establishes a framework for conducting all future section 7 consultations on depletion impacts related to new projects and all impacts associated with historic projects in the Upper Basin. Procedures outlined in the Agreement are used to determine if sufficient progress is being accomplished in the recovery of the endangered fishes to enable the Recovery Program to serve as a reasonable and prudent alternative (RPA) to avoid jeopardy. The RIPRAP was finalized on October 15, 1993, and has been reviewed and updated annually.

In accordance with the 1993 Agreement, the Service annually assesses progress of the implementation of recovery actions to determine if progress toward recovery has been sufficient for the Recovery Program to serve as a RPA for projects that deplete water from the Colorado River. In the last review the Service determined that the Program has made sufficient progress to offset water depletions from individual projects up to 4,500 acre-feet/year. Therefore, it is appropriate for the Recovery Program actions to serve as Conservation Measures in the project description for projects up to 4,500 acre-feet/year.

After many years of successful implementation of the Recovery Program and Agreement, federal action agencies have come to anticipate Recovery Program activities and a requirement of a financial contribution (for new depletions greater than 100 acre-feet) toward these activities serving as RPAs that must be included in their project planning to avoid jeopardy to listed species. Thus, the RPA has essentially become part of the proposed action. The Recovery Program activities will now serve as conservation measures within the proposed action and minimize adverse effects to listed species or critical habitat. The following excerpts summarize portions of the Recovery Program that address depletion impacts, section 7 consultation, and Project proponent responsibilities:

> "All future section 7 consultations completed after approval and implementation of this program (establishment of the Implementation Committee, provision of congressional funding, and initiation of the elements) will result in a one-time contribution to be paid to the Service by water project proponents in the amount of $10.00 per acre-foot based on the average annual depletion of the project . . . This figure will be adjusted annually for inflation [the current figure for FY2017 is $20.89 per acre-foot] . . . Concurrently with the completion of the Federal action which initiated the consultation, e.g., . . . issuance of a 404 permit,

> 10 percent of the total contribution will be provided. The balance . . . will be . . . due at the time the construction commences . . . ."

It is important to note that these provisions of the Recovery Program were based on appropriate legal protection of the instream flow needs of the endangered Colorado River fishes. The Recovery Program further states:

> ". . . it is necessary to protect and manage sufficient habitat to support self-sustaining populations of these species. One way to accomplish this is to provide long term protection of the habitat by acquiring or appropriating water rights to ensure instream flows. Since this program sets in place a mechanism and a commitment to assure that the instream flows are protected under State law, the Service will consider these elements under section 7 consultation as offsetting project depletion impacts."

On March 23, 2017, BLM requested formal consultation for the Project. The BLM received the draft Biological Opinion for their review on May 24, 2017, and the BLM completed its review on May 30, 2017.

BIOLOGICAL OPINION

This biological opinion addresses an average annual depletion of approximately 455.2 acre-feet of water from the Upper Colorado River Basin. Water depletions in the Upper Basin have been recognized as a major source of impact to endangered fish species. Continued water withdrawal has restricted the ability of the Colorado River system to produce flow conditions required by various life stages of the fishes.

Critical habitat has been designated for the Colorado pikeminnow, humpback chub, bonytail, and razorback sucker within the 100-year floodplain in portions of their historic range (59 FR 13374). On February 11, 2016 the Service published a final rule establishing a new regulatory definition (FR Feb. 11, 2016, Vol. 81, No.28) for destruction or adverse modification of critical habitat, which means a direct or indirect alteration that appreciably diminishes the value of critical habitat. In considering the biological basis for designating critical habitat, the Service focused on the primary physical or biological features that are essential to the conservation of the species without consideration of land or water ownership or management. The Service has identified water, physical habitat, and biological environment as the primary constituent elements. This includes a quantity of water of sufficient quality that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species. Water depletions reduce the ability of the river system to provide the required water quantity and hydrologic regime necessary for recovery of the fishes. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year flood plain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats.

DESCRIPTION OF THE PROPOSED ACTION

ACTION AREA

Our regulations define the action area as all areas directly or indirectly affected by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). Water depletions associated with the proposed Normally-Pressured Lance Natural Gas Development project (Project) will result in a loss of water from the Upper Colorado River Basin.

PROJECT DESCRIPTION

The Bureau of Land Management (BLM) Pinedale and Rock Springs Field Offices intends to issue applications for permits to drill (APDs) for Jonah Energy to construct, drill, and complete up to 3,500 natural gas wells and issue a right of way grant (ROW) for the associated pipeline that crosses BLM land (Project). While the natural gas wells have a life expectancy of 30 years, the average annual water depletion is based on the "time of use," which is 10.4 years for this Project. The maximum annual depletion of 455.2 acre-feet for the Project will come from existing and new shallow groundwater wells within the top 1,000 feet of the Wasatch aquifer, and it is assumed these wells are hydrologically connected to the Colorado River Basin. The Project will use an additional 15.9 acre-feet per year during years 10.4 to 40 for road maintenance and dust control. While the maximum annual depletion is 455.2 acre-feet, the Project will use 5,211.1 acre-feet over 40 years. Consumptive water use for this Project includes the construction, drilling, completion, and dust abatement of up to 3,500 new natural gas wells. The Project will be located in portions of T27N R108W, T27N R109W, T28N R108W, T28N R109W, T29N R108W, and T29N R109W, in Sublette County, Wyoming.

CONSERVATION MEASURES

Conservation measures are actions that the action agency and applicant agree to implement to further the recovery of the species under review. The beneficial effects of conservation measures are taken into consideration for determining both jeopardy and adverse modification analyses. As explained in the Consultation History section, the Recovery Program is intended to implement actions that are needed to recover the endangered fishes and avoid jeopardy and adverse modification of critical habitat. Included in the Recovery Program is a requirement for project proponents of projects that cause water depletions greater than 100 acre-feet per year to make monetary contributions to the Recovery Program. The BLM agrees to incorporate any required contribution as a condition of any permit or right of way grant. The conservation measures for this project are below:

The Recovery Program will serve as conservation measures to minimize adverse effects to the endangered fishes and their critical habitat caused by the Project's water depletions. Depletion impacts can be offset by accomplishment of activities necessary to recover the endangered fishes as specified under the Recovery Implementation Program Recovery Action Plan (RIPRAP) and the Project proponent's one-time contribution to the Recovery Program for new depletions greater than 100 acre-feet per year.

NEW DEPLETION

As the project's average annual new depletion of 455.2 acre-feet is below the current sufficient progress threshold of 4,500 acre-feet, the Recovery Program will serve as conservation measures to minimize adverse effects to the Colorado pikeminnow, razorback sucker, humpback chub, and bonytail and designated critical habitat caused by the Project's new depletion.

With respect to the depletion contribution the applicant will make a one-time payment which has been calculated by multiplying the Project's average annual depletion (acre-feet) by the depletion charge in effect at the time payment is made. For Fiscal Year 2017 (October 1, 2016, to September 30, 2017), the depletion charge is $20.89 per acre-foot for the average annual depletion which equals a total payment of $9,509.12 for this Project. Ten percent of the total payment (i.e., $950.91 will be provided to the Service's designated agent, the National Fish and Wildlife Foundation (Foundation), at the time of issuance of the federal approvals from the BLM. The balance will be due at the time the construction commences. The payment will be included by the BLM as a condition of permit or grant. The amount payable will be adjusted annually for inflation on October 1 of each year based on the Composite Consumer Price Index. Funds may be submitted to the National Fish and Wildlife Foundation by check or electronic funds transfer (EFT):

Deposits by check shall be sent to:

National Fish and Wildlife Foundation
1133 15th Street NW, Suite 1000
Washington, D.C. 20005
Attn: Chief Financial Officer

The payment will be accompanied by a cover letter that identifies the project and biological opinion number (**06E13000-2017-F-0260**) that requires the payment, the amount of payment enclosed, check number, and the following notation on the check – "Upper CO Fish Recovery IM.A131." The cover letter also shall identify the name and address of the payor, the name and address of the federal agency responsible for authorizing or funding the Project, and the address of the Service office issuing the biological opinion. This information will be used by the Foundation to notify BLM and the Service that payment has been received. The Foundation is to send notices of receipt to these entities within five (5) working days of its receipt of payment.

To make deposits by EFT, please contact:

Michelle Olson
Manager, Impact-Directed Environmental Accounts
National Fish and Wildlife Foundation
1133 15th Street NW, Suite 1000
Washington, D.C. 20005
202-595-2437 (direct)
202-857-0162 (fax)
michelle.olson@nfwf.org

All deposits must include a notation identifying the name of the project for which the deposit is being made.

STATUS OF THE SPECIES AND CRITICAL HABITAT

The purpose of this section is to summarize the best available information regarding the current range wide status of the listed fish species. Additional information regarding listed species may be obtained from the sources of information cited for these species[1].

COLORADO PIKEMINNOW

SPECIES DESCRIPTION

The Colorado pikeminnow (*Ptychocheilus lucius*) is the largest cyprinid fish (minnow family) native to North America and evolved as the main predator in the Colorado River system. Individuals begin consuming other fish for food at an early age and rarely eat anything else (Sigler and Sigler 1996). It is a long, slender, cylindrical fish with silvery sides, greenish back, and creamy white belly (Sigler and Sigler 1996). Historically, individuals may have grown as large as 6 feet long and weighed up to 100 pounds (estimates based on skeletal remains) (Sigler and Miller 1963), but today individuals rarely exceed 3 feet or weigh more than 18 pounds (Osmundson et al. 1997).

The species is endemic to the Colorado River Basin, where it was once widespread and abundant in warm water rivers and tributaries from Wyoming, Utah, New Mexico, and Colorado downstream to Arizona, Nevada, and California (multiple citations in U.S. Fish and Wildlife Service 2002b). Currently, wild populations of pikeminnow occur only in the Upper Colorado River Basin (above Lake Powell) and the species occupies only 25 percent of its historic range-wide habitat (U.S. Fish and Wildlife Service 2002b). Colorado pikeminnow are long distance migrators, moving hundreds of miles to and from spawning areas, and requiring long sections of river with unimpeded passage. They are adapted to desert river hydrology characterized by large spring peaks of snow-melt runoff and low, relatively stable base flows.

The Office of Endangered Species first included the Colorado pikeminnow (as the Colorado squawfish) in the List of Endangered Species on March 11, 1967 (32 FR 4001). It is currently protected under the Endangered Species Act of 1973 as an endangered species throughout its range, except the Salt and Verde River drainages in Arizona. The Service finalized the latest recovery plan for the species in 2002 (U.S. Fish and Wildlife Service 2002b) but is currently drafting an updated revision.

The Service designated six reaches of the Colorado River System as critical habitat for the Colorado pikeminnow on March 21, 1994 (59 FR 13374). These reaches total 1,148 miles as measured along the center line of each reach. Designated critical habitat makes up about 29 percent of the species' historic range and occurs exclusively in the Upper Colorado River Basin. Portions of the Colorado, Gunnison, Green, Yampa, White, and San Juan Rivers are designated critical habitat. The primary constituent elements of the critical habitat are water, physical habitat, and the biological environment (59 FR 13374).

[1] The latest recovery goals for all four endangered fish, which provide information on species background, life history, and threats, can be found on the internet at: http://www.coloradoriverrecovery.org/documents-publications/foundational-documents/recovery-goals.html

Water includes a quantity of water of sufficient quality delivered to a specific location in accordance with a hydrologic regime required for the species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. This includes oxbows, backwaters, and other areas in the 100-year floodplain that provide access to spawning, nursery, feeding, and rearing habitats when inundated. The biological environment includes food supply, predation, and competition from other species.

Recovery of Colorado pikeminnow in the Colorado River Basin is considered necessary only in the Upper Colorado River Basin (above Glen Canyon Dam, including the San Juan, and Green River sub-basins) because of the present status of populations and because existing information on Colorado pikeminnow biology supports application of the metapopulation concept to extant populations (U.S. Fish and Wildlife Service 2002b). As a result, this biological opinion will focus on the status of the Colorado pikeminnow in that unit.

LIFE HISTORY

The Colorado pikeminnow requires relatively warm waters for spawning, egg incubation, and survival of young. Males become sexually mature at approximately 6 years of age, which corresponds to a length of about 400 millimeters (mm) (17 inches), and females mature one year later (Sigler and Sigler 1996).

Mature adults migrate to established spawning areas in late spring as water temperatures begin to warm, with migration events up to 745 river kilometers (km) round-trip on record (463 miles) (Bestgen et al. 2005). Spawning typically begins after peak flows have subsided and water temperatures are above 16° Celsius (°C) (60.8° Fahrenheit (°F)) (multiple references in Bestgen et al. 2005). Mature adults deposit eggs over gravel substrate through broadcast spawning and eggs generally hatch within 4 to 6 days (multiple references in Bestgen et al. 2005). River flows then carry emerging larvae fish (6.0 to 7.5 mm long (0.2 to 0.3 inches)) downstream 40 to 200 km (25 to 125 miles), to nursery backwaters, where they remain for the first year of life (U.S. Fish and Wildlife Service 2002b).

Colorado pikeminnow reach lengths of approximately 70 mm by age 1 (juveniles) (2.8 inches), 230 mm by age 3 (subadults) (9 inches), and 420 mm by age 6 (adults) (16.5 inches), with mean annual growth rates of adult and subadult fish slowing as fish become older (Osmundson et al. 1997). The largest fish reach lengths between 900 and 1000 mm (35 to 39 inches); these fish are quite old, likely being 47 to 55 years old with a minimum of 34 years (Osmundson et al. 1997).

Reproductive success and recruitment of Colorado pikeminnow is pulsed, with certain years having highly successful productivity and other years marked by failed or low success (U.S. Fish and Wildlife Service 2002b). The most successful years produce a large cohort of individuals that is apparent in the population over time. Once individuals reach adulthood, approximately 80 to 90 percent of adults greater than 500 mm (20 inches) survive each year (Osmundson et al. 1997; Osmundson and White 2009). Strong cohorts, high adult survivorship, and extreme longevity are likely life history strategies that allow the species to survive in highly variable ecological conditions of desert rivers.

POPULATION DYNAMICS

Population dynamics of the Colorado pikeminnow are measured separately in the Green, upper Colorado, and San Juan River basins, because distinct recovery criteria are delineated for each of these three basins (U.S. Fish and Wildlife Service 2002b). In the 2002 recovery plan, initial abundance estimates for wild adults in the basins were: upper Colorado River, 600 to 900; Green River, 6,000 to 8,000; and San Juan River, 19 to 50 (circa 2000 references for individual rivers found in U.S. Fish and Wildlife Service 2002b).

