Mineral Occurrence and Development Potential Report

LEASABLE MINERALS

Eastern Interior
Resource Management Plan

BLM Alaska State Office
Division of Energy and Solid Minerals
Branch of Energy
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I. INTRODUCTION

A. Purpose of Report

This Mineral Occurrence and Development Potential Report (MODPR) was prepared to assure the availability and consideration of leasable mineral resources data during the Eastern Interior (EI) Resource Management Plan (RMP) process. This report provides an intermediate level of detail for mineral assessments as prescribed in the 1985 Bureau of Land Management (BLM) Manual Sections 3031 (Energy and Mineral Resource Assessment) and 3060 (Mineral Reports – Preparation and Review). Information provided in the report will be incorporated into the RMP and the Environmental Impact Statement (EIS).

Identified fluid leasable minerals, including oil, gas, geothermal, and coalbed natural gas, resources are classified according to BLM Handbook H-1624-1, planning for Fluid Mineral Resources. Solid leasable minerals include coal, phosphates, gilsonite, sodium, and oil shale. Fluid and solid leasable minerals are discussed in this report as "leasable" minerals. BLM Manual 3031 specifies that minerals be classified according to mineral potential (utilized to rank the potential for presence or occurrence, as opposed to the potential for development or extraction). This classification system rates potential for the occurrence of mineral resources in categories of High (H), Moderate (M), Low (L), Very Low (V), and no potential (O). The classification is followed by a rating of the level of certainty of the data ranging from A to D, indicating degrees of confidence in the evidence regarding the presence of a particular mineral occurrence. A "D" rating indicates the least amount of data available, while an "A" rating indicates a high degree of data available (Table 1).

Table 1: Rating System for Leasable Minerals Occurrence Potential in the EI Planning Area.

Mineral	Occurrence Classification
Oil	H/B
Natural Gas	H/B
Coalbed natural gas	M/B
Coal	M/A
Oil Shale	L/C
Phosphate	O/D
Sodium	O/D
Geothermal	H/A

Fluid mineral occurrence and development potential in the EI Planning Area is primarily associated with coal, and coalbed natural gas (CBNG), oil and gas, and geothermal. Oil shale is known to occur and was identified in the report, but the information was limited. Phosphates and sodium were not analyzed as there is no existing data for these resources in the planning area, an assumption is made that they do not occur in the planning area.

As described in BLM Manual H-1624-1, federal oil and gas leases (including coal bed methane) fall into one of four categories, described below, that become increasingly restrictive (BLM, 1986). The data summarized in the MODPR will be used to identify and map these leasing areas in the RMP.

1. Open Subject to Standard Lease Terms and Conditions: These are areas where it has been determined through the planning process that the terms and conditions attached to the leasing document are sufficient in allowing exploration and development.
2. Open Subject to Seasonal or Other Minor Constraints: These are areas where it has been determined that moderately restrictive lease stipulations may be required to mitigate impacts to other land uses or resource values. Category 2 leases frequently involve timing limitations such as restricting construction activities in designated Big Game Winter Ranges, or controlled surface use stipulations such as creating a buffer zone around a critical resource.
3. Open Subject to No Surface Occupancy or Other Major Constraint: These are areas where it has been determined through the planning process that highly restrictive lease stipulations are necessary to protect resources. Category 3 leases may prohibit the construction of well production and support facilities. These areas can be subject to directional drilling.
4. Closed to Leasing: These are areas where it has been determined that other land uses or resource values cannot be adequately protected, and appropriate protection can only be ensured by closing the land to leasing through either statutory or administrative requirements. These areas are outlined in 43 CFR 3100.

These areas are identified and mapped in the Resource Management Plan document.

B. Lands Involved

The Eastern Interior (EI) planning area encompasses approximately 31 million acres, 7.9 million acres of which are BLM-administered lands in the Fairbanks District Office. The area is bounded by the Brooks Range at the north, the Dalton, Elliott, and Alaska Highways on the west, the Fairbanks/Anchorage District boundary on the south, and the U.S. - Canada border on the east (Appendix C: Planning Area Map).

The planning area does contain some of the land within northeastern portion of the Fairbanks North Star Borough, but otherwise lands are unincorporated. There are 13 communities within the planning area which include Fort Yukon, Circle, Central, Chicken, and Eagle. Another 11 communities, including Fairbanks, Tok, Arctic Village, and Stevens Village are adjacent to the planning area. While the area is bounded by the Elliott and Dalton Highways on the West, the Alaska Highway on the South and West, and has the Steese and Taylor Highways within the boundaries of the planning area, the majority of lands are road-less. The make-up of the area based on ownership and management jurisdiction can be found in the RMP.

C. Scope and Objectives

This MODPR describes the known, existing mineral resources and current resource management in the planning area with a primary objective to identify areas of High, Moderate, Low, and Very Low mineral potential. By incorporating a wide variety of available geologic information, including State and Federal reports, the minerals report will present a summary of development potential for the entire Eastern Interior Planning Area, regardless of land status. This assessment provides an intermediate level of detail, as required by Manual Section 3031 for all BLM land use plans.

Information contained in this report will be used to prepare a Reasonably Foreseeable Development Scenario Report (RFD). This report will focus on the type, location, and manner of potential environmental disturbances due to leasable minerals exploration, development and production.

II. DESCRIPTION OF GEOLOGY

A. Physiography

The EI Planning Area includes terrains ranging from low flood plain lands to mountains with elevations greater than 5,000 feet with the tallest being Mt. Harper at 6500 feet (Saunders 1967). The planning area (Figure 1) contains vast forest lowland that encompasses many lakes, streams, and rivers (Wahrhaftig 1965). The large Yukon River flows through the planning area, starting on the east side of the EI planning area, on the Canadian border, and flows west through the planning area. The Yukon River meets the Porcupine River along the north-west boundary of the planning area. The eastern body of the massive Yukon Flats lies within the EI planning area and makes up the largest area of the northern portion of the planning area. The southern area of the planning area is primarily made up of the Yukon-Tanana Uplands which stretches from the Yukon River

in the middle of the planning area and abuts the southern boundary of the planning area along the foothills of the Mentasta Mountains. Wahrhaftig's description of Alaska's physiographic provinces remains the authoritative reference, portions of which are described below.

Northern Plateaus Province

Ogilvie Mountains

The Ogilvie Mountains encompasses the area along the most eastern part of the planning area along the Alaskan-Canadian border. Ogilvie Mountains have a local relief of as much as 4,000 ft with some peaks reaching 5,000 ft. Many of the mountains in the area have interconnected ridges with sharp crest lines and precipitous slopes. Many of the deep narrow (tributary) valleys are interrupted by gorges where rivers cross the cliff forming layers of rock. All of the rivers that drain the Ogilvie Mountains drain into the Yukon River. Most of the area is underlain with permafrost. Pingos are common. The Ogilvie Mountains are made up of moderately folded and faulted sedimentary and volcanic rocks ranging in age from late Precambrian to Cretaceous. Some of the cliffs forming beds in the area are made up of limestone, dolomite, quartzite, and greenstone.

Tintina Valley

The Tintina Valley is a combination of low rolling ridges and valleys that stretches northwest into lowlands that connects to the Yukon Flats and is bounded by the Yukon River to the north and the Yukon-Tanana Highlands to the south. The valley is dotted by small lakes, the largest of which is Medicine Lake at two miles in width, and loess-covered terraces with a relief that ranges from 1,000 to 1,500 feet and ridges reaching heights between 2,000 to 2,500 feet. Much of the area is underlined by permafrost that is associated with eroded continental sedimentary rocks of Cretaceous and Tertiary age. Much of the sedimentary structure of the Tintina Valley is associated with the metamorphic and granite rocks of the Yukon-Tintina Upland to the south and the Ogilvie Mountains to the north. Portions of the geology of the valley area are undetermined, such as the geology beneath Circle Hot Springs.

Yukon-Tanana Uplands

The Yukon-Tanana Plateau is made up of rounded even-topped ridges of broad undulating divides and flat-topped spurs all of which have gentle side slopes. Between the Yukon River and the Tanana River the profile of the uplands tends northeast and consists of low ridges that range from 1,500 to 3,000 feet then give way to mountains that range in elevation from 3,000 to 5,000 feet.

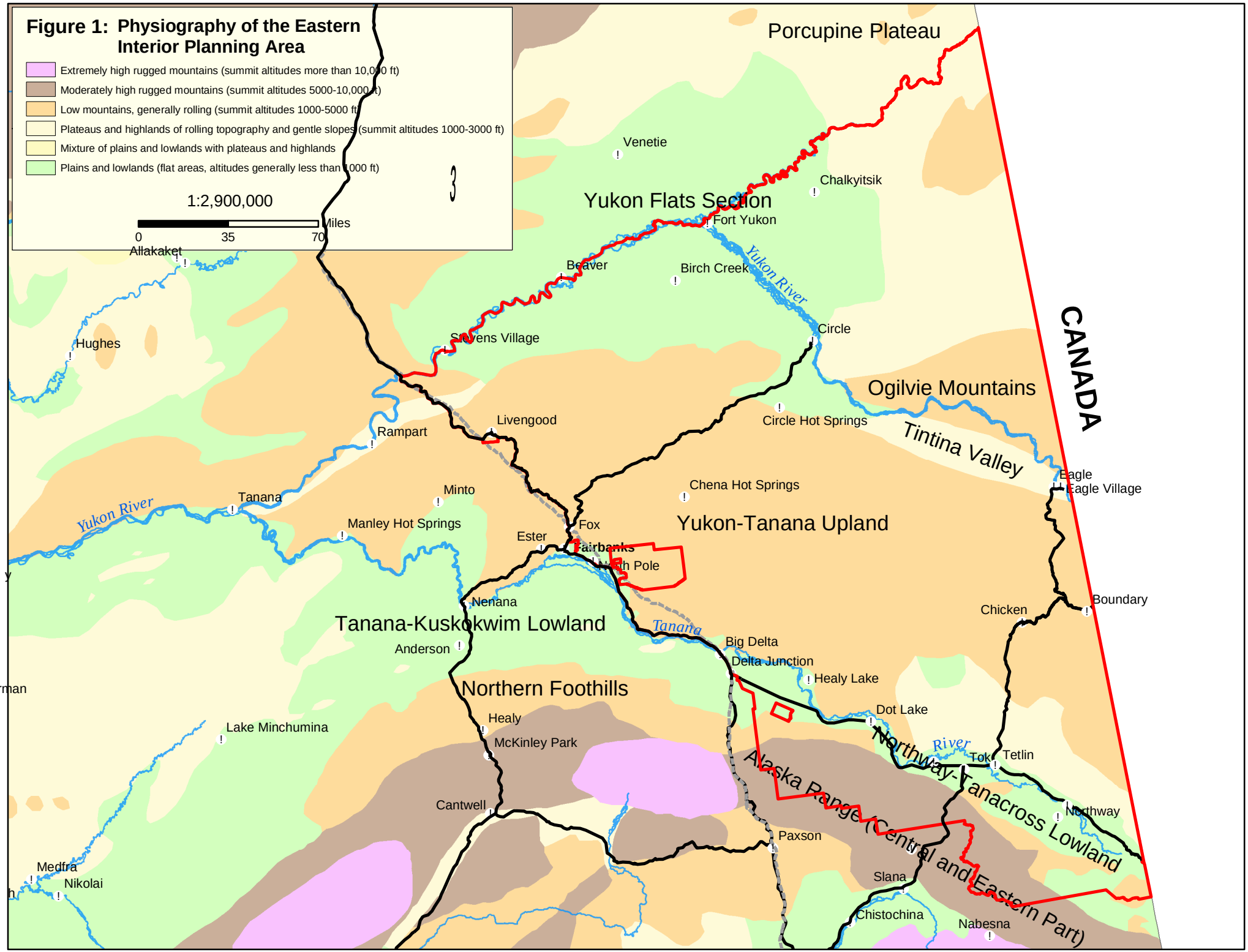

Figure 1: Physiography of the Eastern Interior Planning Area

The western part of the Yukon-Tanana Upland is composed of valleys that have flat alluvial floors with wide V-shaped drainages. All of the area is drained into the Yukon Drainage basin however some streams do collect in the Tanana River, which eventually drains into the Yukon River. Valley floors are underlain with discontinuous permafrost, ice wedges and frozen muck. At higher altitudes periglacial mass wasting is active. At higher altitudes periglacial mass wasting is active. Geological features are primarily associated with a belt of deformed Paleozoic sedimentary and volcanic rocks that includes strings of limestone that stretches along the north side of the upland. The geological feature south of the northern edge of the uplands consists of Precambrian schist and gneiss but includes areas of granite intrusions along with irregular batholiths.

Northway-Tanacross Lowland

The Northway-Tanacross Lowlands range from low rolling hills, lowlands that are nearly level plains to gently rolling moraine-covered plain. The Northway-Tanacross Lowlands drain into the Tanana River. Some portions of the Northway-Tanana Lowlands are separated from the Yukon drainage system by a mere two to five miles. The lowlands contain several large lakes that may be result of alleviation of the lowlands. Predictably, the area contains discontinuous permafrost. Most of the lowlands are geologically similar in that they consist mainly of mantled outwash, gravel, silt, and morainal deposits. Bedrock hills consist mainly of Precambrian schist and Mesozoic granitic intrusions.

Yukon Flats Section

The Yukon Flats are a vast basin that consists of marshy lake-dotted flats rising from 300 feet in altitude on the west to 600-900 feet on the north and east. The northern part of the flats is primarily made up of gently sloping outwash fans of the Chandalar, Christian, and Sheenjek Rivers and the southern area of the Yukon River. The majority of the flats area is nearly flat with areas of rolling marginal terraces with some sharp escarpments that are 150-600 feet above flats. Some of the rolling terraces gradually rise to 1,500 feet at the base of the surrounding uplands. The Yukon Flats is drained by the heavily braided and gradual flowing Yukon River. Near the town of Fort Yukon, the Yukon River takes a sharp bend to the southwest where there are numerous sloughs and meandering courses. The Yukon River is fed by many tributaries that originate in the uplands and mountains surrounding the flats. Some of the larger tributary rivers include the Porcupine, Black, Sheenjek, Birch, and Chandalar Rivers. Thaw lakes are a common occurrence throughout the flats and marginal terraces of the Yukon Flats.

