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Watana Transportation Access Analysis
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Acronyms and Abbreviations

AAC	Alaska Administrative Code
ABF	Alaska Board of Fisheries
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish & Game
ADT	Average Daily Traffic
AEA	Alaska Energy Authority
AHRS	Alaska Heritage Resources Survey
AKNHP	Alaska National Heritage Program
ANCSA	Alaska Native Claims Settlement Act
APA	Alaska Power Authority
APDES	Alaska Pollutant Discharge Elimination System
AREMA	American Railway Engineering and Maintenance-of-Way Association
ARRC	Alaska Railroad Corporation
AS	Alaska Statute
ATV	All-terrain vehicle
BGEPA	Bald and Golden Eagle Protection Act
BLM	Bureau of Land Management
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cm/yr	Centimeters per year
Corps	U.S. Army Corps of Engineers
DEM	Digital Elevation Model
DMLW	Division of Mining, Land and Water
DNR	Alaska Department of Natural Resources
DOT&PF	Department of Transportation & Public Facilities
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
ft	Feet/Foot
GIS	Geographic Information System

GWh	Gigawatt Hour
H	Horizontal
HEA	Healy quadrangle
ICAP	Indirect Cost Allocation Program
m	Meter
MOA	Memorandum of Agreement
MON	Museum of the North
MOU	Memorandum of Understanding
MP	Milepost
mph	Miles per hour
MSB	Matanuska-Susitna Borough
MW	Megawatt
NED	National Elevation Dataset
NEPA	National Environmental Policy Act
NHCCI	National Highway Construction Cost Index
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
OHW	Ordinary High Water
PL	Public Law
RM	River Mile
ROM	Rough Order of Magnitude
ROW	Right of Way
SHP	Susitna Hydroelectric Project
SHPO	State Historic Preservation Officer
SWPPP	Storm Water Pollution Prevention Plan
TBD	To be determined
TLM	Talkeetna Mountains quadrangle
UCI	Upper Cook Inlet
USAF	United States Air Force
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
V	Vertical

1 Introduction

The purpose of the Watana Transportation Access Study is to identify a transportation corridor to be used to provide access to the Watana dam during its construction and operation. The objectives of this report are to:

- Identify the primary ground transportation mode to be used during construction and for the operational life of the dam.
- Identify and evaluate potential access corridors
- Identify suitable access corridors for further study
- Confirm the reasonableness of the proposed airport locations

This report is intended to be a reconnaissance-level study based on engineering, scientific, and environmental information. The information contained in this report is based largely on existing information that was supplemented by limited field investigations performed in October 2011. No public or agency consultation was conducted in the development of this report.

Section 1 of this report provides background information about the proposed project. Section 2 summarizes previous studies that have been done. Section 3 describes the identified corridors and those recommended to be dismissed from future study. Section 4 provides information about the criteria used to evaluate the corridors and summarizes the impacts. Section 5 identifies the suitable access corridors. Section 6 presents a summary of the airport evaluation process.

1.1 Project Background

The Susitna River was identified as a potential large hydropower site in the 1940s by the Bureau of Reclamation. In a 1976 report to Congress, the U.S. Army Corps of Engineers (Corps) proposed a two-dam project capable of producing 7,300 Gigawatt hours (GWh) of hydropower (Harza-Ebasco 1987). This concept was adopted by the Alaska Power Authority (APA), which began managing the project in 1980, and contracted with Acres America to review economic and environmental feasibility and file a Federal Energy Regulatory Commission (FERC) license application. Later, Harza-Ebasco was contracted to update the license application and perform final design.

The 1980s APA Project consisted of two dams: the first located in Watana Canyon at approximately river mile (RM) 184 and a second located at Devils Canyon (referred to as the Devil Canyon site in most earlier studies; RM 152). The 1980s APA Project effort culminated in the development of a license application filed with FERC in 1983, and an amended license application prepared in 1985. The project was cancelled in early 1986.

The current Watana Hydroelectric Project being evaluated by the Alaska Energy Authority (AEA) is located approximately halfway between Anchorage and Fairbanks in the upper Susitna basin (see Figure 1-1). It would create a single dam on the Susitna River at RM 184 in the vicinity of Watana Canyon. The proposed dam site itself is currently not accessible from the existing transportation network. Construction projects of this magnitude typically involve the need to transport large volumes of construction material, equipment, and personnel to the project site, making access an important component of the project. Once construction is complete, access will be needed to support the ongoing operation and maintenance of the dam. The Alaska

Department of Transportation and Public Facilities (DOT&PF) has undertaken a reconnaissance study to identify potential modes and locations of access corridors connecting the existing transportation network to the proposed dam site. The proposed dam site area is bounded by the Parks Highway/Alaska Railroad to the west, the Denali Highway to the north, the Richardson Highway to the east, and the Glenn Highway to the south. This report will evaluate potential transportation (road and rail) access corridors for the Susitna-Watana Hydroelectric Project and confirm that the proposed airport location is reasonable.

Figure 1-1. Location and vicinity map

2 Previous Access Route Studies

As part of the 1980s licensing effort, access to the Watana and Devils Canyon dam sites was considered. The reconnaissance level August 1982 *Access Plan Recommendation Report* identified three general transportation corridors to access the Watana dam site. Those corridors were:

- A corridor running west to east from the Parks Highway to the dam sites on the north side of the Susitna River. This corridor is often referred to as the North corridor.
- A corridor running west to east from the Parks Highway to the dam sites on the south side of the Susitna River. This corridor is often referred to as the South corridor.
- A corridor running north to south from the Denali Highway to the Watana dam site. This corridor is often referred to as the Denali corridor.

Within these three corridors, 18 different alternatives were analyzed. After some refinement and screening, the options were narrowed down to one alignment with each corridor (Plan 13, Plan 16, and Plan 18). These three corridors were then studied in further detail. After additional refinement and analysis, it was concluded that the Plan 18 (also called Denali North) "represented the most favorable solution to both meeting project-related goals and minimizing impacts to the environment and surrounding communities" (Harza-Ebasco 1985). In 1985, a draft environmental impact statement was produced that included a railhead and storage facility at the Cantwell railway station and a new road from the Denali Highway to the Watana site.[2]

3 Access Corridor Identification

Construction projects similar to the proposed Watana Dam require large quantities of construction material. Currently, there is no access to the proposed site, so an access corridor needs to be developed. As there are existing highways and the Alaska Railroad (ARRC) in the vicinity of the dam, both road and rail are considered potential modes of transportation for construction materials. The first step in the corridor identification process was to identify the design criteria for each of these modes.

3.1 Design Criteria

Road. For road access, an assessment of projected traffic volumes (less than 400 average daily traffic [ADT]) and likely vehicles needed during construction (the design vehicle is a WB-120 Double Interstate Semitrailer), resulted in the access roads design criteria listed in Table 3-1. The road is designed for those vehicles needed during construction rather than anticipated future traffic because the design team felt that a road designed for future use (dam support vehicles, recreational traffic, etc) would be insufficient to support construction needs. Public use of the access road is not recommended during the construction of the road or the dam. Some public use

[2] The Draft EIS included additional transportation improvements because that project was also developing a dam at the Devil Canyon site.

of road segments that are already accessible by the public (such as the Denali Highway) will need to be maintained during the project.

Rail. The proposed rail line to the dam site is a single track designed to American Railway Engineering and Maintenance-of-Way Association (AREMA) standards. The maximum grade is 3 percent, which is a compromise between construction costs and train performance. Due to the need to contour around mountainous terrain, small radius curves are used where required. Table 3-1 lists additional rail design criteria.

Table 3-1. Analysis design criteria

Road[a]		**Rail**	
Surface	All-season gravel	Type	Single track
Width	22 feet	Top embankment width	28 feet
Shoulder	5 feet	Minimum radius curve	574 feet
Overall width	32 feet	Maximum grade	3%
Design speed[b]	20–40 mph[c]	Design speed	25 mph[c]

[a] New alignment. Speed limits on the Denali Highway are not expected to change.
[b] Depending on grade. Refers to speed on new road.
[c] mph = miles per hour

For additional information about the design criteria, please see Appendix A.

For the purposes of this study for routes utilizing road access, it is expected that bulk materials (cement, fuel, reinforcing steel, etc.) and manufactured materials (transformers, power parts, etc.) for the dam will arrive in-state at one of the Ports in Southcentral Alaska and be transported to the project site by rail. Depending on the corridor selected, improvements will be necessary at one of the sidings along the ARRC's mainline tracks. Currently, there are passing sidings at Gold Creek, Chulitna, Hurricane, and Cantwell stations that must remain unobstructed to support ARRC's current operations. Approximately 5,000 feet of new railroad siding is recommended to accommodate the unloading and holding of rail cars until ready for return. Additionally, an approximately 40-acre marshalling/lay down yard for the stockpile and storage of materials brought up on the railroad before transfer to large truck would be necessary.

For the purpose of this study, it is also assumed that establishment of a pioneer road to the dam site within the first construction season is important to the overall project schedule. A pioneer road would not be built to pre-established design criteria. The purpose of the pioneer road is to provide basic access to the dam site by personnel and equipment while the road is under construction.

3.2 Corridor Development Methodology

This section describes the methodology used to develop the corridors considered as part of this study. For the current Watana Transportation Access Study, the project team started with the three road alignments and one rail alignment identified in the Alaska Power Authority *Access Planning Study Supplement, September 1982*. The three road (Plans 13, 16, and 18) and one rail alternatives were digitized using GIS software then imported into AutoCad, where they were adjusted to meet the project's design criteria. The mapping used to lay out the corridors was based on the United States Geological Survey (USGS) 100-foot contour data[3].

Next, the project team reviewed USGS 1:63,360 series maps to identify other viable road corridors that should be studied as part of the current transportation access study. As a result of this review, the Butte Creek (East) corridor was identified.

The level of detail of the existing base data and mapping is generally adequate for a planning level study, but it should be recognized that the centerlines presented in this study are subject to change as additional information about the area is identified. To address this potential variation, the project team delineated a broad corridor around each centerline that reflects the anticipated limits of where the possible centerline alignments would be located as the design progresses. The corridor widths are typically 2 miles (approximately 1 mile each side of the centerline) but vary at certain locations along the routes to reflect areas where the project team determined additional data and study are warranted to more precisely identify the road centerline locations. The corridor boundaries varied due to factors including potential wetland areas, terrain, and proximity to potential transmission lines.

The corridors identified through this process (South Road, South Rail, Hurricane [West], Seattle Creek [North], and Butte Creek [East]) are shown in Figure 3-1 and are described in more detail below.

[3] The 100-foot contours were derived from the 90-meter National Elevation Dataset (NED) raster provided by the Alaska Department of Natural Resources.

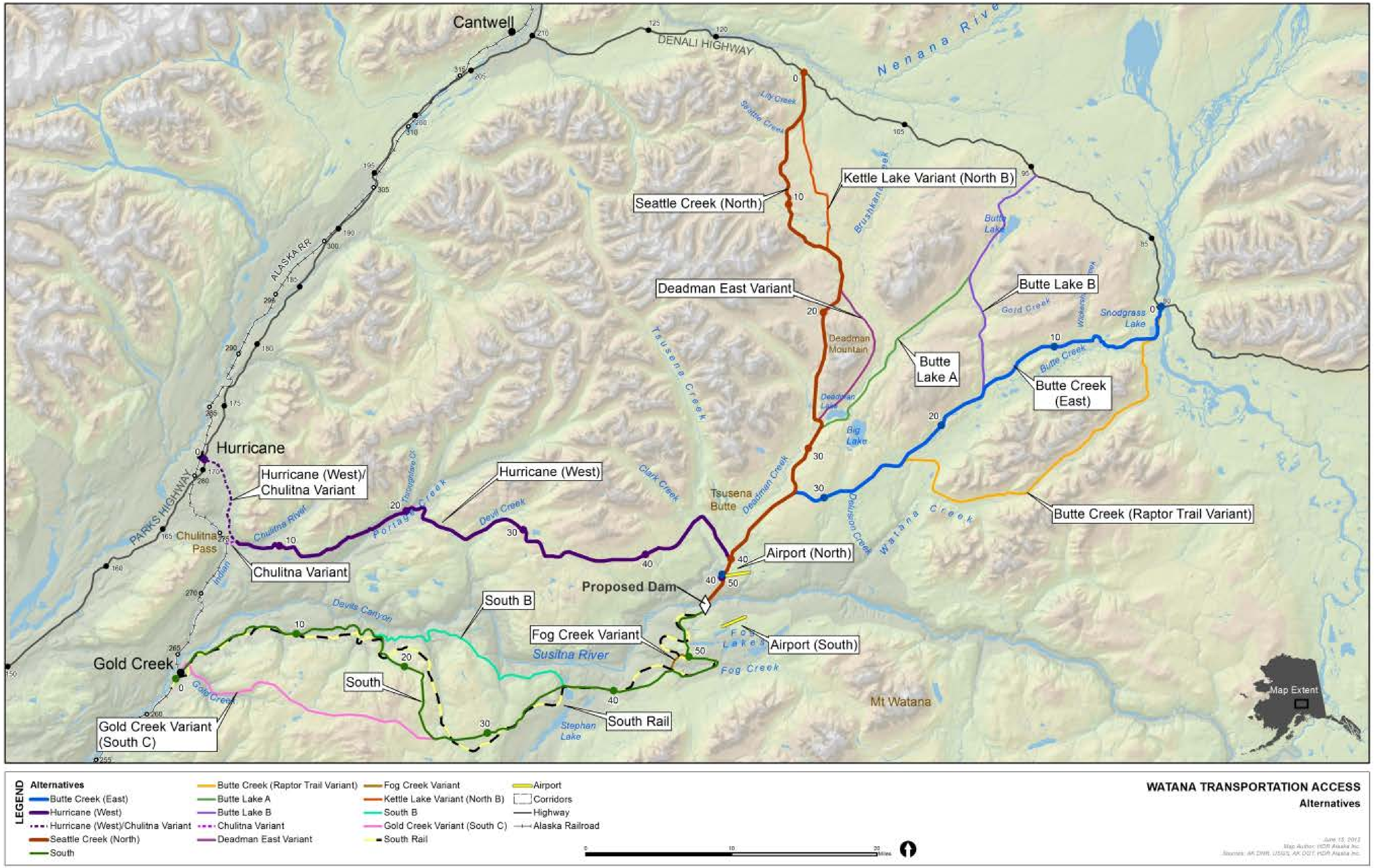

Figure 3-1. Corridors

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3.3 Alternatives[4]

3.3.1 South Road

The South Road corridor is based on Plan 16 from the September 1982 *Access Planning Study Supplement*. The corridor starts at the ARRC Gold Creek Station[5] (ARRC MP 263), adjacent to the Susitna River. This alternative assumes resources (e.g., construction material, workers) are transported to the Gold Creek Station via rail and then transferred onto vehicles. Heading east, the first 16 miles traverses along a moderately steep, north-facing side slope and crosses multiple deeply incised ravines. Near MP 16.5, the alignment heads south to ascend to higher ground to bypass a large, deep ravine located just east of MP 21. When the alignment gets to the headwaters of the ravines at MP 25, the alignment turns northeast toward the dam site.

At 750 feet, the alternative's starting point at the ARRC Gold Creek Station is its lowest elevation. As the corridor travels east, it increases in elevation until it reaches approximately 3,450 feet near the corridor mid-point (between MP 21 and MP 22). From there, the corridor gradually descends to approximately 2,000 feet (the elevation of the south bank of the Susitna River at the dam site). The total length of this alignment is approximately 54.8 miles.

Three variant routings off of this corridor were examined, including the Fog Creek variant, South B variant, and Gold Creek variant (also known as South C).

3.3.1.1 South Road Fog Creek Variant

The South Road Fog Creek variant was developed to shorten the road required to cross Fog Creek. The variant would deviate from the South Road Alignment near MP 44.5, cross Fog Creek, and rejoin the South Road Alignment approximately 5.5 miles later (near MP 50). This variant would be approximately 4.4 miles shorter than the South Road alignment but it would require a bridge approximately 700 feet long. This required construction would substantially increase the cost of this variant by approximately $27 million. A bridge of this size in an area without existing road access would also be very time consuming to construct, and would lengthen the construction schedule. Based on this information, it was decided that the Fog Creek variant was unsuitable and dismissed from further analysis from the South Road corridor.

3.3.1.2 South Road B Variant

The South Road B corridor is a variant of the South Road corridor. The variant was developed in an attempt to shorten the overall corridor length between Gold Creek and the Watana dam site by continuing along the north-facing slope of the Susitna River to a point just north of Stephan Lake. This variant would deviate from the South Road Alignment at MP 15.5, ascend to its maximum elevation of 2,400 feet near MP 25, and rejoin the South Road Alignment 11 miles later at MP 36 just north of Stephan Lake.

The South Road B variant is approximately 4 miles shorter than the South Road alternative. However, the route would require three additional bridges, each with a clear span of 200 to 300 feet. These bridges would increase the cost to build the access route by approximately $32.8 million. For additional information about these bridges, please see Appendix B. The need

[4] Alternative descriptions are based on the proposed centerlines.
[5] A road connection between this location and the Parks Highway was not studied as part of this analysis.

for these two bridges would make it difficult to establish a pioneer road to the Watana dam site in the first construction season and also has the potential to increase the construction schedule. Based on this information, it was decided that the South Road B variant was not suitable and the variant was dismissed from further analysis from the South Road corridor.

3.3.1.3 South Road Corridor—Gold Creek Variant (South C)

Figure 3-2. Example of a steep ravine to be crossed in the Gold Creek variant

This variant was identified because an office review of the terrain in the area indicated that an alignment that ascends the Gold Creek drainage may be possible and would avoid the deeply incised ravines and side-hilling that would be required in the South Road corridor. After ascending Gold Creek valley to its maximum elevation of 3,650 feet (at MP 16), this variant would have fairly level or gently rolling terrain for a substantial portion of the corridor. In the office, using the 100-foot contour topographic map, constructing a road up the Gold Creek drainage appeared to be feasible; however, aerial reconnaissance of this area indicated that a long-span bridge would be required to cross the first major tributary of Gold Creek and rounding the side of the hill where the creek turns east would likely require major rock excavation.

In the upper reaches of Gold Creek, between MP 4 and MP 6, the side slope is scree-covered bedrock, which would make bridge construction extremely challenging. There are several deeply incised gullies with exposed bedrock that would need to be crossed. Additional bridges and major rock excavation would be anticipated to be necessary to traverse the deep gullies (see Figure 3-2). Because the variant would have steeper side slopes, a high probability of extensive rock excavation, the potential for mining claims in the area, and additional costs associated with the extensive and difficult bridges, the South Road alignment was considered a more suitable option and the Gold Creek variant was dismissed from further evaluation as a possible alignment within the corridor.

3.3.2 South Rail

Figure 3-3. West slope above Portage Creek Valley

The South Rail corridor is based on the rail corridor shown in Figures B6, B7, and B8 of the 1982 *Access Planning Study Supplement*. It would leave the ARRC Gold Creek Station (ARRC MP 263) proceeding northeast to start the 17-mile traverse along the north-facing slope of the southern bank of the Susitna River. Twenty miles from Gold Creek Station, the alignment would turn south to ascend the side of a narrow deep ravine. After passing the headwaters of this ravine (near MP 27), the alignment turns east to descend to the lower terrain near Stephan Lake. The terrain between Stephan Lake and the dam site is characterized by rocky hills with lakes, ponds, and wetlands between the hills. The alignment would need to twist and curve around to avoid these lakes, rocky hills, and wetlands.

At the east end of the alignment, where it turns north toward the dam site, the rail line would be routed around to the upper reaches of Fog Creek in order to shorten the length of the bridge needed to span the Fog Creek. North of Fog Creek the alignment snakes around two higher upland areas to reach the dam site.

The rail line was routed using a maximum grade of 3 percent, which is the maximum grade on the ARRC mainline between Seward and Fairbanks. To keep the volume of embankment and excavation, and the length of bridges to a minimum, the shallow 3 percent grade forces the alignment to follow closely the terrain contours. Since it traverses hilly terrain, the alignment curves and twists more than the road alignments, which greatly increases its length. The length of the rail alignment could be shortened by using a 4 percent maximum grade and allowing for higher embankments, deeper excavations, and longer bridges, but that steepness would reduce the potential haul weight and increase operating cost.

At 750 feet, the alternative's starting point at Gold Creek is its lowest elevation. As the alternative travels east, it ascends to a maximum elevation of approximately 3,000 feet between MP 23 and MP 25. From that point, the alternative gradually descends as it continues to travel towards the Watana dam site which has an elevation of 2,000 feet. The total length of this alignment is approximately 60.9 miles.

3.3.3 Hurricane (West)

The Hurricane (West) alternative is based on the North-Access Plan 13 alternative from the September 1982 *Access Planning Study Supplement*. The alternative is approximately 51.7 miles long and is all new construction. The proposed alternative starts on the Parks Highway near Milepost 171, which is across from the ARRC Hurricane station (ARRC MP 282). At 1,750 feet, this is also the lowest point on the alignment. Leaving the Parks Highway, the alternative heads east toward the Talkeetna mountains for 1.3 miles.

Figure 3-4. Steep ravine crossing over to Devil Creek

After reaching the lower slopes of the mountains, it turns southward toward Chulitna Pass where it side-hills around the lower slope of an unnamed mountain to cross Indian Creek at MP 7.8. After crossing Indian Creek, the alternative heads east to enter Portage Creek valley. Here, the alternative cuts along the steep slope on the west side of Portage Creek to Thoroughfare Creek (MP 20.3). After crossing Thoroughfare Creek, the alternative turns to cross Portage Creek (MP 20.5) then ascends a steep gully toward Devil Creek (MP 26.7). After crossing Devil Creek, the alternative ascends to reach higher rolling terrain where it will traverse Tsusena Creek. After crossing Tsusena Creek (MP 44.7), the alternative ascends the bench located just south of Tsusena Butte then proceeds to the dam site.

Of the alignments on the north side of the Susitna River, Hurricane (West) will be the most difficult to construct due to the need to traverse the steep side slopes in Portage Creek valley and to ascend the steep gully located opposite Thoroughfare Creek while leaving the Portage Creek valley. In addition, the contouring around the base of the mountain at Chulitna Pass will be challenging because of this area's steep side slopes and swampy areas. In addition, the railbelt intertie power line is located in this area.

At 1,750 feet, the alternative's starting point at the Parks Highway is its lowest elevation. As the alternative travels east, it ascends to a maximum elevation of approximately 3,250 feet at MP 32.8. From that point, the alternative gradually descends as it continues to travel towards the Watana dam site, which has an elevation of 2,000 feet.

3.3.3.1 Chulitna Variant (Road and Rail)

The two Chulitna variants were developed to use the Chulitna railroad siding because this siding is closer to Anchorage and the proposed dam site. The Chulitna Variant—Rail would start at the Chulitna railroad siding (ARRC MP 274) and would join the Hurricane Alignment near MP 7. An approximately 1-mile access road would connect Chulitna to the Hurricane alignment. This would eliminate the need to build approximately 6 miles of road and would not require any improvements to the Parks Highway. A rail-only access option would restrict the general public's access along the corridor but would provide roadless flexibility for construction and operation of the dam. It would also require more extensive improvements to the siding than an alignment with road access. Based on this information, it was decided that the Chulitna Variant—Rail was less desirable as an access corridor than the Hurricane (West) alignment, and Chulitna Variant—Rail was dismissed as a variant from the corridor.

The Chulitna Variant—Road would use the road from the Hurricane (West) alignment but would use railroad siding at Chulitna (ARRC MP 274) instead of Hurricane (ARRC MP 282). The Chulitna railroad siding would require a similar improvements as the Hurricane siding. However, the increased activity at Chulitna could be considered more disruptive to those living near Chulitna because the area has less existing development than the area around Hurricane. Additional information about the construction logistics would be needed to identify definitively the more suitable location for the rail siding. Consequently, it was decided to keep the Chulitna Variant—Road in the Hurricane (West) corridor for future study if the Hurricane (West) is selected as the preferred access route.

3.3.4 Seattle Creek (North)

The Seattle Creek (North) corridor is based on the Denali-Access Plan 18 alignment identified in the September 1982 *Access Planning Study Supplement*. The corridor starts on the Denali Highway near MP 113.7 (approximately 20 miles east of Cantwell). The corridor heads south for approximately 3 miles. At this point (between the Lily and Seattle Creeks) the corridor splits into western and eastern segments.

The western segment proceeds southward on the western side of Brushkana Creek drainage, crossing Seattle Creek (MP 5.0) and Brushkana Creek (MP 10.9). Then the alignment continues southeast until MP 14.8, where it merges with the eastern segment.

Figure 3-5. Kettle Lake variant

The eastern portion (called the Kettle Lake variant) goes through a group of kettle lakes[6] located in the center of the Brushkana Creek drainage. There is shallow ground water among the kettle lakes, but the ground under this area appears to be thaw stable. Based on the geotechnical reconnaissance of this area, there appears to be a lot of rock rubble in the streams, and water depth in the lakes does not seem to be more than several feet deep at most.

While the Kettle Lake variant is 1.8 miles shorter and is better exposed to the sun, it also appears to be wetter and would likely require additional stream crossings. Additional field work and research would be required to definitively identify the more suitable location for the alignment. Consequently, it was decided to have the alignment use the western segment but keep the Kettle Lake variant in the Seattle Creek (North) corridor for future study if the Seattle Creek (North) corridor is recommended for further study.

At MP 14.8, the corridor runs parallel to Brushkana Creek for a short distance before turning south to ascend up to a higher valley along the western edge of Deadman Mountain. The alignment runs along the lower west flank of Deadman Mountain to stay above the wet soils of the valley floor. Near MP 18.5, the corridor splits into western and eastern segments because the Deadman Mountain area has the highest elevation along the alignment. This elevation may cause snow loading and icing issues for a potential transmission line[7]. The east side of Deadman Mountain, while not as suitable for an access road as the west, would be a viable location if it made economic sense to do so. Additional information is needed before a decision to locate the road on the eastern side of the mountain or to separate the road and

Figure 3-6. Deadman Mountain

[6] Kettle lakes are water-filled depressions left behind after partially buried ice blocks melt.

[7] In an October 25, 2011, meeting with the AEA project team, they indicated they would prefer to locate the transmission line in the same corridor as the road but would prefer to remain under an elevation of 3,000 feet.

transmission line can be made. As a result, the Deadman East variant is included in the Seattle Creek corridor.

Just south of Deadman Mountain (MP 28), the corridor drops down into the Deadman Creek drainage to run along the east side of Deadman Creek, crossing back to the west side of the creek approximately 4.5 miles north of the dam site.

The starting elevation of the corridor at the Denali Highway is approximately 2,700 feet. As the corridor moves south, it ascends to a maximum elevation of approximately 4,100 feet along the west side of Deadman Mountain at MP 20.9. The corridor then descends until it reaches 2,000 feet at the Watana dam site.

The Seattle Creek alignment will require approximately 43.3 miles of new roadway. In addition, 24 miles of the Denali Highway will need to be upgraded. Likely improvements to the Denali Highway appear to be:

- Widening the highway by 8 feet (from 24 feet to 32 feet)
- Approximately 56 culvert replacements
- New bridge structure to replace existing multiple pipe culvert structure
- Additional signage
- Improvement of the Parks Highway/Denali Highway intersection to include a traffic signal and turning lanes[8]

For more information about improvements to the Denali Highway, please see the *Denali Highway Trip Reconnaissance Report* (Appendix C).

3.3.5 Butte Creek (East)

The Butte Creek (East) alignment starts on the Denali Highway in the area near MP 79 (approximately 53 miles east of Cantwell). The alignment travels south for approximately 2.5 miles, following an existing dirt road[9]. Just south of Snodgrass Lake, the alignment heads west to follow the dirt road for approximately 7 miles. From this point, the alignment travels southwest, following the northern side of the Butte Creek Valley crossing Butte Creek (MP 15), Delusion Creek (MP 28.8), and Deadman Creek (MP 37.6). At MP 32.3, the Butte Creek (East) alignment follows the Seattle Creek (North) alignment to the Watana dam site.

The Butte Creek (East) corridor requires approximately 42.5 miles of new roadway, which is the shortest of the alternatives that were considered. However, accessing the corridor requires traveling approximately 53 miles on the Denali Highway, making the dam site approximately 92.8 miles from the Parks Highway. This was the longest of all the corridors. From Hurricane, this alignment takes an additional 80 miles to get to the dam site as compared with the Hurricane (West) alignment.

[8] Depending on the traffic associated with the operation of the dam, it may be possible to remove the traffic signal and turn lanes after dam construction is complete.
[9] This dirt road appears to provide access to a house/cabin located on Butte Creek.

For the Butte Creek (East) corridor, approximately 53 miles of the Denali Highway will need to be upgraded. Likely improvements to the Denali Highway include:

- Widening 53 miles of the highway by 8 feet (from 24 feet to 32 feet)
- replacement of approximately 116 culverts (including 13 small fish culverts and 1 large fish culvert)
- replacing an existing bridge over Seattle Creek
- replacing a multiple pipe culvert structure with a new bridge structure
- Additional signage
- Improvement of the Parks Highway/Denali Highway intersection to include a traffic signal and turning lanes[10]

For additional information on improvements to the Denali Highway, please see Appendix C.

At the alignment start on the Denali Highway the elevation is 2,500 feet; the highest elevation on the alignment is approximately 3,200 feet along the side of the hill just west of Butte Creek and at a saddle southwest of Big Lake. The north bank of the Susitna River at the dam site has an elevation of 2,000 feet.