UPPER COLORADO RIVER – To monitor recovery of the Colorado pikeminnow, the Recovery Program conducts multiple-pass, capture-recapture sampling on two stretches of the upper Colorado River which are roughly above and below Westwater Canyon (Osmundson and White 2009). In the most recent summary of the data (Osmundson and White 2013, in draft) the principal investigators conclude that during the 19-year study period [1992-2010], the population remained self-sustaining. The current downlisting demographic criteria for Colorado pikeminnow (U.S. Fish and Wildlife Service 2002b) in the Upper Colorado River Subbasin is a self-sustaining population of at least 700 adults maintained over a 5-year period, with a trend in adult point estimates that does not decline significantly. Secondarily, recruitment of age-6 (400-449 mm Total Length (TL)), naturally produced fish must equal or exceed mean adult annual mortality (estimated to be about 20 percent). The average of all adult estimates (1992-2010) is 644. The average of the five most recent annual adult population estimates is 658. Osmundson and White (2014) determined that recruitment rates were less than annual adult mortality in six years and exceeded adult mortality in the other six years when sampling occurred. The estimated net gain for the 12 years studied was 32 fish >450 mm TL. Whereas the Colorado River population appears to meet the trend or 'self-sustainability' criterion, it has not met the abundance criteria of 'at least 700 adults' during the most recent five year period (Figure 1). Updated graphs of Colorado pikeminnow abundance in the Colorado River are shown in Figure 1 (adults) and Figure 2 (subadults) (Service 2015a).

Here we review some anecdotal life history information gleaned from recent Recovery Program annual reports to more fully describe the current state of the Colorado pikeminnow population in the Colorado River Subbasin. Colorado pikeminnow population size structure has been consistently tracked through time (Osmundson and White 2014). Elverud and Ryden (2015) report that of the 203 individual Colorado pikeminnow collected in 2015, 81 (40%) were

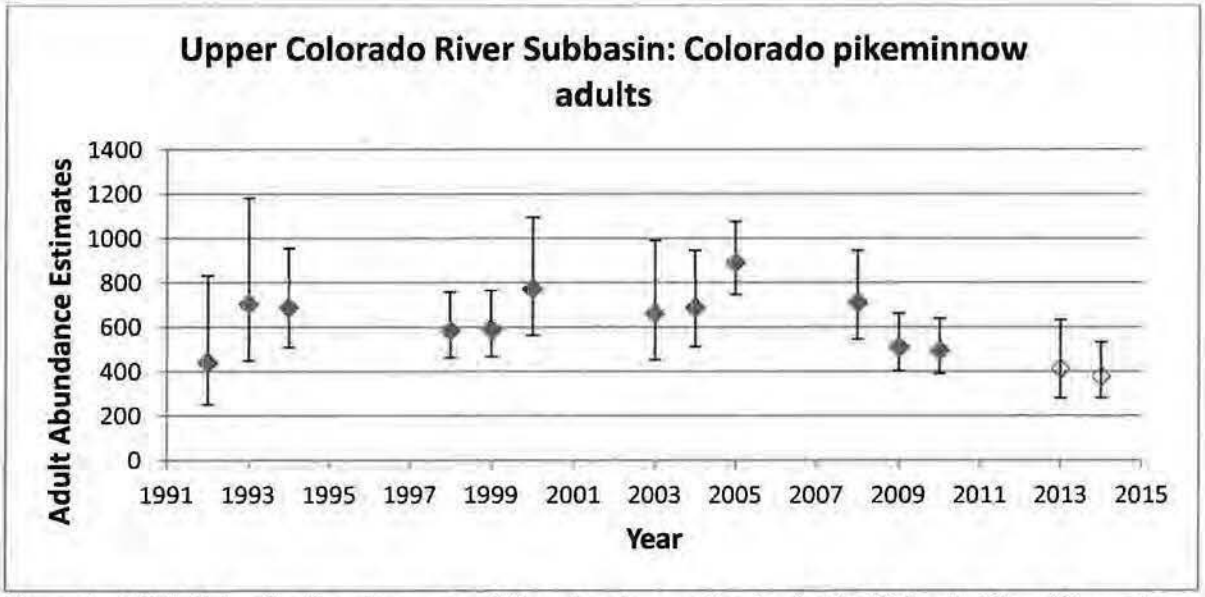

Figure 1. Adult Colorado pikeminnow population abundance estimates for the Colorado River (Osmundson and Burnham 1998; Osmundson and White 2009; 2014). Error bars represent the 95 percent confidence intervals. The 2013-2015 data are preliminary and represented by hollow data points.

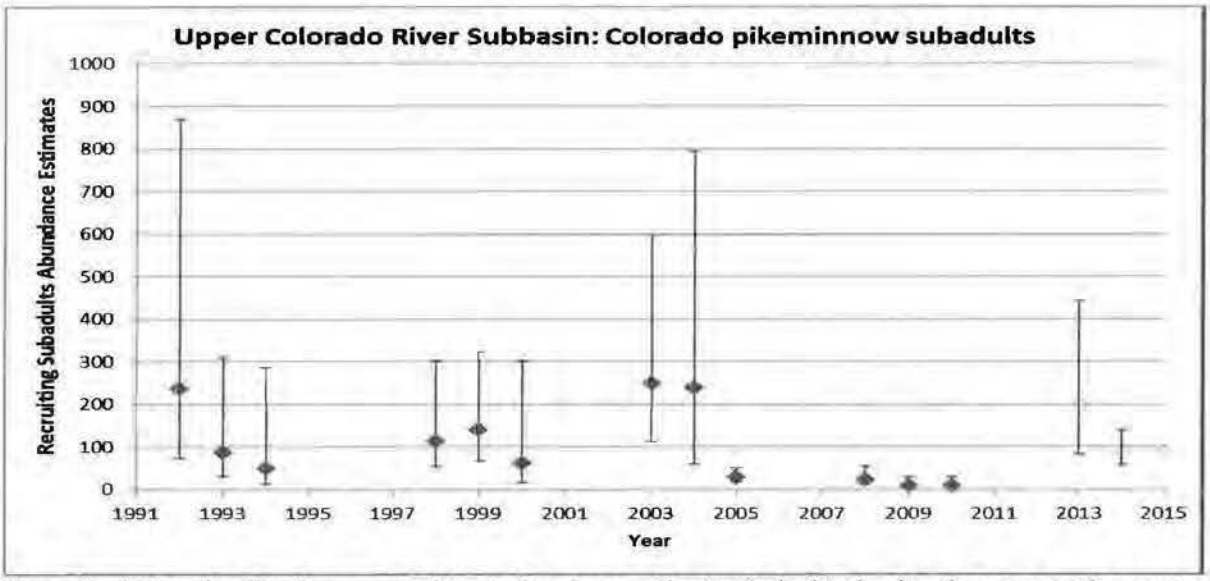

Figure 2. Colorado pikeminnow recruitment abundance estimates (calculated using the same mark recapture methodology as for the adults) for the Colorado River (Osmundson and White 2009, 2014; Service 2015a). Recruits are age-6 (400-449mm TL). Error bars represent the 95 percent confidence intervals. The 2013-2015 data are preliminary and represented by hollow data points.

juvenile fish (<399 mm TL), indicating a pulse of sub-adults recruiting into the adult portion of the population. All of the 81 individual juvenile Colorado pikeminnow were between 300–399 mm TL. Twenty (10%) of the 203 individual Colorado pikeminnow were sub-adults (400-449 mm TL). The remaining 102 individual Colorado pikeminnow captured in 2015 were adult size (>450 mm TL). The adult Colorado pikeminnow ranged from 451 mm TL to 928 mm TL. No Colorado pikeminnow were collected in 2015 that were below the minimum size (150 mm TL) to be PIT-tagged. A healthy number of Colorado pikeminnow spawned 4-5 years ago are poised to enter the adult cohort. These recruit-sized Colorado pikeminnow present in the system today

have largely made it through the gauntlet of troublesome densities of smallmouth bass and the relatively recent influx of nonnative walleye in the lower Colorado River. However, Recovery Program researchers can only speculate how much stronger the current pulse of recruitment would have been in the absence of these nonnative predators. Nonnative predation and competition is currently considered the greatest threat to the Colorado pikeminnow population in the Colorado River Subbasin.

Elverud and Ryden (2015) cautioned that the absence of Colorado pikeminnow less than 300 mm TL in the collections from 2015 suggests spawning success and/or recruitment has been poor the previous three years. Osmundson and White (2014) also expressed concern that pulses of recruitment in this population are too infrequent to provide the recruitment needed to offset adult mortality in the long term. However, some encouraging captures of age-0 Colorado pikeminnow in recent years, particularly in 2015, are discussed below.

To summarize, in the Upper Colorado River Subbasin, the Colorado pikeminnow subpopulation may be self-sustaining, but the number of adults is below the level needed for recovery. Recruitment is quite variable over time, but has exceeded adult mortality in approximately half of the years when measured over the past two decades. The number of age-0 (young of year) Colorado pikeminnow is also quite variable over time, but appears to be less, on average, since the year 2000 than prior to 2000. Colorado pikeminnow are also generally distributed throughout the Colorado River now to the same extent that they were when they became listed.

GREEN RIVER – Population estimates for adult Colorado pikeminnow in the Green River subbasin began in 2000. Sampling occurs on the mainstem Green River from the Yampa confluence to the confluence with the Colorado River and includes the Yampa and White Rivers. The initial year of sampling did not include the lower Green River (near the confluence of the White River to the confluence with the Colorado River). Beginning in 2001, the sampling regime has consisted of three years of estimates followed by two years of no estimates (Bestgen et al. 2005). The first set of estimates showed a declining trend (2000-2003); however, the most recent interpretation (Bestgen et al.; in review) of estimates collected in 2006-2008 and 2011-2013 reveal a gradual but persistent decline in the adult population (Figure 3). Data from the third round (2011-2013) of population estimates for the Green River subbasin are still being analyzed (thus no confidence intervals are shown for the 2011-2013 estimates in Figure 3) (Bestgen et al. 2013). Preliminary results from Bestgen (2013) analysis indicate adults and sub-adults are decreasing throughout the entire Green River subbasin (U.S. Fish and Wildlife Service 2014b).

The downlisting demographic criteria for Colorado pikeminnow in the Green River Subbasin require that separate adult point estimates for the middle Green River (including the Yampa and White river sub-populations) and lower Green River do not decline significantly over a 5-year period, and each estimate for the Green River Subbasin exceeds 2,600 adults (estimated minimum viable population [MVP] number). The average of all estimates (1991-2013; including the CPUE-derived estimates) is 3,083 adult Colorado pikeminnow. The average of the more robust M/R population estimates (2000-2013) is 2,859 adults. The average of the three most recent M/R population estimates (2011-2013) is 1,999 adults. Despite a positive trend in the subbasin population in the early years of the Recovery Program (1991-2000), the most recent trend is clearly negative (causes for this recent decline and the Recovery Program's responses are discussed below).

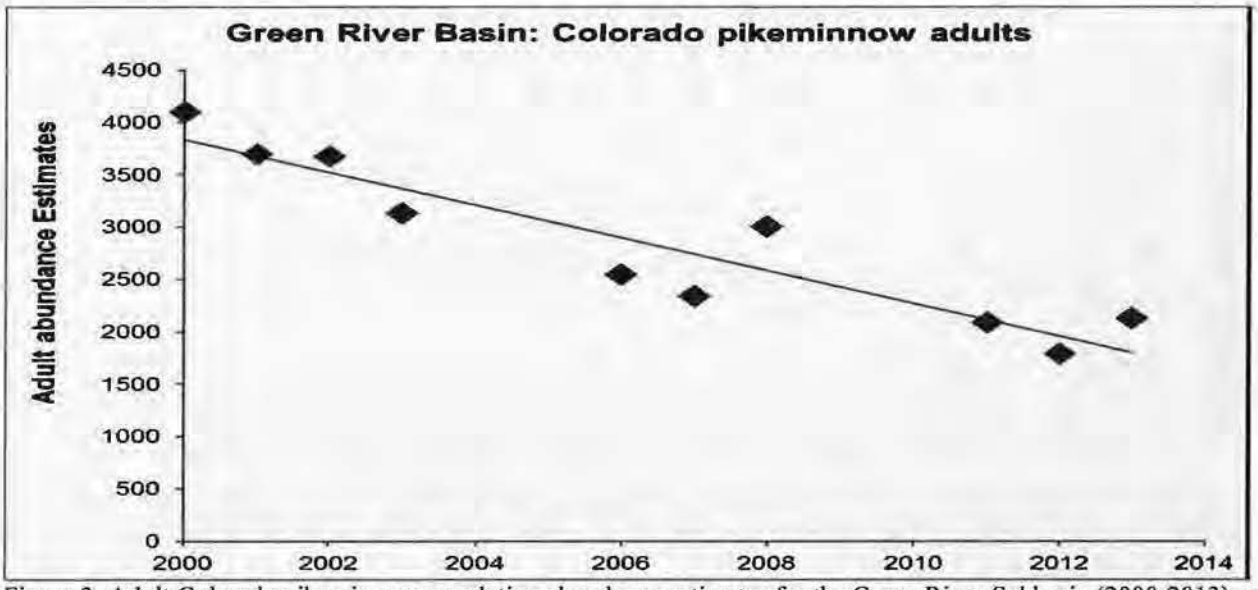

Figure 3. Adult Colorado pikeminnow population abundance estimates for the Green River Subbasin (2000-2013) as reported in Bestgen et al. 2016 (in review). The recent model runs caused recalculation of some earlier (2000-2008) estimates; 95% confidence intervals not available at this time. In 2000, the lower Green River was not sampled. The data depicted for 2000 incorporates an extrapolated lower Green River contribution to the overall population estimate.

Population estimation resumed throughout the Green River Subbasin in 2016 and will continue in 2017 and 2018. Another demographic requirement in the 2002 Recovery Goals is that recruitment of age-6; naturally-produced fish must equal or exceed mean annual adult mortality. Estimates of recruitment age fish (subadults; 400-449mm TL) have averaged 1,455 since 2001, but have varied widely (Figure 4). Recruitment exceeded annual adult mortality only during the 2006-2008 periods. The numbers of recruits throughout the Green River Subbasin were high in 2011, but declined in subsequent years.