Geology of the Yukon Flats is possibly the product of the early Tertiary and late Cretaceous. The Yukon Flats Basin is underlain by the extensive Tozitna terrane, a Devonian to Jurassic oceanic assemblage obducted onto the Arctic Alaska margin during the Jurassic and remobilized at least once during the mid-Cretaceous (Till et al 2005). A

water well drilled in 1954 near Fort Yukon discovered 48 feet of Aeolian sand and of late Pleistocene or recent age underline by 100 feet of sandy gravel of Pleistocene age underlain by 292 feet of fine lake sediment. The results of the well data suggest that the Yukon Flats is the site of a late Tertiary lake that occupied a downwarped basin. The Kandik thrust belts lies east of the Yukon Flats Basin which is expected to be the thrust belt's root zone.

B. Rock Units (Lithology Stratigraphy)

This section presents a summary of rock units in the EI planning area listed chronologically from oldest to youngest. The geologic units are defined using the work of the United States Geologic Survey maps (Till 2006) that describe the rock features of central and eastern interior Alaska

Basement Rocks Units (Proterozoic to Precambrian)

Geological features in the Yukon-Tanana Uplands are defined by undivided Precambrian to Proterozoic basement metamorphic rocks. This band of basement rock is contained by the Tintina Fault Zone on its north-west side and the Victoria Creek Fault Zone on its north-east side. The basement rock is intruded by granite plutons, several of which are associated with the geothermal activity of the Yukon-Tanana Uplands, and sections of sedimentary and igneous rocks corresponding to older parts of the Fairbanks-White Mountain areas.

Paleozoic Rock Units

Rock structures of the Paleozoic era encompass a wide area of the Eastern Interior. The eastern border of the planning area along the Canadian border, referred to as the Porcupine Province (Porcupine Platform), has significant structures that range in periods from Cambrian to Devonian. The area to the South of the Porcupine River and north of the Black River is predominantly defined by Cambrian to Permian sedimentary rocks of the Tatonduk Area. This sedimentary body is intruded by older Devonian and Cambrian strata of the Porcupine sequence and Proterzoic sedimentary rocks of the Tindir Group. Small bodies of rock structure are present along the northern edge of the Tintina Fault and along the length of the Victoria Creek Fault Zone. These groups include sedimentary and igneous rocks corresponding to the older parts of the Schwatka-Rampart area sequence and the Livengood area sequence. At the fault junction there is a body of metamorphosed sedimentary rocks of the Devonian to Silurian period. Several structures of the undivided Early-Jurassic to Devonian Angayucham-Toztina terrane are present along the northern edges of both fault zones. The predominate ages of rocks in the Porcupine Platform are of Paleozoic age which all give way to younger Cenozoic rocks along the eastern edges of the defined Yukon flats area. The Yukon-Tanana Uplands is primarily defined by the Precambrian metamorphic rock and other similarly aged rocks

which are tied to the high geothermal activity of the area, such as Circle and Chena hot springs.

Mesozoic Rock Units

The younger rock structures of the Porcupine Province are predominate along the southern end of the platform along the Canadian border and some smaller bodies stretched along the whole area of the Porcupine Province. These rock units include the Cretaceous sedimentary rocks of the Kandik basin which is spotted in with bodies of Early Cretaceous and Jurassic Glenn Shales. Between the Porcupine River and Black River there are small North-East trending bodies of Cretaceous to Jurassic sedimentary rocks that are intermixed with older sections of the Jurassic to Mississippian Strangle Woman Creek Sequence. In the Yukon-Tanana Uplands a North-East trending structure of Lower Cretaceous and Jurassic sedimentary rocks of the Manley Basin follow the Victoria Creek Fault and acts a divider to the older structures of the Yukon-Tanana Upland terrane and the Livengood Sequence. Other smaller bodies in the Yukon-Tanana Uplands are broken by the faulting zone and include structures of the Devonian and Silurian period metamorphosed sedimentary rocks and some ultramafic rock structures. Small exposures of Tertiary clastic sedimentary rocks are intermixed with similar aged rocks along the fault boundaries.

Cenozoic Rock Units

The main body of the Yukon-Flats basin is predominantly defined by the young Quaternary period unconsolidated and poorly consolidated sediments. This area is rich with young sedimentary deposits and alluvial structures due to its low-land profile and extensive drainage systems, specifically the Yukon River. The Yukon-Flats basin, which is almost all sediment deposits, is bounded by the Brooks Range Structures to the north which is primarily older rock units of the Mesozoic and Paleozoic eras. The flats are contained to the south by the structures of the Yukon-Tanana Uplands and the less extensive units of the Porcupine Platform to the east. Along the Yukon-Tanana Uplands there are some small bodies of Tertiary granitic rocks and few small units of Tertiary clastic sedimentary rocks. It should be noted that USGS data suggest that the basement rock depth in the Yukon-Flats/Yukon-Tanana Uplands boundary are several thousand feet deeper than any residing structures (Till 2006). The area just north-east of Circle Hot Springs, in the break of the Tintina Fault Zone, is expressed by nearly vertical profile to the basement rocks and an area just north of the apex of the junction of the Victoria Creek Fault and Tintina Fault expresses similar structures with the basement rock found several thousand feet nearly vertical. Some Tertiary basalt flows and rare cinder cones are present in the structures in the Porcupine River area in the north-east corner of the planning area with one lone structure appearing as an island in the midst of younger sedimentary deposits in the north-east corner of the Yukon-Flats basin.

C. Geophysics and Geochemistry

Coal Geochemistry

Merritt and Hawley (1986) summarize the geochemistry of coalfields and coal districts of Alaska; workers have produced a significant volume of literature detailing the State of Alaska's undeveloped coal resources in the north of Alaska. The quality of coal is ranked by the amount of metamorphism it has undergone since burial. Coal qualities are divided into four classes or ranks: in decreasing order of carbon content and heat value, these are anthracite, bituminous coal, subbituminous coal, and lignite. Within the bituminous class, coals are further subdivided into five groups based on the amount of volatile matter (low, medium, and high volatile present) and heat value (A, B, and C) (DOE 2004).

The planning area encompasses four main coal areas and a small section in the far east end of the Rampart Field (the Rampart Field overlap with the planning area it will be excluded from further explanation). The Eagle Field, Chicken District, Circle District and Steese District all fall within the planning area. Each of these areas are defined as subbituminous ranked coal with less certain resource potential as defined by Merritt and Hawley (1986).

Geothermal Data

The central portion of the Eastern Interior, primarily the Yukon-Flats, has long been recognized for its geothermal potential. A reconnaissance survey of geothermal potential completed for the area has been conducted by several independent bodies, specifically the owners of the Chena Hot Springs Resort in collaboration with the University of Alaska Fairbanks. Areas where analyzed for levels of argon (^{40}AR/^{39}AR) in 11 test wells that were drilled in the Chena Hot Springs area (Kolker 2007). Further geothermal examinations have been conducted in the Circle and Central area to examine potential of development but not at the level of interest and scale of Chena Hot Springs.

III. DESCRIPTION OF LEASABLE MINERAL RESOURCES

Leasable minerals included in this section comprise of coal, coal bed natural gas, oil and gas, oil shale, and geothermal. Development of Alaska's leasable energy resources offers numerous advantages:

- Alaska is centrally located to serve the entire Pacific Rim. It is closer to the Far East markets than markets located in Australia, Canada, or South Africa.

- Alaska is well positioned to serve European markets by the Northern Sea Route. Specialty armored freighters are able to routinely transit the polar passage during the summer.
- Alaska offers a stable political environment and well-trained workforce.
- Alaska has government participation through tax credits and the provision of infrastructure.

A. Coal

Coal deposits are broken down into three different groups: province, sub-province, basin, field, district, and occurrence. For purposes of this MODPR, only field and districts are applicable. A field is defined as an area that has high resources potential and contains one or more known coal beds of mineable thickness and quality. A district is defined as an area that forms part of a coal field or an isolated area that has less probable resource potential than a coal field (Merritt and Hawley 1986).

Sedimentary rocks with known coal deposits occur in several areas within the planning area. Subbituminous grade coal occurrences can be found in the Eagle Field, as well as the Chicken, Circle, and Steese coal districts. All of the coal deposits within the planning area are part of the larger Upper Yukon coal province. The two chief coal resources in the Upper Yukon coal province are Eagle Field and Chicken District, while lesser coal resources include the Steese District and Circle District (Figure 2) (Merritt 1987). Additional coal occurrences of undefined quantities have been identified in the planning area; however they have not been fully assessed and will not be included in this report. Each field or district is discussed in terms of origin and occurrence, historical information, and development potential.

Eagle Field

The Eagle Field is positioned near the eastern-central part of the planning area, in the Fortymile Subunit, approximately nine miles from the Canadian border on its furthermost easterly flanks. It encompasses 392,500 acres, all of which lies on the southern banks of the Yukon River. The Eagle Field has the greatest development potential in the planning area.

Figure 2: Coal Deposits and Coal Bed Gas Areas of the Upper Yukon Province within the EI Planning Area
Coal Fields and Districts
Coal Bed Gas Assessment Area
EI Planning Area
*All Coal in Planning Area are of Sibbituminous Rank
1:2,250,000
Miles
0 10 20 40 60 80
1
Chalkyitsik
Fort Yukon
Birch Creek
Circle
Steese District
Circle District
Central
Circle Hot Springs
Eagle Field
Livengood
Eagle Village
Eagle
Chena Hot Springs
North Pole
Boundary
Chicken
Chicken District
Delta Junction
Healy Lake
Dot Lake
Tanacross
Tok
Tetlin
Northway Junction
Northway
Trans Alaskan Pipeline

Origin and Occurrence

The Eagle Field lies generally along the Tintina fault of Alaska and Canada. Coal of subbituminous C and lignite rank occur in seams less than five ft thick and are exposed in broad open folds in Late Cretaceous and Tertiary strata. The range in quality can vary from 6,100 to 9,100 Btu/lb, 0.2 to 0.6 percent sulfur, and 2 to 20 percent ash. Resource extent for recoverable coal is identified at 10 million short tons whereas hypothetical resources are estimated to be close to 100 million short tons. A bituminous coal occurrence near the Nation River identifies an exposed section of faulted Tertiary coal (Merritt 1987). This is the only documented coal resource with a higher rank in the planning area. Coal characteristics include low water and ash, but relatively high sulfur. The extent of this resource is uncertain. The coal is primarily associated with shales and mixed with conglomerates. Above and below the Nation River area there are sandstones that are intensely folded and faulted. Near this area conglomerate sandstones have shown that they are overturned folds, which has brought slates above them. The slate is thought to be Paleozoic in age (Collier 1903).

Historical Information

According to A.J. Collier, who conducted several coal studies throughout Alaska, coal was discovered on Washington Creek by Mr. N.B. La Brie in 1897. Shortly after, coal claims were staked along the west side of the creek. These claims were later turned over to the Alaska Coal and Coke Company. Other claims were staked by several other individuals, however, little large scale production came to fruition.

The Alaska Coal Company had a drift tunnel 60 feet long and a slope tunnel that was 106 feet long. As of 1903 five tons of coal had been mined from the workings, but the workings had caved in throughout large areas of the mine (Collier 1903). Much of the coal extracted from this mine and other small workings was transported to the town of Eagle and used as heating fuel. The large placer mine operations in the area used the readily available coal for heating and lighting on their mining claims.

Alaska Commercial Company opened a coal mine operation in the Nation River area and produced about 2,000 tons of coal shortly after the closure of Alaska Coal Company. The mined coal was sledded to various communities along the Yukon and was used in river steamers or transported to the Dawson market (Collier 1903).

Current Production

Despite the large deposits of coal, there is still low potential for development unless nearby infrastructure were to be developed. Development would require a suitable large scale transportation mechanism, such as a rail system, which does not exist in this area.

The harsh arctic climate must be taken into consideration as it can greatly impact mining operations and resource transportation.

Chicken District

Origin and Occurrence

The Chicken District is located about 50 miles south of the Eagle Field on a small tributary to the South Fork of the Fortymile River (Merritt 1987). The coal deposit is located west of the town of Chicken which is connected to the Alaska Highway system via the Taylor Highway and is within the Fortymile Subunit. Geologic features within the Chicken District are of Tertiary age and are made up mostly of glaciated fine and coarse grain rubble. The Tertiary coal-bearing unit here has a potential area of only a few square miles, which is mostly confined to subbituminous coal. Chicken District's most notable coal feature is a 22-foot thick subbituminous seam that dips to near vertical in an outcrop.

Historical Information

Initial reconnaissance of the Yukon coal districts in the late 1800's did not consider the Chicken District as a plausible source of coal to sustain the quickly growing gold communities along the Yukon River. Chicken District coal potential was discovered in conjunction with the gold bonanza that descended upon the area in the early 1900s. Coal that was discovered just to the west of the small community of Chicken was used by the miners as a heating source for cabins and warming fires for mining (Lundberg 2008). Large scale coal mining did not occur until the 1930s when a mine shaft (for coal) was opened into the larger coal bed. The coal from here was used locally in placer mining ventures (Merritt 1986). Gold resources were plentiful enough for mine operators to justify hauling dredges into the remote location. Pedro Dredge, owned by the Alaska Gold Dredging Corporation, was floated up the Fortymile River from Eagle. It initially burned the local coal found in the Chicken District. The dredge was soon converted to burn wood due to the poor quality of the coal—not enough steam could be produced to power the dredge efficiently (Lundberg 2008).

Current Production

There is currently no coal being produced from the Chicken District. The low grade coal and the limited size of the district make it an unattractive source for large scale development. If a coal mining operation were developed it would benefit from the proximity of the Taylor Highway and its connection to the rest of the state. Coal from this area could potentially be used locally for power production either through direct fire or gasification methods.

Circle and Steese Districts

Origin and Occurrence

Circle District is a small body of coal that is bounded by the Tintina Fault to the south and the Yukon River to the north. It is located near the town of Central and Circle Hot Springs. The Circle District encompasses roughly 77,000 acres and is mostly defined as subbituminous coal. Sections of the Tertiary continental sedimentary rocks are exposed in the Steese District which lies roughly 50 miles west of the Circle District (Merritt 1987). The Steese District contains a small body of coal that encompasses 18,000 acres. The material that overlies the coal districts is predominantly alluvium aggregates mixed with valley loess. Bed thickness is typically less than five feet and is predominantly defined as Tertiary subbituminous to bituminous coal. This coal seam stretches across the length of the Tintina Fault all the way to the Rampart Field, roughly 180 miles to the west. All totaled, there is an estimated resources of 50 million short tons of coal (Merritt 1987).

Historical Information

Coal use in the late 1800's and early 1900's around the town of Circle was limited to heating. Later, dredges along the Yukon drainages began to use the coal as a source of fuel. Many gold miners in the Birch Creek mining area bought coal for heating at their mine sites, the main coal demand for the area. Coal mined in the Circle and Steese Districts was usually not shipped to the larger Canadian towns simply due to the fact that there was coal closer to the boarder. Coal mining in the area dried up with the advent of heating fuels. Many dredges switched first to wood burning then diesel power.