3.3.5.1 Butte Creek—Raptor Trail Variant (East—Raptor Trail)

On November 16, 2010, a United States Air Force (USAF) F-22 Raptor crashed in the Watana Creek valley. During March and April 2011, a winter trail was constructed from the Denali Highway to the crash site to recover the wreckage. When the Watana Transportation Access Study began, it was believed that the trail could be used as a potential access route to the Watana dam site. During the aerial reconnaissance flights, project team members discovered that very little of this trail remains and would need to be re-built to be used for the Watana project. During the reconnaissance flights, it was also noted that the alignment should be placed farther toward the center of the Watana Creek valley so the alignment would make better use of flatter terrain. After refining the Watana Creek alignment based on the over-flight, it would make only partial use of the crash-site access trail and previously disturbed grounds are not usable for most of this proposed alternative.

At 100.6 miles (53.5 on Denali Highway and 47.1 of new roadway), the Raptor Trail variant was the longest of all the identified alternatives. Being the furthest from the Parks Highway, this alternative is anticipated to have the longest travel time between the Parks Highway and the Watana dam site. Based on these factors, it was concluded that the Raptor Trail variant was less desirable as an access corridor than the Butte Creek (East) alignment and it was dismissed as a variant from the corridor.

3.3.5.2 Butte Lake Variant (A and B)

Connecting to the Watana dam site through the Butte Lake area was also considered. The Butte Lake A variant intersects the Denali Highway at MP 94.5 to head southwest toward Butte Lake. Between the highway and the lake, the alignment threads through numerous small and large

[10] Depending on the traffic associated with the operation of the dam, it may be possible to remove the traffic signal and turn lanes after dam construction is complete.

ponds. After passing the lake the alignment runs southwest along a fairly wide, broad, level valley to reach Deadman Creek (MP 29); it then travels along the southern side of Deadman Creek until it passes between Deadman Lake and Big Lake. The alignment crosses Deadman Creek twice to skirt around the east side of Deadman Lake, then travels west to connect to the Seattle Creek alignment. From there it traverses the last 20 miles on the same alignment to the dam site.

At the alignment start on the Denali Highway, the elevation is approximately 3,100 feet. The highest elevation on the alignment is approximately 3,500 feet between MP 11 and MP 15; which is between Butte Lake and Deadman Creek. The Butte Lake A variant is approximately 40 miles long, and would require upgrading approximately 40 miles of the Denali Highway.

The first 3.5 miles of this alignment crosses an area with numerous ponds with a high water table. The quality of the subsurface soils around the ponds (near the Denali Highway) is not known and is assumed to be permafrost. The area where the valley is drained by Deadman Creek and the valley leading back to Butte Lake appears to have a high water table and wetlands are prevalent. In order to use drier ground and avoid ponds and oxbow lakes in the area, the alignment crosses Deadman Creek multiple times and would require two bridges. Near Deadman Creek, the alignment crosses another 2.5 miles of soils with a high water table and wetland conditions. Field reconnaissance to confirm soil suitability was not conducted in this area due to poor weather conditions. As a result, it was concluded that the Butte Lake A variant would be kept in the corridor.

Another variant for the Butte Creek (East) corridor was considered. This option, Butte Lake B, departed the Butte Lake A variant southwest of Butte Lake and included a connection to the Butte Creek (East) alternative at approximately the midway point. This option would be 43 miles long. An alignment following Butte Creek may have difficulty in constructing a road in the steep 5-mile portion of the Butte Creek Valley. The valley bottom appears too narrow and active for both the creek and road. In the area where the creek makes a 45-degree bend to the east, the side walls of the valley are too steep for economic road construction due to expected extensive rock excavation. Due to the lack of field reconnaissance in this area, it was determined that the Butte Lake B variant should remain in the corridor.

In summary, the project team started with five corridors. Within these corridors, there were five alignments and multiple variants. Based on existing information about the corridors and aerial reconnaissance, all the variants except five were not reasonable enough to retain in the corridor. The Kettle Lake and Deadman East variants of the Seattle Creek (North) are potential locations for the access road. These variants were included in the Seattle Creek (North) corridor but were not studied in further detail in this report. Chulitna Variant—Road was included in the Hurricane (West) corridor but was not studied in greater detail for this report. Butte Lake A and B variants also were retained in the Butte Creek (East) corridor but were not studied in further detail in this report.

The following five corridors/alignments were advanced into a two-tiered screening process described in Section 5:

- South Road
- South Rail
- Hurricane (West)

- Seattle Creek (North)
- Butte Creek (East)

4 Screening

The Watana Transportation Access Study used a two-tiered screening process. Step 1 was an initial screening based on the initial office study and field reconnaissance. The five corridors (four road and one rail) described in Section 3.3 were evaluated in the Step 1 screening process. This initial screening resulted in the selection of three road corridors for further consideration and the elimination of one road corridor and the one rail corridor. Step 2 screening consisted of a more detailed evaluation of those three potential access corridors. Section 4.1 presents the results of the Step 1 screening and Section 4.2 presents the results of the more detailed Step 2 screening.

4.1 Step 1 Screening

The first level of screening was to perform a preliminary evaluation of each corridor to identify if there were any corridors that were so unsuitable that they would not warrant further consideration to study in more detail. The Step 1 evaluation used the criteria described below to assess each corridor:

Land Status: This criterion evaluates the general land ownership and status along the corridors. In general, all corridors represent a mixture of land ownership including State, Federal, Native, and private properties. The corridors originating from the Denali Highway (Seattle Creek and Butte Creek) generally have State and Federal lands along the majority of the corridor, with Native Corporation land near the proposed dam site. The corridors originating in the Parks Highway/ARRC corridor (Hurricane (West), South Road, and South Rail) have additional impacts to Native land along the routes. While the potential impacts to the various land owners and right of way (ROW) acquisition time varied across the corridors, it was determined land status alone was not sufficient to screen out any corridors during Step 1.

Creek Crossings: All corridors traverse numerous drainages along their routes. These creek crossings were identified in an office study and were evaluated as part of the field reconnaissance. The number of crossings varied by corridor, but no corridor presented a significantly larger number of crossings than the others.

Mode Evaluation–Rail Versus Road: The corridors were screened by mode to evaluate the relative efficiency of roads versus rail to support the construction and operation of the dam. Some of the key differences between the two modes are:

Material handling. A rail corridor potentially reduces the number of times construction materials would need to be handled. The materials would be loaded on the train in Anchorage (or other Port of Entry/point of origin) then unloaded at the project site. Road access to the project site would require materials shipped by rail to be offloaded at a railroad siding (at Gold Creek, Hurricane, or Cantwell), placed in a large lay down yard, and then loaded and transported by truck to the project site.

Ease of Access. A rail-only access to the project site is not as convenient as road access because travel to the site must be scheduled to prevent rail traffic conflict on the rail line. Rail sidings could be used to manage traffic conflicts, but these improvements come with additional construction and operational costs. To make managing the rail traffic more efficient, the rail line would need to be signalized and an electronic train management system put in place. Road access is more convenient than rail access, because dispatching a truck can occur at essentially any time and two-way traffic is more easily accommodated. Rail-only access to the project site would restrict public access along the corridor, which has the potential to reduce access-related impacts (such as the increased potential for hunting and fishing) associated with the proposed project.

Steep grades. Due to the terrain in the project area, the track grades along the route are steeper than the existing rail grades between Anchorage and Gold Creek. Therefore, trains would likely need to be split into smaller sections or additional locomotives would be necessary in order to pull the train from Gold Creek to the project site.

Per mile construction cost. The rail alternative is longer than the shortest road route by approximately 20 miles and is approximately 10 miles longer than the closest road route (South Road). On a per mile basis, rail infrastructure is generally more expensive than road infrastructure. While the embankment the track is built on is narrower than the road embankment, the cost for the track, rail, ties, and subballast makes the per-mile cost for the rail line higher than the per-mile cost for the road. For this project, we estimated this cost differential to be approximately $1 million per mile.

Operation costs. Rail transportation (excluding capital expenditures) is generally less expensive per mile of material transported than truck transportation.

Figure 4-1. Sloughing soils in the South Rail alignment

Vehicle cost and availability. The cost of rolling stock is higher than the cost of large trucks. Additional equipment may need to be purchased if ARRC cannot accommodate the project demands with their existing inventory. Additional trucks are easier to acquire than additional rolling stock.

Vehicle maintenance. Truck fleets are more readily serviced and maintained than rail rolling stock and the cost of maintenance is considerably less.

Logistics. A detailed logistics plan was not developed as part of this study, so evaluating the differential cost of construction between road and rail modes could not be assessed. The difference between the conveniences of the two modes could not be quantified at this level of study either, although road transportation would provide more flexibility for construction and operation of the dam.

Range of* Ma*gnitude (ROM) cost[11]. The cost of constructing a mile of rail was estimated to be $2.5 million and the cost to construct a mile of road was estimated to be $1.5 million.

[11] A more comprehensive cost estimate for these screened-out corridors that was performed using prorated costs from the remaining corridors substantiated the removal of the South Rail and South Road corridors from further consideration.

These construction costs per mile are representative of the average of all alternatives. Individual alternative costs per mile will vary based on terrain. For a breakdown of terrain classification by alignment, please refer to the cost estimate appendix, Appendix D. For 60 miles of rail, this results in a construction cost of $150 million. The cost to construct 50 miles of roadway is estimated to be $75 million.

Since these costs are ROM metrics, these cost differentials were not deemed sufficient to dismiss the South Rail corridor without support from other additional screening criteria.

Field Reconnaissance: Aerial reconnaissance was performed to validate the corridor selections, and to identify locations where the alignments should be modified or whether there were fatal flaws associated with either alignments or variants on the alignments. Reconnaissance focused on each corridor's terrain, geologic conditions, and drainage characteristics. While the majority of the corridors have similar terrain, the South Rail and South Road corridors have deeply incised drainages (estimated at 200 feet deep) that are not present in the other corridors. The adjacent banks were observed to have sloughing soils and consist generally of poor foundation materials for bridges. The distance from bank to bank was estimated to be greater than 200 feet, and bridge abutments would likely have to be 50 to 100 feet from the top of the bank because of the poor quality founding materials. This would result in bridges with mainspans of 300 to 400 feet. Spans of this length necessitate the use of truss bridges for rail crossings and long steel plate girders or similar bridges for road crossings. While these crossing are technically feasible, the cost of these structures is typically more than two to three times the cost of bridges with span lengths less than 150 feet.

Construction Schedule: Because of the size and complexity of the bridges on the South Rail and South Road corridors, the construction schedule would be severely impacted. At a *minimum*, the South Road and South Rail alignments would take at least one additional year to construct than the other three alignments. It would also take at least two years for a pioneer road to be built along the South Road alignment to the dam site. The completed road is likely to take an additional one to two years after the completion of the pioneer road. A pioneer type of access would not be possible on the South Rail alignment. It would be approximately three to four years before trains could access the Watana dam site.

Conclusion: Based on cost (rail, ballast, major bridge crossings), time for construction of initial access, overall construction schedule, and convenience of travel, it was determined that rail was not the preferable mode of access to the Watana dam site and was dismissed from further consideration.

4.2 Step 2 Screening

The Step 2 screening analysis applied more refined criteria than the Step 1 screening analysis to each of the four remaining corridors (South Road, Hurricane [West], Seattle Creek [North], and Butte Creek [East]). The project team identified screening that could be assessed, either qualitatively or quantitatively, and compared between corridors. In general, the analysis was performed based on the centerline for each corridor, which represents the most likely spot for the access road given the available information. The results of the analysis presented in this report may change as the centerline is refined and more detailed information is collected. Criteria were identified and evaluation was performed for engineering, geological and geotechnical conditions, hydrology, fish streams and waterbodies, terrestrial resources, wetlands and vegetation, resource use, land status, cultural, socioeconomics, costs, and permittability. These evaluation areas were selected because of the potential effect they may present to the project costs, necessary land acquisition, project timeline, environmental considerations, impacts to stakeholders, and project permitting. Each category included a number of specific criteria. Each of the criteria and a summary of each corridor's performance are described below.

4.2.1 Engineering

4.2.1.1 Terrain Types and Roadway Grades

Several studies were conducted to assess the terrain and original ground profiles along the alignments for the corridors[12]. Terrain and ground profiles along the alignments were classified as level, rolling, or mountainous according to the values in Table 4-1. Terrain classification was assigned by meeting either the ground profile or cross slope criteria. For example, terrain may be classified as mountainous if it has a level ground profile but a cross slope of greater than 18 percent.

Table 4-1. Terrain classification criteria

Classification	Ground Profile Along the Alignment (% grade)	Cross Slope Along the Alignment (% grade)
Level	0–7	0–14
Rolling	7–12	14–18
Mountainous	>12	>18

In level terrain, horizontal and vertical alignments are controlled by the appropriate design speed and sight distance. Rolling terrain starts to affect vehicle operation, particularly larger vehicles, as the roadway profile grades rise and fall more steeply. In mountainous terrain, the elevation changes are more severe and usually affect the ability to construct the desired horizontal and vertical geometry. Alignment grades should be minimized, when possible, to maximize the performance and operating efficiency of the access route.

Terrain Slope: GIS was used to shade the corridors based on the steepness of the terrain. This was done to provide a visual representation of the terrain in the roadway corridors. Alignments were adjusted to avoid areas of steep terrain, where possible, to minimize steep grades and sidehill cuts. See Appendix E for terrain slope figures.

Terrain Classification: For estimating purposes, the terrain for the alignments was classified into level, rolling, or mountainous categories. The classification of the terrain for each alignment is shown in Table 4-2 and on Figure 4-2.

[12] Unless otherwise noted, analyses were conducted on new alignments only.

Table 4-2. Terrain classifications				
	Terrain Classification (in miles)			**Total Length**
Corridor	**Level**	**Rolling**	**Mountainous**	
South Road	12.4	14.5	27.8	54.8
Hurricane (West)	13.5	14.1	24.2	51.7
Seattle Creek (North)	20.9	15.9	6.5	43.3
Butte Creek (East)	25.1	7.8	9.2	42.0

Red = Not preferable **Green = Favorable**

Original Ground Profiles: Profiles of the existing groundline for each corridor was produced using Civil 3D. Profiles for existing groundlines were created along the centerline of the alignment, and 300 feet right and left of the alignment. The purpose for creating a profile 300 feet right and left of the alignments is to give a representation of the terrain in proximity to the alignments. See Appendix F for corridor plan and profile sheets. Information about the length and percent of the alignment for each grade classification is summarized in Table 4-3.

The original ground profiles for Hurricane (West), Seattle Creek (North), and Butte Creek (East) corridors have similar amounts of level, rolling, and mountainous designation (see Table 4-3). The South Road corridor would need to traverse a much greater amount of mountainous terrain (18.4 miles) and much less level terrain (20.7 miles) than the other three corridors. However, classification of the terrain (Table 4-2, Figure 4-2) shows that the South Road and Hurricane (West) alignments have a significantly higher amount of mountainous terrain than the other two corridors. The Seattle Creek (North) alignment has the least amount of mountainous terrain (6.5 miles) and Butte Creek (East) has the most level terrain (25.1 miles). The Seattle Creek (North) alignment has more mountainous terrain than the Butte Creek (East) alignment both in percent and total miles. Overall, the Butte Creek (East) alignment has the flattest profile of the four. The amount of mountainous terrain will likely affect the cost to construct the facility and the operational efficiency of the facility. When more detailed contour information is available, the alignments should be refined to make better use of level/flat terrain.

Table 4-3. Summary of road grade by alignment							
	Grade Classification						**Total Length**
	Level		**Rolling**		**Mountainous**		
Corridor	**Miles**	**% of Corridor**	**Miles**	**% of Corridor**	**Miles**	**% of Corridor**	
South Road	20.7	37.7	15.7	28.6	18.4	33.7	54.8
Hurricane (West)	45.92	88.7	4.85	9.36	1.00	1.94	51.7
Seattle Creek (North)	39.46	91.28	3.75	8.67	0.02	0.05	43.3
Butte Creek (East)	37.78	94.69	2.03	5.09	0.09	0.22	42.0

Red = Not preferable **Green = Favorable**

[a] Totals may not match due to rounding

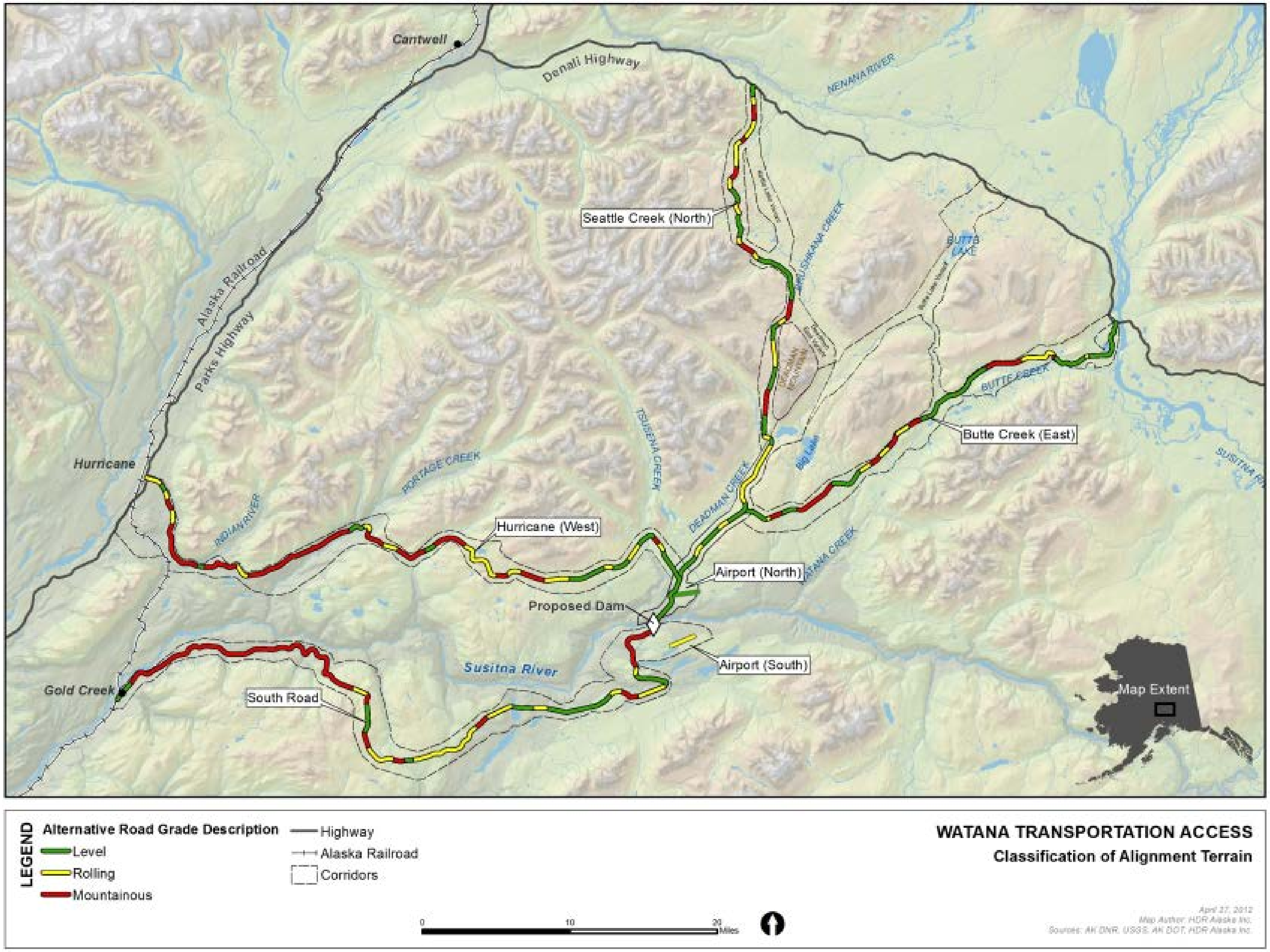

Figure 4-2. Classification of alignment terrain

4.2.1.2 Operational Efficiency During Dam Construction

For the purposes of this analysis, it is assumed that the majority of construction materials will be transported to the Watana dam site from a port in Southcentral Alaska although some materials may come from elsewhere in Alaska. While a detailed logistics plan for the Susitna-Watana project has not been established yet, corridors that provide for the more efficient movement of goods between the Southcentral ports and the dam site are preferable.

To quantify the operational efficiency of the corridors, the project team calculated the length and travel time of each corridor from three locations (see Table 4-4):

- From the Parks Highway at Hurricane to the proposed dam site representing the goods transported by road from Southcentral Alaska. The Parks Highway at Hurricane was chosen as a starting point because this location is common to the three corridors accessible from the Parks Highway.
- From the Parks Highway at Cantwell to the proposed dam site to represent goods transported by road from Interior Alaska (Fairbanks area). The Parks Highway at Cantwell was chosen as a starting point because this location is common to the three corridors accessible from the Parks Highway.
- From the proposed railroad staging area (Gold Creek for South Road, Hurricane for Hurricane [West] and Cantwell for Seattle Creek [North] and Butte Creek [East]) for goods moved by rail from Southcentral Alaska.

Table 4-4. Summary of lengths and travel time[a]

	From Hurricane		From Cantwell		From Railroad Siding	
	Travel Length (miles)	Travel Time[a] (hours)	Travel Length (miles)	Travel Time[a] (hours)	Travel Length (miles)	Travel Time[a] (hours)
South Road	N/A	N/A	N/A	N/A	54.8	1.6
Hurricane (West)	51.7.	1.5	91.0	2.1	52.3	1.5
Seattle Creek (North)	102.6	2.4	63.4	1.8	65.3	1.9
Butte Creek (East)	134.7	3.1	95.5	2.7	97.4	2.8

Red = Not preferable **Green = Favorable**

[a] Estimated, based on the following average running speeds: Parks Highway – 55 mph; Denali Highway – 45 mph; Watana Access – 35 mph

4.2.1.3 Shadow Analysis

For road design and maintenance purposes, it is preferable to have a roadway that is in direct sunlight for more of the time to minimize icing during the winter months. Additionally, roads with better sun exposure typically freeze up later in the fall and thaw more quickly in the spring, reducing snow-clearing costs. For each corridor, a shadow analysis was performed using GIS to identify the length of centerline that was in shadow on September 21 (equinox) and October 21. For each date, shadows were calculated for three time periods (see Table 4-5): one hour after sunrise, solar noon, and one hour before sunset. This analysis includes the effects of shadows cast from surrounding terrain to provide a more realistic assessment of real-world lighting conditions for each corridor.

Table 4-5. Time and date parameters, calculated altitude, angle, and azimuth angle

Date	Time of Angles	Altitude	Azimuth
September 21	8:33	5.78	99
	13:47	27.77	180
	18:56	6.4	258
October 21	9:54	4.79	125
	13:38	16.39	180
	17:19	5.11	234
November 21	11:22	2.87	148
	13:40	7.21	180
	15:54	3.07	211
December 21	12:19	1.77	159
	13:52	3.74	180
	14:48	1.92	200

The analysis was done by using the identified date and time information to generate a hillshade from a 30-meter Digital Elevation Model (DEM) using the Spatial Analyst extension in ArcGIS 10. In this analysis, all hill-shades were created with modeled shadows for each date and time period specified. Once these hill-shades were generated, the areas in light or shadow for each alternative were calculated. Table 4-6 and the maps in Appendix G show the final results for the shadow analysis for each time modeled.

Table 4-6. Approximately length and percentage of each corridor in morning shadow, noon shadow, and evening shadow

Alternative	September 21						October 21					
	AM		Solar Noon		PM		AM		Solar Noon		PM	
	Length (mi.)	%	Length (mi.)	%	Length (mi.)	%	Length (mi.)	%	Length (mi.)	%	Length (mi.)	%
South Road	12.2	22.5	0.1	0.1	10.3	19.1	30.5	56.5	3.2	5.9	22.0	40.8
Hurricane (West)	18.8	36.3	0.7	1.4	13.5	26.1	21.2	40.9	2.7	5.2	14.2	27.4
Seattle Creek (North)	14.6	33.7	0.3	0.7	14.1	32.6	16.6	38.3	1.2	2.8	0.0	0.0
Butte Creek (East)	4.5	10.7	0.0	0.0	8.9	21.2	13.3	31.7	0.0	0.0	6.5	15.5

Red = Not preferable **Green = Favorable**

At solar noon, all four alignments have similar amounts of the roadway in shadow in September and October. In the AM, the Hurricane (West) corridor has slightly more shading in September and October than the Seattle Creek (North) corridor but has more than Butte Creek (East). However, the South Road corridor has more shading in October than Hurricane (West). In the PM, Seattle Creek (North) and Hurricane (West) have more shadow in September, while South Road has the most in October. Overall, the South Road and Hurricane (West) have slightly more shadow than the other two corridors. However, as detailed terrain information was not available for the analysis, these data may change if more accurate information is used.

4.2.1.4 Construction Seasons

The Susitna-Watana Hydroelectric Facility is one of Alaska's most important capital projects. The dam itself will take many years to construct. AEA stated the importance of establishing early access to the dam site with a pioneer road so construction work on the dam and airport can begin as early as possible. The pioneer road would then be upgraded concurrent with dam construction. Corridors that can be constructed in fewer construction seasons[13] would be considered preferable because that would reduce the overall project construction schedule.

Based upon the project team's experience with previous roadway construction projects, it is assumed that in one construction season, 20 miles of roadway could be build in level terrain,

[13] For the purposes of this analysis, winter construction is not assumed because of the need to achieve compaction with moisture and density controls.

15 miles in rolling terrain, and 12 miles in mountainous terrain. The estimated number of construction seasons for the three corridors is shown in Table 4-7.

Table 4-7. Construction season estimate

Corridor		Level	Rolling	Mountainous	Total Construction Seasons
South Road	Miles	20.7	15.7	18.4	—
	Construction seasons	1.0	1.0	1.5	**3.6[a]**
Hurricane (West)	Miles	45.9[b]	4.9	1.0	—
	Construction seasons	2.3	0.3	0.1	**2.7**
Seattle Creek (North)	Miles	39.5	3.8	0.0	—
	Construction seasons	2.0	0.3	0.0	**2.3**
Butte Creek (East)	Miles	37.8	2.0	0.1	—
	Construction seasons	1.9	0.1	0.0	**2.0**

Red = Not preferable **Green = Favorable**

[a] Total does not match due to rounding

[b] Rounded to the nearest tenth of a mile

The South Road alignment will take longer (between three and four construction seasons) to construct than the other three corridors. Hurricane (West), Seattle Creek (North) and Butte Creek (East) are expected to take between two and three construction seasons to complete. The Butte Creek (East) corridor would have the shortest total construction period. With the existing information, a more detailed analysis about construction schedules could not be produced.

4.2.1.5 Avalanche

An avalanche is the sudden release of snow down a slope, occurring due to either natural triggers or human activity. In order for an avalanche to occur, terrain must be level enough to build adequate snow mass, yet steep enough to mobilize the static snow mass into a dynamic slide. Mitigation of many avalanche hazards can be proactive through alignment modifications, modification of surrounding terrain, or initiation of controlled slides during facility operations. If left unaddressed, avalanches can pose safety risks to facility users, temporary closures due to avalanche debris, and high maintenance costs to address snow and debris removal.

Using ArcGIS, the terrain in the project area was evaluated and shaded according to the values presented in Table 4-8. The proposed corridors were then overlaid on the map. The corridors and terrain are presented on Figure 4-3.

Table 4-8. Avalanche potential related to terrain slope

Avalanche Potential	Terrain Slope (%)	Color
Low	0–25	Green
Moderate	25–30	Yellow
High	30–45	Red
Moderate	45–50	Yellow
Low	50–90	Green

Source: Colorado n.d.

Based on the ArcGIS analysis, there are five regions of potential concern for the proposed alignments. These regions are identified in Table 4-9 and also presented on Figure 4-3.

While some planning-level quantifiable results were developed during this assessment, it is important to note the limitations of this assessment of the avalanche hazard for the proposed corridors. This analysis only identifies terrain where avalanches could potentially occur. Identification of specific avalanche paths or chutes and calculation of avalanche run-out was not performed. The avalanche hazard for Region 3 may be largely mitigated or even eliminated if Tsusena Butte is re-contoured as a result of material extraction for either the dam or road construction. While Region 4 shows a small amount of terrain that could produce avalanches, the contributing area may not be capable of sustaining enough snow load to produce a significant avalanche. Region 5 shows some areas that could produce avalanches, but it appears there are terrain features (gullies and benches) between the potential slide areas and the road corridor that would arrest or redirect any avalanches away from the proposed road. Region 6 has some avalanche potential, but hazard is deemed low as avalanches would most likely not reach the road because there is significant run out area and the snow accumulation zone is not very large. In Region 7, the road corridor is in close proximity to 30 to 45 percent slopes; however, the accumulation zone is small.

Table 4-9. Regions of potential avalanche hazard

Region	Route	Location	Description
1	Hurricane (West)	MP 4.5–9.5	Avalanche potential is on the western side of the access corridor. Alignment is side-hilling as it wraps around terrain features.
2	Hurricane (West)	MP 13.5–20.5	Area where the alignment is side-hilling in the Portage Creek drainage.
3	Hurricane (West)	MP 45.0	Corridor may potentially be affected by avalanches on the southern face of Tsusena Butte.
4	Seattle Creek (North)	MP 11.5–13.0	Corridor is potentially affected by avalanches on the east side of adjacent terrain.
5	Seattle Creek (North)	MP 25.5–26.5	Area adjacent to the southwestern face of Deadman Mountain.

Table 4-9. Regions of potential avalanche hazard			
Region	**Route**	**Location**	**Description**
6	South Road	MP 0.6-4.1	Road corridor is south of the Susitna River on the northern slope (side-hilling) of terrain with avalanche potential.
7	South Road	MP 9.8-12.1	Road corridor is south of the Susitna River on the northern slope (side-hilling) of terrain with avalanche potential.