Bestgen et al. 2016 (in review) recognized that the mechanism driving frequency and strength of recruitment events was likely the strength of age-0 Colorado pikeminnow production in backwater nursery habitats. More specifically, they recognized the importance of considering multiple consecutive years of age-0 densities to describe adult densities 7-10 years later. Osmundson and White (2014) saw a similar relationship between a strong age-0 cohort in 1986 and subsequent recruitment of late juveniles five years later, but that relationship was more tenuous in later years. Researchers are particularly concerned with what appears to be very weak age-0 representation in the Middle Green reach (1994 through 2008) and in the lower Colorado River (2001 through 2008) (Figure 5). Bestgen and Hill (2016) reviewed fall densities of age-0 Colorado pikeminnow collected in the middle and lower Green River that date back to 1979. They compared those densities to August and September base flows and discovered that declines in summer base flow magnitude were correlated with declining densities of age-0 Colorado pikeminnow in both reaches. As a result, they recommended new base flow magnitudes to support increased age-0 production. Specifically, base flows between 1,700-3,000 cfs in the middle Green River, and 1,700-3,800 cfs in the lower Green River, increase the frequency and magnitude of age-0 Colorado pikeminnow production.

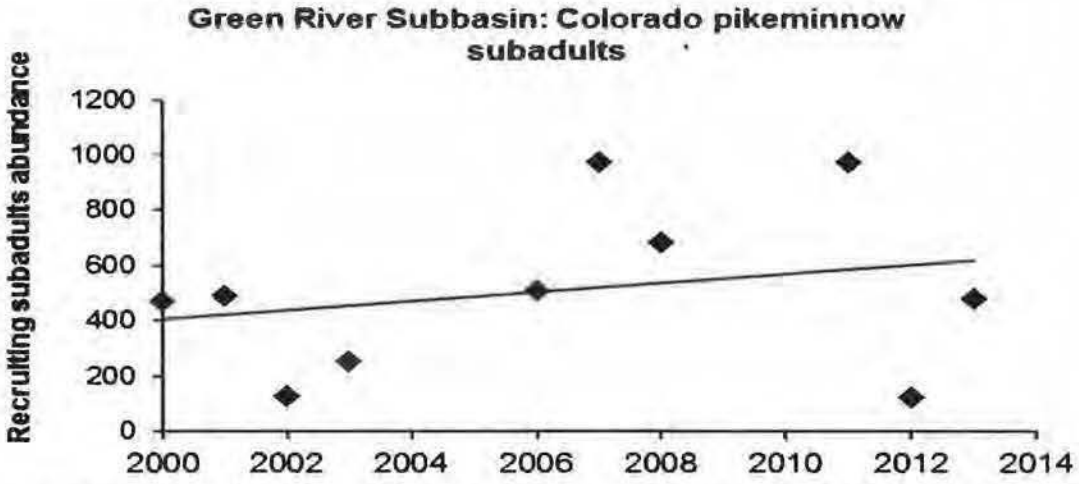

Figure 4. Estimated numbers of Colorado pikeminnow recruits (400-449 mm TL) in the Green River subbasin (Yampa, White, Middle Green, Desolation-Gray Canyons, and Lower Green) for 2001-2013. Data from Bestgen et al. 2016 (in review).

SAN JUAN RIVER – Unlike the Green and upper Colorado River Basins, wild Colorado pikeminnow are extremely rare in the San Juan River. The majority of individuals come from hatchery reared stocks supported by the San Juan River Recovery Implementation Program. This program has stocked more than 2 million age 0 and age 1+ fish in the San Juan River since 2002 (Furr and Davis 2009). No wild adults were collected since 2000 (Elverud 2008) and only five wild-spawned pikeminnow larvae were collected since 2002 (two in 2004; three in 2007) (Brandenburg and Farrington 2009).

Monitoring for adult Colorado pikeminnow currently occurs every year on the San Juan River. In 2013, 149 Colorado pikeminnow were collected during monitoring from RM 180-77, the eighth consecutive year that more than 100 Colorado pikeminnow were caught in this reach (Schleicher 2014). However, only 7 of these fish were greater than 450 mm (18 inches). In addition, 19 Colorado pikeminnow greater than 450 mm (18 in) were collected during the non-native fish removal trips in 2013 (Duran et al. 2014). In order to downlist the species, the San Juan River population of Colorado pikeminnow must reach at least 1,000 Age-5 fish (U.S. Fish and Wildlife Service 2002b).

The majority of individuals come from hatchery reared stocks supported by the San Juan River Recovery Implementation Program. This program has stocked more than 2 million age 0 and age 1+ fish in the San Juan River since 2002 (Furr and Davis 2009). River wide population estimates for age-2+ pikeminnow that have been in the San Juan River at least one year was approximately 4,600 and 5,400 individuals in 2009 and 2010, respectively (Duran et al. 2010; 2013). However, because few adult Colorado pikeminnow were detected in the San Juan River, this population estimate largely consists of juveniles. Other Colorado pikeminnow abundance estimates exhibit substantial annual variation, likely due to the effects of short-term retention from recent stocking events, but no clear population trends were evident in the San Juan River Basin (Durst 2014). Successful Colorado pikeminnow reproduction was documented in the San Juan River in 1993, 1995, 1996, 2001, 2004, 2007, 2009-2011, and 2013. A total of 58 larval Colorado pikeminnow were collected since 1993 (Farrington and Brandenburg 2014); however,

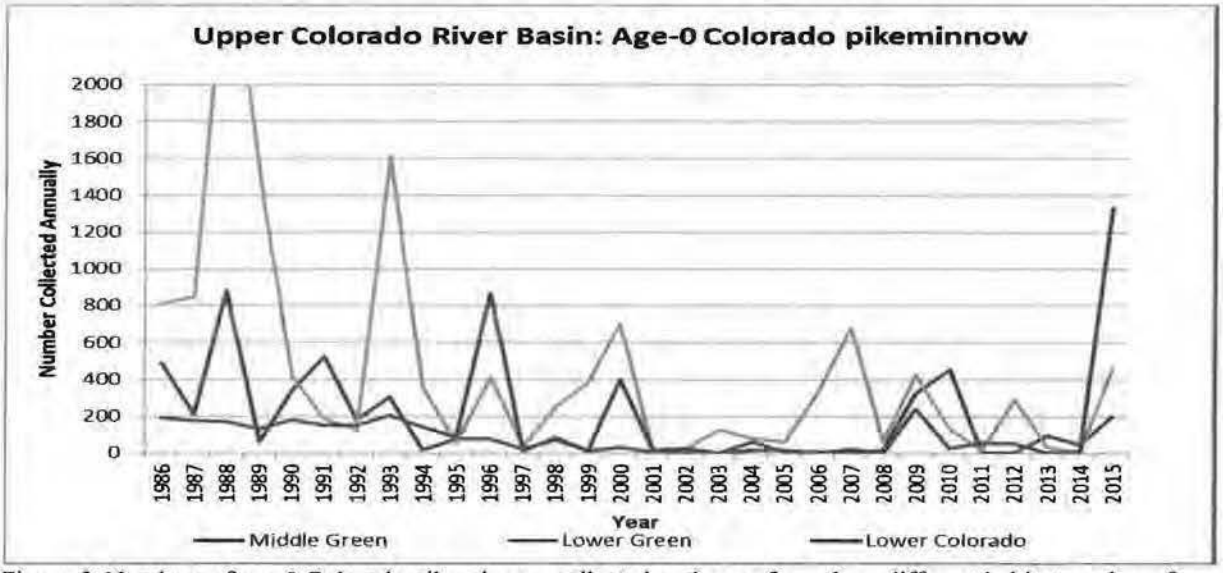

Figure 5. Numbers of age-0 Colorado pikeminnow collected each year from three different habitat reaches of river. A total of 2,892 age-0 fish were collected in the lower Green River in 1988 (Data from Breen et al. 2015.)

there has been little to no recruitment documented in the San Juan River. A total of 48 Age-1+ Colorado pikeminnow were collected in 2013; all presumably the result of augmentation efforts (Farrington and Brandenburg 2014). Since 1998, Colorado pikeminnow were collected during small-bodied monitoring every year except 2001-2003; however, young of year (YOY) Colorado pikeminnow were stocked in each of these years prior to monitoring efforts so these fish were likely hatchery-reared (U.S. Fish and Wildlife Service 2015b). Larval Colorado pikeminnow detections occurred throughout the San Juan River from Reach 4 (RM 106-130) downstream to Reach 1 (RM 0-16) (Farrington and Brandenburg 2014, U.S. Fish and Wildlife Service 2015b). Franssen et al. (2007) found that maintenance of a natural flow regime favored native fish reproduction and provided prey at the appropriate time for Age-1 Colorado pikeminnow.

Tissue samples from Colorado pikeminnow caught during research conducted under the Recovery Program have been analyzed as part of a basin-wide analysis of endangered fish genetics. The results of that analysis indicate that the San Juan River fish exhibit less genetic variability than the Green River and Colorado River populations, likely due to the small population size, but they were very similar genetically to pikeminnow from the Green, Colorado, and Yampa rivers (Morizot in litt. 1996). These data suggest that the San Juan population is probably not a separate genetic stock (Holden and Masslich 1997; Houston et al. 2010).

BASIN-WIDE STATUS AND DISTRIBUTION

The Colorado pikeminnow was designated as an endangered species prior to enactment of the ESA, and therefore a formal listing package identifying threats was not assembled. Construction and operation of mainstem dams, nonnative fish species, and local eradication of native minnows and suckers in advance of new human-made reservoirs in the early 1960's were recognized as early threats (references in U.S. Fish and Wildlife Service 2002b). According to the 2002 Recovery Goals for the species, the primary threats to Colorado pikeminnow populations are streamflow regulation and habitat modification (including cold-water dam releases, habitat loss, and blockage of migration corridors); competition with and predation by nonnative fish species;

and pesticides and pollutants (U.S. Fish and Wildlife Service 2002b). No new threats have emerged since the completion of this document.

As described in previous sections, Colorado pikeminnow are restricted to a portion of their historical range. Within currently occupied habitat, population trends are variable, with periods of noticeable decline, such as the early 2000s, and periods of population increase, such as the late 2000s. The current estimated population numbers in all three upper Colorado sub-basins are below estimates from the late 1990s, indicating that populations have not fully rebounded from the early 2000 population decline.

Based on data collected in 2006–2008 (Bestgen et al. 2010), suspected that nonnative northern pike were suppressing numbers of Colorado pikeminnow in the Yampa River where northern pike outnumbered Colorado pikeminnow at least 3:1. Results from 2011-2013 indicate that the Yampa River portion of the Green River Colorado pikeminnow population continued to decline (Bestgen et al. 2016; in review). Furthermore, Bestgen et al. 2016 (in review) now report that the decline in adult and subadult Colorado pikeminnow has spread through the entire Green River Subbasin.

Nonnative walleye have recently invaded the lower and middle Green River and the lower Colorado River. Possible sources include Lake Powell, Rifle Gap Reservoir in the upper Colorado River drainage and Starvation and Red Fleet reservoirs in the middle Green River drainage. In 2013, the Recovery Program recognized the need to expand an already expansive in-river removal program to target this species.

Major declines in Colorado pikeminnow populations occurred during the dam-building era of the 1930s through the 1960s. Behnke and Benson (1983) summarized the decline of the natural ecosystem, pointing out that dams, impoundments, and water use practices drastically modified the river's natural hydrology and channel characteristics throughout the Colorado River Basin. Dams on the mainstem broke the natural continuum of the river ecosystem into a series of disjunct segments, blocking native fish migrations, reducing temperatures downstream of dams, creating lacustrine habitat, and providing conditions that allowed competitive and predatory nonnative fishes to thrive both within the impounded reservoirs and in the modified river segments that connect them. The highly modified flow regime in the lower basin coupled with the introduction of nonnative fishes decimated populations of native fish.

Major declines of native fishes first occurred in the lower basin where large dams were constructed from the 1930s through the 1960s. In the Upper Basin, the following major dams were not constructed until the 1960s: Glen Canyon Dam on the mainstem Colorado River, Flaming Gorge Dam on the Green River, Navajo Dam on the San Juan River, and the Aspinall Unit Dams on the Gunnison River. To date, some native fish populations in the Upper Basin have managed to persist, while others have become nearly extirpated. River segments where native fish have declined more slowly than in other areas are those where the hydrologic regime most closely resembles the natural condition, such as the Yampa River, where adequate habitat for important life phases still exists, and where migration corridors are unblocked and allow connectivity among life phases.

RAZORBACK SUCKER

SPECIES DESCRIPTION

The largest native sucker to the western United States, the razorback sucker (*Xyrauchen texanus*) is a robust, river catostomid endemic to the Colorado River Basin (Sigler and Sigler 1996; U.S. Fish and Wildlife Service 2002d). The species feeds primarily on algae, aquatic insects, and other available aquatic macroinvertebrates using their ventral mouths and fleshy lips (Sigler and Sigler 1996). Adults can be identified by olive to dark brown coloration above, with pink to reddish brown sides and a bony, sharp-edged dorsal keel immediately posterior to the head, which is not present in the young (Sigler and Sigler 1996). The species can reach lengths of 3 feet and weights of 16 pounds (7.3 kg), but the maximum weight of recently captured fish is 11 to 13 pounds (5 to 6 kg) (Sigler and Sigler 1996; U.S. Fish and Wildlife Service 2002d). Taxonomically, the species is unique, belonging to the monotypic genus Xyrauchen, meaning that razorback sucker is the only species in the genus (U.S. Fish and Wildlife Service 2002d).

Historically, the razorback sucker occupied the mainstem Colorado River and many of its tributaries from northern Mexico through Arizona and Utah into Wyoming, Colorado, and New Mexico (U.S. Fish and Wildlife Service 2002b). In the late 19th and early 20th centuries, it was abundant in the Lower Colorado River Basin and common in parts of the Upper Colorado River Basin, with numbers apparently declining with distance upstream (U.S. Fish and Wildlife Service 2002b). Bestgen (1990) reported that this species was once so numerous that it was commonly used as food by early settlers and that a commercially marketable quantity was caught in Arizona as recently as 1949. Distribution and abundance of razorback sucker declined throughout the 20th century across its historic range, and the species now exists naturally only in a few small, unconnected populations or as dispersed individuals. Specifically, razorback sucker are currently found in small numbers in the Green River, upper Colorado River, and San Juan River sub-basins; the lower Colorado River between Lake Havasu and Davis Dam; Lakes Mead and Mohave; in small tributaries of the Gila River sub-basin (Verde River, Salt River, and Fossil Creek); and in local areas under intensive management such as Cibola High Levee Pond, Achii Hanyo Native Fish Facility, and Parker Strip (U.S. Fish and Wildlife Service 2002b).

