Attachment A

Reasonable Foreseeable Development Scenario For Oil and Natural Gas Resources in the Ring of Fire Planning Area, Alaska

July 2006

REASONABLE FORSEEABLE DEVELOPMENT SCENARIO
FOR OIL AND NATURAL GAS RESOURCES IN THE
RING OF FIRE PLANNING AREA, ALASKA

Prepared by

U. S. DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

ALASKA STATE OFFICE

DIVISION OF ENERGY AND SOLID MINERALS

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ACRONYMS AND ABBREVIATIONS

2D	two dimensional
3D	three dimensional
ADNR	Alaska Department of Natural Resources
AEO	average estimated output
API	American Petroleum Institute
bbl	barrel
bbls	barrels
BBO	billion barrels of oil
Bcf	billion cubic feet
BCFG	billion cubic feet of gas
BLM	Bureau of Land Management
bpd	barrels per day
CBNG	Coalbed natural gas
CFR	Code of Federal Regulations
DOG	Division of Oil and Gas
DST	drill stem test
°F	degrees Fahrenheit
FEIS	Final Environmental Impact Statement
ft	feet
GIP	gas in place
KNWR	Kenai National Wildlife Refuge
LNG	liquid natural gas
mcf	thousand of cubic feet
MMBO	million barrels of oil
MWD	measurement while drilling
NEPA	National Environmental Policy Act
NIA	Notice of Intent to Abandon
P&A	plugging and abandoning
PRMP	Proposed Resource Management Plan
psi	pounds per square inch
RFD	Reasonably Foreseeable Development
SMA	Surface Mangement Agency
sq mi	square mile
Tcf	trillion cubic feet
TCFT	trillion cubic feet of gas
URS	URS Corporation
U.S.	United States
USDOI	U.S. Department of Interior
USEPA	United States Environmetnal Protection Agency
USGS	U.S. Geological Survey
WW II	World War II

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EXECUTIVE SUMMARY

This Reasonably Foreseeable Development (RFD) scenario represents the most likely projection of oil and gas exploration, development, production, and abandonment activity in the Ring of Fire planning area through 2020. Estimating how much oil and gas activity will occur in the Ring of Fire planning area during the next 15 years is difficult at best. Timing and location of future commercial-sized discoveries cannot be predicted until exploration of those reserves occurs. This scenario projects development on the assumption that all areas are open to development under standard lease terms and conditions except those areas closed by statute or for discretionary reasons. Separate estimates are given for seismic activity, drilling, and production activities during the next 15 years. Coalbed natural gas (CBNG) is considered separately from conventional oil and gas.

The Ring of Fire planning area encompasses approximately 1.3 million acres of Bureau of Land Management (BLM)-administered lands in south central Alaska. These lands extend roughly in a 2,500 mile arc from the Aleutian Islands in the southwest, through the Alaska Peninsula and Cook Inlet/Chugach Mountains region, to the panhandle of the southeast Alaska. Three petroleum basins fall entirely or partially within the planning area. These basins, the Bristol Bay Basin (referenced in this report as the Alaska Peninsula Province), Cook Inlet Basin, and the Gulf of Alaska Onshore Tertiary Basin are considered prospectively valuable for oil and gas resources. The analysis of hydrocarbon resource occurrence potential is focused in and around these basin boundaries.

The United States (U.S.) Geological Survey (USGS) has identified six conventional oil and gas plays in the Ring of Fire planning area. These play areas serve as the focus for the projection of oil and gas development within the planning area. The USGS has not conducted a CBNG play analysis within the planning area to date.

Based on the Alaska Department of Natural Resources (ADNR) Five Year Oil and Gas Leasing Program Schedule, the Division of Oil and Gas (DOG) will conduct one lease sale a year from 2004 to 2008 within the Cook Inlet Basin area. In addition, DOG will also hold lease sales once a year within the Alaska Peninsula from 2005 to 2008. Should DOG continue this leasing trend, an additional 24 lease sales (1 per year from 2009 through 2020, 12 in each area) would occur within both the Cook Inlet region and the Alaska Peninsula.

From 1991 through 2003, 11 oil exploration wells were drilled in the Cook Inlet Basin. Given the life of the plan (15 years), roughly 15 oil exploration wells would likely be drilled in the Ring of Fire planning area throughout this timeframe. Between 1973 and 2003, 18 gas exploration wells have been drilled in the Ring of Fire planning area, averaging one gas exploration well drilled per year. However, 17 of these wells were drilled in the last 10 years, indicating a substantial increase in gas exploration in recent years. Should this rate of exploration continue, it is assumed that in the next 15 years, 26 gas exploration wells would be drilled throughout the Cook Inlet Basin.

From 1973 to 2003, 53 oil development wells were drilled in the Cook Inlet Basin. Eleven of these wells, roughly one per year, were drilled in the last ten years. Assuming this one-well-per year trend continues, another 15 oil production wells would be drilled in the next 15 years.

In the same 30-year timeframe, 78 gas development wells, or roughly three wells per year, were drilled in the Cook Inlet Basin. Forty-one of these wells, roughly four per year, were drilled in the last 10 years. Assuming this four-wells-per-year trend continues, another 60 gas production wells would be drilled in the next 15 years.

CBNG development in the Cook Inlet Basin would likely occur in the Matanuska-Susitna Valley and in the southern Kenai Peninsula near Homer. Although these locations are part of the mature Cook Inlet oil and gas basin, we consider this a frontier area regarding CBNG exploration due to limited exploration efforts to date in the Matanuska-Susitna Valley. Under this RFD scenario for CBNG production through 2020, recoverable reserves are assumed to be 1.4 trillion cubic feet (Tcf). The CBNG field would be similar in extent to the established Pioneer Unit, approximately 50,000 acres. To maximize recovery and minimize waste, a 100-acre well spacing pattern would be employed and 500 exploration wells (250 pads or two wells per pad) would ultimately be drilled. Ten percent of these wells would be abandoned as dry holes. Projected acreage disturbance due to CBNG exploration and development under this scenario would total about 1,464 acres.

Total surface disturbance of projected short-term oil and gas exploration and development, including CBNG, is estimated at 2,558 acres.

1.0 INTRODUCTION

Presented in this document is a RFD scenario prepared by BLM, Alaska State Office, in support of the Ring of Fire Proposed Resource Management Plan (PRMP)/ Final Environmental Impact Statement (FEIS). A “Reasonably Foreseeable Development scenario” for oil and gas is a long-term projection (scenario) of oil and gas exploration, development, production, and reclamation activity. The RFD covers oil and gas activity in a defined area for a specified period of time. The RFD projects a baseline scenario of activity assuming all potentially productive areas can be open under standard lease terms and conditions, except those areas designated as closed to leasing by law, regulation or executive order. The baseline RFD scenario provides the mechanism to analyze the effects discretionary management decisions have on oil and gas activity.

The RFD also provides basic information that is analyzed in the National Environmental Policy Act (NEPA) document under various alternatives (U.S. Department of the Interior [USDOI]-BLM IM No. 2004-089).

Impacts caused by oil and gas development, and impacts to oil and gas development cannot be accurately assessed without estimating future oil and gas activities. Estimates of these future activities need to address current crude oil and natural gas prices, anticipated crude oil and natural gas prices, oil and gas occurrence potential, new oil and gas plays, as well as renewed interest in old plays, leasing, seismic survey results, drilling, and production.

2.0 DESCRIPTION OF GEOLOGY

The Ring of Fire planning area encompasses approximately 1.3 million acres of BLM-administered lands in south central Alaska. These lands extend roughly in a 2,500-mile arc from the Aleutian Islands in the southwest, through the Alaska Peninsula and Cook Inlet/Chugach Mountains region, to the panhandle of the southeast Alaska (Figure 1).

Three petroleum basins fall entirely or partially within the Ring of Fire planning area (Ehm 1983) (Figures 1-3). These basins, the Cook Inlet Basin, the Gulf of Alaska Onshore Basin and the Bristol Bay Basin (referenced in this report as the Alaska Peninsula Province) are considered prospectively valuable for oil and gas resources. The analysis of hydrocarbon-resource occurrence and development potential within the Ring of Fire planning area is focused in and around these basin boundaries. For a more comprehensive discussion of the geology and mineral resources of the Ring of Fire planning area, see URS Corporation (URS) (2005).

2.1 COOK INLET BASIN

The Cook Inlet Basin is a northeast-trending forearc basin 200 miles long and 60 miles wide. It covers some 12,000 square miles (sq mi) and is filled with more than 25,000 feet (ft) of Tertiary non-marine sediments. Rocks in the basin area range in age from Pennsylvanian to Recent.

2.1.1 USGS Oil and Gas Play Overview

The following excerpt is from a USGS oil and gas play description for the Cook Inlet Basin (Magoon et al. 1996).

The Cook Inlet Basin produces oil and gas from Tertiary sandstone reservoir rocks that were deposited in a forearc basin. Biogenic gas is produced from the late Tertiary sandstone reservoir rocks, whereas oil with associated gas is produced from the early Tertiary conglomeratic sandstone and sandstone reservoir rocks. Minor amounts of oil have been recovered from late Mesozoic sandstone unconformably underlying the Tertiary rocks. The source rock is the Middle Jurassic Chuitna Formation in upper Cook Inlet, whereas the Upper Triassic and Middle Jurassic are the source rocks for the oil shows in lower Cook Inlet. In upper Cook Inlet, oil generation began as early as the Eocene and peaked in the Pliocene. Until recently, discovered resources were about 1.2 BBO, but with the Sunfish discovery and the McArthur River extension, discovered resources may exceed this amount in upper Cook Inlet.

2.2 ALASKA PENINSULA PROVINCE

The Alaska Peninsula Province forms the eastern boundary of the Bristol Bay Basin. The Peninsula is located west and southwest of Cook Inlet. It extends in a curving 400 mile arc from the vicinity of Lake Illiamna in the northeast to Isanotski Strait at its tip in the southwest. The Peninsula decreases in width from about 100 miles across its base to about 3 miles at its tip. The Alaska Peninsula is primarily a province of Mesozoic and Cenozoic sediments heavily influenced by volcanic and plutonic activity.

2.2.1 USGS Oil and Gas Play Overview

The following excerpt is from USGS oil and gas play descriptions for the Alaska Peninsula (Magoon et al. 1996).

Alaska Peninsula Mesozoic Play (Hypothetical): This is a hypothetical structural play for Mesozoic accumulations under large anticlines along the Alaska Peninsula. The play area includes the outcrop belt of Mesozoic rocks and part of the southwestern Bristol Bay lowlands where Mesozoic rocks are thought to be preserved. The play area is about 440 miles long and 30 to 50 miles wide, extending from lower Cook Inlet on the northeast to the last outcrops of sedimentary rocks in the Cold Bay area on the southwest. The southeast boundary is the national offshore 3-mile territorial limit along the Gulf of Alaska and the northwest boundary is the Bruin Bay Fault and its southwestern projection into the Port Heiden area.

Alaska Peninsula Tertiary Play (hypothetical): This is a hypothetical play for petroleum accumulations in Tertiary shallow marine and nonmarine sandstone in broad open folds underlying alluvium of the Bristol Bay lowlands on the northwestern side of the peninsula. The play area extends from about Becharof Lake, part way down the peninsula, to a narrow strip of coastline opposite Cold Bay, a distance of about 300 miles. The northwest boundary is the national 3-mile offshore territorial limit, and it adjoins the offshore North Aleutian Basin. The average width is about 25 miles.

2.3 GULF OF ALASKA ONSHORE BASIN

The Gulf of Alaska Onshore Tertiary Basin is a lowland and foothills belt 300 miles long and up to 40 miles wide. The onshore province lies seaward of the Chugach-Saint Elias and Fairweather Faults and is bordered by the Ragged Mountain Fault in the west and by Cross Sound in the east.

This distinct physiographic and geologic province is underlain by a thick sequence (over 9 miles) of continental and marine sedimentary rocks that decrease in age seaward (Paleocene through Holocene) (Bayer et al. 1977; Bruns and Plafker 1982). The Tertiary sequence is broadly divisible into two stratigraphic units: 1) a thick lower unit of intensely deformed, well indurated rocks of Paleocene to Eocene age; 2) a less deformed and indurated upper unit of Oligocene to Pliocene age that contains most of the known indications of oil and gas in the province.

Gulf of Alaska Tertiary province can be divided into three major subdivisions that correspond to major tectonic and depositional changes since early Tertiary time (Plafker 1971; Bayer et al. 1977; Bruns and Plafker 1982; Bruns 1988). The major subdivisions are:

1) a lower Tertiary sequence (Paleocene through lower Oligocene) of hard, dense, and intensely deformed and faulted rocks. It is composed of the Orca Group, Stillwater, lower Tokun, and Kulthieth Formations. The Orca Group is a flysch-like sequence of turbidites and interbedded pillow basalts that likely represent deep-sea fan deposits. Continental to shallow marine coal-bearing clastic rocks of the Stillwater, lower Tokun, and Kulthieth Formations, overlie the Orca Group in outcrop, the sequence totals about 22,000 ft in the Katalla district, but appears to thin toward Yakutat Bay. Sandstones in the Kulthieth Formation are potential reservoir rocks for oil and gas (Bird and Magoon, 1988);

2) a middle Tertiary sequence (middle Oligocene through lower Miocene) of richly organic mudstone and siltstone. It unconformably overlies the lower Tertiary strata. This sequence consists of up to 6,000 ft of the Poul Creek Formation including the Katalla Formation (Miller 1975), and up to 2,500 ft of Cenotaph Volcanics and the Topsy Formation. In the central part of the Gulf of Alaska Tertiary province, the middle Tertiary sequence contains many petroliferous beds as well as seeps of oil and gas. Thickness of the middle Tertiary sequence in outcrop varies abruptly within short distances. It ranges from a few hundred ft in the Malaspina district to about 9,000 ft in the Katalla district. Marine shales of the Poul Creek Formation are potential source rocks for oil and gas (Bird and Magoon 1988); and

3) a Miocene through Holocene sequence of about 3,700 ft of nonglacial clastic sediments (conglomerate and sandstone) of the Redwood Formation and up to 18,000 ft of interbedded siltstone, mudstone, sandstone, and conglomeritic sandy mudstone of the Yakataga Formations. These strata are interpreted as marine diamictite with abundant glacial detritus deposited close to tide water by ice rafting. Sandstones in the Yakataga Formation are potential reservoir rocks for oil and gas (Bird and Magoon 1988).

2.3.1 USGS Oil and Gas Play Overview

The following excerpt is from a USGS oil and gas play description for the Gulf of Alaska Tertiary Basin (Magoon et al. 1996).

Yakutat Foreland/Lituya Play (hypothetical): This hypothetical play includes hypothetical accumulations of petroleum, mainly oil and associated gas, in relatively undeformed strata of Cenozoic age. The play lies between Icy Bay and Cape Fairweather, seaward of the Fairweather and Boundary Faults. The play includes the areas beneath the ice of the Malaspina Glacier and the waters of Yakutat Bay, beneath the Yakutat Foreland, the coastal plain between Yakutat Bay and Cape Fairweather, and the Lituya Bay area. Since much of the play is covered by ice, water, or Quaternary alluvium, little is directly known of subsurface structure. The part that lies north or northeast of the onshore continuation of the Dangerous River zone is underlain by rocks of the Yakutat Group; these rocks have been sampled in coreholes east of Yakutat Bay.

Tertiary strata dip steeply away from, and thicken seaward along and south of, the Dangerous River zone. Seaward of and along the Dangerous River zone continuation, thick sedimentary rocks are present and are inferred to include equivalents of the Paleogene Stillwater, Kulthieth, and Tokun Formations, the Oligocene and Miocene Poul Creek Formation, and the Miocene and younger Yakataga Formation. Onshore, Paleogene and Poul Creek Formation strata thin to the east; these strata are as much as 13,000 ft and 6,000 ft thick, respectively, west of Icy Bay but are not known to be exposed in the Lituya Bay area. The Yakataga Formation is as thick as 13,000 ft thick at Icy Bay and also thins to the east. However, just offshore, Paleogene rocks are up to 13,000 ft thick, and Yakataga Formation equivalents are up to 17,000 ft thick. Thus, thick sequences of Paleogene rocks are likely present beneath Malaspina Glacier and Yakutat Bay, and they have been sampled in wells near the shoreline in both Icy Bay and Yakutat Bay, and near the town of Yakutat.

3.0 PAST AND PRESENT OIL AND GAS EXPLORATION ACTIVITY

Similar to the exploration and development efforts in the Cook Inlet Basin, exploration in the Alaska Peninsula and Gulf of Alaska onshore basins has historically focused on structural plays in the search for oil with no attempt to evaluate stratigraphic potential. It should also be noted that during these past exploration efforts, a well having good gas “shows” (evidence for the presence of hydrocarbons) or flowing small to moderate amounts of natural gas was considered insignificant because there was no market for the natural gas.

3.1 COOK INLET BASIN

The first attempt at commercial oil exploration in the Cook Inlet Basin took place on the Iniskin Peninsula in western Cook Inlet where six exploration wells were drilled between 1900 and 1906. Although these proved not to hold commercial quantities of oil and gas, exploration continued throughout the basin for the next 50 years. Commercial oil was finally found in Alaska in 1957 with the Swanson River discovery well drilled by Atlantic Richfield Oil Company in the Kenai National Moose Range, now referred to as the Kenai National Wildlife Refuge (KNWR). The well flowed at a rate of about 900 barrels a day from a depth of 11,000 ft. The first major gas discovery occurred in 1959 by Union Oil Company of California and Ohio Oil Company in the Kenai gas field. In 1962, Pan American Petroleum Corporation discovered the first offshore oil in Cook Inlet. This led to extensive exploration throughout the Cook Inlet region in the 1960s and 1970s.

Eighteen gas fields and eight oil fields have been discovered in the Cook Inlet Basin to date. The McArthur River field, discovered in 1965 and located offshore, is the largest Cook Inlet oil field. The last oil field discovery was the Sunfish/Tyonek Deep in 1991, also located offshore. The Kenai gas field was the first and continues to be the largest commercial gas field in the basin. The most recent gas discovery in the basin was the Happy Valley field in 2003.

Approximately 270 exploration wells have been drilled in the Cook Inlet Basin to date. Of these exploration wells, 24 have been drilled for gas. Natural gas in the basin is found in the Sterling, Beluga, and Tyonek Formations and comes primarily from Tertiary coals (biogenic gas). Oil is found in the Hemlock, Lower Tyonek, and West Forelands Formations. The sources of oil for the Cook Inlet Basin are marine shales of the middle Jurassic Tuxedni Formation.

Coalbed Natural Gas: Demand for natural gas has led to a dramatic increase in CBNG drilling and production since 1996, primarily in Rocky Mountain Basins of the lower 48 states. High natural gas prices are making CBNG economically viable where it previously may not have been. Unlike coventional natural gas wells, CBNG wells produce at low gas rates (typically maxing out around 300 thousand cubic ft (mcf) per day, and can have large inital costs.

Recent oil and gas exploration in the State has included a focus on CBNG exploration, most notably in the Matanuska-Susitna Valley located in the northeastern Cook Inlet Basin. CBNG is a form of natural gas that occurs in large quantities in coal seams. Unlike conventional oil and gas formation, coal is both the source rock and reservoir rock for a CBNG well. Methane is the lightest component of the hydrocarbon chain, meaning that a methane molecule has the highest ratio of hydrogen atoms to carbon atoms. The gas is typically contained within the internal surfaces of the coal and is held in place by hydrostatic pressure created by the presence of water. During production, this water is pumped to the ground surface, which lowers the pressure in the coalbed reservoir and stimulates the release of gas from the coal. The gas itself, which is almost entirely methane, eventually flows through fractures in the coal to the well bore and is captured for use. It may take a while to know whether a well will produce gas, and even longer to know whether it will produce commercial quantities. Gas flow does not peak for a considerable time after initial production.

Until the 1980s, coal seams generally were not considered to be reservoir targets, even though producers often drilled through coal seams to reach deeper hydrocarbon-bearing sandstone and limestone reservoirs. During the second half of the 1990s, CBNG production increased dramatically nationwide to meet ever-growing energy demands.

In the Cook Inlet Basin, coal is the source of up to 7.7 Tcf of the basin's 8.3 Tcf of "conventional" gas (Thomas et al. 2004). The economic viability and timing of any contribution from this resource remains highly uncertain because of high development costs, the lack of sufficient data to predict gas productivity, the amount of water that must be handled and land access issues.

In 1994, the state drilled a CBNG test well near existing roads and pipelines in Wasilla, Alaska (well AK-94 CBNG -1) to a total depth of 1,245 ft in the Tyonek Formation. Eighteen seams of bituminous coal were encountered, the thickest at 6.5 ft, with a net coal thickness of 41 ft (Smith 1995). Thirteen of these seams were sampled for gas content using 38 gas desorption canisters, however, the well was not flow tested due to budget constraints. Smith (1995) reported the following data based on the results of the test well: 1) the CBNG gas has both biogenic and thermogenic sources; 2) the gas content, 98 percent methane, increases with depth; 3) coal moisture is low (9.02 percent at 521 ft and 4.82 percent at 1,236 ft); and 4) upon visual analysis, coal cleat and fracture density is widely spaced. Encouraged by the results of this well, the Alaska Division of Geological and Geophysical Surveys has embarked on a multi-year study to determine whether CBNG could serve as a local energy source in rural Alaska.

Industry exploration efforts in the Matanuska-Susitna Valley began in the late 1990s and included core samples and the drilling of several pilot wells in bituminous coal seams of Tertiary age. In June of 2003, Evergreen Resources began pilot production in the Pioneer Unit (Figure 2) to test the commercial viability of CBNG near Wasilla. The goal of a pilot test is to dewater a portion of the reservoir and record the resulting production profile as quickly as possible. The results provide the basis for determining whether to develop the field and at what well-spacing pattern (Allen 2001). The testing program involved two four-well pilots consisting of three wells forming an equilateral triangle (600 to 700 ft on a side) with a fourth well in the center. The wells reportedly contain up to 160 ft of coal within an approximate cross section of 600 to 1,000 ft (Thomas et al. 2004). Within six months, five of the CBNG wells produced over 2 mcf of gas and about 2.6 million gallons (62,000 barrels [bbls]) of water. The four remaining wells yielded a combined daily production rate of 10,355 cubic ft of gas and 13,356 gallons (318 bbls) of water during the month of December. Produced gas from the wells was vented, and produced water was re-injected into two nearby wells.

In November 2003, Evergreen announced that “initial production results indicate that the wells in the first two pilot projects are probably not capable of commercial production” (Petroleum News 2003). Evergreen is now drilling five stratigraphic core holes north of the Castle Mountain Fault where coal seams are at shallower depths. The coring program will recover coal core samples to determine methane desorption potential, total aggregate thickness of the coal seams, and other data to help estimate future production (Petroleum News 2003).

3.2 ALASKA PENINSULA PROVINCE

Twenty-eight oil wells have been drilled on the Alaska Peninsula to date. Nine shallow wells were drilled on two different oil seeps prior to 1926 and another 19 deeper wells were drilled between 1940 and 1985. Oil or gas shows were observed in nine of the deeper wells, but commercial quantities of hydrocarbons have not yet been found. The following brief history identifies the Alaska Peninsula as an area that generates continuing, albeit intermittent, interest in the search for oil and gas.

The vast coal resources and surface oil seeps on the Alaska Peninsula have attracted exploration interest since the mid-1800s (Table 1). Based on the presence of oil and gas seeps in the vicinity of Puale Bay, then known as Cold Bay, several oil exploration wells were drilled in the early 1900s.

In 1910, the federal government withdrew from entry all oil lands in Alaska (Martin 1921). The Mineral Leasing Act of 1920 renewed interest in the search for oil on the Alaska Peninsula. Oil claims were staked in the vicinity of Puale Bay in the early 1920s (Brooks 1922). Associated Oil Company and Standard Oil of California drilled wells in the early to mid-1920s. Standard Oil drilled two shallow wells and one deep well (about 5,400 ft) without striking commercial quantities of oil (Brooks 1925; Moffitt 1927). Both companies abandoned drilling on the Peninsula by early 1926 (Smith 1929).

By the mid-1930s, the Puale Bay area was once again the scrutiny of oil exploration. Geologists from Standard Oil Company of California, the Tide Water Associated Oil Company and Union Oil Company of California, drilled wells in the Bear Creek Unit area near Jute Bay in 1939. The venture reported no showings of commercial quantities of oil (Smith 1939).

Interest in the oil potential of the Alaska Peninsula lay dormant throughout the 1940s and into the mid-1950s. From 1957 through 1959, Humble Oil and Refining Company drilled the Bear Creek Unit No. 1 to a depth of 14,375 ft and encountered no commercial quantities of oil (Blasko 1976). Several wells have been drilled on the Alaska Peninsula in recent years, the last drilled and abandoned in 1985.

Coalbed Natural Gas: The Alaska Peninsula Province contains coals of Cretaceous and Tertiary age separated by a regional unconformity (Smith 1995). The Cretaceous coals, bituminous in rank, occur in the Chignik Formation and have been penetrated by at least three oil and gas exploration wells (Smith 1995). All had excellent mudlog gas shows. The Tertiary coals range from lignite to bituminous in rank and occur in the Tolstoi, Stepovak, and Bear Lake Formations. These coal seams have been penetrated by five oil and gas exploration wells and reportedly contain minor to good gas shows (Smith 1995). The Tertiary coals extend along the north side of the Alaska Peninsula for over 250 miles.

3.3 GULF OF ALASKA ONSHORE BASIN

The petroleum potential of the onshore Gulf of Alaska Tertiary Basin was first recognized through the discovery of oil and gas seeps east of Katalla in 1896. From 1901 to 1933, 44 shallow wells were drilled in the Katalla area, 28 wells at the Katalla field, and 16 wells at nearby locations. Most wells had oil shows, some had gas shows, and 18 produced oil commercially (about 154,000 bbls) from fracture porosity in sandstone and siltstone of the Poul Creek Formation at depths ranging from 360 to 1,750 ft.

The Katalla field became the only productive area in the Gulf of Alaska Tertiary Basin. Operation of a small refinery at the field began in 1911 but production abruptly ended when the refinery burned down in 1933 (Miller et al. 1959; Blasko 1976; Bruns and Plafker 1982). Although active natural gas seeps were known in this area, there are no records of gas production from this period.

East of Katalla in the coastal area of Yakataga, oil and gas seeps are found on numerous creeks draining southward toward the ocean. The first test well in this area, drilled between 1926 and 1927, had shows of oil and gas. After World War II (WW II), leasing activity on previously withdrawn lands resumed, and in 1951, hundreds of individuals applied for leases covering nearly one million acres in the coastal areas between the Copper River and Cape Fairweather (Miller et al. 1959). Exploration for onshore oil and gas deposits within the basin continued from 1954 to 1963 when an additional 25 wells and five core holes were drilled. Although all were abandoned, records indicate shows of oil and/or gas in nine of the wells (Plafker 1971). No commercial hydrocarbon field has been discovered in the basin to date.

4.0 PAST AND PRESENT OIL AND GAS DEVELOPMENT ACTIVITY

The Cook Inlet Basin is currently the only commercially producing oil and gas region within the Ring of Fire planning area and is the focus of past and present oil and gas development.

4.1 COOK INLET BASIN

Before Prudhoe Bay and the North Slope made the State famous for oil and gas, Alaska's first commercial oil production came from discoveries in Cook Inlet. The Swanson River discovery is often credited as one of the key factors in Alaska becoming the 49th state by showing that Alaska could support itself through resource development revenues. In 1959, two years after the discovery of oil in the Swanson River field, the State established a competitive leasing program by issuing 77,000 lease acres in Cook Inlet Basin and receiving $4 million in bonus bids. Over 5.6 million acres of state land have been leased in 40 state oil and gas lease sales in the Cook Inlet region since 1959. Prior to statehood in 1959, the federal government conducted non-competitive lease sales. About 67,000 acres of the non-competitive federal leases remain active in the Cook Inlet Basin. One competitive federal lease has been issued to date, a 400-acre parcel receiving over $4.5 million in bonus bids.

The first major gas discovery was made in the Kenai field by the Union Oil Company of California and Ohio Oil Company in 1959. Gas production in Cook Inlet began the following year when the Anchorage Natural Gas Corporation signed a 20-year contract for Kenai field gas. By 1983, annual natural gas production had reached 196.4 billion cubic ft (Bcf). Efforts to explore specifically for natural gas in the Cook Inlet Basin did not take place until the late 1990s.

In 1960, following further development of the Swanson River and Soldotna Creek Units, annual production rose to 600,000 bbls. Production peaked at 83 million bbls in 1970. In 1968, Unocal began producing ammonia-urea at a plant in Nikiski, 70 miles southwest of Anchorage, to take advantage of the abundant, inexpensive natural gas. This plant, acquired by Agrium, Inc. in 2000, currently faces a decline in production due to inadequate affordable supplies of natural gas in south central Alaska.

Tesoro Alaska opened the state's first oil refinery in 1969 near Kenai. Based on market demand, throughput rates in recent years have been approximately 50,000 barrels per day (bpd) or 18 million barrels per year. A 70-mile, 37,000 bpd pipeline links the refinery to an Anchorage terminal. The refinery draws feedstock from Cook Inlet and other sources to produce jet fuel, diesel fuel and heating oil, gasoline, liquefied petroleum gas, heavy oils and bunkers, and liquid asphalt. All of the refinery output is consumed within Alaska.

As additional oil and gas fields were discovered in the basin, local demand for the natural gas increased through growing residential and commercial demand (e.g., space heating and electric power generation) in Anchorage and Kenai. In 1969, Phillips and Marathon began operating a liquid natural gas (LNG) plant, located at Nikiski. The plant liquefies one million tons of LNG annually and is the only natural gas liquefaction plant in the U.S. In recent years, LNG exports to Japan accounted for about one third of total production. Cook Inlet natural gas production has remained relatively stable at an average of 213 Bcf per year from 1997 to 2001.

5.0 OIL AND GAS OCCURRENCE POTENTIAL

A projection of future oil and gas activity must first consider where oil and gas resources might occur. Several geologic elements are necessary for oil and gas to accumulate in sufficient quantities. These elements include an organic-rich source rock to generate oil or gas, the combined effects of heat and time, a porous and permeable reservoir rock to store the petroleum in, and some sort of trap to prevent the oil and gas from migrating to the surface. Traps generally exist in predictable places, such as at the tops of anticlines, next to faults, in the updip pinchouts of sandstone beds, or beneath unconformities. Map 4 was drawn to show the occurrence potential for oil and gas throughout the Ring of Fire planning area, and is not meant to imply these resources can be developed economically.

The mineral occurrence potential assignment conforms to the rating system outlined in BLM Handbook H-1624-1, Planning for Fluid Mineral Resources. This system is designed to remain dynamic. As new data is received it can be used to change the rating. The ratings used have four levels: high, medium, low, and no known. The following definitions were used to classify the oil and gas occurrence potential:

HIGH: Inclusion in an oil and gas play as defined by the 1995 USGS National Assessment. In the absence of a play designated by the USGS, a high potential classification was assigned based on the demonstrated existence of: 1) source rock; 2) thermal maturation; 3) reservoir strata possessing permeability and/or porosity; and 4) traps.

MEDIUM: Geophysical or geological indicate the following may be present: 1) source rock; 2) thermal maturation; 3) reservoir strata possessing permeability and/or porosity; and 4) traps. Geological indication is defined by geological inference based on indirect evidence.

LOW: Specific indications that one or more of the following may not be present: 1) source rock; 2) thermal maturation; 3) reservoir strata possessing permeability and/or porosity; and 4) traps.

NO KNOWN: There is a demonstrated absence of a petroleum source, reservoir quality strata, or trapping mechanisms. Demonstrated absence is defined by physical evidence or documentation in the geological literature.

The rationale for determining occurrence potential within Ring of Fire planning area is based primarily on three sources: 1) geology; 2) oil and gas basins map of Alaska; and 3) conventional oil and gas play areas described by the USGS 1995 National Oil and Gas Assessment. The play descriptions include discussions on reservoir rocks, source rocks, exploration status, and resource potential.

Beikman (1980) constructed a generalized geology map of Alaska. This information was used to identify areas within Ring of Fire planning area consisting primarily of igneous and metamorphic rocks. These areas were eliminated from further consideration as prospective oil and gas resources and assigned no known potential. Ehm (1983) delineated three petroleum basins that fall either partially or entirely within Ring of Fire planning area. These basins are generally considered prospective for oil and gas resources and serve as the focus for further analysis using available exploration and drilling data and USGS play descriptions.

The USGS has identified six conventional oil and gas plays in Ring of Fire planning area. A play is a set of discovered or undiscovered oil and gas accumulations or prospects that exhibit nearly identical geological characteristics. A play is defined, therefore, by the geological properties, such as trapping style, type of reservoir, nature of the seal, that are responsible for the accumulations or prospects.

Two principal categories of conventional plays were assessed by in the 1995 USGS National Assessment – confirmed plays and hypothetical plays. A play was considered confirmed if one or more accumulations of the minimum size (one million barrels of oil [MMBO] or six billion cubic ft of gas [BCFG]) had been discovered in the play. Hypothetical plays were identified and defined based on geologic information but for which no accumulations of the minimum size had, as yet, been discovered.

Using these definitions, two plays in the Cook Inlet Basin are confirmed and the remaining four plays are hypothetical. As such, hypothetical plays characteristically carry a much broader degree of uncertainty than do confirmed plays.

5.1 COOK INLET BASIN

The following USGS conventional oil and gas play descriptions for the Cook Inlet Basin are from Magoon et al. (1996).

The Cook Inlet area has been divided into three plays. They are the Beluga-Sterling Gas Play, the Hemlock-Tyonek Oil Play, and the Cook Inlet Late Mesozoic Oil Play, with the latter being a hypothetical play. The Beluga-Sterling Gas Play is a confirmed play for additional gas accumulations, covering 12,318 sq mi of the Cook Inlet Basin and including 18 gas fields containing discovered reserves of 6.14 trillion cubic feet of gas (TCFG). The three largest fields are Kenai (2.52 TCFG), North Cook Inlet (1.44 TCFG), and Beluga (0.86 TCFG). Many of the gas fields are undeveloped because they are too small and too expensive to produce.

Most of the gas is produced from the Sterling Formation, followed by the Beluga Formation and Tyonek Formation. The reservoir rocks in these formations are siliclastic sandstones of late Tertiary age whose average thickness ranges from 24 to 600 ft. The porosity of these reservoirs ranges from 18 to 35 percent and permeability ranges from 3.5 to 4,400 mD. The seals for these accumulations are siltstones associated with these reservoirs. The traps, which can be more than one per field, are mostly structural, but include some combined structural and stratigraphic traps. Structural traps include anticlines and faulted anticlines.

The natural-gas field sizes range from 6 BCFG to 2.52 TCFG. The gas is believed to be biogenic. The stratigraphic section is thermally immature and unable to generate methane. Biogenic gas generated locally would have migrated to adjacent structures or other types of traps.

The Hemlock-Tyonek Oil Play confirms oil accumulations covering 7,335 sq mi of the Cook Inlet Basin and including eight oil fields, two of which were just discovered. So little information is available for the two newly discovered fields that they have been excluded from this discussion. The three largest producing fields are McArthur River (590 MMBO), Swanson River (230 MMBO), and Middle Ground Shoal (182 MMBO).

Eighty percent of the oil is in the Oligocene Hemlock Conglomerate, a conglomeratic sandstone, with the remainder coming from the Oligocene and Miocene Tyonek Formation, a siliciclastic sandstone, and the Eocene West Foreland Formation, a volcaniclastic sandstone. The reservoir thickness ranges from 100 to 1,320 ft. Reservoir porosity ranges from 11 to 20.5 percent, and permeability from 10 to 4,960 mD. The seals for these accumulations are siltstones associated with these reservoirs. The traps are all structural.

The oil has an American Petroleum Institute (API) gravity that ranges from 31° to 42° and a low sulfur content (<0.2 percent). It originated from the Middle Jurassic Chuitna Formation between the Swanson River and Middle Ground Shoal fields. Based on burial history of the source rock, the oil was generated as early as the Eocene and continued into the Pliocene.

The Cook Inlet Late Mesozoic Oil Play covers 8,518 sq mi of accumulations in structural traps throughout the Cook Inlet Basin. The section unconformably underlies the Tertiary sedimentary rocks. Oil has been recovered from the Mesozoic from several wells in the Outer Continental Shelf in lower Cook Inlet and from wells in the Swanson River field area on the Kenai Peninsula.

Potential reservoir rocks are shallow marine and turbidite sandstones within the Upper Cretaceous Matanuska and Kaguyak Formations, Lower Cretaceous calcarenite, and feldspathic sandstones in the Upper Jurassic Naknek Formation. Where these units are penetrated by wells or found in outcrop, they are of poor reservoir rock quality. Seals are siltstones adjacent to these reservoirs and in the unconformably overlying Eocene West Foreland Formation.