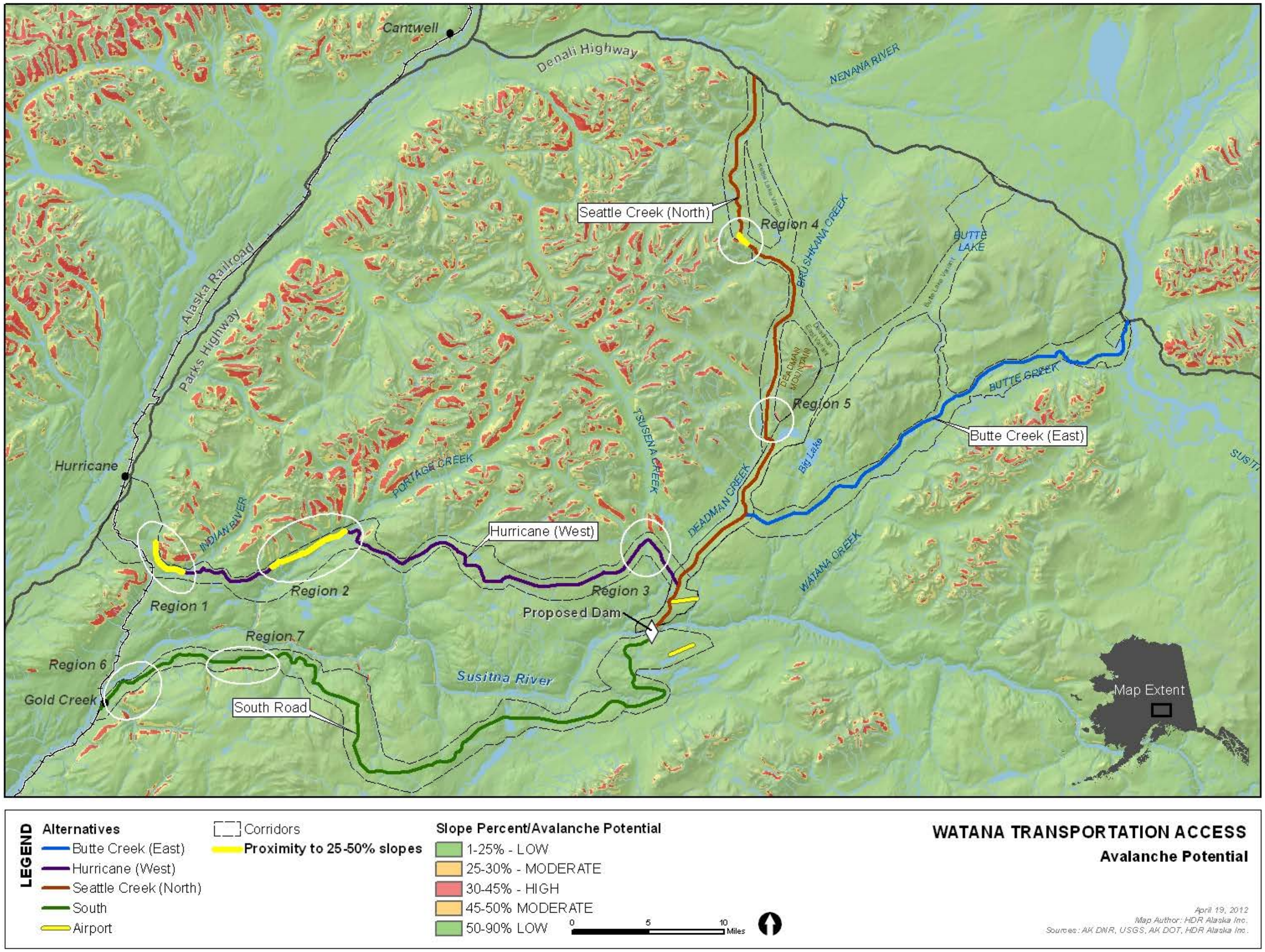

Figure 4-3. Avalanche potential

Based on this initial identification of potential avalanche terrain, the project team determined it was more appropriate to evaluate avalanche hazards based on the miles of roadway in proximity to a moderate or high slope. The basis for this recommendation is that a more detailed analysis may result in minimal or reduced true avalanche hazard, rendering the true avalanche hazard equal for all corridors.

The potential for avalanches for the Hurricane (West) corridor is higher than for the South Road, Seattle Creek (North) and Butte Creek (East) alternatives. Based on this initial screening, the avalanche potential for the Butte Creek (East) alternative appears to be non-existent, the potential for avalanche for the Seattle Creek (North) alternative is slight (0.8 miles), and the potential for the Hurricane (West) alternative is low to moderate (8.7 miles).

4.2.1.6 Railroad Siding and Staging Area

Based on the project team's assumed construction logistics plan for the dam, each alternative must be able to accommodate a rail siding and staging area. The project team developed conceptual railroad staging yard diagrams to determine if there was adequate space available for the needed facilities. The Hurricane (West) alignment would require a staging area in Hurricane (ARRC MP 281). The Seattle Creek (North) and Butte Creek (East) alignments would require a staging area in Cantwell (ARRC MP 319). Both Hurricane and Cantwell have existing sidings that are part of current ARRC operations. These sidings need to be upgraded for use by this project. Improvements at each siding location include the addition of approximately 4,800 feet of siding track, approximately 40 acres of staging area; and storage tanks/silos[14] for fuel, cement, and fly ash. The Hurricane and Cantwell sidings include an access road to the highway (with a traffic light on the Parks Highway).

The South Rail alignment would upgrade the existing Gold Creek siding (ARRC MP 263). Because the South Road alignment would rely on goods, material, and people being brought to the area by rail, the Gold Creek siding would require more extensive improvements than the other alignments. The anticipated upgrades[15] include:

- A passenger siding
- Two sets of double track sidings with appropriate offsets for unloading material, and storage spurs
- Approximately 115 acres of staging area will be needed to support construction staging, material and fuel storage, and track infrastructure.
- A 10,000-square-foot multiuse building for bunking facilities, project office space, and miscellaneous storage

All three of these locations are considered feasible for a railroad siding and staging area; therefore this criterion did not contribute directly to the relative ranking of the corridors. The cost differential for upgrading the sidings was captured under the construction cost criterion.

[14] The silos represent a conceptual location. It is anticipated that silo height will be consistent with airspace restrictions. Without a detailed logistics plan, the sizing and configuration of the silos are unknown and additional silos may be required.

[15] A detailed logistics plan needs to be prepared before the list of improvements at the Gold Creek siding can be fully identified.

Upgrades to the Gold Creek, Hurricane, and Cantwell sidings are shown on Figure 4-5 and Figure 4-6, respectively.

All four alternatives appear to have adequate space for a railroad staging and siding area.

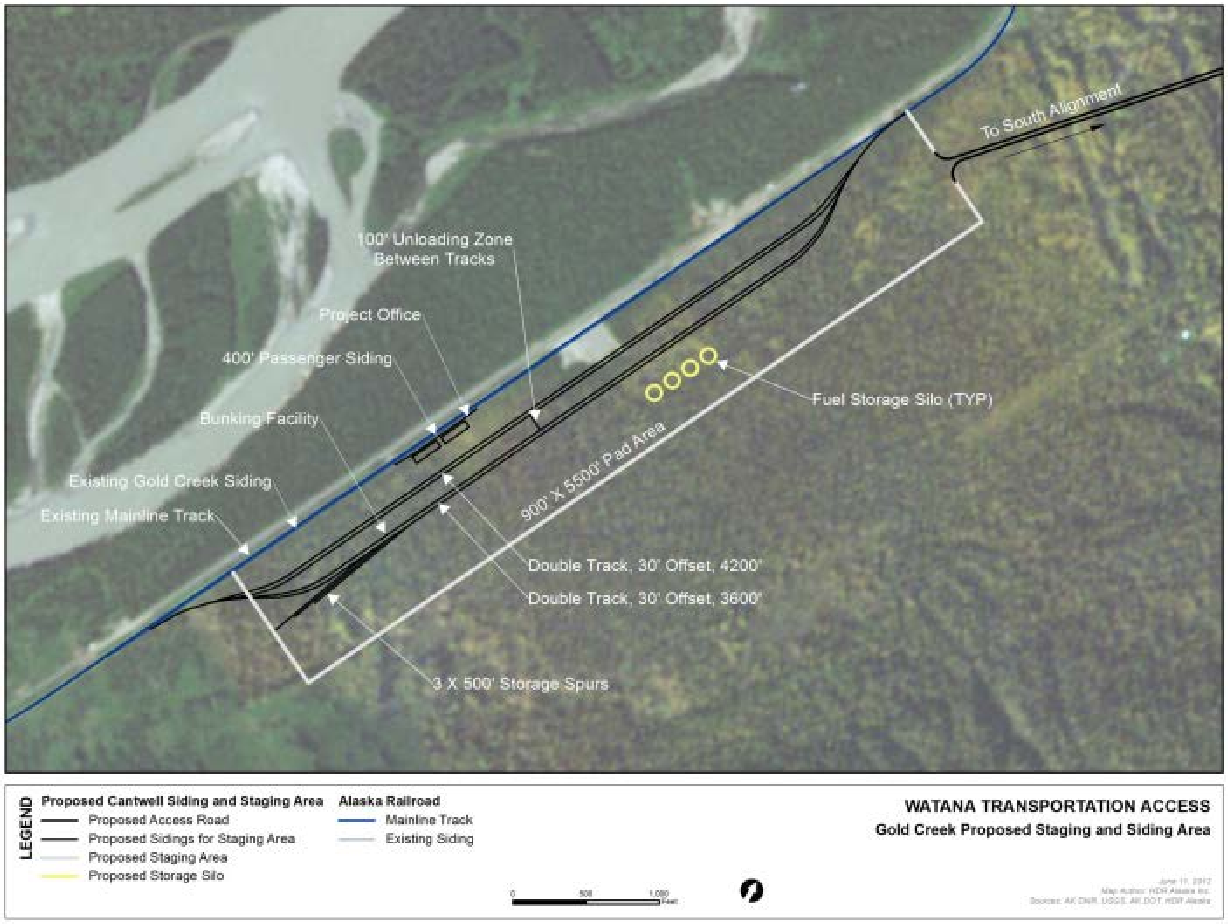

Figure 4-4. Conceptual Gold Creek railroad staging and siding area

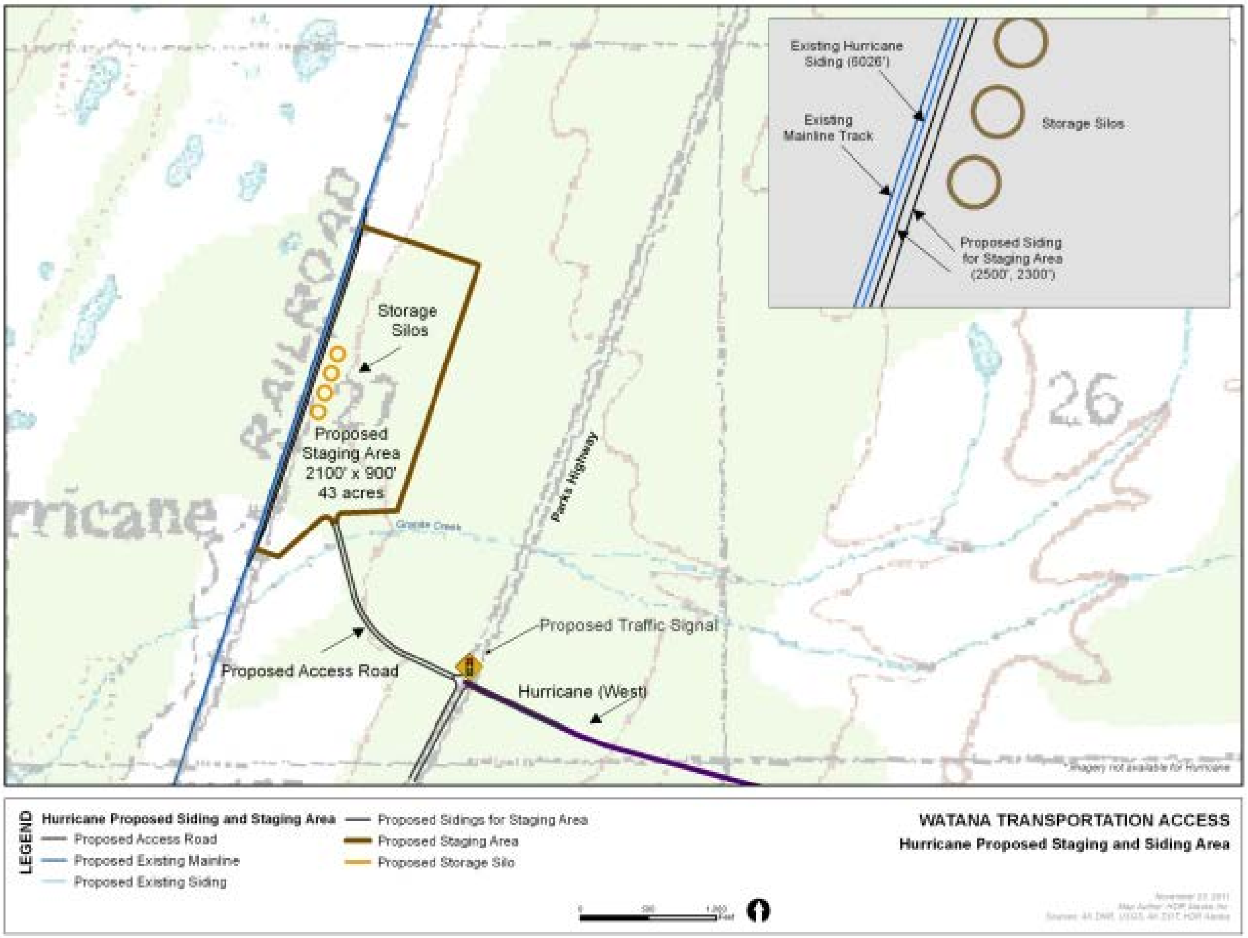

Figure 4-5. Conceptual Hurricane railroad staging and siding area

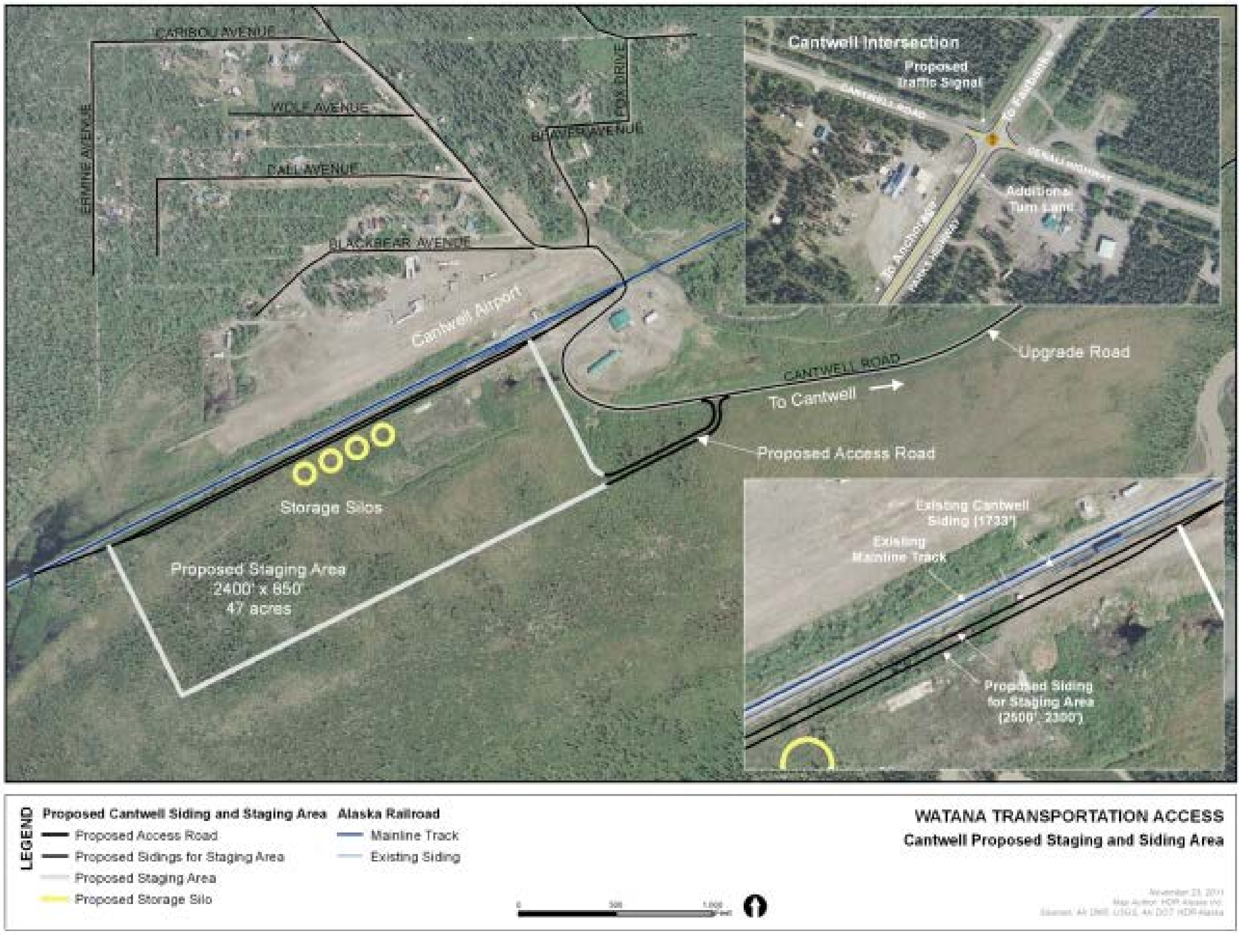

Figure 4-6. Conceptual Cantwell railroad staging and siding area

4.2.1.7 Potential for Co-location of Transmission Lines

As part of the Watana Hydroelectric project, there would be a transmission line connecting the dam to the Railbelt Intertie. While AEA has not identified the ultimate location of the transmission line, there are several advantages to having the transmission line in close proximity to the access corridor, including lower transmission line construction and maintenance costs and reduced project footprint. Currently, AEA is studying transmission lines in the proximity of the South Road, Hurricane (West) and Seattle Creek (North) corridors. AEA has indicated that the elevation of the transmission line should be less than 3,000 feet although short segments that exceed that elevation may be acceptable. Table 4-10 shows the length of alignment (new road only) that exceeds 3,000 feet in elevation.

Table 4-10. New road above 3,000 feet		
Corridor	**Length above 3,000 feet (Miles)**	**Transmission line in close proximity to corridor**
South Road	5.0	Yes
Hurricane (West)	12.5	Yes
Seattle Creek (North)	32	Yes
Butte Creek (East)	6.4	No

Red = Not preferable **Green = Favorable**

4.2.2 Geologic and Geotechnical

The geological and geotechnical criteria were evaluated based on work done in the 1980s combined with aerial reconnaissance and a hand-sampling of selected locations along each corridor by a geotechnical engineer in October 2011 during field reconnaissance. For more detailed information about the geological and geotechnical analysis, please see Appendix H.

Due to the lack of quantifiable data to evaluate the geologic and geotechnical conditions, the project team decided to develop a set of specific development criteria assign each criterion a value between 1 and 5, with 1 being most favorable. These values, assigned by a geotechnical engineer, represent the overall suitability of the criteria for a road corridor and are shown in Table 4-12 (located at the end of this section). The remainder of this section describes each criterion considered.

Other regional geological hazards at the site include regional seismicity and volcanism. While these hazards could impact the project, the project team does not believe that the effects from seismicity or volcanism will be substantially different from one alignment to another. The various evaluation criteria such as subgrade support, foundation support, and slope stability inherently include consideration of seismicity and its effects (such as liquefaction, seismically induced settlement, and lateral spreading). Other wide-area effects such as ground motions should not be appreciably different from one corridor to another. Based on our review of existing data, there are no significant fault alignments that cross the proposed corridors. Additionally, volcanism may impact the project area, but the effects would likely be limited to ash fall events from the closest active volcanoes, which are over 150 miles to the south-southwest of the area.

4.2.2.1 Rock Borrow Availability

Rock borrow availability addresses the proximity of rock materials to the corridors studied for this project. Rock materials will be an important resource for the construction of the proposed access road and associated facilities and structures. Material produced from quarries can be used in a wide variety of applications from embankment development, concrete and/or asphalt aggregate, revetment, rip-rap, and surfacing material. The proximity of the rock materials is important because the distance that the material must be hauled during construction will have a direct impact on the cost of construction. If rock material is not available adjacent to the roadway, additional access roads may be needed to access potential sources, which would also have an impact on the cost of the improvements and will increase the footprint of the project. For successful completion of this project, it will be essential that the final corridor selected have multiple sources of rock material along its full length. These sources will ideally be located adjacent to the final road alignment and will require minimal development of access branch roads to access them.

Each of the corridors appears to have regular sources of potential rock borrow with the exception of the east end of the South Road alignment (between MP 30 and the dam site) and the first several miles of the western end (between MP 0 and MP 10) of the Hurricane (West) alignment. Based on the information available, all four corridors have similar rock material sources available, although Seattle Creek (North) and Butte Creek (East) appear to be slightly more favorable.

4.2.2.2 Rock Borrow Quality

Rock borrow quality addresses the rock material types along each corridor that will be available for construction of the road and associated facilities. Rock material quality is important to the project because some of the uses for the rock will require that the material be durable (i.e., resistant to mechanical degradation). In general, rock material used in the construction of this project must meet the various durability requirements defined in DOT&PF specifications for the material's application (e.g., aggregate or rip-rap). The highest quality, most durable materials should be used in the production of aggregates and rip-rap, while lower quality materials can be used in embankment construction as shot-rock fill.

Typically, intrusive igneous rocks such as granite and diorite yield very high durability values. Extrusive igneous rocks (such as basalt) and lightly metamorphosed rocks (such as phylite) typically have somewhat lower durability characteristics. Highly metamorphosed rocks, such as schist, and sedimentary rocks usually have the lowest durability values. The selected corridor should have rock sources that produce high durability materials that can be developed into rock materials of a wide variety of sizes. High quality sources will reduce the need to import higher durability materials from long distances, thereby reducing the construction costs.

The quality of rock available on each alignment varies, and each alignment has a mixture of high- and low-quality rock. The highest quality rock materials were found to consist of coarse granites and diorites. When found in outcrops, this material was blocky and resistant to weathering. Biotite-rich gneiss and diorite, as well as isolated areas of basalt and phyllite materials, were found north of the dam site along the Seattle Creek (North) alignment. These formations may provide good materials for road construction, but may be somewhat less durable than the granitic rock in other areas. As such, they may not be as reliable as the granite for use as aggregate.

The South Road corridor appeared to cross terrain that likely consists of metamorphosed sedimentary rocks (such as argillite, shale, greywacke quartzite, and conglomerate) and volcanic flow rocks (such as lava, tuff, and agglomerate). Mapping does indicate granite and granodiorite intrusive bodies near the beginning of the project and in the upland portions of the alignment between approximate MP 15 and 30. It is likely that the intrusive igneous rock formations would yield relatively high-quality, durable material for use in this project. Metamorphosed sedimentary rocks may provide construction materials, but would be less reliable as sources of high-quality materials for use as aggregate.

Very poor shaley rock was generally observed in the western half (between MP 5 and MP 13) of the Hurricane (West) alignment. This rock was found to be weak and highly weathered in some places. This material will likely be usable as embankment fill, but will most likely not be able to meet durability requirements for aggregate. Rock materials found between MP 13 and the dam site are likely higher quality and will likely be usable for embankment development and potentially aggregate production.

Biotite rich gneiss and diorite, as well as isolated areas of basalt and phyllite materials were found north of the dam site along the Seattle Creek (North) Corridor between MP 22 and MP 30. These formations may provide good materials for construction of the road, however, they may be somewhat less durable than the granitic rock found in other areas. As such, they may not be as reliable for use as aggregate.

Along the Butte Creek (East) corridor, rock quality is expected to be variable, but generally good, with no obvious areas of rock that is very poor or very low durability.

Based on the available information, Butte Creek (East) and South Road have the best rock quality and Hurricane (West) has the worst rock quality. Table 4-11 shows the results of durability tests conducted on four samples collected during surface reconnaissance activities. The samples were selected to represent the variety of material that exists along the alignments. As can be seen by the testing results, the highest quality material is from the igneous rock types along the alignment. The poorest material was encountered at Observation Point 20 on the Seattle Creek (North) Alignment (see Geotechnical Report in Appendix H for the location) in a coarse-grained granodiorite material. While this, material is igneous in origin, it is biotite rich and appears to be susceptible to mechanical weathering.

Table 4-11. Durability test results

Observation Point	Los Angeles Abrasion Loss	Los Angeles Abrasion Loss Specification	Soundness loss %	Soundness Specification
12	31	<45	1	<9
20	75	<45	11	<9
22	14	<45	1	<9
30	22	<45	2	<9

4.2.2.3 Soil Borrow Availability

Soil borrow availability addresses the proximity of soil materials to the corridors studied for this project. Soil borrow materials will be an important resource for the construction of the proposed access road and associated facilities and structures. Soil borrow materials will likely be most widely used to provide embankment fill materials and as structural fill for the roadway. It could also likely be used in producing fine aggregates and as structural fill around drainage structures, culverts, and bridges, and in utility trenches. As with rock materials sources, the proximity of the soil borrow sources with respect to the proposed roadway will have a direct impact on construction costs. Sources that are farther from the proposed roadway will have longer haul times and will increase the footprint of the project.

To complete the construction of this project, the final corridor selected will need multiple sources of soil borrow along its full length. As with the rock material sources, the soil borrow sources should be located adjacent to the final road alignment to minimize the need for additional access roads.

Soil sources are available along each alignment. The sparsest areas of viable soil deposits along the alignments are likely to be the middle portion of the South Road corridor (between MP 15 and 30) and the middle quarter of the Seattle Creek (North) corridor (approximately between MP 18 to 26) where the corridors traverse high, rocky terrain and the first several miles (approximately between MP 1 and 5) of the Hurricane (West) corridor as it crosses lowlands that may contain shallow groundwater or thick organic deposits.

Based on the information available, all four corridors have similar soil borrow material source availability. The proximity of these sources is slightly favorable for Butte Creek (East) corridor. Slight modifications in the alignments once additional information is gathered may reduce the distance to these sources. Based on the level of detail available, it was concluded that the four corridors perform similarly enough that this criterion individually should not be used as an evaluation criterion.

4.2.2.4 Soil Borrow Quality

Soil borrow quality addresses the soil material types available in the soil borrow sources along each corridor. While soil availability is important, the quality of available material will also impact the cost of the project. Ideally, soil borrow will consist of clean (low fines content), well-graded sand and gravel. Granular or non-frost-susceptible material will most likely be found in outwash and/or alluvial deposits as well as some moraine deposits. This material would lend itself well to development of structural sections for the road as well as structural fill around bridge and culvert foundations. Poorly graded soils or soils with higher fines content (such as those found in glacial till or moraine) may also be acceptable for use, but their applications will be limited to deep embankment development. Regardless of the gradation of the soil fill used, it should not contain significant amounts of free ice, organic detritus, or a significant amount of plastic fines.

Higher quality soil borrow resources along the project corridor will have a positive impact on the construction cost. The high-quality materials will require less processing (washing, screening, etc.) and if they are located at regular intervals along the alignment, they will not need to be imported from long distances. Ideally, the final selected corridor will have multiple high-quality soil borrow sources along its full length.

Soil sources are available along each alignment. A wide variety of material is available from each alignment ranging from glacial till, moraine, and outwash deposits to alluvial materials. The Butte Creek alternative appears to have the highest quality and quantity of soil deposits available of the three considered alignments. The majority of this alignment traverses alluvial terraces and outwash deposits that appear to be relatively clean (low fines content) and well graded. The western quarter of the alignment (near the dam site) begins to transition into glacial till materials that likely include higher fines content.

The South Road will likely have soil deposits that are of glacial origin. While the soils may be naturally dense and compact, they likely contain significant amounts of fines and may be difficult to use effectively in embankment and/or structural section construction. In addition, between approximately MP 15 and MP 30, the soil thickness over bedrock will likely be relatively thin. As the alignment crosses into generally lower-lying areas to the east, soil materials will likely be more abundant. Based on R&M terrain mapping and landforms evident on available satellite imagery, the soil deposits are mostly glacial tills with sporadic lacustrine and alluvial deposits. Significant surface deposits of organics may also be present in the eastern half of the alignment between MP 35 and the dam site which could make mining soil deposits more difficult. The northern half of the Seattle Creek (North) corridor traverses terrain that is likely a mixture of outwash and moraine material between MP 0 and MP 18. While this soil appeared to have relatively low fines content in the areas that we visited, it is likely to have a higher variability in fines content. The southern portion of the Seattle Alignment between MP 18 and MP 26 generally traverses terrain that is shaped by glacial action and therefore is likely dominated by till soils that likely contain relatively high fines content. The portion of the corridor between MP 26 and the dam site appears to traverse terrain dominated by a mixture of outwash, alluvium, and moraine soils.

The portion of the Hurricane (West) corridor between MP 5 and MP 20 traverses soil terrain that likely consists of outwash, alluvial, and moraine soils (where bedrock is not exposed). Many of the outwash soils in this area appear to be high energy deposits, and are likely intermixed with colluvium where they exist on steep side slopes. This material was difficult to observe in the field due to vegetative cover, however given the depositional environment, it is likely to be of variable quality (i.e., variable fines content). Alluvial material is typically relatively clean (low fines content), however, moraine materials can have a wide range of grain sizes including higher fines content. The remaining portion of the Hurricane (West) alignment between MP 20 and the dam site traverses wide, U-shaped valleys that are likely dominated by glacial till deposits with the potential for alluvial deposits in the valley floors. Till soils will likely consist of relatively dense sand and gravel with high silt content.