Current Production

There is currently no production of coal in the Circle District. The proximity of abundant geothermal resources in the area has taken precedence over the use of coal as a source of energy. Development potential is possible, but due to the remote location and low-grade coal, development would be limited in scale and distribution. The Steese Highway, connected to the Alaska Highway system, could act as distribution route for coal. The Steese District is not connected to the road system but is accessible by plane in the summer and tracked vehicles in the winter. Development potential for the Steese District is greatly limited by its remote location and the fact that the coal is of low grade and not a large resource body. The cold arctic climate should be carefully considered when assessing coal development in this area as it will adversely impact mining operations and resource transportation.

B. Coalbed Natural Gas

Methane within coals has long been recognized as a hazard when mining the coals. It wasn't until the 1980s that coalbed natural gas (CBNG) was thought of as a potential reservoir target, even though producers often drilled through coal seams on their way to deeper targets. During the late 1990s coalbed natural gas production increased dramatically nationwide to meet the ever growing energy demands. In 2007, coalbed natural gas accounted for nearly ten percent (1,754 bcf) of total gas production (19,089 bcf) within the United States (EIA 2009).

Coalbed natural gas is low cost, clean burning, natural gas recovered and produced from coal beds. Unlike conventional gas, it is a nontraditional reservoir in the sense that the coalbeds are both the source and reservoir for the methane gas (Tyler et. al 2000). The conversion of plant material to coal (coalification) produces large amounts of gas, comprised of mostly methane, that is then stored on the internal surfaces of the coal. Because coal has such a large internal surface area, due to fractures or cleats, it can store six to seven times the amount of gas than a conventional gas reservoir of equivalent rock volume. Gas within the coal is held in place by hydrostatic pressure (Nuccio 1997).

Exploration costs for CBNG are low, and wells used to extract CBNG are cost effective to drill. Because methane is less dense than oxygen, it rises to the surface as water pressure is reduced within the coal seam by pumping. Coalbed natural gas is extracted, compressed, and then put into pipelines and burned like any other natural gas accumulation. No specialized technology is needed for its immediate utilization. Gas content generally increases with coal rank, with depth of burial of the coalbed, and with reservoir pressure (Nuccio 1997).

In the early stages of coalbed natural gas production large amounts of water may be produced. Water disposal from the production of coalbed natural gas has been handled in many different ways depending on the water quality, quantity, and location that production is occurring. In some locations water has been disposed of at the surface when it has been relatively fresh. However, most water is injected into a rock at depth, often below that of the coalbeds being produced where the water quality of the host rock is less than that of the injected water.

The ideal scenario for maximum coal bed methane production would be to have the following:

- Thick, laterally continuous coals of high thermal maturity
- Adequate permeability
- Basinward flow of groundwater through coals of high rank and gas content orthogonally toward no-flow boundaries (a.k.a. fault systems, structural hingelines, facies changes)

• Generation of secondary biogenic gases
• Conventional trapping along those boundaries to provide additional gas beyond that generated during coalification.

Figure 3: CS1000 P6L Drilling Rig

Rural communities in Alaska have very high energy costs for electrical power generation and space heating that is typically 3-5 times that of urban Alaska (GSA 2005). To meet the energy requirements for rural Alaska during the cold winter months thousands of gallons of heating oil, diesel fuel, and gasoline must be transported to the village to maintain generators, heaters, and vehicles. Rising fuel costs, exponential increases in transportation costs and petroleum based fuels are quickly becoming a stagger hurdle for village finances. Finding an alternative to expensive fuels has become a primary goal for many rural communities. With approximately 40 remote communities situated on or near coal deposits Statewide, one potential source of energy is coal bed gas, a clean burning fuel that is comparable in heating value (approximately 1,000 Btu/scf) to conventional natural gas (GSA 2005). Six villages in the planning area fall within the coal bed natural gas assessment area (Figure 2): Birch Creek, Central, Circle, Circle Hot Springs, Chalkyitsik, and Fort Yukon.

Fort Yukon

Origin and Occurrence

Fort Yukon, a small village on the north bank of the Yukon River, was the site for a coalbed natural gas pilot test project in 2004. The village brings in roughly 620,000 gallons of diesel fuel per year (ADN 2004). With the sharp rise in gas prices over recent years, coalbed natural gas could provide much needed relied to Fort Yukon and other villages near gas-forming coalbeds could model this process. Cooperating entities for the project included BLM, Division of Geological and Geophysical Survey (DGGS), United States Geological Survey (USGS), the State of Alaska, and University of Alaska Fairbanks. This project was designed to demonstrate the use of a lightweight slim hole coring drill rig (Figure 3) and obtain the necessary data to assess the economic and environmental feasibility of producing natural gas from Tertiary-age lignite coal that underlies Fort Yukon (GSA 2005). A lightweight Atlas Copco CS 1000 drill rig was barged to the proposed exploration site and two holes were drilled to extract core samples

of coal. The well reached a total depth of approximately 2,287 feet. Lignite coal was intersected at two different depths, samples were extracted and each sample was analyzed for methane content. Preliminary results of gas content analyses indicated an average of 20 percent to 30 percent gas saturation in targeted coal seams, with a maximum of approximately 50 percent in one single canister (GSA 2005). However, this was not enough gas to make the project economically feasible (Bailey 2007). Future plans for coalbed natural gas at Fort Yukon have been scrapped.

C. Oil and Gas

The USGS prepares estimates of oil and gas resources in the United States based on the concept of a "play," which is defined as a set of oil and/or gas accumulations sharing similar geographic boundaries and geologic attributes, such as source rock, reservoir type, and trap (Beeman et. al 1996). There are two known basins in the planning area; Kandik and Yukon Flats basin (Figure 4). Two plays were identified within the Kandik Basin and three in the Yukon Flats Basin. By definition, plays identified by the USGS are to be considered high potential for future oil and gas exploration.

Four hydrocarbon (one coalbed methane well and three oil and gas wells) have been drilled within the boundaries of the planning area. Two additional shallow holes were drilled in the planning area and encountered gas. Currently, none of the wells drilled in the Eastern Interior Planning Area are producing; the oil and gas potential is not fully realized for this area.

Pending Oil and Gas Leases

There are 294 suspended oil and gas lease offers within the planning area. Most of these pending noncompetitive offers were filed prior to 1975 and grandfathered in by Congress when it passed Sec. 5106(a) of the 1987 Federal Onshore Oil and Gas Leasing Reform Act (101 Stat. 1330-256, 259) (Reform Act). The Reform Act requires BLM to issue leases for these suspended offers unless such lease issuance would not be lawful under other applicable law. Of the 294, 21 have been decisioned out, 172 are within the Yukon Flats National Wildlife Refuge, leaving 102 pending leases on BLM managed lands.

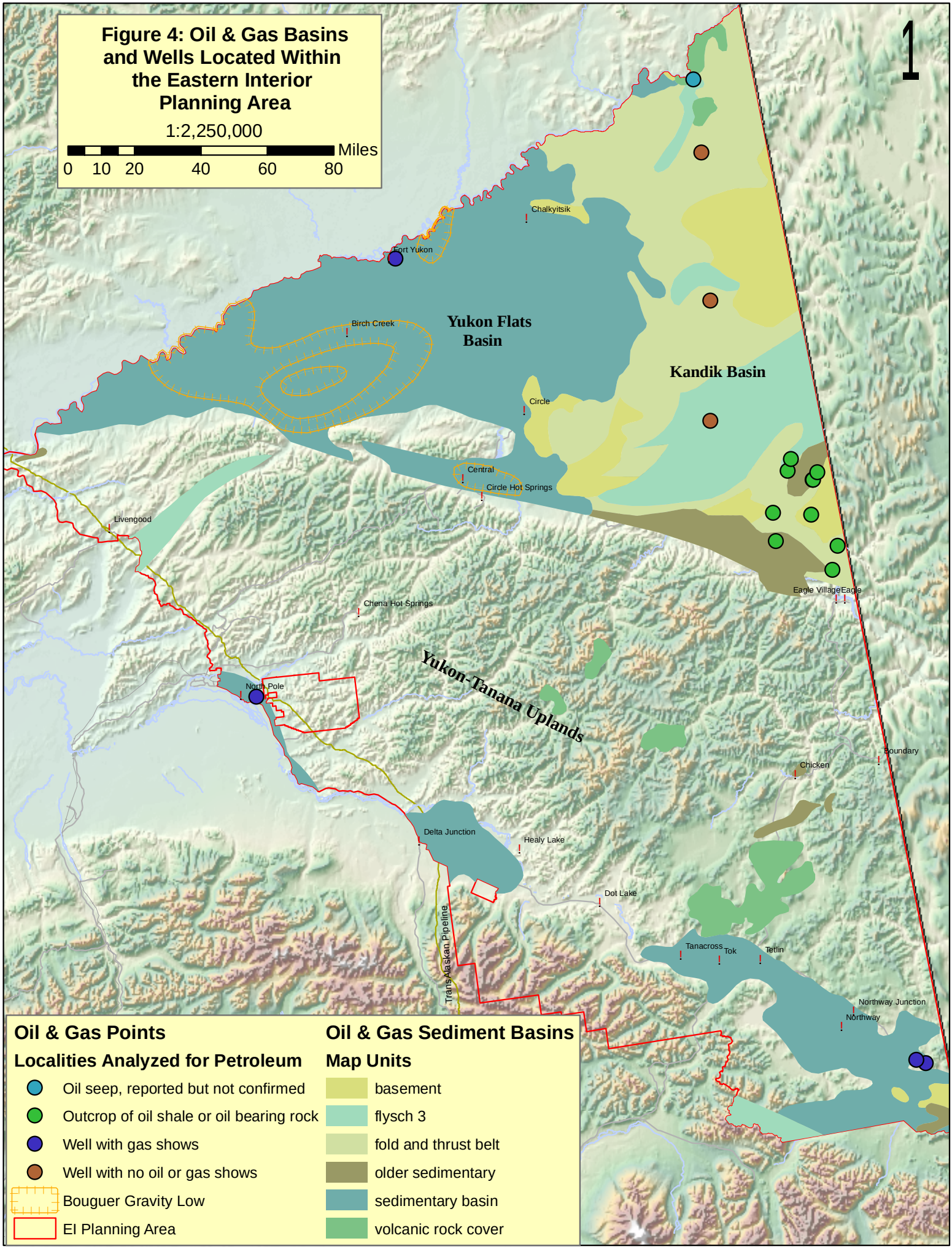
Figure 4: Oil & Gas Basins and Wells Located Within the Eastern Interior Planning Area
1:2,250,000
Miles
0 10 20 40 60 80
1
Chalkyitsik
Fort Yukon
Birch Creek
Yukon Flats Basin
Kandik Basin
Circle
Central
Circle Hot Springs
Livengood
Chena Hot Springs
Eagle Village
Eagle
Yukon-Tanana Uplands
North Pole
Boundary
Chicken
Delta Junction
Healy Lake
Dot Lake
Trans Alaskan Pipeline
Tanacross
Tok
Tetlin
Northway Junction
Northway
Oil & Gas Points
Localities Analyzed for Petroleum
Oil seep, reported but not confirmed
Outcrop of oil shale or oil bearing rock
Well with gas shows
Well with no oil or gas shows
Bouguer Gravity Low
EI Planning Area
Oil & Gas Sediment Basins
Map Units
basement
flysch 3
fold and thrust belt
older sedimentary
sedimentary basin
volcanic rock cover

Kandik Basin

The Kandik Basin is a structural depression containing Paleozoic-Mesozoic sediments that straddles the Yukon-Alaska border. The basin constitutes a fragment of cratonic North America that underwent compression forming a fold and thrust belt with a southeastern vergence. The basin contains six conceptual plays on the Yukon side (three oil and three gas) and two conceptual plays on the Alaska side. The oil and gas potential of the Yukon plays are shown in Table 2 (GOY 2008). The two Alaska plays are defined as the Kandik Pre-Mid Cretaceous Play and the Kandik Upper Cretaceous and Tertiary Non-Marine Strata Play (Stanley 2002). Some median estimate totals for in-place oil are 54 million m^3 (340 Mbbls) and for gas at 38 billion m^3 (1.34 tcf). Significant gas potential is predicted for the Mesozoic and Paleozoic marine structural plays even though risk factors are substantial in the plays. To date, there are no discovered reserves in the Kandik Basin (Table 3). The Canadian Geological Survey predicts three gas fields in excess of 100 bcf. (Hannigan et al 2000).

There is potential for small to moderate sized oil and gas pools in Lower Cretaceous to Upper Devonian and upper Proterozoic sandstones in combined structural-unconformity and thrust-related traps. Triassic, Permian, Carboniferous and Paleozoic carbonates have the potential for stratigraphic traps (Hannigan et al 2000).

Table 2: Plays in the Kandik Basin.

Gas Plays (Bcf)	No. Fields (mean)	Mean Play Potential (in place)	Play Potential 80% Probability (in place)	Play Potential 20% Probability (in place)
Tertiary/Upper Cretaceous nonmarine	30	99.0	33.5	172.9
Mesozoic marine structural	8	189.1	67.5	299.0
Paleozoic marine structural	10	360.8	124.3	572.8
Total Gas (Bcf)	**48**	**648.9**		

OilPlays (MMbbls)	No. Fields (mean)	Mean Play Potential (in place)	Play Potential 80% Probability (in place)	Play Potential 20% Probability (in place)
Tertiary/Upper Cretaceous nonmarine	30	77.8	26.6	135.9
Mesozoic marine structural	---	---	---	---
Paleozoic marine structural	3	21.5	3.1	36.8
Total Oil (MMbbls)	**33**	**99.3**		

Table 3: Kandik Basin (Northern Oil and Gas Directorate Indian and Northern Affairs Canada 1995).