The traps are mostly faulted anticlines that are truncated by the overlying Tertiary rocks, which in many cases contain the oil that migrated up through the Mesozoic section. Other possibilities are unconformities and stratigraphic traps, but these would be very difficult to map using such poor-quality seismic data.

As in the Hemlock-Tyonek Oil Play, the oil is expected to have an API gravity that ranges from 31° to 42° and a low sulfur content (<0.2 percent) and to have originated from the Middle Jurassic Chuitna Formation between the Swanson River and Middle Ground Shoal fields. Based on the burial history of the source rock, the oil was generated as early as the Eocene and continued into the Pliocene.

Coalbed Natural Gas: Coal is abundant in portions of the Tertiary rocks of both the Cook Inlet and Susitna Basins and provides a potential source for large quantities of dry gas. The coal rank ranges from lignite in the Sterling Formation to anthracite in the Chickaloon Formation (Montgomery et al. 2003). Bituminous coals are limited to the Wasilla-Houston area of the Susitna Basin along the Castle Mountain Fault. Sub bituminous coals are found along the western margin of the Susitna Basin and in the Beluga and Yentna coal fields.

The Cook Inlet Basin contains coal deposits within the Chickaloon Formation at its northeast corner and in the Tyonek Formation across its entire extent. Uplift during the Holocene brought thick coals of these formations near the surface, making some onshore areas of the basin prospective for CBNG exploration (Smith 1995).

Tyonek coals beds are abundant and continuous, exceeding 40 ft in thickness. Desorption values for sub bituminous Tyonek coals taken from the State's core test (well AK94 CBNG #1) exceed 100 cubic ft per ton (ADNR/DOG 2004). The core test found multiple seams of sub bituminous coal in a shallow reservoir setting. Desorbed gas content generally increased with depth and exceeded 245 cubic ft per ton at a depth of 1,200 ft for one sample tested. Fracture and cleating observed in the coal samples were also favorable for the producibility of gas from the coals.

Coals of the 3,000 foot-thick Chickaloon Formation, mined between 1914 and 1968, are confined to the upper 1,400 ft and range in rank form bituminous to anthracite. Over half of the estimated coal reserves lie at depths between 1,000 to 2,000 ft (Barnes and Payne 1956). Coals lying north of the Castle Mountain Fault in the Susitna Basin reportedly contain high levels of gas based on results from five oil and gas exploration wells and three U. S. Bureau of Mines core holes drilled between 1951 and 1963 (Smith 1995). Small quantities of mostly methane gas are also reported in shallow water wells near the fault (Smith 1995)

The uplifted margins of the both the Cook Inlet and Susitna Basins offer the highest potential for CBNG gas.

5.2 ALASKA PENINSULA PROVINCE

The following USGS conventional oil and gas play descriptions for the Alaska Peninsula are from Magoon et al. (1996).

Alaska Peninsula Mesozoic Play (Hypothetical): Reservoirs: The primary reservoir objective of this play is Upper Triassic reefoid or biostromal limestone that underlies good oil source rocks. At least three wells penetrated the Upper Triassic section, but none found the biostromal limestone facies. Both the Jurassic sandstones, which are either volcaniclastic graywackes or first-cycle arkoses, and the Cretaceous sandstones, which are lithic rich, have poor reservoir potential.

Source rocks: Mesozoic strata consist of thick sections of deep marine to shallow marine to nonmarine mudstone, sandstone, conglomerate, and minor amounts of limestone. Large oil seeps and oil staining in Mesozoic rocks are found in several places on the peninsula, and good type II oil source rocks have been identified in Upper Triassic and possibly Middle Jurassic rocks. Other marine rocks do not seem to have source-rock potential, although nonmarine paludal (marsh) rocks of the Chignik Formation (Upper Cretaceous) in the southwestern part of the peninsula may locally have lipid-rich rocks that may be potential oil source rocks. At Puale Bay, the only place on the peninsula where Triassic rocks are exposed, limited outcrop sampling of a 1,000-ft-thick section of interbedded petroliferous, argillaceous limestone and shale indicated total organic carbon contents of 1.3–2.8 weight percent (Magoon and Anders 1992). These rocks are barely thermally mature (Ro = 0.6 percent) despite their having been buried by at least 14,000 ft of Jurassic rocks plus an unknown thickness of now-eroded Upper Cretaceous rocks. Well penetrations indicate that Triassic rocks at depth are much more mature, with Ro ranging from 1.0 to over 2.0 percent (Molenaar 1996). Some of this variation is due to nearby intrusive rocks, but it does seem that the geothermal gradient at the time of maximum burial (probably in latest Cretaceous or early Tertiary time) was very much lower than the present gradient, which ranges from 1.65 degrees Fahrenheit (°F) to over 2°F per 100 ft based on bottom temperature data from wells (Molenaar 1996).

Exploration status: Of the 18 significant wells drilled on the peninsula, nine were drilled for Mesozoic prospects and most tested large structures without success. The last well was drilled in 1983 and since then, except for an offshore well drilled by Chevron in the Shelikof Strait in 1985, there has been no activity in the area. Drilling depths for the Triassic rocks would be 12,000 to 20,000 ft.

Resource potential: This is a very speculative play and it is difficult to make a meaningful assessment. There are undrilled possibilities such as the Ugashik Anticline, which has three seeps and has only been drilled to shallow depths. The results of previous deep drilling on the nearby Bear Creek Anticline, which also has large oil seeps, and the nearby large Wide Bay Anticline were disappointing. The lack of adequate reservoir rocks seems to be the main drawback to this play.

Alaska Peninsula Tertiary Play (hypothetical): Reservoirs: Sandstone beds 50 ft to over 100 ft thick are generally common throughout the Tertiary section except in the central part of the play area near Port Heiden and the Gulf Port Heiden Unit number 14 well. There, the Oligocene sequence consists of about 6,000 ft of volcanics, pyroclastics, flows, and agglomerates that grade into sandstones and mudstones to the northeast and southwest.

Source rocks: The source rocks are coaly and carbonaceous strata within the Tertiary section and possibly Mesozoic source rocks that may be present under the southwestern half of the play area. Mesozoic strata are not present under the lowlands in the northeastern two-thirds of the Peninsula because of pre-Tertiary erosion. Hence, except for the possibility of Mesozoic oil source rocks, this is most likely a gas play although there is the possibility that lipid-rich paludal rocks in the nonmarine section could be oil prone.

Marginal thermal maturation for hydrocarbons (Ro = 0.6 percent) seems to be at a depth of about 9,000 to 10,000 ft in the play area (Molenaar in press). Geothermal gradients range from 1.65°F to 2.07°F per 100 ft and average about 1.86°F per 100 ft. Because the Tertiary section is now at its greatest depth of burial, any hydrocarbon generation from Tertiary source rocks is likely still progressing.

Exploration status: Between 1959 and 1983, nine tests ranging in depths from 8,000 – 15,000 ft were drilled for Tertiary prospects. Gas shows were encountered and one test had a slight oil show. Although not as indurated as the Mesozoic sandstones, Tertiary sandstones are generally volcanogenic or lithic and of poor reservoir quality. However, good to fair amounts of water were recovered on a few drill-stem tests.

Resource potential: Because the play area is alluvial covered, seismic surveys are necessary to delineate the structure. Nothing has been published on this, but by analogy with adjacent offshore seismic data, it seems that the structures are broad and gentle. The abundance of coal in the section and the low thermal maturity suggests the area may be favorable for biogenic gas or CBNG. There is little information with which to make resource estimates.

Coalbed Natural Gas: Although the Cretaceous coals of the Alaska Peninsula province have wide aerial extent, Smith (1995) believes the variability of the coal development and discontinuous nature of the thin coal seams make large scale CBNG exploration difficult. Tertiary coals found above 5,000 ft in the Tolstoi Formation have high CBNG potential within the province (Smith 1995). The Bear Lake and Stepovak Formations have low CBNG potential due to their low rank coals.

5.3 GULF OF ALASKA ONSHORE BASIN

The following USGS conventional oil and gas play description for the Gulf of Alaska Tertiary basin is from Magoon et al. (1996).

Yakutat Foreland/Lituya Play (hypothetical): Reservoirs: Potential reservoir rocks are the same as in the Yakataga Fold Belt Play. Overall reservoir potential in any of the formations is most likely poor to fair at best. The depth range of potential lower Tertiary reservoirs is from about 1,500 ft to perhaps 30,000 ft. These estimates are based on well results for the minimum figure and on estimated depth to the base of Paleogene rocks immediately offshore for the maximum figure.

Source rocks: Source rocks are the same as in the Yakataga Fold Belt Play and would lie in the Paleogene sequence. Rocks of the Cretaceous Yakutat Group and the late Cenozoic Yakataga Formation have no source rock potential. No source rocks are known to be present in the Lituya Bay area. the Paleogene rocks found to the west are not known to be present in the Lituya Bay area either onshore or in the adjacent offshore.

Timing and migration: Generation and migration of hydrocarbons could have occurred anytime after deposition of the Paleogene strata, but may have occurred mostly during the late Cenozoic, concurrent with burial by the thick Yakataga Formation. The Dangerous River zone and the entire onshore region lie updip from the offshore Yakutat Terrane Basin axis. Thus, hydrocarbons generated in offshore Paleogene rocks during late Cenozoic burial could migrate updip into the onshore region. Some hydrocarbons have been generated; an exploratory well near Yakutat had oil and gas shows and still leaks a small amount of gas to the surface. Traps other than along the Dangerous River zone could be present beneath Yakutat Bay or the Malaspina area, perhaps created during early deformation of the Paleogene rocks.

Traps: Known or presumed potential traps lie largely along the Dangerous River zone. This feature developed in the early Tertiary, and traps could have formed either during the initial development or during subsequent deposition of strata against and over the zone. Few data are available from onshore to determine actual subsurface structure. Based on prior exploratory drilling, three traps are inferred. Two of these are gentle closures in Icy Bay (inferred from the Standard Oil Co. of California Rioux Bay number 1 well) and on the west side of Yakutat Bay (inferred from the Colorado Oil and Gas Corp. Malaspina 1A well). The third structure lies near the shoreline of the Yakutat Foreland, where seaward-dipping rocks are truncated and may be folded into anticlines, or where a footwall anticline could be present beneath a thrust fault. This area has been partly tested by three wells (Colorado Oil and Gas Corp. Yakutat 1, 2, and 3 wells). Other structures could be present along the continuation of the Dangerous River zone onshore or beneath Yakutat Bay and the Malaspina Glacier.

Exploration status: The play area is moderately explored. Ten wells and coreholes as deep as 13,800 ft have been drilled within the region on structures defined on seismic-reflection data. Further exploration depends on identifying subtle structural or stratigraphic traps, primarily along the Dangerous River zone, and also in the thick sedimentary rocks south and southwest of the Dangerous River zone. Further exploration would be warranted if significant accumulations of oil were found in the adjacent offshore, or if generation and migration of hydrocarbons from the thick offshore Paleogene sequences upward into the onshore sections could be shown or inferred to have occurred.

Coalbed Natural Gas: Most of the coals in the Gulf of Alaska onshore basin have been subjected to metamorphism resulting in intense compressional stresses and severe deformation (Smith 1995). This has driven existing hydrocarbons beyond the oil and gas generation window. Unmetamorphosed areas along the Gulf of Alaska coastline may be suitable for CBNG exploration.

6.0 OIL AND GAS DEVELOPMENT POTENTIAL

The potential for oil and gas development for the entire Ring of Fire planning area is shown in Map 5. This is a baseline scenario and projects development through the year 2020 on the assumption that all areas are open to development under standard lease terms and conditions except those areas closed by statute or for discretionary reasons.

Areas are assigned one of five ratings; high, medium, low, very low, and no known development potential. This projection is based on available data and professional judgment. The timing of the drilling and the areas receiving the greatest attention is difficult to predict. Actual development activity will be determined by accessibility to resources, including the perceived impact of lease stipulations by the petroleum industry; exploration and development costs; the success rate of wells drilled in the future; commodity prices; and production rates that provide an economically viable return on investment.

6.1 COOK INLET BASIN

The Cook Inlet Basin is a maturely developed basin that has produced oil and gas since 1957. The Cook Inlet region continues to be of interest to the petroleum industry. Although oil exploration and production are generally in decline, steady growth in the demand for natural gas within south central Alaska has stepped up exploration drilling for this resource.

The Beluga-Sterling Gas Play is a confirmed play for additional gas accumulations with 18 gas fields containing discovered reserves of 3.14 TCFG. The Beluga-Sterling Gas Play is classified as a heavily explored and developed area (over 1,100 exploratory, development and service wells) with **High** potential for the generation of gas and **High** development potential.

The Hemlock-Tyonek Oil Play is a confirmed play for additional oil accumulations with eight oil fields containing discovered reserves of 76 MMBO. The Hemlock-Tyonek Oil Play is classified as a heavily explored and developed area (over 1,100 exploratory, development and service wells) with **High** potential for the generation of oil and **High** development potential.

The Late Mesozoic Oil Play Play is classified as **High** potential for the generation of oil and **Low** development potential. This assignment is based on the poor reservoir rock quality where penetrated by wells and where it crops out within the basin.

Coalbed Natural Gas: CBNG in the Cook Inlet and Susitna basin is classified as a **High** potential for the generation of methane gas and **Moderate** development potential. CBNG is a major potential resource for south central Alaska with estimated technically recoverable resources of 7 Tcf. The highest potential occurs along the Castle Mountain Fault and along the uplifted basin margins. Montgomery (2003) is encouraged by early drilling results, the shallow coal depths (<5,000 ft), net coal thickness (>150 ft), and moderate gas content. However, the economic viability and timing of any contribution from this resource within the life of the plan is highly uncertain due to the high development costs, land access associated with split estate issues, the lack of sufficient data to predict production flow rates for gas, discouraging CBNG flow-test results to date, and the amount of produced formation water that must be properly disposed.

6.2 ALASKA PENINSULA PROVINCE

The Alaska Peninsula Mesozoic Play is classified as a moderately explored area (22 exploratory wells) with **High** potential for the generation of oil and gas and **Low** development potential. This assignment is based on the following factors: 1) the primary reservoir objective of this play (Upper Triassic limestone) has not been found in the wells that have penetrated this formation; 2) the two remaining potential reservoir rocks (Jurassic and Cretaceous sandstones) are lithic rich and have poor reservoir potential; and 3) the region currently lacks the production infrastructure to deliver exploited resources to market.

The Alaska Peninsula Tertiary Play is classified as a moderately explored area (nine exploratory wells) with **High** potential for the generation of oil and gas and **Low** development potential. This assignment is based on the lack of sufficient subsurface information. This region also lacks the production infrastructure to deliver exploited resources to market.

Coalbed Natural Gas: Tertiary coals within 5,000 ft of the surface in the Tolstoi Formation have **High** CBNG potential and **Low** development potential due to the lack of production infrastructure, high development costs, and land access issues. However, a local market may benefit from CBNG development should this resource be discovered in sufficient quantities near existing communities.

6.3 GULF OF ALASKA ONSHORE BASIN

The Yakutat Foreland/Lituya Play is classified as a moderately explored area (ten exploratory wells and core holes) with high potential for the generation of oil and gas and low development potential. This assignment is based on the following factors: 1) the reservoir potential likely poor to fair at best; 2) no source rocks are known to be present in the Lituya Bay area; 3) the Paleogene rocks to the west are not known to be present in the Lituya Bay area either onshore or in the adjacent offshore; and 4) the region currently lacks the production infrastructure to deliver exploited resources to market.

7.0 RFD BASELINE SCENARIO ASSUMPTIONS AND DISCUSSION

The following projections are based on past and present leasing, exploration, and development activity, as well as professional judgment on geological and related technological and economic factors. It is assumed that there will be no development or production in the Yakutat Forelands or the Alaska Peninsula Province for the life of the plan. This assumption is based on the lack of an oil or gas discovery within theses areas, the fact that no exploratory wells have been drilled during the past 20 years, and that exploration and development dollars in Alaska are likely to be spent on the North Slope and in the Cook Inlet Basin. The results of the State's proposed lease sale along the northern shore of the Alaska Peninsula in late 2005 may change this assumption.

7.1 PROJECTION OF OIL AND GAS LEASING ACTIVITY

Based on ADNR's Five Year Oil and Gas Leasing Program Schedule, DOG will conduct one lease sale a year from 2004 to 2008 within the Cook Inlet Basin area. In addition, DOG will also hold lease sales once a year in the Alaska Peninsula from 2005 to 2008. Should DOG continue this leasing trend, an additional 24 lease sales (one per year from 2009 through 2020, 12 in each area) would occur within both the Cook Inlet Region and the Alaska Peninsula.

It is assumed the remaining lands within the Ring of Fire planning area will not be offered for lease during the life of the plan based on current leasing trends by the state. However, the State has established a licensing program to encourage exploration in areas of Alaska where there is a higher investment risk to the operator. These areas have no existing infrastructure and have relatively low or unknown hydrocarbon potential. Within Ring of Fire planning area, two State exploration licenses have been issued in the Sustina Basin, west of the Parks Highway between Houston and Talkeetna. Exploration licensing gives an interested party the exclusive right to conduct oil and gas exploration. Once the work commitment has been met, e.g., exploration expenditures equal the amount of the winning bid, and if the licensee requests, the State will convert all or a portion of the remaining license area to standard oil and gas leases. The State recognizes the probability of commercial production on licensed lands is very low.

7.2 PROJECTION OF EXPLORATION

Based on the leasing scenario above and exploration activity in the Cook Inlet Basin from 1991 through 2003, it is assumed that at least one exploratory oil well would be drilled per year during the life of the plan. During this 13 year period, 11 oil exploration wells, or 0.85 wells per year, were drilled in the Cook Inlet Basin. Given the life of the plan (15 years), roughly 15 oil exploration wells would likely be drilled in Ring of Fire planning area throughout this timeframe.

Between 1973 and 2003, 18 gas exploration wells have been drilled in Ring of Fire planning area, averaging one gas exploration well drilled per year. However, 17 of these wells were drilled in the last 10 years, indicating a substantial increase in gas exploration in recent years. Should this rate of exploration continue, it is assumed that in the next 15 years, 26 gas exploration wells would be drilled throughout the Cook Inlet Basin.

Of the 114 exploration wells drilled in the basin through 2003, 87 were dry holes reflecting a 24 percent hydrocarbon discovery success rate. This rate increases to 55 percent for the last 10 years and is expected to remain relatively high due to continued improvements in geologic analysis, drilling and completion technology, and the use of advanced exploration technology such as three-dimensional (3-D) seismic surveys. Nondrilling exploration technologies, such as seismic surveys, increase the drilling success rate by identifying favorable areas for producing wells and excluding areas from consideration that have lower development potential. The use of these technologies decreases the number of unsuccessful wells drilled and may result in a net decrease in total wells drilled in an area, along with decreases in surface disturbances and other impacts associated with drilling. Should this success rate remain constant, it is assumed that in the next 15 years, 18 exploration wells would be dry holes, thus further reducing long-term disturbance as these pads and associated roads would be reclaimed.

Based on technology advances in recent years, such as improved drilling efficiencies through the use of 3-D seismic surveys, it is assumed five economic discoveries would be made and each would spur the development of a field (one oil field and four gas fields). To define the limits of the reservoir(s) after a discovery, three delineation wells would be drilled at each field.

7.3 PROJECTION OF DEVELOPMENT

From 1973 to 2003, 53 oil development wells have been drilled in the Cook Inlet Basin. Eleven of these wells, roughly one per year, were drilled in the last 10 years. Assuming this one-well-per-year trend continues, another 15 oil production wells would be drilled in the next 15 years.

In the same 30-year timeframe, 78 gas development wells, or roughly three wells per year, were drilled in the Cook Inlet Basin. Forty-one of these wells, roughly four per year, were drilled in the last 10 years. Assuming this four-wells-per-year trend continues, another 60 gas production wells would be drilled in the next 15 years.

Four of the 131 development wells drilled between 1973 and 2003 were dry holes. Of the 75 oil and gas development wells projected to be drilled during the life of the plan, two to three are assumed to be dry holes.

7.4 PROJECTION OF PRODUCTION

Appendix A displays oil, gas, and water production graphs within the Cook Inlet Basin. The graphs illustrate production rates from 1959 through 2004. They have been separated to display volumes of oil, gas, and water produced by reservoir, lessor (federal or state), and operator. Production rates have been calculated in mcf per day for natural gas, and bpd for oil and water by year (Porhola 2004). Using these past production curves, one could project a 15 percent declining production average per year. In doing so, gas production rates from the Tyonek Formation, for example, would fall from three mcf per day in 2004 to roughly 0.22 mcf per day by 2020. In general, oil and gas production will likely decline steadily through 2020. Figure 3 shows past and projected oil production curves for Alaska, including the Cook Inlet basin, through the year 2022 (ADNR/DOG 2004). Oil production in the Cook Inlet Region is projected to steadily decline through 2022.

Table 2 shows that production in Beaver Creek, Beluga River, Happy Valley, Kenai, McArthur River, Ninilchik, and North Cook Inlet will produce significant quantities of gas through the year 2020, while the Swanson River field will eventually cease production around 2017 (ADNR/DOG 2003)

Figure 4 illustrates gas price comparisons for past and future development in the Cook Inlet basin (Thomas et al. 2004). This figure illustrates Henry Hub gas prices falling to and maintaining a $4.50 per mcf price point through the year 2024, with Gulf Coast well head Average Estimated Output (AEO) rising to around $5.00 per mcf in 2014 and falling to around $4.00 per mcf in 2024.

Exploration wells are currently being drilled in the Beaver Creek and Swanson River Units. With oil and gas prices continuing to rise, future development will more than likely occur in those areas, as well as other areas throughout the Cook Inlet Basin. Aurora Gas believes there could still be up to one billion barrels of undiscovered recoverable oil reserves in the onshore of Cook Inlet (Petroleum News 2004). Aurora Gas is actively drilling in the Nicolai Creek unit on the west side of Cook Inlet. They have mapped five drillable prospects with unrisked expected recoverable reserves of 400 MMBO, and risked reserves of 140 MMBO.

Four of Aurora Gas oil prospects are located within 6 miles of existing oil pipelines, and two of these prospects have been defined by previously gathered 3-D seismic data. All prospects have good road access, which is spurring on Aurora Gas aggressive drilling campaign through the next two to three years. An estimated five to seven billion barrels of oil have been generated from the Middle Jurassic Tuxedni Group marine shales. In-place Cook Inlet oil reserves have been estimated to be at around 3.37 BBO. To date, nearly 1.35 BBO have been recovered from the Cook Inlet Basin.

Oil found to date largely follows three distinct south-southwest to north-northeast structural trends, namely the Trading Bay trend, the Middle Ground Shoal/Granite Point trend and the Swanson River trend. Aurora believes that by following logical extensions of these trends that they will discover and exploit new oil reserves. By expanding exploration patterns throughout the McArthur River and Swanson River fields, onshore oil discoveries could approach or equal past production rates.

7.5 PROJECTION OF RECLAMATION

Reclamation is an ongoing process throughout Ring of Fire planning area. Since 1901, 352 wells have been plugged and abandoned throughout Ring of Fire planning area (Flekenstein 2004). Should abandonment continue at this rate, roughly 161 wells would be plugged and abandoned throughout Ring of Fire planning area through 2020.

7.6 PROJECTION OF COALBED NATURAL GAS DEVELOPMENT

CBNG development in the Cook Inlet Basin would likely occur in areas that are currently the focus of CBNG exploration such as the Matanuska-Susitna Valley and the southern Kenai Peninsula near Homer. Although these locations are part of the mature Cook Inlet oil and gas basin, we consider this a frontier area regarding CBNG exploration due to limited exploration efforts to date in the Matanuska-Susitna Valley. These efforts, which began in the late 1990s, have included core sampling and the drilling of several pilot wells in bituminous coal seams of Tertiary age. The economic viability of the basin’s CBNG resources is highly uncertain because sufficient data on gas and water productivity does not exist.

BLM’s policy regarding RFD of fluid mineral resources in “frontier” areas requires that a minimum level of exploration and development activity be projected for the purpose of impact analysis. For these areas of low development potential, an assumption is made that a baseline discovery will involve certain exploration activity leading up to a discovery and subsequent development activity. According to BLM Handbook H-1624-1, which provides guidance on RFD development, "... projections should be based on past and present leasing, exploration, and development activity as well as professional judgment on geological and technological and economic factors. Extrapolations of historical drilling and/or production activity may be used as the basis for projections."

The potential coalbed natural gas in the Cook Inlet basin is estimated to be about 7 Tcf of technically recoverable resources, assuming 10 percent is accessible for production and a 50 percent recovery rate (Thomas et al. 2004). Unocal estimated the gas in place (GIP) of the Pioneer Unit, located in the Matanuska Valley, at 3.6 Tcf with recoverable reserves at 1.4 Tcf assuming a 40 percent recovery factor (Seamount et al. 2001). When a CBNG project is deemed economical to warrant full-scale production, many wells are often proposed. The number of wells is dependent upon several variables including: 1) number, thickness and depth of coal seams; 2) net coal thickness; 3) access; 4) amount of gas that could be recovered; 5) permeability and porosity; 6) produced water management; 7) the number of CBNG wells that can be served by a disposal well; and 8) disposal well depth.

Under this RFD scenario for CBNG production through 2020, recoverable reserves are assumed to be 1.4 Tcf and accessible from multiple coal seams. The Raton Basin, with estimated reserves of 1.88 Tcf, serves as the model for the predicted number of wells to be drilled in this RFD scenario. Table 3 shows the estimated resources and number of wells drilled for each of the Rocky Mountain CBNG basins.

Table 3. Rocky Mountain CBNG Basins

Basin	States	Producing Wells (1999)	Cumulative Production Thru 1999 (Bcf)	Estimated Resource (Tcf)	Average Per Well Production (mcfd)
San Juan	CO, NM	3,311	6,648	7.69	2,000
Powder River	WY, MT	1,657	120	10.04	200
Raton	CO, NM	405	68	1.88	250
Uinta	UT	370	121	3.81	625
Piceance	CO	40	35	11.55	140

(Lang 2002)

The field size would be similar in extent to the established Pioneer Unit, approximately 50,000 acres. To maximize recovery and minimize waste, a 100 acre well spacing pattern would be employed and 500 exploration wells (250 pads with two wells per pad) would ultimately be drilled. Ten percent of these wells would be abandoned as dry holes.

CBNG development generally involves a larger amount of surface disturbance than conventional oil and gas development due to the dispersed nature of CBNG well development (Table 4). CBNG wells require a network of access roads, drilling sites, pipelines, power lines, compressor stations, and containment ponds. Roads and utility corridors would be positioned to use existing disturbances as much as possible. Existing roads would be used as often as possible, and the gas field would be designed so that as many wells as possible can be serviced from each road. Roads to wells and compressor sites would be limited to single lane width with turnouts. Exploration wells would not have permanent gravel access roads. The operator would co-locate electric power, gas, and water lines with proposed roads when feasible to minimize overall disturbance. Power lines would be aboveground or buried per operator's plans.

Wells would be drilled with truck mounted water well type rigs capable of setting up on uneven terrain. Air is used to drill and remove the cuttings, instead of fluid, to reduce the volume of wastes to be buried on the well pad or hauled off site. A 100 square foot area would be bladed to accommodate the rig and a small reserve pit (6 ft by 15 ft by 15 ft). Wells drilled into different coal seams can be collocated on common well pads and it is assumed that a pad would contain two wells and produce from two different coal seams. Multiple seam completions in a single well bore would be encouraged to the extent technology permits. CBNG production could occur simultaneously from multiple seams or staggered over time from separate seams. During the early development phase, wells would be about 600 ft deep. Over time well depths would increase to more than 1,000 ft deep with a maximum depth of about 4,000 ft. Each pad would require about 1.75 acres; one acre for the pad (190 ft by 240 ft) and 0.75 acres for the access road. Part of the well pad area would be reclaimed for production operations and the entire area would be reclaimed when the well is plugged and abandoned. The long-term surface disturbance (10 to 20 years) at each productive well location where cut and fill construction techniques are used would encompass approximately 0.005 acres.

As wells are abandoned, the associated roads would remain open or be closed at the surface owner's discretion. If the roads were requested to be closed they would be rehabilitated. This includes leaving BLM and State surface roads open if access is desirable.

Wells would be completed using 7-inch steel well casing set and cemented to the surface from the top of the target coal bed. Small diameter tubing and an electric submersible pump would be installed in the well to bring the water to the surface. Once all wells have been drilled, produced water would be gathered and transported to injection wells for disposal. Wells determined to be productive would be shut-in until pipelines and other production facilities are constructed. If the well is determined not to be productive, it will be properly abandoned.

The average well discharge rate for a typical CBNG well is about 400 to 500 bbls of water per day. It is assumed the amount of water produced would not be the same for every well, and that water production would drop off rapidly over time, as the pressure within the coal seam falls and gas begins to flow freely. The early phases of high water production and low gas recovery would last for a period of six months to three years (Ogbe 2000). The produced water would be collected in a buried two-inch polyethylene flowline (pipeline) for transport to one of 23 water disposal facility locations (200 ft by 200 ft each). Pipeline trenches for well gathering lines are expected to disturb portions of 20- to 30-foot wide corridors temporarily and to be reclaimed as soon as practical after construction is completed. Trenches would be constructed along the access roads where possible. Separate gathering lines would be buried in the trenches and would transport methane gas to production pod facilities and produced water to disposal facility.

The water disposal facility would consist of four 400 bbl water tanks, a pump house, piping, and a well house. Those areas where elevation differences require supplemental pumping to transfer the produced water, transfer pumping stations (120 ft by 120 ft pads), consisting of a 400 bbl water tank with associated pump and piping, may also be needed. Water in the tanks would be separated from the gas and piped to a series of injections wells (water disposal wells) to subsurface aquifers geologically isolated from potential underground sources of drinking water. Disposal rates would be dependant on formation characteristics of the injection zones and in this scenario it is assumed that one injection well would service up to 20 CBNG wells (roughly 23 injection wells for the entire field).

Unlike conventional natural gas, CBNG has not generally required special treatment before sale –the gas is merely put through a dehydrator to remove remaining water and then injected into a pipeline. However, impurities would be removed before the gas is sent to a gathering system. Treatment depends on the nature of the produced gas, which is yet to be determined in the Valley.

Produced natural gas (methane) under wellhead pressure would move through the low pressure gas gathering system to a field compressor station (0.5 acres). On average, it takes one small compressor for every 10 to 20 wells to gather the gas prior to being piped to a larger pipeline. Under this RFD scenario the gas gathering system would consist of 45 pod stations, each serving ten CBNG wells, designed to raise the pressure from about 30 pounds per square inch (psi) to 150 psi. A one mile gathering line (approximately 25 ft wide), consisting of two polyethylene flowlines (one per well) would be buried from each pad to the field compressor. These lines would be laid in the travel routes to the wells and would follow the roads to the field compressors. The gas from each well is metered in the pod station and commingled prior to being piped to a larger (sales) compressor. Low-pressure steel lines would be laid from the field compressors to the dales compressor. One sales compressor (five acres) would service 15 pod stations to raise the pressure from 150 psi wellhead pressure to the ENSTAR pipeline pressure of about 800 psi.

Wellheads and metering equipment would be housed in 5-foot high fiberglass well covers painted an unobtrusive color and fenced to protect the facility from damage by wildlife. Electronic flow devices will measure natural gas production, and water will be measured through ultrasonic flow meters. A panel installed at the well starts and stops the pump based on fluid level measurement.

Table 4. Projected acreage disturbance due to CBNG exploration and development.

Facility	Development Phase			Operations
	Length	Width	Acres	Acres
New Roads	210 miles (mi)	15 ft.	382	322
Small Compressor Station (45)	110 ft	105 ft.	12	12
Gas and Water Lines	210 mi	25 ft.	636	636
Drill Pads (250; includes 12 injection wells)	190 ft	240 ft.	262	236
Large Compressor Station (3)	470 ft	470 ft.	15	15
Gas Lines (to sales line)	50 mi	25 ft.	151	130
Water Disposal Facility (23)	200 ft	200 ft.	21	21
Transfer Pumping Station (5)	120 ft	120 ft.	1.6	1.6
Total Disturbance			**1,480.6**	**1,373.6**

7.7 TYPICAL EXPLORATION, DEVELOPEMNT, PRODUCTION AND ABANDONMENT

To fully evaluate the surface disturbance impacts associated with projected oil and natural gas exploration and development in Ring of Fire planning area, the activities typical of these actions as they apply to south central Alaska are discussed below. Table 5 shows typical Alaska oil and gas activities and timeframes.

7.7.1 Geophysical Exploration

The likelihood of the presence of oil and gas is often determined by geological prospecting. Such prospecting can be done on the ground, where on and off-road vehicle travel may be necessary or by aerial survey. Exploration activities may include examination of the surface geology, geophysical survey programs, researching data from existing wells, and/or drilling an exploratory well. Surface analysis includes the study of surface topography or the natural surface features of the area, near-surface structures revealed by examining and mapping exposed bedrock, and geographic features such as hills, mountains, and valleys. Subsurface geology is not always accurately indicated by surface outcroppings. To verify surface indicators and to map the subsurface structures, geophysical exploration is used. An issued oil and gas lease is not required for geophysical exploration to occur; however, it may be permitted prior to or subsequent to leasing by bonded geophysical operators. Exploration activities may occur across the same area many times and continue over a period of years.

Geophysical companies usually conduct seismic surveys under contract with license holders. Contracts may have provisions that allow the geophysical company to sell the data to other interested companies. If sufficient data are already available, additional seismic data acquisition may not be necessary.

Geophysical exploration activities on federal lands in Alaska are regulated by 43 Code of Federal Regulations (CFR) 3151.2. BLM issues permits that include terms and conditions deemed necessary to protect values, mineral resources, and nonmineral resources including specific mitigating measures for public safety warnings, wildlife concerns, property protection (fences, wells, buried utility lines, etc.), and site reclamation. Restrictions in geophysical exploration permits depend on the duration, location, and intensity of the project.

Geophysical surveys help reveal what the subsurface geology may look like. There are three types of geophysical exploration: 1) gravitational field; 2) magnetic field; and 3) seismic characteristics. Gravitational prospecting detects variations in gravitational attraction caused by the differences in the density of various types of rock. Magnetic field methods reveal buried structures (likely to yield oil and gas) because such structures show a strong magnetic response. Magnetic prospecting often replaces or is used to supplement gravitational work. Both surveys consist of taking readings at regular intervals across the land from either hand held instruments, ground vehicles, or aircraft. No actual surface disturbance is involved unless off-road vehicle travel is used to reach survey points. These methods are used to get subsurface information over a large area.

Table 5. Typical Oil and Gas Activities and Timeframe

Project Phase	Duration (years)	Activities
Exploration	1 to 3	• geophysical permitting • environmental studies • seismic surveys to define prospects • well-site surveys and permitting • construct access roads/trails • temporary gravel pads • exploratory drilling • drill delineation wells (after discovery) • land clearing • work camp • water usage • increased air traffic • appraise and engineer reservoirs • drilling muds and discharges
Development	3 to 6	• permitting • identify gravel pits • construct gravel pads, and roads • dock and bridge construction • install drilling rigs • install pipelines • construct base camp • environmental monitoring • drill development wells • vehicle traffic to and from pads • drill re-injection wells • install production facilities and hookup
Production	10 to 30	• well workover (rigs) • pipeline maintenance • gravel pads and roads • produced water • air emissions • work camps • trucking
Abandonment	2 to 5 years per well	• plug and abandon wells • remove production equipment • dismantle facilities • decommission pipeline • restore and revegetate sites • phase out environmental monitoring

Seismic prospecting gives the most reliable and reproducible results. Companies will either gather two-dimensional (2-D) or 3-D seismic data.

Two-dimensional seismic programs usually require fewer personnel and use less equipment than 3-D programs. Generally, geophysical seismic lines are run on wide spacing intervals and are narrowed and concentrated in smaller geographic areas as the target area is better defined. Three-dimensional surveys tend to be used to delineate prospective areas rather than as exploratory tools in frontier areas. With a strong move towards 3-D surveys, 2-D has almost become a thing of the past. However, this is not the case in Alaska. Large areas that have been relatively unexplored can be mapped by acquiring large regional grids of 2-D seismic data that provide exploration teams with the information necessary to evaluate the regional geology and the potential hydrocarbon traps (Rice 1997).

Land-based seismic surveys are typically conducted during the winter months using truck-mounted vibrators or helicopters for remote operations. The method involves sending energy into the earth using an explosive charge or other energy wave-generating device, such as Vibroseis. Vibroseis generates energy waves of continuously varying frequency using metal plates lowered to the ground from beneath each vehicle. With the entire weight of the truck resting on the plate, a hydraulic system vibrates the plate, which transfers the energy into the ground. Depending on rock density, waves bounce back from the various formation layers and are received by listening devices called geophones arrayed along the line of survey. From two to eight trucks are used in tandem. Unless the topography is relatively flat and open, the trucks are restricted to existing roads and trails. An instrument truck equipped with a seismograph records the seismic information on a computer which is subsequently processed and displayed in the form of a seismic reflection profile. The Vibroseis technique works best on a hard surface, as a spongy surface does not transmit the output energy very well.

