DOE/EA-1759

Environmental Assessment Southwest Alaska Regional Geothermal Energy Project Naknek, Alaska

May 2010

U.S. Department of Energy
Golden Field Office
1617 Cole Boulevard
Golden, Colorado 80401

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
$\mu g/m^3$	micrograms per cubic meter
AAAQS	Alaska Ambient Air Quality Standards
ACFEC	Alaska Commercial Fisheries Entry Commission
ADCCED	Alaska Department of Commerce, Community and Economic Development
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish & Game
ADNR	Alaska Department of Natural Resources
AES AK	ASRC Energy Services Alaska, Inc.
ASTM	American Society for Testing and Materials
BLM	Bureau of Land Management
BMP	Best Management Practice
CAA	Clean Air Act
CEA	Cumulative Effects Assessment
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cm	centimeter
CO	carbon monoxide
CWA	Clean Water Act
dB	decibel(s)
DOE	U.S. Department of Energy
EA	Environmental Assessment
EGS	Enhanced Geothermal System
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ft	foot, feet
gal	gallon(s)
GHG	greenhouse gas
GHG	Greenhouse gases

GMU	Game Management Unit
HDR	HDR Alaska, Inc.
IEA	International Energy Agency
km	kilometer(s)
m	Meter
MCH	Mulchatna Caribou Herd
MEQ	microearthquake
mg/m^3	milligrams per cubic meter
mi	Mile
M_L	local magnitude
NAAQS	National Ambient Air Quality Standards
NEA	Naknek Electrical Association
NEPA	National Environmental Policy Act
NH_3	ammonia
NO_2	nitrogen dioxide
NPCH	Northern Peninsula Caribou Herd
O_3	Ozone
OHA	Office of History & Archaeology
OSHA	U.S. Occupational Safety and Health Administration
Pb	Lead
PM_{10}	particulate matter less than 10 microns in diameter
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
ppm	parts per million
PSA	Public Service Announcement
psig	pounds per square inch, gauge
SHPO	State Historic Preservation Office
SO_2	sulfur dioxide
sq ft	square foot/feet
sq km	square kilometers
sq m	square meter(s)
sq mi	square miles
std	standard

TEEIC	Tribal Energy and Environmental Information Clearinghouse
tpy	tons per year
TWUP	Temporary Water Use Permit
U.S.C.	U.S. Code
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WRCC	Western Regional Climate Center

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE) is proposing an action (the Proposed Action) to fund the construction, operation, drilling, well logging, completion, installation of a seismic monitoring network, and testing of two of the exploratory geothermal wells (G2 and G3) and stimulation of one well (G1, G2, or G3), if feasible, on a 49-hectare (120-acre) parcel of land in southwest Alaska. The Naknek Electric Association (NEA) owned land is approximately 8 kilometers (km) (5 miles [mi]) northeast of King Salmon (Figure 1.0-1). Existing infrastructure includes a gravel road to the project area, two gravel pads connected by a gravel road, and a single exploratory geothermal well (G1), currently being drilled. Geothermal conditions are being investigated at various depth intervals to evaluate the potential for commercial production of geothermal fluids by conventional means (i.e., by self-flow or pumping without special stimulation of the rock formation). The permeability of the rock formation in a conventional geothermal reservoir is typically high enough to allow hot, trapped water (heated by the rock formation) to flow naturally to the surface during drilling.

If the geothermal resource should exist in the form of hot, dry rock, Enhanced Geothermal System (EGS) techniques would be used to stimulate the rock formation and permeability so that it can successfully serve as a geothermal reservoir. Stimulation of G1 and drilling additional geothermal wells (G2, G3) would establish the components to set up a production-injection doublet and form a convective hydrothermal system. Using hydraulic stimulation to fracture the rock formations between wells would create flow paths between them through which water could be circulated and heated.

In accordance with DOE and National Environmental Policy Act (NEPA) implementing regulations, DOE is required to evaluate the potential environmental impacts of DOE facilities, operations, and related funding decisions. The decision to use federal funds for this Proposed Action requires that DOE address NEPA requirements and related environmental documentation and permitting requirements.

1.1 National Environmental Policy Act and Related Procedures

The regulatory framework of this Proposed Action, with federal funding, is defined by National Environmental Policy Act (NEPA). The Council on Environmental Quality (CEQ) oversees implementation of NEPA. The procedural provisions of NEPA (Code of Federal Regulations [CFR], 40 CFR Parts 1500–1508) and DOE's implementing procedures for compliance with NEPA (10 CFR Part 1021) require that DOE, as a federal agency:

- Assess the environmental impacts of its Proposed Actions.
- Identify any adverse environmental impacts that cannot be avoided should a Proposed Action be implemented.
- Evaluate alternatives to the Proposed Action, including a "No Action alternative".
- Describe the relationship between local, short-term uses of the environment and the maintenance and enhancement of long-term productivity.
- Characterize any irreversible and irretrievable commitments of resources that would be involved should the Proposed Action be implemented.

These requirements were met before a final decision was made to proceed with any proposed federal action that could cause significant impacts to human health or the environment. This Final Environmental Assessment (EA) is intended to meet DOE's regulatory requirements under the NEPA process, providing the public, tribes, State of Alaska, and other agencies information to make comments on the draft EA.

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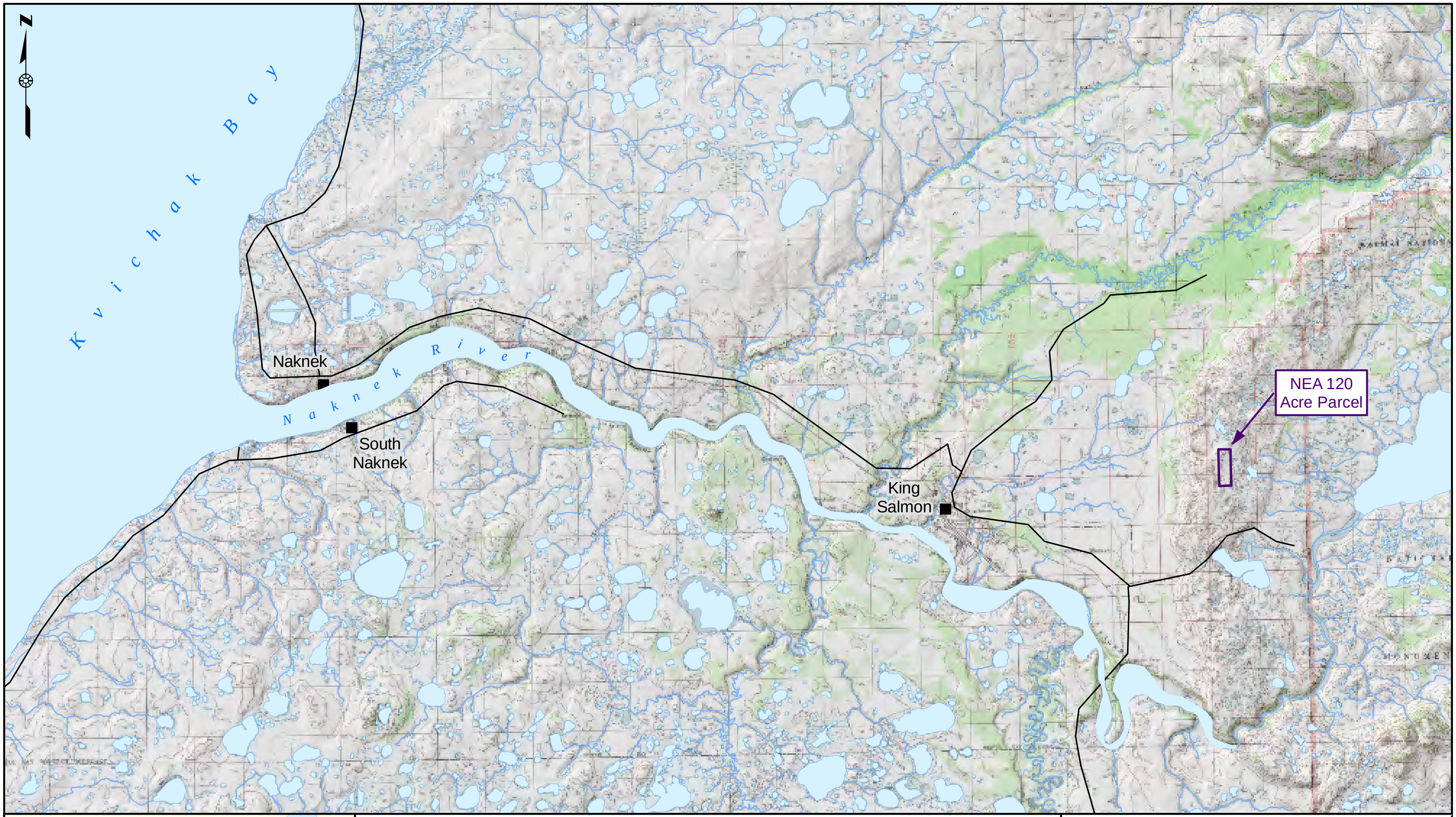

■ Town —— Road

NAD 83, Alaska State Plane Zone 06

ASRC Energy Services
a subsidiary of Arctic Slope Regional Corporation
Regulatory and Technical Services

Naknek Electric Association

LOCATION MAP
Naknek Electric Association
Environmental Assessment

SCALE: 0 1 2 4 Miles

FIGURE: 1.0-1

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1.2 Background

In an effort to provide reliable and affordable electricity, NEA discovered the possibility of local geothermal resources as an alternative to diesel-fueled power generation and researched the potential for project development in 2000. NEA was able to narrow site selection to Pike's Ridge, one of three potential drill areas originally chosen. Drilling the Naknek G1 well began in 2009 and completed in April 2010. While NEA has funded a large portion of preliminary research, other funding was received from Alaska's Denali Commission (2007) and the Federal 2009 Omnibus Bill (energy and water legislation). NEPA was not required as a prerequisite to NEA's receiving Alaska's Denali Commission and Omnibus Bill funding.

NEA services a member-owned cooperative that provides electric power to the communities of the Bristol Bay Borough, including Naknek, South Naknek, and King Salmon (Figure 1.0-1). There are approximately 1,029 services on 143 km (89 mi) of transmission line providing electricity to 628 residential units and 285 commercial units. Consumer density is approximately 7.2 per km (11.6 per mi). These communities are a business and industrial hub for Alaska's Bristol Bay region. This project would decrease and stabilize energy costs, benefiting the public sector (e.g., schools, municipalities, and utilities) and the private sector (e.g., industry and private energy users). By decreasing and stabilizing energy costs, this project would foster economic development in the region, such as commercial fishing and natural resource development. Tourism and service section employment opportunities would also likely grow because the funds that currently are dedicated to heat and electricity generation would be available for development of other projects.

1.3 Scoping

The provisions of NEPA provide the public an opportunity to participate in the environmental review process. DOE has taken measures to maximize public consultation and input during the preparation of this EA. This section describes the steps taken to document public interest in this EA.

On February 19, 2010, DOE/NEA sent out a special edition scoping newsletter to inform the public (within the NEA service area described in section 1.2) of the Proposed Actions and to request comments from the public sector as part of the development of the EA. The comment period was open for two weeks. The scoping newsletter identified the geothermal project overview and benefits, proposed activities, stimulation techniques, and NEPA process. Households, businesses, and public agencies receiving electricity from NEA in Bristol Bay received a scoping newsletter. The newsletter was sent to a total of 628 members. No public comments were received, see Appendix A for a copy of the newsletter.

The draft DOE/EA-1759 was posted for public review, on March 19, 2010 on DOE's Golden Field Office Public Reading Room website and the NEA project website (www.naknekgeothermalproject.com). Copies of the "Notice of Availability" issued for DOE/EA-1759 were made available to the public at the U.S. Post Office branches in Naknek, South Naknek, and King Salmon. Additional "Notice of Availability" postings were posted at the Bristol Bay Borough Building, and NEA and DOE project websites. A Public Service Announcement (PSA) was aired March 19, 22, and 23, 2010 on two local radio stations, KDLG (670 AM) and KAKN (100.9 FM). Both KDLG and KAKN radio stations broadcast to communities of Naknek, King Salmon, and South Naknek, reaching all 628 NEA members. The draft DOE/EA-1759 public comment period closed April 2, 2010. No comments were received. The "Notice of Availability" and PSA announcements featured a U.S. Mail and an email address for the public to provide their comments.

1.3.1 Agency Consultation

To evaluate potential impacts to threatened and endangered birds and cultural resources within the proposed project area, agency consultation occurred through the U.S. Fish and Wildlife Service (USFWS) and Alaska State Historic Preservation Office (SHPO), respectively. DOE received agency concurrence from USFWS, April 8, 2010. In the USFWS review of the Proposed Actions and project impacts, the proposed actions were determined to have no effect on listed species within the project area. The requirements for Section 7 of the ESA (Endangered Species Act) were met.

DOE received agency concurrence from SHPO on April 9, 2010. In their review of the Area of Potential Effect (APE), they determined that no Historic Properties would be affected. Both USFWS and SHPO letters are provided in Appendix C.

1.4 Purpose and Need

The Proposed Action supports and advances DOE's research and development mission in the area of energy efficiency and renewable energy technologies. The goal of this mission is to improve the nation's overall economic strength and competitiveness, energy security, and environmental stewardship through the development, demonstration, and deployment of clean, competitive, and reliable power technologies. The Proposed Action would contribute to achieving this mission. Specifically, the purpose and need of the Proposed Action are to fund the construction, operation, drilling, well logging, completion, installation of a seismic monitoring network, and testing of two of the exploratory geothermal wells (G2 and G3) and stimulation of one well (G1, G2, or G3), if feasible. The Proposed Action is necessary in developing the geothermal resource, which may lead to providing electric power to the NEA service area in the future. If development of the geothermal resource is sufficient to develop a generation facility, the project may expand infrastructure to include a power plant, switch yard, and a tie-in to the current NEA energy grid. Development of the power plant and associated facilities would provide power to the NEA service area at a greatly reduced cost.

The Geothermal Steam Act of 1970 encouraged geothermal development as a means of diversifying energy supplies in the United States. The proposed project would help Southwest Alaska and the United States reach their goals by reducing the Bristol Bay Borough's need for non-renewable energy sources that produce greenhouse gas emissions. Additionally, by decreasing and stabilizing energy costs, this project would foster economic development in the region.

1.5 Organization of this EA

The Proposed Action is described in Section 2. The affected environment within which these actions would occur is characterized in Section 3. The cumulative impacts of these actions and others are assessed in Section 4, and the commitment of resources is discussed in Section 5. Section 6 lists the agencies consulted. Section 7 of this EA lists references cited.

Additionally there are four appendices providing information pertaining to the requirements of the NEPA process:

- Appendix A–Scoping Newsletter,
- Appendix B–Wetlands Report, with findings from the wetlands determination study performed within the project area
- Appendix C–Agency Consultation Letters
- Appendix D–Induced Seismicity Report

2.0 PROPOSED ACTION AND ALTERNATIVES

Two alternatives were evaluated in the EA: the Proposed Action and the No Action alternative.

2.1 Proposed Action

The Proposed Action would include the construction, operation, drilling, well logging, completion, installation of a seismic monitoring network, and drilling of two wells (G2 and G3 on an existing gravel pad) to a depth of approximately 3,658 meters (m) (12,000 feet [ft]) below ground surface. If data from the wells indicate it is necessary, one well (G1, G2, or G3) would be stimulated to fracture the rock and increase permeability within the rock structure. Stimulation protocol would utilize EGS and would increase the potential of the field to produce energy.

2.2 Overview

As discussed previously, DOE proposes to fund NEA's drilling and testing of up to two geothermal production wells, a seismic monitoring network, and stimulation of one of the wells (G1, G2, or G3) as described below. The proposed project site is located on a 49-hectare (120-acre) private land parcel owned by NEA, approximately 8 km (5 mi) east-northeast of King Salmon (Figure 1.0-1). The existing infrastructure and recent site improvements would assist with continuing the geothermal resource exploration and constructing the production system.

2.3 Project Location

The NEA parcel resides within the Bristol Bay Borough Coastal District in Township 17S, Range 44 W, Seward Meridian; Section 14, E½ SW¼; and Section 23, NE¼ NW¼. The site is located on an upland area approximately 32 km (20 mi) from the coastline and 6.5 km (4 mi) from the Naknek River (Figure 1.0-1).

2.4 Existing Facilities

The project area is located near the existing port at Naknek, the King Salmon Airport, and the existing road network surrounding King Salmon, all of which may accommodate proposed activities. Entry to the site is provided by a gravel road connected to the Lake Camp Road that local residents use to access the Lake Camp Recreation site dockage and boat launch at the Naknek River, typically between the months of April and September. Figure 2.4-1 shows the northernmost gravel pad (one of two pads) located on the project site. Figure 2.4-2 is a photo of the site as of September 2009.

NEA has completed or is in the process of completing the following site preparation activities:

- Construction of a 5.5 m (18 ft) wide gravel road approximately 3 km (1.8 mi) in length, from Lake Camp Road to the project site
- Construction of two gravel pads, each approximately 90 m by 110 m (300 ft by 350 ft)
- G1 completed drilling April 2010 and was drilled to approximately 3,050 m−4,270 m (10,000 ft−14, 000 ft) in depth on the northernmost gravel pad (N58° 41' 56", W156° 30' 14").
- A laydown and storage area has been developed on the southernmost gravel pad (Figure 2.4-3).
- Construction of an inert waste monofill, a drilling fluid storage cell, two temporary cuttings storage areas, and a freshwater storage cell.
- A project office and work area with electricity, heat, and facilities to support drilling efforts.