The razorback sucker is listed as endangered under the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et. seq.), under a final rule published on October 23, 1991 (56 FR 54957). The Service finalized the latest recovery plan for the species in 2002 (U.S. Fish and Wildlife Service 2002d) but is currently drafting an updated revision.

The Service's 5-year status review of razorback sucker completed in 2012 reported that 85% of the downlisting recovery factor criteria (U.S. Fish and Wildlife Service 2002c) have been addressed to varying degrees. The Recovery Program (in coordination with the San Juan River Basin Recovery Implementation Program, the Glen Canyon Dam Adaptive Management Program, and the Lower Colorado River Multi-Species Conservation Program) initiated a Species Status Assessment in 2015, which should be completed in FY17. This SSA will serve as the basis for a 5-year status review to be completed the same year.

Fifteen reaches of the Colorado River system were designated as critical habitat for the razorback sucker on March 21, 1994 (59 FR 13374). These reaches total 2,776 km (1,724 miles) as measured along the center line of the river within the subject reaches. Designated critical habitat

makes up about 49 percent of the species' original range and occurs in both the Upper and Lower Colorado River Basins. In the Upper Basin, critical habitat is designated for portions of the Green, Yampa, Duchesne, Colorado, White, Gunnison, and San Juan Rivers. Portions of the Colorado, Gila, Salt, and Verde Rivers are designated in the Lower Basin. The primary constituent elements are the same as those described for Colorado pikeminnow.

Separate, objective recovery criteria were developed for each of two recovery units (the Upper Colorado and Lower Colorado River Basins as delineated at Glen Canyon Dam) to address unique threats and site specific management actions necessary to minimize or remove those threats. This biological opinion's focus is on the Upper Colorado River Basin recovery unit and will therefore describe the status of the razorback sucker in that unit.

LIFE HISTORY

Except during periods before and after spawning, adult razorback sucker are thought to be relatively sedentary and have high fidelity to overwintering sites (U.S. Fish and Wildlife Service 2002d). Adults become sexually mature at approximately 4 years and lengths of 400 mm (16 inches) (Zelasko et al. 2009), at which time they travel long distances to reach spawning sites (U.S. Fish and Wildlife Service 2002d). Mature adults breed in spring (mostly April-June) on the ascending limb of the hydrograph, congregating over cobble/gravel bars, backwaters, and impounded tributary mouths near spawning sites (multiple references in U.S. Fish and Wildlife Service 2002d; Snyder and Muth 2004; Zelasko et al. 2009). Flow and water temperature cues may play an important role prompting razorback adults to aggregate prior to spawning (Muth et al. 2000).

Razorback sucker have high reproductive potential, with reported average female fecundity of approximately 50,000 to 100,000 eggs per fish (U.S. Fish and Wildlife Service 2002d). They are broadcast spawners that scatter adhesive eggs over gravel-cobble substrate (Snyder and Muth 2004). High springs flows are important to egg survival because they remove fine sediment that can otherwise suffocate eggs. Hatching is limited at temperatures less than 10°C (50° F) and best around 20°C (68° F) (Snyder and Muth 2004). Eggs hatch 6 to 11 days after being deposited and larval fish occupy the sediment for another 4 to 10 days before emerging into the water column. Larval fish occupy shallow, warm, low-velocity habitats in littoral zones, backwaters, and inundated floodplains and tributary mouths downstream of spawning bars for several weeks before dispersing to deeper water (U.S. Fish and Wildlife Service 2002d; Snyder and Muth 2004). It is believed that low survival in early life stages, attributed to loss of nursery habitat and predation by non-native fishes, causes extremely low recruitment in wild populations (Muth et al. 2000).

Razorback sucker in the Upper Basin tend to be smaller and grow slower than those in the Lower Basin, reaching 100 millimeters (4 inches) on average in the first year (U.S. Fish and Wildlife Service 2002b). Based on collections in the middle Green River, typical adult size centers around 510 mm (20 inches) (Modde et al. 1996). Razorback suckers are long-lived fishes, reaching 40+ years via high annual survival (U.S. Fish and Wildlife Service 2002d). Adult survivorship was estimated to be 71 to 73 percent in the Middle Green River from 1980-1992 (Modde et al. 1996; Bestgen et al. 2002) and 76 percent from 1990 to 1999 (Bestgen et al. 2002).

POPULATION DYNAMICS

Population estimates during the 1980 to 1992 period were on average between 300 and 600 wild fish (Modde et al. 1996). By the early 2000s, the wild population consisted of primarily aging adults, with steep decline in numbers caused by extremely low natural recruitment (U.S. Fish and Wildlife Service 2002d). Although reproduction was occurring, very few juveniles were found (U.S. Fish and Wildlife Service 2002d).

In the early part of the 2000s, population numbers were extremely low. Population estimates from sampling efforts in the Middle Green River had declined to approximately 100 by 2002, with researchers hypothesizing that wild fish in the Green River Basin could become extirpated because of lack of recruitment (Bestgen et al. 2002). Similarly, in the upper Colorado River, razorback sucker were exceedingly rare. In the 2002 recovery plan, razorback sucker were considered extirpated in the Gunnison River, where fish were last captured in 1976 (U.S. Fish and Wildlife Service 2002d). Similarly, in the Grand Valley, only 12 fish were collected from 1984 to 1990, despite intensive sampling (Osmundson and Kaeding 1991 in U.S. Fish and Wildlife Service 2002d). No young razorback suckers were captured in the Upper Colorado River since the mid-1960s (Osmundson and Kaeding 1991 in U.S. Fish and Wildlife Service 2002d). In the San Juan River we know of only two wild razorback suckers that were captured in 1976 in a riverside pond near Bluff, Utah, and one fish captured in the river in 1988, also near Bluff (Ryden 2006). No wild razorback suckers were found during the 7-year research period (1991–1997) of the San Juan River Basin Recovery Implementation Program (Ryden 2006).

Because of the low numbers of wild fish and lack of recruitment, augmenting the remaining wild populations with hatchery-raised fish is a key step to creating self-sustaining populations. The Recovery Program is rebuilding razorback sucker populations with hatchery stocks. As populations increase, the Program expects to generate mark-recapture population estimates on adult razorback sucker comparable to the data reported for Colorado pikeminnow and humpback chub. Many stocked razorback sucker are being recaptured as part of other studies. Razorback sucker stocked in the Green and Colorado Rivers have been recaptured in reproductive condition and often in spawning groups. Captures of larvae in the Green, Gunnison, and Colorado Rivers document reproduction is occurring. Survival of larvae through their first year remains rare, largely due to a decrease in the availability of warm, food-rich floodplain areas and predation by a suite of nonnatives when the flood plain nursery habitats are available (Bestgen et al. 2011). However, occasional captures of juveniles (just over age-1) in the Green and Gunnison Rivers suggest that survival of early life stages is occurring. Larval captures in the Green, Gunnison, and Colorado rivers document reproduction. Collections of larvae by light trap in the middle Green River have generally been increasing since 2003; in 2013, the largest collection of light trapped larvae occurred (n = 7,376; Figure 5). In 2011, researchers documented spawning by razorback sucker in the White River for the first time.

Major advancements over the last decade have addressed the bottleneck to a self-sustaining wild population of razorback suckers which is larval recruitment to juvenile life stages. By tailoring peak spring releases from Flaming Gorge dam to overlap with larval razorback sucker drift under the Larval Trigger Study Plan (LTSP ad hoc Committee 2012); flows have been high enough in recent years to connect the Green River to off-channel wetland nursery habitats for larval razorback sucker. Picket weirs and similar devices exclude most large-bodied nonnative fishes from certain wetlands, improving water quality and reducing predation pressure on razorback

sucker larvae during their most vulnerable first weeks. At Stewart Lake, a gated wetland near Jensen, Utah, managed by the Utah Division of Wildlife Resources, these management practices have made possible releases of wild-spawned young-of-year razorback suckers to the Green River during annual autumn draining every year since 2013.

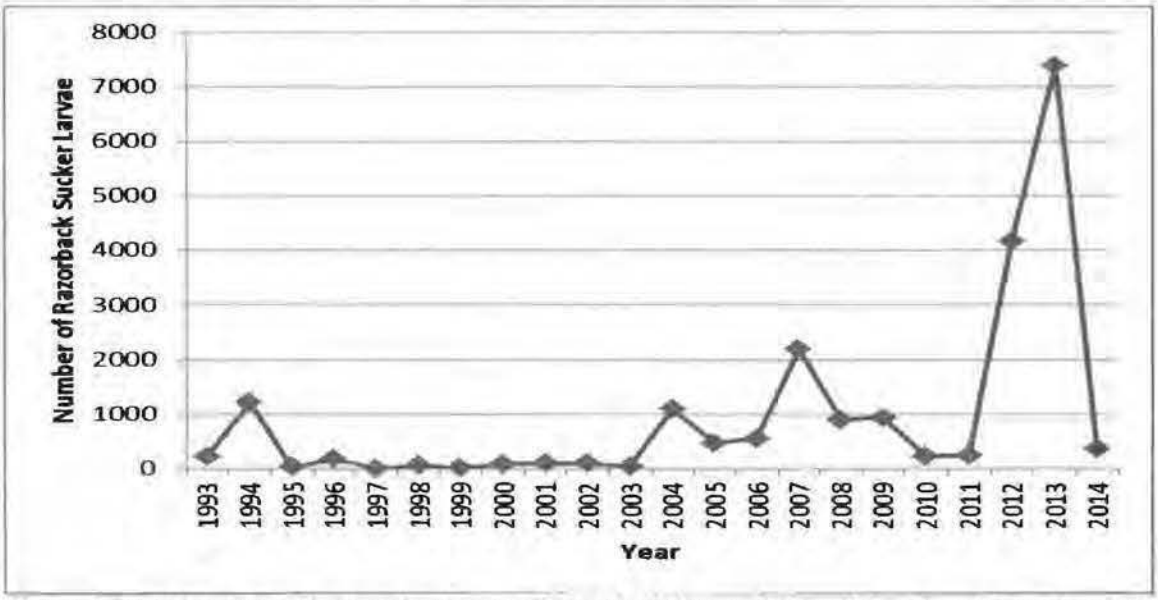

Figure 6. Numbers of razorback sucker larvae collected in light traps in the middle Green River since 1993.

BASIN-WIDE STATUS AND DISTRIBUTION

The razorback sucker was designated as endangered under a final rule published on October 23, 1991 (56 FR 54957). Population conditions cited in the rule include little evidence of natural recruitment over the previous 30 years and a downward trend relative to historic abundance over the previous 10 years. Threats to species centered on significant changes to natural habitat conditions, including diversion and depletion of water, introduction of nonnative fishes, and construction and operation of dams.

Monitoring of wild razorback sucker in the Upper Colorado River Basin shows continued declines in abundance, hypothesized to be from a lack of recruitment. Therefore, recovery of the species has focused on augmentation of populations through hatchery-raised fish and habitat improvements.

According to the 2002 Recovery Goals for the species, the primary threats to razorback sucker populations are streamflow regulation and habitat modification (including cold-water dam releases, habitat loss, and blockage of migration corridors); competition with and predation by nonnative fish species; and pesticides and pollutants (U.S. Fish and Wildlife Service 2002d). No new threats have emerged since the completion of this document. The Service's status review of razorback sucker completed in 2012 (U.S. Fish and Wildlife Service 2012b) reported that 85 percent of the downlisting recovery factor criteria (U.S. Fish and Wildlife Service 2002c) have been addressed to varying degrees; however, nonnative fish species continue to be problematic.

Webber and Beers (2014) report that 59 razorback sucker were detected in 2012, and 553 were detected in 2013. Of the 59 fish detected by the PIAs in 2012, only three razorback suckers were

detected again by the PIAs in 2013. The oldest razorback sucker detected was 15 y old, and the youngest were 3-year-old fish that were stocked in 2011and detected in 2013. Researchers had recaptured forty of these razorback suckers between stocking and detection on the PIA. However, for the remaining 529 razorback suckers (93%), detection at the PIA was the first time they were detected since stocking.

During sampling for Colorado pikeminnow estimates in the Ouray to Green River, Utah, reach of the main channel of the Green River, 938 and 765 razorback suckers were captured in 2011 and 2012, respectively. In the razorback sucker monitoring plan (Bestgen et al. 2012), estimates of large juvenile to adult razorback sucker in three reaches of the Green River ranged from 474 to over 5,000 within a reach. Although these estimates are highly imprecise, they provide further confirmation that stocked fish are surviving in the wild.

Preliminary population estimates were generated for razorback sucker in the Colorado River as a whole (from Palisade, Colorado downstream to its confluence with the Green River). Data used to generate these razorback sucker population estimates was obtained during the Colorado pikeminnow population estimate studies done in 2005 and 2008–2010 (Figure 6; D. Ryden and D. Elverud, USFWS, personal communication, 2015).

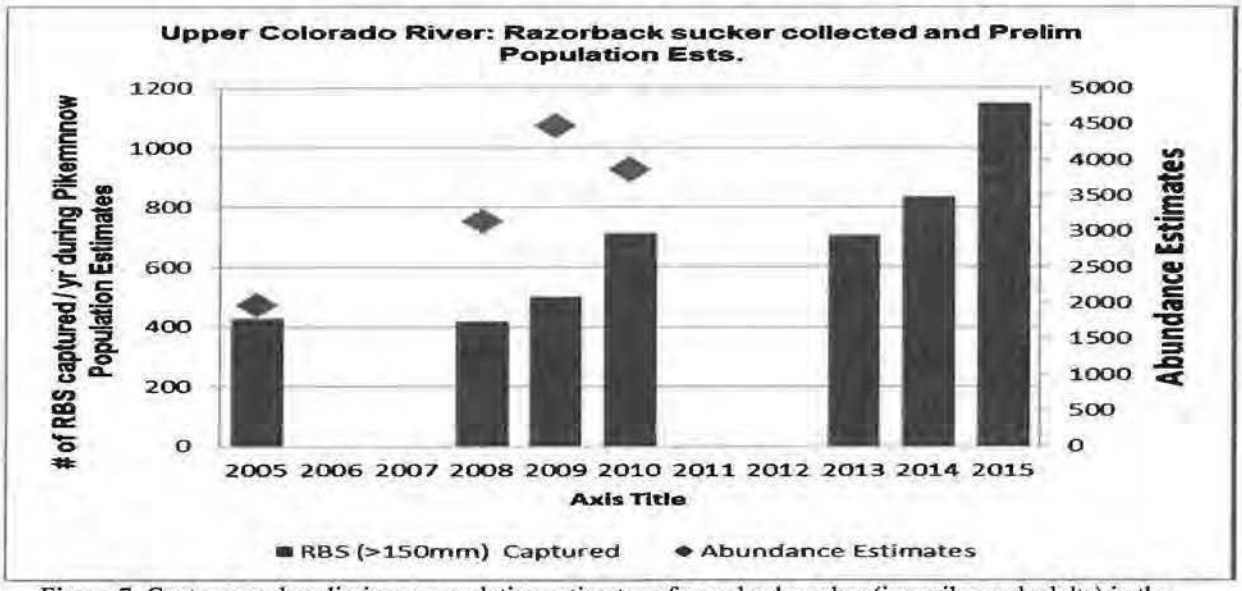

Figure 7. Captures and preliminary population estimates of razorback sucker (juveniles and adults) in the Colorado River (Palisade, Colorado to the confluence of the Green River).