Explosives, although rarely used, are another way to impart energy into the ground for the seismograph to record. The explosives are lowered into drill holes and detonated, or they may be suspended on stakes above the ground to eliminate the need for drilling holes. The drill holes are drilled with either track-mounted drills or with drills slung into position by helicopters. For 3-D seismic operations, 4-inch diameter holes are drilled typically 25 ft deep with five pounds of explosive set at the base of the hole. Surface charge seismic involves placing explosive charges on the ground or above ground attached to wooden stakes some 3 ft high. In difficult terrain, both explosive methods may be used via helicopter to ferry people, materials, and instruments to the detonation points along the lines of survey. This eliminates surface impacts

7.7.2 Exploratory Drilling

If geologic studies indicate oil or gas may be present, lessees (an entity that owns the lease) may initiate drilling of an exploration well. Drilling is the only way to assess whether commercial quantities of oil or gas are present in subsurface rock formations. Drilling wells is expensive and exploratory drilling happens only after mineral rights have been secured, and after preliminary, less expensive exploration activities, such as seismic surveys, reveal the most likely places to find oil or gas. Exploratory drilling operations normally occur in winter to minimize impact. Sometimes temporary roads must be built to the area. Constructed access roads normally have a running surface (width) of approximately 12 ft and a right-of-way of 30 ft. These are low volume, single-lane roads built for a specific purpose or use and returned to a near natural condition upon completion of use. The length is dependent upon the well site location in relation to existing roads or highways.

The drill site is selected to provide access to the prospect to be drilled and, if possible, is located to minimize the surface area that may have to be cleared. A typical drill pad has dimensions of about 300 ft by 300 ft (two acres) and consists of a liner overlain by sand and gravel. Depending on the topography of the well site and access area, construction may require the creation of cut slopes and fill areas. The pad supports the drill rig, which is brought in and assembled at the site, a fuel storage area, and a camp for workers. If possible, an operator will use nearby existing facilities for housing and feeding its crew. If the facilities are not available, a temporary camp of trailers may be placed on the pad. Enough fuel is stored on-site to satisfy the operation's short-term need, which amounts to about 4,500 gallons of diesel and gasoline per day. The storage area is a diked gravel pad lined with 80-miles of synthetic membrane. Additional amounts of fuel may be stored at the nearest existing facility for transport to the drilling area as needed.

Byproducts of drilling activities include muds and cuttings, produced water, and associated wastes. Drilling employs the use of carefully mixed fluids, called muds. Cuttings are small fragments of rock up to an inch across that are dislodged and carried to the surface by drill muds. Drilling muds are maintained at a specific weight and viscosity and are mostly water-based mixtures of clay (bentonite) and other earthen materials designed to be environmentally benign. The muds are used to cool and lubricate the drilling bit, facilitate the drilling action, clean the bottom of the hole, flush out cuttings within the well bore, seal off porous zones in down-hole formations to prevent the flow of drilling fluids into these formations, and maintain reservoir pressure. Drilling mud is circulated through the drill pipe to the bottom of the hole, through the bit, up the bore of the well, and finally to the surface. When the mud emerges from the hole, it goes through a series of equipment used to screen and remove rock chips and sand-size solids. When the solids have been removed, the mud is placed into holding tanks and from the tanks it is pumped back into the well.

Chemicals may be added to maximize the effectiveness of drilling and casing. Oil-based muds and synthetic-based muds may also be used depending on the well depth, well diameter, and subsurface formations.

An exploratory drilling operation using water-based muds generates 7,000 to 13,000 bbls of waste per well, and depending on the depth and diameter of the well, 1,400 to 2,800 of those are cuttings (United States Environmental Protection Agency [USEPA] 1993). Oil-based mud volumes are generally less than water-based, because they are more efficient and oil-based muds may be reconditioned, reused, and re-sold. Newer synthetic-based muds produce less waste, improve drilling efficiency, are reusable, and have advantages in environmental protection over oil or water-based muds (Veil et al. 1999).

BLM and the State discourage the use of reserve pits and most operators now store drilling solids and fluids in tanks, or in temporary on-pad storage areas until they can be hauled out or injected down the annulus of the well in accordance with State of Alaska statute. A permit is required by the State for onsite disposal or storage of drill cuttings. Injection of ground up drill cuttings requires approval from Alaska Oil and Gas Conservation Commission (AOGCC). If a reserve pit is necessary, it is constructed off the drill pad in cut material or below ground level to prevent failure. The pit can be as large as 5 ft deep and 40 ft by 60 ft and is lined with an 80-mile liner to prevent contamination of surrounding soils.

Drilling mud and fluids produced from the well are separated and disposed of, often by reinjection at another facility. With appropriate permits, solids may be left in place in a capped reserved pit. If necessary, a flare pit may be constructed off of the drill pad to allow for the safe venting of natural gas that may be encountered in the well. If the exploratory well discovers oil or gas, it is likely that the gravel pad used for the exploratory well will also be used for development and production operations.

Exploratory drilling is conducted 24 hours a day because of rig-time costs. There are three 8-hour or two 12-hour shifts a day. Pickups or cars are used for workers' transportation to and from the well site.

The actual time to drill a well depends on several factors including the depth of the hole, the number and degree of mechanical problems, and whether it is a dry hole or a producer. One of the primary objectives of drilling an exploration well is the acquisition of downhole information. Formation evaluation covers a variety of data gathering and retrieving methods that include mud logging, wireline logging, formation testing, coring, and measurement while drilling (MWD) surveys. In wildcat wells (wells drilled outside of areas of established production or into deeper untested zones in established fields), it is important that quality data be obtained in order to justify the costly decision to run (or not run) production casing and complete the well.

Mud logging, conducted while the well is being drilled, evaluates the mud circulating back to the surface for the presence of hydrocarbons. Drilling will liberate even small amounts of hydrocarbons from sedimentary rock. The mud log is also used to record and describe the rocks that are encountered in the well.

Wireline logs provide indirect measurements of rock properties and are created by lowering instruments (the logging tool) into the well. They also are used to precisely determine the elevation and thickness of individual rock units or identify potential producing zones.

Formation testing (drill stem test [DST]) involves temporary completion of a well and measures the flow of hydrocarbons to determine whether or not commercial quantities exist in the formation being evaluated.

Coring obtains a whole sample of the subsurface rock by placing a special bit and core barrel at the end of the drill string and drilling a cylindrical sample of the rock. Core barrels are commonly 30 to 60 ft in length and are sent to a laboratory where it can be analyzed for certain properties such as porosity (space in the rock that is filled by fluids), permeability (the ability of the rock to transmit fluids), and the ratio of fluids present in the pores of the rock (oil, gas, and water).

The drilling process is as follows:

- Steel conductor casing, is set 60 ft into the ground.
- The bit rotates on the drill pipe to drill a hole through the subsurface rock formations.
- Blowout preventers are installed on the surface casing and only removed when the well is plugged and abandoned. Blowout preventers are large, high-strength valves that close hydraulically on the drill pipe to prevent the escape of fluids to the surface or into groundwater formations.
- Progressively smaller sizes of steel pipe, called casing, are placed into the hole and cemented in place to keep the hole from caving in, to seal off rock formations, and to provide a conduit from the bottom of the hole to the drilling rig.
- The well produces hydrocarbons, is shut-in, or is plugged and abandoned.

Upon completion of the drilling, the equipment is removed to another location. If hydrocarbons are not discovered in commercial quantities, the well is called a “dry hole.” The operator is then required to follow State and BLM policy procedures for plugging a dry hole. The drill site and access roads are rehabilitated in accordance with the stipulations attached to the approval of the well. If the exploratory well is successful, the operator will probably drill one or two more wells to delineate the extent of the discovery and gather more information about the field. The lessee needs to know how much oil and gas may be present, the quality, and the quality of the rocks in which they are found.

7.7.3 Development and Production

After the discovery of a successful well, additional exploratory wells may be needed for industry to make a decision on whether to develop the field. These additional wells can also provide meaningful information for land managers to help analyze potential impacts of field development and to make decisions based on more accurate information. Industry's decision to develop the field is essentially an economic one and may depend on the type of hydrocarbon present (i.e., oil or gas), the size and productivity of the geologic structure and formation, the distance from infrastructure, the price of oil or gas, and marketability. In some cases, a discovery may not be fully developed although production may take place to recoup some of the costs of exploration.

Once the presence of a reservoir is confirmed, the lessee may decide to pursue development of the reservoir (field) to fully extract the resource. The procedures for drilling development wells are about the same as for exploratory drilling except that there is less subsurface sampling, testing and evaluation. Field development locations are surveyed and a well spacing pattern established by the State with the concurrence of BLM on federal leases. The spacing between wells depends on the State's regulations and the type of hydrocarbon sought. Gas wells are usually spaced one per 640 acres and oil wells often 160 acres or 320 acres. In developed petroleum fields, there are about 2 miles of roads per 160 acres.

Many fields go through several development stages. A field may be considered fully developed and produce for several years and then new producing zones may be found. If commercial hydrocarbons are discovered in a new producing zone (reservoir) in an existing field, it is called a new pool discovery, as distinguished from a new field discovery. New pools can either be deeper or shallower than the existing producing zone and may lead to the drilling of additional wells. When sufficient development wells are completed, the production phase begins. Production allows the lessee to receive a return on investment through extraction, collection, and transportation of the resource to the marketplace. Depending upon reservoir characteristics, which affect the flow of oil and gas to the wellhead, additional development wells are drilled to extract the oil and gas.

After planning and designing the facility layout, the operator constructs gravel pads and drills production wells. To the extent permitted by the geologic target, the locations selected for well sites, tank batteries, pits, and pumping stations are planned so as to minimize long-term disruption of the surface resources. Design and construction techniques and other practices are employed to minimize surface disturbance and effects on other resources, and maintain the reclamation potential of the site. Site-specific geotechnical studies are conducted prior to any development activities to assess the local permafrost conditions. Structures, such as drill rigs and permanent facility buildings, are insulated to prevent heat loss into the ground.

A level drill pad, generally two to four acres in size, is needed to set up and operate the rig. Usually, the dimensions of a pad measure 350 ft by 450 ft, but this may be modified based on the number of wells to be drilled, the natural contours of the land and the other resource values involved. All of the pad must be placed on a "cut" rather than "fill" surface for reasons of safety and rig stability. Once the rig is set up, drilling takes place 24-hours per day, seven days a week. For all surface-disturbing activities, the topsoil is removed and stockpiled for redistribution over the disturbed area prior to reseeding of the site. Restoration of the area normally includes reseeding the area with native species, recontouring and drainage control.

Approximately 30 personnel are needed in drilling a typical well. Drilling may take from two weeks to six months to complete depending on the depth to be drilled. If no economic quantities of gas or oil are found it is considered a dry hole and the facilities are removed and the well pad is reclaimed along with the access road, unless it is needed for other purposes.

Firewalls/containment dikes are to be constructed and maintained around all storage facilities/ batteries. The containment structure must have sufficient volume to contain, at a minimum, the entire content of the largest tank within the facility/battery.

During drilling and after a well is in production, water comes to the surface mixed with oil and gas, and must be separated before further refining. Produced water contains mostly natural substances such as clay and sand, which is mixed with oil, water, and gas found in the subterranean strata. Produced waters are usually saline with some level of hydrocarbons. Associated wastes are other production fluids, such as tank bottom sludges, well work-overs, gas dehydration processes, tank wastewater, and other residues which are considered non-hazardous (low-toxicity) by the USEPA. Like drilling muds, chemicals may be added to produced water to remove harmful bacteria, halt corrosion, break up solids, prevent scale build up, and break oil/water emulsions.

Approximately 10,000 to 35,000 gallons of water a day may be needed for mixing drilling mud, cleaning equipment, and cooling engines. Water sources may be from wells, lakes, or streams. Drilling depths may range between 2,000 ft and 15,000 ft. Transporting and setting up a drill rig capable of reaching the deepest zones requires an access road sufficient to handle the 30 to 40 semi-trucks and trailers of heavy equipment and a daily traffic of 20 to 30 vehicles. These are low volume, single-lane roads, which may be reclaimed after a particular use terminates. These roads normally have a 12 to 14 foot travelway and connect terminal facilities, such as a well site, to collector, local, arterial, or other higher class roads.

Once production is established, pipelines and/or flow lines are constructed in conjunction with the construction of access roads whenever possible to minimize additional disturbance. Pipeline rights-of-way are generally less than 25 ft in width and follow existing rights-of-way where possible. Pipelines are trenched, backfilled, insulated (if buried), or elevated to permit movement of wildlife and to prevent undesirable thawing of permafrost. Pipelines are an economically feasible way to transport oil and gas onshore. Oil transportation by truck is sometimes used, but in many cases, is not economically feasible because of the low quantities of oil that can be transported and high labor costs. Production from multiple wells on one lease may be carried by flowlines to a central processing facility. Central processing and storage facilities can be used for multiple wells on the same contiguous lease or multiple wells in an established unit.

Production and processing equipment at a typical gas well location might consist of a wellhead, a production separator, a dehydrator, and tanks. The wellhead (or christmas tree) has valves used to control the flow of gas and liquids from the well. The gas must be separated from liquids in the production stream (water, gas condensates, or light crude oil) and is diverted to processing equipment on the location. During processing, a production separator removes most of the water and liquid hydrocarbons and a dehydrator removes any remaining water in the gas. The gas then goes through a metering facility and into a sales or gathering pipeline. All hydrocarbon liquids are placed into small tanks, <400 barrel; (one bbl equals 42 gallons) and subsequently trucked from the well site and sold or placed into a pipeline.

In order to move the gas through the pipelines gathering system, compression equipment is used. Field compression units are small and mobile and are sized for the amount of gas that needs to be moved. Gas from the field gathering lines may undergo further processing to remove hydrocarbon condensates and water to ensure the gas meets stringent transportation pipeline specifications. It is then fed into larger transportation lines, often at compressor stations along the route.

Natural gas, in many instances, needs more than simple well site processing due to impurities (e.g., hydrogen sulfide) or large amounts of non-flammable gases such as carbon dioxide. This separation process, which involves large volumes of gas from multiple wells, is conducted at facilities called gas plants. Sometimes the gas contains valuable heavier hydrocarbon compounds such as natural gas liquids (NGLs) that must also be processed out of the methane.

Production operations for natural gas generally include the following:

- Natural gas flows through a high-pressure separator system where liquids (water, condensate, etc.) are removed. Produced oil goes through a separator to remove the natural gas.
- The gas is compressed if necessary.
- The gas is dehydrated to remove any remaining water.
- The gas is metered (e.g., the amount of gas produced is measured).
- The gas is transported to a facility where it passes through a water precipitator to remove oil.

Typical oil well locations consist of a wellhead, pumping equipment, phase separation equipment, storage tanks, and a central processing facility (for multiple wells on the same lease or unit). Oil wells can be completed as flowing wells or pumping wells. Flowing wells have sufficient formation pressure to raise the oil to the surface. Insufficient formation pressure requires the oil to be pumped to the surface via: 1) pump jacks powered by internal combustion engines or electric motors, 2) submersible pumps, when large volumes of fluid have to be produced such as wells containing large amounts of water with the oil, 3) artificial lift or gas lift, where natural gas is pumped into a well to lift the fluids to the surface, or 4) hydraulic pumps where crude oil is pumped down one tubing string, activating a hydraulic piston and well fluids before returning to the surface in a second string or the casing annulus.

When the fluids reach the surface, the oil must be separated from the water and gas though the use of appropriate separation equipment. Large amounts of water are gravity-separated from the oil and routed into tanks for disposal. The remaining fluid is fed into heater-treaters, which separate the gas from the oil and also break apart water-in-oil emulsions that may occur during the production process. The casinghead gas, depending on the quantities produced, can be used on the lease, recovered and placed into pipelines for sale, or vented. After the separation process, oil and water are stored in tanks either at the location or at central processing facilities. The tanks can generally hold 400 to 500 bbls and any given tank battery will have varying numbers of tanks depending upon the productive capacity of the well. Tanks and separation vessels are placed within earthen berms or other containment structures in order to contain spilled fluids in case of an upset condition or rupture of a tank or vessel. Production equipment are required to be painted in colors that will blend into the surrounding environment. Popular colors are brown and green. Some or all of the facility must be fenced.

Production operations for oil generally consist of the following:

- Produced crude oil goes through a separator to remove gas from the oil stream.
- The oil moves to processing facility via a pipeline.
- The gas removed from the oil may be compressed and reinjected to maintain the pressure in the producing formation and assist in oil production.

As more wells are placed in production, roads are improved by regular maintenance, surfacing with gravel and installing culverts. Mineral materials (e.g., sand and gravel) are usually purchased from local contractors and obtained from federal sources. Materials that are obtained from areas of federally owned minerals require a sales contract and are processed through the field office where the materials occur. A new stage of field development can lead to changes in locations of roads and facilities. All new construction, reconstruction, or alterations of existing facilities-including roads, pits, flowlines, pipelines, tank batteries, or other production facilities must be approved by BLM.

If sufficient natural gas reserves are discovered and it is economically feasible, the gas could be made available to local communities through new pipelines. Gas may also be re-injected, as is done on the North Slope.

Pipeline depth must be at least 48 inches. When possible, a common point of collection shall be established to minimize the number of production sites.

The development "footprint" in terms of habitat loss or gravel filling has decreased in size in recent years as advances in drilling technology have led to smaller, more consolidated pad sizes. Longer horizontal departures reduce per acre impacts compared to older field developments. Depending on the depth of the reservoir rock and horizontal deviation ability, the area of surface disturbance per acre of habitat can be minimized. A single production pad and several directionally drilled wells can develop more than one, and possibly several, 640-acre sections. Based on current development practices, surface impact from developing tracts is unlikely to exceed 2 percent per 640-acre section for any given development on leased and developed acreage.

7.7.4 Plugging and Abandonment of Wells

If the well is a dry hole, the site is recontoured and the topsoil is spread over the disturbed area followed by seeding with native plants and grasses. If the well is a producer, that portion of the original pad needed to continue operations will remain unreclaimed for the life of the well (10 to 20 years).

The purpose of plugging and abandoning (P&A) a well is to prevent fluid migration between zones, to protect minerals from damage, and to restore the surface area. Each well has to be handled individually due to a combination of factors, including geology, well design limitations, and specific rehabilitation concerns. Therefore, only minimum requirements can be established initially, then modified for the individual well.

The first step in the P&A process is the filing of the Notice of Intent to Abandon (NIA). Both the Surface Management Agency (SMA) and BLM will review this. The NIA must be filed and approved prior to plugging a past producing well. Verbal plugging instructions can be given for plugging current drilling operations, but an NIA must be filed after the work is completed. If usable fresh water was encountered while the well was being drilled, SMA will be allowed, if interested, to assume future responsibility for the well and the operator will be reimbursed for the attendant costs.

The operator's plan for plugging the hole is reviewed. The minimum requirements are: in open hole situations, cement plugs must extend at least 50 ft above and below zones with which has the potential to migrate, zones of lost circulation (this type of zone may require an alternate method to isolate), and zones of potentially valuable minerals. Thick zones may be isolated using 100-foot plugs across the top and bottom of the zone. In the absence of productive zones and minerals, long sections of open hole may be plugged with 150-foot plugs placed every 2,500 ft. In cased holes, cement plugs must be placed opposite perforations and extending 50 ft above and below except where limited by plug back depth.

A permanent abandonment marker is required on all wells unless otherwise requested by SMA. This marker pipe is usually at least 4 inches in diameter, 10 ft long, 4 ft above the ground, and embedded in cement. The pipe must be capped with the well identity and location permanently inscribed.

The SMA is responsible for establishing and approving methods for surface rehabilitation and determining when this rehabilitation has been satisfactorily accomplished. Possibilities may exist for developing a well for fresh water purposes, utilizing improvements, or making wildlife habitat improvements. Reclamation criteria include: 1) final configuration of the disturbed area; 2) stabilization of the soil; 3) management of the topsoil and addition of appropriate fertilizers; 4) revegetation with prescribed seed mixtures; 5) air, water, and visual quality standards; 6) compliance inspection intervals and bond amounts; and 7) conditions for bond release. At this point, a Subsequent Report of Abandonment can be approved.

7.7.5 Coalbed Natural Gas Development

Drilling for CBNG is very similar to drilling for conventional oil and gas except that generally smaller drilling rigs are used since, at present, CBNG resources are generally at much shallower depths on average than oil and gas. CBNG development also involves a larger amount of surface disturbance than conventional oil and gas development. CBNG ancillary facilities include access roads, pipelines for gathering gas and produced water, electrical utilities, facilities for treating and compressing gas and disposing of produced water, and pipelines for delivering gas under high pressure to transmission pipelines.

Unlike conventional gas, CBNG does not usually require additional treatment or processing before use. The gas is piped from the wellhead to a commercial gas line for direct distribution to homes and businesses. Typical surface disturbance associated with a producing CBNG pad is around 1 acre (ALL Consulting and Montana Board of Oil and Gas Conservation 2004). Surface disturbance would also include construction of off channel water storage, battery sites of about 2 acres each, one high-pressure compressor site of approximately 10 ten acres, and access roads (0.75 acres per pad), pipelines, and electric lines needed to service the wells.

Wells to be drilled on shared sites with up to four wells (one per coal bed) may be located on a common well site. The operator should co-locate electric power, gas, and water lines with proposed roads as much as possible to minimize overall disturbance. CBNG production produces large volumes of water of varying quality for which two disposal methods exist–

surface disbursal or re-injection. Average well discharge for a typical CBNG well is around 12 gallons per minute, or just over 17,000 gallons per day.

Wells are drilled with truck mounted water well type rigs. Because this type of rig can be set up on uneven terrain, the surface is generally not bladed or a pad site constructed unless topography requires it. The drilling and completion operation for a CBNG well normally requires a maximum of 10 to 15 people at a time, including personnel for logging and cementing activities. A 100 ft square area is typically mowed to accommodate the rig and small reserve pits, about 6 ft by 15 ft by 15 ft are constructed to serve all of the drilling wells on that site. A total of about 1 acre is required for the two to five wells drilled on a site (the actual number of wells per site depends upon the number of coal seams to be developed at that site). Wells are completed using 7-inch steel well casing set and cemented to surface from the top of the target coal bed. Small diameter tubing and an electric submersible pump would be installed in the well. Topsoil is stripped and saved from any surface disturbing operation and used for reclamation of the disturbed area (BLM 2003).

The operator will use existing roads and trails to the extent possible. An average of 15 miles or less of new gravel roadways would generally be used for this project. Electrical power and water and gas flow lines will generally follow the road system and, to the extent possible, will use the same right-of-way. Power lines will be plowed in if possible to minimize surface disturbance.

Wellheads will be equipped with 5-foot frost boxes painted an unobtrusive color and fenced to protect the facility from damage by wildlife. Electronic flow devices will measure natural gas production and water will be measured through ultrasonic flow meters. A panel installed at the well starts and stops the pump based on fluid level measurement. Any interested companies must submit a surface use plan, water management plan, and reclamation plan as required in the BLM Onshore Oil and Gas Order Number 1 (BLM 1983).

8.0 SURFACE DISTURBANCE DUE TO OIL AND GAS ACTIVITY ON ALL LANDS

Type of Action	Number of Actions	Area Disturbed[1]	Short Term Disturbance (acres)	Long Term Disturbance (acres)
Geophysical Exploration (miles)	*1,000*	*Using existing roads, old seismic line trails and off-road trails (1 acre per mile)*	*1,000*[2]	*Minimal*
Oil Exploration Wells	15	Drill pads and access road	67[3]	7[4]
Gas Exploration Wells	26	Drill pads and access road	304[3]	48[4]
Coalbed natural gas (CBNG) Gas Wells	500	Drill pads (2 wells per pad) access road,	604[5]	28[6]
Delineation gas wells (offsetting exploration wells)	12	Drill pads, access road, pipelines and utilities	155[7]	155
Gas development Wells	60	Drill pads (5 wells per pad), access road, pipelines and utilities	96[7]	96[8]
Delineation oil wells (offsetting exploration wells)	3	Drill pads, access road, pipelines and utilities	39[9]	39
Oil development Wells	15	Drill pads (3 wells per pad), access road, pipelines and utilities	36[9]	36[9]
Gas separation equipment and compression Facilities	4	Pads, access road, pipelines and utilities	20[10]	20
CBNG Field Compressor Station	45	Pads, access road, gathering pipelines and utilities	534[11]	534
CBNG Sales Compressor Station	3	Pads, access road, pipelines and utilities	76[12]	76
CBNG Gas Lines (miles to sales line)	50	Pipeline: 3 acres initial disturbance per mile, 2.6 acres stabilized per mile	152[13]	152
CBNG Water Disposal Facility	23	Pads, access road, pipelines and utilities	106[14]	106
Conventional Gas transmission pipeline (miles)	120	3 acres initial disturbance per mile; 2.6 acres stabilized per mile	360[15]	312
CBNG Transfer Pumping Station	5	Pads, access road, pipelines, and utilities	9[16]	9
Total Acres Disturbed by Exploratory Drilling, Development and Production			**2,558**	**1,910**

NOTES:

1. Acreage estimates for each component from observed disturbance in Kenai Peninsula area of the Cook Inlet Basin unless otherwise noted.
2. Geophysical exploration (italicized) is not included in the total acres disturbed because it is temporary and minimally intrusive on the environment. Geophysical exploration requires a discretionary approval that is not associated with leasing and subsequent activities.
3. Exploration well – assume 2 acres (300 feet by 300 feet) for drill pad (including worker camp) and for oil wells at 160 acre spacing; 0.5 miles of roads per well by 40 ft width by 15 wells equals 67 acres (30 acres plus 37 acres); for gas wells at 460 acre spacing; 2 miles of roads per well by 40 ft width by 26 wells equals 304 acres (52 acres plus 252 acres).
4. All exploration well pad acreage is reclaimed within two seasons, excluding five discovery wells that are developed into production wells (18 dry holes and 18 non-economic discovery wells by 2 acre pad equals 72 acres reclaimed). It is assumed that access roads are not reclaimed immediately.
5. 500 CBNG wells (2 per pad) – assume 1 acre per pad by 250 pads equals 262 acres; 188 miles of access roads (0.75 miles per pad by 250 pads) by 15 ft. width equals 342 acres.
6. Assume 10 percent dry holes; 50 wells or 25 pads reclaimed immediately (includes 19 miles of access road reclamation). Producing CBNG wells – assume 1 acre per producing well not to be reclaimed immediately.
7. Delineation and development gas wells – assume 3.2 acres (350 feet by 400 feet) per drill pad; 2 mile access road per delineation well by 40 ft width by 12 wells equals 116 acres; assume 4 new gas fields; 3 pads and 15 development wells per field (five development wells per pad); 1 mile access road per development pad by 40 ft width by 12 pads equals 58 acres; 3 acres for associated pipelines and power lines per pad (25 ft utility width by 1 mile per pad by 12 pads equals 36 acres. One exploration well would be used as a worker camp, if needed.
8. Assume nine gas development wells drilled are sub economic.
9. Delineation and development oil wells – assume 3.2 acres (350 by 400 feet) per drill pad; 2 mile access road per delineation well by 40 ft width by three wells equals 29 acres; assume one new oil field; five pads and three development wells per pad; 0.5 mile access road per development pad by 40 ft width by five pads equals 12 acres; assume two development wells drilled are sub economic, 1.5 acres for associated pipelines and power lines per pad (25 ft utility width by 0.5 mile per pad by 5 pads equals 8 acres. One exploration well would be used as a worker camp, if needed.
10. Assume one gas compression facility for each of the four gas field discoveries (5 acres each).
11. CBNG field compressor station (0.5 acres each); assume 0.75 miles of plastic low-pressure gathering lines per pad (225 pads) by 25 ft utility width (parallels pad access road) equals 511 acres; 511 acres plus 23 acres equals 534 acres.
12. CBNG sales compressor station (5 acres each); assume 20 miles of steel low-pressure gathering lines by 25 ft utility width (parallels field compressor access road) equals 61 acres; 61 acres plus 15 acres equals 76 acres.
13. 25 ft corridor from sales compressors to high pressure sales line.
14. Assume 1 acre per pad by 23 pads equals 23 acres; 17 miles of access roads (0.75 miles per pad by 23 pads) by 15 ft width equals 31 acres; assume 0.75 miles of plastic low-pressure gathering lines per pad (23 pads) by 25 ft utility width (parallels pad access road) equals 52 acres; 52 acres plus 23 acres plus 31 acres equals 106 acres.
15. Gas transmission pipelines 3 acres per mile (25 feet wide) and reclaim to approximately 2.6 acres (22 feet) wide; 3 acres/miles x 120 miles equals 360 acres; 2.6 acres/mile x 120 miles equals 312 acres.
16. 5 pads (120’ by 120’) equals 1.7 acres; 7 miles of access roads (0.75 miles per pad by 5 pads) by 15 ft width equals 342 acres.

9.0 BIBLIOGRAPHY

Adkison, W.L., Kelley, J.S., and Newman, K.R., l975b, Lithology and palynology of the Beluga and Sterling Formations exposed near Homer, Kenai Peninsula, Alaska: U. S. Geological Survey Open-File Report 75-383, 239 p.

Alaska Economic Information System - Department of Community & Economic Development; Kenai Peninsula Borough: Economic Overview (publishing date unknown).

Allen, R., 2001. Coalbed methane primer, www.landman.org/ann_papers/allen.doc

ALL Consulting and Montana Board of Oil and Gas Conservation, 2004. Coal Bed Methane Primer, New Source of Natural Gas – Environmental Implications: Background and Development in the Rocky Mountain West, U.S. Department of Energy National Petroleum Technology Office, 60 p.

ALL Consulting, Tulsa, OK and Montana Board of Oil and Gas Conservation, Billings MT; April 2002. Handbook on Best Management Practices and Mitigation Strategies for Coal Bed Methane in the Montana Portion of the Powder River Basin, p.

Atwood, W.W., 1911. Geology and mineral resources of parts of the Alaska Peninsula: U. S. Geological Survey Bulletin 467, 137 p.

Barnes, F.F., 1967. Four preliminary gravity maps of parts of Alaska: U.S. Geological Survey Open-file Report 278, 5 p.

Barnes, F. F., and Payne, T. G., 1956a. The Wishbone Hill District, Matanuska coal field, Alaska, U. S. Geological Survey Bulletin 1016, 88 p.

Barnes, F. F., and Payne, T. G., 1956b. The Wishbone Hill District, Matanuska coal field,Alaska, U. S. Geological Survey Bulletin, 1016, 85 p.

Bayer, K. C., Mattick, R. E., Plafker, G., and Bruns, T. R., 1977, Refraction studies between Icy Bay and Kayak Island, eastern Gulf of Alaska: U.S. Geological Survey Open-File Report 77-550, 45 p.

Beikman, H. M., 1980. Geologic map of Alaska: U. S. Geological Survey, 1 sheet, 1:1,000,000.

Bergquist, H.R., 1961. Early Cretaceous (Middle Neocomian) microfossils in south-central Alaska, in Geological Survey research 1961: U. S. Geological Survey Professional Paper 424-D.

Bird, K. J., and Magoon, L. B., 1988. National assessment of undiscovered conventional oil and gas resources: U. S. Geological Survey Open-File Report 88-373, p. 212-220.

Blasko, D.P., 1976. Oil and gas seeps in Alaska: Alaska Peninsula, western Gulf of Alaska: U.S. Bureau of Mines Report Inventory 8122, 78 p.

Boss, R.F., Lennon, R.B., and Wilson, B.W., 1976. Middle Ground Shoal oil field, Alaska, in Braunstein, Jules, ed., North American oil and gas fields: American Association of Petroleum Geologists Memoir 24, p. 1-22.

Brooks, A.H., 1918. The Alaskan mining industry in 1916: U. S. Geological Survey Bulletin 662, pp 11-62.

Brooks, A.H., 1922. The Alaskan mining industry in 1920: U. S. Geological Survey Bulletin 722, pp 7-67.

Brooks, A.H., 1925. Alaska's mineral resources and production, 1923: U. S. Geological Survey Bulletin 773, pp 3-52.

Bruns, T.R., Fisher, M.A., Magoon, L. B., Molenaar, C.M. and Valin, Z.C., 1995. Southern Alaska 1995 Geologic Report, 23p.

Bruns, T. R., 1988. Petroleum geology and hydrocarbon plays of the Gulf of Alaska onshore province: A report for the National Hydrocarbon Assessment program: U.S. Geological Survey Open-File Report 88-450J, 30 p.

Bruns, T.R., 1995. Gulf of Alaska, *in* Gautier, D.L., Dolton, G.L., Takahashi, K.I., and Varnes, K.L., eds., 1995 National assessment of United States oil and gas resources--Results, methodology, and supporting data: U. S. Geological Survey Digital Data Series 30, one CD-ROM.

Bruns, T. R., and Plafker, George, 1982. Geology, structure and petroleum of the southeastern Alaska and northern Gulf of Alaska continental margins, in Bruns, T. R., ed., Hydrocarbon resource report for proposed OCS lease sale 88; southeastern Alaska, northern Gulf of Alaska, Cook Inlet, and Shelikof Straits: U.S. Geological Survey Open-File Report 82-0928, p. 11-13.

Bureau of Land Management in Cooperation with the USDOI Minerals Management Service, 2003. Northwest National Petroleum Reserve – Alaska, Final Integrated Activity Plan/Environmental Impact Statement, USDOI, Volume One, Section IV, 557p.

Burk, C.A., 1965. Geology of the Alaska Peninsula-Island Arc and continental margin: Geological Society of America Memoir 99, 250 p., scales 1:250,000 and 1:500,000, 3 sheets.

Calderwood, K.W., and Fackler, W.C., 1972. Proposed stratigraphic nomenclature for Kenai Group, Cook Inlet Basin, Alaska: American Association of Petroleum Geologists Bulletin, v. 56, no. 4, p. 739-754.

Capps, S.R., 1923. The Cold Bay District: U. S. Geological Survey Bulletin 739, pp 77-116.

Churkin, Michael, Jr., 1973. Paleozoic and Precambrian rocks of Alaska and their role in its structural evolution: U.S. Geological Survey Professional Paper 740, 64 p.

Conwell, C.N., and Triplehorn, D.M., 1978. Herendeen Bay-Chignik coals, southern Alaska Peninsula: Alaska Division of Geological and Geophysical Surveys Special Report 8, 15 p, 2 plates, scale 1:125,000 approximately.

Detterman, R.L., 1978. Interpretation of depositional environments in the Chignik Formation, Alaska Peninsula, Johnson, K.M., ed., The United States Geological Survey in Alaska: Accomplishments during 1977: U. S. Geological Survey Circular 0772-B, pp B62-B63.

Detterman, R. L., Case, J. E., and Wilson, F. H., 1979. Paleozoic rocks on the Alaska Peninsula, in Johnson, K.M., and Williams, J. R., eds., The United States Geological Survey in Alaska--Accomplishments during 1978: U.S. Geological Survey Circular 804-B, p. B85-B86.

Detterman, R.L., Allaway, W.H., Jr., O'Leary, R.M., Gruzenski, A.L., Hurrell, J.T., and Risoli, D.A., 1980. Sample location map and analytical data for rock samples collected in 1979, Ugashik and Karluk quadrangles, Alaska: U. S. Geological Survey Open-file Report 80-142, 1 sheet, scale 1:250,000.

Detterman, R.L., and Hartsock, J.K., 1966. Geology of the Iniskin-Tuxedni Region, Alaska: U.S. Geological Survey Professional Paper 512, 78 p.

Detterman, R.L., Miller, T.P., Yount, M.E., and Wilson, F.H., 1981. Geologic map of the Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1229, scale 1:250,000.

Doughty, Tom C. Faulder, David D. Hite, David M. Thomas, Charles P., 2004. South-Central Alaska Natural Gas Study. U. S. Department of Energy, National Energy Technology Laboratory, Arctic Energy Office, 21p.

Ehm, Arlen, 1983. Oil and gas basins map of Alaska: Alaska Division of Geological and Geophysical Surveys Special Report 32, 1 sheet, scale 1:2,500,000.

Evergreen Resources, Inc. Webpage, 2004. (http://www.evergreen-res.com/alaskaprofile.html), 1p

Hite, D.M., 1976. Some sedimentary aspects of the Kenai Group, Cook Inlet, Alaska, in Miller, T.P., ed., Recent and ancient sedimentary environments in Alaska: Alaska Geological Society, Anchorage, Alaska, p. I1-I23.

Imlay, R.W., 1981. Early Jurassic Ammonites from Alaska: U.S. Geological Survey Professional Paper 1148, 40 p., plates.