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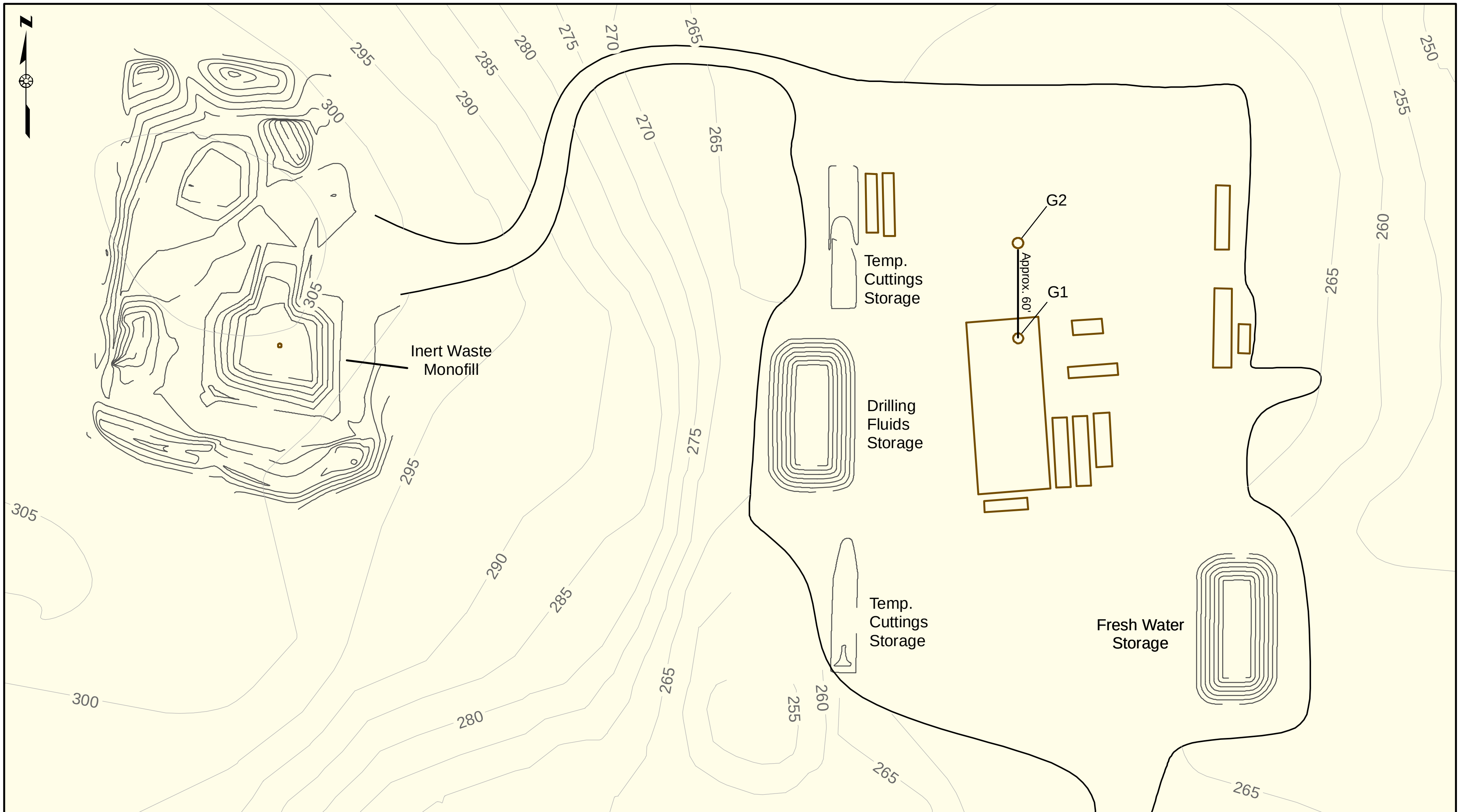

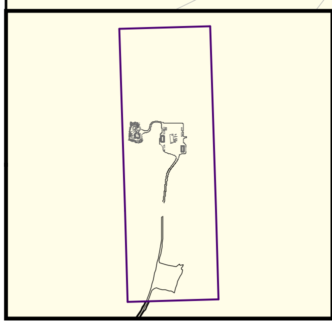

Drill Rig & Supporting Equipment

Storage Cells For Fresh Water Drilling Fluids & Cuttings

Road & Drill Pad Limits

Elevation Contour

ASRC Energy Services
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Regulatory and Technical Services

NAD 83, Alaska State Plane Zone 06

Naknek Electric Association

PROPOSED PROJECT SITE LAYOUT
Northernmost Gravel Pad
Naknek Electric Association
Environmental Assessment

SCALE: 0 40 80 160 Feet

FIGURE: 2.4-1

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Figure 2.4-2 Aerial Photograph of the NEA Geothermal Project Site, September 2009

Notes: Existing infrastructure and equipment include NEA's Drill Rig 7, with supporting equipment and water and drilling fuel storage cells on northern gravel pad; laydown and storage area on the southernmost gravel pad (not pictured in this photograph; see Figure 2.4-3); inert waste monofill (upper left); a heated project office; other heavy equipment and passenger trucks. The gravel road exiting the site (bottom-left corner of photo) connects with Lake Camp Road.

2.5 Water Sources

The water required to support temporary drilling operations would be obtained from an approved surface source, which is a small lake located on the southeast corner of the NEA parcel (N58° 41' 34.706"; W 1560 30' 2.786") (Figure 2.4-3). It may be supplemented by water taken from a water-supply well that would be drilled adjacent to the G1 pad. The lake does not support a resident fish population, according to the Alaska Department of Fish and Game (ADF&G). While the State of Alaska, Temporary Water Use Permit (TWUP) A2009 54 allows for up to a total 12 million gallons (gal) to be withdrawn for G1 and G2. Water needs for drilling of G1 required a total of 2.5 million gal of water, water requirements for the drilling of G2 and G3 can be expected to be comparable. Ultimately, the project is likely to use less water than has been permitted by the State of Alaska.

2.6 Infrastructure Improvements

To accommodate exploration activities, NEA would extend the existing southern gravel pad by 20 m (60 ft) in the north-south direction a total of no more than 1,672 square meters (sq m) (18,000 square feet [sq ft]), or 0.16 hectares (0.4 acres).

These activities would occur while NEA continues to evaluate the geothermal resource from the results of drilling and testing G1. The equipment, materials, and approved stormwater collection and control measures to complete the proposed infrastructure improvements are on-site.

As an exploratory geothermal project, it is difficult to anticipate what type of geothermal system may exist at this point. The following section outlines the exploration and construction activities anticipated for evaluating the proposed geothermal resource for commercial production.

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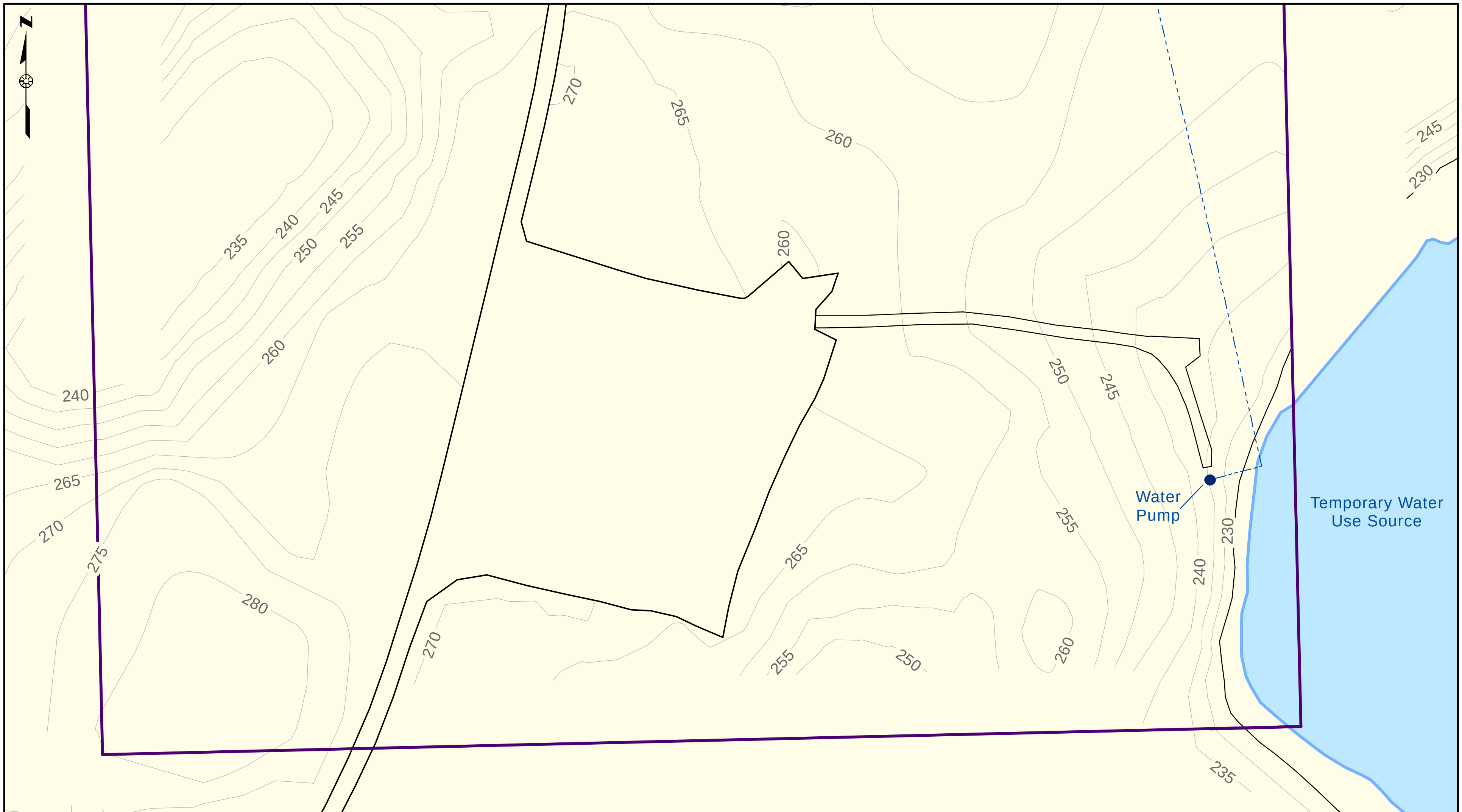

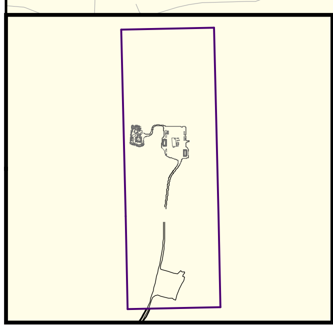

NEA 120 Acre Parcel

Road and Storage Pad

Fresh Water Line

Elevation Contour

NAD 83, Alaska State Plane Zone 06

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Naknek Electric Association

PROPOSED PROJECT SITE LAYOUT
Southernmost Gravel Pad
Naknek Electric Association
Environmental Assessment

SCALE: 0 60 120 240 Feet

FIGURE: 2.4-3

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2.7 Evaluation of Geothermal Resource for Commercial Power Production

To evaluate the commercial geothermal power production capacity and sustainability in the project area, NEA proposes to complete the following steps:

1. Characterize the existing geothermal resource.
2. Develop the geothermal resource with EGS techniques, if deemed necessary as defined by the International Energy Agency's (IEA) *Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems*
3. Determine whether the enhanced geothermal resource is sufficient for commercial power production.

2.7.1 Characterize the Existing Geothermal Resource

NEA will complete drilling, well logging, and testing of G1 to determine whether the rock formation is a conventional hydrothermal reservoir or whether it has low permeability that requires enhancement to create a viable productive reservoir. NEA has completed drilling G1 in April 2010 and will analyze all data currently available, including geology, seismology, core samples, and wellbore logs, to characterize the geothermal resource at the site. Drilling of G1 is not part of the proposed action and was financed largely by NEA, with additional funding received through Alaska's Denali Commission and the federal 2009 Omnibus Bill (energy and water legislation).

Geothermal conditions are being investigated at various depth intervals in G1 to evaluate the potential for commercial production of geothermal fluids by conventional means (i.e., by self-flow or pumping without special stimulation of the rock formation). The permeability of the rock formation in a conventional geothermal reservoir is typically high enough to allow hot, trapped water, heated by the rock formation, to flow naturally to the surface during drilling. The temperature of the heated water as it comes to the surface is one indication of the potential for the doublet to generate electricity. Temperatures higher than 150 degrees Celsius (°C) (300 degrees Fahrenheit [°F]) are generally required to generate electricity.

2.7.1.1 Drilling the Second Geothermal Well

The second deep exploration well, G2, would be a deviated well reaching a maximum total vertical depth of 3,658 m (12,000 ft). The surface collar would be located 18 m (60 ft) north of the G1 well collar and would deviate to the south-southeast, kicking off at the 762 m (2,500 ft) depth level, and reach a maximum hole angle of 11.0 degrees. The bottom-hole location would be approximately 550 m (1,800 ft) south-southeast of the surface location and would reside within the bounds of the NEA parcel (Figure 2.7.1-1).

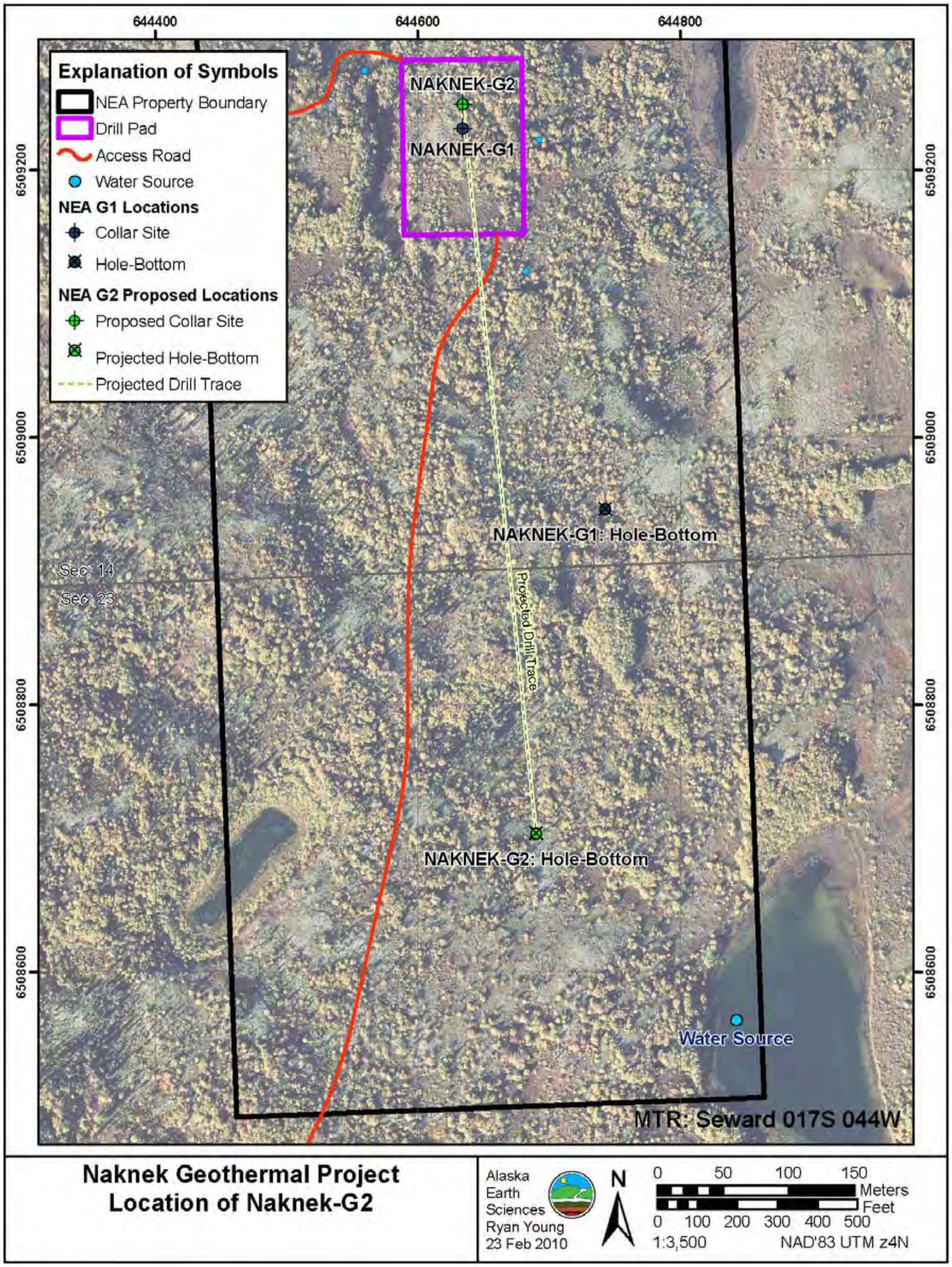
2.7.1.2 Overview

G2 would be a new, full-diameter well with total depth projected between 3,048–3,658 m (10,000–12,000 ft). The well would be cased to a depth of 2,440 m (8,000 ft) and cemented to the surface. Hung casing strings would be cemented throughout the liner lap. The well design would completely isolate geothermal and drilling fluids from contaminating fresh-water aquifers.

2.7.1.3 Equipment and Drilling Process

NEA plans to drill G2 with their NEA Rig 7, which has a National 1320 drawworks, or hoisting mechanism that is essentially a large winch controlling the drilling line raising or lowering the drill stem and bit. The drawworks has a rated capacity of 2,000-horsepower. A pile driver would be used to install the 76-centimeter (cm) (30-inch) conductor pipe to an approximate depth of 30 m (100 ft).

Figure 2.7.1-1 Location of Proposed Well G2 Relative to Existing Well G1



Notes: Surface collar of G2 is located 18.3 m (60 ft) north of G1, and the hole bottom of G2 is located approximately 549 m (1,800 ft) south-southeast from the surface, as depicted by the projected drill trace.

Blow-out prevention equipment would be in use on the well at all times, and all casing would be cemented back to the surface, isolating fresh water aquifers from contact with the activities and fluids in the wellbore.

The drilling and casing procedure to be employed would expedite the process and ensure safety in the presence of unstable formations. The well installation process would be guided by a steering system to drill near vertical, with the borehole staying within permitted property boundaries. The well would be drilled to a depth sufficient to allow for evaluation of reservoir conditions. It is not anticipated that the total well depth would exceed 3,658 m (12,000 ft). Drill data for well G1 indicate the bottom-hole pressures are not anticipated to exceed 5,000 pounds per square inch gauge (psig) (352 kilograms per square cm).

2.7.1.4 Winter Drilling

Drilling of G2 and future wells as needed would likely extend into the winter season (October though April). During this time, extra insulation would be added to barricade heat inside the drilling operation. The engine room, substructures, and mud pits and pumps would remain enclosed and heated by 15 steam systems fed through from the boiler room. Insulated well walls would assist to keep these locations within a desirable temperature range. NEA personnel would be required to dress accordingly to the winter weather conditions. Personnel would avoid prolonged exposure of face, hands, head, wrists, and feet to extreme cold.

2.7.2 Possible Enhancement of the Geothermal Resource

After the drilling and evaluation of G1, G2 would be drilled in order to evaluate another portion of the geothermal reservoir. If G1 and G2 exhibit a permeable hydrothermal reservoir that is adequate for geothermal energy production, then there would be no need to stimulate. If the geothermal resource exists in the form of a low-permeability reservoir with sufficient temperature in G1 and/or G2, NEA may use the technique of hydraulic stimulation to increase the permeability within the reservoir.

To further evaluate the commercial geothermal resource capacity in the project area, NEA proposes to drill a third geothermal well (G3) to be used either with G1 or G2 to construct a production-injection doublet. This doublet would be constructed between two wells and would undergo extensive testing. Prolonged testing, on the order of several months, of the doublets is necessary to model and predict the future reservoir behavior, including the feasibility of its generating the desired power output.

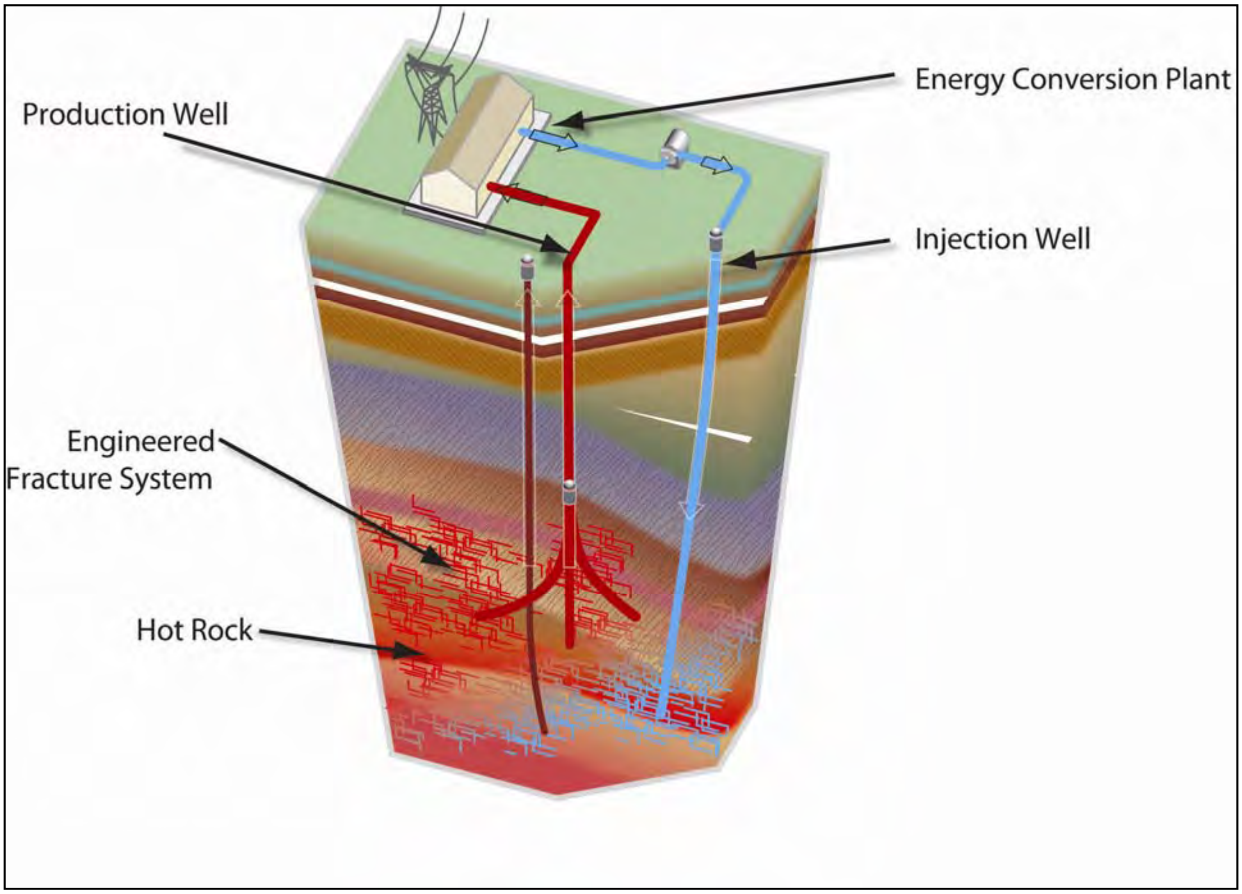
The stimulated rock formation creates fractures (flowpaths) between the geothermal wells through which water can be circulated to capture heat. The wells are then connected to form a production-injection doublet, which would essentially serve as a convective hydrothermal system (i.e., EGS [Figure 2.7.2-1). Prior to stimulation, a seismic monitoring network would be designed and installed to track the reservoir growth induced by stimulation and determine the need for additional wells.