The Service's 5-year status review of razorback sucker completed in 2012 reported that 85% of the downlisting recovery factor criteria (U.S. Fish and Wildlife Service 2002c) have been addressed to varying degrees. The Recovery Program (in coordination with the San Juan River Basin Recovery Implementation Program, the Glen Canyon Dam Adaptive Management Program, and the Lower Colorado River Multi-Species Conservation Program) initiated a Species Status Assessment in 2015, which should be completed in FY17. This SSA will serve as the basis for a 5-year status review to be completed the same year.

HUMPBACK CHUB

SPECIES DESCRIPTION

The humpback chub (*Gila cypha*) is a medium-sized freshwater fish of the minnow family endemic to the Colorado River basin. The species evolved around 3 to 5 million years ago (Sigler and Sigler 1996). The pronounced hump behind its head gives the humpback chub a striking, unusual appearance. It has an olive-colored back, silver sides, a white belly, small eyes, and a long snout that overhangs its jaw (Sigler and Sigler 1996). This fish can grow to nearly 500 mm (20 in.) and may survive more than 30 years in the wild (U.S. Fish and Wildlife Service 2002c). The humpback chub does not have the swimming speed or strength of species such as the Colorado pikeminnow. Instead, it uses its large fins to "glide" through slow-moving areas, feeding on insects.

Historic distribution is surmised from various reports and collections that indicate the species inhabited canyons of the Colorado River and four of its tributaries: the Green, Yampa, White, and Little Colorado Rivers. Presently the species occupies about 68 percent of its historic habitat (U.S. Fish and Wildlife Service 2002c). Historic to current abundance trends are unclear because historic abundance is unknown (U.S. Fish and Wildlife Service 2002c).

Currently, five wild populations occur upstream of Glen Canyon Dam (Figure 6) and two downstream (U.S. Fish and Wildlife Service 2002c). In the Upper Colorado River Basin the two most stable populations are found near the Colorado/Utah border: one at Westwater Canyon in Utah; and one in an area called Black Rocks, in Colorado (Upper Colorado River Endangered Fish Recovery Program and San Juan River Basin Recovery Implementation Program 2010). Smaller numbers in the Upper Basin were found in the Yampa and Green Rivers in Dinosaur National Monument, Desolation and Gray Canyons on the Green River in Utah, and Cataract Canyon on the Colorado River in Utah (U.S. Fish and Wildlife Service 2002c). The two populations in the Lower Colorado River Basin occur in the mainstem Colorado and Little Colorado Rivers. The Little Colorado River population, found in the Grand Canyon, is the largest known population, harboring up to 10,000 fish (U.S. Fish and Wildlife Service 2002c).

The Office of Endangered Species first included the humpback chub in the List of Endangered Species on March 11, 1967 (32 FR 4001). Subsequently, it was considered endangered under provisions of the Endangered Species Conservation Act of 1969 (16 U.S.C. 668aa) and was included in the United States List of Endangered Native Fish and Wildlife issued on June 4, 1973 (38 FR No. 106). It is currently protected under the Endangered Species Act of 1973 as an endangered species throughout its range (ESA; 16 U.S.C. 1531 et. seq.). The Service finalized the latest recovery plan for the species in 2002 (U.S. Fish and Wildlife Service 2002d), but is currently drafting an updated revision.

The Service designated seven reaches of the Colorado River System as critical habitat for the humpback chub on March 21, 1994 (59 FR 13374). These reaches total 610 km (379 mi) as measured along the center line of each reach. Designated critical habitat makes up about 28 percent of the species' original range and occurs in both the Upper and Lower Colorado River Basins. In the Upper Colorado River Basin, critical habitat includes portions of the Yampa, Green, and Colorado Rivers, primarily including canyon habitats, such as Yampa, Desolation

and Gray, Westwater, and Cataract Canyons. Although humpback chub life history and habitat use differs greatly from the other endangered Colorado River fish, the primary constituent elements (water, physical habitat, and biological environment) of their critical habitat are the same (see above).

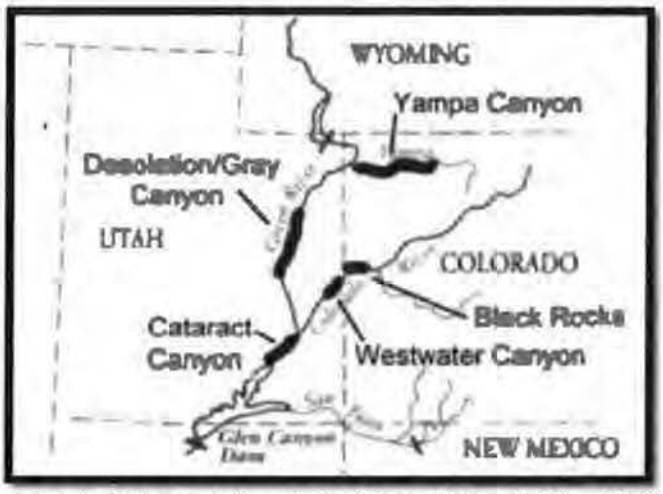

Figure 8. Locations of humpback chub populations in the Upper Colorado River Basin. Taken from Page 12 of Upper Colorado River Endangered Fish Recovery Program and San Juan River Basin Recovery Implementation Program 2010).

Separate, objective recovery criteria were developed for each of two recovery units (the Upper Colorado and Lower Colorado River Basins as delineated at Glen Canyon Dam) to address unique threats and site-specific management actions necessary to minimize or remove those threats. This biological opinion's focus is on the Upper Colorado River Basin recovery unit and will therefore describe the status of the humpback chub in that unit.

LIFE HISTORY

Like other large desert river fishes, the humpback chub is an obligate warm-water species that requires relatively warm temperatures for spawning, egg incubation, and survival of larvae. Unlike Colorado pikeminnow and razorback sucker, which are known to make extended migrations of up to several hundred miles to spawning areas, humpback chubs do not appear to make extensive migrations. Instead, humpback chub live and complete their entire life cycle in canyon-bound reaches of the Colorado River mainstem and larger tributaries characterized by deep water, swift currents, and rocky substrates (U.S. Fish and Wildlife Service 2002c). Individuals show high fidelity for canyon reaches and move very little.

Mature humpback chub typically spawn on the descending hydrograph between March and July in the Upper Basin (Karp and Tyus 1990). Humpback chub are broadcast spawners who may mature as young as 2 to 3 years old. Eggs incubate for three days before swimming up as larval fish (U.S. Fish and Wildlife Service 2002c). Egg and larvae survival are highest at temperatures close to 19 to 22 degrees Celsius (U.S. Fish and Wildlife Service 2002c). Unlike larvae of other Colorado River fishes (e.g., Colorado pikeminnow and razorback sucker), larval humpback chub show no evidence of long-distance drift (Robinson et al.1998).

POPULATION DYNAMICS

Five wild populations of humpback chub inhabit canyon-bound sections of the Colorado, Green, and Yampa Rivers: Yampa Canyon; Desolation and Gray Canyons; Cataract Canyon; Black Rocks; and Westwater Canyon. Recovery goal downlisting demographic criteria (U.S. Fish and Wildlife Service 2002c) for humpback chub require each of five populations in the upper Colorado River basin to be self-sustaining over a 5-year period, with a trend in adult point estimates that does not decline significantly. Secondarily, recruitment of age-3 (150–199 mm TL) naturally produced fish must equal or exceed mean adult annual mortality. In addition, one of the five populations (e.g., Black Rocks/Westwater Canyon or Desolation/Gray Canyons) must be maintained as a core population such that each estimate exceeds 2,100 adults (estimated minimum viable population number).

The Yampa River humpback chub population exists in the lower Yampa River Canyon and into the Green River through Split Mountain Canyon. This population is small, with an estimate of about 400 wild adults in 1998 2000. Sampling during 2003–2004 caught only 13 fish, too few to estimate population size (Finney 2006). In 2007, the Recovery Program brought 400 young-of-year *Gila* spp. caught in Yampa Canyon into captivity as a research activity to determine the best methods for capture, transport, and holding at two different hatchery facilities. Approximately 15 percent of the *Gila* species were tentatively identified as humpback chub by physical characteristics. Geneticists at Southwest Native Aquatic Resources and Recovery Center (SNARRC), Dexter, NM, have since provided preliminary results indicating that the Yampa fish in captivity were hybrids between humpback chub and roundtail chub (Wade Wilson, U.S. Fish and Wildlife Service, personal communication). These fish were considered unsuitable for broodstock and were released into the Green River in Dinosaur National Monument. Currently, it is not known if pure humpback chubs occur in Yampa Canyon.

The Desolation/Gray Canyons population of wild adults was estimated at 1,300 in 2001, 2,200 in 2002, and 940 in 2003 (Jackson and Hudson 2005). Sampling in 2001 and 2002 was conducted in summer, whereas beginning in 2003, sampling was shifted to fall to avoid capturing Colorado pikeminnow that use Desolation Canyon for spawning. In a report on 2006–2007 estimates, researchers (Badame 2012; Figure 7) indicated that this population was trending downward. The declining catch of humpback chub in the upper portions of Desolation Canyon in the 2006–2007 estimates was linked to increasing densities of nonnative smallmouth bass (Badame 2012). Researchers recommended securing a representative sample of adults in captivity. In 2009, 25 adults were taken to Ouray National Fish Hatchery. In 2011, six sites throughout Desolation Canyon were monitored for adults, 55 individual adults were encountered, but recaptures were too few to calculate a population estimate.

On the Colorado River of the upper Colorado River basin, three humpback chub populations are recognized. Black Rocks and Westwater Canyon have enough exchange of individuals that they are considered a single core population. In Black Rocks, estimates of wild adults have varied from about 800 in 1998, 900 in 1999, and 500 in 2000 and 2003 (Figure 7) (McAda 2007). The most recent estimates, in 2007–2008 were 345 and 287, respectively. During the fall of 2011 and 2012, 78 and 112 individual adult humpback chub were caught respectively - similar to the numbers caught in 2007 and 2008 (61 and 74, respectively). Population estimates for Black Rocks for 2011 and 2012 were 379 and 403, respectively. Researchers caution that 78 largemouth bass and the same number of gizzard shad were collected in Black Rocks in 2012.

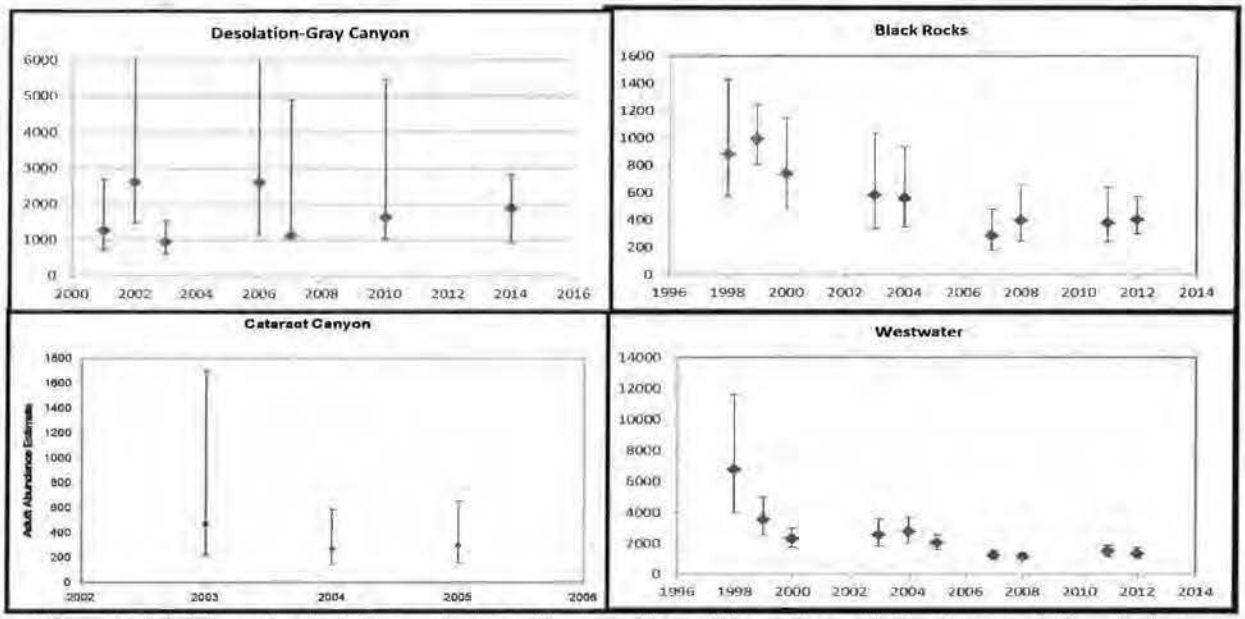

Figure 9. Adult humpback chub population estimates with confidence intervals for four populations in the upper Colorado River Basin (note that the scale differs among the graphs for the different populations). Clockwise from upper left: Desolation-Gray Canyons (from Badame 2011, 2012; Howard 2014); Black Rocks (from Francis and McAda 2011; Francis et al. 2016); Westwater Canyon (from Elverud 2011; Hines et al. 2016); and Cataract Canyon (from Badame 2008).

This represents a ten-fold increase over the 2011 catch. The Westwater Canyon estimates of wild adults range from about 4,700 in 1998 to 2,500 in 1999, 2000, and 2003 (Jackson and Hudson 2005). The 2007–2008 estimates were about 1,750 and 1,300. The large declines in humpback chub densities in both Black Rocks and Westwater Canyons occurred in the late 1990's and are not attributed to more recent increases of nonnative predators in the Colorado River.