On average, the Butte Creek (East) alignment appears to have the highest quality and quantity of soil deposits available of the four considered alignments. A majority of this alignment traverses alluvial terraces and outwash deposits that appear to be relatively clean (low fines content) and well graded. The western portion of the alignment between MP 25 and the dam site likely transitions into glacial till materials that may have higher fines content.

Based on the information available, the Butte Creek (East) alignment crosses terrain that will likely yield the highest quality soil borrow of the four alignments (most of the borrow is anticipated to meet Selected Material Type A or B). The Seattle Creek (North) alignment will likely have a mixture of material types available along its corridor, most of which will likely be Selected Material Type B or C with scattered areas of Selected Material Type A. The remainder of the alignments traverse terrain that will likely yield (on average) relatively low-quality Selected Material Type C. In terms of borrow soil quality, the Butte Creek (East) alignment is preferable to the other three alignments.

4.2.2.5 Subgrade Support

Subgrade support addresses the general support capabilities of the subsurface materials along each corridor. In general, favorable subgrade support conditions consist of shallow bedrock and/or firm, well-drained mineral soils. Poor conditions include thaw-unstable permafrost and thick deposits of soft and compressible (mineral or organic) soils.

Favorable subgrade support conditions will have a positive impact on construction costs in several ways. Firm subgrade support typically provides more ideal construction conditions and presents fewer constructability challenges since conventional equipment can be used. Furthermore, firm subgrade support circumvents the need for costly subgrade improvement such as excavation and replacement of unsuitable soils, and typically results in thinner embankments and structural sections. Additionally, ideal subgrade support conditions allow for steeper embankment slopes that require less material to construct and result in a smaller project footprint.

On average, the majority of the alignments cross ground that is relatively competent and capable of supporting the proposed roadway. The exceptions to this condition are the lowland areas on the extreme west end of the Hurricane alignment and isolated areas of the Butte Creek (East) alignment. The lowlands on the Hurricane alignment exhibit widespread soft conditions that may include thick organic soil deposits. The Butte Creek (East) alignment will likely require crossing isolated, widely spaced, soft, poorly drained features that are typically less than 200 feet long.

Based on the information available, all four corridors have similar subgrade support conditions. Based on the level of detail available, it was concluded that the four corridors perform similarly enough that this criterion should not be used for evaluation.

4.2.2.6 Permafrost Conditions

Permafrost[16] conditions address the state and nature of frozen ground under the various corridors studied for this project. The proposed improvements will have an impact on the thermal regime along each corridor that will likely result in warming of the ground around and under the new road. Based on the location of this project, it is likely that the majority of the ground beneath each alignment is frozen continuously throughout the year. As such, permafrost conditions are most ideal if the subsurface consists of materials that do not lose a significant amount of strength when they are thawed. Such conditions will likely include shallow bedrock and dense soils that have low fines content.

Unfavorable conditions include poorly drained soils, fine-grained soils, and permafrost conditions with large amounts of segregated ice. Such soils are subject to long-term creep under foundation and/or slope loading and typically lose a significant amount of strength when thawed. Having favorable permafrost conditions along the selected corridor will have a cost benefit, as measures (such as insulation and refrigeration) will not need to be taken to maintain the thermal balance under the roadway and associated structures.

Based on field observations and the project location, it is likely that permafrost soils are present over most of each alignment. The most critical zones of permafrost are likely found along the slopes above the bottoms of the wide, U-shaped valleys in the higher regions of each alignment. These areas exhibit characteristics of solifluction[17], which may impact roadways built on these

[16] Permafrost is soil, sediment, or rock that remains at or below 32°F for a minimum of 2 years.

[17] Solifluction is "the slow viscous downslope flow of waterlogged soil and other unsorted and saturated surficial material, normally at 0.5-5.0 cm/yr; esp. the flow occurring at high elevations in regions underlain by frozen ground (not necessarily permafrost) that acts as a downward barrier to water percolation, initiated by frost action and augmented by meltwater resulting from alternate freezing and thawing of snow and ground ice" (Neuendorf et al. 2005).

slopes. Most other areas along each alignment are likely underlain by thaw-stable alluvial or outwash soils or shallow bedrock.

Based on the available information and field observations, the Butte Creek (East) corridor appears to have the least extent of thaw-unstable[18] permafrost conditions, while the Seattle Creek (North) corridor has a moderate extent of thaw-unstable permafrost conditions. On a relative scale, the South Road and Hurricane (West) alignments appear to be between the two other alternatives.

Based on the information available, the Butte Creek (East) alignment is expected to have the least amount of permafrost or it has thaw-stable conditions. Permafrost conditions are less favorable on the South Road, Hurricane Creek (West), and Seattle Creek (North) alignments.

4.2.2.7 Drainage

Drainage addresses the general surface and near-surface drainage characteristics of each corridor. Well-drained conditions are usually found in free-draining soils and in topography that is sloped to allow for the conveyance of surface water. Poor drainage is typically encountered in flat terrain with soils that do not allow for infiltration of surface water (such as in peat bogs or in permafrost terrain). In general, well-drained ground conditions typically result in favorable support conditions for new roads and structures. Development of roadways in poorly drained areas results in higher costs associated with designing and constructing additional drainage provisions in the form of culverts and/or porous embankments. Additional costs may also be associated with development of embankments and structures with poor subgrade support in these areas.

Most of the areas that the four corridors traverse appear to be relatively well drained with the exception of the west end of the Hurricane alignment, the Seattle Creek - Kettle Lake variant, and some areas near the dam site in all four alignments. All of these areas appear to have groundwater near the ground surface and will likely require special provisions for drainage to facilitate construction and area drainage after construction is complete.

Based on the information available, all four corridors have similar drainage characteristics. Based on the level of detail available, it was concluded that the four corridors perform similarly enough that this criterion individually should not be used as an evaluation criterion.

4.2.2.8 Rock Slope Stability

Rock slope stability addresses the stability of rock slopes that are likely to exist along each corridor. In the context of this report, rock slope stability is related only to new rock slopes that will be developed during construction of the road, as most of the rock slopes observed during field reconnaissance appeared to be relatively stable. In general, rock slope stability is determined primarily by the rock material quality and the orientation of major rock structure (joints, bedding, foliation, and shear zones) with respect to the orientation of the rock cut face.

Favorable rock slope conditions will allow for steeper rock slopes and fewer requirements for slope retention (e.g., dowels, bolting, shotcrete) and rock fall mitigation (e.g., catchment basins,

[18] Thaw unstable refers to “Poorly drained, fine grained soils, especially silts and clays. Such soils generally contain large amounts of ice. The result of thawing can be loss of strength, excessive settlement and soil containing so much moisture that it flows”.

barricades, fencing, netting). Unfavorable conditions will necessitate shallower rock slope angles and/or increased measures for retention and rock fall mitigation. In general, favorable rock conditions will have a positive impact on construction costs as less material will need to be removed from rock cuts and fewer engineering measures will need to be taken to ensure that safe conditions persist through the life of the project. The final selected corridor will likely have few rock cuts needed and those that are required will be in areas with favorable conditions.

Most of the rock materials along the various corridors are generally well suited for developing steep cuts with a few exceptions. The rocks along the western third of the Hurricane (West) alignment are relatively weak and prone to weathering, resulting in slopes that will not stand steeply, will be difficult to support with conventional rock retention systems, and will require significant maintenance. The South Road alignment may encounter challenging slope conditions between MP 0 and 20 where the alignment traverses across and up substantial natural slopes. Most of the natural slopes appear to be incised by stream erosion, but due to organic and vegetative cover, it is difficult to determine if shallow rock conditions exist. If shallow rock exists in the natural slopes, cutting steep slopes in the hillsides to establish a road bench should be readily achievable. However, if deep soil deposits exist, poor slope stability conditions (requiring structural reinforcement of slopes and/or development of retaining walls) will persist as these slopes are likely at or near the natural angle of repose for soil. Along the lower lying portions of the South Road alignment, adjacent to stream crossings, steeply incised channels with actively eroding bluff features and poor rock and/or soil conditions may pose significant challenges to designing crossings and may require substantial stabilization measures and/or long bridge spans.

Rock along the Seattle Creek (North) and Butte Creek (East) alignments is expected to be relatively competent on average and likely capable of being developed at steep angles with relatively few long-term maintenance concerns. While the competency of rock in the Seattle Creek (North) and Butte Creek (East) corridors is similar, the Butte Creek (East) alignment appears to have significantly fewer rock cuts than would be necessary for the construction of the Seattle Creek (North) alignment.

The western portion of the Hurricane (West) corridor contains areas with rock quality that may be well suited for developing steep cuts. The Seattle Creek (North) and Butte Creek (East) corridors contain better quality rock for developing steep cuts. Based on this evaluation, the Seattle Creek or Butte Creek corridors are preferable over the Hurricane (West) corridor.

4.2.2.9 Soil Slope Stability

Soil slope stability addresses the stability of natural soil slopes. Soil slope stability is directly related to the material and strength properties of the soil exposed in the face of the slope as well as the soils behind the slope face, and the slope angle. Under ideal conditions (well-drained slopes consisting of angular, coarse soils over a well-drained, stable subgrade) permanent soil slopes can stand at angles approaching 1.5 horizontal (H) to 1 vertical (V) if vegetation is well established on the slope face. Shallower slope angles are needed if vegetative cover is poor or if support or slope soils are fine grained, soft, rounded, or poorly drained. Natural slope conditions may be unstable if the slope is near the maximum slope angle and vegetation is disturbed during construction. Furthermore, natural slopes can be unstable if they are composed of colluvium or if they are in an erosive environment such as undercut slopes in an incised stream channel.

Ideally, the selected corridor will traverse ground that does not require development on steep and/or unstable soil slopes. The construction costs for a roadway that traverses unstable slope conditions will be significantly higher through the need for constructing slope retention.

Unfavorable soil slope conditions exist on each alignment. However, it appears that in most areas, those conditions are avoidable given appropriate route selection. Areas that should be avoided are locations that would require traversing across the fall line on soil slopes that are between 2:1 and 1.5:1. These slopes are found throughout the project area and are largely stable due to established vegetative cover. Disturbing this cover could destabilize the entire slope and cause significant sloughing failures well outside the project limits. Other areas are relatively gentle slopes above the bottoms of the wide U-shaped valleys in the upper elevations of the three alignments and should be relatively stable. Potential solifluction in these areas may not cause dramatic failure events, but could result in long-term maintenance issues over the life of the project. Difficult slope conditions do occur in the western portion of the Hurricane (West) alignment.

The area along Portage Creek where the alignment traverses relatively steep side slopes and crosses deeply incised tributary channels may require additional mitigation to maintain slope stability. This area exhibits oversteepened soil slopes and the potential for significant instability if the vegetative cover is disturbed. Retaining structures will likely be required in this area to reduce the risk of slope failure during construction and the life of the project.

Based on available information, soil slope stability appears to be the best on the Butte Creek (East) alignment and worst on the Hurricane (West) alignment.

4.2.2.10 Waste Area Availability

For the purposes of this analysis, it is assumed that that quarry/borrow pits can be used for waste soil disposal. The distance between the roadway and the quarry/borrow pits will be the primary factor and is accounted in the rock material source availability and soil borrow source availability criteria. Some sites will be less desirable than others due to limited space to store waste during production of materials. In addition, some waste materials may be used to flatten foreslopes, which could be beneficial in thaw unstable permafrost soils where widened embankments can improve driving surface performance.

Additional information would be required to evaluate this criterion in more detail.

Available information is not sufficient to evaluate the corridors based on the availability of waste areas. At this level of evaluation it can be assumed that quarry/borrow sites for any selected corridor will be adequate for soil waste areas.

4.2.2.11 Foundation Support

Foundation support addresses the overall likely subgrade support for structure foundations along the various corridors. From a foundation support standpoint, the most ideal condition is a foundation supported on shallow, competent bedrock. Less ideal conditions range from soft bedrock and/or dense soil support to thick deposits of soft and/or compressible mineral and organic soils that require deep foundations. Other less ideal conditions include thaw unstable permafrost and liquefiable soils. In general, the poorer the foundation support conditions are, the deeper the foundation systems will need to be to transmit structural loads to the subsurface. The cost advantages to selecting a corridor with ideal foundation support conditions is obvious in that shallower foundations require significantly less materials and effort to construct. Ideally, the corridor that is selected will traverse ground that lends itself to development of relatively shallow foundations on bedrock and/or dense, stable, mineral soils.

The South Road alignment appears to have relatively good foundation support between MP 0 and 30 in the alpine areas where bedrock is relatively shallow. In the lowland areas between MP 0 and MP 15 as well as between MP 30 and the dam site, structure foundations will likely bear on glacial till soils. Glacial till soils, while typically dense and adequate for support of structures, may require development of deep foundations if they are overlain by thick organic or lacustrine deposits or to support very high loading. Likewise, challenging slope conditions adjacent to incised channels between MP 30 and the dam site could provide poor foundation support. Based on field observations, the Seattle Creek (North) alignment appears to have favorable foundation support characteristics where the majority of the stream crossings will likely involve developing foundations on dense soil and/or rock substrata. It is likely that soil conditions will be favorable for shallow foundations along the Seattle Creek (North) alignment depending on the size of the crossing.

The Butte Creek (East) alignment is also expected to have relatively good foundation support conditions; however, there will likely be few crossings along this alignment that will be founded on bedrock. As with the Seattle Creek alignment, the soils along the Butte Creek (East) alignment may also be suitable for supporting shallow bridge foundations, depending on the loading requirements.

Foundation support along the Hurricane (West) alignment is expected to be variable with poor conditions in the low lands on the west end of the alignment and good conditions in the eastern two thirds of the corridor. Deep foundations will likely be needed on the extreme west end of the corridor to penetrate soft and compressible surface deposits. Foundations may also be difficult to establish around the deeply incised slopes around the tributaries of Portage Creek.

The South Road with the exception of abutments spanning rivers with deeply incised channels, Butte Creek (East), and Seattle Creek (North) alignments are expected to have the best foundation support conditions. The foundation support conditions for the Hurricane (West) alignment is expected to be variable, with some locations having poor conditions requiring deep foundations for structures.

4.2.2.12 Summary

Overall, based on an assessment of known existing geologic and geotechnical conditions, the Butte Creek (East) corridor is preferred from a geotechnical standpoint. The South Road and Seattle Creek (North) corridors appears to have acceptable geological and geotechnical conditions. The Hurricane (West) corridor presents the greatest number of technical challenges relating to this evaluation criteria (see Table 4-12).

Table 4-12. Summary of geologic and geotechnical conditions

Factor	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Rock borrow availability[a]	2	2	1	1
Rock borrow quality	2	4	3	2
Soil borrow availability[a]	3	2	2	1
Soil borrow soil quality	4	4	3	1
Subgrade support	3	2.5	2	1.5
Permafrost conditions	2	2	3	1
Drainage[a]	2	2.5	1.5	1.5
Rock slope stability[a]	3	3	2	2
Soil slope stability	2	3	2	1
Foundation support[a]	2	3	2.5	2

Red = Not preferable **Green = Favorable**

[a]Not used as evaluation criteria.

4.2.3 Hydrology

Stream crossings were originally identified on USGS topographic maps and aerial imagery. The watershed area draining to each crossing was estimated using 20m Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)[19] contour intervals and USGS mapping. An approximate 50-year (2 percent) flood discharge was estimated using the watershed area, precipitation, and lake area data and the regression equations of Curran et al. (2003). None of the streams identified have gages on them.

Field reconnaissance consisted of flying each access route in a helicopter, identifying each stream crossing (those previously mapped and those that did not appear on the USGS map), landing[20] at selected crossings to estimate channel width and incision depth, and identifying more efficient crossing locations where they existed. The likely structures needed were selected

[19] ASTER is an imaging instrument flying on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System.
[20] No crossings were field verified along the South Road alignment.

based on field observations and estimated design discharge. Most streams were assumed to be fish-bearing unless earlier studies identified them as otherwise.

Generally, streams with an active channel over 20 feet wide or with an estimated peak design flow greater than 650 cubic feet per second (cfs) were assigned bridges (see Appendix B). Culverts were assigned to smaller streams, according to the following criteria: large fish culverts were assigned to fish-bearing streams with peak flows between 200 and 650 cfs; small fish culverts were assigned to fish-bearing streams with flows less than 200 cfs; and drainage culverts were assigned to non-fish-bearing streams. Large fish culverts were defined as those greater than 10 feet in diameter based on design discharge. Small fish culverts have diameters ranging between 48 inches and 9 feet (again, depending upon design discharge), whereas drainage culverts have a diameter less than 48 inches. In some cases, it may be possible through further study or minor route adjustments to use different structures than those indicated.

4.2.3.1 South Road

The South Road alignment crosses 23 streams, including four large fish culverts and four bridges. From the Gold Creek Station adjacent to the Susitna River, this road alternative traverses the north-facing slopes above the Susitna River. The first bridge crossing is a 200-foot structure over Gold Creek near MP 0.5. The stream channel is relatively broad and shallow compared to the incised channels elsewhere on the South Alignment.

The alignment crosses numerous smaller streams flowing north into the Susitna River before encountering Cheechako Creek at MP 15. Cheechako Creek requires a structure with a clear span on the order of 300 to 500 feet, due to the wide and deep canyon formed by the stream.

The alignment jogs south to the headwaters draining into Chinook Creek in order to avoid Chinook's deep ravine. Descending from MP 22 on an eastward course, the alignment navigates between two small lakes downstream of Stephan Lake and crosses additional small streams before approaching Fog Creek near MP 44.

Fog Creek is a large tributary of the Susitna River and is the last drainage requiring bridges before the South Road alignment descends to the proposed dam site on the Susitna River at MP 54.5. The lower reaches of Fog Creek flow through a deep canyon with steep walls and unstable soils. The canyon walls are intermittent vertical, jagged rock formations and with observed rockslides. Rather than attempt to span the canyon, the South Road alignment skirts along the southern rim before crossing the more docile terrain to the east. The first structure in the Fog Creek drainage crosses a major tributary to Fog Creek near MP 45. This structure will have a length between 100 and 300 feet. Near MP 48, another bridge is needed to cross Fog Creek. This bridge is approximately 150 feet in length. At this location, the topography slopes more gradually across the creek, allowing for a shorter bridge and more agreeable access conditions for the movement of equipment and materials making it preferable to crossing Fog Creek closer to the Susitna River. From there the alignment follows the north ridge above the stream approximately three miles back to the west to tie in with the original South Road alignment. The structures associated with the South Road corridor are documented in Appendix B.

4.2.3.2 Hurricane (West)

The Hurricane (West) alignment crosses the most streams of the four alternatives (36 in all, with six bridges and two large fish culverts). The route begins on the Parks Highway, and traverses a hillslope drained by multiple small tributaries to the Chulitna River. The alignment then enters the Indian River drainage, and crosses Indian River with a 150- to 200-foot bridge. Indian River is incised into the surrounding landscape, but several locations were identified where an appropriately graded road could descend into the river valley and back out the other side. Indian River is a steep, bouldery stream, and the crossing should be located at a relatively stable and preferably straight reach, as a bend is more likely to migrate.

After ascending out of the Indian River drainage, the alignment crosses into the Portage Creek drainage, crossing six small tributaries incised into steep gullies. Each of these gullies appears to have relatively stable side slopes at the crossing locations. Stability was judged by assessing the condition of the adjacent vegetation (which was dense and undisturbed). Two of the larger gullies have exposed bedrock cliffs in places. These stream crossings will require relatively deep fill to maintain grade.

Portage Creek is a large tributary to the Susitna River. Thoroughfare Creek joins Portage Creek in the vicinity of the crossing location. There is a large gravel bar immediately downstream of the Thoroughfare/Portage Creek confluence, indicating that this is an active deposition area. We recommend crossing Thoroughfare Creek and Portage Creek upstream of the confluence. Although two bridges would be necessary, Portage Creek appears to be in a more stable channel upstream of the confluence.

After leaving Portage Creek, the alignment crosses Devil Creek, a stable, confined channel incised about 40 feet into bedrock. The alignment then traverses a moderate hill slope and crosses several small streams. One moderately sized stream cut into a gully will likely require a bridge, owing to the depth of incision and large amounts of sediment moving through. The final major crossing is Tsusena Creek, which is the largest drainage on the Hurricane (West) route, and will require a 150- to 200-foot-long bridge to cross.

4.2.3.3 Seattle Creek (North)

There are 15 stream crossings[21] on the Seattle Creek (North) route with the western option, including four bridges and five large fish culverts. The Seattle Creek (North) route leaves the Denali Highway and traverses the Lily and Seattle Creek drainages, both tributaries to the Nenana River. Both Lily Creek and Seattle Creek are crossed in the upper reaches with large fish culverts. The alignment traverses a mild slope into the Brushkana Creek drainage and then crosses Brushkana Creek and a major tributary with short (50-foot) bridges.

The route leaves the Brushkana drainage and enters the Deadman Creek drainage, crossing Deadman Creek three times. The first crossing of Deadman Creek is in a flat, grassy area near the headwaters, and will require a large fish culvert or a short bridge. The second crossing, at the outlet to Deadman Lake, will require a 50- to 75-foot bridge. The creek is steep and incised at this location but banks appear stable. The third crossing of Deadman Creek is the largest creek crossed by any of the alignments and will require a 100- to 150-foot bridge. Deadman Creek alternates between broad, shallow reaches several hundred feet wide and deeper reaches of 90 to 100 feet wide. As the alignment is further refined, specific crossing locations of Deadman Creek at narrower sections should be identified.

[21] This number refers to the stream crossings on the new roadway. There may be additional crossing associated with the Denali Highway.

4.2.3.4 Butte Creek (East)

The Butte Creek (East) route crosses 29 streams, including four that will require bridges and two requiring large fish culverts. The route begins by crossing the outlet to Snodgrass Lake and Wickersham Creek (both would require large fish culverts or short bridges). The alignment then traverses a poorly drained hillside north of Butte Creek, and crosses Butte Creek with a 100-foot bridge. The alignment leaves Butte Creek and continues along a north-facing slope in the Watana Creek drainage, crossing multiple small streams and swampy beaver dam areas. One creek will require a 30-foot bridge, and Delusion Creek will likely require a large fish culvert. The Butte Creek alignment then joins the Seattle Creek alignment and crosses Deadman Creek with a 100- to 150-foot bridge.

4.2.3.5 Summary

All four corridors require similar numbers of bridges (four on South Road, six on Hurricane [West] and four on Seattle Creek [North] and Butte Creek [East]) for the new road alignment. Collectively, the bridges on the South Road and Hurricane (West) alignments are substantially greater (1,000 and 800 feet respectively) than the Seattle Creek (North; 200 feet) and Butte Creek (East; 300 feet) alignments. The Seattle Creek (North) corridor appears to need 4 large fish culverts while the South Road alignment needs 3 and the Hurricane (West) and Butte Creek (East) alignments need only 2 each. The Seattle Creek (North) alignment needs substantially fewer small fish culverts and drainage culverts (7) compared to South Road (15), Hurricane (West; 27) or Butte Creek (East; 21). In addition to the structures along the stretches of new road, the Seattle Creek (North) and Butte Creek (East) alignments will also require the replacement or upgrade of culvert and bridge structures on their respective portions of the Denali Highway, according to the information presented in Appendix C. Overall, the Seattle Creek (North) alternative is preferable. Table 4-13 summarizes the hydraulic conditions of each alignment. For more information about structures, please see Appendix B.

Table 4-13. Summary of hydraulic conditions on new roadway

Factor	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Number of bridges	4	6	3	4
Linear feet of bridge	1,000	800	200	300
Drainage culverts	0	2	4	0
Small fish culverts	15	25	3	23
Large fish culverts	4	2	4	2

Red = Not preferable **Green = Favorable**

4.2.4 Fish Streams/Waterbodies

Fish are an important resource in Alaska and maintaining access to fish habitat is important for the health of this resource. Historically, road culverts have been a barrier to fish passage as they have restricted the ability for fish to access upstream spawning and rearing areas. DOT&PF has a Memorandum of Agreement (MOA) with ADF&G to ensure that road culverts are adequately sized to accommodate fish passage. Fish passage culverts tend to be larger (and more expensive) than drainage culverts and can have an impact on a project's construction cost. The crossing of fish-bearing waters also requires a Title 16 Fish Habitat Permit (see Section 4.2.12.3).

The access corridor study area includes streams and waterbodies within both the Susitna River and Tanana River watersheds (see Figure 4-7). However, most of the streams that may be crossed ultimately drain into the Susitna River watershed. Many of the streams that would be crossed are small, high-gradient tributaries in the upper reaches of larger watersheds (Schmidt 1983). However, each alignment would also cross larger streams as well as small, swampy tundra streams. Most of these tributary streams are small and shallow with variable discharge (Schmidt et al. 1983). Schmidt et al. (1983) reported that rubble, cobble, and boulders dominated the substrate in many of the tributary streams.

A total of 14 fish species have been documented to occur throughout the streams and lakes within the proposed access corridor study area, as listed below. Biologists documented the presence of both resident[22] and anadromous fish species[23] within the access corridor study area (Schmidt et al. 1983; ADF&G 1983, 2011; FERC 1984; Yanusz et al. 2011).

Arctic grayling (*Thymallus arcticus*)

Dolly Varden (*Salvelinus malma*)

Coho salmon (*Oncoryhynchus kisutch*)

Chinook salmon (*O. tshawytscha*)

Pink salmon (*O. gorbusha*)

Chum salmon (*O. keta*)

Sockeye salmon (*O. nerka*)

Rainbow trout (*O. mykiss*)

Lake trout (*S. namaycush*)

Slimy sculpin (*Cottus cognatus*)

Burbot (*Lota lota*)

Round whitefish (Prosopium cylindraceum)

Longnose sucker (Catostomus catostomus)

Humpback whitefish (*Coregonus oidschian)*

Overall, Arctic grayling was the most abundant and perhaps the most widely distributed fish species documented during various baseline studies conducted within the access corridor study area in the early 1980s. Dolly Varden, slimy sculpin, and burbot were also fairly abundant and widespread (ADF&G 1983, Schmidt et al. 1983).

The five species of Pacific salmon indigenous to Alaska all occur in the Susitna River downstream of Devils Canyon (ADF&G 2011, Yanusz et al. 2011). The Susitna River is among the most important salmon-producing systems in upper Cook Inlet (UCI; HDR 2011a). Fisheries resources contribute to the Cook Inlet commercial harvest as well as the important sport and subsistence fisheries (Jennings 1984, Oslund and Ivey 2010, Shields 2010).

[22] Resident fish spend their entire lives in freshwater. Dolly Varden and rainbow trout have both anadromous and resident forms. Resident Dolly Varden are most often found upstream from barriers (i.e., natural falls, manmade dams) that prevent the upstream migration of anadromous fish (Ihlenfeldt 2005).

[23] Additional species have been documented farther downstream in the Susitna River, including, but not necessarily limited to, eulachon (*Thaleichthys pacificus*), northern pike (*Esox lucius*), Pacific lamprey (*Lampetra tridentate*), and Arctic lamprey (*Lethenteron camtschaticum;* HDR 2011a).

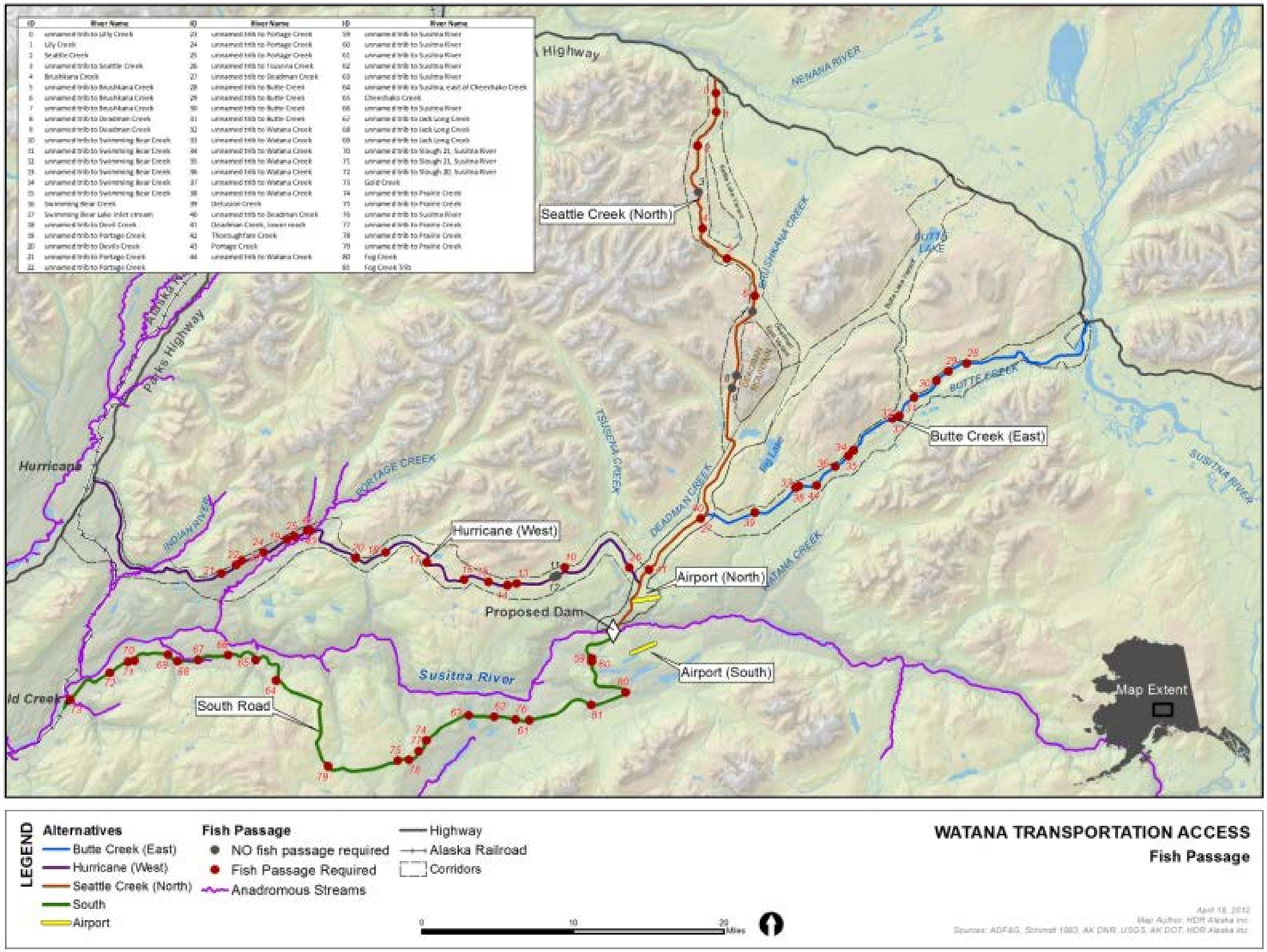

Figure 4-7. Fish and water body map

The ADF&G has confirmed the presence of Chinook salmon in the Susitna River and some of its tributary streams upstream of Devil's Canyon (ADF&G 2011). Chinook salmon is the only pacific salmon species documented upstream of Devils Canyon in the Susitna River or its tributaries to date (ADF&G 2011).