Age	Palaeozoic to Cretaceous; Quaternary cover
Depth to Target Zones	2500-4500 m
Maximum Basin Thickness	Up to 5500 m of Mesozoic rocks
Hydrocarbon Shows	Surface: dead oil in Triassic shales and Paleozoic limestones Subsurface: oil staining and minor gas shows, bitumen
First Discovery	None
Basin Type	Cordilleran: autochthonous shallow-water marine shelf (Paleozoic to early Mesozoic). Compressional Laramide basin (Cretaceous to Recent)
Depositional Setting	Shallow-water carbonate and clastic shelf
Potential Reservoirs	Carbonate reef mounds and facies fronts; fractured carbonates; sandstone lenses
Regional Structure	Long wavelength open folds; minor expansion faults; thrusting in southern portion of basin
Seals	Marine shales and tight carbonates
Source Rocks	Shales and organic rich carbonates
Depth to Oil/Gas Windows	1800-2900 m
Total Number of Wells	1 in US; none in Canada (3 wells in outcrop belt east of basin)
Seismic Coverage	Approximately 200 km along basin margins in Canada (all pre-1980)
Pipelines	None
Area	9209 km² (83% in Alaska)
Area under License	None

Potential Reservoirs

Potential for reservoir development exists in the following horizons (Northern Oil and Gas Directorate Indian and Northern Affairs Canada 1995):

- Tahkandit Formation limestones. In the Alaska portion of the basin, these strata show local porous zones containing a dark brown oil stain.
- Jungle Creek (Calico Bluff) calcareous sandstones. In the Alaska portion of the basin these strata have yielded a pale reddish brown oil cut.
- Ettrain Formation. Within the Kandik Basin the Ettrain limestones are almost twice as thick as those in the Eagle Plain Basin (east of the Kandik Basin in Yukon Territory).
- Hart River Formation limestones and calcareous sandstones.
- Ogilvie Formation. Reefal carbonates have good porosity and permeability in outcrop along the Porcupine River in Alaska. Fractures and vugs (small to medium-sized cavities inside rock) within the formation have yielded a pale greenish-brown oil cut.

- Jones Ridge Formation. Limestones and argillites show good porosity and permeability in outcrops and have yielded a dark brown oil cut.
- Limestones and sandstones of the uppermost Tindir Group have sufficient fracture porosity and could contain hydrocarbons.

Discoveries of hydrocarbons have been made in the Jungle Creek and Hart River formations in the Eagle Plain Basin. Minor gas shows have also been noted from the Ettrain and Ogilvie formations.

Structure, Traps and Seals

The Kandik Basin was pervasively folded and faulted during the Late Cretaceous to Tertiary. Fold axes trend northeastward and relate to wrench movement along the Tintina Fault zone at the southern margin of the basin. Proterozoic and Paleozoic rocks form broad open folds with little fracturing along the hinge lines while Mesozoic and Cenozoic rocks form tight isoclinal folds with fractured hinge lines and steep, commonly overturned limbs.

At least two orthogonal sets of Cretaceous or younger high-angle faults are present within the basin. Low-angle thrust faults have been mapped in the Canadian portion of the basin making over-thrust traps a possibility in this area.

Shales of the Mount Goodenough, McGuire, Kingak, and Ford Lake formations are potential seals for Carboniferous and Cretaceous units. Facies transitions from carbonate to shale (Ogilvie/McCann and Ettrain/Blackie) and from sandstone to shale (Nation River/Ford Lake) are potential lateral seals for lower Paleozoic units. The Canol and upper Road River shales, although relatively thin, could act as top seals for Middle Devonian and older reservoirs. The Lower Cretaceous Kingak Formation could form a regional top seal for reservoirs truncated by the sub-Jurassic unconformity (Northern Oil and Gas Directorate Indian and Northern Affairs Canada 1995).

Source Rocks

Geochemistry indicates that Middle Devonian to Lower Cretaceous source rocks are mature to overmature for oil. Three source rocks have been identified within the Kandik Basin. These are type II and III kerogen-rich shales of the Canol Formation with Total Organic Content (TOC) up to 7%; type I and II kerogen-rich shales of the upper Road River Formation with TOCs up to 5% and the Mount Goodenough Formation type II and III kerogen-rich shales with TOCs up to 2%.

In addition to the above, four other possible source rocks are suggested by high visual estimates of organic content. These are: the limestones of the Tindir Group; the

limestones of the lower and upper Jones Ridge; the cherty shales of the McCann Hill Formation, and the organic-rich “oil shales” of the lower Glenn Formation. Two additional potential source rocks are suggested by analogy with the Eagle Plain Basin. Both the Ford Lake and Blackie formations contain type II and III kerogen but may be overmature for oil in the Kandik Basin (Northern Oil and Gas Directorate Indian and Northern Affairs Canada 1995).

Potential

The geology of the Kandik Basin is comparable with the neighboring Eagle Plain Basin in Yukon, Canada in which several oil and gas discoveries have been made. Similar stratigraphy and trap styles suggest moderate to high potential for discoveries in upper Paleozoic to Mesozoic rocks, particularly in stratigraphic and sub-unconformity traps along the crest of folds and associated with faults. In the Canadian portion of the Kandik Basin, over-thrust traps are an additional possibility. Additional plays, but more risky, are structural/stratigraphic traps associated with facies changes. Lower Paleozoic potential may exist in the carbonate to shale transition zones in the Cambrian through Devonian carbonate sequences. The high exploration risk for plays in the basin relates to reservoir facies development, porosity preservation, source rock maturity, and timing of migration to coincide with Cretaceous tectonics (Northern Oil and Gas Directorate Indian and Northern Affairs Canada 1995).

The two conceptual plays, as defined by the USGS, on the Alaska side: Kandik Pre-Mid-Cretaceous Strata Play, Kandik Upper Cretaceous and Tertiary Non-Marine Strata Play. A conceptual play is a hypothesized play based on the subsurface geologic knowledge of the area.

The Kandik Pre-Mid-Cretaceous Strata Play has a play probability occurrence of 0.06 and has not been quantitatively assessed. The Kandik Upper Cretaceous and Tertiary Non-Marine Strata Play has a probability occurrence of 0.42 and has been quantitatively assessed. The estimated mean of this play is 61.2 MMB Oil and 116.4 Bcf non-associated gas non-associated (Stanley 1995).

Since the Kandik Basin lies beneath the Alaska-Yukon border, the 340 Mbbls must be divided up according to the proportion in each country. The resource estimate for Alaska is 183 Mbbls. Three wells were drilled in the Kandik region, not necessarily in the basin, and are described below (shown in Figure 4).

Louisiana Land and Exploration Co. Doyon Ltd. well No. 1, spudded and completed in 1977, reached a total depth of 11,044 feet and was abandoned as a dry hole. Small black particles of dead oil were encountered at 1,450 feet and possibly solid bitumen at 10,900

feet. The mudlog shows evidence for trace amounts of methane at numerous intervals within the well, including 1,270-1,280 ft, 1,440-1,460 ft, 2,290-2,300 ft, 4,690-4,720 ft, 4,950-4,960 ft, 7,170-7,180 ft, 7,220-7,230 ft, 9,440-9,450 ft, and 9,900-9,980 ft. The origin of this gas is uncertain. The methane may have been a contaminant in water used for drilling (Troutman and Stanley 2002).

Louisiana Land and Exploration Co. Doyon Ltd. well No. 2 was drilled in 1977 to a total depth of 9,123 feet and abandoned as a dry hole. Solid bitumen was reported in Paleozoic dolomite at 6,875 and between 7,400-7,610 feet. Trace amounts of methane appear in the mudlog at depths 3,280-3,290 ft, 3,500-3,510 ft, 3,780-3790 ft, 4,740-4,770 ft, 5,780-5,880 ft, and 6,530-6,540 ft. It is possible that methane was a contaminant in the water that was used to mix the drilling mud (Troutman and Stanley 2002).

Louisiana Land and Exploration Co. Doyon Ltd. well No. 3 was drilled in 1977 to a total depth of 13,533 feet and abandoned as a dry hole. Solid bitumen was reported in Paleozoic limestone and dolomite between 2,690 and 11,100 feet. A trace amount of methane appeared in the mudlog at 2,330-2,340 feet. However, it could have been an artifact related to the resumption of drilling as casing was set just above this depth (Troutman and Stanley 2002).

A description of the two Alaska plays is described below from Stanley 1995:

KANDIK PRE-MID CRETACEOUS STRATA PLAY (HYPOTHETICAL)

Because of the abundance of potential source and reservoir rocks, the Kandik Basin region has been of interest to petroleum geologists for many years (Brabb and Churkin 1969). Upper Precambrian through upper Paleozoic continental-margin strata are unconformably overlain by an organic-rich Triassic-Jurassic horizon. Interest in the petroleum potential of this area was stimulated in 1970 by the spudding of the Doyon No. 1 well in Mesozoic strata about 25 mi west of the Glenn Creek fault (see fig 1). It is unclear why this exploratory well was located so far from the outcroppings of the Paleozoic and Mesozoic strata that lie within the thermal zone of oil generation. Instead, the well penetrated more than 10,800 ft of Jurassic-Cretaceous shale and siltstone with no hydrocarbon shows. Thermal-maturity data indicate that the lack of hydrocarbons is hardly surprising; these rocks are thermally supermature and the Glenn Creek Fault was not penetrated, precluding the possibility of a major overthrust play between rocks east and west of the fault. Structural models, based in part on the thermal data, suggest that such an overthrust play is unlikely in rocks west of the Glenn Creek Fault.

Because of their thermal maturity and together with the apparent lack of porosity in any of the potential reservoir rocks, the area west of the Glenn Creek Fault does not appear to be hydrocarbon prospective. The abundant thermally mature organic-rich shales in the Precambrian, Paleozoic, and Mesozoic section of the region southeast of the fault, however, could generate hydrocarbons.

Reservoirs: The principal structure within Play 204 in the east part of the Kandik Basin is the southwest-plunging Michigan Creek Anticlinorium. Strata younger than Precambrian have been variously stripped off the axis of this anticlinorium; thus, fundamentally compromising the reservoir integrity of this structure, especially for the units lying above the organically very rich Triassic Glenn Shale. Lapping on this structure with angular discordance is a sequence of Upper Cretaceous to lower Tertiary nonmarine strata that have themselves been folded into broad folds. These strata make up the principal components of the Play 205.

Source rocks: Several formations within the upper Precambrian through Middle Mesozoic section contain potential source rocks. None, however, are richer than the Triassic Glenn Shale, which is equivalent to the petroliferous Shublik Shale of the North Slope. The Glenn Shale locally contains more than 10 percent organic carbon. This unit was deposited on a broad shelf region that presumably covered much of northern Alaska. Thus, this organic shale, in combination with older black shales, indicates that the play is not limited as a consequence of the source rock.

Traps: The Kandik Basin is characterized principally by one major anticlinorium, the so-called Michigan Creek Anticline. Though highly dismembered, the overall integrity of the southwest anticlinorium is evinced by the map patterns of Precambrian rocks in the core and the younger strata cropping out along the northern and southern flanks. To the west of this major feature is the Glenn Creek Fault, a major east-verging thrust. The Michigan Creek Anticline itself is likely a ramp anticline that lies above a major blind thrust, a subsurface extension of the system of thrusts of which the Glenn Creek Fault is but one. This part of Alaska lies within the part of the cordillera of North America

characterized by Late Mesozoic craton-directed crustal shortening. The integrity of this trap is suspect because of deep-seated erosion along the crest of the anticline. The existence of ultradeep subthrust traps was not considered owing to a lack of data.

Exploration status: The Doyon No. 1 well is the only exploratory borehole within 30 mi of the play. This well, located about 28 mi northwest of the Michigan Creek Anticline, penetrated the Mesozoic strata west of the Glenn Creek Fault. Vitrinite reflectance data from cuttings from this well indicate very high thermal maturity (R_o of 4.0–5.0 percent) and relatively little variation with depth. A discontinuity in slope occurs in the plot of vitrinite reflectance versus depth at between 2,300 and 2,600 ft deep. Although stratigraphic correlations and formation picks are particularly difficult in this well, several thrust faults and section repetitions are inferred from cuttings and logs at depths below 2,600 ft. Structural repetition of thin thrust plates of similar thermal maturity may account for the remarkably small variation in thermal maturity with depth below 2,600 ft. No traces of either oil or gas were reported from this well.

Resource potential: Although this play contains a world-class source rock in the Glenn Shale, there are no obvious means to charge and preserve reservoirs sourced from this organic-rich shale. The risk associated with both reservoir and trap integrity is so large that we have eliminated this play from further consideration.

KANDIK UPPER CRETACEOUS AND TERTIARY NONMARINE STRATA PLAY (HYPOTHETICAL)

Cropping out in two separate areas within the Kandik Basin are erosional remnants of a once regionally extensive blanket of fluvial strata. These strata lap onto and locally cross the crest of the Michigan Creek Anticline and the traces of the Glenn Creek and Tintina Faults. Deposition of this nonmarine sequence occurred during the waning stages of cordilleran thrusting roughly equivalent to

the Laramide orogenic episodes. The debris is largely locally derived and represents the in-filling of large piggy-back basins in the fold and thrust belt that extends east into Canada.

Reservoirs: The strata of this play are represented by a heterogeneous mixture of conglomerate, sandstone, mudstone, and locally thin horizons of coal. The thicknesses of individual layers are highly varied along the strike, with numerous lateral pinch-outs. Because these are erosional remnants, the total sedimentary package is not preserved. Existing thicknesses are difficult to measure owing to the lack of marker horizons and overall poor exposures; nonetheless, it's probable that the aggregate thickness is at least 6,500 ft. The smaller northern patch of strata is a broad, easterly dipping monocline that buttresses onto the northern flank of the Michigan Creek Anticline. The regionally more extensive southern patch of nonmarine strata evinces numerous folds with flanking dips generally ranging between 10 and 30 degrees. The axes of the folds parallel the regional Michigan Creek anticline and like this large fold, the southern portion of the axes swing to the west, displaying drag features associated with the right-lateral Tintina Fault. Based on the heterogeneity of the strata, the fluvial depositional style, and the occurrence of numerous folds, reservoirs would be characterized by numerous stratigraphic traps and a host of small structural possibilities.

Source rocks: Although some coal has been found in association with these nonmarine strata, the potential of these rocks is limited to biogenic methane. These strata, however, lie above the organic-rich Triassic-Jurassic Glenn Shale as well as other potential source rocks of Paleozoic and late Precambrian age. The nonmarine strata are largely thermally immature, whereas the underlying potential source rocks that crop out on the surface remain today within the thermal zone of oil generation. Thus, from the point of view of maturation and charge, the source-rock situation of this play is excellent.

Traps: Because of extensive localized folding, numerous and varied small structural and stratigraphic traps are likely in this play.

Exploration status: Intermittently during the past 30 years, a variety of petroleum exploration companies have conducted field work in the Kandik Basin, drawn mostly by the occurrence of the organic-rich mudstones (particularly the Glenn Shale). To date, however, not a single exploratory well has been drilled in order to test some portion of the play.