In 2008, the core population (Black Rocks / Westwater combined) dropped below the population size downlist criterion (MVP = 2,100 adults) for the first time. In 2011, we saw some recovery in those populations where the estimate for adults in Westwater Canyon alone was 1,467; however, UDWR reported 1,315 adults in 2012. The core population estimates in 2011 and 2012 were 1846 and 1718, respectively (Figure 8). Population estimates in both Black Rocks and Westwater canyons declined dramatically during the first population estimation rotation in the late 1990s, but have remained relatively stable since that time. Colorado State University's recent robust population estimate analysis more clearly indicated that declines in the Westwater and Black Rock humpback chub populations are due to lapses in recruitment (i.e. adult survival rates have remained stable). Principle investigators agree that reinitiating an age-0 monitoring component is advisable. It should be noted that whatever is affecting humpback chub recruitment has not affected sympatric populations of native roundtail chub; roundtail chubs populations in both canyons have remained stable or have increased since population estimation started. In addition to the potential and recent negative interactions between humpback chub and nonnative predators discussed above, both the Westwater and Black Rocks populations are at risk of potential chemical contamination due to the proximity of a railroad located on the right bank of the Colorado River which at times transports toxic substances.

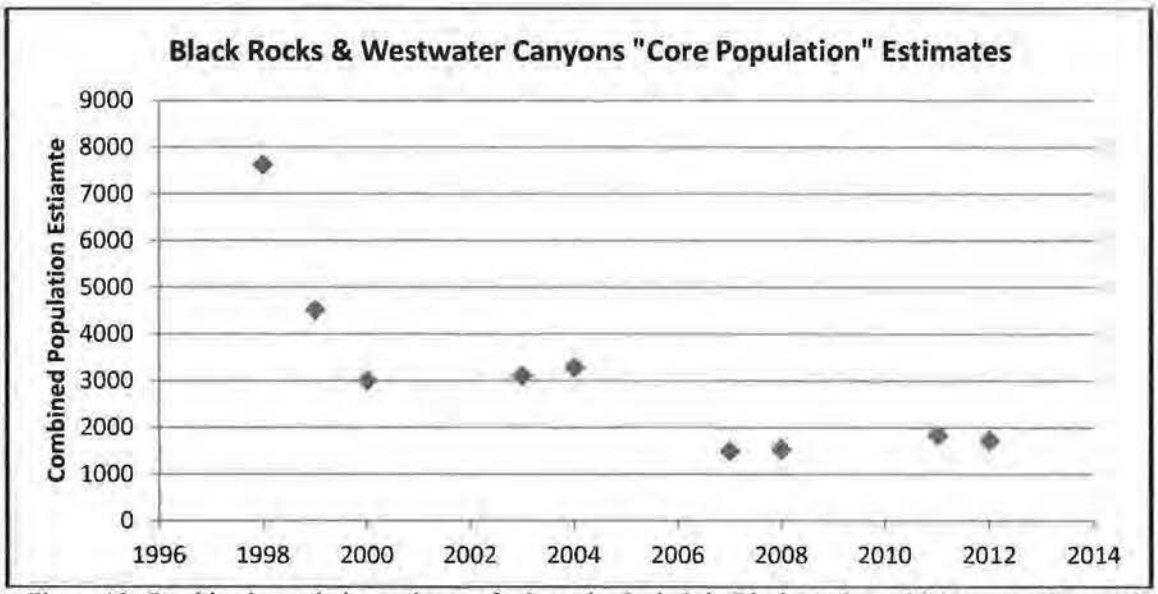

Figure 10. Combined population estimates for humpback chub in Black Rocks and Westwater Canyon based on a robust open model created by Drs. Bestgen and White, Colorado State University. The 2002 Recovery Goal downlist criteria for these combined ("core" population) estimates is 2,100 adults.

The Cataract Canyon humpback chub population is small, with estimates of about 150 wild adults in 2003 and 66 in 2005. Estimates are difficult to obtain in Cataract; therefore, catch-per-unit-effort (CPUE) has been determined to be an acceptable replacement (began in 2008 on a 2-years-on, 2-years-off sampling regime). In 2015, UDWR (Ahrens 2015) reported that the Cataract population appears to be stable with CPUE ranging between 0.010 and 0.035 fish/net-hour. In 2011 and 2012, sampling was reinitiated below the Big Drop rapids after a sampling hiatus in this reach since 2008. Biologists were interested in returning to this area because riverine habitat was being exposed with dropping Lake Powell surface elevation. No additional humpback chub were encountered in the new riverine habitat. Due to high site fidelity often observed in humpback chub, it is likely that re-colonization of this recently created habitat would be slow (Howard 2013).

BASIN-WIDE STATUS AND DISTRIBUTION

The humpback chub was designated as an endangered species prior to enactment of the ESA, and therefore, a formal listing package identifying threats was not assembled. Construction and operation of mainstem dams, nonnative fish species, and local eradication of native minnows and suckers in advance of new human-made reservoirs in the early 1960's were recognized as early threats (U.S. Fish and Wildlife Service 2002c). According to the 2002 Recovery Goals for the species, the primary threats to humpback chub are streamflow regulation, habitat modification, predation by non-native fish species, parasitism, hybridization with other native *Gila* species, and pesticides and pollutants (U.S. Fish and Wildlife Service 2002c). No new threats have emerged since the completion of this document. The Service's status review of humpback chub completed in 2011 (U.S. Fish and Wildlife Service 2011b) reported that 60 percent of the recovery factor criteria (U.S. Fish and Wildlife Service 2002c) have been addressed to varying degrees; however, nonnative fish species and issues dealing with the potential chemical contamination of the river from spills and pipelines continue to be problematic.

As described in previous sections, humpback chub are restricted to a portion of their historical range. Within currently occupied habitat in the Upper Basin, population trends are variable, with one core population remaining quite robust, but other populations threatened with extirpation.

BONYTAIL

SPECIES DESCRIPTION

The bonytail (*Gila elegans*) is a medium-sized freshwater fish in the minnow family, endemic to the Colorado River Basin. The species evolved around 3 to 5 million years ago (Sigler and Sigler 1996). Individuals have large fins and a streamlined body that typically is very thin in front of the tail. They have a gray or olive-colored back, silver sides, and a white belly (Sigler and Sigler 1996). The mouth is slightly overhung by the snout and there is a smooth low hump behind the head that is not as pronounced as the hump on a humpback chub. A very close relative to the roundtail chub (*Gila robusta*), bonytail can be distinguished by counting the number of rays in the fins, with bonytail having 10 dorsal and anal fin rays (Sigler and Sigler 1996). The fish can grow to be 600 mm (24 inches) and are thought to live as long as 20 to 50 years (Sigler and Sigler 1996). Little is known about the specific food and habitat of the bonytail because the species was extirpated from most of its historic range prior to extensive fishery surveys, but it is considered adapted to mainstem rivers, residing in pools and eddies, while eating terrestrial and aquatic insects (U.S. Fish and Wildlife Service 2002a).

Bonytail were once widespread in the large rivers of the Colorado River Basin (multiple historic references in U.S. Fish and Wildlife Service 2002a). The species experienced a dramatic, but poorly documented, decline starting in about 1950, following construction of mainstem dams, introduction of nonnative fishes, poor land-use practices, and degraded water quality (U.S. Fish and Wildlife Service 2002a). Population trajectory over the past century and reasons for decline are unclear because lack of basin-wide fishery investigations precluded accurate distribution and abundance records.

Bonytail are now rarely found in the Green and Upper Colorado River sub-basins and are the rarest of all the endangered fish species in the Colorado River Basin. In fact, no wild, self-sustaining populations are known to exist upstream of Lake Powell; this fish is nearly extinct. In the last decade only a handful of bonytail were captured on the Yampa River in Dinosaur National Monument, on the Green River at Desolation and Gray canyons, and on the Colorado River at the Colorado/Utah border and in Cataract Canyon. In the lower basin, bonytail exist in Lake Mohave and Lake Havasu.

The bonytail is currently listed as endangered under the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et. seq.), under a final rule published on April 23, 1980 (45 FR 27710). The Service finalized the latest recovery plan for the species in 2002 (U.S. Fish and Wildlife Service 2002a), but is currently drafting an updated revision.

The Service designated seven reaches of the Colorado River as critical habitat for the bonytail on March 21, 1994 (59 FR 13374). These reaches total 499 km (312 miles) as measured along the center line of each reach. Portions of the Green, Yampa, and Colorado Rivers are designated as critical habitat, representing about 14 percent of the species' historic range. The primary constituent elements are the same as those described for Colorado pikeminnow, razorback sucker, and humpback chub.

Separate, objective recovery criteria were developed for each of two recovery units (the Upper Colorado and Lower Colorado River Basins as delineated at Glen Canyon Dam) to address unique threats and site specific management actions necessary to minimize or remove those threats. This biological opinion's focus is on the Upper Colorado River Basin recovery unit and will therefore describe the status of the humpback chub in that unit.

LIFE HISTORY

Natural reproduction of bonytail was last documented in the Green River in 1959, 1960, and 1961 at water temperatures of 18°C (U.S. Fish and Wildlife Service 2002a). Similar to other closely related *Gila* species, bonytail in rivers probably spawn during spring over rocky substrates. While age at sexually maturity is unknown, they are capable of spawning at 5 to 7 years old. Recruitment and survival estimates are currently unknown because populations are not large enough for research to occur. Individuals in Lake Mohave have reached 40 to 50 years of age (U.S. Fish and Wildlife Service 2002a), but estimates for river inhabiting fish are not available.

Since 2009, an increasing number of bonytail have been detected at several locations throughout the Upper Colorado River Basin where stationary tag-reading antennas are used. During high spring flows in 2011, more than 1,100 bonytail (16.6% of the 6,804 stocked in early April of that year) were detected by antenna arrays in the breach of the Stirrup floodplain on the Green River. The Price-Stubb antenna array near Grand Junction on the Colorado River detected 356 individual bonytail between November 2010 and September 2014. The fish detected in fall 2011 had been stocked in Debeque Canyon above Price-Stubb, but in spring 2012, some of those fish were moving upstream through the Grand Valley fish passage. In 2015, 22 were detected and 59% were moving upstream, the others were either moving downstream or direction could not be determined (Francis and Ryden 2015a). In addition, 44 bonytail used the Redlands fish ladder and were moved above the diversion for further upstream access to the Gunnison River (Francis and Ryden 2015b).

POPULATION DYNAMICS

Bonytail are so rare that it is currently not possible to conduct population estimates. In response to the low abundance of individuals, the Recovery Program is implementing a stocking program to reestablish populations in the Upper Basin; stocking goals were met or exceeded the past three years (Upper Colorado River Endangered Fish Recovery Program and San Juan River Basin Recovery Implementation Program 2010). Since 1996, over 490,000 tagged bonytail subadults have been stocked in the Green and upper Colorado River subbasins.

To date, stocked bonytail do not appear to be surviving as well as stocked razorback sucker. Researchers continue to experiment with pre-release conditioning and exploring alternative release sites to improve their survival. Since 2009, an increasing number of bonytail have been detected at several locations throughout the Upper Colorado River Basin where stationary tag-reading antennas are used. During high spring flows in 2011, more than 1,100 bonytail (16.6% of the 6,804 stocked in early April of that year) were detected by antenna arrays in the breach of the Stirrup floodplain on the Green River. The Price Stubb antenna array on the Colorado River detected 356 bonytail between November 2010 and September 2014. The fish detected in fall 2011 had been stocked above Price-Stubb in Debeque Canyon, but in spring 2012, some of those fish were moving upstream through the fish passage. In 2015, 22 were detected and 59% were

moving upstream, the others were either moving downstream or direction could not be determined (Francis and Ryden 2015a). In addition, 44 bonytail used the Redlands fish ladder and were moved above the diversion for further upstream access to the Gunnison River (Francis and Ryden 2015b).

BASIN-WIDE STATUS AND DISTRIBUTION

The bonytail was designated as an endangered species under a final rule published April 23, 1980 (45 FR 27710–27713). Reasons for decline of the species were identified as the physical and chemical alteration of their habitat and introduction of exotic fishes. The 1990 Bonytail Chub Recovery Plan further stated that the decline of the bonytail is attributed to stream alteration caused by construction of dams, flow depletion from irrigation and other uses, hybridization with other *Gila*, and the introduction of nonnative fish species. Hence, the primary threats to bonytail populations are streamflow regulation and habitat modification (including cold-water dam releases, habitat loss, and blockage of migration corridors); competition with and predation by nonnative fish species; hybridization; and pesticides and pollutants (U.S. Fish and Wildlife Service 2002a). No new threats have emerged since the 2002 recovery goals were published. The Service's status review of bonytail in 2012 (U.S. Fish and Wildlife Service 2012a) reported that 72 percent of the recovery factor criteria (U.S. Fish and Wildlife Service 2002d) have been addressed to varying degrees.

In 2015, for the first time in a dozen years, evidence was seen that stocked bonytail successfully spawned in the upper Colorado River basin (Bestgen et al. 2016; in review). At least 5 adult bonytail stocked in the Green River gained access to Stewart Lake, a managed floodplain in the middle Green River, Utah, during high flows in May. During the draining in September, 19 age-0 *Gila* sp. (37 to 64 mm TL) among over 405,000 collected fish. Four preserved specimens (41–48 mm TL) were verified as *G. elegans* using morphological and molecular techniques. These fish hatched in late June, well after the wetland was disconnected from the river, which confirmed that reproduction occurred in Stewart Lake. In spite of abundant small-bodied nonnative fish, these young bonytail survived.

DESIGNATED CRITICAL HABITAT FOR LISTED COLORADO RIVER FISHES

HABITAT DESCRIPTION

In the Upper Colorado River Basin, portions of the White, Yampa, Gunnison, Green, Colorado, and San Juan Rivers and their 100-year floodplain are designated as critical habitat for one or more of the federally listed species described above. Critical habitat is defined as specific geographic areas, whether occupied by a listed species or not, that are essential for its conservation and that are formally designated by rule. In the state of Utah, immediately downstream of Wyoming, many of these critical habitat reaches overlap. Critical habitat for the humpback chub and bonytail are primarily canyon-bound reaches, while critical habitat for the Colorado pikeminnow and razorback sucker include long stretches of river required for migration corridors and larval fish drift.

Concurrently with designating critical habitat, the Service identified primary constituent elements (PCEs) of the habitat. PCEs are physical or biological features essential to the conservation of a species for which its designated or proposed critical habitat is based on, such as: space for individual and population growth, and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding,

reproduction, rearing of offspring, germination, or seed dispersal; and habitats that are protected from disturbance or are representative of the species historic geographic and ecological distribution.