The Susitna River Chinook salmon stock is the fourth largest in Alaska (Ivey et al. 2009). Although Susitna River Chinook salmon make a relatively small contribution to commercial fisheries, they are important to recreational and guided sport fisheries (HDR 2011a). In February 2011, the Alaska Board of Fisheries (ABF) declared Willow Creek and Goose Creek Chinook salmon as stocks of concern due to declining escapement numbers (HDR 2011a). Both of these creeks flow into the Susitna River well downstream of the access corridor study area.

Sockeye salmon also occur as far upstream as Devils Canyon (Yanusz et al. 2011, ADF&G 2011). Sockeye salmon is the most abundant and economically valuable salmon species in the Susitna River system (HDR 2011a). The Susitna River is the third largest producer of sockeye salmon in the UCI, following the Kenai and Kasilof river systems (HDR 2011a).

Sockeye salmon stocks in the Susitna River have reportedly declined over the past decade (Shields 2010). In 2008, the ABF deemed the Susitna River Sockeye salmon as a stock of yield concern. As a result, an action plan to develop conservation management measures was set in place by the ADF&G. Although sockeye salmon have been extensively studied in the Susitna River, additional information is necessary to identify spawning locations within the middle and portions of the lower Susitna River (HDR 2011a).

The Susitna River coho, chum, and pink salmon stocks are also important to both the commercial and sport fisheries in the UCI area (HDR 2011a). Coho salmon are abundant in the middle reach of the Susitna River from Talkeetna to Devils Canyon (HDR 2011a). Recent studies have been undertaken to identify the spawning distribution of both coho and chum salmon (Merizon et al. 2010) and determine bank orientation of migrating pink salmon within the Susitna River system (Willette 2011).

Arctic grayling, Dolly Varden, lake trout, and rainbow trout are important for the recreational sport fishery in Alaska and in some areas are important subsistence species. Burbot and various whitefish species are also important food sources for subsistence harvest. A subsistence harvest data gap analysis was recently completed for the Watana Hydroelectric Project (Simeone et al. 2011).

Maintaining natural fish populations also plays an important role for the overall genetic biodiversity of each species. Fish species can act as indicator species for changes in the environment. For example, slimy sculpin has been identified as a good indicator species for acidification in lakes and ponds and possibly for streams (Mansfield 2011).

4.2.4.1 South Road

The South Road alignment would require a total of 23 stream crossings. All streams and waterbodies intersected by this alignment drain into the Susitna River watershed. The Susitna River (including side channels and sloughs) are known to provide habitat for Pacific Salmon (ADF&G 2011). Many of the streams that would be crossed are unnamed tributaries of the Susitna River. Fish data are available for a number of streams that would be crossed. However, much of the available fish data were collected downstream from (i.e. not in the direct vicinity of) the proposed crossing sites (ADF&G 1981, 2011; Schmidt et al. 1983).

A total of 8 of the 23 streams intersected by the southern alignment are known to provide habitat for anadromous fish downstream of the proposed crossing sites (ADF&G 1981, 2011; Schmidt et al. 1983). The South Road alignment is presumed to provide fish passage at all 23 proposed stream crossings.

4.2.4.2 Hurricane (West)

The Hurricane alignment would require a total of 36 stream crossings. All streams and waterbodies intersected by this alignment drain into the Susitna River watershed. The majority of streams that would be crossed by the Hurricane (West) alignment are smaller tributary streams to larger systems. However, the Hurricane alignment would also cross a number of larger streams, such as Pass Creek, the Indian River, and Thoroughfare, Portage, Devil, Tsusena, and Deadman creeks.

The Hurricane (West) alignment would cross Granite Creek west of the Parks Highway to facilitate access to the existing railroad line. The ADF&G *Anadromous Waters Catalog* (*AWC*) lists Granite Creek (AWC No. 247-41-10200-2381-3600) as providing habitat for anadromous fish (ADF&G 2011). Bader and Sinnott (1989) captured juvenile Chinook and coho salmon at a point downstream of the proposed crossing (Bader and Sinnott 1989, ADF&G 2011).The *AWC* nomination does not identify the presence of passage barriers; therefore, anadromous fish presence at the Hurricane (West) alignment crossing site is assumed. Fish passage at the crossing site would be provided via either bridge or culvert.

Pass Creek, located southwest of the Hurricane route crossing, is specified as an anadromous stream in the *AWC* (AWC No. 247-41-10200-2381-3236) and is designated to provide habitat for all five species of Pacific salmon (ADF&G 2011). However, a waterfall located downstream of the Hurricane alignment crossing presents a barrier to upstream migration of anadromous fish (ADF&G 2011). The Hurricane alignment intersects nine small, unnamed tributaries to Pass Creek. A limited electro-fishing assessment conducted by ADF&G found Dolly Varden and slimy sculpin at the one location sampled (Buckwalter et al. 2003). Since no other data regarding fish presence are available for these small tributary streams, culverts would be designed to pass resident fish (e.g., Dolly Varden and slimy sculpin).

Three additional streams—Indian River (AWC No. 247-41-10200-2551), Thoroughfare Creek (AWC No. 247-41-10200-2582-3201), and Portage Creek (AWC No. 247-41-1020-2585)—are cataloged (ADF&G 2011) to provide habitat for anadromous fish at the crossing sites. Passage for anadromous fish, including salmon, would need to be provided at each crossing. The Hurricane alignment would include bridges to span the width of the four anadromous fish streams.

The Hurricane (West) alignment would also cross 10 small, unnamed tributaries of Portage Creek, the mainstem of Devil Creek and 3 of its tributaries, and 7 smaller tributaries to the upper Susitna River (in the Swimming Bear drainages; Schmidt et al. 1983). The Hurricane (West) alignment would also cross Tsusena Creek and 2 of its tributaries.

Since fish presence sampling has not been conducted in many of these tributary streams and passage barriers have not been identified to date, fish presence should be assumed. The Hurricane (West) alignment would be required to provide fish passage at all 36 proposed stream crossings.

4.2.4.3 Seattle Creek (North)

The Seattle Creek (North) alignment would cross streams within both the Nenana River and Susitna River watersheds. Seattle Creek and Brushkana Creek are the two major drainages crossed within the Nenana River watershed. Deadman Creek is the major stream crossed within the Susitna River watershed.

The Seattle Creek (North) alignment would require a total of 15 stream crossings. In the 1980s, biologists conducted fish presence surveys in the vicinity of 10 of the 15 stream crossing sites and recorded general habitat and water quality conditions (Schmidt et al. 1983). Resident fish species were confirmed to be present in the vicinity of 9 proposed crossing locations (Schmidt et al. 1983). Schmidt et al. (1983) identified three crossing sites as having intermittent flow and deemed them unsuitable for long-term fish use; therefore, these three sites were not sampled for fish presence at that time.

Biologists documented the presence of Dolly Varden, slimy sculpin, and Arctic grayling (Schmidt et al. 1983). All three species were relatively widespread (Schmidt et al. 1983). No anadromous fish habitat was identified along the Seattle Creek alignment (Schmidt et al. 1983). Biologists captured sculpin near nine of the proposed crossing locations and Dolly Varden and Arctic grayling near six of the proposed crossings. Fish were captured from all but one of the sites sampled. No data are available for one of the 15 stream crossings.

Based on field data reported by Schmidt et al. (1983), the Seattle Creek alignment would be required to provide fish passage at 12 of the 15 stream crossings. Fish passage would not be required at the three crossing sites where intermittent flow was identified. Habitat descriptions for streams crossed within the study area are provided by Schmidt et al. (1983).

4.2.4.4 Butte Creek (East)

The Butte Creek (East) alignment would require a total of 29 stream crossings. The Butte Creek (East) alignment would cross streams and waterbodies that ultimately drain into the Susitna River. Butte Creek, Watana Creek, Delusion Creek, and Deadman Creek are the major streams crossed by the Butte Creek (East) alignment.

In the 1980s, biologists conducted fish presence surveys in the Watana Creek and Deadman Creek drainages (ADF&G 1983, Schmidt et al. 1983). Arctic grayling, burbot, longnose suckers, and sculpin were found to occur within both drainages (ADF&G 1983). Additionally, Dolly Varden presence was confirmed throughout Deadman Creek, while lake trout were captured from its middle and upper reaches (Schmidt et al. 1983). The presence of round whitefish was confirmed in the lower portion of Watana Creek (ADF&G 1983). No fish data were identified for Butte Creek.

The presence of anadromous fish has not been identified in any one of the streams that would be crossed by the Butte Creek (East) alignment (Schmidt et al. 1983; ADF&G 1983, 2011). However, Chinook salmon presence has been confirmed in the Susitna River just upstream from Delusion Creek (ADF&G 2011).

The majority of fish data available for streams intersected by the Butte Creek (East) alignment was not collected in the vicinity of the proposed crossing sites. Since data are not available for the proposed crossing sites, fish presence was assumed. Therefore, the Butte Creek (East) alignment would be required to provide fish passage at all 29 proposed crossing sites.

4.2.4.5 Summary

The Hurricane (West) alignment has the highest number of crossings compared to the other alternatives and the highest number of crossings over anadromous waters (see Table 4-14). However, proposed crossings over the four major anadromous streams would be designed with full span bridges.

The Seattle Creek (North) alignment has the fewest number of stream crossings and does not cross anadromous streams. However, the Seattle Creek (North) alignment would span between two watersheds: the Susitna and the Tanana. Impacting fewer watersheds is preferable because potential impacts (such as introduction of an invasive species) would affect a smaller geographic area if they were to occur. Additional research would be needed to identify potential impacts. The Butte Creek (East) alignment has a total of 29 stream crossings.

Table 4-14. Summary of fish crossings

	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Salmon stream crossings	8	4	0	0
Stream crossings requiring passage for resident fish	23	32	15	29

Red = Not preferable **Green = Favorable**

4.2.5 Terrestrial Resources

There are 142 species of birds (mostly migratory), 38 species of mammals, and one amphibian (the wood frog, *Rana sylvatica*) known or suspected to occur in the Susitna River basin (see Appendix I). In the upper and middle Susitna basins, where all the access corridors are located, 135 bird species have been documented (Kessel et al. 1982). The Susitna River basin, divided into five subbasins, extends west and south of the corridor study area, but excludes the northern part of the Seattle Creek corridor (ABR 2011).

There are no Federally or State-threatened, endangered, or candidate species of plants or animals known to occur in the study area (ABR 2011, HDR 2011a). Fifty-five bird species (including Trumpeter swans), one mammal (Alaska tiny shrew), and the wood frog are species of concern designated by various agencies and organizations in the Susitna basin (HDR 2011a). There are 17 plant species considered rare or sensitive in the Upper and Lower Susitna sub-basins (see Appendix I).

All migratory bird species are protected by the Federal Migratory Bird Treaty Act, which makes it unlawful to “pursue…take, capture, kill…any migratory bird…nest, or egg…unless authorized under a permit.” Take is defined in regulations as: “pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect.” Both bald and golden eagles occur in the study area. They have additional protection under the Federal Bald and Golden Eagle Protection Act (Eagle Protection Act). Both acts are regulated by the U.S. Fish and Wildlife Service (USFWS), which sets project-specific timing windows for construction, establishes areas of impact, and stipulates buffers surrounding known nests.

The Eagle Protection Act provides for the protection of bald and golden eagles by prohibiting, except under certain specified conditions, the taking, possession, and commerce of such birds. The management guidelines (USFWS 2007) include definition of zones around nest trees to avoid disturbance. The primary zone extends 330 feet from the nest tree, and land clearing or construction may be discouraged year-round. Human disturbance is discouraged, particularly during the spring-summer nesting season. A secondary zone ranges to a distance of 660 feet from the nest, and human disturbance must be minimized during the breeding season, but construction may be possible outside the nesting season (USFWS 2007).

The USFWS and FERC have recently developed a Memorandum of Understanding (MOU) regarding protection of migratory birds (FERC and USFWS 2011). While the MOU covers all species of migratory birds, it emphasizes "Species of Concern" that are identified by various names by agencies and multi-organization working groups. The MOU does not have regulatory authority that would affect alternative selection; consultation with USFWS and working groups will occur according to the terms of the MOU during the NEPA process.

Because of emphasis on certain species during previous studies for the Susitna Hydroelectric Project (SHP), caribou, moose, black and brown bears, Dall sheep, bald and golden eagles, ducks, and trumpeter swans were the focus of this Watana Transportation Access study. Available and pertinent summary information on wildlife species, status, distribution, habitat use, and past environmental reviews and recommendations for access routes were reviewed (APA 1981; Acres 1982; Kessel et al. 1982; ADF&G 1984, 2009 a–f; BLM 2002; ABR 2011; HDR 2011a).

Terrestrial resource data for the project area are largely from studies conducted in the early 1980s, with limited updates available (ABR 2011). Many of the earlier studies were focused on the Watana impoundment and/or downstream areas, and did not explicitly or completely cover the three alternative corridor routes proposed in this report. More current wildlife data may reflect changes in species distribution and habitat use, but this information is not readily available from ADF&G (ABR 2011). Recent eagle nest survey data for the project area is unavailable. Since nest occupation can vary from one year to the next, current data is essential to accurately determine areas subject to the USFWS primary or secondary zones. While this analysis assumes that the alternatives' corridor widths are sufficient to avoid impacting primary or secondary eagle nest zones, a take permit may be required if disturbance is unavoidable.

There is no complete and current wildlife habitat mapping for the selected species that covers the entire access corridor study area. GIS data is not available for brown or black bears from the Alaska Habitat Mapping Guide (ADF&G 2009 a–f). The Susitna Area Planning habitat maps (ADF&G 1984), some of which include more detail than the Habitat Guide maps, are not available digitally, so the information gathered from them is only referred to in the text.

Environmental reviews and recommendations of access alternatives chosen in the 1980s are not completely applicable to the proposed alternatives in this analysis due to differences in configurations and locations (APA 1981). In addition, there was no environmental analysis for an access corridor in the Butte Creek (East) route area (APA 1981).

Due to these data limitations, most of the following analysis was based on the available maps and reports, and is presented as a qualitative comparison between the alternatives.

4.2.5.1 South Road

The South Road corridor is anticipated to have fewer adverse impacts to caribou compared to the other three alignments. It intersects the least mapped winter habitat (449.6 acres), summer habitat (942.2 acres), and migration area (0 acres) than Hurricane (West), Seattle Creek (North), or Butte Creek (East). "The upper Prairie Creek, Stephan Lake and Fog Lakes areas support one of the largest year-round moose concentrations in the region" (APA 1981 2-29 and 2-30). The South Road corridor intersects the fewest acres of moose general habitat and calving habitat. The South Road corridor intersects slightly more rutting and winter moose habitat than the Seattle Creek (North) corridor but less than Hurricane (West) and Butte Creek (East). "The upper Prairie Creek, Stephan Lake and Fog Lakes areas support one of the largest year-round moose concentrations in the region" (APA 1981 2-29 and 2-30).

The South Road corridor does not intersect mapped sheep habitat (Figure 4-10 and Table 4-15). This alignment impacts fewer acres of general habitat for migratory ducks than the Hurricane (West) alignment but more than the other two alignments. This alignment impacts slightly more acreage of general swan habitat than the Hurricane (West) alignment and more than Seattle Creek (North) and Butte Creek (East).

Bears, especially brown bears, have been known to inhabit the area near upper Prairie Creek, Stephan Lake, and Fog Lake. This area is near a "midsummer migratory route for bears moving from the Susitna River to Prairie Creek." (APA 1981 2-30).

4.2.5.2 Hurricane (West)

With a few exceptions, the Hurricane (West) corridor has fewer adverse impacts to caribou and moose compared to the Seattle Creek (North) route, because this corridor traverses or approaches fewer areas of productive habitat and zones of species concentration or movement (APA 1981, Acres 1982). This corridor includes both summer and winter caribou habitat range (ADF&G 1984; see Figure 4-8 and Table 4-15), but earlier studies suggested that this area has little use by caribou (APA 1981, ABR 2011). Most or all of the entire corridor is mapped for general, summer, or rutting, or winter habitat for moose (ADF&G 1984; Figure 4-9 and Table 4-15), but moose were not considered abundant in this area during the early 1980s except for the mouth of Tsusena Creek (APA 1981).

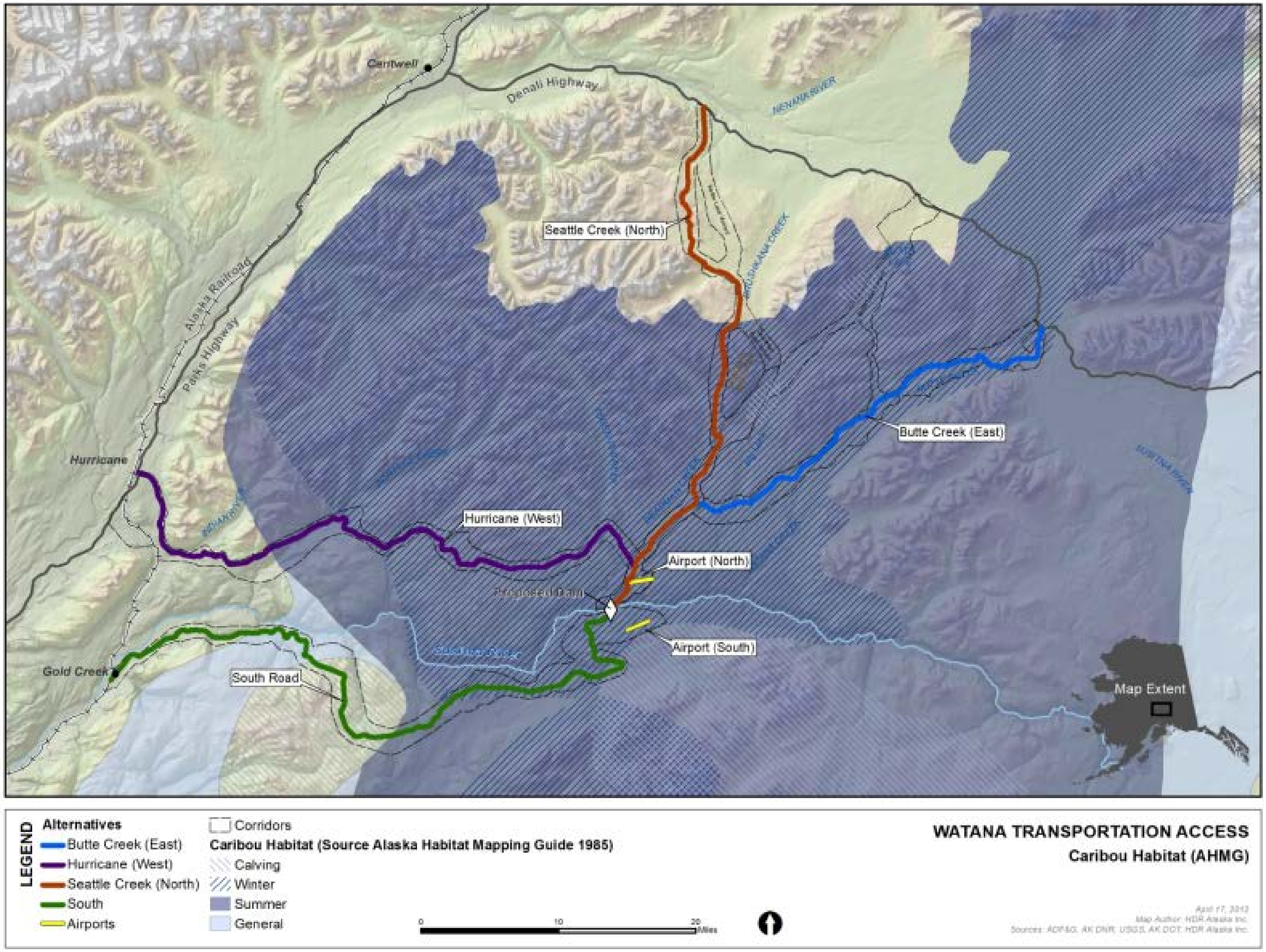

Figure 4-8. Caribou habitat

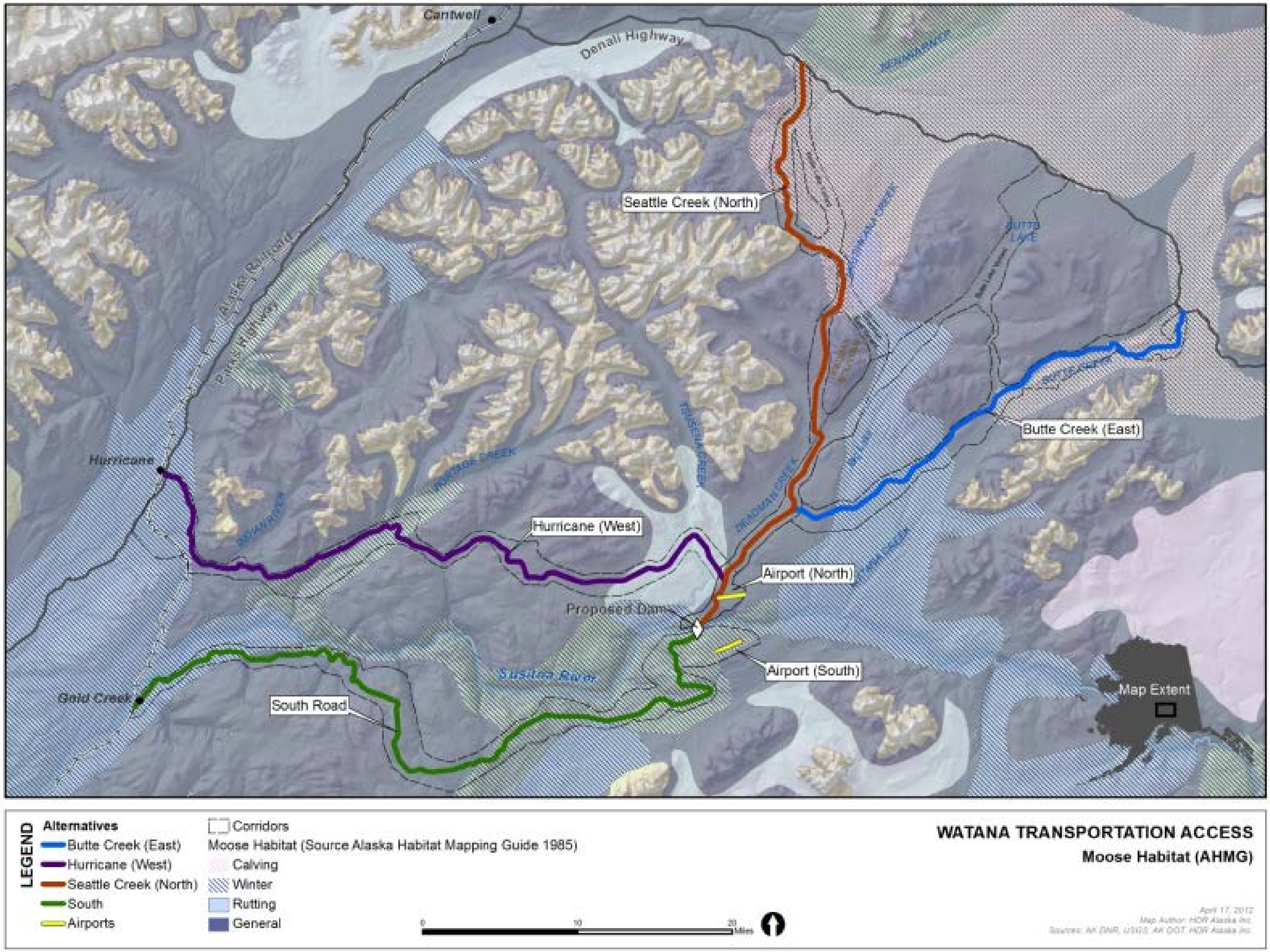

Figure 4-9. Moose habitat

Along the eastern half of the corridor, brown bears were more common than black bears (APA 1981). An area just north of the corridor and south of the headwaters of Devil and Clark Creeks was mapped as a brown bear denning area, and Portage Creek was identified as a brown bear concentration area during seasonal salmon abundance (ADF&G 1984). The extreme western end of the corridor was mapped as "intensive use" by black bears during the spring (ADF&G 1984), and the mouth of Tsusena Creek was also considered important habitat for black bears (APA 1981). The rest of the corridor is mapped as "general distribution" of black bears.

The Hurricane (West) corridor comes the closest to mapped Dall sheep habitat of the four alternatives, but does not intersect sheep habitat (Figure 4-10 and Table 4-15).

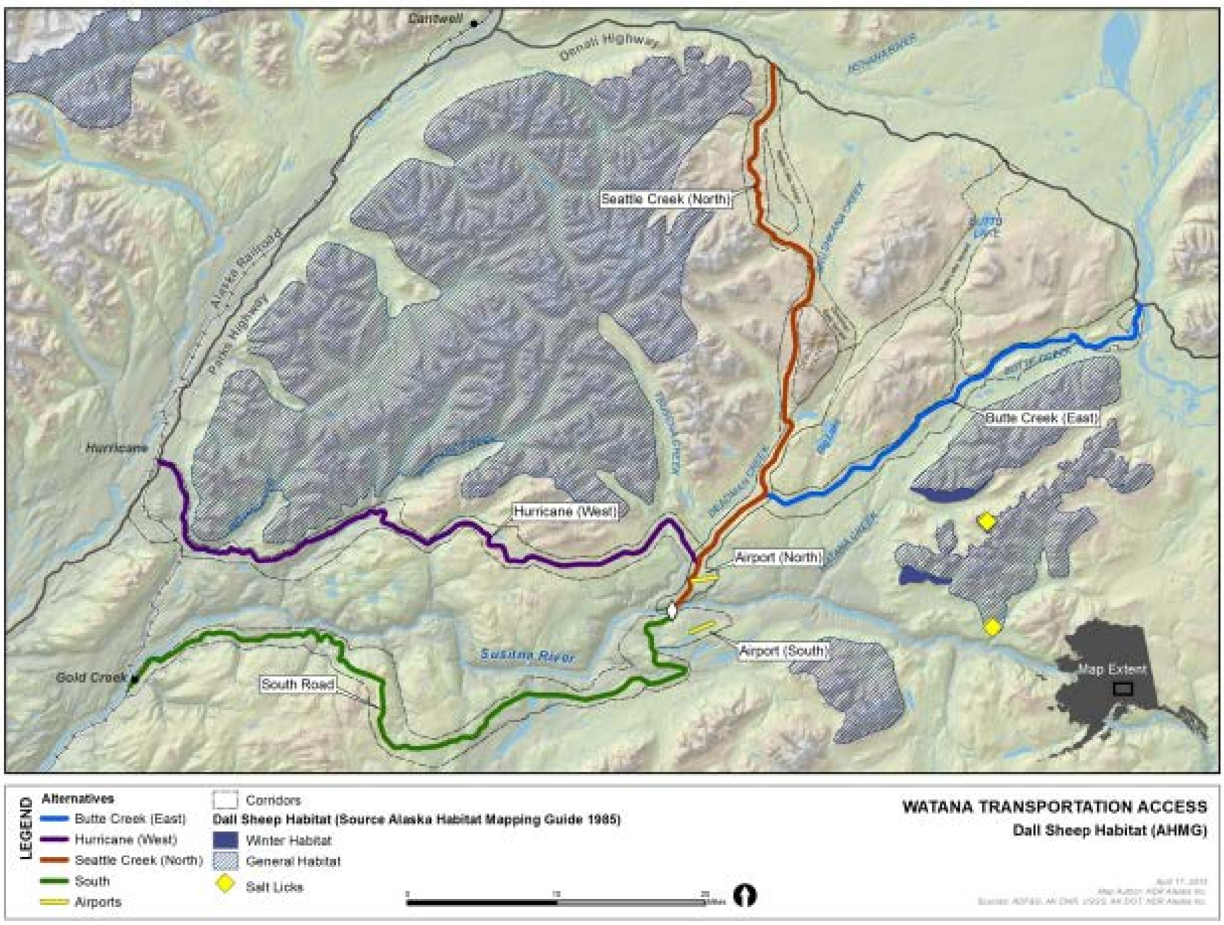

Figure 4-10. Dall sheep habitat

The Hurricane (West) corridor intersects the most migratory duck habitat (387 acres) of the four corridors, and intersects the same amount of trumpeter swan habitat as the Butte Creek (East) route (65 acres; see Figure 4-11; Table 4-15).