Jones, D.L., and Detterman, R.L., 1966. Cretaceous stratigraphy of the Kamishak Hills, Alaska Peninsula, in Geological Survey research 1966: U.S. Geological Survey Professional Paper 550-D, p. D53-D58.

Jones, D.L., Silberling, N.J., Berg, H.C., and Plafker, George, 1981. Map showing tectonostratigraphic terranes of Alaska, columnar sections, and summary description of terranes: U.S. Geological Survey Open-file report 81-792, 20 p., 2 sheets.

Knappen, R.S., 1929. Geology and mineral resources of the Aniakchak district: U.S. Geological Survey Bulletin 797, pp 161-226.

Keller, A., and Reiser, H.N., 1959. Geology of the Mount Katmai area, Alaska: U.S. Geological Survey Bulletin 1058-G, p. G261-G268.

Kellum, L.B., Davies, S.N., and Swinney, C.M., 1945. Geology and oil possibilities of the southwestern part of the Wide Bay anticline, Alaska: U. S. Geological Survey Open-file Report 34, 17 p.

Kennedy, G.C., and Waldron, H.H., 1955. Geology of Pavlof Volcano and vicinity, Alaska: U.S. Geological Survey Bulletin 1028-A, pp 1-19.

Grantz, Arthur, Jones, D.L., and Lanphere, M.A., 1966. Stratigraphy, paleontology, and isotopic ages of upper Mesozoic rocks in the south- western Wrangell Mountains, Alaska: U. S. Geological Survey Professional Paper 550-C, p. C39-C47.

Hayes, J.B., Harms, J.C., and Wilson, Thomas, Jr., 1976. Contrasts between braided and meandering stream deposits, Beluga and Sterling Formations (Tertiary), Cook Inlet, Alaska, in Miller, T.P., ed., Recent and ancient sedimentary environments in Alaska: Alaska Geological Society, p. J1-J27.

Lang, Karl, 2002. Options for Coalbed Methane Water Management, Petroleum Technology Transfer Council, Network News Vol. 8, No. 1, First Quarter 2002.

Keller, A.S., and Reiser, H.N., 1959. Geology of the Mount Katmai area, Alaska: U.S. Geological Survey Bulletin 1058-G, pp 261-298.

Kirschner, C.E., and Lyon, C.A., 1973. Stratigraphic and tectonic development of Cook Inlet petroleum province, in Pitcher, M.G., ed., Arctic geology: American Association of Petroleum Geologists Memoir 19, p. 396-407.

Kremer, M.C., Stadnicky, G., 1985. Tertiary stratigraphy of the Kenai Peninsula - Cook Inlet region, in Sission, A., ed., Guide to the Geology of the Kenai Peninusla, Alaska: Alaska Geological Society, P.O. Box 101288, Anchorage, p. 24-42.

Kruuskra, V.A., and Boyer, C.M., Jr., 1993. Economic and parametric analysis of coalbed methane, *in* Law, B.E. and Rice, D.D., Hydrocarbons from Coal; American Association of Petroleum Geologist Studies in Geology No. 38; Tulsa, Oklahoma; p.373-394.

Lyle, W.M., Morehouse, J.A., Palmer, I.F., Jr., and Bolm, J.G., 1979. Tertiary formations and associated Mesozoic in the Alaska Peninsula area, Alaska, and their petroleum-reservoir potential, Alaska Division of Geological and Geophysical Surveys Geologic Report 62, 65 p., 19 plates.

Mancini, E.A., Deeter, T.M., and Wingate, F.H., 1978. Upper Cretaceous arc-trench gap sedimentation on the Alaska Peninsula: Geology, v. 6, No. 7, pp 437-439.

Marathon Oil Company Alaska Production Region, 2003. Marathon Oil Company Exploration and Production in the United States, Alaska, http://www.marathon.com/Our_Business/Marathon_Oil_Company/Exploration_Production/United_States/Alaska/, 1p.

Magoon, L.B., Molenaar, C.M., Bruns, T.R., Fisher, M.A., and Valin, C.Z., 1996. Region 1, Alaska, Geologic Framework, *in* Gautier, D. L., Dolton, G.L., Takahashi, K.I., and Varnes, K.L., eds., National Assessment of United States Oil and Gas Resources--Results, Methodology, and Supporting Data: U.S. Geological Survey Digital Data Series DDS-30, Release 2, p. 1-14.

Marlow, M.S., Gardner, J.V., Vallier, T.L., McLean, H., Scott, E.W., and Lynch, M.B., 1979. Resource report for proposed OCS Lease Sale No. 70, St. George Basin, Shelf Area, Alaska: U. S. Geological Survey Open-file Report 79-1650, 79 p.

Martin, G.C., 1905. Notes on the petroleum fields of Alaska in Report on progress of investigations of mineral resources in Alaska in 1904, ed. A. H. Brooks: U.S. Geological Survey Bulletin 259, p. 128-139.

Martin, G.C., 1921. Preliminary report on petroleum in Alaska: U.S. Geological Survey Bulletin 719, 83 p.

Martin, G.C., 1926. The Mesozoic stratigraphy of Alaska: U.S. Geological Survey Bulletin 776, 493 p.

McLean, H., 1979. Observations of the geology and petroleum potential of the Cold Bay-False Pass area, Alaska Peninsula: U.S. Geological Survey Open-file Report 79-1605, 34 p.

Merritt, R.D., Eakins G.R., and Clough, J.G., 1982. Coal investigations of the Susitna Lowland, Alaska: Alaska Division of Geological and Geophysical Surveys Open-file Report 142, 89 p., 4 sheets, scale 1:250,000.

Miller, D.J., 1975. Geologic map and sections of the central part of the Katalla District, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-722.

Miller, D.J., Payne, T.G., and Gryc, George, 1959. Geology of possible petroleum provinces in Alaska: U.S. Geological Survey Bulletin 1094, 131 p.

Moffit, F.H., 1927. Mineral industry of Alaska in 1925: U.S. Geological Survey Bulletin 792, pp 1-39.

Montgomery, S.L., Barker, C.E., Seamount, D., Dallegge, T.A., and Swenson, R.F., 2003. Coalbed Methane, Cook Inlet, South-central Alaska: A potential giant gas resource: American Association of Petroleum Geologists Bulletin, Vol. 87, N0. 1, pp. 1-13.

Ogbe, David, 2000. Guidelines for Designing Water Guidelines for Designing Water Disposal Systems for Coalbed Methane Production in Alaska, Presented March 3, 2000 – West Coast PTTC Workshop Anchorage, AK.

Onshore Oil and Gas Order No. 1, 1983. Approval of Operations on Onshore Federal and Indian Oil and Gas Leases, U.S. Department of the Interior, Bureau of Land Management, 10 p.

Plafker, George, 1971. Possible future petroleum resources of Pacific-margin Tertiary basin, Alaska, in Future petroleum provinces of North America: American Association of Petroleum Geologists Memoir 15, p. 120-135.

Rice, Shawn, 1997. On-shore geophysical exploration: Anchorage, Alaska Science, Traditional Knowledge, and the Resources of the Northeast Planning Area of the National Petroleum Reserve-Alaska., NPR-A Symposium Proceedings, April 16-18, 1997 Anchorage, Alaska.

Richter, Donald H., Wilson, Frederic H., Labay, Keith A., and Preller, Cindi C., 2002. Abstract - Geologic Map of Wrangell-Saint Elias National Park and Preserve, AK; 1 sheet.

Seamount, D, Sullivan, F., Brandenburg, T., Crandall, R., Tabler, K., Downey, R., Childers, D., Carson, S., Smith, L., Barker, C., Thomas, D., Cross, R., and Pavia, G., 2001. West Coast PTTC Workshop Anchorage, AK.

Smith, P.S., 1929. Mineral industry of Alaska, in 1926: U.S. Geological Survey Bulletin 797, pp 1-50.

Smith, T. N., 1995. Coalbed methane potential for Alaska and drilling results for the upper Cook Inlet basin, Intergas '95 proceedings, May 15-19, 1995, 21 p.

Smith, T.N., and Clough, J.G., 1993. Coalbed methane potential for Alaska: 1993 American Assoc. of Petroleum Geologists Annual Convention Program, abs. p. 184.

Smith, P.S., 1939. Areal geology of Alaska: U.S. Geological Survey Professional Paper 192, 100 p.

Smith, W.R., and Baker, A.A., 1924. The Cold Bay-Chignik district, Alaska: U.S. Geological Survey Bulletin 755, pp 151-218.

State of Alaska, 2002. Alaska Oil and Gas Conservation Commission Annual Report, Alaska Oil and Gas Conservation Commission, 347 p.

Tesoro National Website, 2004. Refining and Marketing – Kenai, AK, MC2 Studios, Inc., http://www.tesoropetroleum.com/kenai.html, 1p.

Thomas, C.P., Doughty, T.C., Faulder, D.D., Hite, D.M., 2004. Department of Energy, 2004, South-Central Alaska Natural Gas Study, U.S. Department of Energy, National Energy Technology Laboratory, Arctic Energy Office, DE-AM26-99FT40575, 207 p.

URS Corporation, 2005. Mineral potential report - Ring of Fire Planning Area, Alaska, Unpublished report prepared for the Bureau of Land Management, Anchorage Field Office, Alaska, 68 p.

U.S. Department of the Interior, 1989. Oil And Gas Surface Operating Standards For Oil And Gas Exploration And Development; Bureau of Land Management and U.S. Department of Agriculture – Forest Service Rocky Mountain Regional Coordinating Committee (RMRCC), Third Edition, 45 p.

U.S. Fish and Wildlife Service, 1985. Kenai National Wildlife Refuge Final Comprehensive Conservation Plan-Environmental Impact Statement-Wilderness Review, United States Fish and Wildlife Service, 195 p.

U.S. Geological Survey, 1995. Circular 1118 by U.S. Geological Survey, 1995, National Assessment Of United States Oil And Gas Resources, Overview of the 1995 National Assessment of Potential Additions to Technically Recoverable Resources of Oil and Gas-Onshore and State Waters of the United States, National Oil and Gas Resource Assessment Team, 30 p.

Veil, J.A., Daly, J.M., Johnson, N. 1999. EPA Speeds Regs for Offshore Synthetic-based Mud. Oil and Gas Journal, 97(37):78-85)

Whitney, J.W., Levinson, R.A., and van Alstine, D.R., 1985. Paleomagnetism of Early Tertiary Alaska Peninsula rocks and implications for docking of Peninsular Terrane, 60th Annual Meeting AAPG-SEPM-SEG Pacific Section Program and Abstracts, p. 32.

Waldron, H.H., 1961. Geologic reconnaissance of Frosty Peak volcano and vicinity, Alaska: U.S. Geological Survey Bulletin 1028-T, pp 677-708.

Wilson, F.H., 1980. Late Mesozoic and Cenozoic tectonics and the age of porphyry copper prospects, Chignik and Sutwik Island quadrangles, Alaska Peninsula: U.S. Geological Survey Open-file Report 80-543, 94 p., plates.

Wilson, F.H., Detterman, R.L., and Case, J.E., 1985. The Alaska Peninsula terrane; a definition: U.S. Geological Survey Open-File Report 85-450, 17 p.

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Figure 1

Ring Of Fire General Planning Area Map

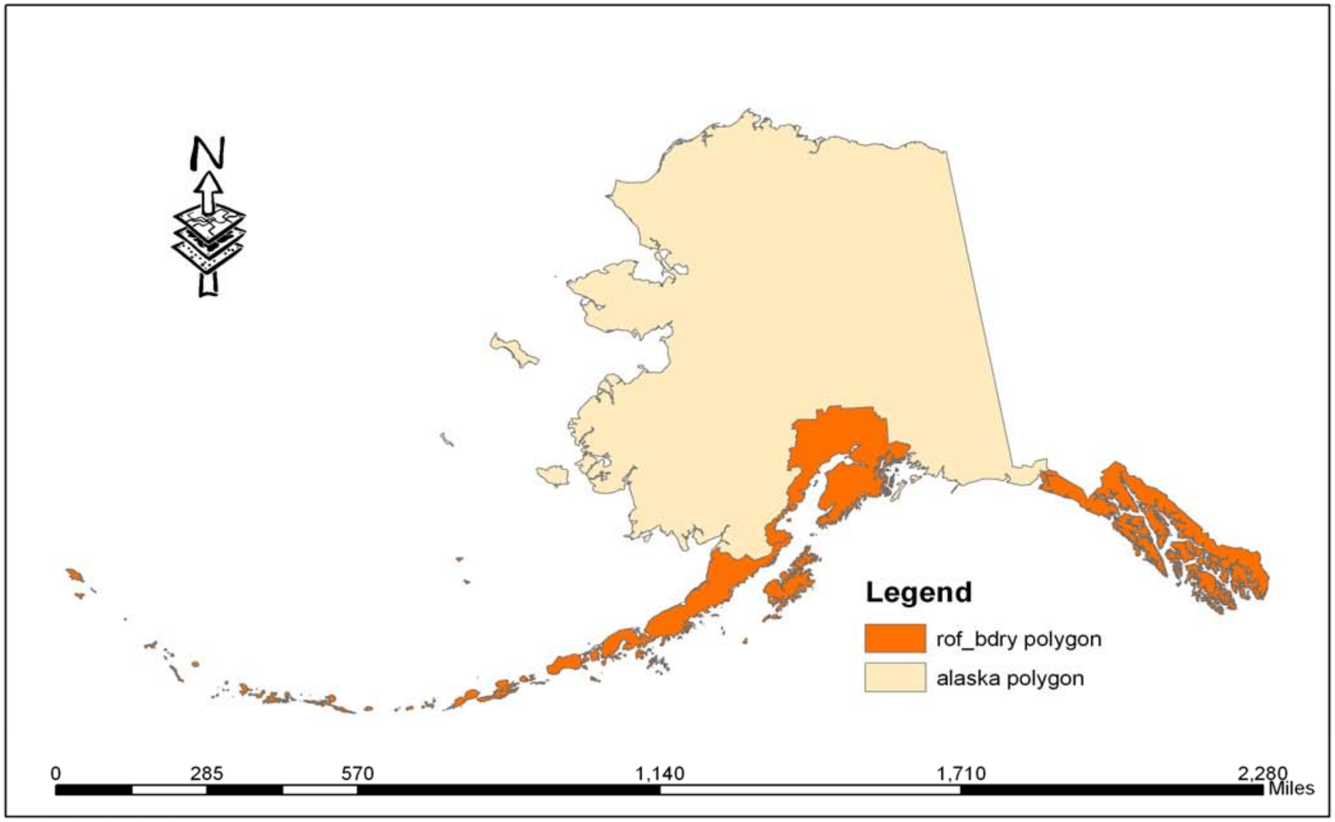
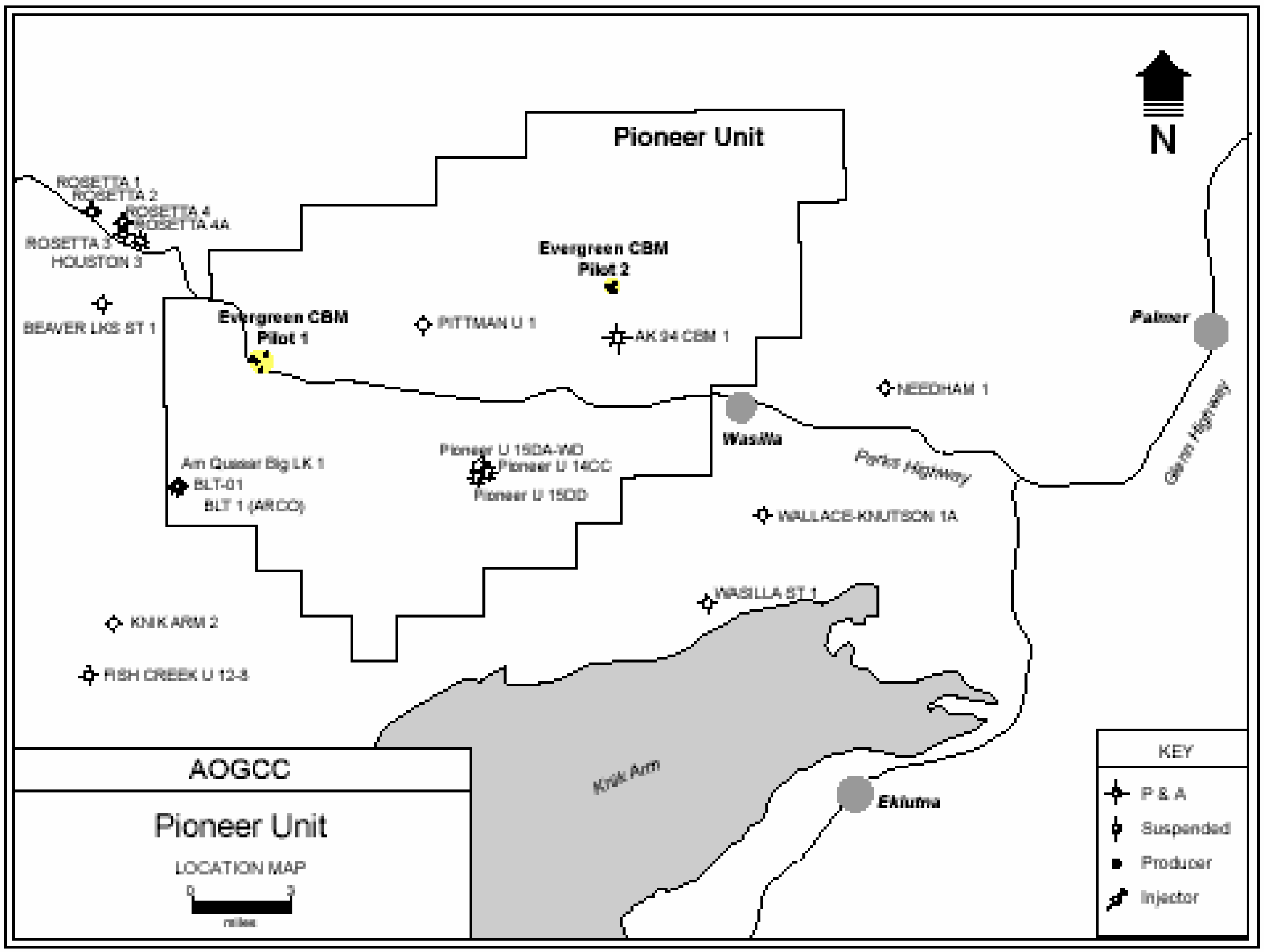


Figure 2

Pioneer Unit Location Map



288

Figure 3

Historic and Projected Oil Production 1969 - 2022

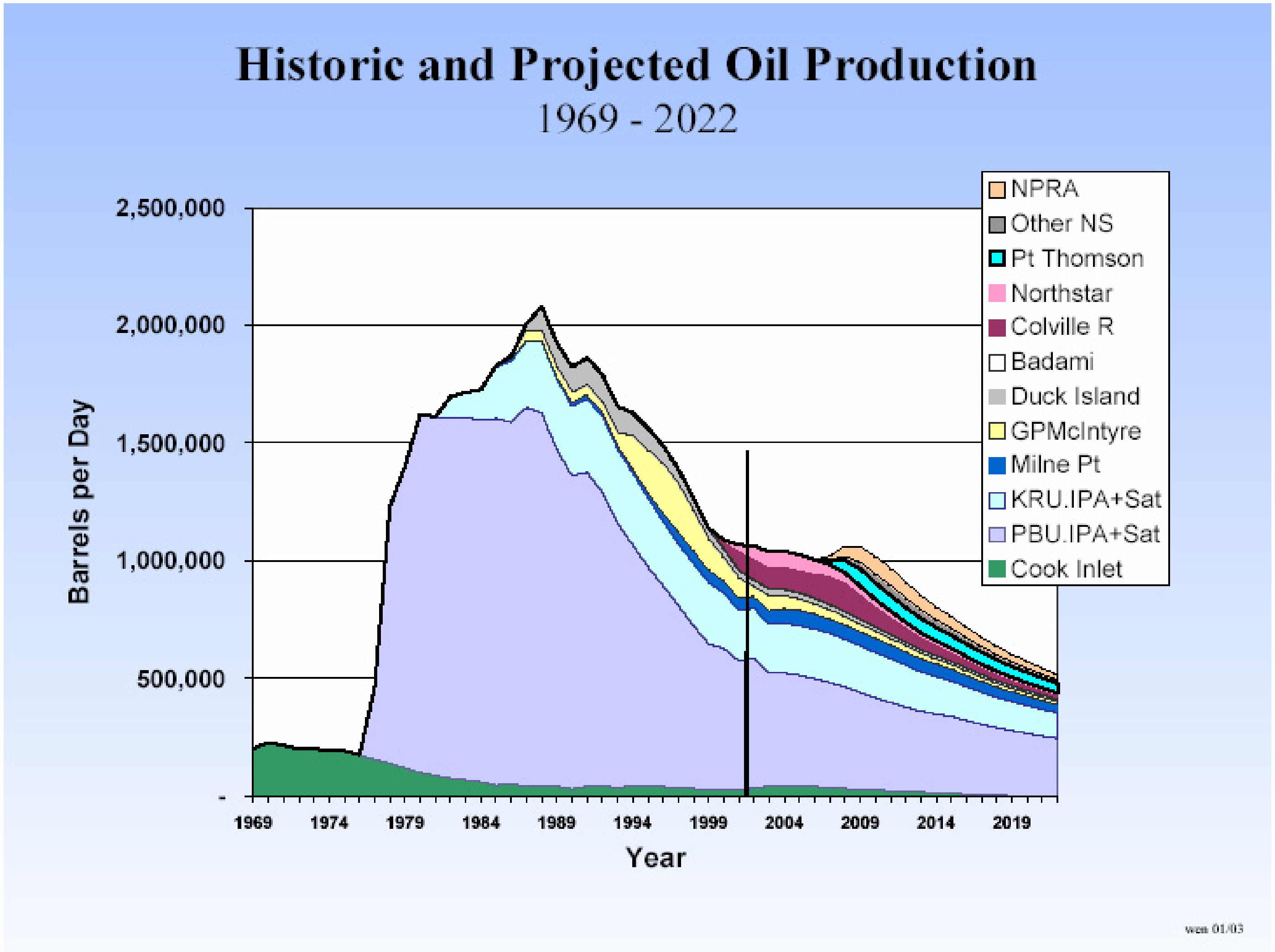


Figure 4
Alaska Peninsula Oil and Gas Area

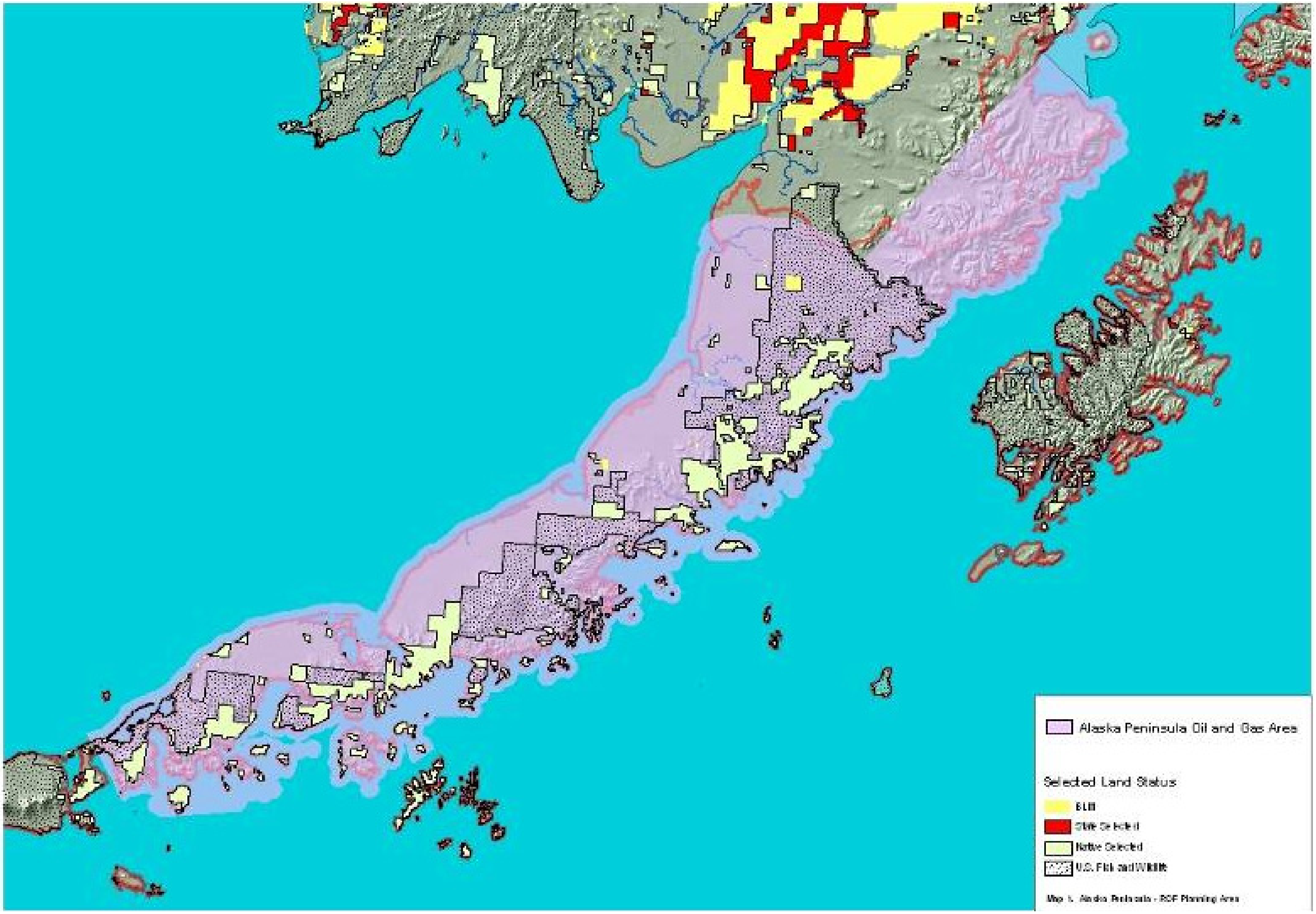


Figure 5
Cook Inlet Oil and Gas Basin

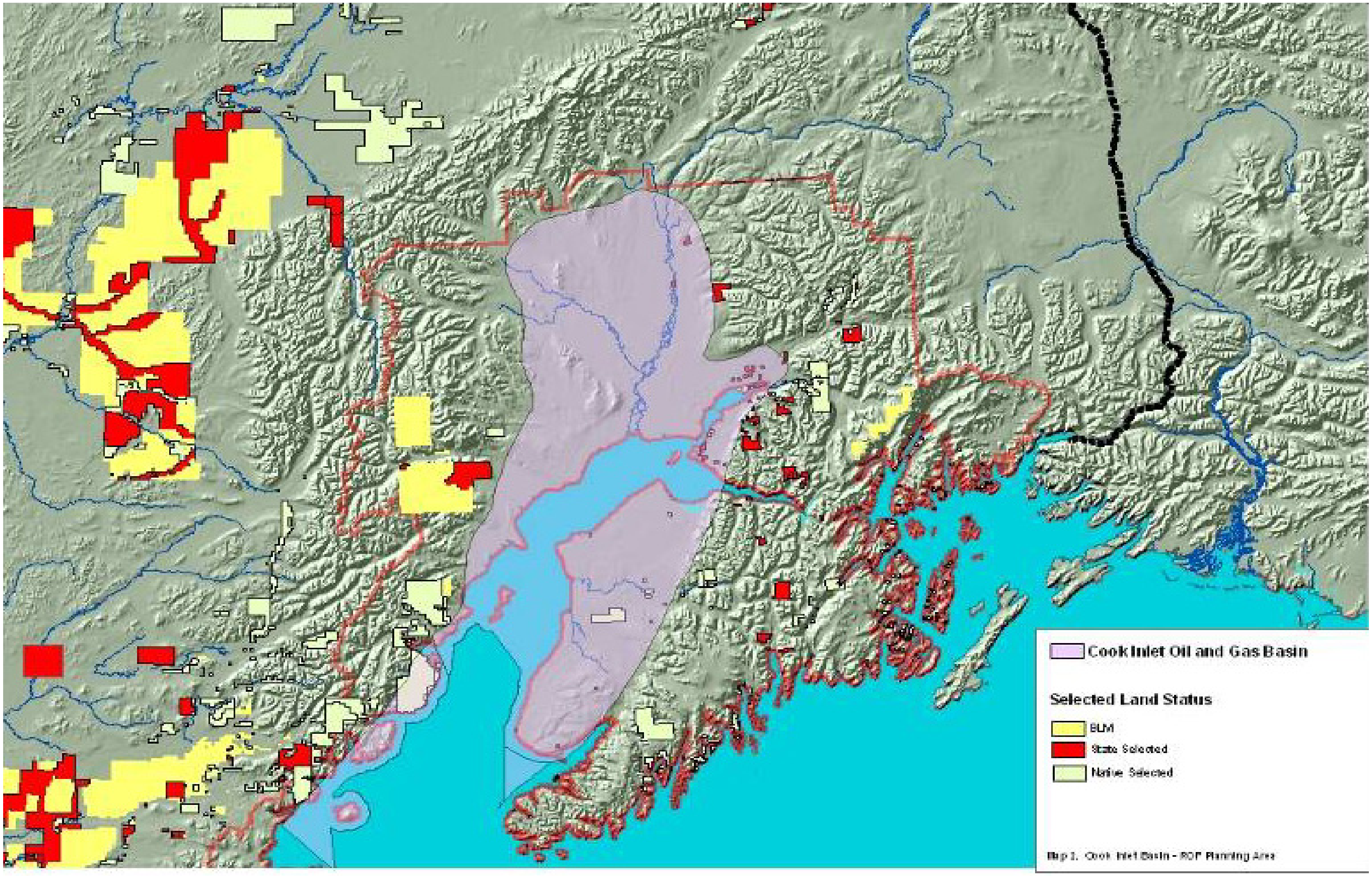


Figure 6
Yakutat Oil and Gas Area

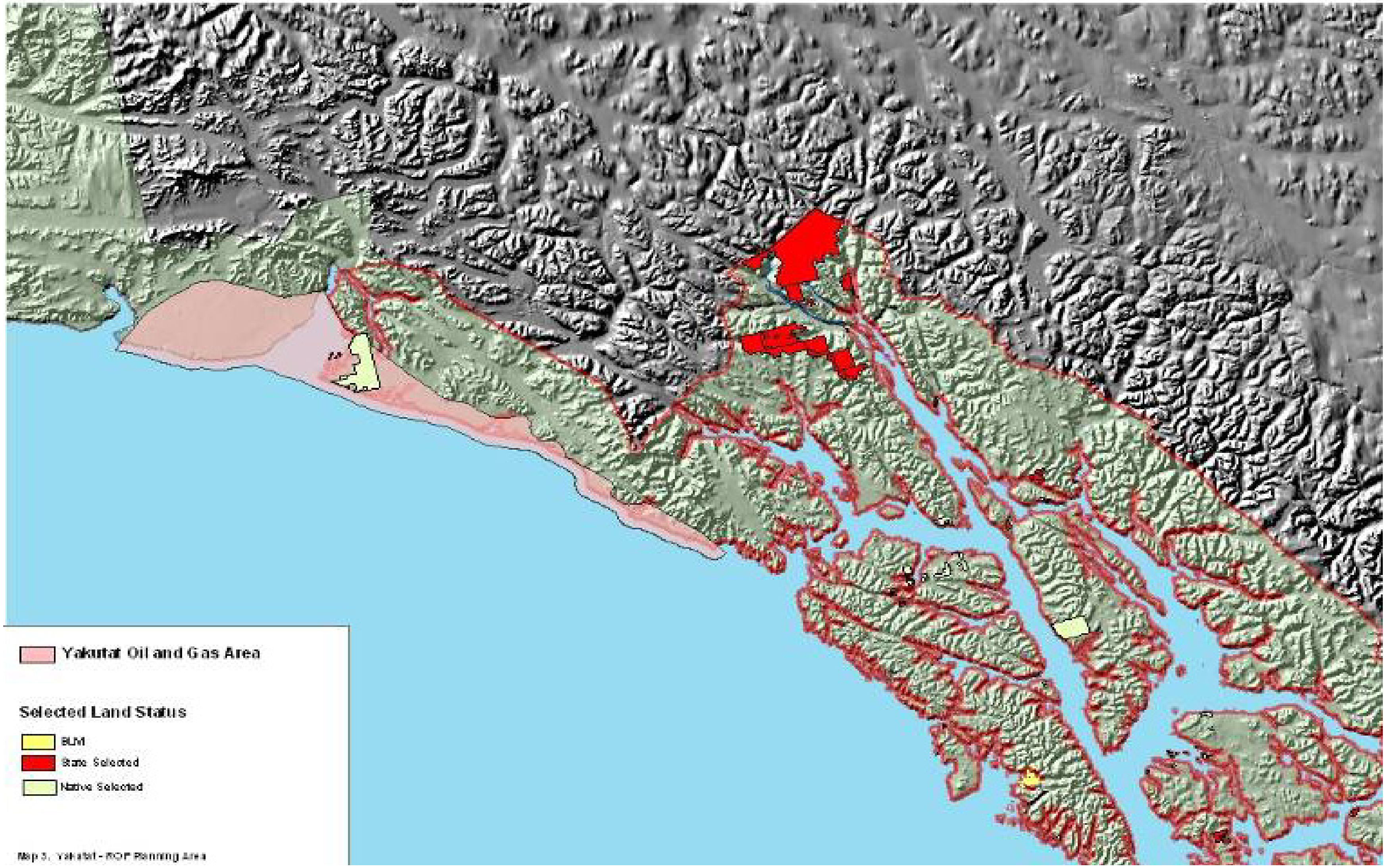


Figure 7
Areas of Potential Oil and Gas Development

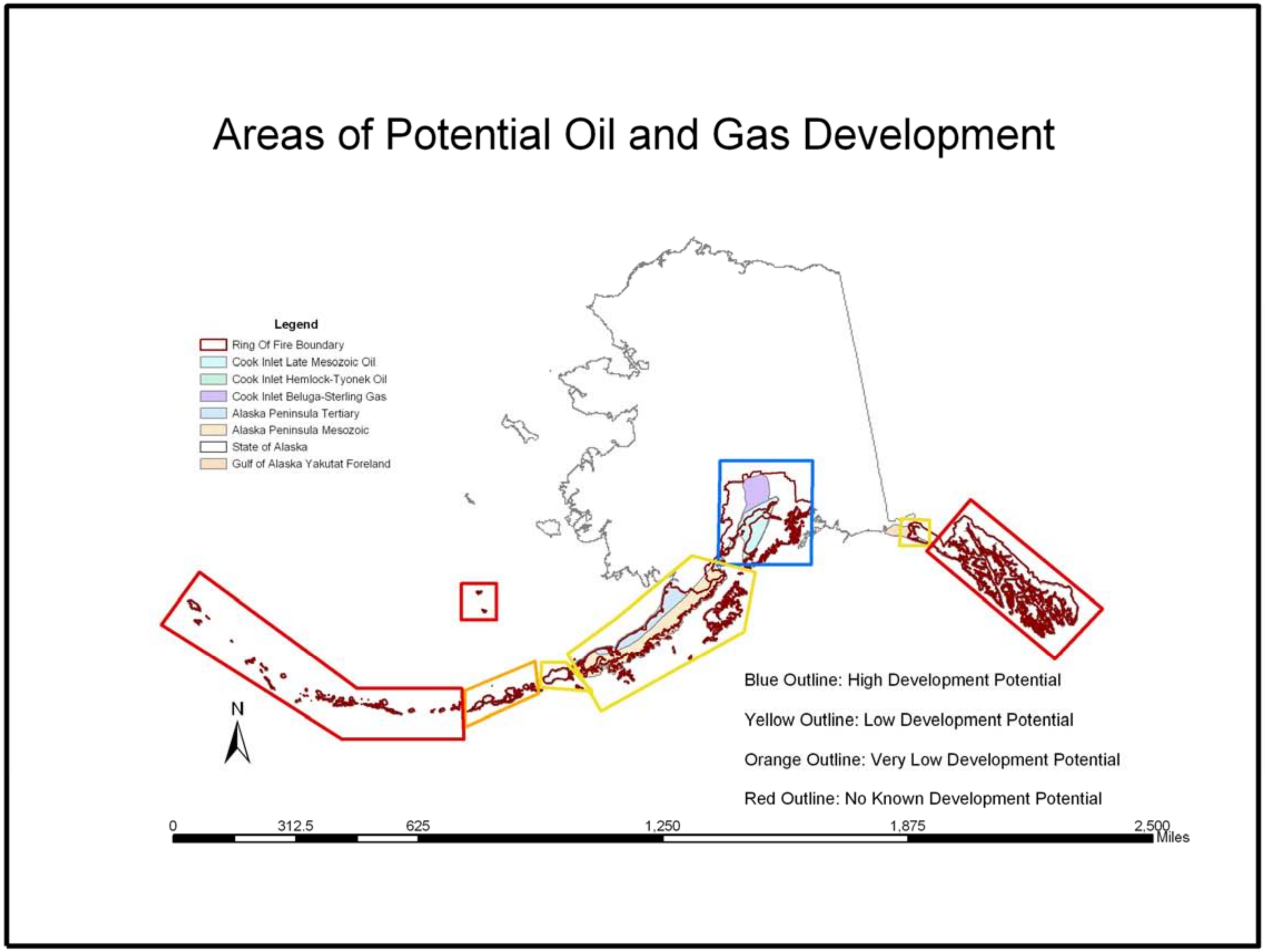


Figure 8
Areas of Potential Oil and Gas Occurrence

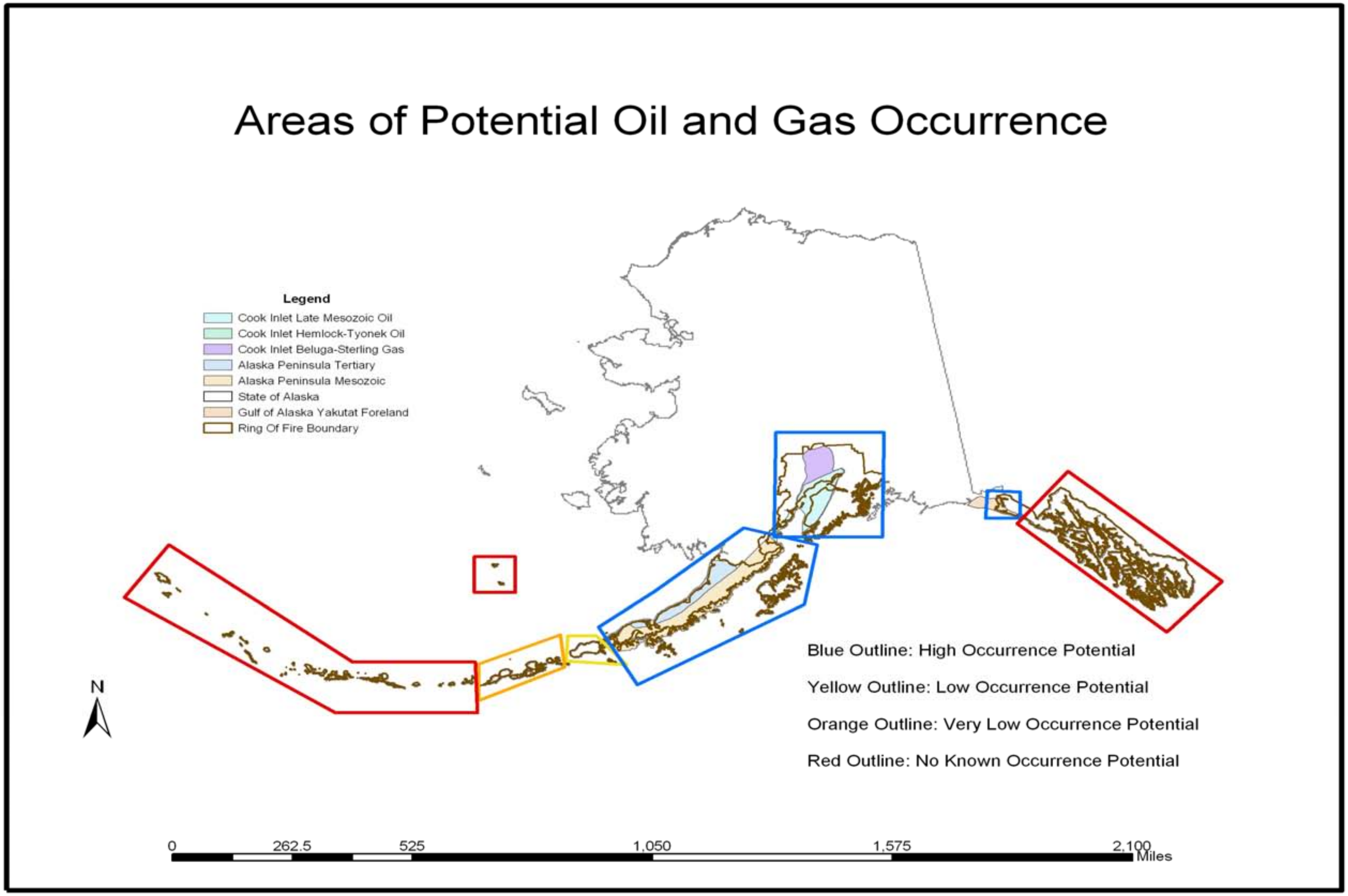


Table 1. Wells drilled for petroleum on the Alaska Peninsula (1903 to 1984).