2.7.3 Determine Whether Enhanced Geothermal System Is Adequate for Commercial Power Production

NEA plans to use the data collected during the drilling of G1, G2, and G3 (if necessary) and the testing of the resultant production-injection doublets to determine whether the geothermal resource in the area is sufficient to generate geothermal power.

If deemed feasible, NEA intends to maximize the commercial potential of the geothermal resource and plan for development. This scenario is analyzed in Section 4.0, Cumulative Impacts.

Figure 2.7.2-1 Schematic of Enhanced Geothermal System



Notes: Hydraulic stimulation is used to create an engineered fracture system in the injection well. The production well is drilled into the stimulated zone of the injection well and undergoes hydraulic stimulation to increase the size of the fracture system. The two wells are connected to create a production-injection doublet, which would be used to generate electricity in the energy conversion plant. Multiple production wells can be drilled and connected to the injection doublet to increase the flow of geothermal fluid.

2.7.3.1 Stimulation of the First Geothermal Well

In the absence of a naturally flowing hydrothermal system with sufficient permeability, NEA would develop a stimulation design and a seismic monitoring network (as identified in the IEA *Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems* for G1 or G2 prior to stimulation. Effective stimulation involves identifying target zones by analyzing wellbore data to determine the stress-field orientation and the dominant mode of faulting in the area. The wellbore data would be analyzed to determine the distribution and orientation of natural fractures and borehole failure phenomena encountered during drilling (tensile fractures and breakouts).

These analyses are used to identify the most prospective zones (areas most susceptible to fracturing under increased pressure) for the stimulation process, including an initial mini-fracture procedure. The mini-fracture involves injecting water into the well at relatively low pressures to increase the pore pressure in the well, creating a network of small fractures due to shear failure.

During the stimulation process, a seismic monitoring network would be designed and installed to assist with tracking new fractures, determining the modes and sense of failures, and characterizing the stress cycles associated with stimulation.

2.7.3.2 Drilling the Third Geothermal Well, if Necessary

If G1 and G2 are low-permeability wells that require stimulation, a third deep exploration well, G3, would be a deviated well reaching a maximum total vertical depth of approximately 3,658 m (12,000 ft), designed to intersect the stimulated fracture zone created by the stimulation described in Section 3.1.5. The surface collar would be located approximately 18.3 m (60 ft) from both the G1 and G2 well collars and would deviate to an angle and depth to be determined by the results and analysis of G2.

Overview

G3 would be a new, full-diameter well with total depth projected between 3,048 m–3,658 m (10,000 ft–12,000 ft). The well would be cased to a depth of 2,438 m (8,000 ft) and cemented to the surface. Hung casing strings would be cemented throughout the liner lap. The well design would completely isolate geothermal and drilling fluids from contaminating fresh-water aquifers.

Equipment and Drilling Process

NEA plans to drill G3 with NEA Rig 7. A pile driver would be used to install the 76-cm (30-inch) conductor pipe to an approximate depth of 31 m (100 ft). Blow-out prevention equipment would be in use on the well at all times, and all casing would be cemented back to the surface, isolating fresh-water aquifers from contact with the activities and fluids in the wellbore.

The well installation process would be guided by a steering system to drill the borehole within permitted property boundaries. The well would be drilled to a depth sufficient to allow for evaluation of reservoir conditions. It is not anticipated that the total well depth would exceed 3,658 m (12,000 ft). Drill data for well G1 indicate the bottom-hole pressures are not anticipated to exceed 5,000 psig.

The present casing design calls for the well to be drilled in several stages of different diameters, so that the open-hole interval would not exceed 1,500 m (5,000 ft) at any stage of drilling. This design would allow the well to be drilled more quickly and more safely in the presence of any severe losses of circulation or unstable formations; the upper portion of the hole would still be completed with a large enough casing diameter to minimize pressure losses due to friction during production. The larger-diameter completion in the upper portion of the well would also allow a large, shaft-driven pump to be installed, in the event that it is desirable to produce the well by pumping.

NEA received a Permit to Drill for G1 from the Alaska Department of Natural Resources (ADNR) and anticipates permit approval to drill for G2 prior to spud. The well design and drilling procedures and specifications are included in these permits and are proprietary information.

Well Completion

Well configuration for G2 and G3 (if drilled) will include the following components (G2 well design is shown in Figure 2.7.3-1).

- 76-cm (30-inch) conductor pipe driven to 30 m (100 ft)
- 51-cm (20-inch) surface casing at 122 m–213 m (400 ft–700 ft)
- 33.7-cm (13 3/8-inch) casing cemented to surface inside a 44.5-cm (17 ½-inch) hole at 914 m (3,000 ft)
- 24.5-cm (9 5/8-inch) casing hung inside the 33.7-cm (13 3/8-inch) casing with a 900-m (300-ft) liner tap and cemented inside a 31.1-cm (12 ¼-inch) hole from 823 m–2,438 m (2,700 ft–8,000 ft)

- 19.5-cm (7 5/8-inch) combination of slotted and blank liner, hung inside the 24.5-cm (9 5/8-inch) casing with a 30-m (100-ft) lap to total depth
- 21.6-cm (8 ½-inch) open hole drilled to 3,658 m (12,000 ft)

The well head design includes:

- 30.5-cm (12-inch) master valve
- 34.6-cm by 30.5-cm (13 5/8-inch by 12-inch) expansion spool
- 33.7-cm by 34.6-cm (13 3/8-inch by 13 5/8-inch) casing head

Well Testing and Logging

After well completion, each well would be tested to evaluate geothermal reservoir characteristics. Typically, the geothermal fluids are pumped from the well through on-site test equipment, including standard flow metering, recording, and sampling apparatus, to determine flow characteristics. The pressure and temperature at various depths in the wellbore would also be analyzed to determine whether the geothermal resource is sufficient for electricity generation.

Additionally, core samples and wellbore logs would be analyzed to characterize the reservoir by mapping open/flowing zones and measuring the permeability within these zones.

2.7.3.3 Construction Crew and Schedule

During drilling of G1, peak hire included 36 employees in November of 2009; 18 of those employees were local residents. Currently, it is anticipated drilling G2 and G3 would require a total of up to 36 employees. Drilling operations would run 24 hours a day, 7 days a week, for a duration of 72 days. Figure 2.7.3-1 shows the G2 well design. Figure 2.7.3-2 graphs drilling activity associated with depth and days 1 through 72.

Based on the current schedule, G1 was drilled to final depth in April 2010 and testing and well completion are in progress. The drill rig and other resources would remain on-site and be available to begin work on G2.

Figure 2.7.3-1 Naknek G2 Well Design

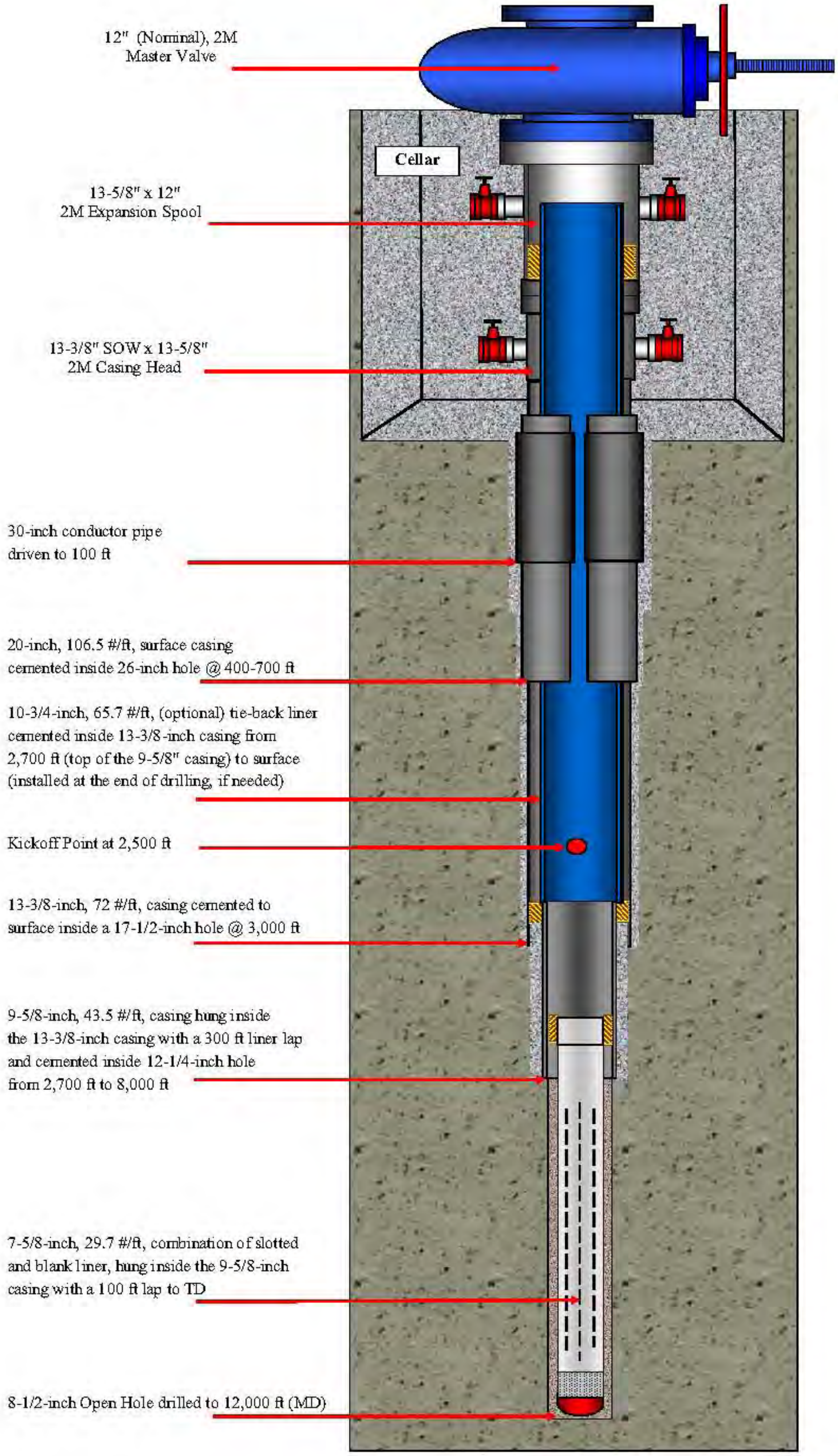
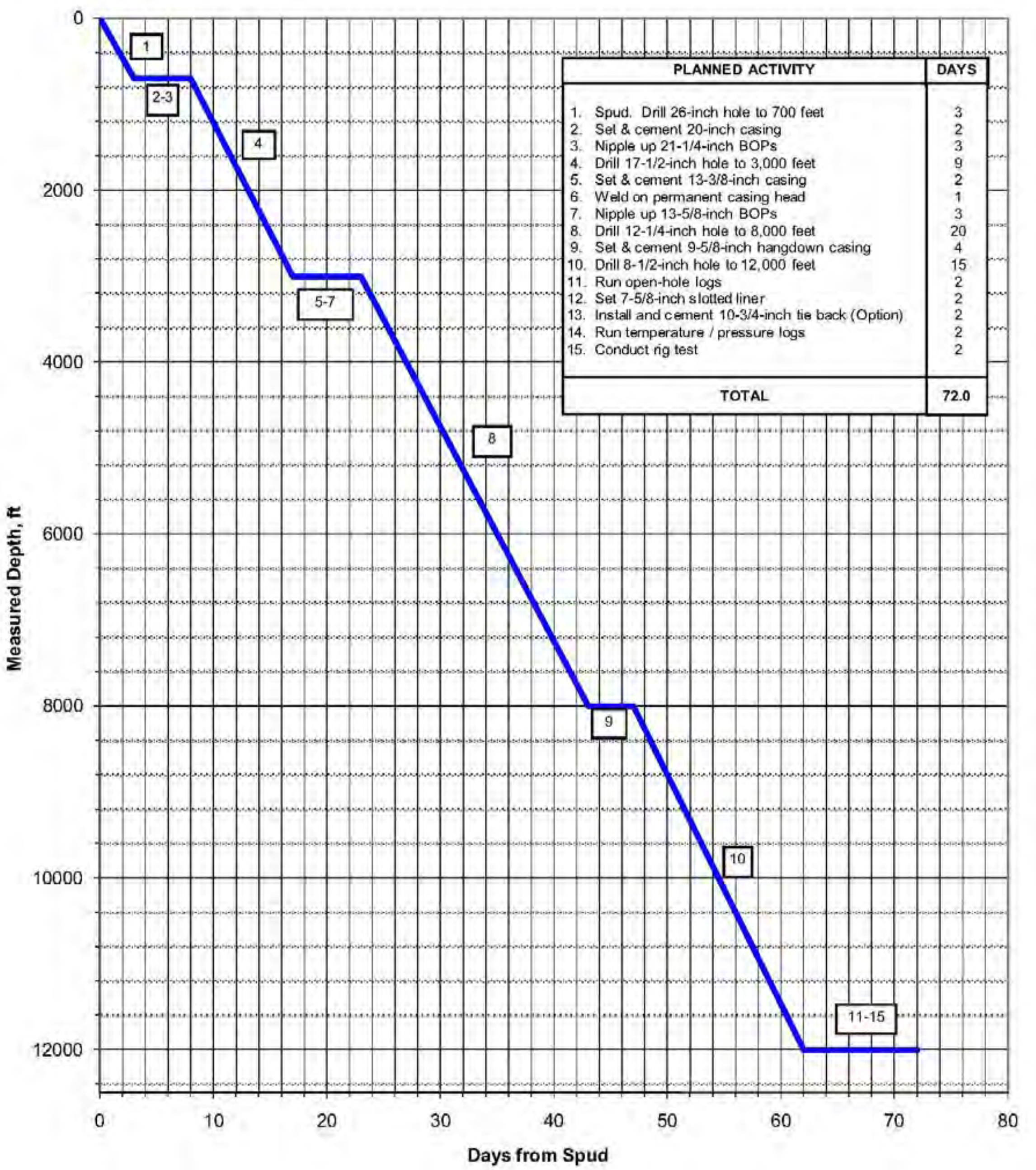


Figure 2.7.3-2 Drilling Days versus Depth for Naknek G2



Note: Drilling is expected to take 72 days from spud, May 2010, to completion, July 2010.

2.8 Operations

The viability of geothermal resources in the proposed project area would ultimately determine the project's operational plan. The results from drilling the first exploratory well, G1, would narrow the engineering scope and may determine what type of geothermal system exists. It is not known whether a conventional geothermal system exists or whether the geothermal resource requires enhancement to develop a geothermal system.

The results of G1 testing would indicate the reservoir type and provide initial hydrologic data. The resulting geothermal system (conventional or enhanced) would only be tested in this exploratory phase of the project. The test findings would assist in planning the production and operational phase of this project.

2.9 Decommissioning

It is not anticipated that any wells would be decommissioned during exploration and testing of geothermal resources. G1 would be completed and would undergo extensive testing to characterize the geothermal resource and reservoir rock. G2 and G3 would be drilled, completed, and tested similarly to G1. Well decommissioning (abandonment) involves plugging, capping, and reclaiming the well site. When necessary, decommissioning procedures would comply with American Society for Testing and Materials (ASTM) International D5299. Decommissioning options would be compatible with all applicable federal, state, and local requirements.

2.10 No Action Alternative

If the No Action alternative is implemented, expansion of the existing well system would not occur. Because this is a necessary precursor step to evaluation of geothermal resources and development of these resources, the need for economical, low-cost electricity within the NEA service area would not be met, and benefits from the low-cost energy would not be realized.

2.11 Applicant Committed Measures

The applicant committed measures will mitigate potential effects associated with the reserve tank and waste disposal, stormwater collection, air quality, noise, biological resources, and seismicity. The Proposed Actions will be implemented throughout the life of the project.

2.12 Reserve Tank and Waste Disposal

Three containment areas for waste have been constructed:

- An inert waste monofill—waste that is neither chemically nor biologically reactive would be disposed of here.
- A drilling fluids storage cell—36 m by 21 m by 4 m (117 ft by 70 ft by 14 ft) (300,000 gal). Drilling fluids are estimated to be less than 250,000 gal and would be stored here until they can be pumped back down the well into a lost circulation zone.
- A temporary cuttings storage area—drill cuttings are estimated to be 914 cubic m (1,000 cubic yards) per well and would be stored here until approved for disposal through beneficial reuse or in the inert waste monofill.

2.13 Stormwater Collection

Ground disturbance would be kept to a minimum to help prevent soil erosion during construction. The following Best Management Practices (BMPs) would be implemented for erosion protection:

- Preserve vegetation where possible.
- Compact and seed topsoil on the perimeters of the drill pad and monofill and on the down-slope side of the access road.
- Five culverts would be used to control stormwater flowing through the project area.
- Silt fences would be installed to protect wetlands and drainages as described below:

  - At the toe of the slope where the road crosses through any poorly drained areas
  - At the north end of the drill pad to prevent sediment from contaminating the mapped wetland to the north. Sediment would be removed and taken to the inert waste monofill when it has reached 23 cm (9 inches) of accumulation

2.14 Air Quality

To control the generation of dust on-site, the following BMPs would be implemented:

- Soils, material stockpiles, and other surfaces would be watered as necessary to reduce dust emissions.
- Roadways, laydown areas, storage areas, and gravel surfaces would be kept in clean condition.

2.15 Noise

It is not anticipated that noise levels, associated only with temporary drilling activities, would be high enough to affect any biological resources in the area. Noise levels generated by exploration activities are expected to dissipate to a range of 60-80 decibels (dB) approximately 8 km (5 mi) from the project area. The typical office has about 50 dB of background noise. The area is fairly isolated and the drilling of G1 has not produced any unwanted effects. Efforts to control noise emissions would include installing the appropriate mufflers and noise abatement equipment, as necessary.

2.16 Biological Resources

Measures within the project design would be utilized to avoid and minimize impacts. Mitigation measures like BMPs include the following actions:

- Temporary water use of a nearby pond is permitted through ADNR. Additionally, no impacts to fish would occur because project activities are not occurring near fish streams, rivers, or lakes and activities would not disrupt sensitive periods of fish or their life cycle (e.g., spawning).
- Workers would be instructed to avoid disturbances to terrestrial mammals as much as practical. Hazing, if necessary, would be performed only by designated personnel. Vehicles would not be used to haze wildlife.
- Minimize the amount of land disturbance and develop and implement stringent erosion and dust control practices.
- Reduce habitat disturbance by keeping vehicles on established access roads or well pads and by minimizing foot traffic in undisturbed areas.
- Develop a spill management plan.
- Locate well pads outside of the 100-year floodplain.
- Report observations of potential wildlife problems, including wildlife mortality, to the appropriate wildlife agency.
- On-site facilities would be maintained in a sanitary manner to prevent attracting wildlife. Any food and putrescible waste would be stored so that it cannot be accessed by wildlife.
- Erosion-control measures would be installed around any area that is disturbed during construction to minimize erosion and sedimentation flowing into waterways.
- Vegetation that is cleared for construction activities would be allowed to grow back to a natural state.