Resource potential: Owing to the porous nature of the nonmarine package of strata, the absence of any significant oil seeps, and the abundance of prolific petroleum source rocks that remain in the oil-generating window, it seems highly likely that oil and gas accumulations reside within this play. The occurrence of numerous small folds and the extreme variability of strata along their strike also make it likely that any pools of petroleum will be numerous and small.

Yukon Flats Basin

The Yukon Flats Basin is the easternmost of the Central Alaska basins (Figure 4). These basins formed along large scale translational faults such as the Tintina, Kaltag, Border Ranges, and Castle Mountain. As such, they share formational and depositional histories.

In 2004, the USGS conducted a study of the Yukon Flats Basin and determined the existence of technically recoverable oil. The report estimated a resource of 173 MMbbls of oil (Figure 5), 127 MMbbls of natural gas liquids (Figure 6), and 5.46 trillion cubic feet of gas (Figure 6). Unfortunately, the lack of deep wells within the basin contributes to an uncertainty in this resource assessment. The coalbed natural gas test well conducted by the BLM and USGS is the deepest hole drilled in the basin; it reached a total depth of approximately 2,287 feet. The results were not favorable, as coal with only minor amounts of biogenic methane were encountered.

Assessment Unit	Accumulation type	MAS	Prob. (0-1)	Oil (MMBO)			
				F95	F50	F5	Mean
Tertiary Sandstone	Oil	0.5	0.81	0.00	106.77	560.35	165.57
	Gas	3					
Subthrust	Oil	0.5	0.24	0.00	0.00	3.39	0.61
	Gas	3					
Crooked Creek	Oil	0.5	0.48	0.00	0.00	28.75	6.47
	Gas	3					
Coalbed Gas	Gas						
Total undiscovered oil and gas resources				0.00	106.77	592.48	172.66

Figure 5: Oil potential by play. Probability based on decimal (.81 = 81% likely to exist). From Stanley et al. 2004.

Assessment Unit	Accumulation type	Total undiscovered resources							
		Gas (BCFG)				Natural-gas liquids (MMBNGL)			
		F95	F50	F5	Mean	F95	F50	F5	Mean
Tertiary Sandstone	Oil	0.00	103.49	565.05	165.80	0.00	6.04	34.46	9.97
	Gas	0.00	4,629.17	12,862.56	5,117.36	0.00	98.15	295.67	112.51
Subthrust	Oil	0.00	0.00	3.36	0.61	0.00	0.00	0.20	0.04
	Gas	0.00	0.00	92.91	15.94	0.00	0.00	2.04	0.35
Crooked Creek	Oil	0.00	0.00	29.06	6.55	0.00	0.00	1.76	0.40
	Gas	0.00	0.00	714.96	156.36	0.00	0.00	15.89	3.42
Coalbed Gas	Gas	Not quantitatively assessed							
Total undiscovered oil and gas resources		0.00	4,732.66	14,627.89	5,462.63	0.00	104.18	350.02	126.67

Figure 6: Gas and Natural-gas liquids by play. These plays are based on the probabilities given in Figure 6. From Stanley et al. 2004.

The existing data base for conventional oil and gas resource assessment in this basin consists of about 418 line miles of reconnaissance 2D seismic data with ancillary magnetic and Bouguer Gravity data. The interpretation of these illustrates the subsurface extent of the Yukon Flats Basin and its major features. Shallow core samples and outcrops peripheral to the Yukon Flats basin include Tertiary-age sandstones, conglomerates, siltstones and lignite/coal, including one thermally mature “oil shale” (TOC 17.96% and HI 936 mg/g).

There are several exploration wells east of the Yukon Flats. However, the basin itself has never been open to oil and gas drilling. Lease offerings, particularly those in Alaska, demonstrate that there is interest in exploring basins with oil and gas potential.

There are three major areas of comparatively thick sedimentary fill (>2,500 m or 8,200 ft.). The area west of Ft.Yukon is deeper than 3,500 m (about 11,500 ft), The elongated area from about Stevens Village to Beaver is deeper than 5,000 m (about 16,500 ft). The Birch Creek portion of the basin is deeper than 8,500 m (about 16,500 ft). At depths greater than about 8,200 ft there is sufficient geothermal heat to initiate the generation of hydrocarbons. Consequently, the deep areas of the Yukon Flats Basin have comparatively high potential for generating oil or gas. The areas immediately peripheral to the deep areas have potential for upward and laterally migrating hydrocarbons (Plate 1). A conservative estimate of the area in which hydrocarbons may have migrated into is about 3.2 million acres.

The available reconnaissance 2D seismic data also shows that the Birch Creek deep portion of the basin can be divided into multiple Geologic Plays, based on stratigraphic units, unconformities, folds, normal fault, thrust fault and strike-slip fault trapping mechanisms. Current geological interpretations suggest similar strata and potential prospects exist in the Fort Yukon and Stevens-Beaver parts of the basin. The recent U.S. Geological Survey Assessment divides the basin into three Geologic Plays shown in Figure 7 (Stanley and others 2005). The 2005 USGS Assessment identifies these as:

1) Tertiary Sandstone Play
2) Sub-thrust Play and
3) Crooked Creek Play.

Most of the estimated technically recoverable resources are in the Tertiary Sandstone Play. An earlier BLM analysis using the same seismic survey data suggested the Yukon Flats Basin had a mildly deformed and thick Oligocene to Pliocene section, overlying a mid-Cretaceous through Eocene highly faulted extensional basin (Foland 1989). The reconnaissance seismic data across the southern part of the basin included large scale transtensional/strike slip faulting with attendant thrust faults forming potential oil and gas traps. Analogies to modern rift sequences indicate there is potential for organic-rich lacustrine facies in these tectonic regimes.

In an attempt to characterize a portion of the reservoir, Exxon drilled 26 core samples (Figure 8) and collected 40 outcrop samples (Figure 9) from Tertiary rocks. Gravity and seismic geophysical information suggested approximately 4,575 meter thick local depocenters. Potential energy resources were classified as coalbed methane, shalebed methane, and conventional oil and gas. Porosities calculated from core samples at the basin margin averaged 4 percent, but varied between 1.1 to 11.7 percent. In these samples permeability ranged from 0.001 to 171.3 millidarcies (md) with an average of 0.4 md.

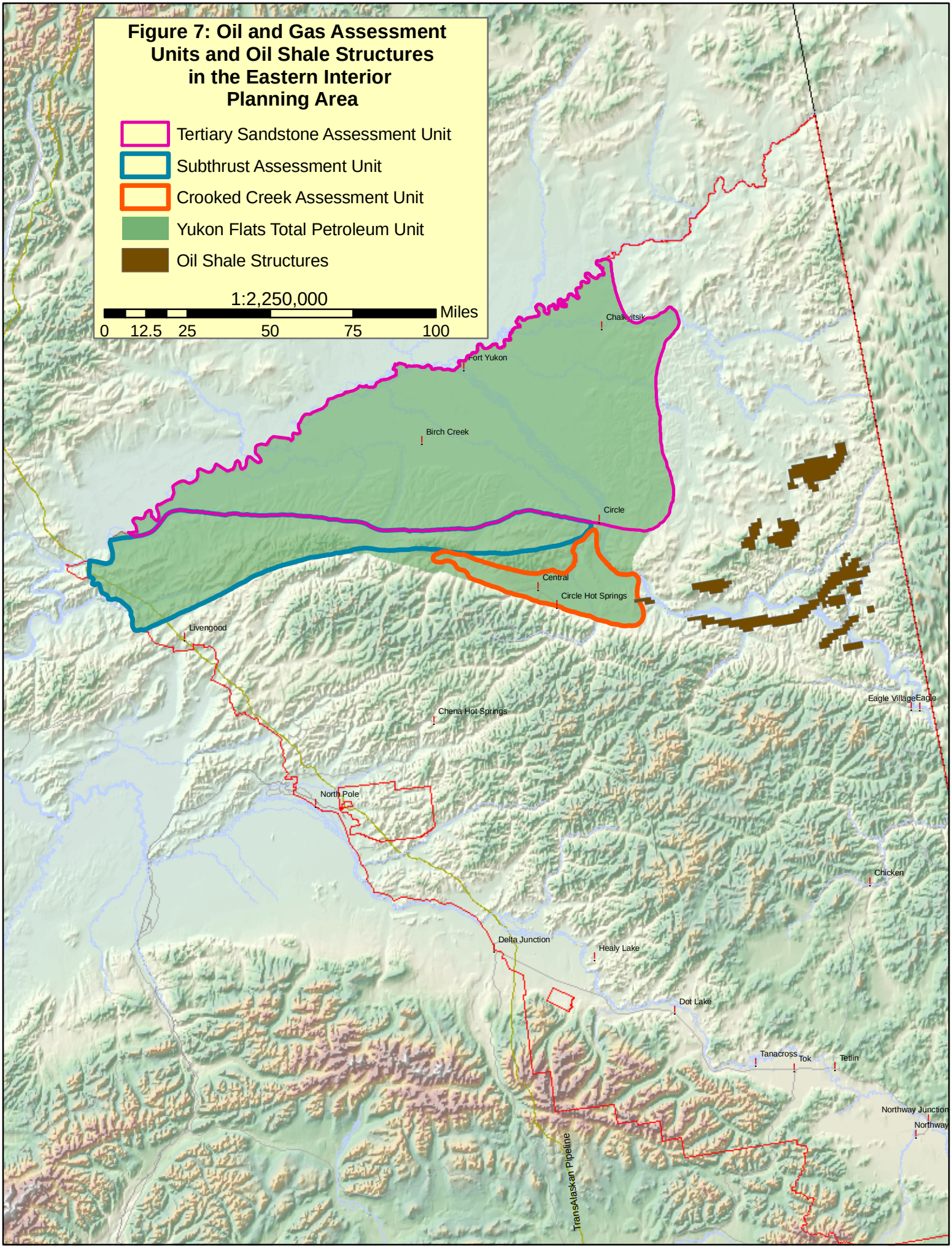
Figure 7: Oil and Gas Assessment Units and Oil Shale Structures in the Eastern Interior Planning Area
Tertiary Sandstone Assessment Unit
Subthrust Assessment Unit
Crooked Creek Assessment Unit
Yukon Flats Total Petroleum Unit
Oil Shale Structures
1:2,250,000
Miles
0
12.5
25
50
75
100
Chalkyitsik
Fort Yukon
Birch Creek
Circle
Central
Circle Hot Springs
Livengood
Chena Hot Springs
Eagle Village
Eagle
North Pole
Chicken
Delta Junction
Healy Lake
Dot Lake
Tanacross
Tok
Tetlin
Northway Junction
Northway
TransAlaskan Pipeline

Yukon Flats Basin outcrop samples showed average porosities of 13 percent with a range of 2.7 to 38.7 percent. Permeability averaged approximately 20 md with a range of 0.006 to 203 md. Porosity is the percent volume of pore space of the rock that is available to store oil and gas. Permeability is a measure of how well connected the pore spaces are. If permeability is reasonably high, hydrocarbons can flow through the pore space and reach the wellhead for maximum economic recovery (Reifenstuhl 2006). As a reference, Porosity (in percent), 0–5 negligible, 5–10 poor, 10–15 fair, 15–20 good, >20 very good; Permeability (in millidarcies), <1.0–15 poor to fair, 15–50 moderate, 50–250 good, 250–1,000 very good, >1,000 excellent (North 1985).

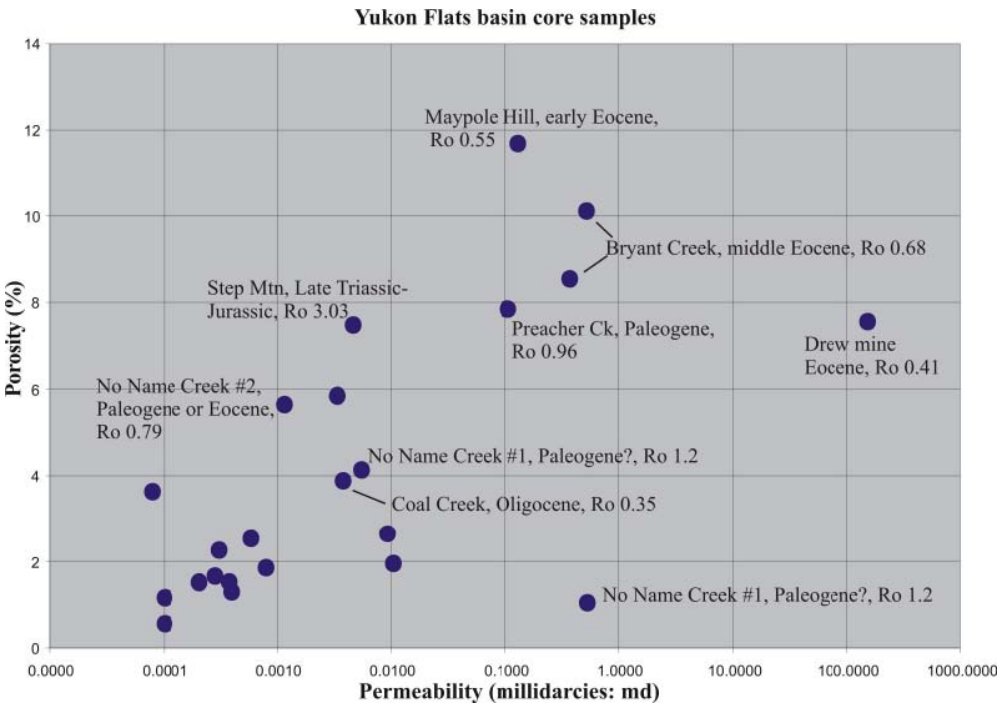

Figure 8: Porosity versus permeability for Yukon Flats basin drill core samples. These samples are from the Exxon shallow drill core material from drill sites around the perimeter of the Yukon Flats basin. (From Reifenstuhl 2006).

Potential reservoir sandstones are exposed as outcrops northeast of Rampart, along the Yukon River, where a more-than-1-km-thick stratigraphy of probable Eocene units includes thick, meandering stream deposits of sandstone, conglomerate, and lignite coal beds up to 10 cm thick. At Schieffelin Creek, on the Yukon River, several hundred meters of Eocene to Oligocene fluvial sandstone, pebbly sandstone with lesser conglomerate, and minor coal are well exposed and yield good petrophysical characteristics (8.8 md permeability and 15.8 percent porosity) (Reifenstuhl 2006).