	Well	Company	Year	T(S)	R(W)	sec	1/4 1/4	Depth	Formation	Results	Status
				Seward Meridian							
1	Pacific Oil #1	Pacific Oil & Commercial	1903	29	40	3	NW/4	1,421	Shelikof	Oil residue, shows, gas	P&A
2	Costello #1	J.H. Costello	1903	29	40	10	NW/4	728	Shelikof	Shows of oil & gas	P&A
3	Pacific Oil #2	Pacific Oil & Commercial	1904	29	40	3	SE/4	1,542	Shelikof	Shows of oil & gas	P&A
4	Costello #2	J.H. Costello	1904	29	40	10	SE/4	unknown	unknown	unknown	P&A
5	Lathrop #1	Standard Oil of Calif. Do.	1923	29	43	17	SE/4	500	Naknek	unknown	P&A
6	Finnegan #1	Tidewater Assoc.	1923	29	43	30	NE/4	560	Naknek	Trace of oil	P&A
7	McNally	Standard Oil of Calif.	1925	29	43	29	NW/4	510	Shelikof	Unknown	P&A
8	Lee #1	Standard Oil of Calif. Do.	1926	29	43	20	SW/4	5,034	Shelikof	Shows of oil & gas	P&A
9	Alaska #1	Tidewater Assoc.	1926	29	43	20	SW/4	3,033	Shelikof	Shows of oil & gas	P&A
10	Crammer #1	Standard Oil of Calif. Do.	1940	30	43	10	SE/4	7,596	unknown	Light oil in fractures, stain in Kialagvik Fm	P&A
11	Bear Creek #1	HumbleCShell	1959	29	41	36	NE/4	14,375	Kamishak	Oil stains in Kialagvik	P&A
12	Great Basins #1	General Petroleum Do.	1959	27	48	2	SW/4	11,080	Batholith	No oil shows are reported	P&A
13	Great Basins #2	General Petroleum Do.	1959	27	48	35	SE/4	8,865	Batholith	No oil shows are reported	P&A
14	Canoe Bay #1	Pure Oil	1963	54	78	8	NE/4	6,642	Hoodoo	No indication of oil generation	P&A
15	Wide Bay #1	Richfield Oil Co.	1963	33	44	5	NW/4	12,568	Kamishak	Oil stained sands in Kialagvik	P&A
16	Sandy River Fed #1	Gulf Oil Co.	1963	46	70	10	SE/4	13,068	Stepovak	Oil staining on sandstones at 10,000 ft	P&A
17	Ugashik #1	Great Basins Oil Co. .	1966	35	52	8	SE/4	9,476	Meshik	Oil staining noted at 10,000 ft.	P&A
18	Painter Creek #1	Cities Service So	1967	35	51	14	NW/4	7,912	Shelikof	Flowed gas. H20 cut in mud - Naknek Fm	P&A
19	David River # 1A	Pan American	1969	50	80	12	SE/4	13,769	Shelikof	Oil stained sands - Stepovak & Tolstoi	P&A
20	Hoodoo Lake #1	Pan American-Standard of Calif.	1970	50	76	21	NE/4	8,049	Stepovak	No indication of oil generation	P&A
21	Hoodoo Lake #2	Pan American-Standard of Calif.	1970	50	76	35	NE/4	11,243	Stepovak	Oil and gas shows in Stepovak and Tolstoi	P&A
22	Port Heiden #1	Gulf Oil Co.	1972	37	59	20	SE/4	15,015	Batholith	No indication of oil generation	P&A
23	Cathedral River #1	AMOCO Production	1974	51	83	29	SE/4	14,301	Unknown	Proprietary data	P&A
24	Big River #1	Phillips Petroleum Co.	1976	49	68	15	SW/4	11,371	Unknown	No known production	P&A
25	Koniag #1	Chevron Oil Co	1981	38	49	2	SW/4	10,907	Unknown	No known production	P&A
26	AMOCO Becherof St. 1	AMOCO	1984	28	48	10	NE/4	9,023	Unknown	No known production	P&A

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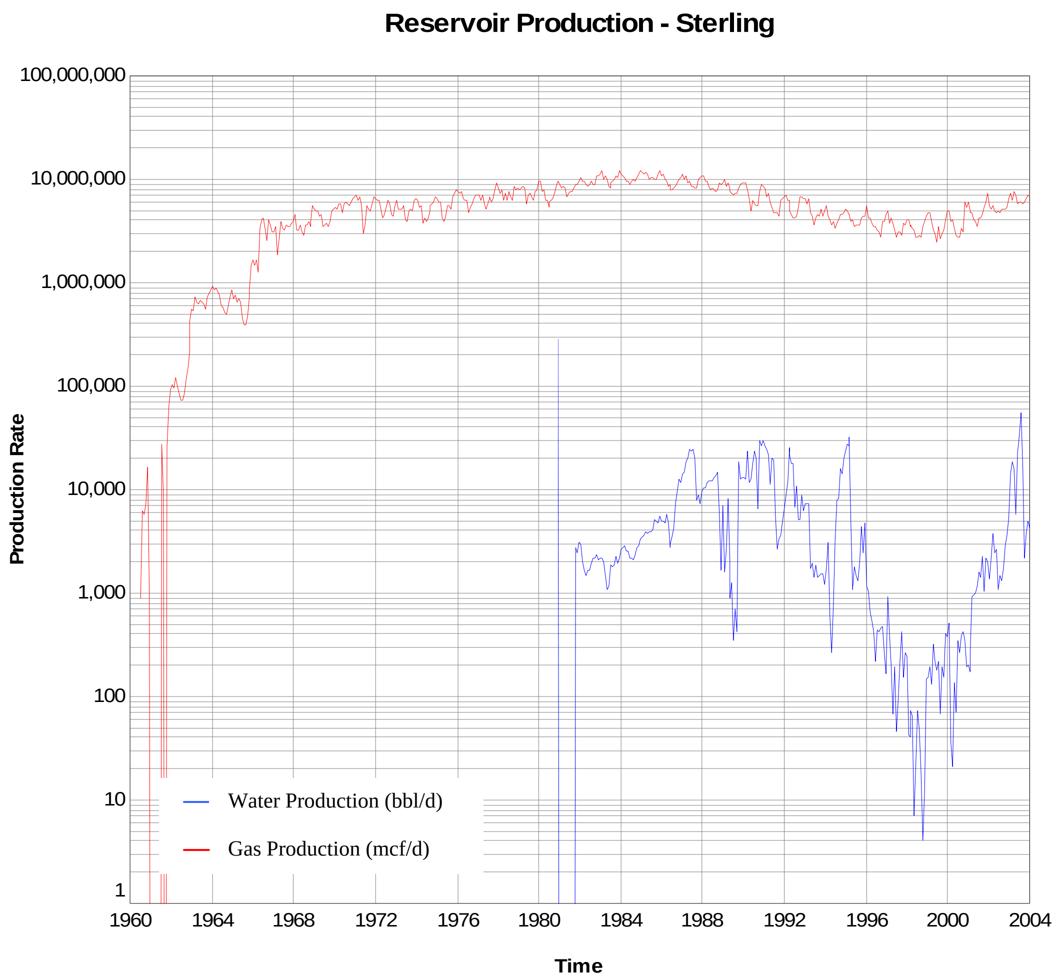
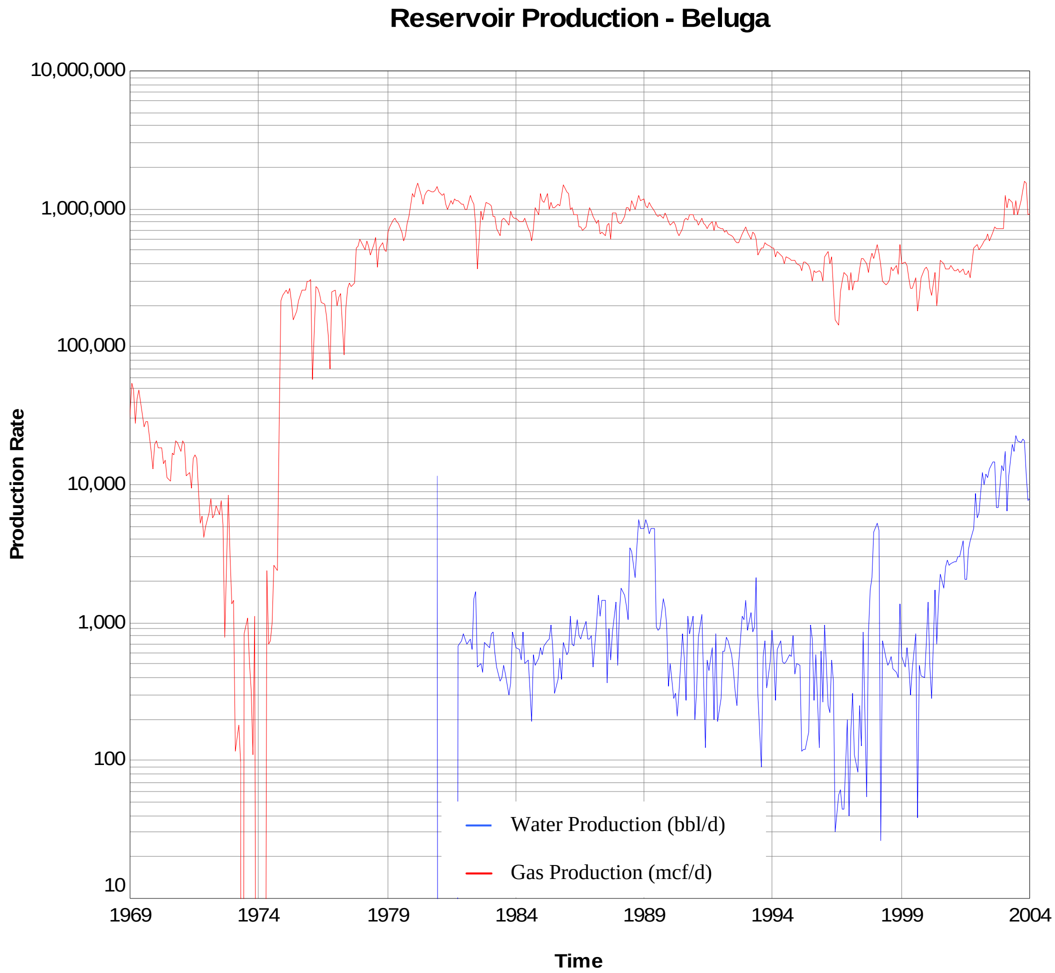
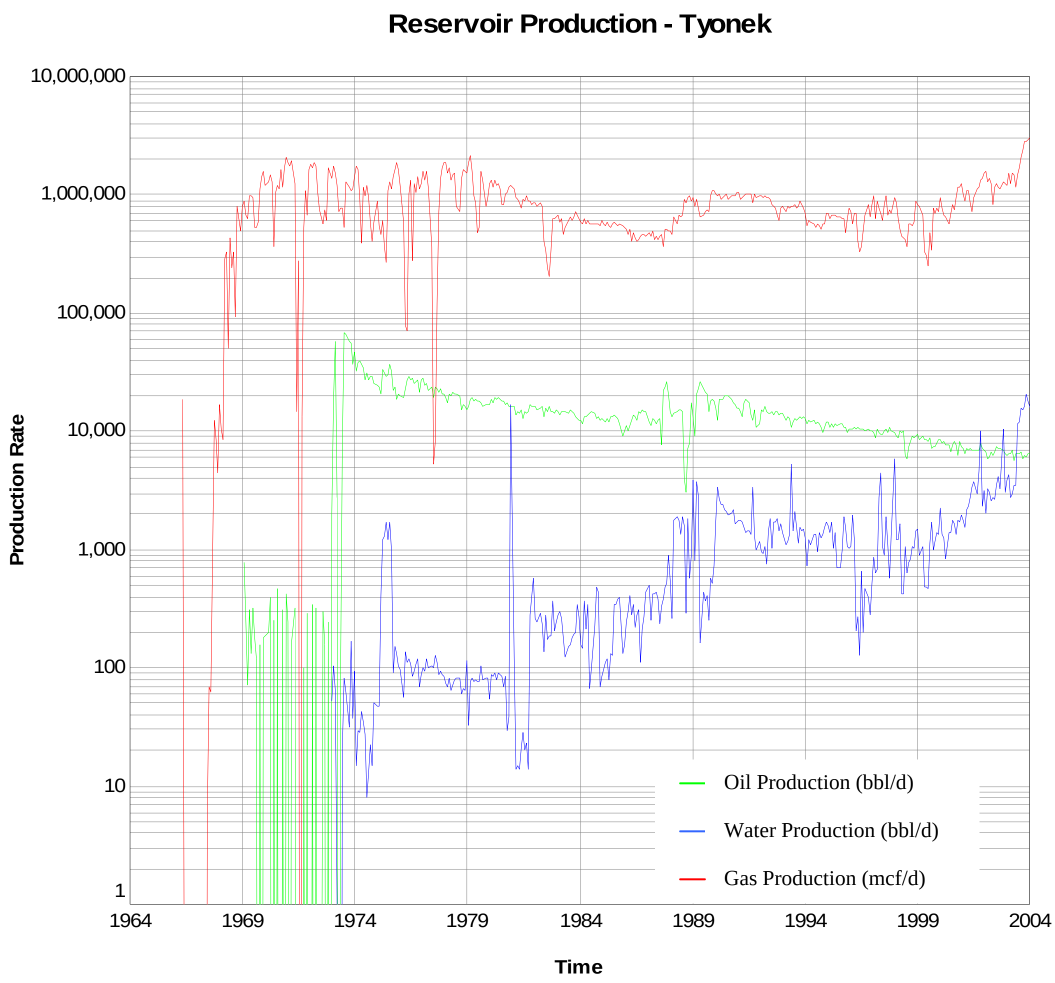
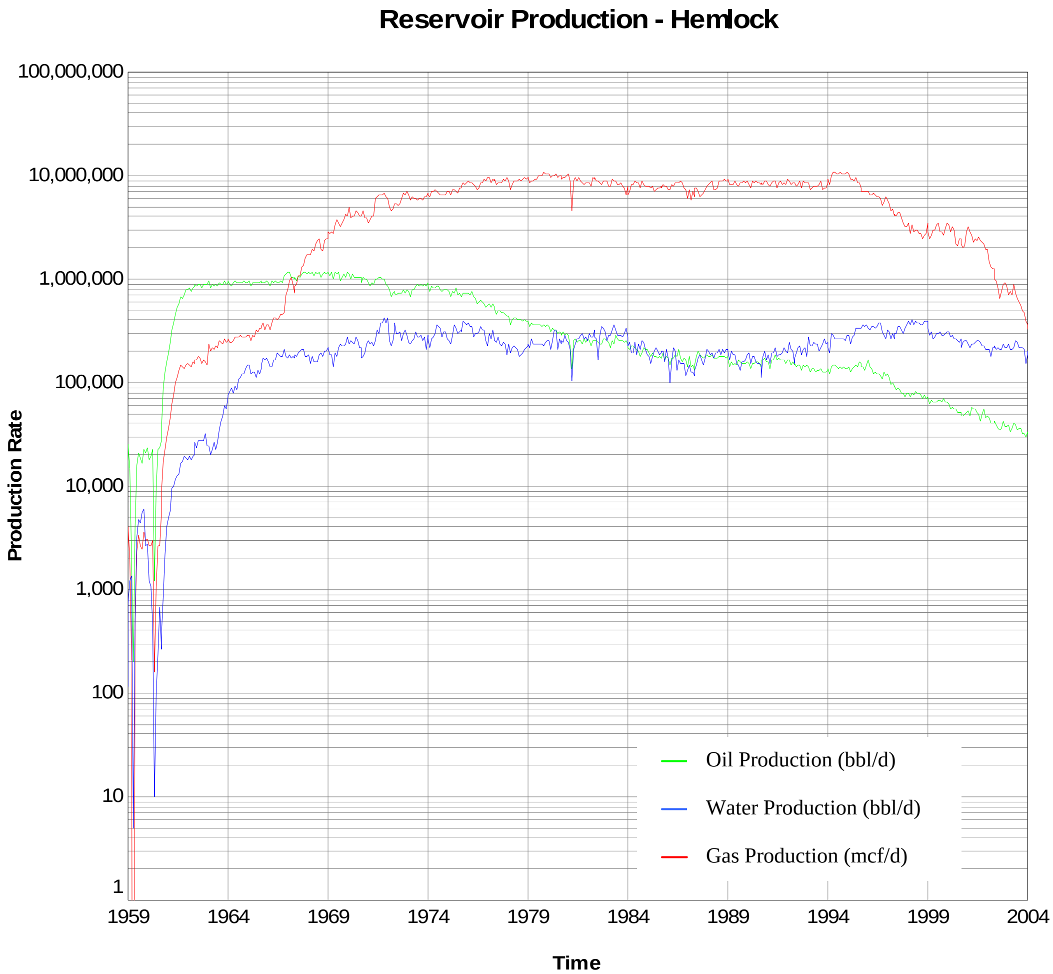
Appendix A

Production Graphs

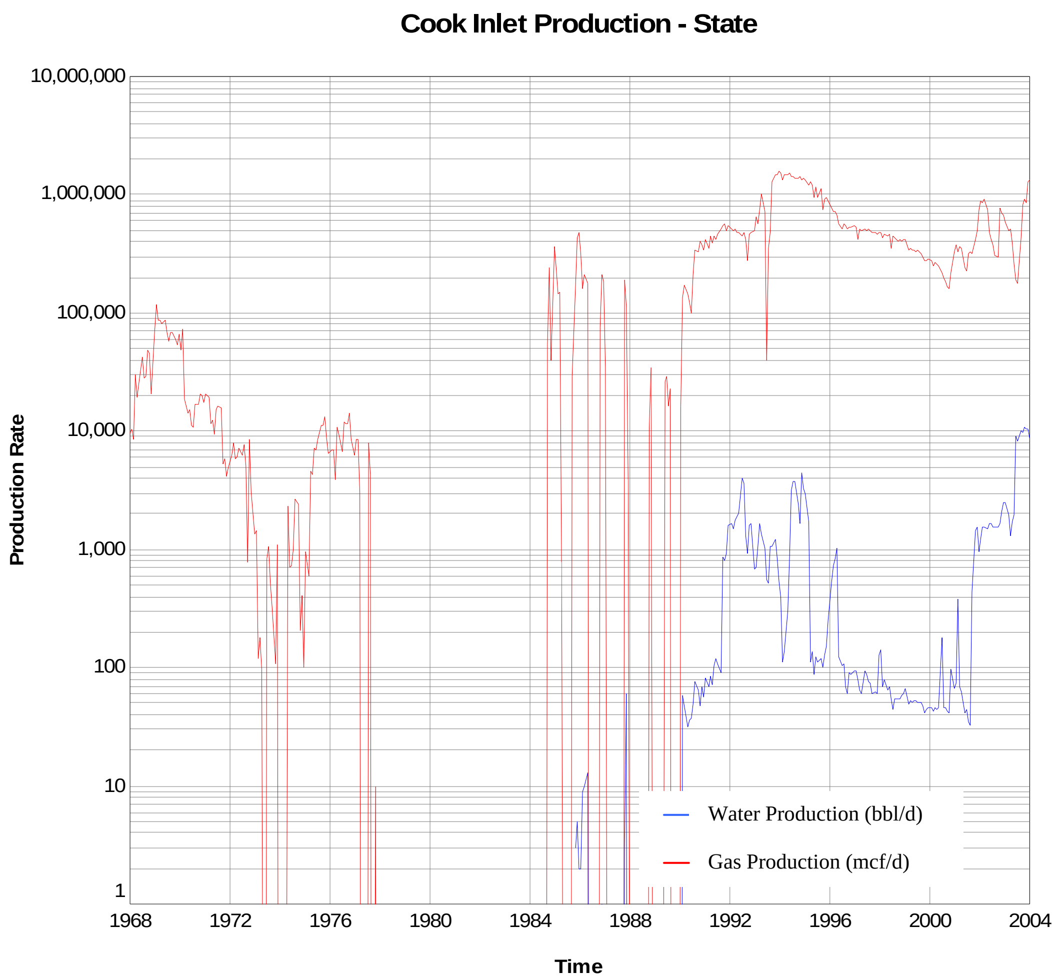

Reservoir Production - Sterling
Production Rate
100,000,000
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004
Time
Water Production (bbl/d)
Gas Production (mcf/d)

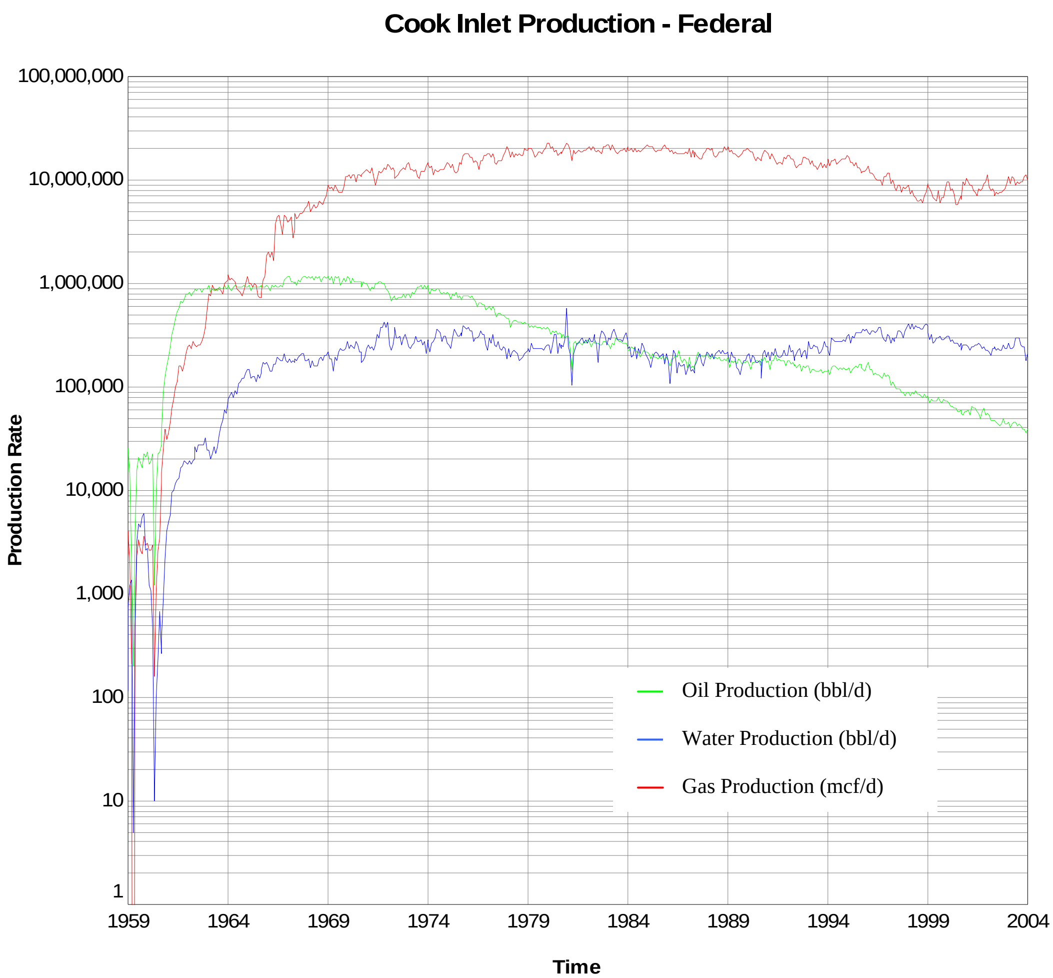

Reservoir Production - Beluga
10,000,000
1,000,000
100,000
10,000
1,000
100
10
Production Rate
1969
1974
1979
1984
1989
1994
1999
2004
Time
Water Production (bbl/d)
Gas Production (mcf/d)

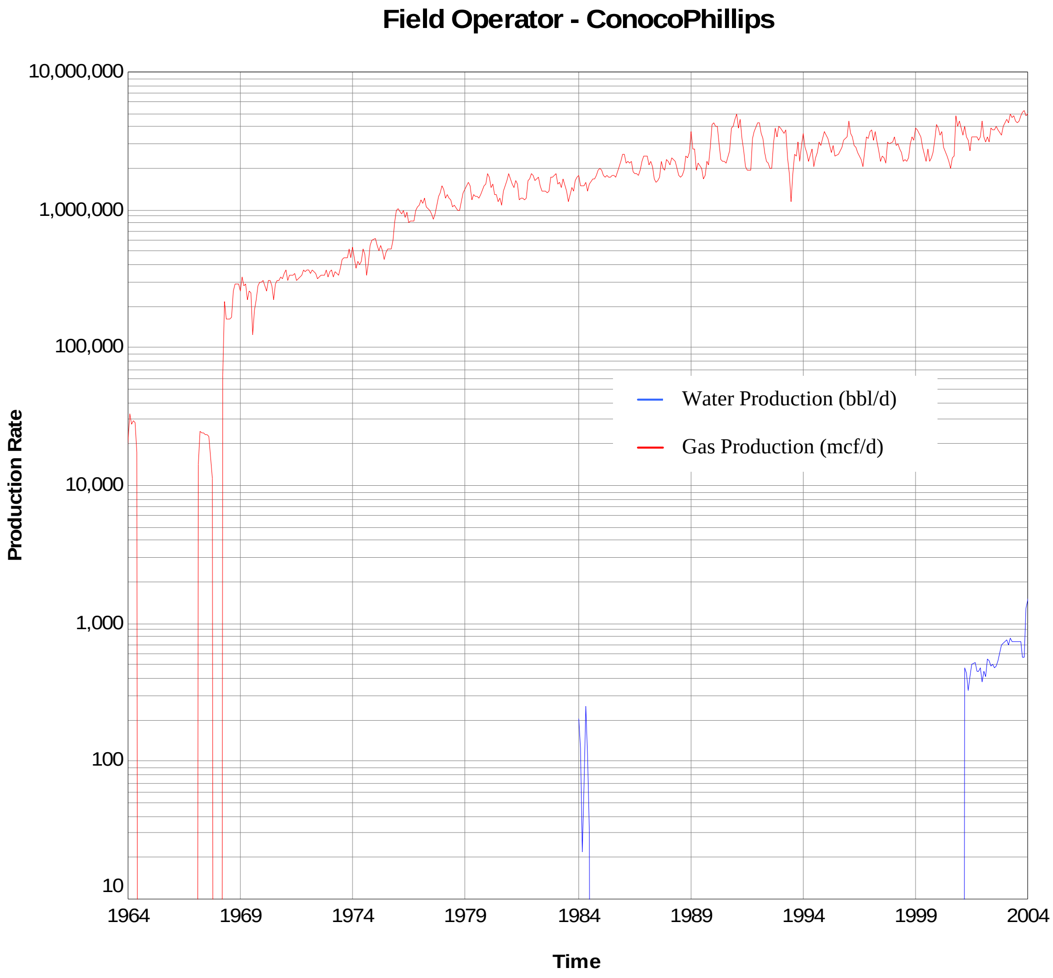

Reservoir Production - Tyonek
Production Rate
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
1964
1969
1974
1979
1984
1989
1994
1999
2004
Time
Oil Production (bbl/d)
Water Production (bbl/d)
Gas Production (mcf/d)



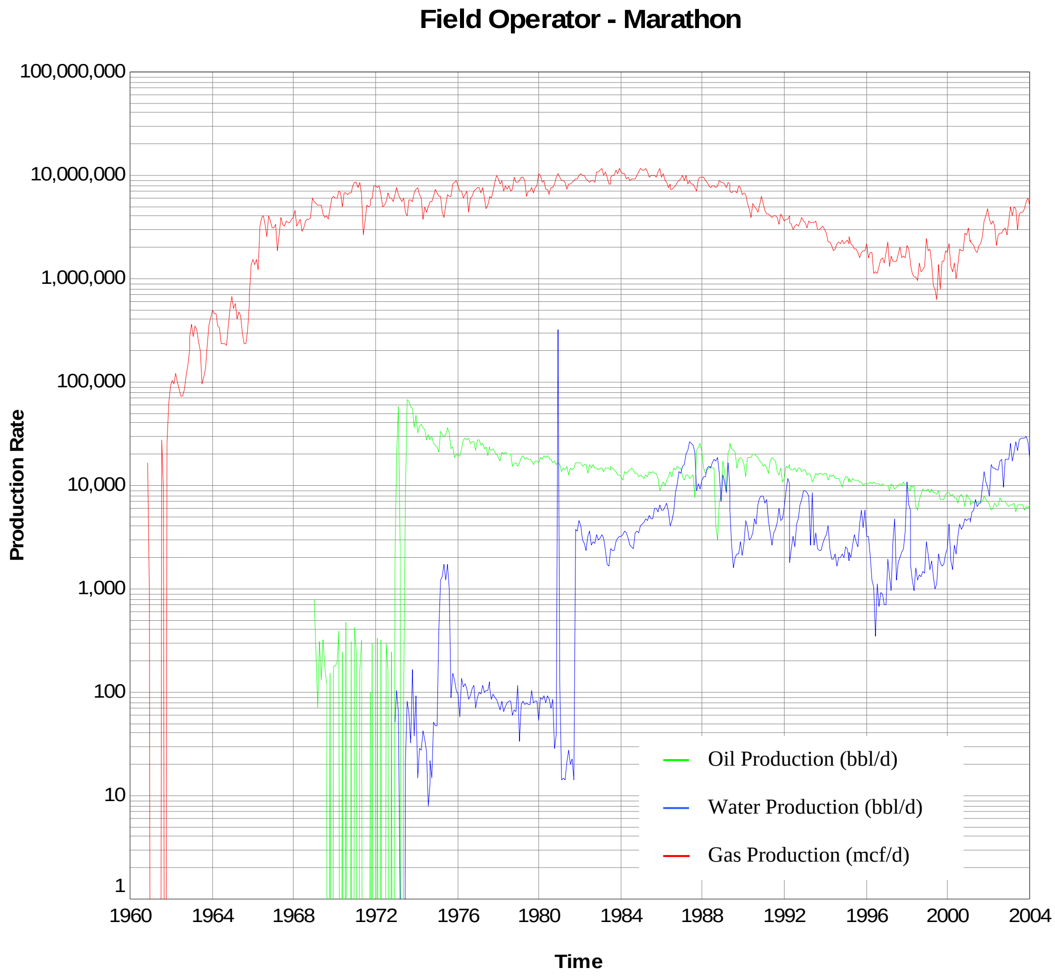
Reservoir Production - Hemlock
Production Rate
100,000,000
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
Time
Oil Production (bbl/d)
Water Production (bbl/d)
Gas Production (mcf/d)

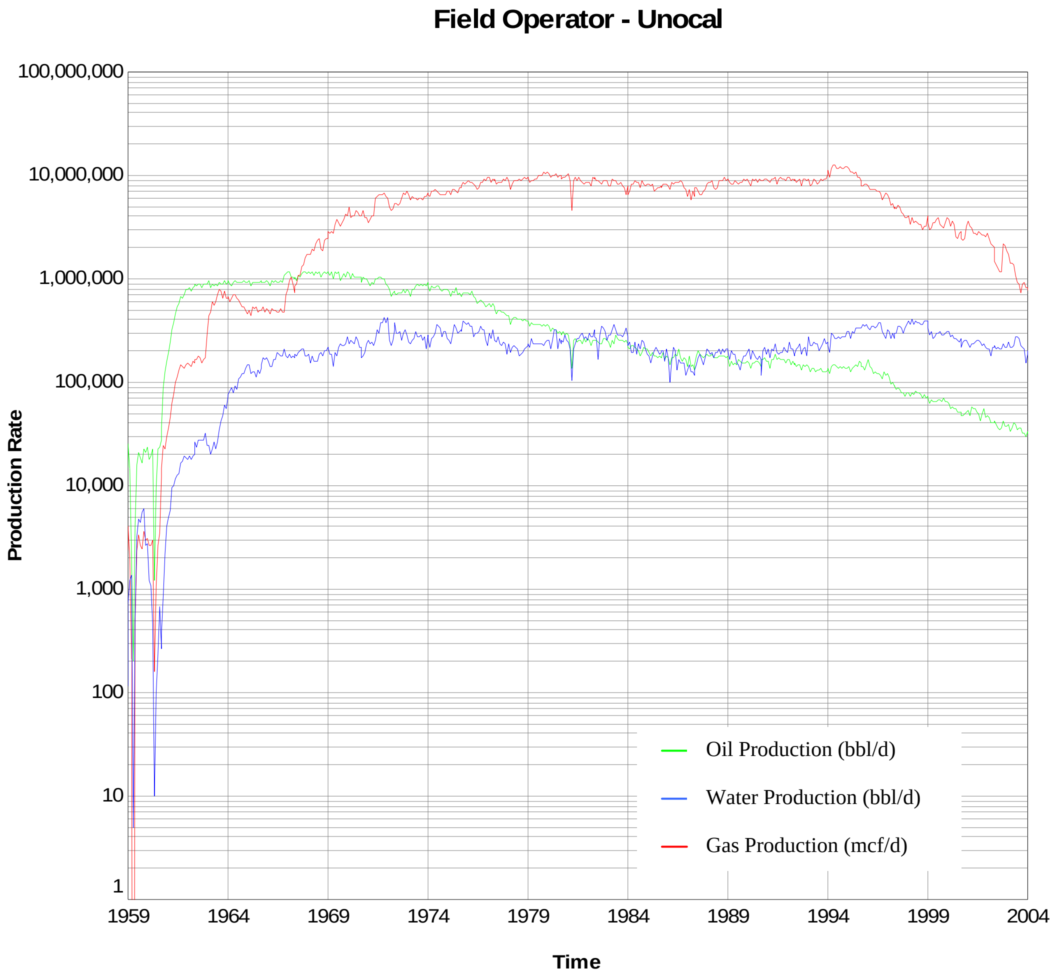

Cook Inlet Production - State
Production Rate
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004
Time
Water Production (bbl/d)
Gas Production (mcf/d)


Cook Inlet Production - Federal
100,000,000
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Production Rate
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
Time
Oil Production (bbl/d)
Water Production (bbl/d)
Gas Production (mcf/d)



Field Operator - ConocoPhillips
Production Rate
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1964
1969
1974
1979
1984
1989
1994
1999
2004
Time
Water Production (bbl/d)
Gas Production (mcf/d)


Field Operator - Marathon
Production Rate
100,000,000
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004
Time
Oil Production (bbl/d)
Water Production (bbl/d)
Gas Production (mcf/d)


Field Operator - Unocal
100,000,000
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Production Rate
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
Time
Oil Production (bbl/d)
Water Production (bbl/d)
Gas Production (mcf/d)

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Attachment B

Reasonably Foreseeable Development Scenario
For Locatable and Salable Minerals
Ring of Fire Planning Area, Alaska

July 2006

REASONABLY FORESEEABLE DEVELOPMENT SCENARIO
FOR LOCATABLE AND SALABLE MINERALS
RING OF FIRE PLANNING AREA, ALASKA

Prepared for

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

ANCHORAGE FIELD OFFICE

Prepared by

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

ALASKA STATE OFFICE

DIVISION OF ENERGY AND SOLID MATERIALS

JULY 2006

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ACRONYMS AND ABBREVIATIONS

ADNR	Alaska Department of Natural Resources
AEIDC	Arctic Environmental Information and Data Center
AFO	Anchorage Field Office
AMIS	Alaska Mineral Information System
APMA	Alaska Placer Mining Application
ARDF	Alaska Resource Data Files
BLM	Bureau of Land Management
CFR	Code of Federal Regulations
CNF	Chugach National Forest
DGGS	Alaska Division of Geological and Geophysical Surveys
FEIS	Final Environmental Impact Statement
FLPMA	Federal Land Policy and Management Act
KMDA	Known Mineral Deposit Area
kW	kilowatt
MAS/MILS	Mineral Availability System/Mineral Industry Location System
NEPA	National Environmental Policy Act
PGE	platinum group elements
PRMP	Proposed Resource Management Plan
PWS	Prince William Sound
RDI	Resource Data, Inc.
RFD	Reasonably Foreseeable Development
st	short ton
stpd	short ton per day
TNF	Tongass National Forest
URS	URS Corporation
U.S.	United States
USBOM	U.S. Bureau of Mines
USGS	U.S. Geological Survey

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EXECUTIVE SUMMARY

The Anchorage Field Office (AFO) of the Bureau of Land Management (BLM) has prepared a Proposed Resource Management Plan (PRMP)/Final Environmental Impact Statement (FEIS) for the Ring of Fire planning area to provide a comprehensive framework for managing and allocating uses of the public lands and resources within the Anchorage District. This planning process meets the requirements of the National Environmental Policy Act (NEPA) through a detailed description of the alternatives and environmental consequences resulting from each alternative. The Federal Land Policy and Management Act of 1976 (FLPMA) requires the Secretary of the Interior, with public involvement, to develop, maintain, and when appropriate, revise land use plans that provide tracts or areas for the use of the public lands.