The Service has identified water, physical habitat, and the biological environment as the primary constituent elements of critical habitat for listed Colorado River fish species (59 FR 13374). Water includes a quantity of water of sufficient quality delivered to a specific location in accordance with a hydrologic regime required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are important elements of the biological environment.

HABITAT USAGE

The four listed fish species are adapted to a hydrologic cycle characterized by large spring peaks of snowmelt runoff and low, relatively stable base flows (U.S. Fish and Wildlife Service 2002b). High spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, form gravel and cobble deposits used for spawning, and rejuvenate backwater nursery habitats (U.S. Fish and Wildlife Service 2002b).

Throughout most of the year, juvenile, subadult, and adult Colorado pikeminnow use relatively deep, low-velocity eddies, pools, and runs that occur in near-shore areas of main river channels (multiple references in U.S. Fish and Wildlife Service 2002b). Adults require pools, deep runs, and eddy habitats maintained by high spring flows. In spring, however, adults use floodplain habitats, flooded tributary mouths, flooded side canyons, and eddies that are available only during high flows (multiple references in U.S. Fish and Wildlife Service 2002b). Newly hatched larval fish drift downstream to backwaters in sandy, alluvial regions, where they remain through most of their first year of life (multiple references in U.S. Fish and Wildlife Service 2002b). Because of their mobility and environmental tolerances, adult Colorado pikeminnow are more widely distributed than other life stages.

Similar to Colorado pikeminnow, razorback sucker use a variety of habitats throughout their life cycle. Outside of the spawning season, adult razorback suckers occupy a variety of shoreline and main channel habitats including slow runs, shallow to deep pools, backwaters, eddies, and other relatively slow velocity areas associated with sand substrates (U.S. Fish and Wildlife Service 2002d). In spring and winter adult razorback sucker require deeper, low-velocity habitat, but are known to occupy shallow sandbars in summer (McAda and Wydoski 1980 in Zelasko et al. 2009). Reproductive activities are believed to take place in off-channel habitats and tributaries because razorback sucker aggregations were reported in these areas. Off-channel habitats are much warmer than the mainstem river and razorback suckers presumably move to these areas for spawning and other activities, such as, feeding, resting, or sexual maturation. Off channel and floodplain habitat is also important to young razorback sucker. After hatching, razorback sucker larvae drift downstream to low-velocity floodplain or backwater nursery habitat. The absence of seasonally flooded riverine habitats is believed to be a limiting factor in the successful recruitment of razorback suckers in their native environment. Starvation of larval razorback suckers due to low zooplankton densities in the main channel and loss of floodplain

habitats which provide adequate zooplankton densities for larvae food is one of the most important factors limiting recruitment.

Unlike Colorado pikeminnow and razorback sucker, humpback chub show high site fidelity for canyon-bound reaches of mainstem rivers. Past captures of adults were associated with large boulders and steep cliffs. Reproductive habitat is not defined because although humpback chub are believed to broadcast eggs over mid-channel cobble and gravel bars, spawning in the wild has not been observed for this species. It is believed that upon emergence from spawning gravels, humpback chub larvae remain in the vicinity of bottom surfaces near spawning areas. As larval fish mature, backwaters, eddies, and runs were reported as common capture locations for young-of-year humpback chub.

While bonytail are closely related to humpback chub, their habitat usage may be slightly different. Bonytail are observed in pools and eddies in mainstem rivers, but recent information collected by the Recovery Program suggests that floodplain habitats may be more important to the survival and recovery of the bonytail than originally thought. Although spawning events in river habitat has not been documented, bonytail probably spawn in rivers over rocky substrates because spawning is observed in reservoirs over rocky shoals and shorelines. Recent hypotheses surmise that flooded bottomlands may provide important bonytail nursery habitat.

ENVIRONMENTAL BASELINE

Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed state or federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation process.

STATUS OF THE SPECIES IN THE ACTION AREA

While the Project occurs in Wyoming, depletions associated with the Project from the Green River, a tributary to the Colorado River, adversely affect all four endangered fish species within the Upper Colorado River Basin Recovery Unit. The use of water from the Upper Colorado River Basin affects the habitat quantity and quality downstream of the Project location, for many miles.

Within this Recovery Unit, specific recovery criteria are established for the Green River sub-basin for all four species, including population demographics. Self-sustaining and stable populations of these species in the Green River sub basin are required for full species recovery (U.S. Fish and Wildlife Service 2002a, 2002b, 2002c, 2002d). The entire length of the Green River and its 100 year floodplain are designated as critical habitat for at least one species between the Yampa River confluence and the Colorado River confluence (Federal Register: 59 FR 13374).

The largest, most productive and most robust population of Colorado pikeminnow occurs in the mainstem Green River (combining the lower Green River, Desolation/Gray Canyon, and middle Green River populations). Higher abundance of Colorado pikeminnow juveniles and recruits in the 2006 to 2008 sampling period is attributed to a relatively strong year class of age-0 Colorado

pikeminnow produced in the lower Green River in 2000 (Bestgen et al. 2010). Length frequency histograms, especially in the Desolation-Gray Canyon and lower Green River reaches, indicate that abundance of Colorado pikeminnow recruits was much higher in period 2006 to 2008 than from 2000 to 2003 (Bestgen et al. 2010). The importance of Green River populations is also evident because increased abundance of adult Colorado pikeminnow in the White River and middle Green River through 2008 almost certainly derived from upstream movement (high transition rates) of large numbers of juvenile and recruit-sized Colorado pikeminnow that originated in downstream reaches of the Green River in 2006 and 2007 (Bestgen et al. 2010). Colorado pikeminnow spawn in two principal sites: Gray Canyon in the lower Green River, and the lower Yampa River (U.S. Fish and Wildlife Service 2002b).

The action area includes the largest concentration of razorback suckers in the Upper Colorado River Basin, found in low-gradient flat-water reaches of the middle Green River between and including the lower few miles of the Duchesne River and the Yampa River. Known spawning sites for razorback sucker are located in the lower Yampa River and in the Green River near Escalante Ranch, but other, less-used sites are probable, such as Desolation Canyon (U.S. Fish and Wildlife Service 2002d). Both Colorado pikeminnow and razorback sucker are migratory spawners, whose young emerge as larval fish from spawning locations and drift downstream. Because Colorado pikeminnow and razorback sucker spawning locations occur downstream of the Project, all life stages are present within the action area.

Humpback chub occur in Westwater Canyon, Desolation/Gray Canyons and Cataract Canyon, but not in other river reaches in the action area. Preliminary population estimates in 2002 approximate 2,000 to 5,000 humpback chub in Westwater Canyon, 1,500 in Desolation/Gray Canyons, and 500 in Cataract Canyon (U.S. Fish and Wildlife Service 2002c).

Bonytail are so rare that it is currently not possible to conduct population estimates. However, the action area includes the middle Green River, which is part of the current stocking program area (along with the Yampa River in Dinosaur National Monument).

STATUS OF CRITICAL HABITAT IN THE ACTION AREA

The action area includes critical habitat units, which are identified as essential for the species' recovery (U.S. Fish and Wildlife Service 2002a, 2002b, 2002c, 2002d). While historical water depletions do not occur within all critical habitat units, historical changes in Green River and Colorado River water volume have nonetheless affected critical habitat by changing the amount of water flowing into these designated habitat units. The action area includes critical habitat units on the mainstem Green River and Colorado River below the Green River confluence.

As previously described, all four of the listed Colorado River fish require the same Primary Constituent Elements (PCEs) essential for their survival. Water, physical habitat, and the biological environment are the PCEs of critical habitat. This includes a quantity of water of sufficient quality that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, when inundated, provide access to

spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are important elements of the biological environment.

Historically, the Green River produced high spring turbid flows that maintained critical habitat by inundating floodplains, maintaining side channels, flushing fine sediment, and creating backwaters (Muth et al. 2000). However, with the completion of Flaming Gorge Dam in 1962, the mainstem Green River became highly regulated. The dam and reservoir physically altered the Green River and surrounding terrain and modified the pattern of flows downstream (Muth et al. 2000). Most notably, the construction of the dam created a fish passage barrier and transformed miles of riverine habitat into lacustrine habitat. These two changes isolated fish populations and decreased the amount of native habitat.

Operation of the dam also results in effects to native fish communities. Historically, water releases from Flaming Gorge Dam did not mimic natural flow patterns and introduced colder water into the river from the deep pool behind the dam (Muth et al. 2000). Alteration of the natural flow regime affects stream vegetation communities and channel morphology, which modify native fish habitat (Muth et al. 2000). Natural flow regimes may act as cues for important life history events, like spawning. Life history events are similarly affected by water temperature, with colder temperatures disrupting the temporal spawning regime of native fish.

Additionally, Flaming Gorge Dam created new water resource impacts, such as irrigation potential, municipal use, and recreational fisheries of introduced non-native species. Water storage provided by the dam allowed local communities to increase water usage for agriculture and municipal purposes. Increased water depletion from the Green River decreases native fish habitat and limits the amount of backwater nursery habitat for juvenile fish. Also, increased water supply for agriculture and municipal purposes increases the likelihood of degraded water quality from agricultural runoff (pesticides, fertilizers, etc.) and wastewater inputs.

All four federally listed species evolved in desert river hydrology, relying on high spring flows and stable base flows for habitat conditions essential to their survival (see STATUS OF THE SPECIES AND CRITICAL HABITAT). In addition to main channel migration corridors, Colorado pikeminnow, bonytail and razorback sucker rely on floodplain and backwater habitats for various stages of their life history. High spring flows also act as spawning queues. In contrast, humpback chub rely more on canyon-bound reaches with swift currents and white water.

Currently, two primary reaches of Colorado pikeminnow nursery habitat are present in the Green River system. The lower reach occurs from near Green River, Utah, downstream to the Colorado River confluence. The upper reach occurs from near Jensen, Utah, downstream to the Duchesne River confluence. Larvae from Desolation Canyon colonize flooded backwater areas in the lower Green River area. These backwaters are especially important during the Colorado pikeminnow's critical first year of life. The Project is located upstream of both nursery habitat reaches and floodplain habitat.

Bottomlands, low-lying wetlands, and oxbow channels flooded and ephemerally connected to the main channel by high spring flows appear to be important habitats for all life stages of razorback

sucker. These areas provide warm water temperatures, low-velocity flows, and increased food availability.

Humpback chub occur in Desolation/Gray Canyons, and within the action area. Adults require eddies and sheltered shoreline habitats maintained by high spring flows. These high spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, and form gravel and cobble deposits used for spawning. Flow recommendations were developed that specifically consider flow-habitat relationships in habitats occupied by humpback chub in the upper basin, and were designed to enhance habitat complexity and to restore and maintain ecological processes.

PRIMARY CONSTITUENT ELEMENT – WATER - The quality and quantity of water in the action area of the Green River has decreased from water projects, most notably Flaming Gorge Dam and the Central Utah Project. A number of tributaries to the Green River appear on the State of Utah's 303(d) list of impaired streams for various reasons (Utah Division of Water Quality 2004). Tributaries and sections of the Price, San Rafael, and Duchesne Rivers are listed for elevated salinity, total dissolved solids, and chlorides, as are portions of Ashley and Pariette Draw Creeks. Brush, Pariette Draw, and Lower Ashley Creeks are listed for elevated selenium. Willow and Indian Canyon Creeks are listed for elevated total dissolved solids. Ninemile Creek is listed for elevated temperature. Lake Fork Creek is listed for elevated sediments. Lastly, Pariette Draw Creek is listed for elevated boron. These elevated pollutants pose a risk to this PCE. As these tributaries reach the main stem, these pollutants are introduced to the Green River as well. Currently the Green River acts as a dilution for these pollutants, as is evident by the Green River not appearing on the State of Utah's impaired water list. However, these pollutants still occur in the river and as new water depletions occur, these pollutants will be found in higher concentrations.

Large water diversion projects, large-scale agricultural water use, and climate change have all altered the water quantity in the Green River over the past 150 years. Most notably, Flaming Gorge Dam has altered the magnitude and timing of flows in endangered fish habitat. Peak spring flows in the Green River at Jensen, Utah, have decreased 13 to 35 percent and base flows have increased 10 to 140 percent due to regulation by Flaming Gorge Dam (Muth et al. 2000). However, since 2006 changes were made in the operation of Flaming Gorge Dam that provide flow and meet temperature requirements for native fish. The next major step in providing adequate habitat for the endangered fish is determining how to protect flows to consistently meet demands and endangered fish flow recommendations (see Flow Protection in the Green River, below). As part of this effort, researchers have created hydrologic models to determine how often the flow recommendations would be met using current operations and past water supplies.

PRIMARY CONSTITUENT ELEMENT – PHYSICAL HABITAT- The completion of Flaming Gorge Dam created a fish passage barrier. Native Colorado pikeminnow, razorback sucker, humpback chub, and bonytail can no longer migrate into Wyoming from the lower Green River. Fish barriers isolate populations, decreasing the ability of individuals to interact, and hinder the transfer of genetic material. The quantity and timing of flows influence how the channel and various habitats are formed and maintained. Channel narrowing is a problem because as the channel width decreases, water velocity increases, and the amount of low velocity habitats, important to the early life stages of the fish, decreases. Habitat below Flaming Gorge Dam has

historically been shaped by an artificial flow regime which decreased low flow habitats, disrupted vegetative communities, and altered channel morphology. However, recent operation changes have made this flow regime match more natural conditions. These changes affect temperature, channel morphology, and habitat conditions.

PRIMARY CONSTITUENT ELEMENT – BIOLOGICAL ENVIRONMENT- This PCE is impaired by the presence of non-native fishes common in the Green River. Non-native fishes occupy the same backwaters that are very important for young Colorado pikeminnow and razorback sucker. Specifically, largemouth (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), northern pike (*Esox lucius*), and channel catish (*Ictalurus punctatus*) are present in this system and predate upon juvenile native fish. Programs are ongoing to remove bass, walleye and northern pike from this system. Other non-natives found in the Green River include centrarchids and non-native cyprinids. Reduction in flows contributes to further habitat alterations that support nonnative fish species, such as increased temperatures, reduced habitat availability, and reduced turbidity.

FACTORS AFFECTING THE SPECIES ENVIRONMENT IN THE ACTION AREA

This baseline includes state, tribal, local, and private actions already affecting the species or that will occur contemporaneously with the consultation in progress. Unrelated federal actions affecting the same species or informal consultation are also part of the environmental baseline, as are federal and other actions within the action area that may benefit listed species or critical habitat.