2.17 Seismicity

NEA is committed to follow the IEA *Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems* to minimize impacts that may cause seismic events. This includes the following steps:

- Review laws and regulations
- Assess natural seismic hazard potential
- Assess Induced Seismicity Potential
- Establish a dialogue with Regional Authority
- Educate Stakeholders
- Establish Microseismic Monitoring Network
- Interact with Stakeholders
- Implement Procedure for Evaluating Damage

An Induced Seismicity Report has been produced for this project and is presented in Appendix D. More details can be found at: http://www.iea-gia.org/documents/ProtocolforInducedSeismicityEGS-GIADoc25Feb09.pdf.

3.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This section describes the existing environmental, social, and economic conditions of the project area and the potential environmental effects that could result from implementation of the Proposed Action or No Action Alternative.

3.1 Physical Environment

The physical environment section provides an overview of the affected environment and environmental consequences associated the naturally occurring features located around and within the project area. The physical environment section includes: meteorology, air quality, geology, soils, and seismicity.

3.1.1 Meteorology

3.1.1.1 Affected Environment

The Bristol Bay climate is classified as a maritime continental zone. Summer temperatures are influenced by the open waters of the Bering Sea. Winter temperatures are more continental due to the presence of sea ice buildup in the coastal zones during the coldest months of the year (Western Regional Climate Center [WRCC] 2009). Average temperatures in Bristol Bay (near King Salmon) typically remain above freezing for most of the year. King Salmon experiences the greatest precipitation during July–November (Table 3.1.1-1). King Salmon is 8 km (5 mi) southwest of NEA's proposed project area and has average conditions representative of the project area.

TABLE 3.1.1-1 Average Seasonal Conditions in Bristol Bay Borough

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Temperature (°F)	16.7	16.8	23.3	32.4	42.7	50.6	55.2	54.2	47.4	34.4	24.9	19.0
Average Precipitation (inches)	1.54	1.12	1.16	1.19	1.38	1.67	2.33	3.46	3.38	2.61	2.11	1.89
Mean Snowfall (inches)	0.50	5.90	6.10	4.40	0.80	0.10	0.00	0.00	0.00	3.00	6.50	9.60

3.1.1.2 Environmental Consequences

The effects of drilling and the production of injection wells would have no effect on the meteorology of the area. Meteorology of an area is based on long-term averages and the size and scope of the project indicate that it would not contribute to short-term, and certainly not long-term, changes in King Salmon or Bristol Bay meteorology.

3.1.2 Air Quality

3.1.2.1 Affected Environment

The air resources within the Bristol Bay area are generally considered pristine or of very good quality. Winds and weather systems tend to repeatedly shift as air masses continually change.

Air quality may be affected by natural or human-related activities. During the summer, wildfires may increase the airborne particulates and degrade air quality. Human-related causes of degraded air quality stem from emissions, primarily from electrical power-generating facilities that run on diesel fuel in nearby towns such as Naknek, New Stuyahok, and Dillingham. Small amounts of pollutants are also emitted from vehicles, aircraft, power boats, and heavy construction equipment within the Bristol Bay area. The region is sparsely populated, however, and effects on air quality are generally localized and temporary.

Air quality within the project area is subject to federal and state regulations. The U.S. Environmental Protection Agency (EPA) has transferred much responsibility to the Alaska Department of Environmental Conservation (ADEC), Division of Air Quality. These responsibilities include monitoring, permitting, and enforcement to ensure that air quality remains within standards.

The Clean Air Act (CAA) has established a framework for modern air pollution control. National Ambient Air Quality Standards (NAAQS) have been established by the EPA and include:

- Nitrogen dioxide (NO_2)
- Small-diameter particulate matter ($PM_{2.5}$ and PM_{10})
- Sulfur dioxide (SO_2)
- Carbon monoxide (CO)
- Lead (Pb)
- Ozone (O_3)

The State of Alaska has adopted the federal NAAQS and has added controls on:

- Reduced sulfur compounds (measured as SO_2)
- Ammonia (NH_3)

There are primary and secondary air quality standards. Primary standards protect human health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards protect public welfare, including protection against reduced visibility and damage to crops, vegetation, animals, and buildings. National and State of Alaska Ambient Air Quality Standards (AAAQS) are summarized in Table 3.1.2-1.

TABLE 3.1.2-1 National and Alaska Ambient Air Quality Standards

Pollutant	Averaging Period	NAAQS[(a)]	AAAQS[(b)]
NO_2	Annual (arithmetic mean)	100 µg/m^3 (0.053 ppm) [(c)]	100 µg/m^3
	1-hour [(a)]	100 ppb	–
$PM_{2.5}$	24-hour [(e)]	35 µg/m^3 [(c)]	–
	Annual (Arithmetic Mean)	15 µg/m^3 [(c)]	–
PM_{10}	24-hour [(f)]	150 µg/m^3 [(c)]	150 µg/m^3
	Annual (arithmetic mean)	–	50 µg/m^3
SO_2	3-hour [(g)]	1,300 µg/m^3 [(d)] (0.5 ppm) [(d)]	1,300 µg/m^3
	24-hour [(g)]	365 µg/m^3 (0.14 ppm)	365 µg/m^3
	Annual (arithmetic mean)	80 µg/m^3 0.03 ppm	80 µg/m^3
CO	1-hour [(g)]	40,000 µg/m^3 (35 ppm)	40 mg/m^3
	8-hour [(g)]	10,000 µg/m^3 (9 ppm)	10 mg/m^3
Pb	Rolling 3-month	0.15 µg/m^3 [(c)]	–
	Quarterly (arithmetic mean)	1.5 µg/m^3 [(c)]	1.5 µg/m^3
O_3	1-hour [(h)]	0.12 ppm [(c)] (235 µg/m^3)	235 µg/m^3
	8-hour 2008 std [(i)]	0.075 ppm [(c)] (147 ug/m^3)	–
	8-hour 1997 std [(j)]	0.08 ppm [(c)]	–
Reduced sulfur compounds measured as SO_2	30-minute [(g)]	–	50 µg/m^3
NH_3	8-hour [(g)]	–	2.1 mg/m^3

a = National Primary and Secondary Ambient Air Quality Standards, 40 CFR Part 50, July 1, 2009
b = State of Alaska Ambient Air Quality Standards, 18 AAC 50.010, November 4, 2009
c = primary standard is the same as secondary standard
d = secondary standard
e = To obtain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m3.
f = Not to be exceeded more than once per year on average over 3 years
g = Not to be exceeded more than once per year
h = EPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").
i = To obtain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm.
j = To obtain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

µg/m^3 = micrograms per cubic meter
std = standard
CO = carbon monoxide
mg/m^3 = milligrams per cubic meter
NH_3 = ammonia
NO_2 = nitrogen dioxide
O_3 = ozone
Pb = lead
$PM_{2.5}$ = particulate matter less than 2.5 microns in diameter
PM_{10} = particulate matter less than 10 microns in diameter
ppm = parts per million
SO_2 = sulfur dioxide

An area that does not meet the national air quality standard for one or more criteria pollutants is designated a nonattainment area, and a regulatory process is applied in accordance with the CAA to develop a strategy and timeline for the area to return to compliance by a designated date. There are currently three nonattainment areas in Alaska. The community of Eagle River located approximately 486 km (302 mi) from King Salmon in Southcentral Alaska and the Mendenhall Valley located near Juneau 1,867 km (1,160 mi) from King Salmon are PM_{10} nonattainment areas, and a portion of the Fairbanks North Star Borough near Fairbanks approximately 1,070 km (666 mi) from King Salmon, is a $PM_{2.5}$ nonattainment area. All attainment areas are located at such a substantial distance from the project area, it is unlikely that they will have an effect on or be affected by the Proposed Actions.

The ADEC completed an in-depth study of Alaska's sources of greenhouse gasses (GHG). Carbon dioxide, methane, nitrous oxide, and synthetic hydrocarbons (chlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, halons, and sulphur hexafluoride) are the gasses typically referred to as GHGs. The United Nations' Intergovernmental Panel on Climate Change linked a steep rise in the atmospheric concentrations of these gasses to climate change (ADEC 2008). In Alaska, industrial source refinements, or "Alaska's oil and gas companies and the energy utilities providing power to Alaskan households," are shown to have the highest GHG emissions, totaling 29 percent (ADEC 2008).

3.1.2.2 Environmental Consequences

Under State of Alaska regulations, 18 AAC 50.502(c)(1)(C), the drilling, completion, and testing of well will not require an Alaska Department of Environmental Conservation, Air Quality Control Minor Permit. The air emissions expected during drilling, completion, and testing of wells include exhaust from vehicular traffic and drill rigs, and dust from traffic on unpaved roads. The emissions calculations based on AP-42 emission factors for NO_2, SO_2, Pb and PM_{10} are shown in Table 3.1.2-2. Project actual emissions are expected to be much less than the calculated emissions shown below.

TABLE 3.1.2-2 Emissions Calculations for Southwest Alaska Geothermal Project

Total Calculated Emissions	NO_2 (tpy)	SO_2 (tpy)	PM_{10} (tpy)	Pb (tpy)
Total	964.9	161.8	29.1	0.00033

Note: tpy – tons per year

Additional emissions may arise in the release of geothermal fluid vapors (especially hydrogen sulfide, carbon dioxide, mercury, arsenic, and boron, if present in the reservoir). Most construction activities, such as site clearing and grading, road construction, well pad development, and sump pit construction, have been completed.

Drilling of production and injection wells would have more intense exhaust-related emissions over a period of 1–5 years. Ultimately, the environmental consequences would depend upon the amount, duration, location, and characteristics of the emissions and the meteorological conditions (e.g., wind speed and direction, precipitation, and relative humidity). Emissions during this phase would not have a measurable effect on climate change.

The emissions categories that geothermal energy would affect are electricity production and residential and commercial usage. Combined, these GHGs total 13 percent of Alaska's GHG emissions (ADEC 2008). Geothermal proactively reduces dependence on carbon-based fuel used to heat homes. Compared to oil and gas, geothermal energy emits little or no GHGs and has the potential to reduce commercial and residential emissions to near zero. Naknek is a relatively small community. The impact would not have a substantial effect on air quality, but rather may prove a method to improve air emissions.

3.1.3 Geology

3.1.3.1 Affected Environment

The project area falls within the ecological sub-region of southwestern Alaska called the Bristol Bay-Nushagak Lowlands (McNab and Avers 1994). These lowlands are characterized by a flat-to-rolling landscape dotted with glacial moraine and thaw lakes. The moraine and outwash-mantled area has a local relief of 15 m–76 m (50 ft–250 ft); at the inner boundaries, the elevation reaches 91 m–152 m (300 ft–500 ft).

The Bristol Bay-Nushagak Lowlands were glaciated in the Pleistocene epoch and are underlain by hundreds of feet of resulting outwash and morainal deposits mantled by silt and peat. Outwash resulting from the period of glaciations is coarse near the mountains to the east and north and graduates to fine sand near the coast to the south. Surrounding mountains have a thin Quaternary deposit along their base (McNab and Avers 1994; Wahrhaftig 1965).

3.1.3.2 Environmental Consequences

Locally, should EGS methodology be implemented, the geology would be affected due to the creation of additional cracks and fissures in rock layers from increased water pressure. Geologic resources in the immediate area of the project would also be unavailable for the life of the project, though this would have no direct effect on the geology itself. There would be no effect to the geology of the Nushagak Lowlands as a whole, however. Additional cracking and fissuring at depths required by an EGS have the potential to create geologic hazards and induce minor seismic events and, as such, have the potential to further affect local geology. This is covered more in Section 3.1.5.2.

3.1.4 Soils

3.1.4.1 Affected Environment

The soil taxonomy of this region is dominated by Typic Haplocryands, Fluvaquentic Cryofibrists, Typic Vitricryands, Histic Pergelic Cryaquepts, Pergelic Cryaquepts, and Typic Crochrepts. These soil types were formed from ash deposits from nearby volcanoes with gravelly glacial till, outwash deposits, or silty alluvium beneath (Gallant et al. 1995).

In the immediate project area, 0.5 m–0.6 m (1.5 ft–2.0 ft) of topsoils and silt are typically found over sand and gravel. According to the project's Storm Water Pollution Prevention Plan, the soils range from sandy gravels to gravelly sands and are generally well-sorted, containing minimal amounts of silt. While silt content is usually less than five percent, the soil under the northern portion of the drill pad contains more persistent silt lenses (Alaska Earth Sciences 2009).

Wetlands can be found to the north and northeast of the project area. These, along with suspected wetlands along the access road, are protected with silt fencing. Silt fencing has been installed at the toe of the drill pad and along five culverts adjacent to the access road and would control storm water flowing through the project area. Any topsoil that has been stripped in this process or that would be stripped with the construction of geothermal wells would be compacted and seeded to prevent erosion. Topsoil on the perimeter of the drill pad and monofill on the down slope of the access road has been track-compacted and seeded to prevent erosion (Alaska Earth Sciences 2009).

3.1.4.2 Environmental Consequences

During construction, ground disturbance would be as minimal as possible to prevent erosion and vegetation would be preserved as much as possible (Alaska Earth Sciences 2009). While there is potential for ground disturbance, all disturbances would be mitigated with stabilization and revegetation techniques. There would be minimal permanent disturbance in addition to the preliminary construction that has been completed.

Soil compaction may reduce aeration, permeability, and water-holding capacities of the soils; this leaves the possibility for additional runoff and erosion. Also, disturbing and relaying soil may result in mixing of soil characteristics and types and has the potential to also affect permeability and water-holding capacity by integrating structures, textures, and rock content. Additionally, future vegetation may also be affected by soil compaction, which makes it harder for vegetation to root in the soil because of increased density.

Implementing stimulation techniques to well G1 and drilling wells G2 and G3 would result in minimal ground disturbance and would have a minimal effect on soils. After construction, all areas not necessary for daily operations would be stabilized and revegetated. Additionally, there would be no effect on mineral resources from this project.

3.1.5 Seismicity

3.1.5.1 Affected Environment

The project area is situated in a moderately active seismic area. The last activity to occur in the area was on February 5, 2010, at 10:45 p.m., centered 63 km (39 mi) from King Salmon (the community closest to the project area). The magnitude of this event was 3.1, and the depth was 197.9 km (123 mi). The Alaska Volcano Observatory is located in King Salmon and monitors seismicity in the area closely.

During the process of creating an underground heat exchanger by opening permeable space in the rock using EGS, or during subsequent circulation of water to recover the heat, stress patterns in the rock may change and produce microearthquakes (MEQs) or *induced seismicity*. In almost all cases, these events in the deep reservoir have been of such low magnitude—and had so little energy relative to natural earthquakes—that they pass unnoticed.

Normally, EGS systems fracture previously unfractured, or unfaulted, rock to produce a new reservoir or open old fracture systems. But if a pre-stress fault exists near the well that is close to failure, it is possible to induce/trigger a larger event on that fault, as the EGS system is changing the local stress environment in the area.

The difference between microseismic events created directly by fluid injection and a natural earthquake is significant: to the extent that they are sometimes felt, induced seismicity usually falls into the category of a nuisance, like a pneumatic hammer or the passing of a train or large truck, whereas a natural earthquake may cause extensive damage. For example, experience and scientific data indicate that the vibration at depth from an MEQ related to fluid injection is unlikely to cause any damage to modern buildings. A more detailed assessment of seismicity is presented in the Induced Seismicity report, Appendix D.

3.1.5.2 Environmental Consequences

Given the location and depth of injection for this EGS well, seismologists anticipate the risk to people and structures is low, and there is only a perceived danger, as people are not used to feeling MEQs. Seismologists providing expertise to NEA have assessed that there is a northwest to southeast trending fault near the G1well site that can be influenced by the EGS stimulation process. NEA expects most of the events (multiple MEQs) that may result from the stimulation process would be small (i.e., less than a local magnitude (M_L) of 3.1) and located within 10 km.

NEA would complete the following activities to assess the possibility of induced seismicity due to geothermal exploration according to the IEA *Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems*:

- Run sonic logs in G1 to develop a velocity model for the area.
- Deploy a passive seismic array to collect baseline seismic data, calibrate the seismic velocity model, and prepare for later stimulation.
- Conduct stress modeling by analyzing principal tensile stress, sonic, density, and wellbore image logs jointly with certain critical drilling parameters (mud weights, etc.) to estimate the orientation and perhaps some of the magnitudes of the principal stresses in the area.
- Design and install a seismic monitoring system, including preparation of an Induced Seismicity Protocol, to monitor ground movements.
- Pre-stimulate G1 and incorporate results into planning for the full stimulation.
- Monitor the seismic network before, during, and after the full stimulation.

A temporary, surface-based seismic array would be deployed to collect baseline seismic data, calibrate the seismic velocity model, and prepare for later stimulation. An initial seismic velocity model would be developed for locating events, using available geophysical and geological information. The primary focus would be on MEQs from the immediate vicinity of the site, but regional earthquakes and possibly ambient noise would also be evaluated to provide additional information on velocity structure. These analyses can provide detailed information on the seismic response to stimulation, local fault geometries, the local velocity structure, and state of stress surrounding the site, which would be used to develop the seismic monitoring system.

The seismic monitoring plan would include measures for monitoring induced seismicity before, during, and after stimulation, as well as the IEA *Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems* for the project. The main objectives of the on-site injection seismic monitoring would record continuous data and provide NEA as much on-site data analysis as possible, with the primary efforts going into event recording, location, and magnitude estimation.

3.2 Biological Resources

The following is a description of the affected biological environment found or potentially found in the vicinity of the Proposed Action area. Each section describes both the affected biological environment and potential environmental consequences of the proposed action within the project area. Topics include:

- Birds and waterfowl
- Terrestrial mammals
- Fisheries resources
- Threatened and endangered species
- Vegetation and wetlands
- Water resources
- Cultural resources

3.2.1 Birds and Waterfowl

3.2.1.1 Affected Environment

The proposed project would be located within or near breeding grounds, staging grounds, and migratory corridors for many species of land birds, waterfowl, shorebirds, and seabirds. Many of the species potentially found in the area winter in the contiguous United States or Central and South America. Table 3.2.1-1 lists species that are potentially found in or near the project area and their migration and breeding times. For a more complete list of birds in the area, see Bureau of Land Management (BLM), The Bay Proposed Resource Management Plan Final Environmental Impact Statement.

TABLE 3.2.1-1 Peak Migration and Breeding Periods of Select Waterfowl, Land Birds, and Shorebirds Potentially Found in the Project Area

Species	Migration[1]	Breeding[2]
Brant	Mid-Feb–Mid-May Early Sept–Late Nov	Late May–Mid-July
Cackling Goose	Mid-Apr–Mid-May Late Sept–Early Nov	Late May–Early Aug
Tundra Swan	Mid-Mar–Early May Early Sept–Late Nov	Mid-May–Mid-Sept
Mallard	Mid-Feb–Late Mar Early Sept–Early Dec	Mid-Apr–Early Sept
Northern Pintail	Mid-Feb–Late Mar Early Sept–Mid-Nov	Early Apr–Late July
Common Loon	Late Apr–Mid-May Late Sept–Mid-Nov	Late May–Early Oct
Steller's Eider	Early May–Mid-June Mid-Aug–Mid-Oct	Mid-June–Early Aug
Pacific Golden Plover	Late Apr–Mid-May Early Aug–Early Sept and Early Oct–Early Nov[3]	Early June–Early Aug
Solitary Sandpiper	Mid-Apr–Early May Early Aug–Mid-Aug	Late May–Mid-July
Western Sandpiper	Mid-Apr–Early June Late June–Mid-Oct	Late May–Late July
Rusty Blackbird	Early Mar–Mid-May Mid-Sept–Late Nov	Early July–Early Sept
Alder Flycatcher	Early Mar–Early June Aug	Late June–Late July
Myrtle Warbler	Mid-Apr–Mid-May Mid-Sept–Early Nov	Late May–Early Aug
Yellow Warbler	Mid-Apr–Mid-May Mid-Aug–Mid-Sept	Late May–Early Aug
Fox Sparrow	Mid-Apr–Early May Late Sept–Early Dec	Mid-May–Early Aug

Notes:
1. Top line represents migration into breeding grounds; bottom line represents migration out of breeding grounds.
2. Breeding includes nest construction, mating, egg incubation, and care for young.
3. Juveniles migrate later than adults.