The Ring of Fire planning area encompasses an area from the Aleutian Islands at the southwestern tip of Alaska, through the Alaska Peninsula, parts of southcentral Alaska, through the southeast panhandle. The planning area is divided into four geographic regions: Alaska Peninsula/Aleutian Chain region, Kodiak region, southcentral region, and southeast region.

Reasonably Foreseeable Development (RFD) scenarios provide a mechanism to analyze the effects that discretionary planning decisions have on mineral development based upon four alternatives. This RFD scenario is used to predict the type, location, and manner of potential disturbance due locatable minerals extraction in the planning area over the next 15 years. This report has been formulated to project and predict development regardless of specific land management authority (federal, State, Native, or private), but concentrates on the high mineral potential areas located on unencumbered BLM lands and State- and Native-selected lands.

A range of four alternatives was developed during the Ring of Fire PRMP/FEIS process. These include Alternative A – No Action (Current Management), Alternative B – Resource Development, Alternative C – Resource Conservation, and Alternative D – Proposed Action. Due to the diminutive amount of BLM-managed lands within the planning area, the level of disturbance from reasonably foreseeable locatable mineral activity would be minimal. If the maximum amount of activity is allowed (Alternative B – Resource Development), an estimated total of 59 acres could potentially be disturbed in the Ring of Fire planning area. If the least amount of activity is allowed (Alternative C – Resource Conservation), an estimated total of 5 acres could potentially be disturbed on existing valid operation in the Ring of Fire planning area. If reasonable accommodations are given to all parties, (Alternative D – Proposed Action), an estimated maximum total of 59 acres could potentially be disturbed in the Ring of Fire planning area. However, due to its sensitive nature, the Neacola Mountains-Blockade Glacier area could remain closed to mineral entry and thus diminish the disturbed acreage estimate.

1.0 INTRODUCTION

The Anchorage Field Office (AFO) of the Bureau of Land Management (BLM) has prepared a Proposed Resource Management Plan (PRMP)/Final Environmental Impact Statement (FEIS) in the Ring of Fire planning area to provide a comprehensive framework for managing and allocating uses of the public lands and resources within the Anchorage District. This planning process will meet the requirements of the National Environmental Policy Act (NEPA) through a detailed description of the alternatives and environmental consequences resulting from each alternative. The Federal Land Policy and Management Act of 1976 (FLPMA), as amended, provides the authority for the BLM land use planning on public lands. In particular, Section 202 (a) requires the Secretary of the Interior, with public involvement, to develop, maintain, and when appropriate, revise land use plans that provide by tracts or areas for the use of the public lands. Implementing regulations are contained in 43 Code of Federal Regulations (CFR) 1610. BLM Manual, 1601 Land Use Planning, and a handbook (H-1601-1 Land Use Planning Handbook), provide procedures and guidance for the planning process.

The Ring of Fire planning area encompasses an area some 2,500 miles long, from the Aleutian Islands at the southwestern tip of Alaska, through the Alaska Peninsula, parts of southcentral Alaska, through the southeast panhandle. The planning area is divided into four geographic regions: (1) Alaska Peninsula/Aleutian Chain region, (2) Kodiak region, (3) southcentral region, and (4) southeast region. The southcentral region includes the Cook Inlet area, Matanuska-Susitna Valley, and Kenai Peninsula, but excludes eastern Prince William Sound (PWS) and the Wrangell Mountains to the east. The southeast region extends from Yakutat Bay to the southeastern tip of Alaska.

This Reasonably Foreseeable Development (RFD) scenario: 1) provides a mechanism to analyze the effects that discretionary planning decisions have on mineral development, and 2) summarizes basic information used in developing the various alternatives analyzed in the NEPA document. By incorporating available geologic and economic information, as well as utilizing federal and State mineral assessment reports, this RFD scenario is used to predict the type, location, and manner of potential locatable mineral extraction in the Ring of Fire planning area over the next 15 years. RFD scenario's have been formulated to project and predict development regardless of specific land management authority, federal, State, Native, or private; but concentrates on the high mineral potential areas located on unencumbered BLM land and State- and Native-selected lands. The following sections present what has been identified about the geology, known mineral occurrences, and unknown potential of the Ring of Fire planning area.

2.0 DESCRIPTION OF GEOLOGY

2.1.1 Mineral Terranes

The Ring of Fire planning area is underlain by 13 mineral terrane units whose geologic settings are considered highly favorable for the existence of metallic mineral resources (Arctic Environmental Information and Data Center [AEIDC] 1982, Resource Data, Inc. [RDI] *et al.* 1995). The geologic nature of each terrane will determine specific commodities and mineral deposit types. Unmapped areas are generally evaluated as having poor to only moderate mineral potential. Mineral terranes located within each region are discussed below and listed in Table 1 and shown in Figures 1 through 3.

Table 1. Mineral Terranes Identified in the Ring of Fire Planning Area

Map unit	Name	Description	Favorable deposits
IGA	Alkalic granitic rocks	Syenite, locally including peralkaline granite and monzonite	Uranium, rare earth elements, and molybdenum
IGF	Felsic granitic rocks	Granite and quartz monzonite	Tin, tungsten, molybdenum, uranium, and thorium
IGI	Intermediate granitic rocks	Granodiorite and quartz diorite	Copper, gold, and molybdenum
IGU	Undivided granitic rocks	Granite	Uranium, thorium, rare earth elements, tin, tungsten, molybdenum, copper, and gold
IMA	Mafic intrusive rocks	Gabbro, locally including mafic-rich intermediate rocks including mafic monzonite and diorite	Copper and nickel with byproduct platinum and cobalt
IUM	Ultramafic rocks	Peridotite and dunite	Chromium, nickel, and platinum group metals with byproduct cobalt
SCB	Continental sedimentary rocks	Coal-bearing sandstone, shale, and conglomerate	Coal and uranium with byproduct vanadium
SGS	Graywacke and shale	Interbedded with minor volcanic rocks	Gold or a variety of metals
VFI	Intermediate volcanic rocks	Trachyandesite and andesite	Uranium and thorium
VFU	Felsic volcanic rocks	Undivided hyolite and quartz latite	Copper, lead, and zinc with byproduct silver and gold
VMU	Mafic volcanic rocks	Undivided primarily basalt	Copper and zinc with byproduct silver and gold
VSF	Sedimentary and felsic volcanic rocks	Undivided rhyolite, quartz latite, and associated sediments	Copper and zinc with byproduct silver and gold
VSM	Sedimentary and mafic volcanic rocks	Undivided basalt and associated sediments	Copper and zinc with byproduct silver and gold

Alaska Peninsula/Aleutian Chain Region: Felsic granitic rocks; favorable for tin, tungsten, molybdenum, uranium, and thorium deposits. Intermediate granitic rocks; favorable for copper, gold, and molybdenum deposits. Coal-bearing sedimentary rocks; favorable for coal and uranium with byproduct vanadium deposits. Felsic and intermediate volcanic rocks; favorable for epithermal gold, silver, and mercury deposits. Undivided mafic volcanic rocks; favorable for copper and zinc deposits with byproducts of silver and gold. Undivided sedimentary and felsic volcanic rocks; favorable for copper, lead, and zinc deposits with byproducts of silver and gold. Undivided sedimentary and mafic volcanic rocks; favorable for copper and zinc deposits with byproducts of silver and gold (Figure 1).

Kodiak Region: Felsic granitic rocks; favorable for tin, tungsten, molybdenum, uranium, and thorium deposits. Intermediate granitic rocks; favorable for copper, gold, and molybdenum deposits. Ultramafic rocks; favorable for chromium, nickel, and platinum group metal deposits with byproduct of cobalt. Graywacke and shale; favorable for gold deposits or a variety of metals. Undivided sedimentary and mafic volcanic rocks; favorable for copper and zinc deposits with byproducts of silver and gold (Figure 1).

Southcentral Region: Felsic granitic rocks; favorable for tin, tungsten, molybdenum, uranium, and thorium deposits. Intermediate granitic rocks; favorable for copper, gold, and molybdenum deposits. Undivided granitic rocks: favorable for uranium, thorium, rare earths, tin, tungsten, molybdenum, copper, and gold deposits. Mafic intrusive rocks; favorable for copper and nickel deposits with byproducts of platinum and cobalt. Ultramafic rocks; favorable for chromium, nickel, and platinum group metal deposits with byproduct of cobalt. Coal-bearing sedimentary rocks; favorable for coal and uranium deposits with byproduct of vanadium. Interbedded graywacke and shale with minor volcanic rocks; favorable for gold or a variety of metal deposits. Felsic and intermediate volcanic rocks; favorable for epithermal gold, silver, and mercury deposits. Undivided mafic volcanic rocks; favorable for copper and zinc deposits with byproducts of silver and gold. Undivided sedimentary and mafic volcanic rocks; favorable for copper and zinc deposits with byproducts of silver and gold (Figure 2).

Southeast Region: Alkalic granitic rocks; favorable for uranium and rare earths deposits. Felsic granitic rocks; favorable for tin, tungsten, molybdenum, uranium, and thorium deposits. Intermediate granitic rocks; favorable for copper, gold, and molybdenum deposits. Undivided granitic rocks; favorable for uranium, thorium, rare earths, tin, tungsten, molybdenum, copper, and gold deposits. Mafic intrusive rocks; favorable for copper and nickel deposits with byproducts of platinum and cobalt. Ultramafic rocks; favorable for chromium, nickel, and platinum group metal deposits with byproduct of cobalt. Coal-bearing sedimentary rocks; favorable for coal and uranium deposits with byproduct of vanadium. Interbedded graywacke and shale with minor volcanic rocks; favorable for gold or a variety of metal deposits. Undivided felsic volcanic rocks; favorable for copper, lead, and zinc deposits with byproducts of silver and gold. Undivided mafic volcanic rocks favorable for copper and zinc deposits with byproducts of silver and gold. Undivided sedimentary and felsic volcanic rocks; favorable for copper, lead, and zinc deposits with byproducts of silver and gold. Undivided sedimentary and mafic volcanic rocks; favorable for copper and zinc deposits with byproducts of silver and gold (Figure 3).

2.2 Known Mineral Deposit Areas

Known Mineral Deposit Areas (KMDAs) are described as a management tool for determining the likelihood of future discoveries in a particular area. They are based on a high concentration of historic mines and prospects, mineral occurrences in the Mineral Availability System/Mineral Industry Location System (MAS/MILS) database, and favorable geologic trends determined by mineral terrane mapping and have either been identified during mineral assessment studies or shown on the Mineral Terranes of Alaska map (Maas et al 1995; RDI *et al.* 1995). Bittenbender *et al.* (1999) and Still *et al.* (2002) define KMDAs as having a high concentration of mineral occurrences of a single type, which suggests an increased likelihood that the rocks host significant mineral deposits compared to other areas. The most recent version of KMDAs electronically available (RDI *et al.* 1995) is depicted on Figures 1 through 3. In some areas of the Ring of Fire planning area, more recent BLM or United States (U.S.) Geological Survey

(USGS) have resulted in revisions of KMDA boundaries investigations (e.g., Bittenbender *et al.* 1999; Nelson and Miller 2000; Still *et al.* 2002).

Alaska Peninsula/Aleutian Chain Region: No KMDAs have been identified in the Alaska Peninsula/Aleutian Chain region.

Kodiak Region: No KMDAs have been identified in the Kodiak region.

Southcentral Region: No KMDAs have been identified in the southcentral region.

Southeast Region: KMDAs were established in the southeast region during development of the Tongass National Forest (TNF) Land Management Plan in 1991, and during the mid-1990s for the rest of the Ring of Fire planning area by the U.S. Bureau of Mines (USBOM) (RDI *et al.* 1995).

2.3 High Mineral Occurrence Potential Areas

High, medium, and low mineral potential areas within the Ring of Fire planning area have been identified in the Mineral Occurrence and Development Report written by URS Corporation (URS) (2004) and are shown on the locatable mineral potential maps (Figures 1 through 3). The following section is based upon those findings.

Alaska Peninsula/Aleutian Chain Region: Seven small areas with high mineral potential have been identified in the Alaska Peninsula/Aleutian Chain region. The sites include: Mount Chiginak area; northern Chignuk Bay-Black Peak area; the southern part of Unga Island; the Mount Dana area; two locations on Unalaska Island at the northwest and southeastern areas; and the central Umnak Island between Inanudak Bay and Thumb Point (Figure 4).

Kodiak Region: Three small areas with high mineral potential have been identified on Kodiak Island and two small areas on the Trinity Islands. The sites on Kodiak Island include: just north of Low Cape on the west end of the island; the area along Sevenmile Beach; east of Rocky Point; on the northwest end of the island; and the area between the head of Uganik Passage and Terror Bay on the northwest end of the island. The sites on the Trinity Islands include the western end of Tugidak Island and the southwestern edge of Sitkinak Island (Figure 4).

Southcentral Region: Thirty-four areas with high mineral potential have been identified in the southcentral region. The sites include: the headwaters of Crevice Creek; the north side of Bruin Bay; Mt. Spurr; the Tordrillo Mountains; the Camp Creek area; the Peters Creek and Cache Creek area; the Talkeetna Mountains; the Willow Creek and Chickaloon areas; the Girdwood area; Resurrection Creek to Cooper Landing area; Moose Pass to Seward area; Knight Island; and several sites in the western PWS (Figure 5).

Southeast Region: Thirty-three areas with high mineral potential have been identified in the southeast region. The sites include: two areas near Yakutat along Monti Bay and the Black sand Spit areas; the Minnesota Ridge in the Muir Inlet area; two areas on Mt. Seltat; four areas along Lynn Canal, three on the east side and on the west side; the Juneau area, two sites on the west side of Taku Inlet, the northern part of Admiralty Island; six sites scattered along Baranof Island; on the southeastern side of Kupreanof Island; the northwest and southeast sides of Cleveland Peninsula; five sites on the eastern to southern end of Prince of Wales Island; and the southcentral part of Duke Island (Figure 6).

3.0 HISTORICAL EXPLORATION ACTIVITY

Historical exploration activity is discussed here to describe the extent of current mineral industry activity within the entire Ring of Fire planning area. This discussion creates a baseline of understanding as to which target areas the mineral industry is interested and to what extent their activity is occurring. Information for this section comes from numerous sources including the BLM and State mining claim databases, Alaska Division of Geological and Geophysical Surveys (DGGS) 2003 *Mineral Industry Activity Report* (Szumagala *et al.* 2004), and URS's Draft *Mineral Occurrence Potential Report* (2004).

3.1.1 Mineral Claim Staking

Mining claims have been staked throughout the Ring of Fire planning area. Extensive claim staking has historically occurred on Unga Island, the Petersville-Cache Creek, Collinsville, Hatcher Pass, Crow Creek, Hope/Resurrection Creek, Haines-Skagway, Juneau-Admiralty Island, Chichagof-Baranof Island, Stikine, Ketchikan-Hyder, and Duke Island areas. The following discussion covers the entire area, and then defines those mining claims staked on BLM unencumbered, State- or Native-selected lands.

Alaska Peninsula/Aleutian Chain Region: The only active claims in the Alaska Peninsula/Aleutian Chain region are State claims on Unga Island. These claims are not located on BLM unencumbered, State- or Native-selected lands.

Kodiak Region: There are no active federal or State mining claims on BLM unencumbered, State- or Native-selected lands on Kodiak Island.

Southcentral Region: Numerous active federal and State mining claims are located in the southcentral region. No active mining claims are located on BLM unencumbered lands. A dozen or so federal claims are located on state land in the Petersville-Cache Creek, Collinsville, and Hatcher Pass areas, and have federal subsurface estate. These claims were located prior to State selection, and the federal government retains the subsurface estate as long as these claims remain active. Very few active mining claims are actually located on State- and Native-selected lands. Those active mining claims are located in the Chickaloon, Knik River, Girdwood, Hope/Resurrection Creek, and the Moose Pass areas. The Chickaloon and Knik River areas are Native-selected and the Moose Pass area is State-selected. Girdwood, Hope/Resurrection Creek, and the Moose Pass areas are located within the Chugach National Forest (CNF).

Southeast Region: Numerous active federal and State mining claims are located in the southeast region. Active federal mining claims are located on BLM unencumbered lands on the west side of Silver Bay, Baranof Island. Active federal claims are located on State land in the Porcupine Creek area and have federal subsurface estate. These claims were located prior to State selection, and the federal government retains the subsurface estate as long as these claims remain active. Active mining claims are located on State-selected lands in the Porcupine Creek area, Tsirku River area, Juneau area, northern end of Admiralty Island, north of Hyder, head of Trocadero Bay Prince of Wales Island, and on the Duke and Kelp Islands. Most of the active mining claims in the southeast region are located within TNF.

3.1.2 Exploration Activities

The DGGS publishes yearly reports outlining the exploration activity in Alaska. The following information is based on the current information for 2003 (Szumigala *et al.* 2004) covering the entire Ring of Fire planning area.

Alaska Peninsula/Aleutian Chain Region: No current exploration activity is occurring in the Alaska Peninsula/Aleutian Chain region.

Kodiak Region: No current exploration activity is occurring in the Kodiak region.

Southcentral Region: Current exploration in the southcentral region is occurring at Shulin Lake, located along the Kahiltna River, approximately 25 miles south of Peters Creek. This is a diamond property being explored by Golconda Resources, Ltd. and Shulin Lake Mining Co. by diamond drilling on a structure about 1.25 miles in diameter.

Southeast Region: Current exploration in the southeast region is occurring at four locations. These include: Greens Creek Mine, Woewodski Island, Union Bay, and Duke Island. Exploration is continuing at the Greens Creek silver mine by Kennecott Minerals Co. to extend the mineralized zones and resources of the mine. Drilling was conducted on the west side of the Gallagher Fault, which truncates the large ore body. Bravo Venture Group with Olympic Resources Group, LLC drilled the Lost Lake silver, lead, zinc prospect, on Woewodski Island, intersecting volcanogenic massive sulfide mineralization consisting of semi-massive and massive sphalerite, galena, and silver. Pacific Northwest Capital Corp., Freegold Ventures Ltd., and Lonmin PLC continued an extensive exploration program on their Union Bay platinum prospect, located near Ketchikan. Additional federal claims were staked and extensive channel sampling and diamond drilling was conducted on the Jaguar, Mt. Burnett, North, and Continental zones. Quaterra Resources, Inc. continued their exploration activities on Duke Island, south of Ketchikan, by staking new claims covering new copper discoveries identified from geophysical anomalies.

3.1.3 Federal and State Field Studies

No known field studies are currently being conducted in the Ring of Fire planning area by any pertinent federal or State agency. The USBOM and BLM, in cooperation with the USGS and DGGS, have completed mineral assessment studies and economic studies throughout the southeast region. Studies were completed for the Chichagof, Hyder, Juneau, Ketchikan, Kupreanof, and Petersburg mining districts.

3.1.4 Geophysical Surveys

Aeromagnetic surveys were conducted during the 1960s through the 1980s (URS 2004). Digital aeromagnetic surveys were conducted in the southcentral region in the early 2000s. Airborne geophysical programs have been flown in the Ketchikan and Stikine areas in the southeast region (Bittenbender *et al.* 2001) in support of the mineral assessment studies conducted for the Ketchikan and Sitka mining districts.

No other known airborne geophysical programs have been conducted by federal or State agencies within the Ring of Fire planning area.

3.1.5 New Deposit Discoveries

The DGGS publishes yearly reports outlining the exploration activity in Alaska. The following information is based on the current information for 2003 (Szumigala *et al.* 2004).

Alaska Peninsula/Aleutian Chain Region: No new discoveries were reported during 2003 in the Alaska Peninsula/Aleutian Chain region.

Kodiak Region: No new discoveries were reported during 2003 in the Kodiak region.

Southcentral Region: No new discoveries were reported during 2003 in the southcentral region.

Southeast Region: Quaterra Resources Inc. continued their exploration activities on Duke Island, south of Ketchikan, finding new copper discoveries identified from geophysical anomalies.

4.0 PAST AND PRESENT DEVELOPMENT ACTIVITY

Past and present development activity is discussed here to characterize the extent of current mineral industry activity within the entire Ring of Fire planning area. This discussion creates a baseline of understanding regarding the mineralized targets of interest to the mineral industry and to what extent their development activities are occurring. Information for this section comes from numerous sources including the DGGS 2003 *Mineral Industry Activity Report* (Szumagala *et al.* 2004) and URS's *Draft Mineral Occurrence Potential Report* (2004).

4.1.1 Past Development Activity

There has been extensive development activity within the Ring of Fire planning area boundary including large scale mining operations. These operations include the Apollo Mine in the Alaska Peninsula/Aleutian Chain region, the Independence Mine in the southcentral region, and the A-J and Kensington Mines in the southeast region. Extensive placer mining activity has occurred in the Petersville-Cache Creek, Collinsville, Hatcher Pass, Crow Creek, and Hope/Resurrection Creek areas in the southcentral region, and in the Yakutat, Haines-Skagway, Juneau-Admiralty Island, Chichagof-Baranof Island, Stikine, Ketchikan-Hyder, and Duke Island areas in the southeast region, to name a few. Only one inactive prospect (Belle) is located on BLM unencumbered lands within the Ring of Fire planning area, and is located east of Sitka in the southeast region.

Table 2 lists the mineral occurrences in the high mineral potential areas that are located on BLM unencumbered lands and State- and Native-selected lands in the Ring of Fire planning area boundary. Numerous properties located in the southcentral region are located in CNF, and in TNF in the southeast region. This information was derived using BLM's Alaska Mineral Information System (AMIS) (BLM 2004) and the USGS's Alaska Resources Data Files (ARDF) (USGS 2005).

Table 2. Select Mineral Occurrences Located in the High Mineral Potential Areas in the Ring of Fire Planning Area

Deposit Name	ARDF/ Amis No.	Commodities	Deposit Type	Land Status
ALASKA PENINSULA/ALEUTIAN CHAIN REGION				
Native-Selected Lands				
Unnamed	UK002/144-002	Cu, Mo	Unknown	Native-selected
Steeple Point	UK011/144-011	Au, Ag	Hot Springs Au-Ag (Cox 25a)	Native-selected
Unnamed	UN020/143-023	Cu	Porphyry Cu (Cox 17)	Native-selected
Makushin Volcano S	UN003/143-001	S	Fumarolic Sulfur	Native-selected
PMRGX-18	PM025/138-041	Pb, Zn	Unknown	Native-selected
Pyramid	PM023/138-039	Cu, Mo	Porphyry Cu-Mo (Cox 21a)	Native-selected
SOUTHCENTRAL REGION				
Native-Selected Lands				
Kings Bay Placer	95-074	Au	Placer Au (Cox 39a)	USFS/Native-selected
State-Selected Lands				
Crown Point Mine	95-114	Au, Ag, Cu, Pb, Zn	Chugach-type (Bliss 36a.1)	USFS/State-selected
East Point Mine	95-095	Au, Ag	Chugach-type (Bliss 36a.1)	USFS/State-selected
Skeen-Lechner	95-116	Au, Ag, Pb, Zn	Chugach-type (Bliss 36a.1)	USFS/State-selected
Falls Creek Mine	95-113	Au, Ag	Chugach-type (Bliss 36a.1)	USFS/State-selected
California Creek	95-115	Au, Pb, Zn	Chugach-type (Bliss 36a.1)	USFS/State-selected
Jones	95-160	Au	Placer Au (Cox 39a)	USFS/State-selected
Mine 7-1/2	95-361	Au, Ag	Chugach-type (Bliss 36a.1)	USFS/State-selected

Table 2 (continued). Select Mineral Occurrences Located in the High Mineral Potential Areas in the Ring of Fire Planning Area

Deposit Name	ARDF/ Amis No.	Commodities	Deposit Type	Land Status
Canyon Creek	95-267	Au	Placer Au (Cox 39a)	USFS/State-selected
Crow Creek Mine	AN104/85-254	Au	Placer Au (Cox 39a)	USFS/State-selected
Raggedtop Mountain	AN106/85-322	Au	Chugach-type (Bliss 36a.1)	USFS/State-selected
Jewell/Monarch[1]	AN107/85-101	Au	Chugach-type (Bliss 36a.1)	USFS/State-selected
Brenner	AN108/85-296	Au, Mo, Pb, Zn	Chugach-type (Bliss 36a.1)	USFS/State-selected
Agostino	AN109	Au	Chugach-type (Bliss 36a.1)	USFS/State-selected
Summit Mountain	AN111/85-323	Au	Chugach-type (Bliss 36a.1)	USFS/State-selected
Bahrenberg Mine[2]	AN110/85-297	Au, Ag, Cu, Pb, Zn	Chugach-type (Bliss 36a.1)	USFS/State-selected
Monarch Mine	85-295	Au, Ag, Cu, Mo	Chugach-type (Bliss 36a.1)	USFS/State-selected
SOUTHEAST REGION				
BLM unencumbered Lands				
Belle	114-163	Ag, Cu, Au	Unknown	BLM
Native-Selected Lands				
Situk Beach	YA007	Au, Fe, PGE, Ti	Beach placer (Cox 39a)	Native-selected
Yakutat Beach	YA002/108-010	Au, Fe, Ti	Beach placer (Cox 39a)	Native-selected
Crystal	119-030	Qtz crystals	Unknown	Native-selected
Westlake	CR214/119-060	Cu, Pb, Au, Zn	Unknown	Native-selected
Hope	CR213	Au, Ag, Cu	Unknown	Native-selected
Bluebird	CR214	Au	Low-sulfide Au-Qtz (Cox 36a)	Native-selected
State-Selected Lands				
Nancy	CR107/119-082	Cu	Unknown	USFS/State-selected
Cable Creek	CR106	Au, Cu, Zn	Kuroko massive sulfide (Cox 28a)	State-selected
Judd Harbor	122-003	Fe, Ni, Cr	Alaskan PGE (Cox 9)	USFS/State-selected
Tsiruku River	109-037	Au, Ag	Placer Au (Cox 39a)	State-selected
Le Blondeau	SK050/109-103	Au, Ag	Polymetallic veins (Cox 22c)	State-selected
Salmon Creek	JU131/112-168	Au	Placer Au (Cox 39a)	State-selected
Goldstein	JU133/112-196	Ag, Au, Cu	Low-sulfide Au-Qtz (Cox 36a)	State-selected
Hallum	JU144/112-129	Au	Low-sulfide Au-Qtz (Cox 36a)	State-selected
Cottonwood Creek	SK049/109-024	Au	Placer Au (Cox 39a)	State-selected
Nugget Creek	SK048/109-034	Au	Placer Au (Cox 39a)	State-selected
Big Nugget Mine	109-057	Au	Placer Au (Cox 39a)	State
Porcupine Creek	SK041/109-036	Au	Placer Au (Cox 39a)	State
KODIAK REGION				
State-Selected Lands				
None				
Native-Selected Lands				
None				

Notes: [1] 3,100 tons averaging 1.75 oz/ton gold and 0.75 oz/ton silver
[2] Reserves at 344 tons

Ag = silver	Pb = lead
Au = gold	PGE =platinum group elements
Cr = chromium	Qtz = quartz
Cu = copper	S = sulfur
Fe = iron	Ti = tin
Mo = molybdenum	USFS = U.S. Forest Service
Ni = nickel	Zn = zinc

4.1.2 Present Development Activity

The DGGS publishes yearly reports outlining the development activity in Alaska. The following information is based on the current information for 2003 (Szumigala *et al.* 2004) covering the entire Ring of Fire planning area.

Alaska Peninsula/Aleutian Chain Region: No current development activity is occurring in the Alaska Peninsula/Aleutian Chain region.

Kodiak Region: No current development activity is occurring in the Kodiak region.

Southcentral Region: No current lode development activity is occurring in the southcentral region. Placer gold development occurred in the Petersville-Cache Creek, Collinsville, and Hatcher Pass areas.

Southeast Region: Current development in the southeast region is occurring at two locations. These include: The Greens Creek Mine and Kensington Mine in the Juneau area. Development is continuing at the Greens Creek silver mine by Kennecott Minerals Co. and Hecla Mining Co. consisting of access drifting and underground diamond drilling. Coeur Alaska continued to permit the Kensington Mine in cooperation with federal, State, and local agencies. These properties are located within TNF. No development work was reported on placer deposits in the southeast region (Szumigala *et al.* 2004).

4.1.3 Mining Activity

The DGGS publishes yearly reports outlining the mining/production activity in Alaska. The following information is based on the current information for 2003 (Szumigala *et al.* 2004) covering the entire Ring of Fire planning area.

Alaska Peninsula/Aleutian Chain Region: No current mining activity is occurring in the Alaska Peninsula/Aleutian Chain region.

Kodiak Region: No current mining activity is occurring in the Kodiak region.

Southcentral Region: Three small placer operations reported mining activity in the southcentral region on Crow, Canyon, and Quartz Creeks. Crow Creek is the only placer operation located on State-selected lands within the southcentral region.

Southeast Region: The Greens Creek Mine was the only producing mine in the southeast region. Reported mill throughput was 781,200 tons of ore with metal recovery of 76,200 tons of zinc, 24,800 tons of lead, 11,707,000 ounces of silver, and 99,000 ounces of gold.

5.0 INDUSTRIAL MINERALS

Industrial minerals have been identified within the Ring of Fire planning area as discussed in the URS's *Mineral Occurrence Potential Report* (2004). All of the occurrences discussed are located in the southeast region. Occurrences include gypsum on Chichagof Island, asbestos on Admiralty and Annette Islands, graphite near Stikine, fluorite near Wrangell, mica on Sitklan Island, wollastonite on Prince of Wales Island, and limestone, barite, and gemstones occur throughout the area. Limestones and marbles, pure enough to be considered for development, occur on Prince of Wales and Dall Islands. None of these deposits occur on or near BLM unencumbered or State- or Native-selected lands, and therefore are not considered as part of this report.

6.0 SALABLE MINERALS

Salable minerals including sand and gravel, building stone, pumice, clay, and limestone are common throughout the Ring of Fire planning area (URS 2004). Production of sand and gravel during 2003 is reported by the State of Alaska (Szumagala *et al.* 2004) to include a small amount from Bristol Bay Borough lands in the Alaska Peninsula/Aleutian Chain region. Totals include 5,138,000 tons of sand and gravel from 16 operations in the southcentral region and 1,124,200 tons of sand, gravel, and rock from nine operations in the southeast region. There are no known current salable mineral activities on BLM unencumbered or State- or Native-selected lands within the Ring of Fire planning area.

Building stone, including limestone and marble, has been reported to be quarried primarily in the southeast region. Prince of Wales and Dall Islands have large quantities of pure limestone and marble quarried (URS 2004). Kodiak Island, the Turnagain Arm area, both sides of lower Cook Inlet, and the Matanuska-Susitna Valley, have had dimension stone quarried for riprap and construction purposes (URS 2004).

Pumice deposits occur throughout the Alaska Peninsula/Aleutian Chain region (URS 2004). As there is no foreseeable development potential for this material due to the great distances from the markets, this material will not be considered as part of this report.

Clay deposits occur in the southcentral region in the Bootleggers Cove clay in the Anchorage area, Sheep Mountain in the Matanuska Valley, near Homer, and Moose Pass on the Kenai Peninsula (URS 2004). There is an extremely small foreseeable development potential for this material due to the lack of markets. This material will not be considered as part of this report.

7.0 REASONABLY FORESEEABLE DEVELOPMENT BASELINE SCENARIO ASSUMPTIONS AND DISCUSSION

In this section the discussion is concentrated upon mineral occurrences located on BLM unencumbered lands and the State- and Native-selected lands. This is where the estimated disturbances and cumulative impacts from future mineral resource development are identified and discussed by the alternatives derived during the PRMP/FEIS process.

7.1 Locatable Minerals Economic Assumptions

The following section is a discussion of the economic viability of mining within the Ring of Fire planning area. The purpose of this discussion is to present mine deposit models, estimate amount of activity by model, and estimate the amount of disturbance of the activities through the year 2020. All discussions are based upon the following assumptions.

- All potentially productive areas are open to mineral entry, except those closed by law, regulation, or executive order (e.g., wild and scenic rivers, natural resource areas, special recreation management areas, and areas of critical environmental concern). Lands discussed in this report include BLM unencumbered lands and State- and Native-selected lands.
- Land conveyances will be completed and withdrawals will be lifted by 2010, which should allow for additional exploration.
- Additional exploration in some areas will increase the related reserve base to make mining economically feasible.
- Current management decisions influence current willingness to invest in exploration for long-term development, beyond 2020. In particular, restrictions on access now may preclude future development.
- The mine deposit models created for this report are hypothetical mining and milling scenarios made without exploration of potential mine sites or significant information about ore bodies and environmental conditions. All disturbance estimates would be increased or decreased by different terrain, ore grade, and mine development requirements. However, the bases for the estimates are active mines of a similar nature.