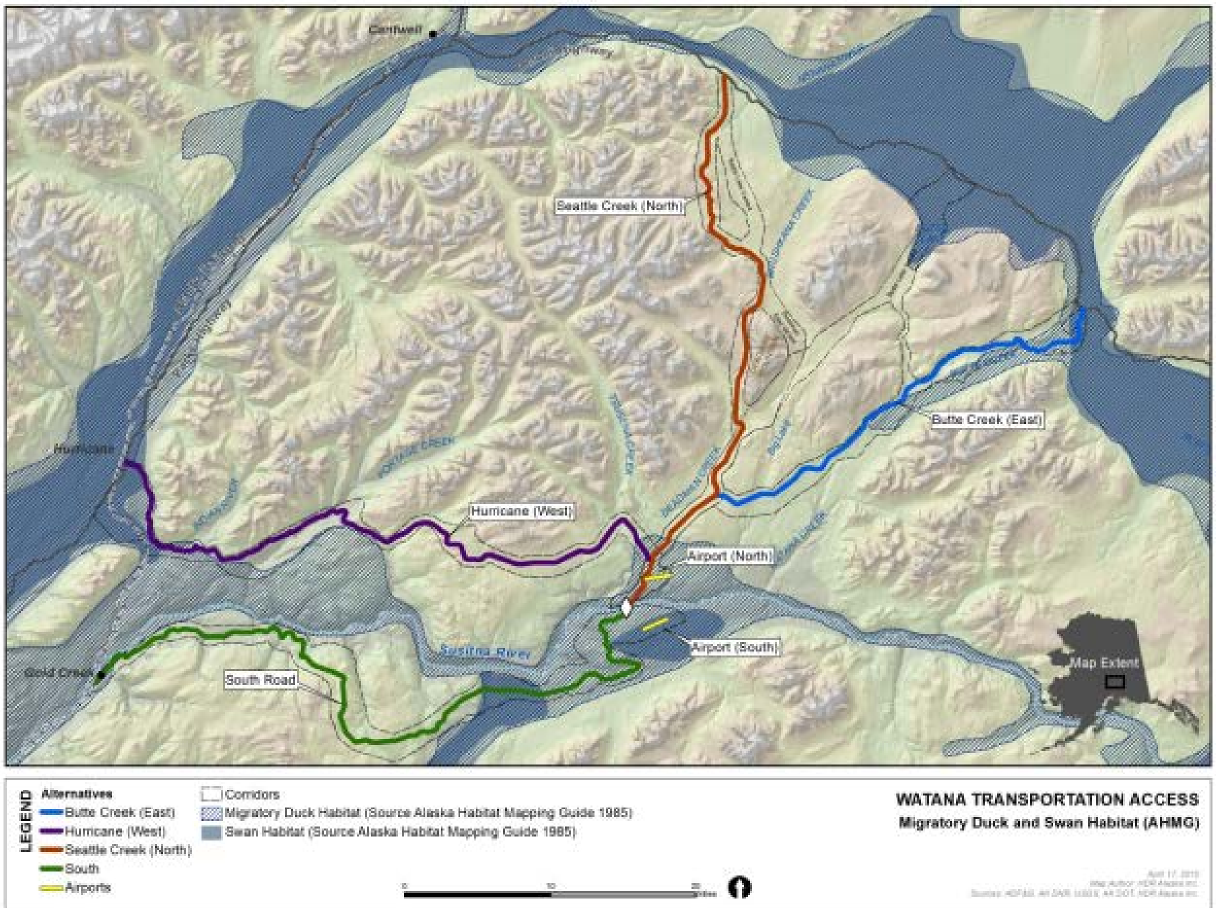

Figure 4-11. Duck and swan habitat

4.2.5.3 Seattle Creek (North)

The Seattle Creek (North) route has more potential for wildlife disturbance and increased public access to caribou and brown bear habitat and movement zones than much of the Hurricane (West) route (Acres 1982). Moose and caribou were considered the most numerous big game species along this route, compared to estimates along variations of the West route (APA 1981). More than half of the corridor has been mapped as general habitat for moose (ADF&G 1984, ADF&G 2009 a–f), although upper Deadman and Brushkana Creeks have been mapped as a fall concentration area (ADF&G 1984), and the northern part of the corridor has been mapped as both calving and winter habitat (Figure 4-9; Table 4-15). The corridor intersects year-round habitat (see Figure 4-8) for a subherd of the Nelchina caribou herd (up to 1,500 animals), and seasonal habitat for some of the migratory Nelchina and Delta herds (APA 1981, ABR 2011).

This corridor bisects an area of about 32 square miles west of Deadman Mountain that was mapped as a brown bear denning area (ADF&G 1984). No brown bear concentration areas are intersected or nearby (ADF&G 1984). The entire corridor is mapped as "general distribution" for black bears.

This corridor is well outside Dall sheep habitat (Figure 4-10; Table 4-15), and intersects the least amount of migratory duck habitat (322.1 acres) and trumpeter swan habitat (0 acres) of the four alternatives (Figure 4-11; Table 4-15).

4.2.5.4 Butte Creek (East)

The Butte Creek (East) route was not included in previous environmental reviews of access alternatives (APA 1981, Acres 1982). This entire corridor has been mapped as year-round range for caribou (ADF&G 1984; Figure 4-8), and the entire corridor crosses general, winter, rutting, and calving habitat areas for moose (ADF&G 2009 a–f; Figure 4-9). This corridor does not intersect or closely pass brown bear denning or concentration areas or Dall sheep habitat (ADF&G 1984; Figure 4-10). The entire corridor is mapped as "general distribution" for black bears (ADF&G 1984).

The Butte Creek (East) intersects a similar amount of duck habitat (763.5 acres) than the South Road corridor, less duck habitat (744.7 acres) than the Hurricane Creek (West) corridor (965.3 acres), but more than the Seattle Creek (North) corridor (322.1 acres; Figure 4-11). This corridor intersects an less of trumpeter swan habitat than the South Road (166.4 acres) and the Hurricane Creek (West) corridor (163.6 acres), but more than the Seattle Creek (North) corridor (0 acres).

4.2.5.5 Summary

There are no Federally or State-threatened, endangered, or candidate species of plants or animals known to occur in any of the three corridors. The South Road corridor appears to pose the least impact to caribou. The South Road corridor impacts the least amount of general moose habitat but the highest amount of winter habitat. The Hurricane (West) corridor appears to be less impactful to moose and caribou compared to the Seattle Creek and Butte Creek corridors because it has fewer areas of productive habitat and zones of species concentration or movement.

The South Road corridor intersects a similar amount of migratory duck habitat (763.5 acres) to the Butte Creek (East) corridor. This is less than the amount of migratory duck habitat impacted by Hurricane (West) but more than double that of Seattle Creek (North). This corridor also impacts a similar amount of trumpeter swan habitat (166.4 acres) as the Hurricane (West) corridor.

The Hurricane (West) corridor intersects the most migratory duck habitat (965.3 acres) of the four corridors, and intersects more trumpeter swan habitat than Seattle Creek (North) alternative (0 acres) or the Butte Creek (East) route (71.3 acres).

The Seattle Creek (North) corridor is well outside Dall sheep habitat, and intersects the least amount of migratory duck habitat (322.1 acres) and trumpeter swan habitat (0 acres) of the three alternatives.

The Butte Creek (East) intersects less duck habitat (744.7 acres) than the Hurricane (West) corridor (965.3 acres), but more than the Seattle Creek (North) corridor (322.1 acres). This corridor intersects more trumpeter swan habitat than Hurricane (West) corridor (163.6 acres) or the Seattle Creek (North) corridor (0 acres).

As the GIS mapping for terrestrial resources did not cover the entire area being studies and may not reflect current conditions, each corridor was also ranked using professional judgment of available information for the selected species as a whole. The corridors were ranked on a 1 to 5 scale with 1 representing no impact to terrestrial resources and 5 representing a significant impact to threatened and endangered species (see Table 4-15).

Table 4-15. Summary of impacts to terrestrial resources				
	Corridor			
	South Road	**Hurricane (West)**	**Seattle Creek (North)**	**Butte Creek (East)**
Caribou				
Winter habitat (acres)	449.6	1,797.8	1,489.0	2,5520
Summer habitat (acres)	942.2	2,226.0	1,489.0	2,552.0
Migration (acres)	0.0	162.7	1,46.3	146.3
Habitat qualitative score	2	2	3	3
Moose				
General habitat (acres)	738.8	1,703.4	1,677.1	1,404.0
Calving habitat (acres)	0.0	0.0	922.2	584.3
Rutting habitat (acres)	320.5	838.2	50.5	534.7
Winter habitat (acres)	1,255.0	874.3	951.0	1,147.8
Habitat qualitative score	2.5	2	3	3
Dall sheep				
Habitat (acres)	0.0	0.0	0.0	0.0
Habitat qualitative score	1	2	1	1
Migratory duck				
General habitat (acres)	763.5	965.3	322.1	744.7
Swan				
General habitat (acres)	166.4	163.6	0.0	71.3
Nesting habitat (acres)	0.0	0.0	0.0	93.0
Bear				
Habitat qualitative score	3.5	3	2.5	2

Red = Not preferable **Green = Favorable**

4.2.6 Wetlands and Vegetation

4.2.6.1 Wetlands

Wetlands are regulated by the Corps, whose permitting authority requires identification of measures to minimize harm to wetlands. This is typically demonstrated in alternative development that demonstrates alignment placement attempting to avoid identified wetlands. Acreage quantification of wetland type will identify the relative impacts of the three project alternatives to jurisdictional wetlands.

The USFWS National Wetland Inventory (NWI) mapped wetlands in the general project area in 1984 (see Figure 4-12 and Appendix J). NWI mapping is an effective tool for large-scale planning and wetland analysis but is generally not suitable for a Section 404 permit application. NWI mapping is based primarily on aerial photographic interpretation with limited ground verification, and therefore wetland boundaries tend to be overly simplistic, with many smaller wetlands not included in the mapping.

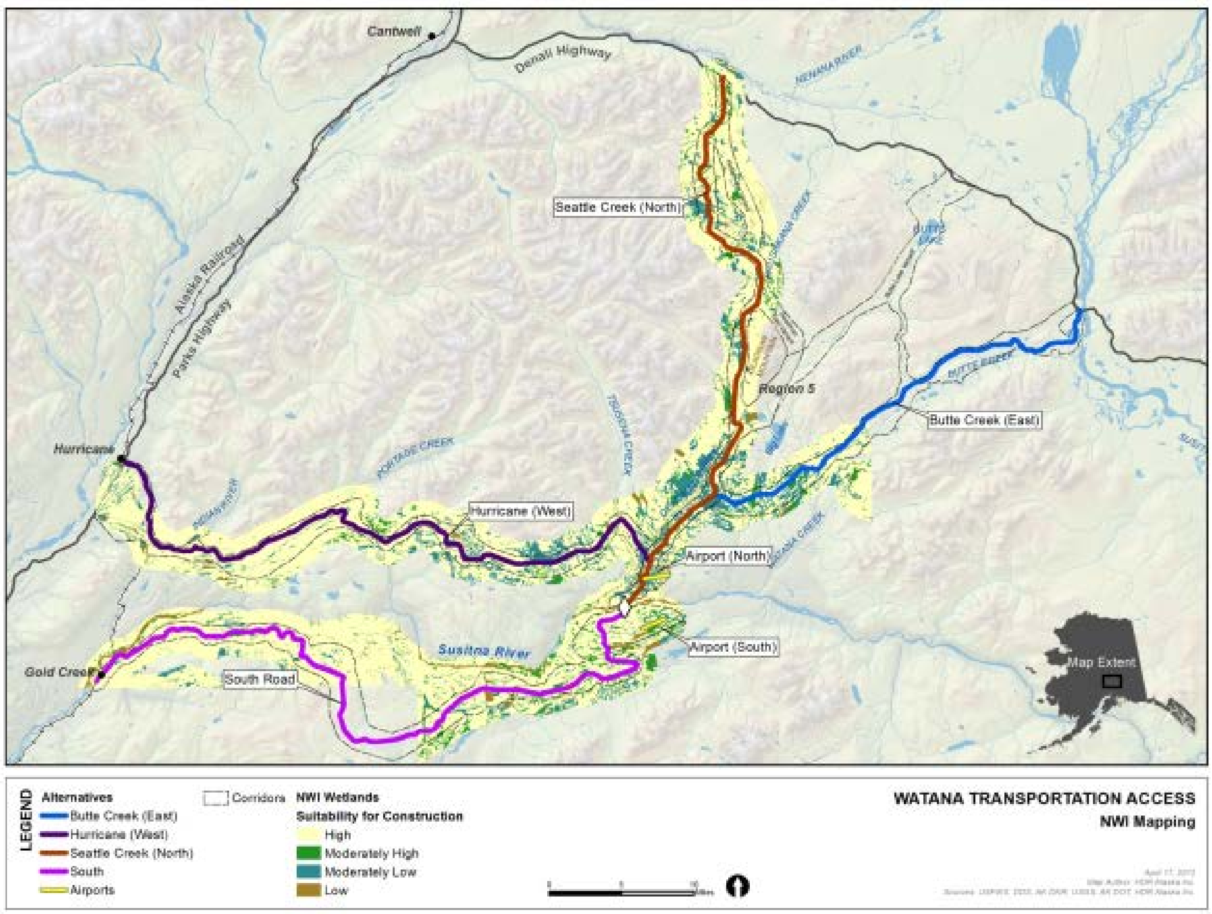

Figure 4-12. Wetlands

Current NWI mapping does not include, approximately half of the Butte Creek (East) alternative and a portion of the South Road alternative, and the inventory therefore does not include the extent of the current project alternatives. Digital Data Services, Inc. digitized hardcopy NWI maps into a GIS layer in 2011 to support an evaluation of mapped wetlands within each proposed project alternative corridor. A small portion of the westernmost portion of the Hurricane (West) alternative was not included in the digitized effort; however, the existing NWI mapping was digitized by HDR to complete digital coverage for that alternative. Mapping boundaries in the project area are shown in Appendix J. No other wetland mapping datasets exist that would provide a more detailed inventory or accurately describe functional analysis of wetlands within each alternative corridor.

In general, wetlands may serve environmentally beneficial functions including water quality regulation, animal habitat provision, and flood protection, which are provided relative value by the Corps. While functional assessment methodology is often applied to field investigations, and field indicators are recorded to determine potential functional performance of a wetland, these activities are outside the scope of the Watana Transportation Access Study, which is to identify potential landscape-level impacts that would deter further study and selection of a project corridor. This study has used typical wetland functions based on wetland types to determine construction suitability, and has not verified the existence of these functions in the field.

4.2.6.2 Construction Suitability Categories

For this evaluation, wetlands and uplands identified through NWI mapping were classified into four construction suitability categories (Table 4-16). Areas with a high suitability rating (Category 1) are expected to allow for the easiest construction and have the fewest regulatory and design permitting challenges. Areas with a low suitability rating (Category 4) are expected to pose the greatest challenges to construction, including the most permitting and design challenges. Category 4 areas would likely require water crossings, addressing strong regulatory concern and stringent environmental considerations, and result in a longer, more complicated permit acquisition process. These suitability categories are based on the wetland type associated with the NWI mapping data and the general wetland functions that these wetland types typically perform.

Uplands were ranked as Category 1 because a Section 404 permit would be unnecessary for construction in these areas.

The wetland types listed in Category 2 represent forested and scrub/shrub wetlands. These wetlands may perform functions including groundwater discharge, wildlife habitat provision, and sediment and pollutant retention. This category was associated with a “moderately high” suitability ranking. These wetlands were assigned a slightly lower suitability because forested and scrub/shrub wetlands are generally widespread and are least likely of all the wetlands to perform functions that are unique to wetlands.

Emergent wetlands are dominated by grass-like plants, are represented in Category 3, and have a “moderately low” suitability ranking. The functions of emergent wetlands can be highly variable depending on their topographic position and level of inundation or saturation. In general, emergent wetlands provide functions for groundwater discharge, stormwater runoff attenuation, and habitat for water-dependent wildlife. In addition, many emergent wetlands perform water quality improvement functions and do so at a greater rate than other wetland types because they have more water movement within and through them. The water input and movement typically causes emergent wetlands to provide more productive habitat and allows them to export organic material to support downstream ecosystems. Emergent wetlands near human development (including roads) may protect water quality by retaining sediments and other pollutants.

The wetland types included in Category 4 represent open water habitats. In general, these wetlands represent the most unique wetland types within the project area, and have been assigned a ”low” suitability ranking. Permanently flooded wetlands, streams, and lakes were assigned to this category because they typically provide important wildlife movement corridors, improve stream water quality, provide habitat cover for fish, and stabilize stream banks against erosion. These wetlands and waterbodies are also likely to export organics to aquatic systems, and perform flood flow attenuation that protects downstream habitats and water quality.

Any fill placed in the wetlands included in Categories 2, 3, and 4 would likely require a Corps Section 404 Permit.

Table 4-16. NWI wetland classification association with general categories

Category (Suitability for Construction)	Wetland Type and NWI Code	
1 (High)	Uplands (U)	
2 (Moderately High)	Forested Wetlands PFO4/SS1B	Scrub/Shrub Wetlands PSS1A PSS1B PSS1/4B PSS/F04B
3 (Moderately Low)	Emergent Wetlands PEM1C PEM1F	 PSS1/EM1B PSS1/EM1C
4 (Low)	Lake or Reservoir Basins L1OWH Rivers or Stream Channels R3OWH	Additional Open Water Codes PEM1H POWH

The acreage of wetland category, as grouped by association in Table 4-16, was determined for each project alternative corridor for a 300-foot buffer (150 feet either side of centerline) and represents a potential right-of-way corridor-level assessment of wetlands associated with each corridor. Table 4-17 presents wetland category impacts, by alternative, for this area.

As noted above, NWI mapping is not available in either hand-drawn or digital formats for the eastern approximately half of the Butte Creek (East) alternative and approximately 316.5 acres of the South Road alternative. Because of this lack of data, total acreage calculations for the Hurricane (West) and Seattle Creek (North) alternatives should not be directly compared to those for the South Road and Butte Creek (East) alternatives. It is likely, given the landscape location of the alternative in the Susitna River valley, that wetlands are present throughout the unmapped area. Additionally, riverine wetlands are included in Category 4 and have the greatest relative value; it is expected that the Butte Creek (East) alternative would be within close proximity of riverine wetlands along the unmapped portions of the route. It is likely that the total acreage of wetland impacts is underrepresented by the available data presented in Table 4-17.

Table 4-17. Acres of wetland impacts, by alternative and category

Alternative [a]	Total acres of wetland impact (Categories 2–4 combined)	Acres of impact, by category			
		1	2	3	4
South Road[b]	226.8	1,449.6	150.4	69.9	6.5
Hurricane (West)	553.9	2,589.6	59.0	485.3	9.6
Seattle Creek (North)	699.2	1,928.9	199.9	490.1	9.2
Butte Creek (East)[c]	544.1	817.2	95.5	442.6	6.0

[a] Each alternative assumed a 300-foot buffer

[b] NWI mapping is not available for approximately 316.5 acres of the South Road alternative; therefore, the acreage of impacts shown for this alternative are not for the entire corridor.

[c] NWI mapping is not available for approximately half of the Butte Creek (East) alternative; therefore, the acreage of impacts shown for this alternative are not for the entire length of the route.

Using existing data, the Seattle Creek (North) alternative impacts the greatest total acres of wetlands, but impacts similar acreage of Category 3 and 4 wetlands as the Hurricane (West) alternative. While the Corps will require preparation of a permit for impacts to all wetlands regardless of the wetland's relative value, wetland impacts to Category 3 and 4 wetlands are expected to receive the greatest scrutiny for efforts made during preliminary design to avoid or minimize impacts. Consultation with the Corps will be necessary to further evaluate permit stipulations and conditions, including potential mitigation options. For more information about wetlands, please see Appendix J.

4.2.6.3 Vegetation

Earth cover habitat types for the Gulkana region, which includes the project area, was mapped by the Bureau of Land Management (BLM) and Ducks Unlimited in 1997, and contains highly diverse landscapes used by a variety of animals (BLM 2002). While this mapping effort was initially focused on wetland and upland boundaries, the project scope was expanded to quantify nine habitat types: forest, shrub, herbaceous, aquatic, barren, urban, agriculture, cloud/shadow, and other. Each habitat type is further delineated into subtypes. This dataset is incomplete for the project area, so acreage of impact to vegetation types was not calculated. Vegetation cover alone is not subject to regulatory authority, and so would not be a considerable factor in alternatives screening.

The BLM includes 17 plant species considered rare or sensitive in the Upper and Lower Susitna sub-basins; these are listed below in Table 4-18 (HDR 2011a). None of the listed species are subject to management restrictions, permit limitations, or law; however, consultation with BLM regarding distribution and potential impact to listed species will be required during the NEPA process.

Table 4-18. BLM-listed rare and sensitive plants in the project area

Species[a]	Sensitive (S) or Watch List (W) Plant [c]
Aphragmus eschscholtzianus	W
Arnica mollis	—
Artemisia laciniata[d]	W
Botrychium ascendens	S
Ceratophyllum demersum	—
Douglasia alaskana	S
Douglasia gormanii	W
Draba ruaxes	—
Erysimum asperum var. angustatum	S
Papaver alboroseum	S
Potamogeton robbinsii	W
Ranunculus kamchaticus	W[e]
Smelowskia pyriformis	S
Stellaria alaskana	W
Taraxacum carneocoloratum	W
Thlaspi arcticum	W
Viola selkirkii	—

[a] Query of BIOTICS Database (Santosh 2011) unless otherwise noted
[b] AKNHP 2008
[c] BLM 2010
[d] MON 2011
[e] Listed by BLM as *Oxygraphis glacialis*

4.2.7 Land Status

There are several land ownerships[24] in the project area, including the Federal and State governments, Alaska Native corporations, and other private land owners (see Figure 4-13). Federal lands in the project area are controlled by the BLM. State lands include properties owned by the State of Alaska (State), properties selected by the State of Alaska (State Selected), and

[24] Due to the conceptual level of this study, minimal efforts have been made to avoid specific parcels and to ensure that impacts to certain parcels may be minimized through future design refinements.

properties selected by the State of Alaska for which the state has been granted tentative approval by the Secretary of the Interior for transfer of these properties to state ownership (State TA), but title to these properties has not yet transferred. Native corporations (Native) lands may include Selected Regional Native Corporation Lands (Native Selected). Other private lands may include ownership by private citizens or corporations (Private), and Boroughs (Borough). Native allotments have been identified in the South Road corridor but not the other three corridors.

In general, the time it takes to acquire ROW/construction rights varies by ownership. Based on previous experience, BLM lands generally take the longest to acquire, with an estimated time of 24 to 36 months from the time the application is filed and accepted by the BLM as complete. In general, it can take up to 3 months to prepare an application. It is recommended that consultation with the BLM be initiated early in the project development process (pre-application). The pre-application can and usually pulls in other Federal/State agencies to participate. This pre-application meeting is very important for this project as there are several BLM field offices that manage the various lands. When an application such as this one involves lands under more than one jurisdiction of more than one office, the BLM Field Manager having jurisdiction over the application process will be determined. Only one permit needs then to be filed. After successful negotiations, BLM would issue a ROW Grant for the right of way. Land issues for BLM may be managed out of the Fairbanks, Anchorage, or Glennallen BLM office. If the ROW does not require any federal land (i.e. the ROW is all state land), there would be no BLM involvement in the ROW acquisition process.

Lands owned by Native corporations typically take between 18 and 24 months to negotiate acquisition. Should negotiation for Native lands not be achievable, the State does have condemnation authority for the property. However, condemnation of Native land would be precedence-setting, as the State has not condemned Native lands to date.

A Native allotment refers to a piece of unappropriated, and unreserved public land granted to an eligible applicant under the Alaska Native Allotment Act of May 17, 1906, as amended. The acquisition process from a Native allotment can be complex because out of the roughly 15,000 proposed or existing allotments, only a little more than half have been certified. The process for acquiring land from an allottee or an allottee's heirs can be a lengthy process. Most allotments are restricted which means the process must work through the Bureau of Indian Affairs (BIA). If an allotment has had its restriction classification removed, then the process would be the same as acquiring land from any other private property owner. Only a very small number of allotments have had their restriction classification removed.

The restricted allotments are managed by the BIA for the allottee and/or their heirs. Each allotment can contain up to 160 acres and may be divided into as many as four parcels at different locations. The location of an allotment frequently changes during the adjudication process. Reasons for these changes include a lack of an adequate legal description, overlapping land boundaries, land that has been already conveyed to another party prior to filing, filing on top of other land uses such as 17(b)[25] easements or a lake or river or within a State park. Many allotments are still being surveyed. Until the survey is complete the exact location of the allotment is not guaranteed. The BLM is working on surveying as time allows. Acquiring

[25] A 17(b) easement is an easement "on lands which will be conveyed to Alaska Native Village and Regional Corporations in order to allow public access to public land and water" (DNR 2012).

property from any restricted native allotment is coordinated through the BIA. This process typically takes between anywhere from 6 month up to a year to complete. There are some cases where this process has taken over 2 years to complete. On some projects, the acquisition process has stalled due to the inability to locate allottees or to reach agreement on the terms of the acquisition. Private lands, including those owned by private individuals, private corporations, or Boroughs, generally takes up to 18 months for ROW acquisition. State lands generally take a similar amount of time to acquire for State-supported projects. State-, Private-, and Borough-owned land acquisition usually is not on the critical path for projects of this type.

For a road access corridor, a 300-foot ROW is typically acquired. The quantity of land from each landowner type for a preliminary ROW is summarized in Table 4-19. The acreage of land by land owner type for the corridor is also shown in Table 4-19 to indicate how future changes to the alignment could influence ROW acquisition.

None of the four corridors cross designated Wilderness lands or wild and scenic rivers, or would require the acquisition of land from Denali State Park. Near Gold Creek, the ARRC tracks are located at the boundary of Denali State Park. Any activity west of the tracks would require the acquisition of land from the park. The South Road alignment would require the acquisition of land from the Nelchina Public Use Area. The Nelchina Public Use Area was created by the legislature in 1985 to:

- Protect fish and wildlife habitat, particularly caribou calving areas, trumpeter swan nesting areas, and other important habitats for moose, Dall sheep and brown bear so that traditional public uses of fish and wildlife populations may continue;
- Perpetuate and enhance public enjoyment of fish and wildlife and their habitat, including fishing, hunting, trapping, viewing, and photography;
- Perpetuate and enhance general public recreation in a quality environment;
- Perpetuate and enhance additional public uses described in the Susitna Area Plan;
- Allow additional public uses of the area in a manner compatible with the purpose specified above. (AS 41.23.010)

The Hurricane (West) corridor contains 19,443 acres of State-owned land, which is the lowest of the four corridors. The Butte Creek corridor contains the most State land (27,939 acres). The Hurricane corridor also contains the most Federal land (14, 817 acres). This is almost double the amount of Federal land in the Seattle Creek (North) and Butte Creek (East) corridors. The South Road corridor does not contain any Federal land. The South Road corridor contains substantially more Native corporation land (40,828 acres) than the other three corridors. The Hurricane (West) corridor contains much less Native corporation land (300 acres). The other two corridors contain the fewest acres of Native corporation land (45 acres each). In each corridor, land is owned by Cook Inlet Regional Corporation, Knikatnu, and Tyonek Native Corporation[26]. It also contains the most private/Borough land. Within the MSB[27], GIS records indicate there are approximately 10 private landowners[28] in the South Road corridor, 118 private landowners in the Hurricane

[26] Specific landowner information was not available for lands within the Denali Borough.
[27] Specific landowner information was not available for lands within the Denali Borough.
[28] A landowner may own one or more parcels.