Life History

Land birds

In general, land birds including songbirds and raptors migrate into or near the project area in May. Male songbirds establish a territory and sing almost constantly to attract a mate and defend their nesting territory (Handel 1997). Both male and female attend to the nest and the young, usually switching roles throughout the season. Unlike waterfowl, land birds molt their flight feathers in stages in order to remain capable of flight all year.

Feeding habits vary widely between evolutionary groups. For example, warblers glean insects from the leaves of hardwood trees, sparrows consume seeds from trees off the forest floor, and thrushes feed primarily on berries (Handel 1997).

Waterfowl

Geese, swans, and ducks migrate to or through the project area in April (Dau and Mallek 2007), as lakes and streams thaw. Geese generally mate for life and do not breed until age 2 or 3. Mates establish a territory to nest and produce four to five eggs. Later in the summer, geese families often join and defend their young together. During this time, juveniles are growing their first flight feathers, while the adults molt and regrow their flight feathers (Bellrose 1976).

Swans reach breeding age during their fifth year of life; at this time, they typically find a partner and remain monogamous for life. Nests are large, 2 m–4 m (6 ft–12 ft) in diameter and are constructed on the margins of large ponds or lakes. On average, the female lays four eggs, which incubate for 31–35 days. Over a period of 11 to 15 weeks, the adult female would molt her flight feathers as the young grow and fledge in preparation for migration in September or October. The adult male is also present to help guard the young during this time (Bellrose 1976).

Many duck species begin migrating into the project area as pairs in March or April (Dau and Mallek 2007). A nest is usually constructed near a pond or lake, but species such as the Mallard often place the nest in upland tundra to conceal it from predators. Shortly after, breeding males leave the nest and the female is left to lay the eggs and raise the ducklings. The number of eggs produced varies by species, but can be as many as 15. There is, however, a high juvenile mortality rate. Both males and females molt their flight feathers after breeding and before migration begins in the late fall (Bellrose 1976).

Shorebirds

There are many shorebirds that stage or breed in or near the project area (Table 3.2.1-1). These species are known for flying long distances without rest, only stopping to feed and rest as they near the breeding grounds (Alerstam 1993). These staging areas are known to be very important to the migratory success of many shorebird species (Iverson et al. 1996).

Typically, shorebird females arrive on the breeding grounds a few days prior to the males to establish territories near feeding areas (Oring and Reed 1997). The male and female construct a nest together, either on a rocky shore or in a marsh along a coastline or other water source. Shorebirds usually produce a clutch of three to five eggs, though in some species a female may have several clutches with other mates over the course of the breeding season (Hays 1972).

Seabirds

Seabirds found in or near the project area include auklets, murres, murrelets, gulls, and cormorants. Gulls often nest in colonies found on tussocks, lake islands, river bars, coastal areas, and cliffs (Johnson and Herter 1989). Nests consist of shallow depressions where one to three eggs are laid. Fledging occurs in late August, though the juveniles are still vigorously defended by the adults (Roseneau and Herter 1984). Gulls are scavengers as well as predators, feeding on anything from marine mammal feces to fish, invertebrates, or bird carcasses and eggs (Swartz 1966; Roseneau and Herter 1984).

Distribution

Land birds

Songbirds and raptors found in the project area mostly inhabit forested areas and have relatively small home ranges. Songbirds are likely to be common throughout the project area, while raptors such as eagles would be common near fish streams, lakes, and cliffs.

Waterfowl
Breeding waterfowl are likely to be common throughout the project area, though coastal and upland areas would have different species compositions. Recent waterfowl surveys have determined that diving ducks, such as scaup and scoters, are found continuously throughout the coastal area, while dabbling ducks such as mallards and northern pintail are distributed in distinct patches (Platte and Butler 1995).

Shorebirds
The Bristol Bay coastline provides productive shorebird habitat for replenishing fat reserves after breeding and prior to migration. According to the BLM (2007), Kvichak Bay is a well-known staging ground for shorebirds that breed in the Arctic.

Seabirds
Gulls are the primary seabird found in the project area. Within the project area, they would likely nest in tussocks, lake islands, and river bars.

Abundance

Land birds
There are no reliable estimates available for land bird abundance in the project area. It is expected that songbird populations are not substantial due to the relatively unforested landscape. Raptors are likely to be found in large numbers near the mountainous areas surrounding the lowlands because of the abundance of fish streams and lakes.

Waterfowl
Recent surveys of the Emperor goose, Steller's eider, and Pacific brant populations in southwestern Alaska have shown a continuing decline in numbers. This may be attributed to the illegal harvest of these species in Alaska (Dau and Mallek 2007). Current estimates of waterfowl near the immediate project area are not available, but the Bristol Bay Lowlands are thought to make up 10 percent of all duck production in Alaska (USFWS 2008).

Shorebirds
Abundance data for shorebirds are sparse for the project area. The Western Hemisphere Shorebird Reserve Network recently designated Nushagak Bay as a Regional Shorebird Reserve due to its importance as a shorebird wintering, migration, and breeding habitat.

Seabirds
Seabird abundance information is lacking for the project area. The Togiak National Wildlife Refuge has conducted surveys of seabird populations on the refuge since 1990 and has recorded a negative trend in numbers of black-legged kittiwakes and common murres (USFWS 2008).

3.2.1.2 Environmental Consequences

Potential effects on birds and waterfowl from the proposed project are expected to be temporary and minimal. Not all species listed in Table 3.2.1-1 would be affected by the proposed project, but they are included due to their potential presence in the project area.

Disturbance and Displacement

The activities associated with the Proposed Action that have the greatest potential to cause disturbance and displacement effects would be conducted during the winter or early spring, when most birds that breed in the project area are on their wintering grounds. This would greatly reduce or eliminate the human disturbance or displacement of nesting birds, which has been shown to have significant negative effects during breeding season (Carney and Sydeman 1999).

Habitat Loss or Alteration

Habitat loss from the proposed geothermal exploration and production would be minimal due to the small area that the facilities require. Expansion of the drill pad and the anthropogenic noise generated by exploration and production activities may increase the amount of habitat affected. However, in general, this noise is above background levels only in the immediate vicinity of the project area. Activities such as pile-driving the conductor casing into the geothermic well are much louder but would be completed prior to spring migration of birds into the area. Overall, the portion of habitat lost or altered would be very small in relation to the amount of suitable habitat still available.

Population Impacts

At this time, it is not possible to completely assess the impacts of the proposed geothermal exploration and production project on bird populations in the project area. Studies have shown that species with large bodies and relatively small wing profiles are more likely to strike power lines and other structures due to their diminished ability to make rapid flight path changes (Bevanger 1998; Bevanger and Brøseth 2004). Waterfowl are the most likely birds to be present in the project area and are, therefore, assumed to be potentially affected more than other bird groups. However, death and wounding caused by bird strikes are not expected to result in measureable effects on the population level.

3.2.2 Terrestrial Mammals

3.2.2.1 Affected Environment

Large terrestrial mammals such as moose, caribou, and brown bear use the Alaska Peninsula area extensively. These species are an important subsistence resource for local communities and are hunted for sport. Sport hunting for large game provides economic value by employing guides, lodge personnel, and other personnel who provide additional support services. The project area is within Game Management Unit (GMU) 9. The ADF&G manages terrestrial mammals found within the area.

Life History

Moose

Wintering and calving moose make seasonal movements up to 100 km (60 mi) between their rutting, calving, and wintering areas, with breeding taking place during the fall rut (Rausch and Gassaway 1994). The peak of the rut occurs at the end of September and early October. By the time the rut is over, males have depleted much of their fat reserves and resume feeding in late fall. Calves develop during the winter and are born in the spring, from mid-May to early June.

Maternal moose become solitary in early spring and find secluded areas for giving birth (Cederlund et al. 1987; MacCracken et al. 1997). Twinning may occur when habitat conditions provide adequate forage and the cow is nutritionally fit. When cows are nutritionally stressed, single calves are more common (Franzmann and Schwartz 1985). When selecting birth sites, cow moose may select for forage, visibility, southerly exposures, and relatively high elevations in an attempt to have adequate forage nearby and avoid predators (Bowyer et al. 1999). After birth, cow moose may remain near the birth site for several weeks (Addison et al. 1990).

Winter use concentration areas may be sensitive habitat because moose can be low on fat reserves and forage limited. Moose lose body mass during winter (Schwartz 1997) and experience more starvation and predator-related mortality than during other times of the year. The cause of moose mortality is often winter severity (Ballard et al. 1991). Moose are restrictive in their movements, particularly during late winter when snow can be deep (Peek 1997). They often winter in river valleys containing shrub riparian vegetation (Rausch and Gassaway 1994).

Caribou

Caribou have distinct phases of activities that include wintering and calving. Wintering and calving occur in different areas, which allow the caribou to keep moving, enabling them to cover large areas and find food (Valkenberg 1999).

Distinct caribou herds are distinguished by their traditional calving grounds (Cameron et al. 1979). Calving occurs in mid- to late-May. After calving, caribou aggregate to avoid predators. Caribou use high mountains to escape inland predators, avoid biting insects, and escape the summer heat (Cameron and Smith 1992; Pollard and Noel 1994; Valkenberg 1999).

Migration routes used for many years may suddenly be abandoned in favor of movements to new areas with more food (Valkenberg 1999). Therefore, caribou distributions change periodically.

Brown Bear

Brown bears consume a wide variety of food that includes vegetation, salmon, moose, and caribou (Eide et al. 1994). In the winter, most brown bears enter dens and hibernate. Brown bears may spend 5–7½ months within their dens. Denning frequently occurs in snow-accumulating areas of moderate to high relief, such as riverbanks, lake basins, dunes, and gullies, often with southern exposures (MMS 2002).

Distribution

Moose

Moose are relatively new inhabitants of the Bristol Bay area (Woolington 2008). Until recently, few were found within the project area primarily inhabited the Nushagak-Mulchatna River (Woolington 2008). Moose are now relatively common throughout the project area.

Caribou

Two distinct caribou herds are found within the project area: the Mulchatna Caribou Herd (MCH) and Northern Peninsula Caribou Herd (NPCH). The MCH has changed much of its wintering, calving, and post-calving areas. In the 1980s and early 1990s, the MCH wintered along the north and west side of Iliamna Lake, north of the Kvichak River. Starting in the late 1980s and early 1990s, the MCH moved its winter range southwest of this area and by the mid-1990s, the MCH began wintering south of the Kuskokwim River in increasing numbers. MCH caribou calving areas have dramatically changed over the years. Calving areas have spread northward and are now spread through a vast area from just outside Dillingham, north to the confluence of the Holitna and Hoholitna Rivers (Woolington 2007a).

The NPCH winters in the same vicinity as the MCH, between the Naknek River and Lake Illiamna. Traditionally, the NPCH's primary calving grounds are in the Bering Sea flats between the Cinder and Bear rivers. Now a greater portion of the herd calves in mountainous terrain between the Meshik River and Katmai National Park (Butler 2007a).

Caribou from both the MCH and the NPCH may be found within the project area. During the winter months, calving caribou may be found in the western portion of the project area.

Brown Bear

The Alaska Peninsula, including Bristol Bay and the project area, is a premier area for large brown bears and supports a guiding industry for big game hunters and support services for bear viewing.

Brown bears are widely distributed and commonly found within the project area. Brown bear distributions are influenced by a combination of factors, which includes food concentrations of fish and caribou. Brown bears are common throughout the northern Bristol Bay area and are seasonally abundant along salmon spawning areas such as the Nushagak, Mulchatna, Togiak, and Kulukak drainages and the Wood/Tikchik Lakes. Brown bears can also be found along the Kvichak, Alagnak, and Naknek drainages. Occasionally, brown bears can also be found near caribou aggregations (Woolington 2007b).

Abundance

Moose

Surveys indicate that moose populations in Game Management Unit (GMU) 9 have been relatively stable over the past 28 years and densities remained low. Subunits 9B and 9C, areas that include a portion of the project area, had an estimated population of 2,000 and 800 moose, respectively (Butler 2008). In the last three decades, however, moose have expanded into GMU 17 and increased substantially in numbers. An estimate of moose populations for subunit 17C north of the Igushik River, an area where the project is to occur, is 3,670 individuals (Woolington 2008).

Caribou

The MCH dramatically increased from 20,618 animals in 1981 to 200,000 animals in 1996, likely due to a succession of mild winters, movements into previously unused range, relatively low predation rates, and a harvest rate of less than 5 percent since the late 1970s (Woolington 2007a). No herd information was available from 1996 to 1999, but the population probably peaked in 1996 or 1997 and has declined since (Woolington 2007a). Based on a 2006 survey, the population estimate was 45,000 animals.

The overall population of the NPCH has decreased over the years. The estimated population of the NPCH has ranged from 20,000 in 1984 to an estimated low of 2,500 in 2005 (Butler 2007a).

Brown Bear

Brown bear densities vary within GMU 9, with lower densities in the western section of Unit 9B and the Bristol Bay coastal plain. Not including national park lands or McNeil State Game Sanctuary, surveys have indicated that densities in 1991 were at one bear per 10.7 sq km (4.13 sq mi), for an estimated population of 5,679 bears. Surveys flown between 1999 and 2005 suggest that the overall bear density in GMU 9 is closer to one bear per 9.1 sq km (3.5 sq mi), for an estimated population of 6,000–6,800 bears. This estimate is low due to lack of information about certain parts of GMU 9, where 1991 densities are assumed (Butler 2007b).

3.2.2.2 Environmental Consequences

The development and existence of the proposed geothermal exploration and production facilities are not anticipated to have an effect on terrestrial mammals and would not obstruct movements. The activities associated with the project could potentially lead to temporary disturbance and displacement and habitat loss or alteration.

Disturbance and Displacement

Disturbance and displacement of terrestrial mammals due to human activities are anticipated to be temporary, localized, and minor. During construction, terrestrial mammals may encounter various types of disturbances that include machinery traffic and human foot traffic, which may lead to displacement.

Displacement of terrestrial mammals may result from activities associated with expansion of the workpad and ongoing geothermal exploration and production. Displacement can potentially increase mortality, increase stress, and result in group composition changes when disturbances are frequent and intense. Overall, disturbances and displacement are expected to be few and minor, particularly because workers would not be permitted to harass wildlife.

A study of moose in Norway concluded that they responded to human foot traffic more than to mechanical disturbance (Anderson et al. 1996). Human disturbances caused flight responses that occurred at greater distances than mechanical disturbances. Anderson et al. (1996) suggested that moose reacted to fear of hunters and were becoming habituated to nonthreatening vehicles. Moose in Wyoming that were bedded within 300 m (1,000 ft) and feeding within 150 m (500 ft) of snowmachines altered their behavior in response (Colescott and Gillingham 1998). Although moose within 300 m (1,000 ft) of the snowmachine trail were displaced to less favorable habitats, Colescott and Gillingham (1998) concluded that snowmachine traffic did not appear to significantly alter moose activity.

Much research has been conducted on the effects of disturbance and displacement on caribou. Concern has arisen over industrial activity displacing calving caribou to less preferable habitat. Researchers have drawn contradictory and controversial conclusions about whether and how many caribou are affected by industrial development on the North Slope of Alaska, where many industrial activities have occurred. Several studies suggest that pregnant cows and cows with newborn calves avoid areas disturbed by industrial activities (Dau and Cameron 1986; Cameron and Smith 1992; Nellemann and Cameron 1996). As development of industrial infrastructure occurred near the Prudhoe Bay area, calving areas shifted southward away from the development (Lawhead and Johnson 2000; Wolfe 2000). Other studies have indicated that bull caribou and barren cows tolerate some levels of disturbance, especially once habituated to those disturbances (Murphy and Curatolo 1987; Pollard et al. 1996; Cronin et al. 1998).

Caribou distribution has been found to be correlated with indices of terrain ruggedness; caribou preferred areas dominated by fine-textured, rugged terrain and avoided areas with flatter terrain (Nellemann and Cameron 1996). Displacement on the North Slope may have reduced the use of rugged terrain by 52 percent. Caribou appeared to be displaced away from developed areas that had terrain ruggedness. This displacement, which is positively correlated with forage quality and biomass availability, may result in underuse and overuse of habitat, which can potentially compromise nutrition of lactating females, body condition, and subsequent reproductive success.

Moving vehicles are the most frequent form of disturbance. Disturbances within 600 m (1,969 ft) from a road with moderate to heavy traffic have resulted in considerable reductions in the amount of time caribou spent lying down (Murphy and Curatolo 1987). Habituation has been documented due to repeated exposure to human activities on a regular basis in predictable and nonthreatening environments (Miller et al. 1972; Vilmo 1975; Roby 1978; Davis et al. 1985; Valkenburg and Davis 1985; Cronin et al. 1994).

Large predators such as brown bears and black bears generally occur in low densities. Disturbances and displacement may occur to some extent if maintenance was needed during the summer months of the operation phase. Some studies have indicated that brown bears have been locally displaced from roads (Mattson 1988; McLellan 1988; Archibald et. al 1987; Harting 1987). The strongest responses were to the presence of humans on foot in open areas of low human use (McLellan and Shackleton 1989). Few of these predatory species are likely to be encountered.

Disturbance and displacement effects could occur as a result of the Proposed Action, but effects would likely be temporary, localized, and minor to individuals and populations of terrestrial mammals.

Habitat Loss or Alteration

The Proposed Action will occur within the existing project area, 3.5 hectares (8.75 acres). The proposed actions will not result in habitat or alteration that may impact wildlife. Wildlife will be able to pass freely around the pads and structures. The activities associated with the Proposed Action and the existence of the geothermal exploration and production site are not anticipated to lead to mortality of terrestrial wildlife. Workers would be subject to Alaska state laws and not permitted to harass wildlife. Terrestrial wildlife mortality due to project activities is not anticipated.

3.2.3 Fisheries Resources

3.2.3.1 Affected Environment

The Bristol Bay region is home to the world's largest sockeye salmon run. The major salmon producer near the project is the Naknek River. The Naknek watershed, which is the closest and largest waterbody to the project, is world-renowned for its rainbow trout *(Oncorhynchus mykiss)* and salmon *(Oncorhynchus spp.)* fishing in the river proper and lake trout *(Salvelinus namaycush)*, Arctic char *(S. alpines),* Dolly Varden *(S. malma),* and northern pike *(Esox lucius)* fishing in Naknek Lake. Smaller tributaries include King Salmon and Eskimo creeks. The closest the Naknek River comes to the project site is approximately 4.0 km (2.5 mi), and the closest tributary, the Eskimo Creek, is approximately 2.1 km (1.3 mi) from the project site. King Salmon Creek is farther away than Eskimo Creek.

Life History

Pacific salmon are anadromous, inhabiting freshwater after egg emergence, then traveling to the sea for variable amounts of time. After their seaward migration, they return to their natal stream to spawn as mature adults. The salmon die shortly after spawning (Mecklenberg et al. 2002). Each of the five Pacific salmon species vary in their freshwater residency and time spent in marine waters (Table 3.2.3.-1). The rainbow trout, Arctic char, Dolly Varden, and northern pike reside their entire life in the Naknek River system.