7.2 Mining Process Discussion

The mining process generally consists of exploration, development, extraction, processing, and reclamation.

Mineral exploration begins with prospecting, which is generally inexpensive and results in little environmental impact. Access to remote areas is generally the most expensive part of prospecting in Alaska, but other significant expenses include geochemical sampling, geophysical surveying, satellite remote sensing, and other sophisticated methods for identifying mineral deposits. After identifying a valuable target on open public (federal) land, the prospector will stake and record claims. A claimant begins target testing to confirm the presence of a deposit and determine its size, shape, characteristics, and mineral grade. This requires drilling test holes over an extended area. Because of the expense, drilling is generally limited to the extent necessary to identify sufficient reserves, which would support the costs of development.

Helicopter use can limit surface impacts where road building would otherwise be required. If the target location appears to be economic, the prospector will apply for appropriate permits to develop and operate a mine.

Mine development prepares the site for extraction, and primarily involves establishing the infrastructure necessary to mining. This includes power and water supplies, support and mineral processing facilities, and transportation facilities such as roads and airplane landing sites. Surface locations for ore stockpiles, waste rock, heap leach piles (if used), and tailings impoundments are also prepared. For an open pit mine, initial stripping of surface soils and overburden uncovers the ore body. For an underground mine, shafts or adits, drifts, crosscuts, ramps, and raises are excavated. Development generates substantial capital costs, and involves environmental impacts over the area of development. A large mine with facilities might cover a few thousand acres, with much of the surface disturbance occurring during development.

Extraction (or mining) is generally defined as drilling, blasting, loading, and hauling the ore out of the mine. Waste material may be used to backfill large mined-out areas in surface or underground mines. Continued mining will result in growing waste dumps, heap leach piles, tailings ponds, and other surface disturbances. With placer mining, generally a short section of a surface stream is relocated, the old streambed is cleared, and exposed gravels are processed through sluices. The stream is returned to its former location as part of the reclamation of the area. Suction dredging of placer deposits does not require stream relocation because a pump suctions sediment from the stream bottom to process through sluices.

Mineral processing at a mine site concentrates the ore material before shipment to a smelter or refinery. Exceptions to this include some copper ores, which may be produced on site. Concentrating includes crushing and grinding the ore, then putting the resulting material through physical or chemical processes to separate the valuable minerals from waste tailings. These tailings are disposed of in tailings ponds near the site, and the water may be recycled for reuse at the mine. The tailings may contain trace amounts of minerals, waste rock, and chemicals from processing. At some locations, tailings from old mines are remined with modern processes that allow additional mineral recovery. Tailings may be used to backfill underground stopes (voids). Tailings ponds are engineered to high standards to prevent discharge of acid runoff.

Reclamation is complete when the area is returned to beneficial non-mining use. Common practices include capping waste dumps and tailings piles with soil, removing buildings and roads, planting appropriate ground cover, and directing water flow to minimize acid runoff. This requires long-term monitoring to assure the efforts work as expected.

7.3 Forecast Deposit Model Types and Mining Production Rates

The following section uses information from similar reserves to estimate disturbance that could result from development of deposit types located on unencumbered BLM land and State- and Native-selected lands within the Ring of Fire planning area. The primary model source was Mineral Deposit Models (Cox and Singer 1986). Where information from the deposit or nearby deposits was substantially different from the Cox and Singer model, the local information was used rather than the models. Appendix 1 lists the deposits, models, reserves/resources, their estimated disturbed acreages and mine production rates.

7.3.1 Alaska Peninsula/Aleutian Chain Region

Hot-spring Gold-Silver (Cox and Singer Model 25a)

Modeled deposit reserves: not modeled by Cox and Singer.

Deposit Name	ARDF/AMIS No.	Resources	Reference	Land Status
Steeple Point	UK011	None reported[1]	Pilcher, 2000	Native-selected

Notes: [1]Samples contain arsenic, copper, gold, molybdenum, silver, and zinc; all at low value; no reserve estimate.

The USGS ARDF (Pilcher 2000 and 2002) describes over 80 locations of epithermal gold vein deposits in this portion of the Ring of Fire planning area, with additional locations not assigned deposit types. Prospects with reserve estimates range from 30,000 to 110,000 short tons (st). No prospects have been mined. This analysis used a reserve of 135,000 st and production of 100 st per day (stpd). At that production rate, disturbance is estimated to be 40 acres for basic facilities with no specific terrain or mining considerations identified. If necessary, employee housing, marine access, and road construction would be an additional 30 acres, based on an 8.5-mile road.

Conclusion: Based on recurring interest in some occurrences and prospects, it is likely one or more areas will be further explored in the reasonably foreseeable future with disturbance less than 5 acres. The time required for conveyance, exploration, permitting, and development would put the start of production near the end of the 15-year period. Any development on or near BLM-managed lands could disturb up to 70 acres of the surface.

Porphyry Copper (Cox & Singer Model 17)

Modeled deposit reserves: median deposit is 155 million st, with 80 percent between 21 and 1,212 million st (Cox and Singer 1986).

Deposit Name	ARDF/AMIS No.	Resources	Reference	Land Status
Unnamed	UN020/143-023	None reported	Wilson 1996	Native-selected
Pyramid	PM023/138-039	126 million st	Pilcher 2002	Native-selected
Unnamed	UK002/144-002	None reported	Pilcher 2000	Native-selected

Notes: st = short ton

The Pyramid location was explored in 1974 to 1975 and found to have up to 0.403 percent copper and 0.25 percent molybdenum. The reserves were estimated at 126 million st, which compares favorably with the median of the Cox and Singer model. Much less is known about the unnamed occurrences, though descriptions suggest they may be porphyry copper or similar deposits.

A reserve of 126 million st could produce 17,000 stpd for 21 years. The resulting disturbance might reach 1,340 acres by the end of the mine life. However, the reported quality is 0.403 percent copper and 0.25 percent molybdenum, which in the present market would not support the costs of production.

Conclusion: For all sites, additional exploration might occur within the foreseeable future and might result in 5 acres of disturbance during the next 15 years. The limited information on the unnamed occurrences indicates substantial exploration may be required to determine development potential, and any development is unlikely before 2020. Developing the Pyramid location requires permitting after land conveyance, and may not occur within 15 years due to ore quality.

Fumarolic Sulfur (Cox & Singer Model not identified)

Modeled deposit reserves: not identified.

Deposit Name	ARDF/AMIS No.	Resources	Reference	Land Status
Makushin Volcanic S	UN003/143-01	Reserve estimate 9,000 st high grade ore and up to 122,500 st low grade ore	Wilson 1996	Native-selected

Notes: st = short ton

This occurrence may extend to 30 acres, though the high grade area is estimated to be about 5 acres. The depth of the mineral is up to 16 feet, but estimated to be only 2 feet for the high grade area. The location is within the crater of a remote volcano with active fumaroles and vents, making it an unlikely target in the current sulfur market. Sulfur from oil and natural gas entirely replaced mining in 2000, and is expected to meet sulfur demand in the foreseeable future (Ober 2004). Given the limits of the crater and size of the reserve, any development might result in 40 to 60 acres of disturbance, depending on the ore grade cutoff used. Production rates range from 13 to 93 stpd for 2 to 4 years.

Conclusion: This location and any similar locations will not be developed in the foreseeable future.

Lead-Zinc (Cox & Singer Model not identified)

Modeled deposit reserves: not identified.

Deposit Name	ARDF/AMIS No.	Resources	Reference	Land Status
PMRGX-18	PM025	None reported	Pilcher, 2002	Native-selected

Information about this occurrence is limited, suggesting that the time necessary to explore and permit exceeds the foreseeable period. This occurrence may be similar to the Apollo Mine in the same region, though that operation targeted gold and silver. The Cox and Singer Model 22c (Polymetallic veins) is identified as representative of the Apollo Mine reserve (Pilcher 2002). This model indicates median 8,400 st, with 80 percent between 320 and 220,460 st (Cox and Singer 1986). A mine at the average of the model, reserves of 8,400 st, would require a very high grade ore body to be economic, and might result in 40 acres of disturbance. Production might occur at a rate of 12.5 stpd for less than 2 years.

Conclusion: With the time necessary for conveyance, exploration, and permitting, this occurrence will not be developed in the foreseeable future. Exploration might occur in the foreseeable future, with 5 acres disturbance.

7.3.2 Kodiak Region

No mineral deposits were identified on BLM unencumbered or State- and Native-selected lands in the Kodiak region. No deposit modeling was completed for this area.

7.3.3 Southcentral Region

Gold-Quartz Veins (Chugach-type) (Cox and Singer Model 36a)

Modeled deposit reserves: median deposit is 33,000 st, with 80 percent between 1,100 and 1 million st (Cox and Singer 1986).

Deposit Name	ARDF/ AMIS No.	Resources	Reference	Land status
Jewel/Monarch Mine	AN107/85-101	3,100 st high potential	Bickerstaff and Huss 1998	USFS/State-selected
Brahrenberg Mine	AN110/85-297	344 st	Bickerstaff and Huss 1998	USFS/State-selected
Agostino	AN109	High potential	Bickerstaff and Huss 1998	USFS/State-selected
Raggedtop Mountain	AN106/85-322	None reported	Bickerstaff and Huss 1998	USFS/State-selected
Brenner	AN108/85-296	None reported	Bickerstaff and Huss 1998	USFS/State-selected
Summit Mountain	AN111/85-323	None reported	Bickerstaff and Huss 1998	USFS/State-selected
Crown Point Mine	95-114	None reported	BLM, 2004	USFS/State-selected
East Point Mine	95-095	None reported	BLM, 2004	USFS/State-selected
Skeen-Lechner	95-116	None reported	BLM, 2004	USFS/State-selected
Falls Creek Mine	95-113	None reported	BLM, 2004	USFS/State-selected
California Creek	95-115	None reported	BLM, 2004	USFS/State-selected
Mile 7-½	95-361	None reported	BLM, 2004	USFS/State-selected
Monarch Mine	85-295	None reported	BLM, 2004	USFS/State-selected

Notes: st = short ton
USFS = U.S. Forest Service

The mines identified with high development potential have remained inactive since the 1930s or 1940s (Bickerstaff and Huss 1998). These locations have had very little activity for up to 70 years, so it appears that they have little economic value. If development were to occur, disturbance would be somewhat less than 70 acres with mill and marine facilities required by an underground operation. A reserve of 344 to 3,100 st would produce at 1 to 6 stpd for 1 or 2 years from startup, and require about 12 employees.

Conclusion: Additional exploration would likely result in 1 to 5 acres disturbance at any occurrence, with 13 acres for all. Additional development is not expected in the foreseeable future.

Placer Gold (Cox & Singer Model 39a)

Modeled Deposit Reserves: median is 1.2 million st, with 80 percent between 24,250 and 55 million st (Cox and Singer 1986).

Deposit Name	ARDF/AMIS No.	Resources	Reference	Land Status
Crow Creek	AN104/85-254	1.2 million cubic meters	Bickerstaff and Huss 1998	USFS/State-selected
Jones	95-160	None reported	BLM, 2004	USFS/State-selected
Canyon Creek	95-267	None reported	BLM, 2004	USFS/State-selected
Kings Bay Placer	95-074	None reported	BLM, 2004	USFS/Native-selected

Notes: USFS = U.S. Forest Service

The State of Alaska Annual Placer Mining Application (APMA) for the Crow Creek Mining Company indicated 4.5 acres currently disturbed, with 1 acre disturbed and reclaimed during the year (Alaska Department of Natural Resources [ADNR] 2004). This is indicative of placer operations throughout the area.

No estimate of production rate was made because of the variability possible in placer mining.

Conclusion: Other than the operating Crow Creek Mine, there is no indication that any of these occurrences would begin production in the foreseeable future. Additional exploration might result in 1 to 5 acres disturbance at any occurrence, with 3 acres total for locations other than Crow Creek. The Crow Creek site is likely to disturb and reclaim 1 acre per year for 15 years.

7.3.4 Southeast Region

Alaskan Platinum Group Elements (Cox and Singer Model 9)

Modeled Deposit Reserves: not modeled by Cox and Singer.

Deposit Name	ARDF/AMIS No.	Resources	Reference	Land Status
Judd Harbor/Duke Island	PR001/122-003	None reported, averages of 0.037 ppm Pt, 0.033 ppm Pd, and 0.010 ppm Rh	Berg 1999	State-selected

Notes: ppm = parts per million; Pt = Platinum; Pd = Palladium; Rh = Rhodium

Additional exploration would be required to determine the economic feasibility of this location. Quality parameters suggest the grade is too low to be economic, even at recent record prices. No reserve estimate was possible, so no production rate was estimated.

There is exploration in the area, with new copper discoveries on Duke Island. Development of other discoveries may make this occurrence economic in the future, but it is currently too speculative to suggest it will happen.

Conclusion: This occurrence will not be explored or developed in the foreseeable future.

Placer Gold (Cox and Singer Model 39a)

Modeled deposit reserves: median is 1.2 million st, with 80 percent between 24,250 and 55 million st (Cox and Singer 1986).

Deposit Name	ARDF/AMIS No.	Resources	Reference	Land Status
Nugget Creek	SK048/109-034	None reported	Crafford 2001	State-selected
Cottonwood Creek	SK049/109-024	None reported	Crafford 2001	State-selected
Tsiruku River	109-037	None reported	BLM, 2004	State-selected
Salmon Creek	JU131/112-168	None reported	Barnett and Miller 2003	State-selected
Situk Beach	YA007	None reported	Hawley 1999	Native-selected
Yakutat Beach	YA002/108-010	36 million cubic meters	Hawley 1999	Native-selected
Big Nugget Mine	109-057	None reported	BLM, 2004	State-selected
Porcupine Creek	SK041/109-036	152,000 cubic yards	Crafford 2001	State-selected

The APMA (ADNR 2004) for the Crow Creek Mining Company in the southcentral region indicated 4.5 acres currently disturbed, with one acre disturbed and reclaimed during the year. This is indicative of placer operations throughout the state.

The Porcupine Creek area, including the Porcupine Creek mine shown above, has reported production of 79,650 troy ounces of gold between 1898 and 1985. Recent production at the mine has been limited to times of high gold prices. Reserve estimates indicate there may be more than 1,611 troy ounces of gold remaining in the unmined gravels. These reserves have not supported sustained production at gold prices since 1945.

No estimate of production rate was made because of the variability possible in placer mining.

Conclusion: There is no indication that any of these occurrences would begin production in the foreseeable future. If any placer mine is developed on or near BLM land in this region, disturbance at any time is expected to be five acres or less per operation, with direct employment of three to six miners. Exploration may disturb one to five acres at any location, with a total disturbance of eight acres for these occurrences.

Underground Copper (Cox and Singer Model not identified)

Modeled deposit reserves: not identified.

Deposit Name	ARDF/AMIS No.	Resources	Reference	Land Status
Nancy	CR107/119-082	None reported	Grybeck 2004	USFS/State-selected

Information about this occurrence is limited, suggesting that the time necessary to explore and permit exceeds the foreseeable period. Such exploration might disturb up to five acres of surface. This copper occurrence may be similar to the Nelson and Tift Mine (ARDF PR005) or White Knight prospect (ARDF KC053) in the same region.

The Nelson and Tift Mine is identified as a copper skarn model 18b, though the mine sold only gold (Berg, 1999). It had reserves estimated at 1,300 st. The larger White Knight prospect is identified as a polymetallic vein model 22c though staked claims were for gold (Berg 1999). The reserve median for this model deposit is 8,400 st, with 80 percent between 320 and 220,460 st (Cox and Singer 1986). Those reserves would allow for 12.5 stpd for less than two years, and require only eight employees. Surface disturbance would be up to 70 acres. A mine of this size would require a very high grade ore body.

Conclusion: With the time necessary for conveyance, exploration, and permitting, this occurrence will not be developed in the foreseeable future.

Low-Sulfide Gold Quartz (Cox and Singer Model 36a)

Modeled deposit reserves: median is 33,000 st, with 80 percent between 1,100 and one million st (Cox and Singer 1986).

Deposit name	ARDF/AMIS no.	Resources	Reference	Land status
Goldstein	JU133/112-196	None reported	Barnett 2003	State-selected
Hallum	JU144/112-129	None reported	Barnett 2003	State-selected
Westlake	CR214/119-060	None reported	Grybeck 2004	Native-selected
Bluebird	CR214	None reported	Grybeck 2004	Native-selected

Limited information and previous workings at these sites suggest little additional development potential, unless additional exploration identifies economic reserves. Even so, if the deposits were Low-Sulfide Gold-Quartz Veins, as ARDF indicates, initial reserves would have been about 33,000 st. Mine production would be about 35 stpd for 2.7 years, if most of the ore remains after the early mining. This would be similar to the Chugach-type mine with disturbance of up to 70 acres for development and about five acres during exploration. Development would require low access costs or high grade ore.

Conclusion: Exploration and development are unlikely before 2020.

Kuroko Massive Sulfide (Cox and Singer Model 28a)

Modeled deposit reserves: median is 1.6 million st, with 80 percent between 133,000 and 20 million st (Cox and Singer 1986).

Deposit Name	ARDF/AMIS No.	Resources	Reference	Land Status
Cable Creek	CR106	None reported	Grybeck 2004	State-selected

The occurrence at Cable Creek is at roadside and has been sampled by government and industry. The quality is low, but suggests a possible Kuroko-type massive sulfide deposit nearby. Additional exploration is required to identify such a deposit. Such exploration would result in about 5 acres disturbance. If a Kuroko-type deposit is identified, it might contain 1.6 million st. This would support production of 660 stpd for over 7 years and result in over 120 acres surface disturbance. While this could result in a large to very large mine for the region, it is speculative to suggest such a deposit could be located, explored, and developed in the foreseeable future.

Conclusion: Although development is unlikely before 2020, additional exploration may occur at this site, resulting in up to 5 acres of disturbance.

Polymetallic veins (Cox and Singer Model 22c)

Modeled deposit reserves: median is 8,300 st, with 80 percent between 320 and 220,000 st (Cox and Singer 1986).

Deposit Name	ARDF/AMIS No.	Resources	Reference	Land Status
Le Blondeau	SK050/109-103	None reported	Crafford 2001	State-selected
Belle	114-163	None reported	BLM, 2004n	BLM
Hope	CR213	None reported	Grybeck 2004	Native-selected

The Le Blondeau prospect information is limited to sample results and a possible model type. Additional exploration is required, and might result in about 5 acres disturbance during exploration. The small deposit size for a silver-gold-cobalt mine makes development uneconomic, so exploration would be required to identify adequate reserves to support the cost of extraction. Production for this small of a deposit is estimated to be 12.5 stpd for less than 2 years, or higher production for a shorter period.

The Belle and Hope occurrences are not classified as polymetallic vein deposits, but have been included in this model based on minerals reported. While the model gives production and disturbance information that may apply, the lack of information makes it unlikely that any development will occur in the foreseeable future.

Conclusion: Although development is unlikely, additional exploration may occur at Le Blondeau, resulting in up to 5 acres of disturbance. No activity is likely at Belle and Hope occurrences.

8.0 SURFACE DISTURBANCE DUE TO LOCATABLE MINERAL ACTIVITY

Information used to develop the estimated surface disturbance resulting from locatable mineral activity with the Ring of Fire planning area was derived from the BLM's AMIS database, the USGS ARDF open-file reports, the URS's *Draft Mineral Occurrence Potential Report* (2004), USBOM mineral terranes map, federal and state mining claim databases, and DGGS yearly 2003 *Mineral Industry Report*. All mineral activities discussed are restricted to BLM unencumbered or State- and Native-selected lands. The following discussion is written to fit the development alternatives derived during the PRMP/FEIS process.

8.1 Estimate of <u>Current Surface Disturbance</u> Resulting from Locatable Mineral Activity

Alaska Peninsula/Aleutian Chain Region: No locatable mineral activity is currently being conducted in this region (Szumigala *et al.* 2004). No active mining claims are located on BLM unencumbered or State- and Native-selected lands.

There is no current surface disturbance resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the Alaska Peninsula/Aleutian Chain region.

Kodiak Region: No locatable mineral activity is currently being conducted in this region (Szumigala *et al.* 2004). No active mining claims are located on BLM unencumbered or State- and Native-selected lands.

There is no current surface disturbance resulting from locatable mineral activity on BLM unencumbered or State and Native-selected lands in the Kodiak region.

Southcentral Region: Mineral activity reported during 2003 for the southcentral region includes one exploration project (Shulin Lake) and three small placer operations (Crow, Canyon, and Quartz creeks) (Szumigala *et al.* 2004). Active placer mining claims on Crow, Canyon, and Quartz creeks are located within CNF. Active placer mining claims located in the Petersville-Cache Creek, Collinsville, and Hatcher Pass areas (Szumigala *et al.* 2004) are on State land with federal subsurface estate, but are currently not actively being operated. No active mining claims are located on BLM unencumbered lands.

A total of four placer properties and 13 gold-quartz vein (Chugach-type) properties are located within the High Mineral Potential Areas listed in Table 2 and Appendix 1, and shown on Figure 5. Of these properties the only active placer operation, the Crow Creek Mine, is used mainly as a tourist recreational panning site. All the remaining placer properties and the gold-quartz vein properties are currently inactive.

Estimated current surface disturbance for the entire southcentral region includes 5 acres for the Shulin Lake exploration project and 15 acres for the Crow Creek, Canyon Creek, and Quartz Creek mines. Total estimated surface disturbance in the southcentral region resulting from active locatable mineral activity would be 20 acres.

Estimated current surface disturbance resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the southcentral region includes 5 acres for the Crow Creek Mine.

Southeast Region: Mineral activity reported during 2003 for the southeast region includes four exploration projects (Greens Creek Mine, Union Bay, and Duke and Woewodski islands), two development projects (Greens Creek and Kensington mines), one hard rock mining operation (Greens Creek Mine), and one placer operation (Big Nugget Mine) (Szumigala *et al.* 2004).

A total of eight placer properties and three low-sulfide gold-quartz; one each Kuroko massive sulfide, Alaskan platinum group elements (PGE), and polymetallic vein; and five unknown properties are located within the High Mineral Potential Areas listed in Table 2 and Appendix 1 and shown on Figure 6. Two placer operations on Porcupine Creek (Big Nugget Mine and Porcupine Creek) are located on State land with federal subsurface estate and are currently inactive. One historical inactive lode prospect (Belle) is located on BLM unencumbered land east of Sitka. Of these operations only the Big Nugget Mine has had any active mining during the recent past, but is currently inactive. No active mining claims are located on BLM unencumbered lands.

Estimated current disturbance for the entire southeast region area includes 20 acres for the exploration projects (Greens Creek Mine, Union Bay, and Duke and Woewodski islands), 140 acres for the development projects (Greens Creek and Kensington mines), and 200 acres for the mining operation (Greens Creek Mine). Total estimated surface disturbance in the southeast region resulting from active locatable mineral activity is 360 acres.

There is no current surface disturbance resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the southeast region.

8.2 Estimate of Future Surface Disturbance for Mines, Mills, Roads, and Locatable Mineral Related Infrastructure that May Result from Projections of Future Activity

Alaska Peninsula/Aleutian Chain Region: There is expected to be a very small amount of reasonably foreseeable future locatable mineral activity in the Alaska Peninsula/Aleutian Chain region. Future exploration activities are estimated to occur at three locations (Steeple Point, PMRGX-18, and Pyramid). Three other locations (Makushin Volcano S and two unnamed) are unlikely to be developed. These locations are listed in Table 2 and Appendix 1, and shown on Figure 4.

Total estimated future surface disturbances resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the Alaska Peninsula/Aleutian Chain region is 15 acres.

Kodiak Region: There is no estimated reasonably foreseeable future surface disturbance resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the Kodiak region.

Southcentral Region: There is expected to be a very small amount of reasonably foreseeable future locatable mineral activity in the southcentral region. Future yearly exploration activities are estimated to continue at one location (Shulin Lake), possible development of placer operations in the Petersville-Cache Creek, Collinsville, and Hatcher Pass areas, and continued mining at three placer operations on Crow, Canyon, and Quartz creeks.

A total of four placer properties and 13 gold-quartz vein (Chugach-type) properties are located within the High Mineral Potential Areas listed in Table 2 and Appendix 1, and shown on Figure 5. Of these properties the only active placer operation, the Crow Creek Mine, is used mainly as a tourist recreational panning site. All the remaining placer properties and the gold-quartz vein properties are currently inactive.

Estimated future surface disturbance for the entire southcentral region includes 5 acres for the Shulin Lake project, 15 acres for the Crow Creek Mine, three acres for the Kings Bay, Jones, and Canyon Creek placers, 5 acres for the Petersville-Cache Creek, Collinsville, and Hatcher Pass area placer operations, and 13 acres for the lode properties. Total estimated surface disturbance in the southcentral region resulting from active locatable mineral activity would be 36 acres if all the above properties were actively mining.

Total estimated future surface disturbance resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands is 31 acres, as listed in Appendix 1.

Southeast Region: There is expected to be a continuation of the activities occurring on the four exploration projects (Greens Creek Mine, Woewodski Island, Union Bay, and Duke Island), two development projects (Greens Creek and Kensington Mines), one hard rock mining operation (Greens Creek Mine) and one placer operation (Big Nugget Mine) in the southeast region (Szumigala *et al.* 2004).

A total of eight placer properties and three low-sulfide gold-quartz; one each Kuroko massive sulfide, Alaskan PGE, and polymetallic vein; and five unknown properties are located within the High Mineral Potential Areas listed in Table 2 and Appendix 1, and shown on Figure 6.

Estimated future disturbance for the entire southeast region includes 30 acres for the exploration projects (also includes Cable Creek and Le Blondeau), 140 acres for the development projects, 200 acres for the mining operation, and 8 acres for the placer operations. Total estimated future surface disturbance in the southeast region resulting from locatable mineral activity is 378 acres.

Total estimated future surface disturbance resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands is 18 acres, as listed in Appendix 1.

8.3 Estimate of Staged Future Surface Reclamation of Disturbance Activity

Alaska Peninsula/Aleutian Chain Region: If the exploration activities were to occur at three locations (Steeple Point, PMRGX-18, and Pyramid) there would be 15 acres of disturbance requiring reclamation. As there is no current exploration activity in the Alaska Peninsula/Aleutian Chain region, an estimate of future staged reclamation cannot be made.

There is no reasonably foreseeable estimated staged future surface reclamation of disturbance resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the Alaska Peninsula/Aleutian Chain region.

Kodiak Region: There is no reasonably foreseeable estimated staged future surface reclamation of disturbance resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the Kodiak region.

Southcentral Region: If all the estimated activities were to occur for the entire southcentral region, disturbance would include 5 acres for the Shulin Lake project, 15 acres for the Crow Creek Mine, 3 acres for the Kings Bay, Jones, and Canyon Creek placers, 5 acres for the Petersville-Cache Creek, Collinsville, and Hatcher Pass area placer operations, and 13 acres for the lode properties. A total estimated surface disturbance of 36 acres would need to be reclaimed in the southcentral region.

The only reasonably foreseeable estimated staged future reclamation of disturbance would be possible activity on the federal mining claims located on State land in the Petersville-Cache Creek, Collinsville, and Hatcher Pass area. That estimate would be no more than 5 acres per year resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the southcentral region.

Southeast Region: If all the estimated activities were to occur for the entire southeast region, disturbance would include 30 acres for the exploration projects (also includes Cable Creek and Le Blondeau), 140 acres for the development projects, 200 acres for the mining operation, and 8 acres for the placer operations. A total estimated surface disturbance of 378 acres would need to be reclaimed in the southeast region.

The only reasonable foreseeable estimated staged future reclamation of disturbance would be possible activity on the federal mining claims located on State land in the Porcupine Creek area (Big Nugget Mine). That estimate would be no more than 5 acres per year from exploration, development, or mining work conducted on placer gold deposits.

8.4 Estimated Total Surface Disturbance

(Total surface disturbance = current + future disturbance)

Alaska Peninsula/Aleutian Chain Region: The reasonably foreseeable estimated total surface disturbance in the Alaska Peninsula/Aleutian Chain region is zero acres of current disturbance plus 15 acres of future disturbance, for a total of 15 acres on BLM unencumbered or State- and Native-selected lands.

Kodiak Region: There is no reasonably foreseeable estimated total surface disturbance resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands on Kodiak Island.

Southcentral Region: The reasonably foreseeable estimated total surface disturbance in the southcentral region is five acres of current disturbance plus 31 acres of future disturbance, for a total of 36 acres on BLM unencumbered or State- and Native-selected lands.

Southeast Region: The reasonably foreseeable estimated total surface disturbance in the southeast region is zero acres of current disturbance plus 18 acres of future disturbance, for a total of 18 acres on BLM unencumbered or State- and Native-selected lands.

8.5 Estimated Total Net Surface Disturbance

(Total net surface disturbance = current + future disturbance – reclamation)

Alaska Peninsula/Aleutian Chain Region: The reasonably foreseeable estimated total net surface disturbance in the Alaska Peninsula/Aleutian Chain region is zero acres of current disturbance plus 15 acres of future disturbance minus zero acres of reclamation, for a total of 15 acres on BLM unencumbered or State- and Native-selected lands.

Kodiak Region: There is no reasonably foreseeable estimated total net surface disturbance resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the Kodiak region.

Southcentral Region: The reasonably foreseeable estimated total net surface disturbance in the southcentral region are 5 acres of current disturbance plus 31 acres of future disturbance minus 5 acres for reclamation, for a total net of 31 acres on BLM unencumbered or State- and Native-selected lands.

Southeast Region: The reasonably foreseeable estimated total net surface disturbance in the -southeast region are zero acres of current disturbance plus 18 acres of future disturbance minus 5 acres for reclamation, for a total net of 13 acres on BLM unencumbered or State- and Native-selected lands.

8.6 Estimated Number and Type of Infrastructure Facilities that May Impact Air Quality

Alaska Peninsula/Aleutian Chain Region: There will be no reasonably foreseeable infrastructure facilities that may impact air quality resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the Alaska Peninsula/Aleutian Chain region.

Kodiak Region: There will be no reasonably foreseeable infrastructure facilities that may impact air quality resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the Kodiak region.

Southcentral Region: Infrastructure facilities affecting air quality for one placer operation, located on State-selected land in the Petersville-Cache Creek area, would be limited to a small diesel or gasoline generator (50 kilowatts [kW]) and/or small water pumps (less than 40 horsepower), if the operation is located away from existing electric power lines. The one exploration effort might require similar infrastructure during the short summer season. The development project located on State-selected lands within CNF would also require diesel generators for electrical power (up to 1,200 kW peak load), if power lines to the location were not feasible. In addition, there would be emissions from heavy equipment and some potential for windborne dust from disturbed areas that were not stabilized. Operations would be required to meet applicable federal and State air quality standards for permitting.

The small size of the operations, as well as the short period of operation would create a minor impact on the local air quality.

Southeast Region: For the one exploration prospect and placer operation located on State-selected lands, each operation might require a small diesel or gasoline generator (50 kW) and/or small water pumps (up to 40 horsepower). The one development prospect, located on State-selected lands, might require diesel generators (800 to 3,534 kW peak load), if existing power lines to the location are not feasible. In addition, there would be emissions from heavy equipment and some potential for windborne dust from disturbed areas that were not stabilized. Operations would be required to meet applicable federal and state air quality standards for permitting.

The small size of the operations, as well as the short period of operation would create a minor impact on the local air quality.

8.7 Estimated Quantity and Quality of Produced Water Disposed on the Surface

Alaska Peninsula/Aleutian Chain Region: There will be no reasonably foreseeable water disposed on the surface resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the Alaska Peninsula/Aleutian Chain region.

Kodiak Region: There will be no reasonably foreseeable water disposed on the surface resulting from locatable mineral activity on BLM unencumbered or State- and Native-selected lands in the Kodiak region.

Southcentral Region: Water for the one possible operating placer operation, located on State-selected land in the Petersville-Cache Creek area, would be limited to the amount put through a gravity separation process (500 gallons per minute, possibly recycled), plus domestic use of 9,000 to 18,000 gallons annually. The one exploration effort would require smaller quantities of water for drilling and domestic use, assuming a much shorter work year. The development project, located on State-selected lands within CNF, would also require water for processing and domestic use. The size of the reserve makes on-site flotation milling unlikely, but if it occurs, it would be a closed circuit for water use, using only the initial input and makeup water for the amount remaining in the tailings. About 11,000 gallons would be required for the initial day of processing, and about 400,000 gallons per year for makeup water. It is assumed that mine discharge will generally provide this water, and surface water will be required infrequently and there would be no untreated discharge of produced water. It is estimated that employees will require up to 280,000 gallons per year of potable water from a local water source, which will be discharged appropriately. Operations would be required to meet applicable federal and State water quality standards for permitting.

The small size of the operations, as well as the short period of operation would create a minor impact on the local water quality.

Southeast Region: Each of the four placer operations located on State-selected lands and one placer operation located on Native-selected lands might require water for a gravity separation process (500 gallons per minute, possibly recycled), plus domestic use of 9,000 to 18,000 gallons annually. The exploration effort would require smaller quantities of water for drilling and domestic use, assuming a much shorter work year. The development prospect, located on State-selected lands, might require water for processing and domestic use. The on-site flotation milling is less likely for the smaller reserve size, but probable for the larger estimate. It would be a closed circuit for water use, using only the initial input and makeup water for the amount remaining in tailings. Initial requirements would be 96,000 gallons for the first day, plus approximately 3.6 million gallons of makeup water during each year of operation. It is assumed that mine discharge will generally provide this water, and surface water will be required infrequently, and there would be not untreated discharge of produced water. It is estimated that employees will require 175,000 to 665,000 gallons per year of potable water from a local water source, which will be discharged appropriately. Operations would be required to meet all applicable federal and State water quality standards for permitting.

The small size of the operations, as well as the short period of operation would create a minor impact on the local water quality.

9.0 REASONABLE FORESEEABLE DEVELOPMENT SCENARIO DISCUSSION BY ALTERNATIVE

9.1 Alternative 1 – No Action (Current Management)

Under the No Action Alternative (Current Management) BLM-managed lands are currently withdrawn from mineral entry either by the Alaska Native Claims Settlement Act d(1) withdrawals or by State- or Native selection. Currently no locatable mineral activity is occurring in the Alaska Peninsula/Aleutian Chain region or in the Kodiak region. All current activity is occurring in the southcentral and southeast regions.

Most of the locatable mineral activity in the southcentral region does not occur on BLM unencumbered land or State- or Native-selected lands. Only one placer operation is located on State-selected lands and several hard rock operations are located on state land with federal subsurface estate. In the southeast region, one exploration and four placer operations are located on State- and Native-selected lands. Two placer operations are located on State land with federal subsurface estate.

If locatable mineral activity were to occur on every existing operation, as allowable by present BLM authority, an estimated total of 5 acres could potentially be disturbed in the Ring of Fire planning area. The activity would be restricted to the Petersville-Cache Creek and Hatcher Pass areas in the southcentral region and the Porcupine Creek area in the southeast region. Due to the small size of the existing operations, as well as the short period of operation there would be a minor impact on the local air and water quality.

9.2 Alternative B – Resource Development

Under the Resource Development Alternative, all future mineral activities would be allowed in the Ring of Fire planning area as all withdrawals would be repealed. There is no reasonably foreseeable future locatable mineral activity in the Kodiak region. All reasonably foreseeable future mineral activity will occur in the Alaska Peninsula/Aleutian Chain, southcentral, and southeast regions. However, due to its sensitive nature, the Neacola Mountains-Blockade Glacier area could remain closed to mineral entry.

All of the locatable mineral activity in the Alaska Peninsula/Aleutian Chain region is located on Native-selected lands. Most of the locatable mineral activity in the southcentral region area does not occur on BLM unencumbered land or State- or Native-selected lands. Only one placer operation is located on State-selected lands and several hard rock and placer operations are located on State land with federal subsurface estate. In the southeast region, one exploration and four placer operations are located on State and Native-selected lands. Two placer operations are located on State land with federal subsurface estate.

If locatable mineral activity were to occur on every existing operation, as allowable by present BLM authority, an estimated total of 59 acres could potentially be disturbed in the Ring of Fire planning area. The activity would be restricted to the Alaska Peninsula/Aleutian Chain, southcentral, and southeast regions. Due to the small size of the existing operations, as well as the short period of operation there would be a minor impact on the local air and water quality.