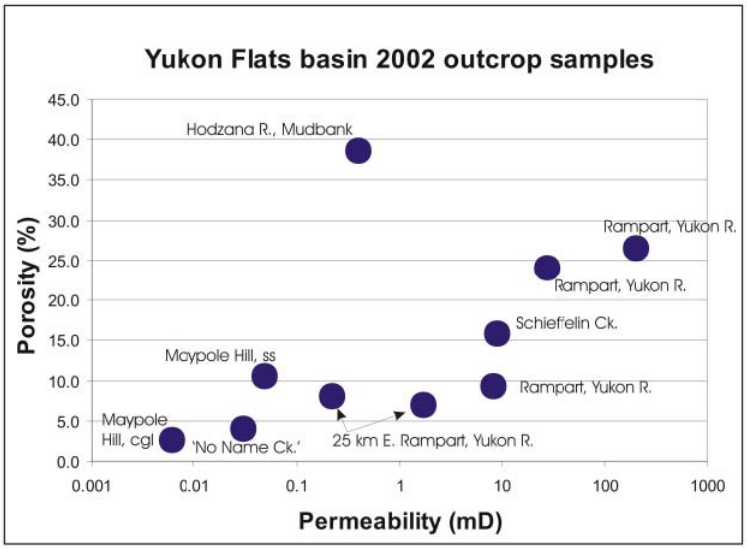

Figure 9: Porosity versus permeability for Yukon Flats basin outcrop samples.

Shallow Wells with Gas Shows

Gas was found in two additional unnamed wells in the Northway lowlands, southeast of the village of Northway. The westernmost well was drilled to a total depth of 350 feet in unconsolidated Quaternary deposits by the Alaska Propane Company Incorporated. Gas was discovered between 195 and 220 feet with the bottom of the permafrost at 250 feet (Miller et al 1959).

The easternmost well was drilled as a water well at Seaton's Roadhouse through unconsolidated Quaternary deposits. The total depth of the well was not given; however, gas was encountered at a depth of 200 feet and was thought to be trapped by permafrost (Miller et al 1959).

Doyon Exchange

A proposed land exchange was proposed between the U.S. Fish and Wild Service and Doyon Ltd. (an Alaska Native Claims Settlement Act (ANCSA) Corporation) that would allow Doyon to receive about 110,000 acres of Refuge lands with oil/gas potential and 97,000 acres of oil and gas interests (no surface occupancy). This exchange did not occur as on July 2, 2009, the USFWS issued a press release identifying the "no action alternative." This meant that no land exchange would occur and each area would remainn status quo. The exchanged lands Doyon could have received, had estimated potential for Alpine size fields (200-300 Mmbbls). A discovery with development could have an effect on BLM lands as an identified pipeline route could bisect BLM managed lands (YFEIS 2008).

D. Oil Shale

Origin and Occurrence

Oil shales have been identified in the southeastern margin of the Kandik Basin with exposed areas near Trout Creek and along the banks of the Yukon River. Initial estimations found that deposits along Trout Creek may contain 28 gallons of oil per ton, but further investigation found actual oil quantities may be as low as 0.3 to 7.6 gallons with an average of 4.8 gallons per ton (Brabb and Churkin 1969). USGS investigations have found that oil shales explored along the Yukon River, across the banks from the Nation River, contained 1.7 to 12.3 gallons per ton with an average of 4.0 gallons per ton (Troutman and Stanley 2002).

The oil shales of the Kandik basin are components of three organic-rich formations (Northern Oil and Gas Directorate Indian and Northern Affairs Canada, 1995). The source rocks of these formation have been identified as type II and III kerogen- rich shales in the Canol Formation with TOCs up to 7%; type I and II kergon-rich shales of the upper Road River Formation with TOCs up to 5% and a Mount Goodenough Formation with type II and III kerogen rich shales with TOCs close to 2% (Northern Oil and Gas Directorate Indian and Northern Affairs Canada, 1995).

There is potential for oil shale bodies to exist. However, that potential is not fully understood, the USGS is planning further investigations to examine the full resource of oil shale.

Current Production

There is currently no production of oil shales in the planning area. Further exploration must be conducted to fully realize the extent of oil shales in the planning area. If production became feasible, infrastructure would need to be developed to support development and transportation. The Arctic climate should be taken into consideration if development of oil shales becomes feasible since it can impact extraction, transportation, and safety.

E. Geothermal

Alaska contains some of the largest geothermal resources in the United States. However, exploitation of these resources is hindered by the lack of infrastructure and the small size of Alaskan markets (Economides et. al 1983). Geothermal resources of varying temperatures are known to occur throughout the Eastern Interior planning area (Figure 10). Thermal springs are produced by subsurface hydrothermal systems, which transfer heat to the surface through fluids, as opposed to through solid rock. Some areas that have been identified include; Chena Hot Springs, Circle Hot Springs, Big Windy Hot Springs, and Flat Creek Hot Springs. All of these geothermal resources are identified hot springs in the State of Alaska; however, they are not classified as Known Geothermal Resource Areas (KGRA). The current law, US Code Title 30, Section 1001(e), defines a KGRA: "an area in which the geology, nearby discoveries, competitive interests, or other indicia would, in the opinion of the Secretary, engender a belief in men who are experienced in the subject matter that the prospects for extraction of geothermal steam or associated geothermal resources are good enough to warrant expenditures of money for that purpose."

A chain of geothermal activities occurs throughout Interior Alaska with origins stretching from the Seward Peninsula to as far east as the Yukon Territories. The heat source driving the geothermal activity in Interior Alaska has not been established. However, all of the hot springs are in or near granite plutons of early Tertiary age. Further, many of the hosting plutons are known to contain anomalously high concentrations of radioactive elements Uranium and Thorium (Kolker et al 2007).

Chena Hot Springs

Chena Hot Springs is located 50 miles east of Fairbanks in the center section of the Eastern Interior Planning area. Access to this popular geothermal resort is by car along Chena Hot Springs Road which connects the resort to the city of Fairbanks.

Origin and Occurrence

The Chena Hot Springs Geothermal Resource, like all interior Alaskan hot springs, is located along the margins of a granitic pluton. The plutons that lie within this area are giant intrusive cooled bodies of magma that pushed up millions of years ago. Biotite from a single monzogranite sample of the pluton yielded an age of 59 Ma, conventionally accepted as the age of the Chena Hot Springs body (Kolker et al 2007). Granite rock fractures easily. The fractures can extend the length of the pluton which acts as a conduit for water to circulate deep into the earth's crust. The deep circulated water quickly travels up the fracture, or short circuits, to the surface, along the way absorbing heat from the surrounding body of granite. In the case of the Chena Hot Springs system, this short

circuit is probably caused by the intersection of two small faults, the primary one located parallel to Spring Creek and identifiable by the string of natural hot springs and seeps along one section (Chena 2007). The heat that is derived from the granitic pluton originates from the decay of heavy metals such as Uranium and Thorium. As the metals decay, the heat is trapped in the host rock which creates a high geothermal gradient allowing the intrusive water to be heated quickly without being circulated to extreme depths of the earth's crust. In the case of Chena Hot Springs, it appears the water is circulating to a depth of approximately 3000-5000ft and reaching a maximum temperature of 250ºF (Chena 2007). The pluton that encompasses the Chena Hot Springs area is roughly 5x40 km^2 which allows for a large area of thermal mass to heat water. Extensive fracturing allows for a combined flow rate of 840 liter per minute between 10 of the effluent springs that occur around the Chena area.

Historical Information

Chena Hot Springs was first documented in 1904 by a survey party from the US Geological Survey who noticed steam rising up from hills near where they were working. News of the sighting made its way through Fairbanks where two brothers, Robert and Thomas Swan, decided they would venture north to find these elusive springs. The main factor driving their mission was finding a way to relieve pain for Robert who suffered from rheumatism (CHSR 2007).

The brothers loaded a boat and headed north arriving at the mouth of Monument Creek a month later. From there they made their way by foot to the headwaters of Monument Creek where they found natural hot springs.

The spring water was tested by the Department of Agriculture to identify the properties of effluent. Examination concluded that the water from Chena Hot Springs was different from any other hot springs in the United States. The principal characteristics of the Chena Hot Springs waters consisted of its content of sulfate, chloride and bicarbonate of sodium. In fact, it was very similar to the waters of a famous hot springs in Bohemia (CHSR 2007).

By 1911, the springs had been transformed into the first resort in Interior Alaska. The springs hosted guests who could enjoy a bath house, twelve small cabins, and a horse stable all the while enjoying a release from the busy life of Fairbanks (CHSR 2007). A trail, which eventually evolved into a carriage road, connected the resort to Fairbanks. It took a traveler between 4 to 14 days to travel to the resort. Today a guest can drive on a paved road for a total of one hour to the door step of the resort's lodge.

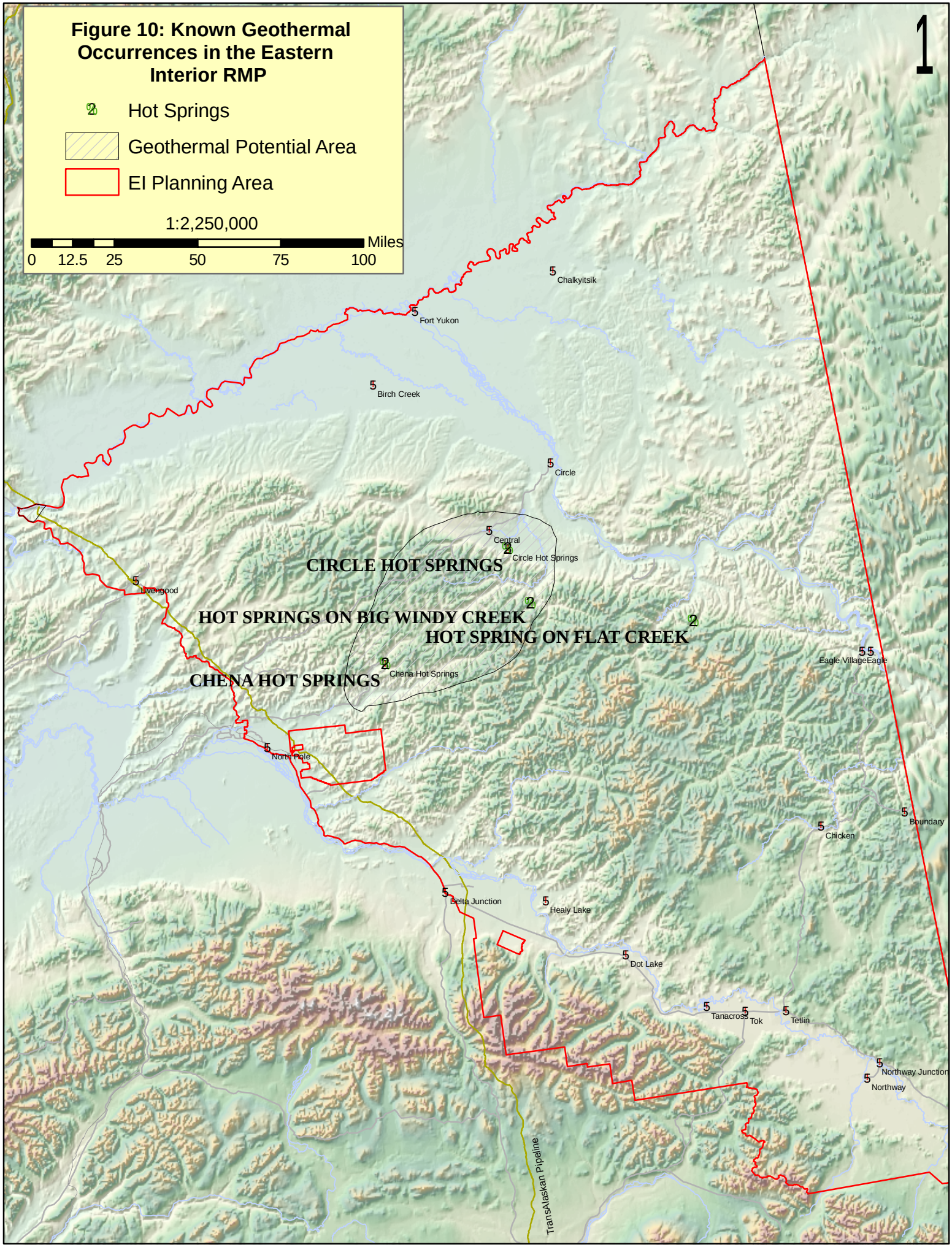
Figure 10: Known Geothermal Occurrences in the Eastern Interior RMP
Hot Springs
Geothermal Potential Area
EI Planning Area
1:2,250,000
0 12.5 25 50 75 100 Miles
1
Chalkyitsik
Fort Yukon
Birch Creek
Circle
Central
Circle Hot Springs
CIRCLE HOT SPRINGS
Livengood
HOT SPRINGS ON BIG WINDY CREEK
HOT SPRING ON FLAT CREEK
Chena Hot Springs
CHENA HOT SPRINGS
Eagle Village
Eagle
North Pole
Boundary
Chicken
Delta Junction
Healy Lake
Dot Lake
Tanacross
Tok
Tetlin
Northway Junction
Northway
TransAlaskan Pipeline

Current Production

Prior to 2006, none of Alaska's geothermal resources had been utilized to produce electricity or heat. Chena Hot Springs is not connected to the main power grid of Fairbanks so it had to produce its own power via diesel generators and heat buildings using heating oil. Rising energy costs drove a change in planning structure at Chena and in 2004 the resort, in cooperation with United Technologies Corporation (UTC) and the Department of Energy, set out to solve their energy crisis using their local resources (Chena 2007).

The project began by identifying the extent of the geothermal body, temperature gradients, and flow rates. A series of wells were drilled to varying depths to test the structure of the geothermal body and determine feasibility of power production. The water at Chena is not hot enough to drive power production on conventional methods so an alternative turbine system was developed by UTC. The newly developed turbine system uses a secondary (binary) fluid, R-134a, which has a lower boiling point than water. The fluid then passes through a heat exchanger with 165° F water from the geothermal wells. Heat from the geothermal water causes the R-134a to flash to vapor which then drives the turbine (Chena 2007). The R-134a condenses on the back side of the closed loop system and then returns back to evaporator. The condensing loop uses cool water from a nearby creek to cool the gas which in turn only raises the water a few degrees before returning to the stream. Because this is a closed loop system virtually nothing is emitted to the atmosphere (Chena 2007).

The energy that is produced via the turbine generator is used to power all of the facilities at the resort. The system is so efficient that there is excess power which is utilized to produce hydrogen which is used as a fuel for heating and in the future for hydrogen vehicles. The resort hosts two large green houses which are heated by free geothermal energy and the electricity allows ample growing light during the long dark winters. Chena Hot Springs also hosts the world's only year-round ice museum which is chilled via the incredible power system and an absorption chiller.