TABLE 3.2.3-1 Pacific Salmon Phases of Occupation in Freshwater and Marine Environments

Common Name	Freshwater Residency	Duration at Sea
Sockeye	1–2 years	3–4 years
Chum	0 years	3–5 years
Coho	1 year; up to 4 years	2–3 years
Pink	0 years	18 months
Chinook	3 months–2 years	1–5 years

Reference: Mecklenberg et al. 2002.

Distribution

The Alaska Department of Fish and Game, Anadromous Waters Catalog fisheries distribution database lists all five Pacific salmon species, Arctic char, and Dolly Varden in the Naknek River. Chum, coho, Chinook, and pink salmon are found to spawn in King Salmon Creek. Coho and Chinook salmon rear in Eskimo creek.

Abundance

Sockeye salmon dominate fish abundance in the Naknek River. Methods typically used to determine abundance occur through seasonal escapement and commercial and subsistence catch records. Most sockeye bound for their natal rivers are harvested by commercial and subsistence users. Under ADF&G management principles, a sustainable number of sockeye salmon must escape and return to their natal stream each year. Despite a large annual migration of chum, Chinook, coho, and pink salmon, abundance monitoring in most Bristol Bay Rivers region targets sockeye salmon.

3.2.3.2 Environmental Consequences

The proposed drilling sites are located away from any water sources, except for two unamed small lakes. The two lakes are approximately 150 m–200 m (492 ft–656 ft) from the G2 drill site. There are no fish in either lake in proximity to the drill sites. There are no anadromous salmon streams within the project area. While the Naknek River supports a large quantity of salmon, and Eskimo Creek has rearing coho and Chinook salmon, the proposed project site would not cross any part of the Naknek River, Eskimo Creek, or their riparian zones. The construction and existence of the proposed drilling sites would not have any effects on fish or fish habitat in the area because there are no fish present in the project area.

3.2.4 Threatened and Endangered Species

3.2.4.1 Affected Environment

No threatened and endangered species are found in the immediate vicinity of the project area. Steller's eider, however, use the coastal and marine environment near the project area or around the vicinity of King Salmon.

The Alaska breeding population of Steller's eiders was listed as a threatened species under the Endangered Species Act on June 11, 1997. This was a result of an apparent long-term decline in numbers and a restriction in breeding range. Causes of the decline are unknown but may have included increased predation pressure on the North Slope and Yukon-Kuskokwim Delta breeding grounds, subsistence harvest, ingestion of lead shot, and exposure to contaminants (Henny et al. 1995). Critical habitat has been designated for the Steller's eider in breeding areas on the Yukon-Kuskokwim Delta, staging areas in the Kuskokwim Shoals, and molting areas near the Seal Islands, Nelson Lagoon, and Izembek Lagoon on the Alaska Peninsula (USFWS 2005). There is no designated critical habitat within the project area.

Life History

The smallest of the four eider species, Steller's eiders breed only once every few years. Steller's eiders nest near tundra ponds or in drained lake basins but occupy marine waters during the remainder of the year. After nesting, they move into the nearshore marine waters of southwest and southcentral Alaska and mix with the Russian Pacific eider population. They molt in autumn in lagoons along the north side of the Alaska Peninsula. Important habitat for Steller's eiders includes the Yukon-Kuskokwim Delta nesting areas and the Kuskokwim Shoals fall molting and spring staging areas (USFWS 2005).

Distribution

Coastal and offshore areas provide habitat for Steller's eiders. The Alaska breeding population is primarily confined to the Arctic Coastal Plain of Alaska's North Slope. Some birds winter near the molting areas, while others winter off the south side of the Alaska Peninsula, eastern Aleutian Islands, Kodiak Archipelago, and southern Cook Inlet. In spring, Steller's eiders concentrate in the Kuskokwim River and Bristol Bay areas, waiting for the ice to recede before migrating to nesting areas. Steller's eiders can be found near or within Kvichak Bay where they molt (USFWS 2005).

Abundance

Today, the Alaska breeding population is primarily confined to the Arctic Coastal Plain in low densities and is extremely scarce in western Alaska. The threatened Alaska breeding population is thought to be in the hundreds or low thousands on the Arctic Coastal Plain and in the dozens on the Yukon-Kuskokwim Delta (USFWS 2005).

3.2.4.2 Environmental Consequences

The construction and existence of the proposed transmission line is not anticipated to have an effect on threatened and endangered species because the project area is not habitat for any threatened or endangered species. The USFWS concurred the requirements of section 7 of the ESA have been satisfied and the USFWS concurs with the determination that the Proposed Action will have no effect on listed species, see Appendix C for USFWS concurrence letter.

Disturbance and Displacement

No disturbances or displacement of Steller's eiders are anticipated to occur. In the rare event that Steller's eiders occur within the project area, disturbance and displacement would not occur because most activities take place during the winter when water bodies are frozen.

Habitat Loss or Alteration

No habitat loss or alteration would occur because Steller's eiders are not expected to use the habitat within the project area. As described earlier, Steller's eider habitat use is restricted to coastal and marine waters during the non-breeding season.

Mortality

Since no Steller's eiders are anticipated to occur within the project area, mortality is not an issue.

3.2.5 Vegetation and Wetlands

3.2.5.1 Affected Environment

The purpose of this subsection is to evaluate and summarize the results of the office-based Wetland Determination Report (HDR Alaska, Inc. [HDR] 2009) and the follow-up supplemental field investigation completed on April 17, 2009, for the proposed road corridor and geothermal well pads near King Salmon, Alaska.

It is understood that the field investigations were completed outside of the growing season, limiting direct observation of wetland indicators, according to the 2007 U.S. Army Corps of Engineers (USACE) Regional Supplement (USACE 2007). Growing season is estimated as the time from the onset of vegetation green-up in the spring until the time in late fall when woody deciduous species lose their leaves and the last herbaceous plants cease flowering and their leaves become dry or brown. The accuracy of the field determination is based on the confirmation of winter season ground truthing and may need to be confirmed during the growing season.

As identified in the April 3, 2009, report, five cover types identified in the project area include mixed broadleaf/needleleaf, woodland lichen tundra, stunted needleleaf scrub/shrub, shrub/sedge wet meadow, and broadleaf scrub/shrub thickets. In an effort to include areas of wetland impacts that otherwise may not be included, the field determination conservatively included potential areas that appeared to be wetland. Overall, 17 sites were ground-truthed, of which five sites had preliminary wetland determination forms completed. It is possible that areas mapped as uplands may be wetland and subject to the regulation under Section 404 of the Clean Water Act (CWA). Areas near the north pad site are mapped as wetlands and confirmed as wetlands with ground-truthing.

The mapped wetlands occur in persistent, emergent vegetation in depressions with concave surfaces. Soils in the mapped wetlands were poorly drained, with thick organic mats. Mapped wetlands were saturated with water or flooded. The wetlands shown in Appendix B are the areas that may be subject to USACE jurisdiction. Placement of dredged or fill material within them, or grading of soil within them, might be subject to regulation under Section 404 of the CWA.

3.2.5.2 Environmental Consequences

A review of the wetland determination prepared by HDR, dated April 2009, shows wetlands within the vicinity of the Proposed Action. However, the Proposed Action does not involve placing fill in previously undisturbed areas, therefore, no impacts to wetlands or vegetation are expected. Since no fill is being placed in wetlands, the Proposed Action does not require a Section 404 permit. If the gravel pads are expanded in the future, it is recommended that efforts be taken to avoid, minimize, and mitigate to the maximum extent practicable all wetland impacts in accordance with Section 404 of the Clean Water Act.

3.3 Water Resources

3.3.1 Affected Environment

The Naknek River drainage area is approximately 9,583 sq km (3,700 sq mi). The watershed includes seven interconnecting lakes. Naknek Lake collects runoff from the volcanoes and mountains to the east, west, and south. The 35-km (22-mi) Naknek River drains Naknek Lake into Kvichak Bay. The Naknek River is tidally influenced from the mouth to King Salmon. The diurnal range (average difference between mean higher high water and mean lower low water) is 6.9 m (22.6 ft) at the mouth and 1 m (3.2 ft) near King Salmon (National Climatic Data Center 1988). Many small streams and creeks feed into the Naknek River.

Although minimal water quality information is available on most waterbodies in the area, the surface water in these watersheds is thought to be of good quality. The U.S. Geological Survey (USGS) has established stations to conduct water quantity and quality monitoring in some of the drainages.

The USGS gauged Eskimo Creek (located near the King Salmon airport) from 1973–1984. During those years, daily stream flow averaged 0.5–150 cubic feet per second, with highs occurring during spring and fall, and lows occurring during mid-winter. In 1996, the State of Alaska placed King Salmon Creek, Eskimo Creek, and the Naknek River on the federal Clean Water Act (CWA) Section 303(d) listing for impairments by petroleum hydrocarbons and oil and grease. With federal remediation efforts, all three waterbodies were removed from the impaired waters list in 2003.

3.3.2 Environmental Consequences

The activities associated with proposed geothermal exploration are not expected to have any direct effects on water resources within the proposed project area. In general, the proposed project area is a small footprint. Effects on water resources during the exploration and drilling phase are expected to remain negligible. Survey activities would have little or no impact on surface water or groundwater. Exploration drilling would involve some ground-disturbing activities that could lead to increased surface runoff.

Drilling into the reservoir can create pathways for geothermal fluids (which are under high pressure) to rise and mix with shallower groundwater. Effects of these pathways may include the alteration of natural circulation of geothermal fluids and the usefulness of the resource. Geothermal fluids may also degrade the quality of shallow aquifers. The stormwater pollution prevention requirements and other industry guidelines would ensure that soil erosion and surface runoff are controlled. Proper drilling practices and closure and capping of wells can reduce the potential for drilling-related effects.

All geothermal fluids would be appropriately contained in an on-site reserve tank and waste disposal areas (see section 2.6). Temporary effects on surface water may also occur as a result of the release of geothermal fluids during well testing, if they are not contained. Geothermal fluids are hot and highly mineralized and if released to surface water could cause thermal changes and changes in water quality. Accidental spills of geothermal fluids could occur due to well blowouts during drilling, leaks in piping or well heads, or overflow from sump pits. Proper well casing and drilling techniques, however, mitigate these risks. Overall compliance with state and federal regulations would protect water quality and the limitations of water rights as issued.

3.4 Cultural Resources

Cultural resources are physical resources associated with people, a society, or multiple societies. They are both built and natural parts of the physical environment and have some cultural value to one or more sociocultural groups (King 1998). They include historic sites, archaeological sites, cultural landscapes, historic documents, spiritual places, Native cultural items, historic and archaeological artifacts, and community values.

Section 106 of the National Historic Preservation Act of 1966 (as amended) requires that impacts on cultural resources be considered prior to the commencement of any project with federal involvement, including federal funding or permits. This is further defined in the implementing regulations, 36 CFR 800.

3.4.1 Affected Environment

3.4.1.1 Central Yup'ik and Alutiiq Cultural History

At the time of European contact, the study area was occupied by two culturally and linguistically distinct groups: the Central Yup'ik and the Alutiiq. The Central Yup'ik inhabited the northern shore of Bristol Bay, as well as the eastern shore as far south as Egegik Bay. The Alutiiq people generally occupied the upper Alaska Peninsula east of King Salmon and Kodiak Island (BLM 2007). Today, both cultures persist in the region, and people continue to participate in traditional cultural activities. This section, however, focuses on the past.

3.4.1.2 Prehistory

The earliest archaeological sites in the Central Yup'ik Bristol Bay region date to approximately 6,000–8,000 BC. These oldest sites, belonging to a period known as the Paleoarctic, are located along the upper Ugashik drainage. The people who left these sites focused primarily on hunting large land mammals, especially caribou, with a blade technology (BLM 2007). Following the Paleoarctic period, the Bristol Bay region was occupied from the north by people assigned to the Northern Archaic tradition (circa 3,000 BC) and Arctic Small Tool tradition (2,000–1,000 BC). These groups all maintained a focus on the hunting of large land mammals, caribou in particular (BLM 2007).

From the Alaska Peninsula to the south, the Ocean Bay tradition was the first cultural group in the region to demonstrate a maritime adaptation, specializing in fishing and hunting marine mammals. The Katchemak tradition developed subsequent to Ocean Bay, appearing in the archaeological record around 2,000 BC. It was during this period that material culture became increasingly complex, with more elaborate and decorative hunting implements and the use of ground stone slate tools and lamps. A more sedentary lifestyle during this period is evidenced by larger, more permanent houses (BLM 2007).

Upper Bristol Bay groups became more heavily focused on marine resources somewhat later, concurrent with their shift to more permanent settlements seen in the Norton tradition between approximately 300–1,000 AD. The earliest remains of pottery come from Norton sites, as well as the earliest constructed houses and net sinkers used for catching salmon. Ground stone tools, in contrast to chipped stone technology in use in the region prior to the Norton tradition, appear around this time as well (BLM 2007).

Archaeologists generally agree that the Alutiiq were descendants of the prehistoric people belonging to the Katchemak Tradition. Alutiiq sites along the Naknek and Savonovski rivers date back approximately 4,500 years, the first 500 of which were focused on hunting caribou and other large land mammals. Around 4,000 years ago, people switched to an emphasis on fishing (BLM 2007).

During the late prehistoric, the Alutiiq who had migrated toward the coast were most likely displaced by Central Yup'ik populations moving south and east from the other side of Bristol Bay. By the time of contact, Alutiiq people living near the project area were living around Naknek Lake and the Savonoski drainage (BLM 2007). Salmon continued to be an important subsistence resource and on the coast people increasingly relied upon sea mammals. Further inland, large land mammals were the subsistence staple. Both coastal and inland groups supplemented subsistence resources seasonally with birds, fresh water fish, furbearers, and berries (BLM 2007).

3.4.1.3 Historical Period

The first Russian exploration in the Bristol Bay region was that of Admiral Nageav in 1767. Subsequent expeditions in the area were sporadic. The first permanent Russian presence in the study area was a Russian American Company trading post constructed at the mouth of the Nushagak River in 1818 and called the Novo-Alexandrovsky Redoubt. Missionaries with the Russian Orthodox Church soon followed, building schools at fur trading posts and converting the Native inhabitants in the area to Orthodoxy. Russians remained a significant presence in the area until the sale of Alaska in 1867. Russian men married Native women, and their children—called creoles—were given Russian citizenship and the protection of the Russian government (BLM 2007).

Americans were slow to take interest in the region, with the exception of the missionaries, who began arriving in the late 1880s. The 1912 eruption of Novarupta was a significant event in the region, forcing the relocation of at least one village, Savonoski. The resulting tephra provides a secure stratigraphic identifier for undisturbed sites in the vicinity (BLM 2007).

The driving force behind the eventual influx of outsiders to the Bristol Bay region was salmon. The first cannery was established on Nushagak Bay in 1883 at Kanulik. It was only the first of many. Within a period of 25 years, there were ten canneries in Nushagak Bay, and by the 1920s there were 25 canneries operating within Bristol Bay, including floating canneries, a recent innovation at the time (BLM 2007). The region was quickly over-fished, and in an effort to save what remained of the fishery, stream guards were located on major streams by the Bureau of Fisheries (BLM 2007).

3.4.2 Environmental Consequences

While numerous archaeological sites have been identified in the broader Naknek River drainage, no known or potential cultural resources or archeological sites were identified within 3.2 km (2 mi) of the geothermal project area (ADNR Office of History and Archaeology [OHA] 2010). Prior research describes site locations in the Naknek River drainage as occupying river bluffs, with some use of substantial perennial water source margins and high overlooks (e.g., Dumond 1987, 2003; Harritt 1987). NEA's geothermal project area comprises undulating, fairly wet ground amidst black spruce, and three small ponds lie on the APE Effect margins. The project area thus contains none of the landform features associated with a moderately high archaeological probability for the Naknek River vicinity.

3.5 Land Use

3.5.1 Affected Environment

The project site is situated within a section of remote land with little infrastructure. The land is used primarily by local Native residents from Naknek, King Salmon, and South Naknek for recreation and subsistence purposes. Subsistence and recreational fishing occurs mostly in the summer months, while hunting takes place during fall and winter. Fishing is conducted out of the Naknek River tributaries, such as the northward flowing Smelt and Chimenchun Creeks. Hunting areas are accessed by navigable waters in the summer and frozen rivers and tundra during the winter. The project site is not currently used as an area where residents obtain subsistence resources. Currently, the project site is connected to the existing road system via Lake Camp Road. This is a maintained dirt road providing access from King Salmon and Naknek. Lake Camp road also provides access to Naknek Lake, which is under ownership of the U.S. Park Service.

The surface acreage surrounding the NEA parcel is owned by Paug-Vik Inc., Ltd., a village corporation with subsurface rights retained by Bristol Bay Native Corporation. NEA has a 100-ft easement to access the site with a road and utility corridor. Bristol Bay Borough and the State of Alaska have no jurisdiction over the land or the geothermal resource. Most of the land in the Bristol Bay Borough is Native-owned (Figure 3.5.1-1).

3.5.2 Environmental Consequences

Proposed activities would occur within the existing 49-hectare (120-acre) project area. The existing project area holds no special land use designation. The location is not identified as an area critical to biological resources or local residents for subsistence use. Proposed activities are expected to disturb only the immediate vicinity of the existing surveying or drilling site. Exploration activities are unlikely to affect aviation, subsistence, aesthetics, or general use on surrounding lands.

3.6 Noise

3.6.1 Affected Environment

NEA is currently conducting drilling and construction activities in their project area. King Salmon is the nearest community to the project area and is located approximately 8 km (5 mi) southwest of NEA's project site. Noise from NEA's project area is not expected to carry to King Salmon. The only noise receptors expected to be in the project vicinity would be NEA employees and subcontractors, bird and wildlife species, and perhaps subsistence hunters.

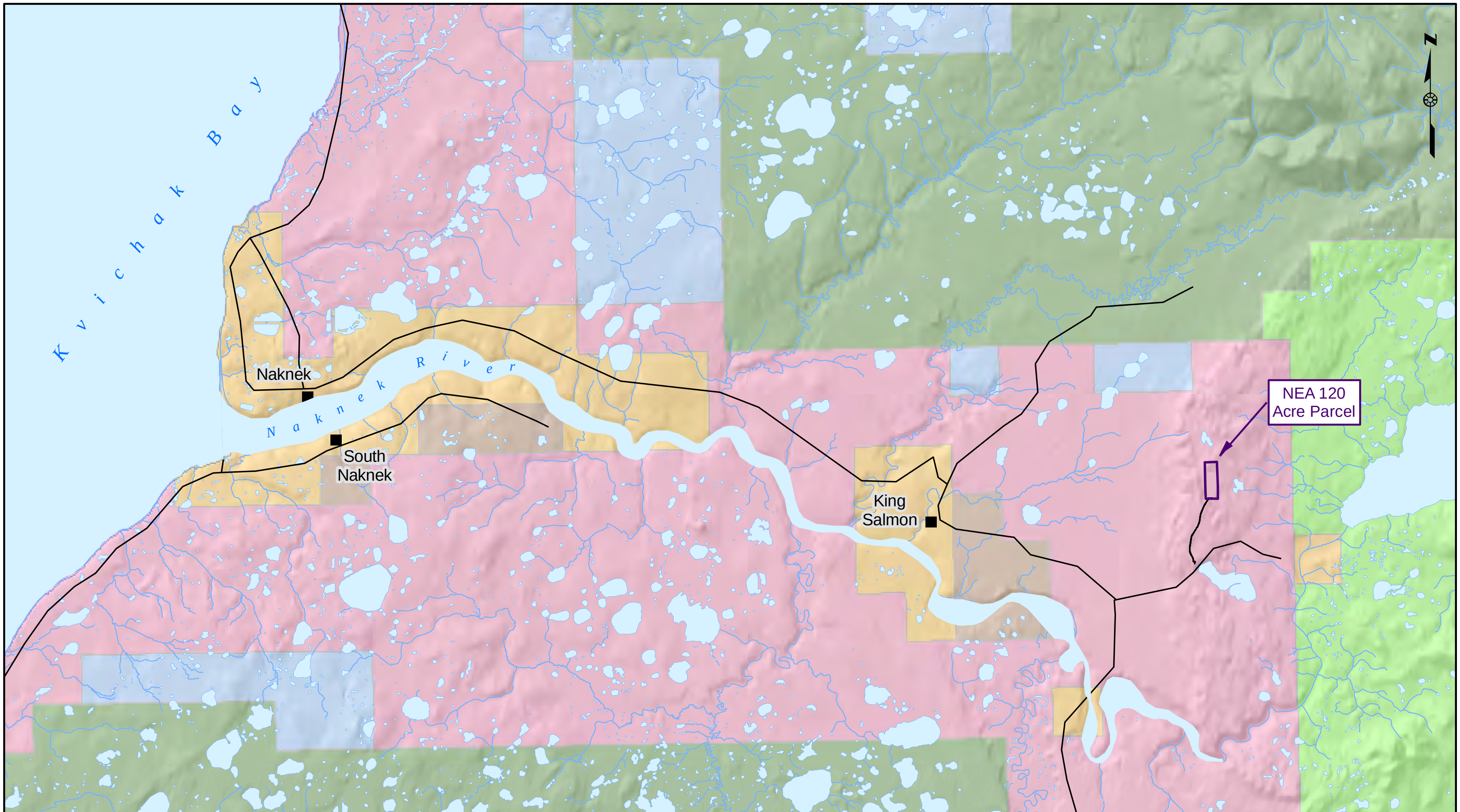
3.6.2 Environmental Consequences

Drilling and construction activities are already occurring at NEA's project site. The additional activities described in this EA would likely increase the noise level at the project site by a small amount, but probably not enough to affect the environment.