9.3 Alternative C – Resource Conservation

Under the Resource Conservation Alternative, no future mineral entry would be allowed in the Ring of Fire planning area as all withdrawals would remain in place. However, locatable mineral activity would still be allowed in existing “grandfathered” operations in the southcentral and southeast regions. These operations occur in the Petersville-Cache Creek, Collinsville, and Hatcher Pass area in the southcentral region and the Porcupine Creek area in the southeast region, as identified in the No Action Alternative. Currently no locatable mineral activity is occurring in the Alaska Peninsula/Aleutian Chain or Kodiak regions.

If locatable mineral activity were to occur on every existing operation, as allowable by present BLM authority, an estimated total of 5 acres could potentially be disturbed in the Ring of Fire planning area. Under this alternative no further disturbance would be allowed. Due to the small size of the existing operations, as well as the short period of operation there would be a minor impact on the local air and water quality.

9.4 Alternative D – Proposed Action

Under the Proposed Action, all future mineral activities would be allowed in the Ring of Fire planning area, as all withdrawals would be repealed. There is no reasonably foreseeable future locatable mineral activity in the Alaska Peninsula/Aleutian Chain or Kodiak regions. However, due to its sensitive nature, the Neacola Mountains-Blockade Glacier area of the southcentral region could remain closed to mineral entry.

Most of the locatable mineral activity in the southcentral region does not occur on BLM unencumbered land or State- or Native-selected lands. Only one placer operation is located on State-selected lands and several hard rock and placer operations are located on State land with federal subsurface estate. In the southeast region, one exploration and four placer operations are located on State- and Native-selected lands. Two placer operations are located on State land with federal subsurface estate.

If locatable mineral activity were to occur on every existing operation, as allowable by present BLM authority, an estimated total of 59 acres could potentially be disturbed in the Ring of Fire planning area, less depending upon classification of the identified sensitive areas. The activity would be restricted to the Petersville-Cache Creek and Hatcher Pass areas in the southcentral region and the Porcupine Creek area in the southeast region. Due to the small size of the existing operations, as well as the short period of operation there would be a minor impact on the local air and water quality.

10.0 REFERENCES

Alaska Department of Natural Resources (ADNR). 2004. Alaska Placer Mining Application (APMA) Mining Applications. November 2004. http://www.dnr.state.ak.us/cgi-bin/discus/

Arctic Environmental Information and Data Center (AEIDC). 1982. Mineral terranes of Alaska -- 1982; University of Alaska, Anchorage, 6 figures (1:1,000,000 scale).

Barnett, J.C., and Miller, L.D. 2003. Juneau quadrangle, Alaska Resource Data Files (ARDF); U.S. Geological Survey (USGS) Open-File Report 03-456, p. 304-05, 308-09, 331-332, 25 October 2004. http://ardf.wr.usgs.gov/

Berg, H. 1999. Ketchikan quadrangle, ARDF; USGS, 25 October 2004. http://ardf.wr.usgs.gov/

Bickerstaff, D., and Huss, S.W. 1998. Anchorage quadrangle, ARDF; USGS Open-File Report 98-599, p 222-224, 228-242, 25 October 2004. http://ardf.wr.usgs.gov/

Bittenbender, P.E., Bean, K.W., and Still, J.C. 2001. Stikine airborne geophysical survey followup, central southeast Alaska; BLM Technical Report 37, 116 p.

Bittenbender P.E., Still, J.C., Mass, K.N., McDonald, M.E., Jr. 1999. Mineral resources of the Chichagof and Baranof Islands area, southeast Alaska; BLM Technical Report 19, 222 p., 3 plates.

Bureau of Land Management (BLM). 2004. Alaska Minerals Information Service (AMIS); November 2004. (Available at the BLM Alaska State Office)

Cox, D.P., and Singer, D.A. 1986. Mineral deposit models; USGS Bulletin 1693, 379 p.

Crafford, T.C. 2001. Skagway quadrangle, ARDF; USGS Open-File Report 01-193, p. 87-89, 105-111, 25 October 2004. http://ardf.wr.usgs.gov/

Grybeck, D.J. 2004. Craig quadrangle, ARDF; USGS Open-File Report 2004-1384, p. 236-239, 454-457, 25 October 2004. http://ardf.wr.usgs.gov/

Hawley, C.C. 1999. Yakutat quadrangle, ARDF; USGS Open-File Report 99-333, p. 6-8, 17-18, 25 October 2004. http://ardf.wr.usgs.gov/

Maas, K.M., Bittenbinder, P.E., and Still, J.C. 1995. Mineral Investigations in the Ketchikan Mining District, Southeastern Alaska: U.S. Bureau of Mines (USBOM) Open-File Report 11-95, 606 p.

Nelson, S.W, and Miller, M.L., 2000, Assessment of mineral resource tracts in the Chugach National Forest, Alaska; USGS Open-File Report 00-026, 16 p.

Ober, J.A. 2004. Mineral commodity summary 2004, Sulfur; USGS, 5 December 2004. http://minerals.usgs.gove/minerals/pubs/commodity/sulfur/sulfumcs04.pdf

Pilcher, S.H. 2000. Umnak quadrangle, ARDF; USGS Open-File Report 00-118, p. 5-6, 25-26, 25 October 2004. http://ardf.wr.usgs.gov/

Pilcher, S.H. 2002. Port Moller quadrangle, ARDF; USGS Open-File Report 02-47, p. 47-49-52-53, 25 October 2004. http://ardf.wr.usgs.gov/

Resource Data, Inc. (RDI), Alaska Earth Sciences, Inc., and USBOM. 1995. Mineral terranes and known mineral deposit areas; Published by USBOM, 5 p.

Still, J.C., Bittenbender, P.E., Bean, K.W., and Gensler, E.G. 2002. Mineral assessment of the Stikine area, central southeast Alaska: BLM Technical Report 51, 560 p.

Szumigala, D.J., Hughes, R.A., and Harris, R.H. 2004. Alaska's mineral industry 2003; Alaska Division of Geological and Geophysical Surveys (DGGS) Special Report 58, 71 p.

URS Corporation (URS). 2004. Mineral Occurrence Potential Report for the Ring of Fire Planning Area; 58 p., 33 figures.

U.S. Geological Survey (USGS). 2005. Alaska Resource Data Files; March 2005. http:// http://ardf.wr.usgs.gov/

Wilson, F.H. 1996. Unalaska quadrangle, ARDF; USGS Open-File Report 96-270, p. 5-6, 30, 25 October 2004. http://ardf.wr.usgs.gov/

11.0 ACKNOWLEDGEMENTS

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12.0 STATEMENT OF QUALIFICATIONS

Mark P. Meyer, Physical Scientist and Darla D. Pindell, Mineral Economist, BLM, Division of Energy and Solid Minerals.

Figures

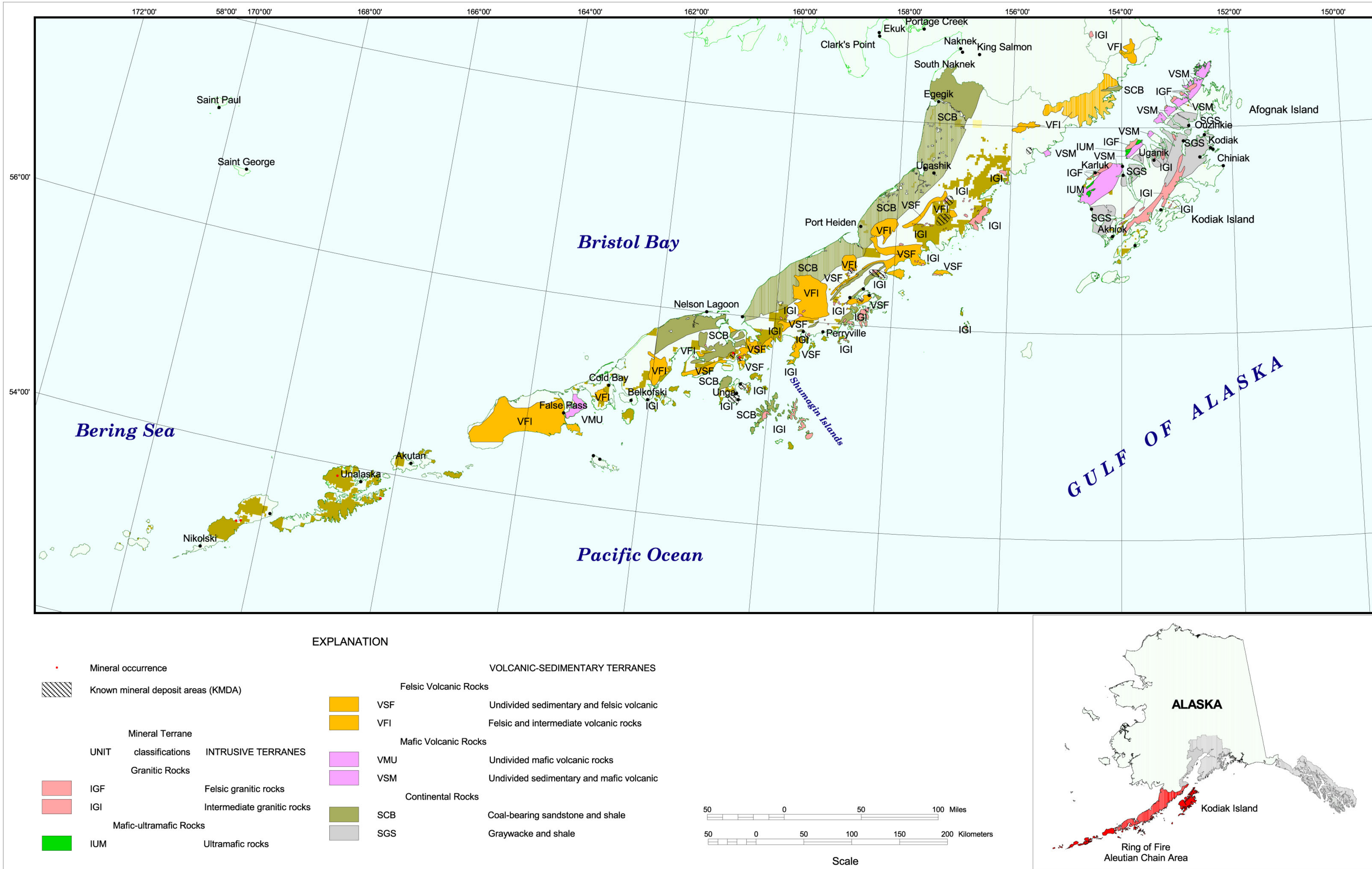

Figure 1. -- Locatable mineral occurrence and mineral terrane map of the Ring of Fire RMP, Alaska Peninsula/Aleutian Chain, and Kodiak Island planning areas.

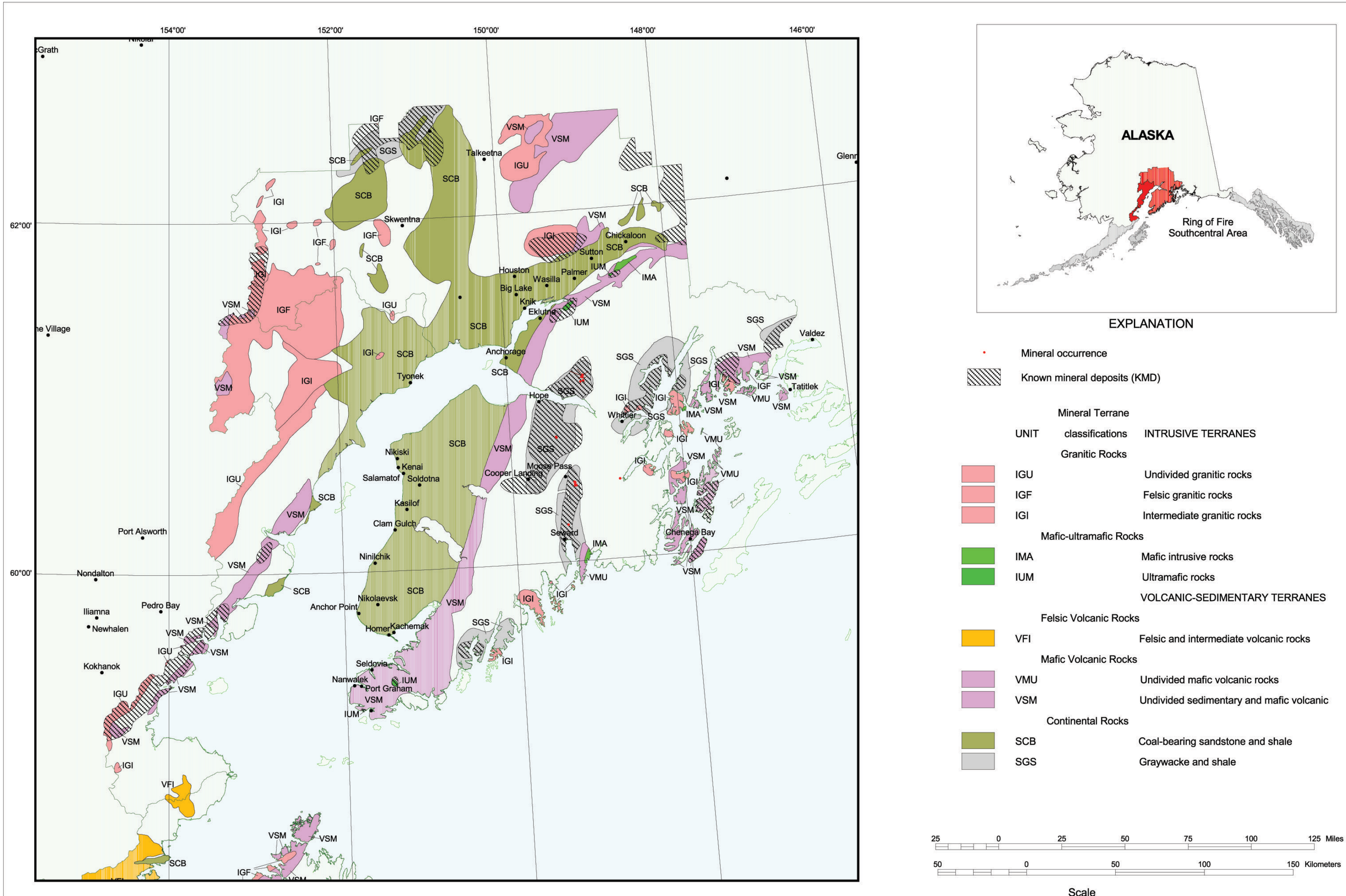

Figure 2. -- Locatable mineral occurrence and mineral terrane map of the Ring of Fire RMP, Southcentral Alaska planning area.

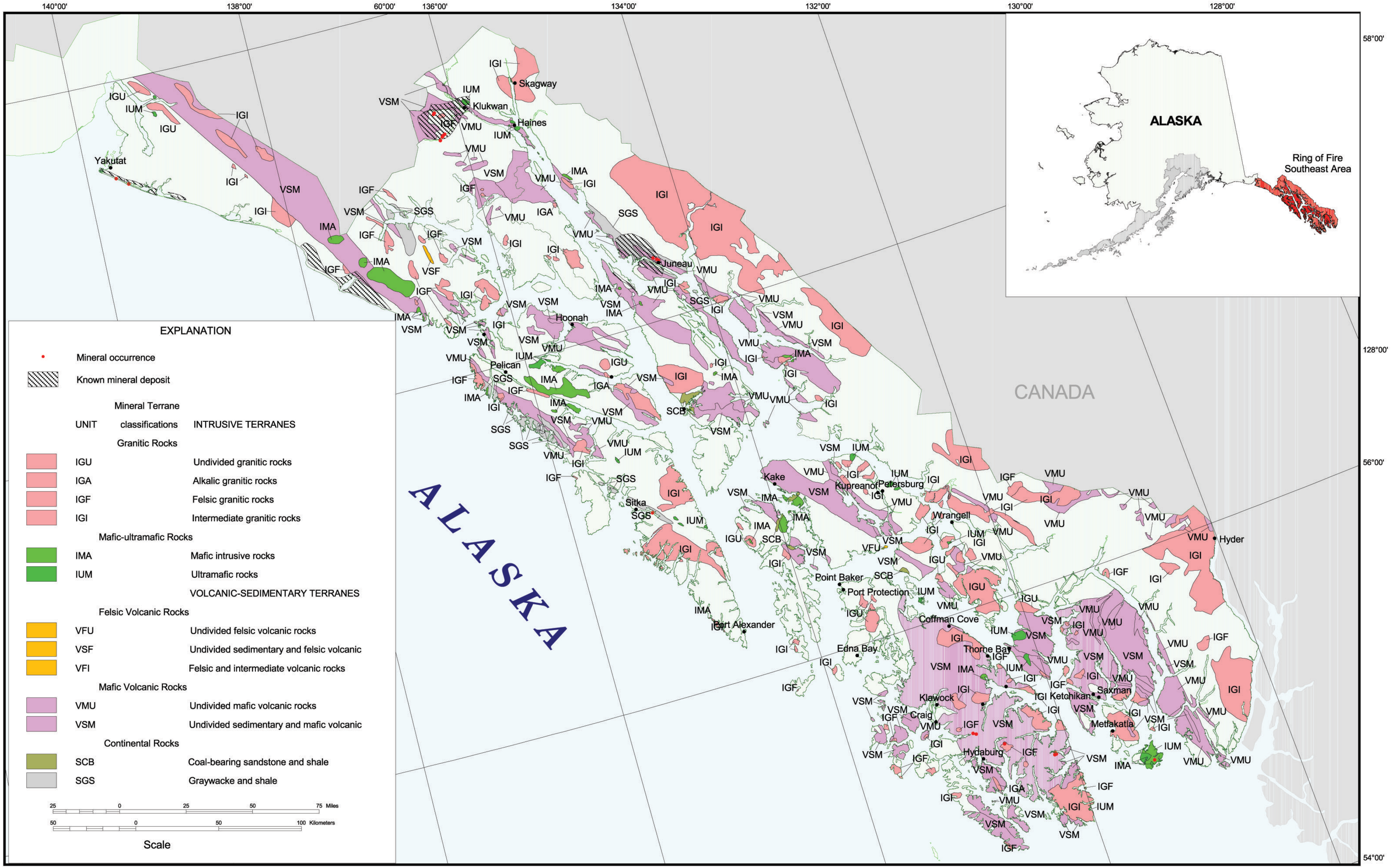

Figure 3. -- Locatable mineral occurrence and mineral terrane map of the Ring of Fire RMP, Southeast Alaska planning area.

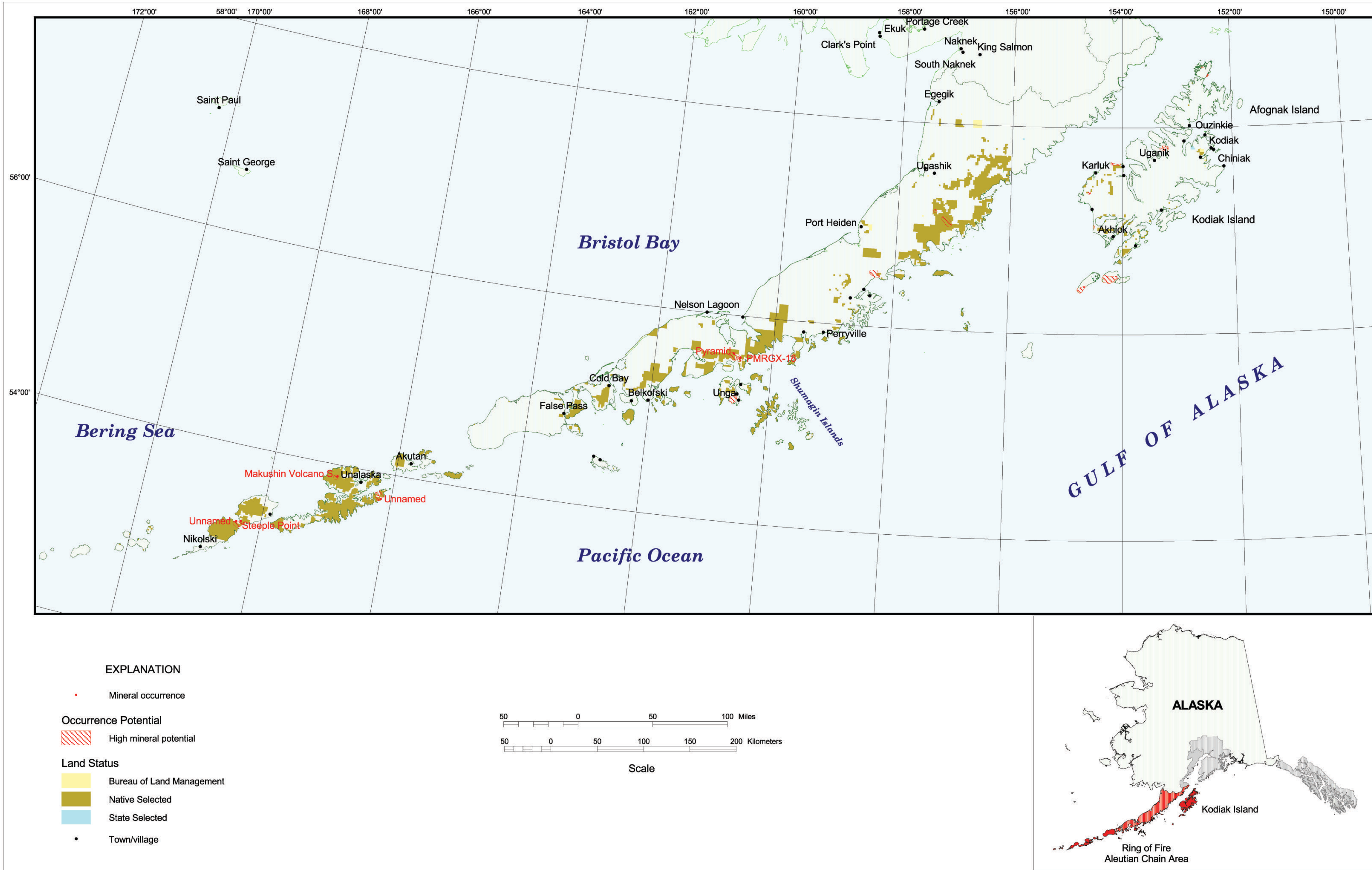

Figure 4. -- Locatable mineral potential map of the Ring of Fire RMP, Alaska Peninsula/Aleutian Chain, and Kodiak Island planning areas.

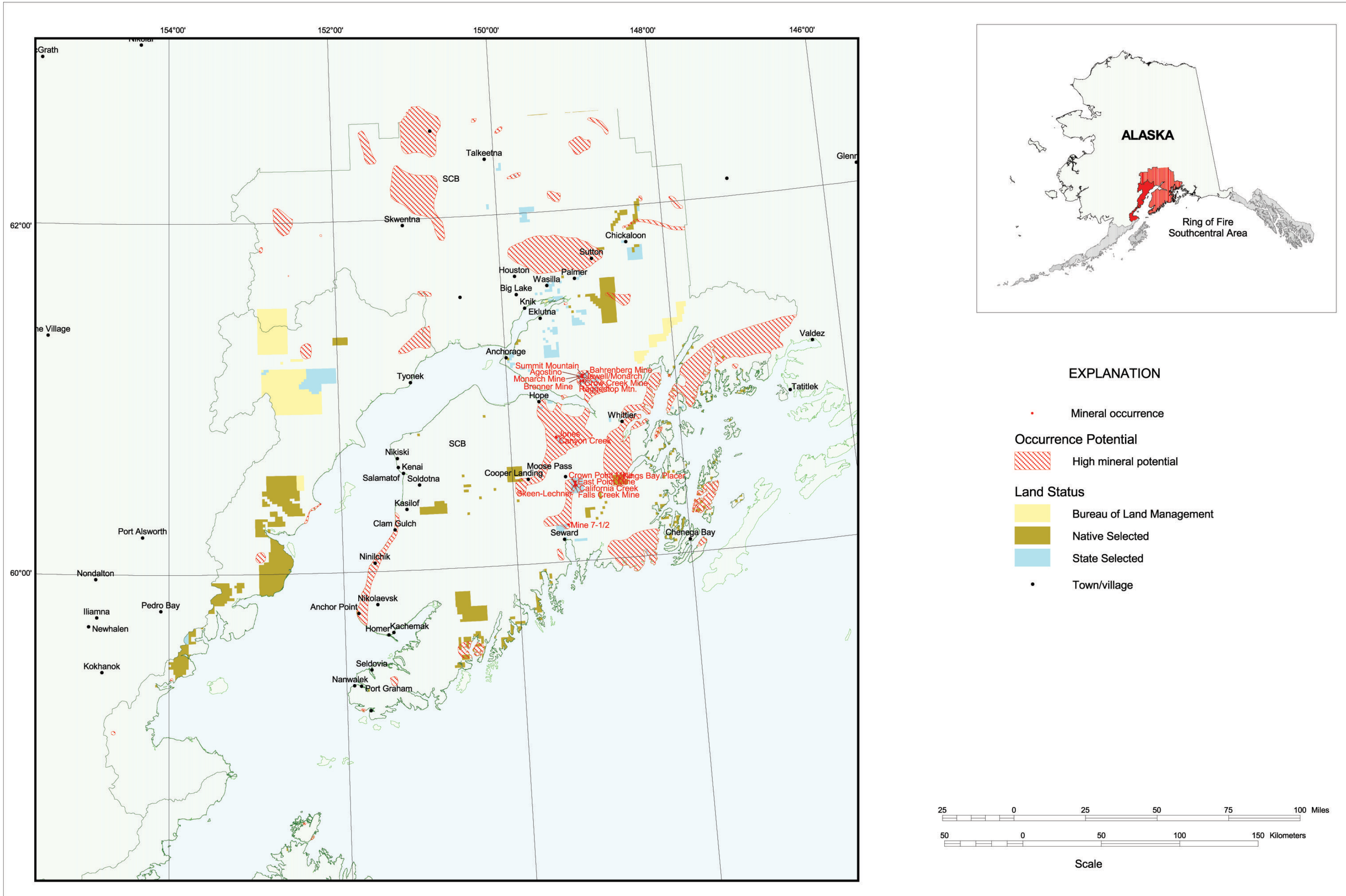

Figure 5. -- Locatable mineral potential map of the Ring of Fire RMP, Southcentral Alaska planning area.

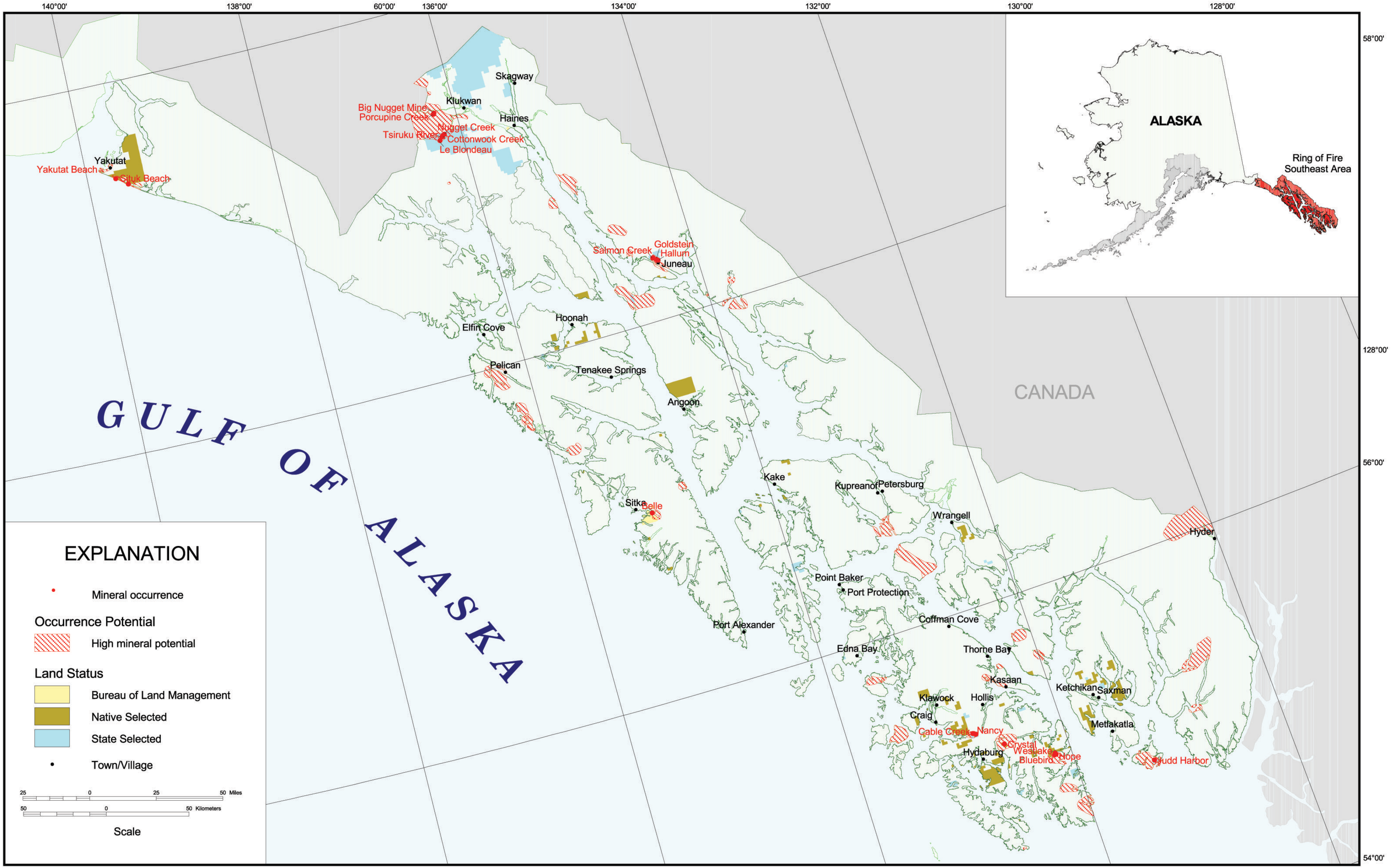

Figure 6. -- Locatable mineral potential map of the Ring of Fire RMP, Southeast Alaska planning area.

APPENDIX 1

Estimated Disturbance from Mineral Development within the Ring of Fire Planning Area

Appendix 1. Estimated Disturbance from Mineral Development within the Ring of Fire Planning Area

PoD	Deposit Name	Status	Deposit Model Type (Cox and Singer)	Reserves/Resources	Mine Production Rates (Estimated)	Disturbed Acreage (Estimated)	Reasonably Foreseeable Alternative B
ALASKA PENINSULA/ALEUTIAN CHAIN							
u	Unnamed	NS	Cu, Mo	Unknown, 126 million st used for analysis	Unknown, 17,000 stpd used for analysis	5 acres for exploration, 40 to 70 acres for development	0 acres
l	Steeple Point	NS	25a - Hot-spring Au-Ag	Unknown, 135,000 st used for analysis	Unknown, 100 stpd used for analysis	5 acres for exploration, 40 to 70 acres for development	5 acres
u	Unnamed	NS	17 - Porphyry Cu?	Unknown, 126 million st used for analysis	Unknown, 17,000 stpd used for analysis	5 acres for exploration, 40 to 70 acres for development	0 acres
u	Makushin Volcano S	NS	Fumarolic Sulfur	9,000 to 122,500 st	1 to 6 stpd	40 to 60 acres	0 acres
l	PMRGX-18	NS	Pb-Zn	Unknown, 8,400 st used for analysis	Unknown, 12.5 stpd used for analysis	5 acres for exploration, 40 acres for development	5 acres
l	Pyramid	NS	21a - Porphyry Cu-Mo?	126 million st	17,000 stpd	5 acres for exploration, 1,340 acres for development	5 acres
SOUTHCENTRAL							
u	Kings Bay Placer	NS	39a - Placer Au	Unknown	Not estimated	1 to 5 acres	1 acre
u	Crown Point Mine	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	East Point Mine	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	Skeen-Lechner	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	Skeen-Lechner	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	Falls Creek Mine	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	California Creek	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	Jones	USFS/SS	39a - Placer Au	Unknown	Not estimated	1 to 5 acres	1 acre
u	Mile 7-½	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	Canyon Creek	USFS/SS	39a - Placer Au	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
h	Crow Creek (active)	USFS/SS	39a - Placer Au	1.2 million cubic meters	Not estimated	4.5 to 5 acres currently disturbed; 15 acres additional disturbance and reclamation	15 acres
u	Raggedtop Mountain	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	Jewel/Monarch Mine	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	3,100 st	6 stpd	1 to 5 acres for exploration, <70 acres for development	1 acre

Appendix 1. Estimated Disturbance from Mineral Development within the Ring of Fire Planning Area (continued)

PoD	Deposit Name	Status	Deposit Model Type (Cox and Singer)	Reserves/Resources	Mine Production Rates (Estimated)	Disturbed Acreage (Estimated)	Reasonably Foreseeable Alternative B
u	Brenner	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	Agostino	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	Summit Mountain	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
u	Brahrenberg Mine	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	344 st	1 stpd	1 to 5 acres for exploration, <70 acres for development	1 acre
u	Monarch Mine	USFS/SS	36a.1 - Au-Qtz veins (Chugach-type)	Unknown, 344 st used for analysis	Unknown, 1 stpd used for analysis	1 to 5 acres for exploration, <70 acres for development	1 acre
SOUTHEAST ALASKA							
	Belle	BLM	Ag, Cu, Au	Unknown, 8,400 st used for analysis	Unknown, 12.5 stpd used for analysis	5 acres for exploration, 40 acres for development	0 acres
u	Situk Beach (Beach Placer)	NS	39a - Placer Au	Unknown	Not estimated	1 to 5 acres	1 acre
u	Yakutat Beach	NS	39a - Placer Au	36 million cu m	Not estimated	1 to 5 acres	1 acre
	Crystal	NS	Qtz crystals	Unknown	Minimal disturbance for personal collection	Minimal disturbance for personal collection	0 acres
u	Westlake	NS	Cu, Pb, Au, Zn	Unknown, 33,000 used for analysis	Unknown, 35 stpd used for analysis	5 acres for exploration, 40 to 70 acres for development	0 acres
	Hope	NS	Au, Ag, Cu	Unknown, 8,400 st used for analysis	Unknown, 12.5 stpd used for analysis	5 acres for exploration, 40 acres for development	0 acres
u	Bluebird	NS	36a - Low-sulfide Au-Qtz	Unknown, 33,000 st used for analysis	Unknown, 35 stpd used for analysis	5 acres for exploration, 40 to 70 acres for development	0 acres
u	Nancy	USFS/SS	Underground Cu	Unknown, 8,400 st used for analysis	12.5 stpd	5 acres for exploration, 40 acres for development	0 acres
u	Cable Creek	SS	28a - Kuroko massive sulfide	Unknown, 1.6 million st used for analysis	Unknown,658 stpd used for analysis	5 acres for exploration, 121 acres for development	5 acres
nd	Judd Harbor/Duke Island	USFS/SS	9 - Alaskan PGE	Unknown	Not determined	Not determined	0 acres
u	Tsiruku River	SS	39a - Placer Au	Unknown	Not estimated	1 to 5 acres	1 acre
u	Le Blondeau	SS	22c - Polymetallic veins	Unknown, 8,400 st used for analysis	Unknown, 12.5 stpd used for analysis	5 acres for exploration, 40 acres for development	5 acres
u	Salmon Creek	SS	39a - Placer Au	Unknown	Not estimated	1 to 5 acres	1 acre
u	Goldstein	SS	36a - Low-sulfide Au-Qtz	Unknown, 33,000 used for analysis	Unknown, 35 stpd used for analysis	5 acres for exploration, 40 to 70 acres for development	0 acres
u	Hallum	SS	36a - Low-sulfide Au-Qtz	Unknown, 33,000 used for analysis	Unknown, 35 stpd used for analysis	5 acres for exploration, 40 to 70 acres for development	0 acres

Appendix 1. Estimated Disturbance from Mineral Development within the Ring of Fire Planning Area (continued)

PoD	Deposit Name	Status	Deposit Model Type (Cox and Singer)	Reserves/Resources	Mine Production Rates (Estimated)	Disturbed Acreage (Estimated)	Reasonably Foreseeable Alternative B
u	Cottonwood Creek	SS	39a - Placer Au	Unknown	Not estimated	1 to 5 acres	1 acre
u	Nugget Creek	SS	39a - Placer Au	Unknown	Not estimated	1 to 5 acres	1 acre
u	Big Nugget Mine	SS	39a - Placer Au	Unknown	Not estimated	1 to 5 acres	1 acre
u	Porcupine Creek	SS	39a - Placer Au	152,000 cubic yards	Not estimated	1 to 5 acres	1 acre

Notes: PoD = Probability of development: h = high, m = moderate, l = low with exploration required, u = unlikely
Status: USFS = U.S. Forest Service, NS = Native-selected , SS = State-selected
Ag = silver
Au = gold
Cu = copper
Pb = lead
PGE = platinum group elements
Mo = molybdenum
Qtz = quartz
st = short ton
stpd = short ton per day
Zn = zinc

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