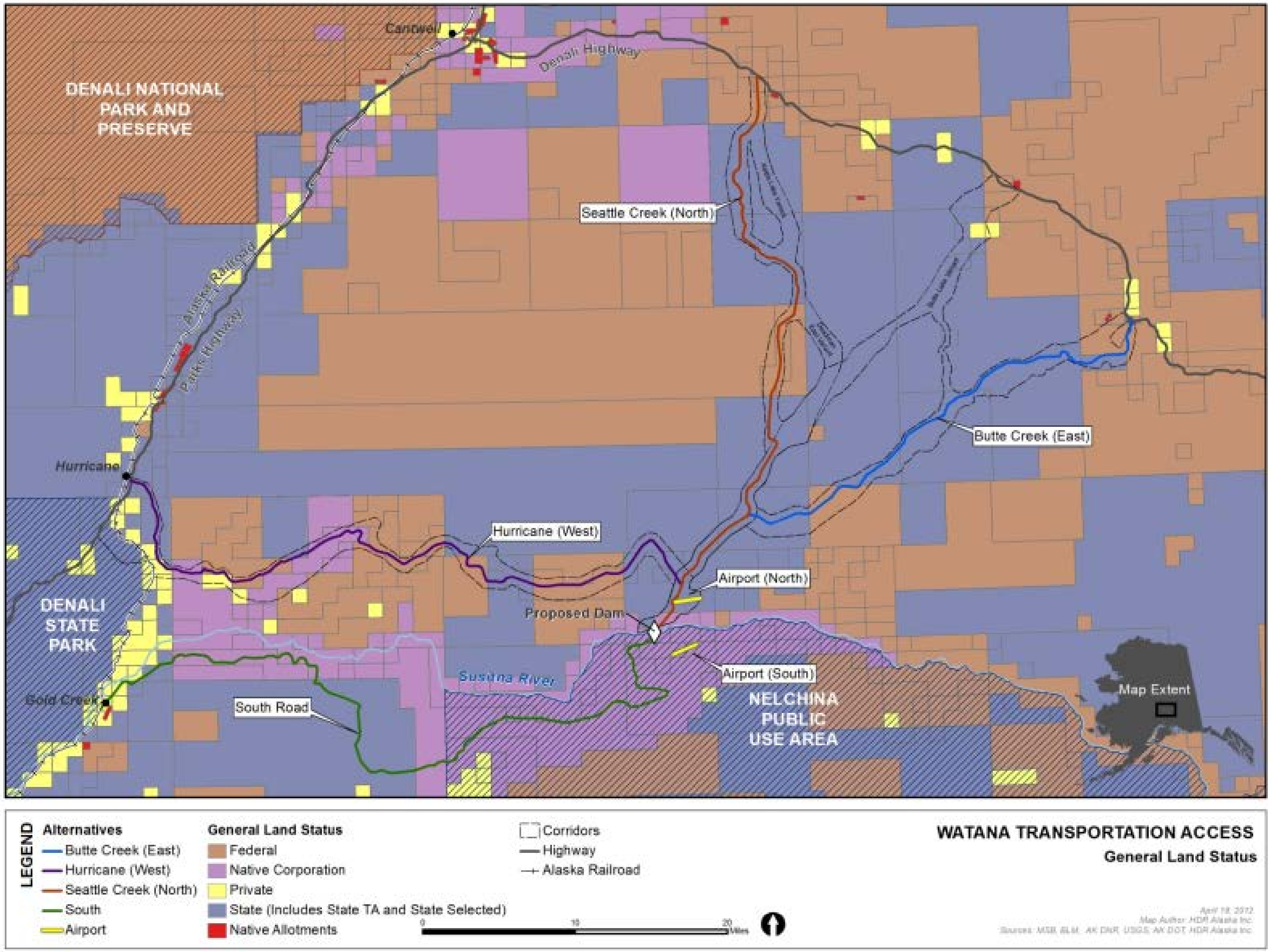

Figure 4-13. Generalized land status

(West) corridor, and two private landowners in the Butte Creek (East) corridor. There are no identified privately owned lands within the Seattle Creek (North) corridor[30]

The potential Hurricane (West) ROW uses the most federal land (771 acres) compared to South Road (0 acres), Seattle Creek (North; 357 acres) and Butte Creek (East; 255 acres). The potential Butte Creek (East) ROW uses the most state owned land (1,230) which is only slightly more than Seattle Creek (East; 1,174 acres). The South Road ROW contains the least amount of State owned land (417 acres). The South Road ROW contains substantially more Native corporation land (1,466 acres) than the other three alternatives. The Hurricane (West) ROW contains a substantial amount more private land (300 acres) than the other 2 alternatives (45 acres each). The South Road and Hurricane (West) ROW are the only two that would use private/Borough-owned land.

The proposed location of the railroad laydown yard at Gold Creek associated with the South Road alignment is on land owned by the State of Alaska, CIRI, and seven private owners. The proposed location of the railroad laydown yard at Cantwell associated with the Seattle Creek (North) and Butte Creek (East) alternatives is owned by Native corporations while the proposed location of the railroad laydown yard at Hurricane is on State owned land.

Overall, the Seattle Creek (North) and Butte Creek (East) alternatives would be about the same from a land status perspective. The ROW need for the Hurricane (West) corridor has the potential to require the acquisition of more Federal and Native lands than the other corridors. The South Road ROW is the only one of the four that would not require the acquisition of Federal land. The actual length of time to acquire the ROW necessary for the project will depend on a number of factors including the number of landowners to negotiate with and their willingness to sell.

Table 4-19. Land status summary

Land type	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Wilderness designated lands	0	0	0	0
Wild and scenic rivers	0	0	0	0
Denali State Park (acres)	0	0	0	0
Nelchina Public Use Area	27,584	0	0	0
Corridors (acres)				
Federal lands	0	14,817	6,613	10,238
State lands	13,719	19,443	36,042	50,634
Native	40,828	9,521	896	896
Private or Borough	1,692	5,160	0	818

[30] The parcel information does not include the northern third of the Seattle Creek (North) corridor. Based on BLM data, this land appears to be all state or federally owned.

Table 4-19. Land status summary

Land type	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
ROW (acres)[a]				
Federal lands	0	771	357	255
State lands	417	749	1,174	1,230
Native	1,466	300	45	45
Private or Borough	112	66	0	0

Red = Not preferable **Green = Favorable**

[a] ROW acres impacted is based on a 300-foot wide ROW.

4.2.8 Fish and Wildlife Uses

The fish and wildlife resources in the potential access corridors are important to a variety of user groups that participate in managed hunts and recreational/subsistence fisheries. Development of an access route to the Watana dam site may provide users new and expanded access to these resources, potentially resulting in increased harvest pressure on some fish and wildlife populations. Analyses of proposed access routes from the 1980s Susitna Hydro Project (Terrestrial 1981, Acres 1982) were reviewed and compared to the current alternatives. In addition, current data gap reports for subsistence resources (Simeone et al. 2011), terrestrial resources (ABR 2011) and aquatic resources (HDR 2011) were included in the review along with current management area reports and databases available on the ADF&G Web site. Detailed geographic information on resource uses was not available at a high enough resolution to perform a spatial analysis of access alternatives. As a result, this category was scored on an objective ranking system (1 [best] to 5 [worst]) using professional judgment of the resource specialists conducting the review.

4.2.8.1 Subsistence Uses of Fish and Wildlife Resources

Subsistence hunting and fishing are economically and culturally important to Alaskans. Both State and Federal management authorities have a mechanism for establishing preferences among subsistence users when a fish or wildlife population is not large enough to support harvests by all those who are eligible for subsistence. This process is called a "Section 804" process under Federal and a "Tier II" process under State management. The subsistence preference is granted through a customary and traditional use determination made by the Alaska Boards of Fisheries and Game.

For the purpose of wildlife population management and harvest reporting, the state of Alaska is divided into 26 game management units. The Watana dam site, reservoir and potential access corridors are located in Game Management Unit (Unit) 13 and more specifically within sub unit 13 E (Figure 4-14, GMU 13 and project features). The State has made customary and traditional use determinations for all major resources within Unit 13: salmon, non-salmon fish, Dall sheep, black bear, grizzly bear, caribou, and moose. This means that all of these resources are classified as subsistence resources. Of these, caribou and moose are most popular (Simeone et al. 2011). All Alaskan residents as defined by the State are eligible to participate in subsistence hunts.

The Nelchina caribou herd occupies Unit 13 and is important to a large number of hunters due to its accessibility and proximity to Fairbanks and Anchorage (Harper 2009). All of the caribou hunts in Unit 13 are subsistence hunts. In 1990 more than 6,000 people obtained subsistence permits to hunt caribou and achieved the allowable harvest in 3 days (Simeone et al. 2010). Consequently in 1991, the State instituted a Tier II hunt to limit the number of hunters and prevent over-harvest. From 2003 to 2008, the state Tier II subsistence hunt in Unit 13 accounted for 60 to 90 percent of the Nelchina herd’s total annual harvest. The majority of the balance of the harvest is taken by the Federal registration hunt, which takes place on BLM lands.

4.2.8.2 Sport Hunting and Fishing

A new access road to the Watana dam site will also provide new opportunities for hunters and fishers. Expanded access opportunities to fish and wildlife resource areas may result in indirect impacts due to increased harvest pressure or user conflicts. Sport fishing use areas in the upper Susitna fall under the Northern Cook Inlet management area. Unit 3, a sub area of this management area, incorporates the upper Susitna basin above Talkeetna to the Oshetna River. Sport fishing activity ranged from 1,900 to 8,440 angler days in the 10-year period from 1995 to 2006 (Ivey et al. 2009).

Unlike some hunts which are limited by registration or drawing systems, sport fishing is unrestricted as to the number of users that can participate. In the 1980s, a statewide sport fishing organization supported the alignment alternatives that would provided the most access for its members to new fishing areas (Acres 1982). Local groups may not share that position, leading to user conflicts. Modifications to fishing methods, means, seasons, and harvest allocations through the Board of Fisheries is one manner in which these changes may have to be mitigated in the future.

Where access alignments cross tundra, as opposed to forested areas, there is a greater opportunity for off-road all-terrain vehicles (ATVs) to exit the roadway. To minimize secondary impacts to caribou and other resources special land use policies governing road use and off-road ATV use may need to be adopted.

4.2.8.3 South Road

The South Road alignment has a similar elevation to the Hurricane (West) and is lower than the other two corridors. This alignment is not accessible from the existing roadway network which means it has less potential for access than the other three alignments. This may reduce the potential for secondary effects.

This route will cross or is in proximity to fish bearing streams which may increase sport fishing activity in the area. However, the lack of connection to the existing road network may limit this.

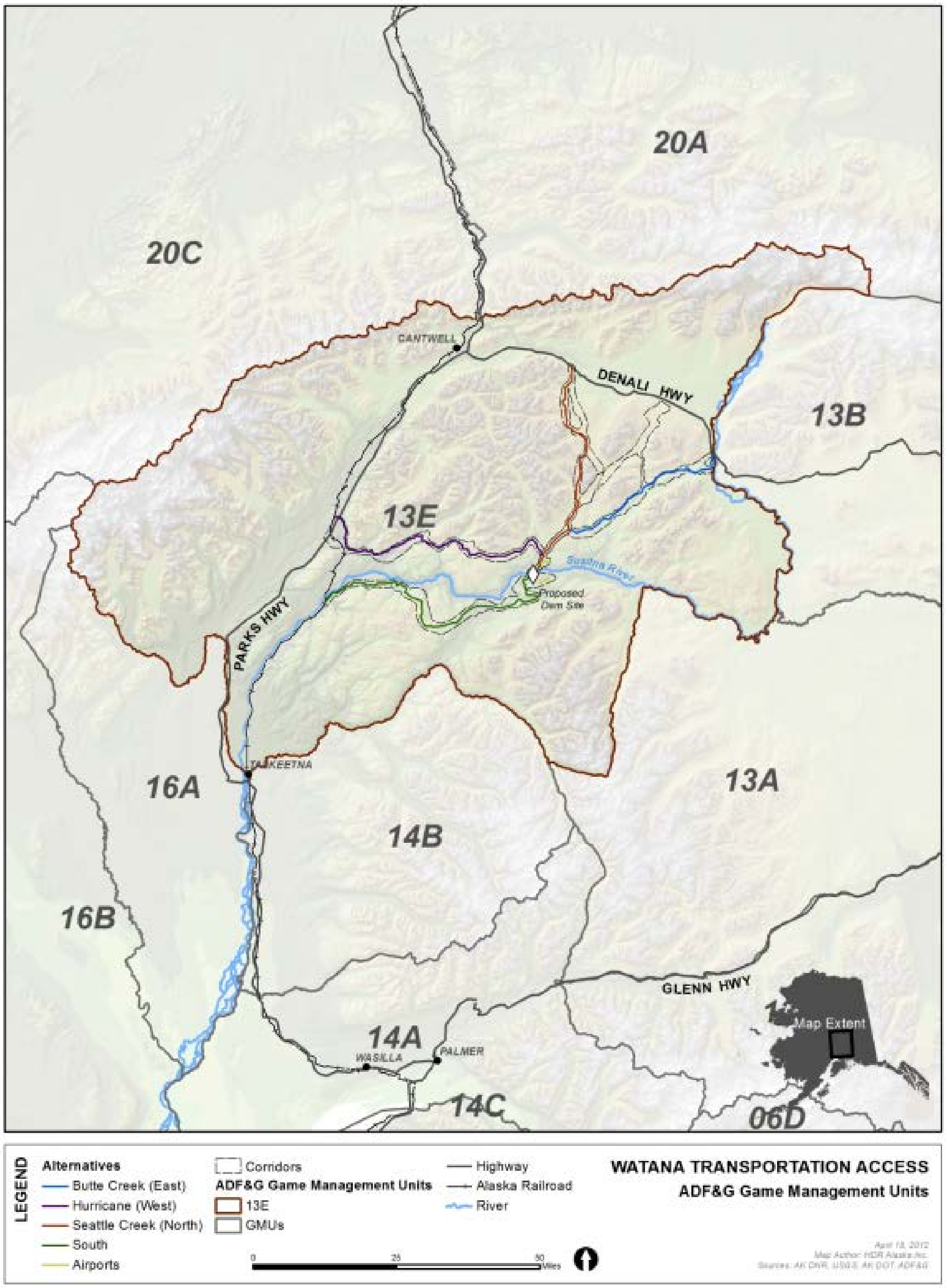

Figure 4-14. Game management units

4.2.8.4 Hurricane (West)

The Hurricane (West) alignment has a similar elevation to the South Road alignment but is lower in elevation than the other two corridors and passes through forest land between MP 0 and MP 22. This habitat type limits the opportunities for ATV access to adjacent resource areas, and as a result may pose a reduced potential for secondary effects discussed for the other alternatives. Because this route is lower in elevation, it crosses less of the Nelchina caribou range than the other alternatives.

The route will cross Indian Creek and Portage Creek, both salmon-producing streams. These new access points may result in increased sport fishing pressure on these systems.

4.2.8.5 Seattle Creek (North)

This alignment passes through range habitat for the Nelchina caribou herd and has the potential to have secondary impacts due to the increased hunter access. Previous studies cautioned that increased hunting pressure may result from the new access (Acres 1982). Because much of this alignment crosses tundra, there is a greater opportunity for ATVs to exit the roadway than with the Hurricane (West) alignment.

Much of the alignment crosses, or is in proximity to, seasonal Arctic grayling habitat where recruitment and growth are thought to be low (Acres 1982). Opening new sport fishing access to the area may put pressure on the stability of the population.

4.2.8.6 Butte Creek (East)

This alignment passes through important range habitat for the Nelchina caribou herd and has the potential to have secondary impacts due to the increased hunter access. Because much of this routing crosses tundra, there is a greater opportunity for ATVs to exit the roadway.

Much of the route crosses or is in proximity to Butte Creek, which likely provides seasonal Arctic grayling habitat. Providing access to more angling opportunities in the area could put pressure on grayling populations.

4.2.8.7 Summary

All four corridors involve the construction of a road into areas that currently do not have access except by off-road vehicle.

The South Road and Hurricane (West) alignments cross less of the Nelchina caribou range than the Seattle Creek (North) or Butte Creek (East) alignment because the former are at a lower elevation. Because the Hurricane (West) alignment passes through forested land instead of tundra like Seattle Creek (North) and Butte Creek (East), there is less potential for people to use off-road vehicles to access adjacent areas.

All four alignments will also provide new access points to fishing opportunities, which may put pressure on local fish populations. The South Road alignment will provide less access for the general public then the other three alignments because it is not connected to the existing road network. Table 4-20 summarizes the qualitative assessment of impacts to sport fishing and recreational and subsistence hunting for each alternative.

Table 4-20. Summary of fish and wildlife uses (qualitative assessment)

Factor	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Sport fishing	2	3	2	2.5
Recreational and subsistence hunting	2	2	3	3

Red = Not preferable Green = Favorable

4.2.9 Cultural Resources

Cultural resources are subject to consideration under Section 106 of the National Historic Preservation Act (NHPA). Under the Act, Federal agencies must consider the effects of Federal undertakings on historic properties. Historic properties are cultural resources such as prehistoric archaeological sites, historic buildings, or traditional cultural properties that have been evaluated and found eligible for listing in the National Register of Historic Places (NRHP). Cultural resources are also subject to consideration under Section 4(f) (49 USC 303), AS 41.35.070 (Alaska Historic Preservation Act), and NEPA. Coordination of the NHPA with NEPA is outlined in 36 CFR 800.8, which states that "Agency officials should ensure that preparation of an…EIS and record of decision includes…identification of historic properties, assessment of effects upon them, and consultation leading to resolution of adverse effects."

Cultural resource site location information is restricted and withheld from public records disclosure under state law (AS 40.25.110) and the Federal Freedom of Information Act (PL 89-554); consequently, site locations are not identified in this document but are discussed in general geographic terms for each corridor analysis. The restriction of site location information is allowed by AS 40.25.120(a)(4), Alaska State Parks Policy and Procedure No. 50200, the National Historic Preservation Act, and the Archaeological Resources Protection Act.

For this analysis, cultural resources were identified through a review of the Alaska Heritage Resources Survey (AHRS) database and Office of History and Archaeology records, including studies associated with the 1980s Watana licensing effort. Based on the AHRS review, previously recorded cultural resources in the Watana Access area consist primarily of prehistoric surface lithic scatters on south-trending and/or south-facing ridge systems, terraces, and knolls. Lithic scatters are prehistoric distributions of cultural items that consist primarily of lithic (i.e., stone) material. Often they include not only chipping debris from stone tool manufacture activities, but also formed tools such as projectile points, bifaces, or knives. Because AHRS site locations can vary up to 60 meters in some instances, AHRS sites reported in this study are located within or up to 60 meters outside the access corridors.

Most AHRS sites were identified during cultural resource surveys for the 1980s Watana licensing effort or the 1980s intertie project; however, some sites were recorded during identification of important traditional and historical sites ([14][h]1 sites) under the Alaska Native Claims Settlement Act (ANCSA). Only one previously recorded site within the Access Study area has been evaluated for eligibility for inclusion in the NRHP. The site, HEA-0353: Seattle Creek Bridge, was determined to be not eligible for listing in the NRHP and therefore does not require consideration as a historic property under the NHPA. However, the Denali Highway was listed on 11/30/2010 by DOT&PF and the SHPO as an "Alaska road to be treated as NRHP Eligible." Consequently, maintenance or improvement plans to the Denali Highway for the Watana Access project should consider this designation.

It is important to note that absence of sites within the AHRS is not necessarily indicative of absence of sites on the landscape, as much of Alaska has never been archaeologically surveyed. It can be assumed that site concentrations identified in the AHRS likely represent areas that were archaeologically surveyed, while areas with no sites likely represent areas that have not been archaeologically surveyed. Because of the disparity in archaeological survey coverage, this analysis is based upon not only upon information in the AHRS, but also the professional judgment of HDR's cultural resource specialists.

4.2.9.1 South Road

The South Road corridor runs along the south side of the Susitna River, skirts the base of north facing slopes, then works through the Stephan Lake and Fog Creek areas until its intersection with the Susitna River. Only one previously recorded site (the historic Susitna River Railroad Station at Gold Creek) is located within the South Road corridor (see Table 4-21); however lithic scatters are present at other locations1 to 2 miles from the currently defined corridor. As previously discussed, this lack of recorded sites within the corridor reflects a lack of previous cultural resource survey in the corridor area and should not be interpreted to mean that there is little potential for disturbance to cultural resources should this alignment be constructed. The north-facing slopes present relatively low potential for containing prehistoric sites. However, the Stephan Lake and Fog Creek areas are characterized by low-elevation bluff and ridge systems in close proximity to fresh water. The presence of archaeological sites within 1 to 2 miles of the defined alignment corridor combined with this topography indicate a high potential for containing prehistoric archaeological sites, particularly those associated with hunting and tool manufacture, in some areas.

Table 4-21. AHRS sites within or adjacent to the South Road corridor

AHRS Number	Site Name/Description	NRHP Status
TLM-0005	Gold Creek/Susitna River Railroad Station	NE[a]

[a] Not evaluated

4.2.9.2 Hurricane (West)

The Hurricane (West) alignment follows the Susitna River from the Parks Highway and skirts the bases of numerous south-facing slope, terrace, and ridge systems. Given their proximity to freshwater creeks and the Susitna River, as well as south-facing aspect, these landforms present a high potential for containing prehistoric archaeological sites, specifically those associated with hunting and tool manufacture.

A total of 28 previously recorded sites are located within the Hurricane corridor (see Table 4-22). Many of the sites are large lithic scatters spread out along ridge and terrace tops, consisting of both surface and subsurface components. Artifacts identified at these sites include tool manufacture flakes, bifacial tools, and other lithic deposits. Other sites have been identified outside the proposed road corridor. Construction of the Hurricane corridor could open up access to Tsusena Butte, potentially causing disturbance to these sites.

Table 4-22. AHRS sites within or adjacent to the Hurricane access corridor		
AHRS Number	**Site Name/Description**	**NRHP Status**
TLM-0272	ARRC Timber Bridge MP 276.1	NE[a]
TLM-0112	Irregular Stone Ring	NE
TLM-0110	Lithic Scatter	NE
TLM-0111	Rectangular Depression	NE
TLM-0109	Lithic Scatter	NE
TLM-0108	Lithic Scatter	NE
TLM-0107	Lithic Scatter	NE
TLM-0106	Chert Biface Tool	NE
TLM-0275	Lithic Scatter	NE
TLM-0113	Lithic Scatter	NE
TLM-0114	Lithic Scatter	NE
TLM-0101	Two Flakes	NE
TLM-0103	Lithic Scatter	NE
TLM-0202	Single Flake	NE
TLM-0209	Lithic Scatter	NE
TLM-0203	Lithic Scatter	NE
TLM-0176	Two Flakes	NE
TLM-0214	Lithic Scatter	NE
TLM-0002	Chulitna RR Station	NE
TLM-0160	Three Waste Flakes (Subsurface)	NE
TLM-0015	Two Flakes	NE
TLM-0016	North Arrow Site (hearth and flaking station)	NE
TLM-0192	Cobble Stone	NE
TLM-0018	Corps Trailer Site (subsurface lithic deposit)	NE
TLM-0165	Lithic Scatter	NE
TLM-0167	Single Flake	NE
TLM-0017	Lithic Scatter	NE
TLM-0137	Two Flakes	NE

[a] Not evaluated

4.2.9.3 Seattle Creek (North)

The Seattle Creek (North) access route runs north-south along Seattle Creek from the Denali Highway to Deadman Creek. A total of 20 previously recorded sites were identified within or adjacent to the Seattle Creek corridor (with an additional 5 along the Denali Highway; see Table 4-23). Most sites consist primarily of small, discrete surface lithic scatters containing only a few flakes. Based on landforms, slope, and aspect, the Seattle Creek corridor overall has a medium potential for containing additional unrecorded cultural resources, though potential is higher in the area around Deadman Lake and Deadman Creek.

Table 4-23. AHRS sites within or adjacent to the Seattle Creek access corridor

AHRS Number	Site Name/Description	NRHP Status
TLM-0160	Three Waste Flakes (Subsurface)	NE[a]
TLM-0015	Two Flakes	NE
TLM-0016	North Arrow Site (hearth and flaking station)	NE
TLM-0192	Cobble Stone	NE
TLM-0018	Corps Trailer Site (subsurface lithic deposit)	NE
TLM-0165	Lithic Scatter	NE
TLM-0167	Single Flake	NE
TLM-0017	Lithic Scatter	NE
TLM-0137	Two Flakes	NE
HEA-0248	Lithic Scatter	NE
HEA-0182	Lithic Scatter	NE
HEA-0181	Lithic Scatter	NE
HEA-0184	Two Articulated Flake Fragments	NE
HEA-0180	Lithic Scatters	NE
TLM-0098	Two Waste Flakes	NE
TLM-0117	Four Waste Flakes	NE
TLM-0250	Lithic Scatter (Rita)	NE
TLM-0251	Lithic Scatter (Rebecca Site)	NE
TLM-0183	Single Chert Flake	NE
TLM-0099	Lithic Scatter	NE
Denali Hwy between Parks Hwy and Seattle Creek Access		
HEA-0450	Denali Highway	NE; considered eligible
HEA-0097	Edmonds Creek Site (late	NE

Table 4-23. AHRS sites within or adjacent to the Seattle Creek access corridor		
AHRS Number	**Site Name/Description**	**NRHP Status**
	prehistoric site)	
HEA-0115	20-Mile Shelter Cabin	NE
HEA-0274	No Information	NE
HEA-0353	Seattle Creek Bridge	NE

[a] Not evaluated

4.2.9.4 Butte Creek (East)

Like the Hurricane (West) corridor, the Butte Creek (East) corridor runs east-west and is in close proximity to freshwater creeks and south facing slope, ridge and terrace systems. However, the corridor is separated from the Susitna River by large landforms. A total of 19 previously recorded sites were identified within or adjacent to the Butte Creek (East) corridor (with an additional 12 located along the Denali Highway; see Table 4-24). Several sites along the Butte Creek (East) alignment were recorded within the last year by the BLM and the Office of History and Archaeology and descriptive information regarding the sites' features and artifacts is not yet available. The remaining cultural resources within the Butte Creek (East) alternative were recorded during Ahtna, Inc., Section 14(h)(1) selections, and include the grave of Chief Nicholai and prehistoric lithic scatters associated with Caribou hunting in the area of Snodgrass Lake. There is one paleontology site (HEA-0212) within the corridor. Paleontology sites do not fall under the purview of NHPA; however, they are subject to consideration under 41.35.070, the Alaska State Historic Preservation Act.

Table 4-24. AHRS sites within or adjacent to the Butte Creek access corridor		
AHRS Number	**Site Name/Description**	**NRHP Status**
TLM-0160	Three Waste Flakes (Subsurface)	NE[a]
TLM-0015	Two Flakes	NE
TLM-0016	North Arrow Site (hearth and flaking station)	NE
TLM-0192	Cobble Stone	NE
TLM-0018	Corps Trailer Site (subsurface lithic deposit)	NE
TLM-0165	Lithic Scatter	NE
TLM-0167	Single Flake	NE
TLM-0017	Lithic Scatter	NE
TLM-0137	Two Flakes	NE
HEA-0463	No Information (BLM using)	NE
HEA-0441	No Information (BLM using)	NE
HEA-0440	No Information (BLM using)	NE
HEA-0439	No Information (BLM using)	NE

Table 4-24. AHRS sites within or adjacent to the Butte Creek access corridor

AHRS Number	Site Name/Description	NRHP Status
HEA-0424	Denali Block Site (no information)	NE
HEA-0425	Denali Block Site (no information)	NE
HEA-0309	Lithic Scatter	NE
HEA-0212 (Paleo)	Paleontology Site	NE
HEA-0307	Chief Nicholai Grave	NE
HEA-0308	Lithic Scatter	NE
Denali Hwy between Parks Hwy and Butte Creek Access		
HEA-0450	Denali Hwy	NE; considered eligible
HEA-0097	Edmonds Creek Site (late prehistoric site)	NE
HEA-0115	20-Mile Shelter Cabin	NE
HEA-0274	No Information	NE
HEA-0353	Seattle Creek Bridge	NE
HEA-0098	Sand Dune Site (lithic scatter)	NE
HEA-0100	No Information	NE
HEA-0432	Large Square Depression	NE
HEA-0122	Grimes Site (biface tool)	NE
HEA-0272	No Information	NE
HEA-0352	Brushkana Creek Bridge	NE
HEA-0268	No Information	NE

[a] Not evaluated

4.2.9.5 Summary

The Hurricane (West) Corridor contains the greatest number of identified sites (28), while the Seattle Creek (North) and Butte Creek (East) corridors (excluding the sites along the Denali Highway) each contain only two-thirds of that number (see Table 4-25) and the South Road corridor contains only one identified site. The South Road, Hurricane (West) and Butte Creek (East) corridors hold the highest potential for containing additional unrecorded sites, while the potential for additional sites in the Seattle Creek corridor is lower. While sites are located along the Denali Highway between the Butte Creek (East) and Seattle Creek (North) corridors and the Parks Highway (including the Denali Highway itself), these sites can likely be more easily avoided or mitigated, as improvements to the Denali Highway associated with the Watana Access will typically not involve re-routing or movement of the existing Denali Highway alignment.

There are a total of nine cultural resource sites located within three of the four access corridors, as the corridor(s) approach the Susitna River. These sites are all lithic scatters or subsurface tool manufacturing sites and are concentrated between Deadman and Tsusena Creeks and the Susitna River. It can be assumed that all three of the access corridors would impact these sites in the same way; consequently they were not factored into the discussion and scoring analysis of the four corridors presented below.

Based on the presence of and disturbance to known sites, the potential for additional unrecorded sites, and the potential to increase access to previously inaccessible areas of high site concentration outside the access corridor, the Hurricane (West) corridor would likely have the greatest impact on cultural resources. The Seattle Creek (North) corridor, with fewer reported AHRS sites and lower potential for containing additional sites, would likely cause the least disturbance to cultural resources.

Table 4-25. Summary of cultural resource sites by corridor

Factor	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Cultural Resources on new roadway	1[a]	28	20	19
Cultural Resources on Denali Highway	0	0	5	12
Total	**1**	**28**	**25**	**31**

Red = Not preferable **Green = Favorable**

[a] Although only one known cultural resource is identified within the South Road corridor, the potential for portions of the corridor to contain additional sites is high.

4.2.10 Socioeconomics

The development of an access route to the Watana dam site will affect the socioeconomic characteristics of the surrounding region. Socioeconomic impacts may be both positive and negative. The potential for socioeconomic impacts was evaluated based on analyses of proposed access routes from the 1980s Susitna Hydro Project (APA 1981) and the current Socioeconomic data gap report (HDR 2011b). The socioeconomic impacts will vary greatly depending on construction activities. A construction camp-based project will have substantially fewer impacts on the socioeconomics of the surrounding area than one where construction workers are expected to reside in nearby communities. For the purpose of this study, we have assumed that a construction camp near the Watana dam site will be used. For the purposes of this report, the project team assumed that only employees will be housed at the dam site and will be transported to the dam site on a two-week on/two-week off (or similar) schedule. The majority of the socioeconomic impacts of the access corridor will be associated with changes in traffic levels. The magnitude and location of potential impacts varies depending on the route and location of the Watana dam access route tie-in with existing transportation facilities. In addition, all of the proposed alternatives would provide road access to a large area that has no existing roads. This may cause changes to recreation, subsistence activities, and business use that currently occurs in the area.