NEA's proposed project would include the use of one drill rig, pile drivers, and typical construction site equipment for the pad expansion and widening of the access road. There would also be an increase in noise associated with additional vehicle traffic along the widened access road.

Area uses that have the potential to be negatively affected by high noise levels are considered "noise-sensitive" land uses. Examples of effects that arise from loud noises are sleep disturbance, annoyance, displacement of local wildlife, and disturbance or interference with subsistence activities. Since King Salmon is the nearest community to the project site and is located approximately 8 km (5 mi) southwest of NEA's project site, the majority of residents in the community center are not expected to be affected by noise generated from drilling and construction activities.

The majority of loud sounds at the project area would be generated by the drill rig and pile drivers. Sounds produced during geothermal drilling by typical drill rigs, such as the rig used by NEA, range from about 80–115 dB (Tribal Energy and Environmental Information Clearinghouse [TEEIC] 2010). Pile drivers typically emit sounds ranging from 82–105 dB acoustic (Eaton 2000). NEA plans to continue following U.S. Occupational Safety and Health Administration (OSHA) noise regulations and guidelines for worker exposure. There are no noise ordinances that encompass the project site.



Land Status:

- BLM
- Native
- Private or Municipal
- State
- State and Native
- U.S. Fish and Wildlife Service
- U.S. Park Service
- Wild and Scenic Rivers Management

■ Town
— Road

NAD 83, Alaska State Plane Zone 06

ASRC Energy Services
a subsidiary of Arctic Slope Regional Corporation
Regulatory and Technical Services

Naknek Electric Association

LOCAL LAND USE AND ZONING

Naknek Electric Association
Environmental Assessment

SCALE: 0 1 2 4 Miles

FIGURE: 3.5.1-1

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3.7 Infrastructure

3.7.1 Affected Environment

3.7.1.1 Transportation

The Bristol Bay Borough and entire Bristol Bay Region are limited to intercommunity travel primarily by air or water. There are no roads connecting the majority of villages throughout the region. Severe seasonal weather conditions, inadequate marine facilities, limited roads, and the lack of bridges impede the movement of people and goods. The Bristol Bay Borough is located between the city of Dillingham and the Lake and Peninsula Borough. Naknek and King Salmon are connected by a 25-km (16-mi) asphalt-surfaced road. Access to air service is available at the regional hub of King Salmon, as well as the nearby world-class Bristol Bay commercial fishing grounds.

3.7.1.2 Utilities

The utilities sector includes water treatment and distribution systems, sewer, wastewater, solid waste treatment and disposal, and bulk fuel storage for power, heating, and transportation. Clean water and safe sanitation systems are essential to the Bristol Bay Borough economy, especially for seafood processing. Also important is availability, safe storage, and timely distribution of bulk fuel used to power electrical facilities that run water pumps and sanitation systems in area communities. The Borough operates a piped sewage system and a piped drinking water system for about 90 percent of households.

3.7.1.3 Energy

NEA imports about 1.5 million gal of diesel each year to generate power for the Naknek-King Salmon grid. NEA's power plant uses excess heat from diesel generation to warm the Borough's elementary and high schools, a clinic, the school superintendent's office, a swimming pool, an emergency building, the utility's building, and five homes.

3.7.1.4 Geothermal Project Infrastructure

The NEA Southwest Alaska Regional Geothermal Energy Project was created to evaluate and develop geothermal resources within the Bristol Bay Borough in Alaska. As part of this project, the following activities have been performed and infrastructure has been developed:

- A 2.9-km (1.8-mi) long gravel road from Lake Camp Road to the project site has been constructed.
- Two gravel pads, each approximately 91 m by 107 m (300 ft by 350 ft) have been constructed.
    - A geothermal evaluation well, G1, is currently being drilled to approximately 3,048 m–4,267 m (10,000 ft–14,000 ft) in depth on the northern gravel pad.
    - A laydown and storage area has been developed on the southern gravel pad.
- Three containment areas for waste have been developed: an inert monofill, a drilling waste monofill, and a temporary waste storage area.
- A small pond has been developed and permitted as a water source, with a permitted withdrawal rate of up to 12 million gal over a 2-year period.
- A project office and work area supplied with electricity, heat, and other necessary facilities have been established to support drilling efforts.

Based upon the current schedule, well G1 would be drilled to final depth in February 2010, and testing and well completion would be performed in March 2010. The drill rig and other resources would be available to begin work on well G2 in April 2010.

3.7.2 Environmental Consequences

Should geothermal power eventually prove viable, the most dramatic impacts would be the delivery of reduced-cost energy. Ultimately this project may decrease and stabilize energy costs, benefiting the public sector (e.g., schools, municipalities, and utilities) and the private sector (e.g., industry and private energy users). Outside the primary village boundaries, the project area is remote with little or no infrastructure. While the long-term outcome of the Proposed Action may not lead to a large increase in transportation and utilities, the project would likely have a positive outcome on energy resources within the region.

3.8 Aesthetics

3.8.1 Affected Environment

The visual character, or aesthetics, of a particular area is subjective and depends upon the viewer. The aesthetic value placed on NEA's project area is dependent upon a combination of the visual character, visual quality, and the opinion of the viewer.

A large portion of the project area is relatively undeveloped and undisturbed by human influence and, in some areas, could be characterized as open space. The project area is approximately 2.43 km (1.51 mi) from the Katmai National Park boundary and approximately 14.1 km (8.76 mi) from the Becharof National Wildlife Refuge boundary. Each land type is managed according to agency mandates or guidelines that involve some level of protection from development. The project would not intersect any of these state or federally recognized lands.

3.8.2 Environmental Consequences

The aesthetic value of NEA's project area is not likely to be greatly affected by proposed project development. The aesthetic value of a natural scenic area diminishes to varying degrees with the addition or increase of manmade developments or facilities. Due to the existing drill pad and access road, the change in landscape would be minimal with 0.4 hectares (1 acre) of additional surface disturbance.

Expanding the northernmost gravel pad (Figure 2.4-1) 18 m (60 ft) to the north would increase the project footprint and, in turn, slightly decrease the aesthetic value of the project area. However, the ratio of the project area to the surrounding landscape is such that the overall aesthetic value of the area would be minimally affected.

The drilling of an additional well in NEA's project area would no more than slightly affect the visual quality of the landscape. The components of the activity that would have the greatest effects are drilling crews and equipment and they would be present only temporarily, restoring preconstruction views upon their exit.

3.9 Socioeconomics

Socioeconomic resources within the project area that could be affected by the proposed installation of a new transmission line are identified and reviewed in this section, including:

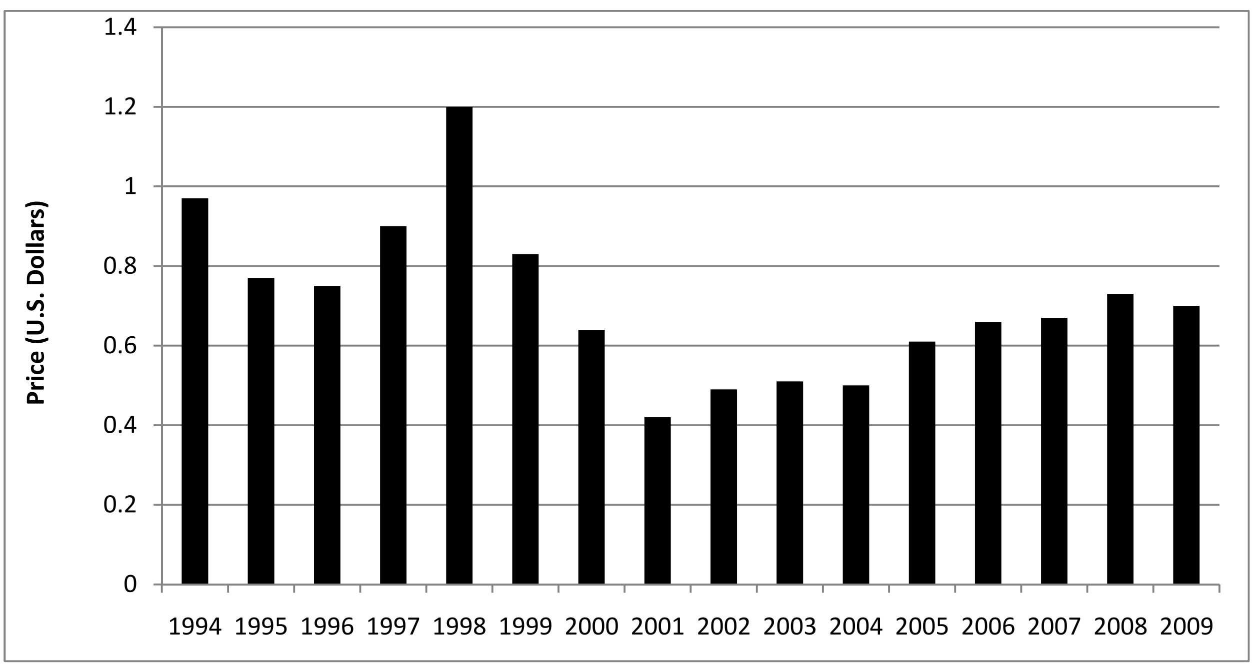
- Community profiles
- Subsistence
- Environmental Justice issues

3.9.1 Community Profiles

NEA member communities King Salmon, Naknek, and South Naknek are governed under the Bristol Bay Borough. Incorporated in 1962 as the state's first borough, today it is considered a regional hub for several communities. King Salmon, the site of a former U.S. Air Force Base, provides a fully operational airport, regularly scheduled aircraft service, and cargo travel to and from Anchorage.

Commercial fishing is a vital part of the economy. In 2008, total inshore return to the Naknek-Kvichak commercial fishing district of Bristol Bay was approximately 17.80 million sockeye salmon. The total commercial catch totaled more than 10.39 million sockeye salmon. Compared to sockeye salmon commercial catches, other salmon species—Chinook, chum, coho, or pink salmon—in the Naknek-Kvichak system are relatively small. Restrictions require mesh to target sockeye salmon. The most popular periods for commercial fishing occur between the last two weeks of June and typically last about six weeks. The steady decline in price per pound for sockeye has lowered the annual price paid to Bristol Bay fisherman from 1994–2009 (Figure 3.9-1).

Figure 3.9.1-1 Average Price per Pound of Sockeye Salmon Paid to Commercial Fisherman in Bristol Bay Borough 1994–2009



Source: ADF&G 2009

Decreasing fish prices have contributed to higher unemployment rates and the percent of residents living below the poverty line. Because there is little governmental infrastructure in South Naknek, residents are more reliant on commercial fishing jobs than adults residing in Naknek and King Salmon. As a result, the declining price of salmon has resulted in more than a fourth of the community living below the poverty line (Table 3.9-1).

TABLE 3.9.1-1 Employment Demographics of Bristol Bay Borough

Community	Total Population	Unemployment Rate	Percent of Adults Not in Workforce	Percent of Residents Living Below Poverty Level
King Salmon	409*	8.86	28.61	12.42
Naknek	552*	9.38	35.56	3.73
South Naknek	68*	24.14	60.71	27.08

Reference: Alaska Department of Commerce, Community and Economic Development (ADCCED). 2009. Community Database Online. Available online at http://www.commerce.state.ak.us/dca/commdb/CF_BLOCK.htm. Accessed February 19, 2010.
* Estimated population (not certified)

3.9.1.1 King Salmon

King Salmon, on the north bank of the Naknek River, is located on the Alaska Peninsula, approximately 457 km (284 mi) southwest of Anchorage. Demographically, the community is somewhat unique in the region, with a Native population consisting of Aleuts, Athabascans, and Yup'ik Eskimos. This is a result of several factors, including the historical boundary between the three groups, the 1912 Mount Katmai eruption, the commercial salmon fishery, and the growing importance of the community in the mid-20th century (ADCCED 2009).

As of 2009, 48 residents held commercial fishing permits (Alaska Commercial Fisheries Entry Commission [ACFEC] 2009). Considered a transportation hub for the region, King Salmon is also a departure point for the Katmai National Park and Preserve. Fishing is one of the main tourist attractions for the area and access to bear viewing and outdoor adventure activities, such as rafting and hiking in the park, are also available (ADCCED 2009).

The state-owned airport in King Salmon has regularly scheduled jet service from Anchorage and the Aleutians. A seaplane base is located nearby at Lake Brooks. A 24-km (15-mi) road connecting King Salmon to Naknek allows goods barged to Naknek to be taken by truck to King Salmon year-round. There is no school in King Salmon. Children attend the school in Naknek. There is one health clinic (ADCCED 2009).

3.9.1.2 Naknek

The community of Naknek is located on the north bank of the Naknek River. It is approximately 478 km (297 mi) southwest of Anchorage. The overall economy is based on government employment and salmon fishing and processing. Naknek functions on a cyclic economy, with several thousand seasonal employees arriving each summer to work in the commercial and sport fishing industries. One hundred twenty Naknek residents hold commercial fishing permits (ADCCED 2009). The overwhelming majority of those are set or drift net permits for salmon, although a combined total of six permits issued to Naknek residents are for halibut, herring, king crab, and sablefish (ACFEC 2009). Millions of pounds of salmon are processed each year and sent to domestic and international markets. Trident Seafoods, North Pacific Processors, Ocean

Beauty, and other fish processors operate facilities in Naknek. Naknek is also the seat of the Bristol Bay Borough.

The first inhabitants in Naknek and the surrounding region were Yup'ik Eskimos and Athabascan Indians. Russian settlers and fur trappers eventually moved in, and the first salmon cannery opened on the Naknek River in 1890. With continued fishing success, there were approximately twelve canneries in Bristol Bay by 1900. Over the years, Naknek has developed as a major fishery center (ADCCED 2009).

Naknek has a population of approximately 552 people. A total of 47.1 percent of the population is Alaska Native or of Alaska Native descent and are represented by the Naknek Village Council, a federally recognized tribe. In general, Naknek is made up of non-Natives, Yup'ik Eskimos, Alutiiq, and Athabascans.

Naknek has two separate, lighted, gravel runways—the privately owned, Tibbetts airstrip, and the state-owned Naknek airport. The Naknek airport is located near a lake suitable for landing float planes. Jet services are available at King Salmon, which is connected to Naknek by a road. The Bristol Bay Borough operates the cargo dock at Naknek, which is the Port of Bristol Bay. No commercial docking facilities are available at the canneries, although the development of a fishermen's dock, freight dock, and industrial park are regional priorities. Pickup trucks and cars are common, and taxis are available (ADCCED 2009).

3.9.1.3 South Naknek

South Naknek is located opposite Naknek on the south bank of the Naknek River. Much smaller than Naknek, with a population of approximately 68 individuals in 2008, it is closely tied to the larger community. The two communities also share a common prehistory and history, with some minor differences. Like Naknek, South Naknek was permanently settled as a result of the salmon canneries around the turn of the 20th century and was historically occupied seasonally by the Sugpiaq Aleuts (ADCCED 2009).

South Naknek has its own federally recognized tribe, the South Naknek Village. Approximately 84 percent of the residents are Alaska Native or Alaska Native descendants. The community maintains a traditional subsistence lifestyle, which focuses heavily on fishing and hunting and is augmented by a cash economy (ADCCED 2009). Thirty-three residents held commercial fishing permits for the drift or set net salmon fishery in 2009 (ACFEC 2009).

South Naknek has its own small health clinic, but Camai Medical Center in Naknek offers supplemental services. Children go to school in Naknek, as there is no school in South Naknek (ADCCED 2009).

3.9.2 Subsistence

Subsistence is defined as the "customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation" (U.S. Code [USC] Title 16, Section 3113 [16 U.S.C. § 3113]). Subsistence is a fundamental part of life in rural Alaska. It continues to hold significant cultural importance among Alaska Native communities and plays a large economic role as well. The majority of rural Alaskan communities participate in a mixed-cash, or mixed, subsistence/market economy, including those within the study area (Wolfe 2000).

Historically, the proposed project area was occupied by two cultural groups: the Central Yup'ik and the Alutiiq. Though there have been many changes to the traditional lifestyles practiced by the Yup'ik and the Alutiiq people in the area, many people in the region continue to rely heavily on subsistence resources. The resources most heavily relied upon in the region are fish, caribou, and moose. Additionally, upland game, bears, furbearers, and waterfowl are important supplemental resources (BLM 2007).

Subsistence is an important aspect of cultural and economic life within Bristol Bay communities. Subsistence resources provide the majority of food that some households within the project area consume in a given year, as well as provide a valuable source of trade and bartering items. Subsistence resources are also widely shared among family and friends within and between communities (Krieg et al. 2009).

Resources that are only regionally available, such as seal oil on the coast, are traded for resources more commonly available inland. Resources can also be traded for cash or non-food items, a practice that has become more accepted in recent years (Kreig et al. 2009).

Community-wide harvest estimates are not available for all of the communities within the project area, as systematic surveys have not been conducted for all locations in recent years. The ADF&G conducted many surveys in the 1980s and has more recently been updating information for some communities. More recent studies have also focused on a sample of certain communities: their levels of participation in harvesting and the use of wild resources, which resources are used in those communities, areas used for subsistence purposes, and the sharing and receipt of wild resources (Krieg et al. 2009).

3.9.3 Environmental Justice

Executive Order (EO) 12898, passed into law in 1994, was created to take into account potential environmental effects of federal projects on minority and low-income populations. According to the CEQ 1997 guidance, the main principles of EO 12898 address the following:

- Consider the composition of the affected area to determine whether minority populations, low-income populations, or Indian tribes are present in the area affected by the Proposed Action, and, if so, whether there may be disproportionately high and adverse human health or environmental effects on minority populations, low-income populations, or Indian tribes;
- Consider relevant public health data and industry data concerning the potential for multiple or cumulative exposure to human health or environmental hazards, to the extent such information is reasonably available;
- Recognize the interrelated cultural, social, occupational, historical, or economic factors that may amplify the natural and physical environmental effects of the proposed agency action;
- Develop effective public participation strategies acknowledging and seeking to overcome linguistic, cultural, institutional, geographic, and other barriers to meaningful participation; ensure meaningful community representation in the NEPA process; and
- Seek tribal representation in the process in a manner that is consistent with the government-to-government relationship between the United States and tribal governments, the federal government’s trust responsibility to federally recognized tribes, and any treaty rights.