The power production system Chena Hot Springs is the only one of its kind in the world. The implementation and successful completion of this system shows that low temperature geothermal source can successfully produce electricity.

Circle Hot Springs

The springs are located near the Yukon River, 162 miles northeast of Fairbanks, almost at the center of the Eastern Interior Planning Area. The springs are accessible via the Steese Highway which is connected to the Alaska Highway system. An airstrip near the hot springs allows for aircraft access; however there are no provisions for aircraft. The lodge is currently not in operation.

Origin and Occurrence

The hot springs that make up Circle Hot Springs are part of a larger geothermal structure that encompasses most of central Alaska, known as the Circle intrusive complex. The elevation around the Circle intrusive complex ranges from 1000 ft. to 4000 ft. above sea level and experiences only 8 to 12 inches of precipitation per year (Wilkinson 1987). Because of the elevation, low precipitation, and cold, long winters, the area is comparable to a sub arctic desert.

The intrusive bodies form an irregular shape and lie parallel to the Tintina fault zone. The total exposed area of the complex is 56 square miles (Wilkinson, 1987). Similar to the geothermal structures of Chena Hot Springs, Circle Hot springs plutons that lie within the intrusive complex are granite bodies that are structurally fractured to allow water flow from surface systems. Decay of heavy metals in the granite heat the host rock creating a temperature gradient high enough to heat water to 140 ^{o} F in some locations. The surface area that lies within the complex supports multiple hot water springs at various flow rates. Ten of the more popular springs that are located near the resort have a combined flow rate of 449 gallons per minute (Liss et. al 1989).

Historical Information

The Circle Hot Springs have a rich history of being used for bathing and relaxation purposes; their use as a source of energy is not evident. Athabascans from the area utilized the springs long before the arrival of non-native peoples (TRM 2008). In 1893 William Greats found the hot springs, gold miners in the area heard of the discovery and began to utilize the springs. Miners were the main users of the springs until 1905 when Cassius Monohan homesteaded 106 acres around the springs. In 1909 Franklin Leach bought the homestead and built the first resort (TRM 2008). The materials to build the resort were floated down the Yukon River then taken by wagon from the town of Circle 60 miles to the resort. In 1927 the Steese Highway was built to connect the mining town of Circle to Fairbanks (TRM 2008). The opening of the highway allowed visitors to easily access the springs via Fairbanks. In 1930 a newer resort was built on the same site and is currently standing today. The new resort has changed owners several times but is currently not in operation.

Current Production

There is currently no production of the Circle Hot Springs for electricity or large scale heating systems. The pool at the resort is heated with geothermal water. Geothermal has also been used for space heating throughout the history of the resort. High potential is present for development of the geothermal source for power production. The temperature of the springs are not hot enough to be developed using traditional geothermal systems,

however, the proven technology of the Chena Hot Springs Resort could be applied to Circle Hot Springs. The Department of Energy has taken notice of the successful program at Chena and is currently examining other development opportunities in Alaska (DOE 2008).

Big Windy Hot Springs

Big Windy Hot Springs is located in the Steese National Conservation Area (NCA) and contains several geothermal seeps and pools in a remote mountain area. Big Windy Hot Springs is part of a scattered group of geothermal belts that reside within the eastern interior of Alaska. The hot springs are located in the Fairbanks District of the Bureau of Land Management and are about 22 miles south of Circle Hot Springs as the crow flies. Access is limited primarily to helicopter, winter travel, or cross country hiking.

Origin and Occurrence

The pluton associated with Big Windy Hot Springs is approximately 11.5 mi^2 and intrudes host rock that is principally quartz-mica schist, quartzite, pelitic schist, and marble (Juday 1998). The Big Windy Creek pluton is a light to medium gray, medium grained biotite-muscovite granite and Potassium-argon age determination on the granite gives an age of 60.6 + 0.6 million years (Juday 1998). The hot springs are low volume springs measuring only 2 gal./min. from the largest hot spring and maintaining a temperature near 136° F. Research suggests that combined hot water discharge of all springs and seeps at the Big Windy site as 237 gal./min. and an overall pH of 6.41 (Juday 1998). The hottest waters have been measured at 142° F in the main pool whereas water temperatures are typically in the 104° to 118° F range in the smaller pools and seeps (Juday 1998). The best estimate of reservoir temperature is 307° F and isotope analyses confirm that the major component of hot spring discharge is meteoric (water circulating at depth) and circulate to a depth of 3-3.5 mi before emerging to the surface (Juday 1998).

Historical Information

History of the area is limited to random visitors who made the long trip to the springs. Early sourdoughs reportedly ventured to the springs as a location to relax but no development of any sort ever took hold. Few visitors today make the long trek to the remote springs. The hot springs are currently managed in a Research Natural Area (RNA). RNAs are tracts of federally owned land and water established and managed for the primary purpose of research and education.

Current Production

There is currently no production of the resources available at Big Windy Hot Springs. Due to its remote location and lack of infrastructure, there is a low potential for production of the springs.

Flat Creek Hot Springs

Flat Creek, a tributary of the Charley River, is a small 25-yard-wide mound, often free of snow in the winter, that gives some suggestion of thermal activity, but no water has been identified leaking from the area. All in all these reported springs in the Yukon-Tanana uplands appear to be of very limited significance (Nava, J., et. al. 1974).

IV. RECOMMENDATIONS

The intention of this report is to identify areas of high development potential for leasable minerals that could become an area of interest to industry during the life of the plan (Table 5). Rankings given in this report are based solely on documented literature and BLM's interpretations of their conclusions.

Table 5: Resource Development Potential

Coal	Low
Coal Bed Natural Gas	Low
Oil and Gas	High
Geothermal	Moderate

It is the recommendation of this report to further study those areas of having oil and gas potential in a Reasonable Foreseeable Development Scenario (RFD). Coal will not be examined in the ensuing oil and gas RFD as it will be addressed in an amendment to the EIS if leasing requirements are met in 43 CFR 3420.1-4. Geothermal and coalbed natural gas will not be addressed in the RFD as the development potential is low despite a moderate occurrence ranking in Table 1. Impacts associated with these activities will be consistent with impacts related to oil and gas exploration, development, and production.

V. SPECIFIC MANDATES AND AUTHORITIES

A series of statutes establish and define the authority of the Secretary of the Interior to make decisions regarding fluid minerals leasing and development.

A. Laws

1. *Mineral Leasing Act of 1920*

This Mineral Leasing Act, as amended, is the primary authority under which the Federal government leases the majority of Federal onshore minerals (currently applies to coal, phosphate, sodium, potassium, oil, oil

shale, gilsonite, and gas). It provides that all public lands be open to mineral leasing unless a specific land order has been issued to close the area. The Act gives the BLM responsibility for oil and gas leasing on about 570 million acres of BLM, National Forest, and other Federal lands, as well as private lands where mineral rights have been retained by the Federal government. The BLM works to assure that development of mineral resources is in the best interests of the Nation.

2. *Mineral Leasing Act for Acquired Lands of 1947*

The Mineral Leasing Act (Ch. 513, 61 Stat. 913; 30 USC 351, 352, 354, 359) provides that all deposits of coal, phosphate, oil, oil shale, gas, sodium, potassium, and sulfur that are owned or may be acquired by the United States and that are within the lands acquired by the United States may be leased by the Secretary of the Interior under the same conditions as contained in the leasing provisions of the mineral leasing laws. No mineral deposit covered by this section shall be leased except with the consent of the head of the Executive Department, independent establishment, or instrumentality having jurisdiction over the lands containing such deposit, or holding a mortgage or deed of trust secured by such lands that is unsatisfied of record, and subject to such conditions as that official may prescribe to ensure the adequate use of the lands for the primary purposes for which they have been acquired or are being administered.

3. *Geothermal Steam Act of 1970*

The Geothermal Steam Act (30 USC 1001 et seq.), as amended, authorizes the Secretary of the Interior to issue leases for development and utilization of geothermal steam and associated geothermal resources in: lands administered by the Secretary, including public, withdrawn and acquired lands; National Forests or other lands administered by the USFS, including public, withdrawn and acquired lands; lands conveyed by the U.S. subject to a reservation to the U.S. of geothermal steam and associated geothermal resources. The Secretary also is prohibited from issuing leases on lands not subject to leasing under § 226-3 of the Mineral Leasing Act of 1920 (wilderness study areas). §§ 1002, 1014 and 1027. This authority has been delegated to the BLM, given the assurance that the land may continue to be used adequately for the purposes for which it was withdrawn or acquired.

4. *Alaska Native Claims Settlement Act (ANCSA)*

The Secretary may convey to a Native, upon application within two years from the date of enactment of this Act, the surface estate not to exceed 160 acres of land occupied by the Native as a place of primary residence on August 31, 1971.

5. *Federal Land Policy and Management Act of 1976*

The Federal Land Policy and Management Act (FLPMA) of 1976, as amended and supplemented, requires that BLM prepare land-use plans and that BLM administered lands be managed in a manner that recognizes the Nation's need for domestic sources of minerals, food, timber, and fiber from the public lands (FLPMA, Sec. 102 (a) (12)).

6. *Federal Coal Leasing Amendments Act of 1976*

The Federal Coal Leasing Amendments Act (FCLAA) of 1976, which amended Section 2 of the Mineral Leasing Act of 1920, requires that all public lands available for coal leasing be leased competitively. There are two notable exceptions to this requirement: (1) preference right lease applications where a lease may be issued on a noncompetitive basis to owners of pre-FCLAA prospecting permits; and (2) modifications of existing leases where contiguous lands of less than 160 acres are added non-competitively to an existing lease.

7. *Surface Mining Control and Reclamation Act of 1977*

The Surface Mining Control and Reclamation Act of 1977, 30 U.S.C. 1201 *et seq*., requires application of unsuitability criteria prior to coal leasing and to proposed mining operations for minerals or mineral materials other than coal.

8. *Alaska National Interest Lands Conservation Act (ANILCA)*

Section 905. Subject to valid existing rights, all Alaska Native allotment applications made pursuant to the Act of May 17, 1906, as amended, which were pending before the Department of the Interior (DOI) on or before December 18, 1971, were approved. The land described in the allotment application may be valuable for oil and gas, coal, and sand and gravel but must be held in reserve to the U.S. government. Section 1008 establishes an oil and gas leasing program for non-North Slope Federal lands.

9. *Federal Oil and Gas Royalty Management Act of 1982 (30 U.S.C. 1701)*
The Federal Oil and Gas Royalty Management Act (FOGRMA) authorizes the Secretary of the Interior to implement and maintain a royalty management system for oil and gas leases on Federal lands, Indian lands, and the Outer Continental Shelf. This includes the development of enforcement practices that ensure the prompt and proper collection and disbursement of oil and gas revenues owed to the U.S. and Indian lessors and those inuring to the benefit of States.

10. *Federal Onshore Oil and Gas Leasing Reform Act of 1987*
The 1987 Leasing Reform Act (30 USC 181, et seq.; PL 100-203) requires the BLM to offer all lands available for leasing competitively prior to leasing noncompetitively and adds environmental provisions to the leasing process. The Act was a response to concerns that leasing often was occurring at below market rates and to concerns about environmental protection. The Act also provides for inspections and enforcement of operations once commenced. In addition, the BLM is required to have the consent of the USFS before leasing oil and gas on USFS lands. The maximum competitive lease size is 5,760 acres in Alaska. The maximum noncompetitive lease size is 10,240 acres.

11. *Energy Policy Act of 1992*
Since passage of the Energy Policy Act of 1992 (Section 2509), both competitive and noncompetitive leases are issued for a 10-year period. Both types of leases continue for as long thereafter as oil or gas is produced in paying quantities.

12. *Alaska Land Status Technical Corrections Act of 1992*
Amends Section 905 of ANILCA: Reserves to the U.S. all interests in oil, gas, and coal in the conveyed lands, and the right of the U.S., of lessee or assignee of the U.S., to enter on lands conveyed to the applicant or to the heirs of the applicant, to drill, explore, mine, produce, and remove the oil, gas, or coal.

13. *Energy Policy Act of 2005*
The passage of the Act is projected to expand domestic oil and gas production by making reforms to the permitting process to encourage new exploration in environmentally friendly ways. The Denali Commission was tasked to implement an energy program that addresses energy development, energy transmission, replacement/clean-up of fuel tanks,

construction of fuel transportation networks, power cost equalization programs and projects using coal as a fuel. Specific commodities are also addressed in the Act. Exportation and importation of natural gas would be handled by the Federal Energy Regulatory Commission (FERC). Gas hydrates production are encouraged by providing royal incentives or by allowing the Secretary to grant royalty relief for natural gas from gas hydrate resources. The Act encourages the recapturing of produced or natural carbon dioxide for sequestration in oil and gas fields (to enhance production) and provides royalty incentives for enhanced recovery techniques. It also provides a demonstration grant program to encourage the injection of carbon dioxide.

B. Executive Orders

There are no executive orders specific to leasable minerals.

C. Regulations

The BLM is committed to ensuring that oil and gas operations on Federal lands are conducted in accordance with all applicable regulations, Onshore Orders, Notices to Lessees and permit conditions of approval. The Nationwide Oil and Gas Inspection and Enforcement (I&E) Strategy provides consistent methods and procedures for conducting and documenting inspections, prioritizing inspections, determining workload and staffing needs, and projecting inspection accomplishments.

Regulations that govern the BLM's oil and gas leasing program may be found in Title 43, Groups 3000 and 3100, of the Code of Federal Regulations (CFR):

Subpart 3000 - Minerals Management
Subpart 3100 - Oil and Gas Leasing
Subpart 3150 - Onshore Oil and Gas Geophysical Exploration
Subpart 3160 - Onshore Oil and Gas Operations:

> The regulations in this part govern operations associated with the exploration, development and production of oil and gas deposits from leases issued or approved by the U.S., restricted Indian land leases and those under the jurisdiction of the Secretary of the Interior by law or administrative arrangement, including the National Petroleum Reserve - Alaska.

Subpart 3180 - Onshore Oil and Gas Unit Agreements: Unproven Areas

The regulations in this part prescribe the procedures to be followed and the requirements to be met by the owners of any right, title, or interest in Federal oil and gas leases and their representatives who wish to unite with each other, or jointly or separately with others, in collectively adopting and operating under a unit plan for the development of any oil or gas pool, filed, or like area.

Regulations that govern the BLM's coal program may be found in Title 43, Groups 3000 and 3400, of the CFR.