UPPER COLORADO RIVER ENDANGERED FISH RECOVERY PROGRAM - The Upper Colorado River Endangered Fish Recovery Program was established in 1988 to help recover the four endangered fish species (see Consultation History). The Recovery Program implements management actions within seven Program elements, as dictated from species' recovery goals, with the focus of down-listing and de-listing the species. Five of these actions impact the species in the action area: instream flow identification and protection; habitat restoration; non-native fish management; propagation and stocking; and research and monitoring.

Current management actions performed by the Recovery Program in the Project action area include, but are not limited to:

- Overseeing non-native fish removal activities in the Green River Basin, downstream of the Project. Nonnative fishes of immediate primary concern and currently explicitly targeted for management are northern pike, smallmouth bass, walleye, and burbot (*Lota lota*). These nonnative fish species pose significant threats to the endangered fishes because of their high or increasing abundance and range expansion, their habitat and resource requirements overlap with those of the endangered fish species, and their predatory impact;
- Participating in the Flaming Gorge Technical Workgroup, which manages releases from Flaming Gorge Dam to benefit endangered fish species while meeting other legal purposes of the dam. This technical team establishes base flow and spring peak release criteria from Flaming Gorge that meet the Flow Recommendations (Muth et al. 2000); and
- Stocking of bonytail and razorback sucker into the middle and lower Green River.

FLOW PROTECTION IN THE GREEN RIVER - Recovery cannot be accomplished without securing, protecting, and managing sufficient habitat to support self-sustaining populations of the

endangered fishes. Identification and protection of instream flows are key elements in this process. The first step in this process, identifying instream flows needed for recovery, was completed for the action area with the publication of the Flow Recommendations (Muth et al. 2000). However, there is no legal protection of flows in the Utah portion of the Green River. The process for meeting this recovery goal is ongoing, as described below.

Several approaches may be taken under Utah water law to protect instream flows, including: 1) acquiring existing water rights and filing change applications to provide for instream flow purposes; 2) withdrawing unappropriated waters by governor's proclamation; 3) approving presently filed and future applications subject to minimum flow levels; and 4) with proper compensation, preparing and executing contracts and subordinating diversions associated with approved and perfected rights.

Although Utah water law may not fully provide for all aspects of instream-flow protection, the State believes they can provide an adequate level of protection. Utah examined available flow protection approaches in the 1990's and determined that their primary strategy will be to condition the approval of presently filed and new applications, making them subject to predetermined streamflow levels. To accomplish this, the State Engineer adds a condition of approval to post-1994 water right applications above Jensen filed after the policy is adopted. The condition states that whenever the flow of the Green River (or other streams) drops below the predetermined streamflow level, then diversions associated with water rights approved after the condition is imposed are prohibited. Based on past legal challenges to the State's authority to impose conditions associated with new approvals, it was determined that this is within the authority of the State Engineer.

This approach does not specifically recognize an instream-flow right; however, it does protect the flows from being diverted and used by subsequently approved water rights. This approach was adopted as policy by the State Engineer. The policy requires that presently filed and new applications to be approved are subject to the summer and fall flow recommendations. As flow recommendations are finalized and accepted, Utah will review options for protecting the recommended flows. In 2009, Utah determined that the aforementioned "subordination" method of flow protection may not be feasible below Jensen. The Recovery Program's Water Acquisition Committee formed a task force to develop other options for protecting fish flows on the Green River. In 2010, modeling began (and is ongoing) to determine the volume of water that would be needed to protect fish flow targets under current demands and projected future demands. Preliminary results of modeling indicate that under current and future demands the lowest flow years may not meet the flow recommendation targets in Reach 3 without additional protected volumes of water. The volume of water needed and flow protection are planned to be determined by 2017.

PARTICIPATION IN THE FLAMING GORGE TECHNICAL WORKGROUP - The Flaming Gorge Technical Working Group (FGTWG) was established pursuant to the Operation of Flaming Gorge Dam Final Environmental Impact Statement (FEIS) as recommended in the Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam (Flow Recommendations) (Muth et al. 2000). Members of the FGTWG include biologists and hydrologists from the Recovery Program, Bureau of Reclamation (BOR), the U.S. Fish and Wildlife Service, and Western Area Power Administration. The Record of

Decision on the FEIS clarified the purpose of the FGTWG as limited to proposing specific flow and temperature targets for each year's operations based on current year hydrologic conditions and the conditions of the endangered fish. The FGTWG was also charged with integrating, to the extent possible, any flow requests from the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) into the flow proposal so that Recovery Program research could also be facilitated. This process concurrently serves the informal consultation and coordination requirements of the ESA for the action agencies as committed to in the ROD.

Flaming Gorge operations greatly impact the hydrologic conditions found in the action area. The BOR sets Flaming Gorge releases to support target flows at the Jensen gauge (Reach 2 from the FEIS), which in turn substantially affect the flows at the Green River, Utah gauge (Reach 3). Recommended base flows in Reach 3 are measured immediately downstream of the Project; therefore adequate base flows in Reach 3 would support all Project features (i.e. water use, boat passage, fish passage). However, BOR and the Service recognize that between Flaming Gorge and Green River, Utah, there are many stream miles, inputs and withdrawals, and disparate weather patterns. Therefore, BOR does not manage Flaming Gorge to attempt to meet Reach 3 targets; instead they assume that managing for Reach 2 targets should adequately meet Reach 3 targets. While meeting Reach 2 targets may not always cause Reach 3 targets to be met, water supplied for Reach 2 does support higher base flows in Reach 3. As long as hydrology and climatic patterns supply adequate runoff, continued cooperation between the FGTWG members to release adequate base flows for Reach 2 will support conditions at the Project area.

ENDANGERD FISH STOCKING - Each year tens of thousands of bonytail and razorback sucker are stocked into the main stem Green River. Two primary stocking locations are in the middle Green River near Ouray National Wildlife Refuge and in the lower Green River at Green River State Park. Stocking these fish in the main stem river is designed to supplement the population and eventually create a self-sustaining population.

EFFECTS OF THE ACTION

EFFECTS TO ENDANGERED SPECIES

The Project will adversely affect Colorado pikeminnow, razorback sucker, bonytail, and humpback chub by reducing the amount of water in the river system upon which they depend by up to 455.2 acre-feet per year. The effects to all four species primarily result from the effects of the action upon their habitats. In general, the proposed action will adversely affect the four listed fish by reducing the amount of water available to them, increasing the likelihood of water quality issues, increasing their vulnerability to predation, and reducing their breeding opportunities by shrinking the amount of breeding and nursery habitat within their range.

Removing 455.2 acre-feet per year from the Colorado River Basin will alter the natural hydrological regime that creates and maintains important fish habitats, such as spawning habitats, and reduces the frequency and duration of availability of these habitats of the four endangered fish. The reduction of available habitats will directly affect individuals of all four species by decreasing reproductive potential and foraging and sheltering opportunities. Many of the habitats required for breeding become diminished when flows are reduced. As a result, individual fish within the action area may not find suitable breeding locations or will deposit eggs in less than optimal habitats more prone to failure or predation. In addition, reduction in

flow rates lessens the ability of the river to inundate bottomland, a source of nutrient supply for fish productivity. Water depletions also exacerbate competition and predation by nonnative fishes by altering flow and temperature regimes toward conditions that favor non-natives.

The proposed depletions affect the water quality in the action area by increasing concentrations of heavy metals, selenium, salts, pesticides, and other contaminants. Increases in water depletions will cause associated reductions in assimilative capacity and dilution potential for any contaminants that enter the river. The Project depletions will cause a proportionate decrease in dilution, resulting in an increase in heavy metal, selenium, salts, pesticides, and other contaminant concentrations in the Colorado River system. An increase in contaminant concentrations in the river can result in an increase in the bioaccumulation of these contaminants in the food chain which could adversely affect the endangered fishes. Selenium is of particular concern due to its effects on fish reproduction and its tendency to concentrate in low velocity areas that are important habitats for Colorado pikeminnow and razorback sucker.

The proposed Project will affect the physical condition of habitat for the four listed fish by resulting in a reduction of water. This reduction will contribute to the cumulative reduction in high spring flows, which are essential for creating and maintaining complex channel geomorphology and suitable spawning substrates, creating and providing access to off-channel habitats, and possibly stimulating Colorado pikeminnow spawning migrations. Adequate summer and winter flows are important for providing a sufficient quantity of preferred habitats at a duration and frequency necessary to support all life stages of viable populations of all endangered fishes. To the extent that the proposed Project will reduce flows, the ability of the river to provide these functions will be reduced. This reduction of water affects habitat availability and habitat quality.

To the extent that it will reduce flows and contribute to further habitat alteration, the proposed project may contribute to an increase in nonnative fish populations. The modification of flow regimes, water temperatures, sediment levels, and other habitat conditions caused by water depletions has contributed to the establishment of nonnative fishes. Endangered fishes within the action area will experience increased competition and predation as a result.

EFFECTS TO CRITICAL HABITAT

All four of the listed Colorado River fish require the same primary constituent elements (PCEs) essential for their survival. Therefore, we are combining our analysis of all four species into one section. Because the amount of designated critical habitat varies for each of the four species, the amount of critical habitat will vary; however, the effects will be the same for all critical habitats within the action area.

PRIMARY CONSTITUENT ELEMENT – WATER - The Project will deplete up to 455.2 acre-feet per year from the Colorado River Basin. Removing water from the river system changes the natural hydrological regime that creates and maintains important fish habitats, such as spawning habitats, and reduces the frequency and duration of availability of these habitats of the four endangered fish. In addition, reduction in flow rates lessens the ability of the river to inundate bottomland, a source of nutrient supply for fish productivity and important nursery habitat for razorback sucker. Water depletions change flow and temperature regimes toward conditions that

favor nonnative fish, thus adding to pressures of competition and predation by these nonnative fishes as discussed above.

Changes in water quantity would affect water quality, which is a PCE of critical habitat. Contaminants enter the Colorado River from various point and non-point sources, resulting in increased concentrations of heavy metals, selenium, salts, pesticides, and other contaminants. Increases in water depletions will cause associated reductions in assimilative capacity and dilution potential for any contaminants that enter critical habitat in the Colorado River. The subject depletions will cause a proportionate decrease in dilution, which in turn would cause a proportionate increase in heavy metal, selenium, salts, pesticides, and other contaminant concentrations in the Upper Colorado River Basin, affecting water quality.

Water, physical habitat, and the biological environment are the PCEs of critical habitat. This includes a quantity of water of sufficient quality that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100 year floodplain, when inundated, provide access to spawning, nursery, feeding, and rearing habitats. Food supply, predation, and competition are important elements of the biological environment.

PRIMARY CONSTITUENT ELEMENT – PHYSICAL HABITAT - The Project will affect the physical condition of habitat for the four listed fish by resulting in a reduction of water. This reduction will contribute to the cumulative reduction in high spring flows, which are essential for creating and maintaining complex channel geomorphology and suitable spawning substrates, creating and providing access to off channel habitats, and possibly stimulating Colorado pikeminnow spawning migrations. Adequate summer and winter flows are important for providing a sufficient quantity of preferred habitats for a duration and at a frequency necessary to support all life stages of viable populations of all endangered fishes. To the extent that the subject action will reduce flows, the ability of the river to provide these functions will be reduced. This reduction of water affects habitat availability and habitat quality.

PRIMARY CONSTITUENT ELEMENT – BIOLOGICAL ENVIRONMENT - To the extent that it will reduce flows and contribute to further habitat alteration, the Project may contribute to an increase in nonnative fish populations. The modification of flow regimes, water temperatures, sediment levels, and other habitat conditions caused by water depletions has contributed to the establishment of nonnative fishes. Endangered fishes within the action area would experience increased competition and predation as a result.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. In Wyoming, most water depletions within the Colorado River Basin include a federal nexus and will be addressed in future section 7 consultations.

CONCLUSION

After reviewing the current status of the Colorado pikeminnow, humpback chub, bonytail, and razorback sucker, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that the Project, as described in this biological opinion, will not reduce the reproduction, numbers, or distribution of endangered fish in a manner that would be expected to reduce appreciably the likelihood of survival and recovery of endangered fish in the wild, and that the Project, as described, is not likely to destroy or adversely modify designated critical habitat.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury of wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

Colorado pikeminnow, humpback chub, bonytail, and razorback sucker are harmed from the reduction of water in their habitats resulting from the subject action in the following manner: (1) individuals using habitats diminished by the proposed water depletions could be more susceptible to predation and competition from non-native fish, and (2) habitat conditions may be rendered unsuitable for breeding because reduced flows would impact habitat formulation and maintenance as described in the biological opinion.

Estimating the number of individuals of these species that would be taken as a result of water depletions is difficult to quantify for the following reasons: (1) determining whether an individual forwent breeding as a result of water depletions versus natural causes would be extremely difficult to determine; (2) finding a dead or injured listed fish would be difficult, due to the large size of the action area and because carcasses are subject to scavenging; (3) natural fluctuations in river flows and species abundance may mask depletion effects, and (4) effects that reduce fecundity are difficult to quantify. However, we believe the level of take of these species can be monitored by tracking the level of water reduction and adherence to the Recovery Program. Specifically, if the Recovery Program (and relevant RIPRAP measures) is not implemented, or if the current anticipated level of water depletion is exceeded, we fully expect the level of incidental take to increase as well. Therefore, we exempt all take in the form of harm that would occur from the removal of 455.2 acre-feet of water per year. Water depletions above the amount addressed in this biological opinion would exceed the anticipated level of incidental take and are not exempt from the prohibitions of section 9 of the ESA.

The implementation of the Recovery Program is intended to minimize impacts of water depletions; therefore, support of Recovery Program activities by BLM as described in the proposed action exempts BLM and Project proponent from the prohibitions of section 9 of the ESA. The BLM is responsible for reporting to the Service if the amount of average annual depletion is exceeded.

REASONABLE AND PRUDENT MEASURES

In addition to the conservation measures identified earlier in this document, we believe the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take of Colorado pikeminnow, humpback chub, bonytail, and razorback sucker.

1. The BLM and Project proponents must implement a monitoring and reporting program to ensure that the annual depletion does not exceed 455.2 acre-feet per year and that the cumulative depletion for the Project does not exceed 5,211.1 acre-feet.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, the BLM and Project proponent must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

In order to implement a monitoring and reporting program:

1. The Project proponents will regularly (e.g., quarterly) provide a written report of water withdrawn from the groundwater wells to BLM.
2. The BLM will track annual and cumulative depletions and will work with the Project proponents to identify alternate water sources if depletions approach the amounts identified above in the reasonable and prudent measures.

REINITIATION NOTICE

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

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