The predominant minority populations in the communities of the Bristol Bay Borough are Alaska Natives, Yup’ik’ and Alutiiq in particular. All of the communities in the study area have high Native populations and minority populations in excess of 50 percent, with the exceptions of King Salmon (29 percent minority population) and Naknek (45.3 percent minority population). Many of the members of these communities live a mixed subsistence lifestyle, relying heavily on subsistence resources. Based upon these factors, the residents of the communities to be served by the proposed project are targets of EO 12898.

3.9.4 Environmental Consequences

Should drilling of geothermal wells G2 and G3 result in successful energy prospects, the long-term socioeconomic effect would result in power delivery to Bristol Bay Borough communities at a greatly reduced rate. The proposed project could result in a reduced cost for residential consumers of an estimated $35.30 to $58.85 per month. Commercial, state, and federal consumers, as well as public schools, can expect to see a reduction in monthly costs of between $111.40 and $137.90 per 500 kilowatt-hour used.

3.10 Intentional Destructive Acts

In December 2006, the DOE Office of General Counsel issued interim guidance stipulating that NEPA documents completed for DOE actions and projects should explicitly consider intentional destructive acts (i.e., acts of sabotage or terrorism). Drilling, construction, and operation of exploratory geothermal wells would not involve the transportation, storage, or use of radioactive, explosive, or toxic materials. Consequently, it is highly unlikely that construction or operation of the geothermal project would be viewed as a potential target by saboteurs or terrorists. The project location is not near any national defense infrastructure or in the immediate vicinity of a major inland port, container terminal, freight trains, or nuclear power plants. The Proposed Action would not offer any targets of opportunity for terrorists or saboteurs to inflict adverse impacts to human life, health, or safety.

4.0 CUMULATIVE EFFECTS

For the purposes of this study, cumulative effects are defined as effects that are incremental in nature and occur from a Proposed Action when added to other past, present, and reasonably foreseeable future actions (DOE 2008). Cumulative effects are often referred to as “nibbling” effects (The Cumulative Effects Assessment [CEA] Working Group 1999). Approaches used to perform cumulative effects assessments are numerous and vary significantly based on many factors, including but not limited to the footprint of the Proposed Action, persistence of the Proposed Action and scope of activities associated with the Proposed Action. This cumulative effects assessment takes a project screening approach (CEA Working Group 1999) because the Proposed Action is considered a small action. The assessment incorporates key components considered essential for any cumulative impacts assessment, including scoping, analysis, evaluation and summary (physical environment, biological resources, and socioeconomic/community resources), and future considerations (Smith 2006).

4.1 Evaluation and Summary

This cumulative effects assessment evaluated the combined effects of past activities directly related to the Proposed Action, the Proposed Action alternative, and reasonably foreseeable future actions associated with the Proposed Action. Because the Proposed Action is one step in a multi-step process for the exploration, evaluation, and development of geothermal resources, the cumulative impacts assessment is a particularly important part of the EA.

The Proposed Action is a part of the NEA Southwest Alaska Regional Geothermal Energy Project. Parts of the Southwest Alaska Regional Geothermal Energy Project that have already been completed or are ongoing include construction of a 2.9-km (1.8-mi) long by 5.5 m (18 ft) wide gravel road from Lake Camp Road to the project site, construction of two gravel pads connected by a gravel road [Total disturbance 4.9 hectares (12.2 acres)], and drilling of a single exploratory geothermal well. More specific information on the existing infrastructure is included in Section 2.4.

The Proposed Action discussed in Section 2.0 includes drilling, logging and testing of two geothermal wells (G2 and G3) and the possible stimulation of an exploratory well (G1, G2, or G3). Reasonably foreseeable actions include the possible drilling of up to three more wells (G4 through G6).

If the Proposed Action is carried out and the geothermal resource is determined to be of sufficient size and temperature to allow the development of a geothermal power generation facility, a reasonably foreseeable future action is the construction of the Southwest Alaska Regional Geothermal Energy Project. This includes construction of a 25-megawatt power plant, a switch yard, and a tie-in to the current NEA energy grid via a 2.9-km (1.8-mi) power line. This project would also provide electric power to the entire NEA service area.

4.2 Meteorology and Air Quality

Past actions have had no effect on regional meteorology and temporary and local effects on air quality. Air quality effects were associated with the construction of the gravel road and pad, predominately from dust emissions. Periodic effects from dust are expected from vehicle traffic along the gravel road and pads. These effects are extremely localized and temporary.

The Proposed Action is not likely to have any effect on meteorology and air quality, with the exception of effects associated with expansion of existing gravel pads and widening of the existing gravel access road. These effects are expected to be temporary and localized, associated only with construction activities. After construction activities are completed, the effect of the Proposed Action is expected to be limited to dust from vehicle traffic along the gravel road and pads and would be the same as those from past actions.

Construction and operation of the Southwest Alaska Regional Geothermal Energy Project would have a temporary and localized negative effect on air quality during the construction phase due to use of the existing gravel pads and the access road (dust) and performance of construction activities (emissions from diesel- and gasoline-fired engines). However, the long-term effects are expected to be positive. The operation of the Southwest Alaska Regional Geothermal Energy Project would result in the closure of the existing NEA diesel-fired generation facility and reduction of 1.5 million gal of diesel fuel currently used to generate power for the NEA service area. This would result in the reduction of 33.3 million pounds of GHGs, primarily carbon dioxide, not entering the atmosphere (EPA–http://www.epa.gov/oms/climate/420f05001.htm accessed 2/23/2010). In addition, the availability of lower-cost electricity could result in industrial users by freeing up more capital.

4.3 Geology, Soils, and Seismicity

Past actions have included the ground-disturbing activities of gravel pad and gravel access road construction. These activities have localized but permanent effects on soil compaction and permeability in the areas of pad and road construction. Current activities include drilling and completion of G1, which are not expected to have a significant effect on the geology of the area.

The Proposed Action would result in some ground-disturbing activities because of the expansion of existing gravel pads and widening of the existing gravel access road. These effects would be limited to the actual pad and road expansion areas. These activities have localized but permanent effects on soil compaction and permeability in the areas of pad and road construction.

The Proposed Action also includes drilling and completion of wells G2 and G3 and possible stimulation of one well. Further, reasonably foreseeable actions include the drilling of additional wells (G4-G6). Drilling of wells is not expected to significantly affect the geology of the area. However, stimulation of one of the geothermal wells through EGS may have a permanent effect on geology in the immediate area of the project. EGS would create additional cracks and fissures in rock layers from increased water pressure. Additional cracking and fissuring at depths required by an EGS have the potential to induce minor seismic events and, as such, have the potential to further affect local geology. An Evaluation of the Environmental Impacts of Induced Seismicity at the Naknek Geothermal Project is provided in Appendix D. NEA is committed to following the IEA *Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems* to minimize possible induced seismic events.

Except for the drilling and completion of the geothermal wells, reasonably foreseeable future actions are expected to have no effect on geology, soils, or seismicity (as, the geothermal activities would follow the IEA protocol).

4.4 Biological Resources

4.4.1 Birds and Waterfowl

The direct effects of past actions on birds and waterfowl are expected to be temporary and minimal, with the most likely effects being injuries of bird strikes on the drill rig mast. These effects are temporary and localized. Indirect effects include loss of habitat on areas where the pads and road have been constructed. Although these effects are permanent, because of the large amount of undeveloped land in the vicinity of the project, loss of habitat due to pad and road construction is likely to have a minimal effect.

4.4.2 Terrestrial Mammals

Past actions, the Proposed Action, and reasonably foreseeable actions are not expected to have an effect on terrestrial mammals due to the large amount of undeveloped land in the vicinity of the project area.

4.4.3 Fisheries Resources

The project area is located away from any water sources, except for two small lakes, which do not contain fish. Past actions, the Proposed Action, and reasonably foreseeable actions are not expected to have any effects on fish or fish habitat in the area because there are no fish present in the project area.

4.4.4 Threatened and Endangered Species

Past actions, the Proposed Action, and reasonably foreseeable actions are not expected to have an effect on any listed threatened or endangered species. The presence of threatened or endangered species would be incidental, and no important nesting or staging habitat has been identified in the project area.

4.4.5 Vegetation and Wetlands

Effects of past activities on vegetation are small and limited to where ground-disturbing activities have occurred (i.e., gravel pad and gravel access road). These activities have localized but permanent effects on the vegetation in these areas. Based upon the wetland determination, wetlands were not disturbed during gravel pad and road construction activities; therefore, there were no effects on wetlands.

Effects from the Proposed Action on vegetation are small and limited to where ground-disturbing activities have occurred (i.e., gravel pad and gravel access road). These activities have localized, but permanent, effects on the vegetation in these areas. Based upon the wetland determination, wetlands are not likely to be disturbed during proposed drilling activities.

The effects of reasonably foreseeable future actions on vegetation and wetlands are expected to be minimal and only due to construction of a power line to connect the proposed geothermal power plant to the NEA grid. All other activities associated with the construction and operation of the power plant and switch yard are expected to have no effect on vegetation and wetlands because they would take place on the existing or expanded gravel pads.

4.5 Water Resources

The project area is located away from all surface water resources, except for two unnamed, non-fish bearing lakes. One of these lakes, approximately 76 m (250 ft) in depth, is the water source used to support drilling activities. Water withdrawal of up to 12 million gal over 2 years has been approved via a TWUP from the ADNR (ADNR 2009). While the designated permit does not establish a water right, it provides room for water extraction and a recharge period so that the resource is maintained. Permit conditions require permittees to follow measures ensuring water quality is not degraded in the process of withdrawal. Water discharged shall not be discharged at a rate resulting in sedimentation, erosion, or other disruptions to the bed and banks of the above waters. Gas, fuel, or petroleum products are not permitted near the lake surface or ground waters.

Future development within the project site may include the implementation of a water supply well. Should the well be developed, a Class C drinking well would likely be drilled adjacent to the G1 pad.

4.6 Cultural Resources

A review of cultural and archaeological resources did not locate any cultural resources in the project area. Therefore, any activities within the project are not expected to contribute to cumulative effects on cultural resources.

4.7 Land Use

The Proposed Action is located in an undeveloped area that is predominately used for recreation and subsistence purposes by local Native residents from the nearby communities of Naknek, South Naknek, and King Salmon. The past actions have likely reduced the level of recreation and subsistence use activities in the vicinity of the project because the project area would be avoided by recreational and subsistence users. The Proposed Action is not likely to have additional effects on land use in the area. Because of the large amount of undeveloped land in the vicinity of the project, removal of the project lands from recreational and subsistence use is likely to have minimal effect. Reasonably foreseeable future actions are not likely to have any additional effects on land use.

4.8 Noise

Past and ongoing actions, primarily construction and drilling activities, have produced and would continue to produce noise at the project site. The Proposed Action would produce noise for the foreseeable future at the project site at a similar level as past construction and drilling activities. OSHA noise regulations and guidelines would be followed for workers. The nearest community, King Salmon, is located 8 km (5 mi) away from the project site. Because of the distance of the project site from King Salmon, no effects on local residents are expected.

Reasonably foreseeable future actions are likely to produce similar amounts of noise (i.e., construction of the proposed power plant) or less noise (i.e., operation of the proposed power plant) than past actions or the Proposed Action. Because of the distance of the project site from King Salmon, no effects on local residents are expected.

4.9 Visual and Aesthetic Resources

The project is located in a relatively undeveloped portion of the Bristol Bay Borough. Past and ongoing actions, primarily construction and drilling activities, break up the undeveloped landscape with obvious human development (e.g., gravel pad, road, and drill rig). The landscape is not within a special use area and has not been designated as scenic; therefore, although there has been an effect, the visual and aesthetic value of the project area has not been significantly degraded.

The aesthetic value of the project area is not likely to be greatly affected by the Proposed Action or reasonably foreseeable future actions. The aesthetic value of a natural scenic area diminishes to varying degrees with the addition or increase of manmade developments or facilities. Since there is already an existing drill pad and access road, the change in landscape would not be great.

4.10 Energy Source and Needs

Past actions have had no effect on Bristol Bay Borough energy sources. Past and ongoing actions have required the use of diesel-powered equipment (e.g., drill rig) and gasoline-powered equipment (vehicles). However, the energy used is minimal when compared to the petroleum-based products that are currently used within the NEA service area. It is expected that the Proposed Action would have similar effects on energy sources and needs as past actions.

Completion of the NEA Southwest Alaska Regional Geothermal Energy Project would dramatically improve the availability and decrease the cost of energy within the NEA service area.

4.11 Socioeconomics

Past and ongoing activities have had a positive effect on the economy of the NEA service area. Thirty-six local Bristol Bay Borough residents, of whom 18 are Alaska Natives, were employed during the peak employment period in November 2009. Local vendors, including hotel, food service, and hardware suppliers, have benefited from spending to support past and ongoing project activities.

The Proposed Action is expected to have a positive effect on the economy of the NEA service area. It is anticipated that up to 36 local Bristol Bay Borough residents would be employed as part of the Proposed Action, for up to 72 days. Of the local hires, a number of them are expected to be Alaska Natives. Typically, the winter and early spring is a time of higher unemployment for the region since a large portion of the Bristol Bay economy is based on the seasonal fishery that runs from mid-summer to late fall. Because the project is anticipated for early spring 2010, the availability of jobs during the off-season would provide much needed economic stimulus to the region. In addition, the Proposed Action would result in additional spending at local businesses in support of project activities.

A reasonably foreseeable future action is the completion of the NEA Southwest Alaska Regional Geothermal Energy Project. Construction and operation of the project would have a temporary, positive effect on the local Bristol Bay Borough economy during the construction phase. Construction activities are likely to employ a significant number of local residents, including Alaska Natives. Upon completion of the project, the availability of lower-cost electricity to the NEA service area would benefit local residents by increasing their disposable income, thereby improving their quality of life, and would benefit local businesses by freeing up more capital.

4.12 Assessment

Cumulative effects assessments require an analysis of resources potentially affected in relation to the major components of the Proposed Action. The analysis approach is inherently subjective but is based on professional judgment and collaboration amongst an interdisciplinary team. The tabular analysis tool provided in Table 4.12-1 shows anticipated effects of past actions, proposed actions, and reasonably foreseeable future actions. An evaluation of this analysis is provided in Section 4.1, along with an explanation and rationale for using this approach.

TABLE 4.12-1 Cumulative Effects Assessment

	Past		Present			Future		
Potentially Impacted Resources	Pad and Road Construction	Drilling and Testing Well G1	Drilling and Testing Wells G2 and G3	Hydraulic Stimulation/ Fracturing	Expansion of Pads and Road	Drilling and Testing Wells G4 – G6	Construction of Power Plant, Switch Yard and Power Line Connect to NEA Grid	Cumulative Effects
Meteorology and Air Quality	m t l	n/a	n/a	n/a	m t l	n/a	c p	c p
Geology, Soils, and Seismicity	s t l	m t l	m t l	m t l	s t l	m t l	n/a	s t l
Biological Resources	s t l	s t	s t	n/a	s t l	s t	s t l	s t l
Birds and Waterfowl	s t l	s t	s t	n/a	s t l	s t	s t l	s t l
Terrestrial Mammals	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Fisheries Resources	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Threatened and Endangered Species	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Vegetation and Wetlands	s l	n/a	n/a	n/a	s l	n/a	s l	s l
Water Resources	n/a	s l t	s l t	s l t	n/a	s l t	n/a	s l t
Cultural Resources	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Land Use	s l	s l	s l	s l	s l	s l	s l	s l
Noise	s t l	s t l	s t l	n/a	s t l	s t l	s t l	s l
Visual and Aesthetic Resources	s l	s t l	s t l	n/a	n/a	s t l	s l	s l
Energy Sources and Needs	s t l	s t l	s t l	s t l	s t l	s t l	c p	c p
Socioeconomics	s l t	s l t	s l t	s l t	s l t	s l t	m p l	c p l

Note: Cumulative impact score is based on a subjective review of each resource and assignment of possible ratings based upon the size of the effect and type of effect.
Size of Effect
s = small
m = moderate
c = considerable
Type of Effect
n/a = no effect anticipated
p = positive
t = temporary
l = local

5.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The CEQ's NEPA Guidelines (40 CFR 1502.16) require the discussion of any irreversible or irretrievable commitments of resources that would be involved with the Proposed Actions. The purpose of this section is to identify irreversible and irretrievable commitments of environmental resources required to execute the Proposed Action.

5.1 Irreversible Commitment of Resources

The irreversible commitment of resources is described as the "loss of future options." It applies primarily to non-renewable resources, such as cultural resources, or resources that are renewable after a regeneration period, such as soil productivity. The term may also apply to the loss of an experience as an indirect effect of a "permanent" change in the nature or character of the land. An irretrievable commitment of resources is defined as the loss of production, harvest, or use of natural resources. The amount of production foregone is irretrievable, but the action is not irreversible.

The resource resulting from the Proposed Action could include a small impact to wetlands near the project area with BMPs minimizing impacts to the wetlands. These wetland resources, however, are expected to regenerate after the construction activities are stabilized with vegetation. Overall direct disturbance of the project site is to approximately 49 hectares (120 acres) of land. Cumulatively, water needs for drilling another five wells would require about 12.5 million gal of water (based on the previously drilled G1 well). The temporary, reversible commitment of resources associated with the project lifespan include temporary use of water resources from a nearby pond, as well as land, and soil. No endangered species are expected to be affected.

Induced Seismicity is assessed further in Appendix D. NEA would follow the IEA *Protocol For Induced Seismicity Associated with Enhanced Geothermal Systems* to minimize induced seismic events.

6.0 AGENCIES AND PERSONS CONSULTED

TABLE 7.0-1 Agencies and Persons Consulted

Contact	Position	Affiliation
Joanne Slemons	Petroleum Land Manager	Alaska Department of Natural Resources
Matt Rader	Natural Resource Spec V	Alaska Department of Natural Resources, Department of Oil and Gas
Michael Walton	Natural Resource Specialist	Alaska Department of Natural Resources, Diving of Mining, Land, and Water
Jodi Delgado-Plikat	Project Review Coordinator	Alaska Department of Natural Resources, OPM/Division of Ocean and Coastal Management
Mike Daigneault	Habitat Biologist	Alaska Department of Fish and Game, Department of Habitat
Adele Lee	Natural Resource Spec III	Alaska Department of Natural Resources, Department of Oil and Gas
Chris Nahorney	Natural Resource Spec II	Alaska Department of Natural Resources, Diving of Mining, Land, and Water
Kellie Westphal	Natural Resource Mgr II	Alaska Department of Natural Resources, Diving of Mining, Land, and Water
Dan Seamount	Commissioner	Alaska Department of Administration-Oil and Gas Conservation Commission
Jim Bales	Habitat Biologist II	Alaska Department of Fish and Game, Department of Habitat
Ellen Simpson	Habitat Biologist IV	Alaska Department of Fish and Game
Linda Markham	Office Assistant II	Alaska Department of Transportation and Public Facilities
Fran Roche	Environ Program Spec III	State of Alaska Environmental Conservation-Division of Water
Sharmon Stambaugh	Environ Program Manager III	State of Alaska Environmental Conservation-Water Quality Programs
Sally Ryan	Environmental Engineer Associate II	State of Alaska Environmental Conservation-Air Permits Program
Stephanie Mann	Environ Program Spec III	State of Alaska Environmental Conservation-Solid Waste
Christine Ballard	Natural Resource Spec I	Alaska Department of Natural Resources, OPM/ Division of Ocean and Coastal Management
Judith E. Bittner	Chief, Office of History and Archaeology, and State Historic Preservation Officer	Alaska State Historic Preservation Office
Susan Savage	Wildlife Biologist	U.S. Fish and Wildlife Service
Alan Skinner	Regulatory Specialist	U.S. Army Corps of Engineers Alaska District
James Whitlock	Natural Resource Specialist	U.S. Department of Interior BLM, Anchorage Field Office
Rosie Fay	Community Development Coordinator	Bristol Bay Borough
Marv Smith	Borough Manager	Bristol Bay Borough
Ellen Lance	Wildlife Biologist–Endangered Species Department	U.S. Fish and Wildlife Service

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