Public lands are available for coal leasing only after they have been evaluated through the BLM's multiple-use planning process. In areas where development of coal resources may conflict with the protection and management of other resources or public land uses, the BLM may identify mitigating measures to leases such as either stipulations to uses or restrictions on operations.

1. *Onshore Oil and Gas Orders No. 1 and No. 2*

   Onshore Oil and Gas Orders No. 1 and No. 2 are authorized under 43 CFR Parts 3160 and 3180, and provide uniform National standards for performance and operations when conducting oil and gas exploration and development on public land. Onshore Order No. 1 requires conformance with Federal and State laws and regulations and ensures environmental safeguards, public health and safety, and proper reclamation of disturbed lands. This Order was revised March 2007 to use performance based standards in certain instances in lieu of the current prescriptive requirements. The change also takes into account other regulations to eliminate overlap and redundancies, clarify procedures, regulatory requirements, and streamline processes. Order No. 2 establishes specific requirements and standards for operation and equipment. (Refer to Proposed Rule 43 CFR Part 3100, et. al. above.)

2. *Onshore Oil and Gas Leasing and Operations: Proposed Rule (43 CFR Part 3100, et. al.)*

Subpart 3104 of the proposed rule states that the BLM can include stipulations restricting surface use on leased land, or restrict the use of the lease after issuance through conditions of approval in order to protect environmental quality and resources, threatened or endangered species, cultural or historic resources, or private or other rights when the surface area is not managed by the BLM. Conditions of approval may include measures to modify the location or design of proposed operations, restrict timing of surface disturbance, or interim and final mitigation.

Subpart 3120 discusses public land available to leasing. Recreation and Public Purpose land is subject to oil and gas leasing under stipulations, if appropriate. It should be noted that the proposed rule was published in the *Federal Register* for review and comment by the public, and is subject to revision prior to becoming final.

3. *Geothermal Resources Leasing and Operations: Final Rule (43 CFR Part 3200, et al.)*

A final rule issued in September 1998 amends the regulations that implement the Geothermal Steam Act of 1970 *(Federal Register*, September 30, 1998). The final rule revises 43 CFR parts 3200, 3210, 3220, 3240, 3250, and 3260, which implement the classification, leasing, exploration, drilling, and utilization requirements of the Act. These regulations affirmed that the BLM may issue geothermal leases on land administered by the Department of the Interior including public, withdrawn, and acquired lands; lands administered by the Department of Agriculture with their concurrence; lands conveyed by the U.S. government wherein geothermal resources were reserved to the U.S.; and lands subject to Section 24 of the Federal Power Act as amended (16 USC 818) with concurrence from the Secretary of Energy. The BLM cannot issue leases for land on which the Secretary of the Interior has determined the issuance of the lease could cause unnecessary and undue degradation of public land and resources; lands administered by the National Park Service or a National Recreation Area; lands where it is determined that a lease is likely to result in a significant adverse effect on a significant thermal feature within the National Park System (if activities resulting from a lease might result in such an effect, the BLM will

include stipulations to protect the feature in the lease or permit); wildlife management areas or hatcheries administered by the Department of the Interior; or Indian trust or restricted lands.

Geothermal leases are issued through competitive bidding for Federal lands within a Known Geothermal Resource Area (KGRA), or noncompetitively for Federal lands outside of a KGRA. BLM issues both types of leases from the Alaska State Office.

D. Policy

Maintain opportunities for mineral exploration and development while maintaining other resource values.

Withhold oil and gas leasing in the planning area until an RMP is in place.

Instruction Memorandum No. 97-145

Fiscal Year (FY) 1998 Oil and Gas Inspection and Enforcement (I&E) Strategy

The BLM is committed to ensuring that oil and gas operations on Federal and Indian lands are conducted in accordance with all applicable regulations, Onshore Orders, Notices to Lessees and permit conditions of approval. The nationwide Oil and Gas I&E Strategy provides consistent methods and procedures for conducting and documenting inspections, prioritizing inspections, determining workload and staffing needs, and projecting inspection accomplishments.

Instruction Memorandum No. 2000-191

1. Conduct drilling inspections on all high priority drilling wells. The priority will be determined at the time of Application for Permit to Drill (APD) approval and inspections conducted in accordance with that priority.

2. Conduct plugging and abandonment inspection on all wells determined to be high priority at the time of approval of the Notice of Intent to Abandon (NIA).

Note: High priority drilling and abandonment inspections shall take precedence over production inspections if scheduling conflicts arise. Drilling and plugging inspections are externally driven, while production inspections are controlled internally and can be more easily rescheduled. Ensuring that drilling and plugging operations are in compliance from the outset will minimize potential problems in the long term, particularly with regard to contamination of subsurface water resources, and reduce future liability problems and workloads. These operations often occur outside normal work hours. Field Offices must ensure that resources are available to conduct these inspections.

3. Inspect all Federal and Indian leases rated high to the FOGRMA criteria annually.

4. Inspect all Tribal and Allotted Indian low priority producing leases in accordance with any negotiated frequency agreed to with Tribal governments and Individual Indian Allottees.

5. Conduct all Work over operations rated high. Review and identify any critical operations to be conducted upon approval of the work plan. Inspect those operations deemed to be high priority at the time of approval.

6. Inspect all low priority Federal and Indian producing leases every three (3) years.

Current Management with Existing Land Use Plans

Leasable minerals were primarily closed in the previous plans that cover the Eastern Interior planning area. The plans included decisions which would open some areas to leasing. However these decisions were not implemented. All of the planning area is under ANCSA 17(d)(1) withdrawal which closes the lands to the mineral leasing laws. The current planning effort will review these withdrawals and determine if there is a need to remove or revise them. Minerals decisions from the existing land use plans are summarized below.

Fortymile Management Framework Plan (MFP)

The Fortymile MFP made an effort to encourage coal exploration, leasing and development, particularly in the Chicken Creek area. The MFP encouraged lifting

unnecessary withdrawals that restrict mineral entry, specifically cited included PLO 5250. However, these withdrawals were never lifted. Specific oil and gas resources were not mentioned, however, the plan called for making sand and gravel available to meet local construction needs for infrastructure that would benefit leasable mineral development (i.e. highway, railway, airfield, and pipeline construction and maintenance purposes).

The Fortymile Management Framework Plan specifically allowed for coal exploration and development to occur in the Chicken Creek area. However, existing withdrawals were never revoked so the area has remained closed to leasing. The MFP also directs management to protect and maintain those lands identified in the MFP Step 1 Overlay as being underlain by coal deposits and assure that these lands remain available to exploration, leasing, and development. Known leasable closures identified in the plan include the ANCSA d(1) withdrawals and the immediate area of the Walker Fork Campground.

Steese National Conservation Area

Mineral exploration (including leasable minerals) for the Steese National Conservation Area (SNCA) must contact the Authorized Officer to ensure the activity will conform to the management prescriptions for this area and not compromise or impair the unit's primitive values. However, infrastructure for development including roads, equipment, and structures are not compatible with primitive recreation and the primitive values of the SNCA.

Areas where leasable mineral exploration and development is not compatible with the SNCA includes both the Primitive Management Unit (the high country adjacent to the White Mountains National Recreation Area and the Pinnell Mountain Trail Corridor) and the Semi-Primitive Motorized Restricted Management Unit. These areas are closed to mineral entry under the 1872 Mining Law and to the leasing of oil and gas, non-energy minerals and geothermal resources.

The Semi-Primitive Motorized Special Management unit will be opened under the 1872 Mining Law to mineral entry (43 CFR 3800). It will also be open to oil and gas leasing (43 CFR 3100), geothermal leasing (43 CFR 3200) and to leasing of non-energy minerals (43 CFR 3500). All operations on leases and mining claims are subject to the following special stipulations.

1. Prior to commencing operations, the operator shall demonstrate that his operation will have no long-term, significant, adverse, effects on caribou habitat or caribou populations.

2. Seasonal restrictions will be imposed between May 1 and June 15, or between August 15 and September 30, if the operation will interfere with caribou calving or caribou migration.

The SNCA Record of Decision (ROD) believed that this management unit contains areas of high mineral potential. It also contains important caribou range, which is required by ANILCA to be a special consideration in the SNCA. Mineral development can be allowed to occur in this management unit only if such development has no long-term impacts on caribou.

Note: The decision to open the Semi-Primitive Motorized Special Management Unit was never implemented. The area remains withdrawn from mineral leasing.

All Research Natural Areas will remain closed to mineral entry and all types of mineral leasing.

Coal

Since there is no known potential or demand for coal in the area, no lands will be opened to coal leasing. Coal leasing is not proposed in this plan (SNCA) and therefore is not addressed.

White Mountains National Recreation Area (WMNRA)

Section 1010 of ANILCA directs the Secretary to "assess the oil, gas, and other mineral potential on all public lands in the State of Alaska in order to expand the data base with respect to the mineral potential of such lands." The Secretary is also directed to allow for access by air for such activities. The BLM is working with the State Division of Geological/Geophysical Survey, the Bureau of Mines, and the U.S. Geological Survey in an effort to further develop mineral assessments of these and other lands in Alaska. Any proposed study will also receive review and comment by the mineral industry, so the best utilization of government and private mineral assessment capabilities can be made. Information gathered through exploration by private companies will assist the Bureau in, meeting this legal requirement. Such information, in combination with information which will be collected on wildlife and other resources, will be very useful in evaluating possible amendments to this plan. In accordance with Section 1010, all exploration will be carried out in an environmentally sound manner, with no appreciable alteration of the natural character or ecological systems of the Area.

Because of the multiplicity of exploration methods which might be employed, anyone proposing to explore for minerals within the WMNRA must contact the Authorized

Officer. Any cross-country movement of equipment will have to be approved in advance by the Authorized Officer.

Prescription for Primitive Management Unit
The Primitive Management unit will remain closed to all mineral leasing.

Anyone proposing to explore for minerals within the WMNRA must contact the Authorized Officer. Activities which conform to the management prescriptions for this unit and which will not impair the unit's primitive values will be allowed. Permits will generally not be required for helicopter landings. However, the use of off-road vehicles (except snowmachines) will not be permitted.

Prescriptions for Semi-Primitive Motorized Management Unit
The area open to the leasing of lode deposits in the Semi-Primitive unit will also be opened to oil and gas leasing under 43 CFR 3100. Oil and gas development within the Semi-Primitive Motorized management Unit is compatible with the recreational objectives for that unit and with the intent of ANILCA. Improved access associated with mineral development will benefit some recreational users.

Note: this decision was never implemented and the Semi-Primitive Motorized Management Unit remains withdrawn from mineral leasing.

Because of the multiplicity of exploration methods which might be employed, anyone proposing to explore for minerals within the WMNRA should contact the Authorized Officer. In this unit, exploration activities which entail the use of mechanized equipment, explosives, etc., require an approved plan of operations or a prospecting permit prior to any activity.

Areas which are closed to mineral leasing include crucial caribou calving areas and Dall sheep habitat. The Beaver Creek NWR encompasses the presently known nesting habitat for peregrine falcon, and this area is also closed to mineral leasing.

Possible Surface Use and Occupancy Restrictions (from WMNRA-ROD 1986)

Species	Crucial Use Area	Dates
Caribou	Calving/movement routes	May 1 – June 15
Dall Sheep	Lambing, movements Mineral licks Winter range	May 1-31 May 15-July 15 Oct 1-May 1
Grizzly Bear/Black Bear	Denning	Nov 1 – April 31
Peregrine Falcon/Other	Nesting	April 15 – Aug 31

Raptors	Prey gathering	
Furbearers	Denning	May 1 – June 15
Fish	Spawning Over wintering	May 1 – Sept 1 Dec 1 – April 15

Coal and Geothermal

In accordance with 43 CFR 3201.1-6 and 43 CFR 3400.2, neither coal nor geothermal leasing is allowed within the National Recreation Area.

Fort Greeley RMP

The Ft. Greeley RMP described the Middle Tanana Basin as having moderate potential for oil and gas. However, leasable minerals were considered closed until the determination made by PL 99-606 Section 12(a) was revaluated, which is not yet completed. Locatable minerals required a mineral assessment before making the lands available. Fort Greely is excluded from the Eastern Interior Planning Area.

Beaver Creek River Management Plan

The Beaver Creek RMP is closed to leasable minerals where ANCSA 17 (d)(1) withdrawals are in place. Additionally, leasing is restricted within a half mile of a "wild" designated river (Section 606 ANILCA). Federal lands within the protracted survey sections, which are wholly or in part within one mile of the bank of Beaver Creek National Wild River, were withdrawn from all forms of appropriation under the public land laws, and from location and entry under the mining laws, and from leasing under the mineral leasing laws (Public Land Order 5179, as amended).

Upper Black River Subunit

There is no existing land use plan for the upper Black River area. This area remains closed to mineral leasing due the existing ANCSA 17 (d)(1) withdrawals.

Consistency with Other Plans

Fish and Wildlife Service

Yukon Flats National Wildlife Refuge

Leasing minerals within the Refuge is inconsistent with the purpose of the Refuge. They were established to conserve fish and wildlife populations and habitats in their natural diversity including nesting waterfowl, other migratory birds, Dall Sheep, bears, moose, wolves, wolverines, other furbearers, caribou, and salmon; to fulfill international treaty

obligations; to provide for continued subsistence uses; and to ensure necessary water quality and quantity.

A land exchange is being considered by the Yukon Flats Refuge. This land exchange would provide an opportunity for development of some high potential oil and gas lands in the planning area that are currently not available to leasing.

State of Alaska

Deposits of coal, phosphates, oil shale, sodium, potassium, oil, gas, geothermal resources and state land containing these deposits are subject to disposition under regulations, recommended by the director and adopted by the commissioner, and the provisions of Alaska Statute Title 38 Chapter 5, Section 145 and Section 181. In applying the acreage limitations the commissioner may apply the rule of approximation. The uses of the rule of approximation made before March 31, 1960, by the commissioner are ratified.

State Mineral Closures

The State of Alaska Department of Natural Resources identified several areas that reside in or close to the Eastern Interior planning area that had conflicting usage plans and therefore were closed to all mineral extraction activity. Mineral order 601 outlines areas within the State Tanana Basin Area Plan that are closed to all subsurface activity; mining activity in these areas would not be compatible with significant surface uses (AKDNR, 1990). The order identified three areas that lie within the EI Planning Area boundary and two that straddle the Eastern Interior border. The Chatanika River Corridor, Delta-Clearwater River Corridor, and Grapefruit Rocks lie within the Eastern Interior boundary while the Brown Lake and Delta Critical Habitat areas are immediately adjacent to the planning boundary, all of which are closed to mineral operations. Each of these units was closed because of conflicts with important recreation and habitat values.

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