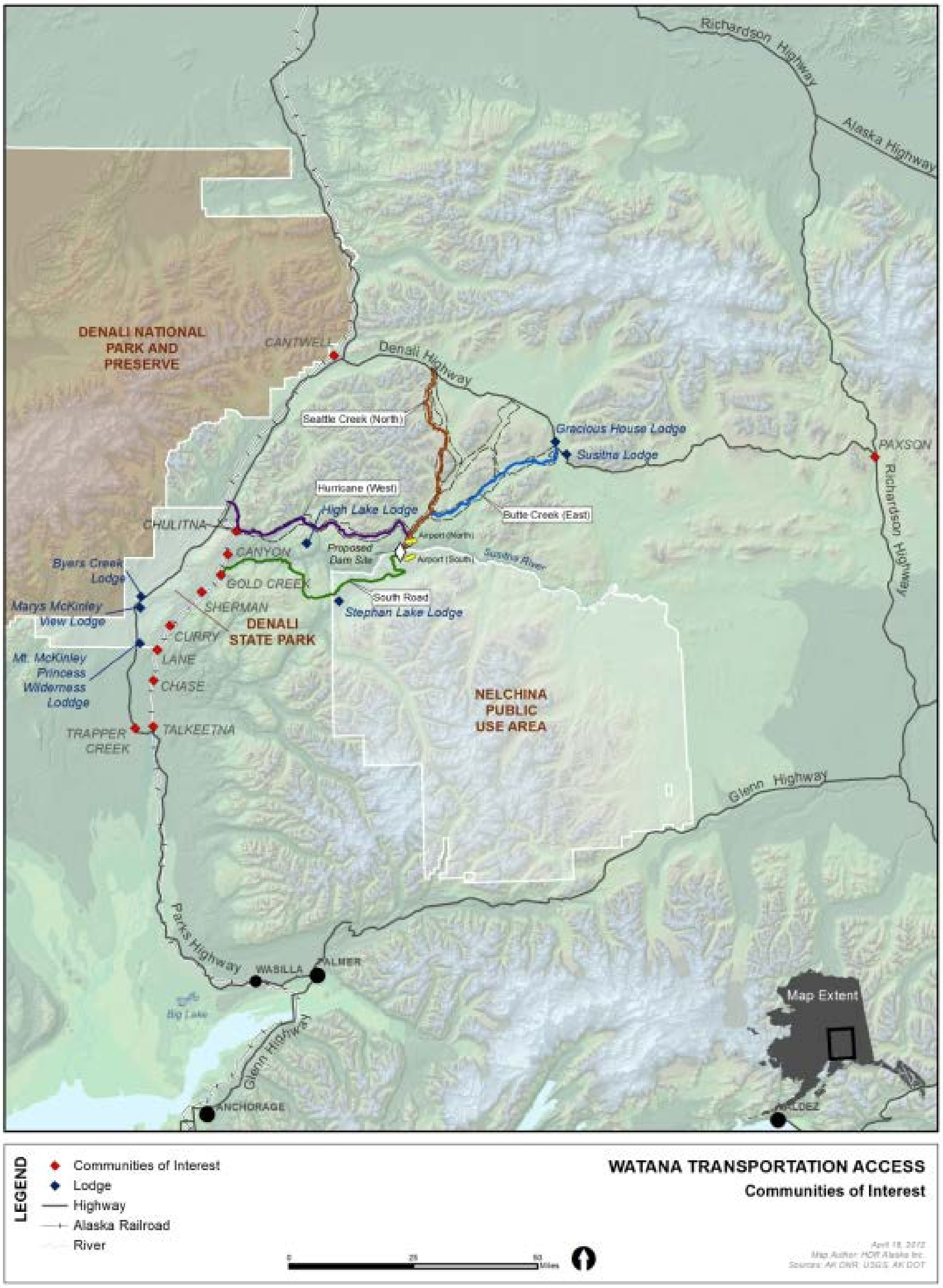

Figure 4-15. Communities of interest

Communities likely to be impacted by the Watana access project include those within the Denali and Matanuska-Susitna Boroughs and specifically those along the Parks and Denali Highway Road Corridors. Communities in the immediate vicinity of the project area include Cantwell (population 219), Trapper Creek (population 481), Chase (population 34), and Talkeetna[31] (population 876; Figure 4-15; USCB 2010). In addition to these communities, other settlements also exist along the existing ARRC corridor near the Curry, Sherman, Gold Creek, Canyon, and Chulitna railroad stations. The extent to which each of these communities experiences socioeconomic impacts depends largely on where the junction between the proposed access corridor and existing transportation facilities occurs.

Other communities located along existing transportation corridors (such as Wasilla [population 7,831], Anchorage [population 291,826], and Whittier [population 220]), also have the potential for socioeconomic impacts related to the transportation of construction materials. Socioeconomic impacts on these communities are likely to be similar for all Susitna-Watana dam access alternatives.

4.2.10.1 South Road

The junction between the South Road alignment and the existing transportation network occurs at ARRC MP 263 of the Alaska Railroad. Socioeconomic impacts to communities located on the ARRC tracks are likely to be the result of increased train traffic. The specific communities that will be impacted depends on if trains are coming from the south, the north, or both.

The construction of the South Road alignment would likely result in substantial project-related traffic and activity within the Gold Creek area. Gold Creek is expected to have additional impacts because it is the point of modal shift from rail to road for goods, material, and people. The increased distance from larger cities such as Wasilla and Anchorage may result in an increased demand for housing, community services, and utilities in the community; additional employment opportunities; increased income; and changes to community culture and way of life.

The construction and operation of the South Road alignment could have impacts on residents and owners of cabins in the area. While access to the area would still be limited to ARRC and ATV access from the Parks Highway, it would be easier for people to travel between Gold Creek and the proposed dam site.

The increased activity in the area is also anticipated to impact one remote lodge (Stephens Lake Lodge) in the project area.

4.2.10.2 Hurricane (West)

The junction between the proposed Hurricane (West) alignment and existing transportation routes occurs at MP 171 of the Parks Highway, across from the ARRC station near Hurricane (ARRC MP 282). Socioeconomic impacts would likely impact communities in the immediate area including Talkeetna and Trapper Creek (86 and 56 miles, respectively, from the proposed junction; see Table 4-26). Project impacts related to increased traffic on the Parks Highway may be minimal in Talkeetna, as the community is located on a 14-mile spur road off the highway itself.

While it is anticipated that the many of the construction goods and materials will be moved by rail to an improved siding at Hurricane, construction supplies will also be transported by truck. The movement of construction goods and materials along the Parks Highway is likely to result in

[31] In an advisory ballot vote on October 5, 2011, the community of Talkeetna communicated their opposition to the construction of the Susitna-Watana Dam to the Talkeetna Community Council by a vote of 109 to 19 (KTNA 2011).

increased traffic that may impact communities farther south along the Parks Highway, including Montana, Willow, Houston, and Wasilla (75, 101, 114, and 129 miles, respectively, from the proposed junction). An increase in traffic from construction activities and post-construction users (recreationalists, hunters, fishermen, etc.) may change the quality of life for some area residents, but may also provide increased opportunities and traffic for local businesses. Impacts from increased road traffic depend on the degree to which materials and supplies are moved by road or via rail.

The Hurricane (West) alignment would likely have the fewest impacts (positive or negative) to communities on the Parks and Denali Highways north of MP 171 such as Cantwell (39 miles from the proposed junction; see Table 4-26) because construction traffic would not need to pass through the community (HDR 2011b). As the community closest to the proposed site, Cantwell may still experience an increased demand for housing and services during construction, but potentially to a lesser extent than if access is provided via the Seattle and Butte Creek alternatives.

The construction and operation of the Hurricane (West) alignment could have impacts on residents and owners of cabins along the ARRC corridor. The Hurricane (West) alignment could provide direct road access to people who live in or own cabins near the ARRC station of Chulitna. Access to this area is currently limited to ARRC and ATV access from the Parks Highway. The Hurricane route would not provide direct road access to cabins and communities farther south along the ARRC corridor, but it may provide an alternative point of access for trails leading to those locations.

The proposed Hurricane access route may also alter land use and businesses activities that currently occur east of the Parks Highway. The Hurricane access route is likely to provide ground access to the area near the High Lake Lodge, a commercial lodge that is currently accessed by airplane. Road access near the lodge would likely alter the remote characteristics of the lodge, but may also provide different business opportunities. Guiding companies that provide services in the area may experience similar changes in the type of recreational experience and use of the area, but may benefit from increased ease of access. In summary, the Hurricane access route is likely to have greater impacts on communities along the Parks Highway corridor and the ARRC corridor, including Trapper Creek, and may be better positioned to rely on services from larger population centers farther south in Anchorage and Wasilla. The Hurricane (West) alignment has the only remote lodge identified in the area. The construction of this alignment may have an impact on the character of the lodge. There are other lodges located near the Parks Highway that may be affected by an increase in traffic during construction. No residential or business relocations are anticipated with this alternative.

4.2.10.3 Seattle Creek (North)

The junction between the proposed Seattle Creek access route and existing transportation routes occurs at MP 113.7 of the Denali Highway. The development of the Seattle Creek access route would likely shift many of the socioeconomic impacts farther north along the Parks Highway to the community of Cantwell (20 miles from the proposed junction). However, project equipment and construction materials would still likely be transported up the Parks Highway corridor, either on the Highway itself or by rail to an improved siding at Cantwell. Project-related traffic is still likely to have some impact on communities along the Parks Highway from Wasilla to Cantwell.

The construction of the Seattle Creek (North) alignment would likely result in substantial project-related traffic and activity within the community of Cantwell. The upgrade of the western 20 miles of the Denali Highway would require construction work directly adjacent to the community. The increased distance from larger cities such as Wasilla and Anchorage may result in increased reliance on and demand for housing, community services, and utilities in the community; additional employment opportunities; increased income; and changes to community culture and way of life. There would also be impacts (including noise and traffic) related to the railroad laydown yard at Cantwell.

The development of access to the Watana dam site via the Denali Highway would provide ground access to a region that is relatively remote and currently used primarily for recreation and subsistence purposes. The Seattle Creek access route would directly impact cabins at Big Lake, near the access route corridor.

The upgrade of the Denali Highway also has the potential to change access to the Denali Highway area. Currently, the Denali Highway is open only seasonally to vehicle traffic, and is used by snow machine users, dog mushers, skiers, and hunters in winter. The upgrade of the western 20 miles of the Denali Highway has the potential to change seasonal land use in the area and may provide different opportunities for businesses operating in the area. No residential or business relocations are anticipated with this alternative.

In summary, the Seattle Creek (East) alignment is likely to have an impact on the community of Cantwell, with fewer impacts to Talkeetna and Trapper Creek, similar to that of the Butte Creek (East) alignment. It is not anticipated to impact remote lodges in the project area. Construction-related traffic may impact lodges located along the Parks Highway. The August 1982 *Access Plan Recommendation Report* indicated that an access route in this vicinity would not conflict with the interested of Native organizations and local communities.

4.2.10.4 Butte Creek (East)

The junction between the proposed Butte Creek (East) alignment and existing transportation routes occurs at MP 81 of the Denali Highway, approximately 53 miles east of Cantwell and 81 miles west of the community of Paxson, located at the junction of the Denali and Richardson Highways. As part of the Butte Creek (East) alignment, 53 miles of the Denali Highway east from Cantwell would be upgraded and would become available for year-round use.

The socioeconomic impacts of the Butte Creek (East) alignment are expected to be virtually the same as those described for the Seattle Creek (North) alignment, with the community of Cantwell likely to experience the largest number of socioeconomic impacts. The community of Paxson may also experience some spillover effects, but, as most construction traffic and activity would occur via Cantwell and the Parks Highway, they are likely to be more minor impacts.

Businesses located along the Denali Highway, including the Alpine Creek Lodge at MP 68 and the Gracious House Lodge at MP 82, are likely to experience substantial impacts, both as a result of construction-related traffic and activity and as a result of increased use and seasonal access to the area. No residential or business relocations are anticipated with this alternative.

In summary, the Butte Creek (East) alignment is likely to have a moderate impact on the community of Cantwell and the fewest impacts to Talkeetna and Trapper Creek. It is anticipated to impact one remote lodge in the project area and one lodge located adjacent to the proposed junction with the Denali Highway. Construction-related traffic may also impact lodges located along the Parks Highway.

4.2.10.5 Summary

The socioeconomic impacts are expected to be greater during the construction of the proposed project than during its operation. The socioeconomic impacts may vary greatly depending on construction logistics (how workers are housed, hours of operation, traffic generated, etc.). The South Road alignment would have the greatest impact to communities located along the ARRC tracks. The Seattle Creek (North) and Butte Creek (East) alignments both use the Denali Highway and would result in increased impacts to Cantwell. The Hurricane (West) alignment would have fewer impacts to Cantwell. Hurricane (West), Seattle Creek (North) and Butte Creek (East) alignments are likely to have similar impacts to Talkeetna.

Table 4-26. Distance between Parks Highway Junction and selected communities

	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Distance between Parks Highway junction and Cantwell (miles)	N/A	39	0	0
Distance between Parks Highway junction and Talkeetna (miles)	N/A	86	125	125

Red = Not preferable   Green = Favorable

4.2.11 Costs

Costs for each corridor were estimated based on conceptual engineering and using DOT&PF bid tabs (see Table 4-27). For a detailed breakdown of costs per corridor and assumptions used for estimating purposes, see Appendix C.

New alignments: Alignments in each corridor were established that met the design criteria for the project through a conceptual engineering process. The terrain in each corridor was evaluated and classified as level, rolling, or mountainous. Due to the length of the corridors and the coarseness of the contour data (20m and 30m intervals), only representative sections of profiles were developed in each terrain type. These representative sections (approximately 5 miles) were modeled using Civil 3D to generate earthwork quantities. Following aerial reconnaissance of the corridors, there was a concern about the slope stability in mountainous terrain with excavations on the uphill sides when sidehilling. To address this concern, retaining walls were assumed and included in the corridor estimates to minimize excavation on the uphill sides. Once quantities were developed for the three representative sections, the quantities were normalized on a per mile basis. Miscellaneous construction items were also estimated on a per mile basis.

Denali Highway: Following a field reconnaissance effort on the Denali Highway to document existing conditions and evaluate the necessary improvements to support the Seattle Creek (North) and Butte Creek (East) alternatives, quantities were developed by estimating the existing embankment fill or cut heights, number and size of culverts, and bridge deck area for replacement bridges. Miscellaneous construction items were estimated on a per mile basis.

Other items: Costs for intersection improvements, rail sidings, staging areas, and the airport were also estimated. These costs were not used in the analysis for comparing the three access routes as they are deemed to be essentially the same for all corridors. Table 4-27 presents the estimated costs in 2011 dollars for the corridors; totals are exclusive of ROW costs.

Table 4-27. Estimated cost in 2011 dollars (in millions)

	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Road (new alignment)	251.2	211.5	149.1	144.0
Road (Denali Highway)	—	—	14.6	31.7
Roadway subtotal[a]	251.2	211.5	163.7	175.7
Rail sidings and intersection improvements[b]	28.3	9.1	9.1	9.1
Airport	36.7	36.7	36.7	36.7
Total access cost	**316.2**	**257.3**	**209.5**	**221.5**

Red = Not preferable **Green = Favorable**

[a]Used for comparison of access alternatives

[b] This total does not include costs to upgrades to the ARRC mainline that may be needed.

The South Road alignment is estimated to cost approximately $316.27 million, which is the highest cost of the four alternatives. The Hurricane (West) alignment is estimated to cost approximately $257.3million. The Seattle Creek (North) alignment is expected to cost approximately $209.5 million, which includes $14.6 million to upgrade the Denali Highway and $149.1 million to connect the Denali Highway to the Watana dam site. The Butte Creek (East) alignment has a similar cost. It is expected to cost $221.5million, which includes $31.7 million to improve the Denali Highway and $144.0 million to connect the Denali Highway to the Watana dam site. The South Road alignment presents greater technical/engineering challenges than the other three alignments. This translates to a higher potential of construction cost escalations.

The South Road alignment is expected to have rail improvements costing approximately $28.3 million. The other three alternatives are expected to have railroad and roadway intersection improvements costing approximately $9.1 million, regardless of the alternative selected.

The airport is expected to cost approximately $36.7 million, regardless of the alternative selected, and will not affect the overall evaluation.

4.2.12 Permits

All proposed corridors will require the construction of new roadways, with the Seattle Creek and Butte Creek alignments also needing to upgrade portions of the Denali Highway to be used as year-round access. Because much of the project will include similar impacts to resources, permits required for the construction of all access road alternatives are anticipated to require similar permits and permitting strategies. The following permits are anticipated[32] for all proposed alternatives.

4.2.12.1 Section 404 Permit (Corps)

The Corps reviews, coordinates, and issues permits for the removal or placement of fill into wetlands and other waters of the United States under Section 404 of the Clean Water Act. A Section 404 permit would be required for all build alternatives that would affect wetlands and other waters under Section 404 jurisdiction. The Section 404 permit application and approval also requires the following:

- Endangered Species Act Section 7 consultation with the National Marine Fisheries Service (NMFS) and USFWS
- NHPA Section 106 consultation with the State Historic Preservation Office (SHPO)
- Coordination and conference with ADF&G
- Section 401 Water Quality Certification from ADEC

The Corps would also require authorization under Section 10 of the Rivers and Harbors Act for any build alternative that includes construction of a structure that would cross navigable waters or result in the modification of navigable waters. It is not anticipated that the proposed project corridors would involved the placing a structure over Federally navigable waterways.

The Section 404 application process for large projects may take as little as 9 months, and up to 2 years, depending on the amount of field data collected, progress of engineering plans, and preliminary agency consultation conducted prior to permit submittal. The Corps will not issue a Section 404 permit without an approved environmental document and requires that the chosen alternative be the least environmentally damaging while still meeting the purpose of and need for the project. In general, the Section 404 permit has the most potential to cause delays to the construction schedule.

4.2.12.2 Eagle Take Permit (USFWS)

Bald and golden eagles may nest in the project vicinity and are protected under the Bald and Golden Eagle Protection Act (Eagle Protection Act; 16 USC 668). Some activities are eligible for Federal permits under 50 CFR 22.26; USFWS 2011. The Eagle Protection Act prohibits anyone without a permit from “taking” bald and golden eagles except as permitted under USFWS regulations. Due to the location of the proposed corridors and the anticipated proximity to active and inactive bald eagle nests, an eagle take permit may be necessary. Prior to submitting the eagle take permit, a preconstruction survey of the project corridor will be conducted to identify current nest locations and status of nests. Compensatory mitigation measures and post-construction monitoring may be necessary to offset impacts.

Obtaining an eagle take permit generally takes 30 to 90 days following submittal and requires a $500 application fee[33] at the time of submittal. The amount of time required to obtain this permit is directly related to preliminary agency coordination and completion of the preconstruction survey prior to submittal.

[32] Other permits may be needed if new regulations are enacted, project funding changes, etc.
[33] The permit application fees are November 2011 rates and are subject to change in the future.

4.2.12.3 Title 16 Fish Habitat Permit (ADF&G)

The Fishway and the Anadromous Fish Acts are Alaska Statutes (AS) that require projects to obtain a Fish Habitat Permit from the ADF&G for certain activities in fish-bearing streams. Activities that may affect fish passage and all activities within or across anadromous fish streams require a Title 16 Fish Habitat Permit. All project alternatives will require Title 16 Fish Habitat permits; see Table 4-28 for the number of fish-bearing waters crossed for each alternative. Where no data exist for a waterway, for the purposes of this report, it was assumed fish are present and an application will be required.

Title 16 permits are generally obtained within 30 to 90 days of submittal, given sufficient field data has been collected, crossing design information is provided, and appropriate preliminary agency coordination has occurred. It is not uncommon for ADF&G to issue conditional permits that require additional design information to be provided and approved by ADF&G prior to construction.

4.2.12.4 Land Use Permit (DNR, Application for Easement AS 38.05.850)

For crossing State navigable waterways, an easement application will be necessary from the DNR, Division of Mining, Land and Water (DMLW). The DNR retains ownership of navigable stream beds from ordinary high water (OHW) to OHW and will require a permit for construction over or work in waters identified as navigable. A navigational analysis will be required under 11 Alaska Administrative Code (AAC) 51.035[34] by the DMLW to determine if any of the waterways crossed are considered navigable by the State of Alaska.

Generally, land use permits are obtained 60 to 90 days following submittal, as long as the navigational determinations have been completed and sufficient agency coordination has occurred prior to submittal. There is a $ 100 fee per land use permit application, due at the time of submittal. DNR has the option to issue a Public Notice, which requires a 30-day review period, or not. If DNR determines that sufficient public scoping has been conducted, it may determine that the notice is not needed.

4.2.12.5 APDES Construction General Permit (ADEC)

Beginning in 2008, the ADEC assumed the role from EPA to administer the Alaska Pollutant Discharge Elimination System (APDES). This program was formerly called the National Pollutant Discharge Elimination System. An APDES construction permit, issued by the ADEC, is required for all construction activities that result in ground disturbance of 1 acre or greater. A Storm Water Pollution Prevention Plan (SWPPP), which is related to the APDES permit, must also be approved by the ADEC before construction can begin.

This permit and the associated plans are the responsibility of the contractor and will be obtained prior to the start of construction.

[34] A river, stream, lake pond, slough, creek, bay, sound, estuary, inlet, strait, passage, canal, sea, ocean, or any other body of water or waterway within the territorial limits of the State of Alaska or subject to its jurisdiction, that is navigable in fact for *any* useful purpose such as commerce, hunting, trapping, log floating, landing or take off of aircraft, public boating or *any* other recreational purpose.

4.2.12.6 Floodplain Development Permit

A Floodplain Development Permit would be required for a construction activity that includes development in the mapped floodplain or floodway. A review was conducted of mapped floodplains/floodways in the vicinity of the proposed project corridors. All corridors lie outside of the mapped flood hazard areas so a MSB floodplain development permit will not be required (MSB 2011). A review of the Federal Emergency Management Agency (FEMA) Map Service Center Web site indicates that there are no FEMA mapped flood hazard areas located in the Denali Borough (FEMA n.d.).

4.2.12.7 Borough Land Use Permit

If any borough-owned material sources/sites would be used, a conditional land use permit from the borough would be required. A land use permit would also be required for any grubbing/ clearing to take place prior to ROW acquisition on MSB- or Denali Borough-owned lands.

Borough land use permits take 60 to 90 days to obtain, assuming that the lands (material sources/sites) have been surveyed and appropriate coordination has occurred with each respective Borough prior to submittal.

4.2.12.8 Contractor-specific Permits

Additional contractor-specific permits may be required for the construction of an access route. These permits may include the APDES construction permit noted above and also may include Temporary Water Use Permits from the DNR, DMLW, Water Section; and a material sale permit[35] from DMLW if materials are going to be used from state sources. If materials are extracted or used from a state source, a site reclamation plan may be necessary.

Other permits may include additional Title 16 Habitat permits for temporary water usage from fish-bearing waters, an ADEC dewatering permit, and various local land use permits, which will be acquired following route selection and the right-of-way acquisition process begins.

A listing of all applicable permits and regulatory requirements and their statutory authority is located in Appendix K. Anticipated permits by alternative are described in Table 4-28. The same permits are required; however, the number and complexity of the permits will vary based upon potential project impacts to areas resources.

4.2.12.9 Summary

Based on the available information, all four alignments need the same permits (see Table 4-28), with one exception; the Seattle Creek (North) and Butte Creek (East) alignments are not anticipated to need a Title 16 Habitat permit for anadromous stream crossings. While all resident fish stream crossings can be addressed in one Title 16 Habitat permit, the Hurricane (West) alignment would have to address 32 crossings, compared to 23 for South Road, 14 for Seattle Creek (North) and 29 for Butte Creek (East). Permits that address more stream crossings are likely to take longer to prepare. Separate Title 16 Habitat permits have to be prepared for anadromous stream crossings. The South Road alignment would require eight permits and Hurricane (West) alignment would require four permits. Butte Creek (East) would only require one permit application and none would be required for the Seattle Creek (North) crossing.

[35] A material sales permit may also be provided to the contractor from DOT&PF.

Without additional information about impacts of each corridor, it would be difficult to assess the ease of obtaining these permits. However, it would take more effort to prepare permits for the Hurricane (West) and South Road alignments than Seattle Creek (North) or Butte Creek (East).

Table 4-28. Summary of permits

Permit	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
ADF&G— Title 16 Habitat[a] (Resident, number of crossings)	23	32	15	29
ADF&G—Title 16 Habitat[a] (Anadromous, number of crossings)	8	4	0	0
Corps 404/401	1	1	1	1
USFWS Bald Eagle[b]	1	1	1	1
DNR Land Use AS 38.05.850	TBD	TBD	TBD	TBD
NMFS–EFH Assessment	1	1	1	1
ADEC APDES (Contractor)	1	1	1	1
DNR Temp Water Use Permits (Contractor)[c]	TBD	TBD	TBD	TBD
MSB Flood Hazard Permit	N/A	N/A	N/A	N/A

Red = Not preferable **Green = Favorable**

[a]It is assumed that Title 16 applications will be required for all stream crossings; however, some resident crossings may be able to be combined onto one application. All anadromous crossings will result in separate applications.

[b]An eagle survey will be conducted prior to construction.

[c]Additional Title 16 applications may be necessary is water is withdrawn from fish-bearing waters.

5 Summary of Findings

The purpose of the Watana Transportation Access Study was to evaluate potential access corridors from the existing transportation network to the proposed Watana Dam site. Corridors were initially identified by reviewing historical studies developed for the project in the 1980s. The goal of this study was not just to update or validate previously studied access routes, but to also evaluate other potentially feasible corridors. Major evaluation criteria included operational, engineering, environmental, and cost factors. Corridors were evaluated to identify the advantages and disadvantages and to identify suitable transportation access corridors that balances the advantages and disadvantages.

The South Road alignment is only accessible from the ARRC tracks, making it the least convenient of the four corridors. While this corridor has many benefits including the fewest linear miles located above 3,000 feet and no acquisition of Federal land, it is also the longest route, has the most linear feet of bridges, the highest cost, and a high potential for cultural resource impacts. The need to transport the majority of goods, materials, and people by rail is likely to increase the cost to construct the Watana dam. This cost has not been quantified as part of this report but is a real operating cost that must be evaluated as the project advances. Rail access also increases the logistical challenges associated with construction. For example, rail access is less convenient than road access because travel must be scheduled in advance to avoid conflicting with other rail traffic.

The Hurricane (West) alignment is the closest to the Parks Highway/ARRC corridor but it requires the most new construction. While it has many favorable conditions, it also has the second most linear feet of bridges, the most stream crossings requiring fish passage, the most Federal land, the least State land, and a high potential for cultural resource impacts. The alignment also has the second highest cost of the four corridors.

The Seattle Creek (North) has acceptable engineering and geological/geotechnical conditions. It also traverses to the highest point (4,100 feet) of the four corridors and includes the greatest number of miles at higher elevations, with 32 miles of the alignment being above 3,000 feet. However, it has the fewest number of new culverts and crosses the fewest fish-bearing streams. The Seattle Creek (North) alignment has a similar cost to the Butte Creek (East) alignment, and both alignments include upgrades to the Denali Highway (see Appendix B for the breakdown of the associated upgrades and costs). However, the distance between the Watana dam site and the Parks Highway/ARRC corridor is approximately 30 miles shorter than the Butte Creek (East) alignment, as the new roadway would start farther west on the Denali Highway. This would reduce the amount of Denali Highway that needs to be upgraded, and results in a shorter haul than the Butte Creek (East) corridor.

The Butte Creek (East) alignment has the most suitable geological/geotechnical conditions of the four corridors. However, this alternative is farthest from the Parks Highway/ARRC corridor. The additional length (and thus travel time), will increase the cost to construct the Watana dam. This cost has not been quantified because a logistics plan has not been developed, but it could be substantial. While this alignment does not cross any salmon streams, it would require crossing 29 streams that would require fish passage. While this corridor has the fewest reported wetland impacts, wetland information was only available for a portion of the corridor. It is believed that the unmapped area contains a substantial amount of wetlands and that if the entire alignment was mapped, Butte Creek (East) would have the greatest wetland impacts of the three alternatives.

The Seattle Creek (North) and Butte Creek (East) alternatives are preferable to the South Road and Hurricane (West) alternative in many categories (such as cost, engineering, and geology/geotechnical). The South Road and Hurricane (West) alignment fare better than the other two corridors for moose and caribou impacts, but these resources were primarily evaluated based on a *relative* comparison. In terms of cultural resources, fish passages, migratory ducks, swans, and bears, the South Road and Hurricane (West) corridors are not preferable over the other two corridors. Many of the environmental impacts are associated with increased access to the resources being studied. Because it does not connect to the existing road corridor, the South Road corridor would be expected to have fewer access related impacts than the other three corridors. Regardless of the corridor selected, mitigation measures may be implemented to reduce potential impacts on environmental resources.

Table 5-1 summarizes the criteria where meaningful differences were discernible among the alternatives to help identify a preferred corridor. Criteria that did not result in a discernible, substantial difference or have enough detail to support a planning-level decision are not reported; the results for the criteria that are not reported in the summary were found to be relatively uniform across the four corridors and did not contribute to the selection of suitable corridors that meets the project's cost and schedule goals.

Based on the information provided above, the project team concluded that the South Road and Hurricane (West) corridors would be less desirable as the access road corridor than the other two corridors. The Seattle Creek (North) and Butte Creek (East) corridors are both reasonable for a future access road and have similar costs. However, the Seattle Creek (North) corridor appears to best meet the schedule and cost goals for the future Watana dam access road corridor. The Seattle Creek (North) corridor is approximately 30 miles closer to the Parks Highway/ARRC corridor than the Butte Creek (East) corridor which is likely to result in lower dam construction costs. Being closer is also anticipated to reduce operations and maintenance costs of the Watana Dam. It will also reduce impacts along the additional 30 miles of the Denali Highway. The Seattle Creek (North) corridor is also preferred over the Butte Creek (East) corridor because it has greater potential for the access road and power transmission lines to be co-located. In a meeting on October 25, 2011, AEA and their consultants indicated that the Butte Creek (East) corridor is not being considered as a location for a potential power transmission line. They also indicated that the transmission line could share a corridor with the access road within most of the Seattle Creek (North) corridor.

As this project is further developed and additional information is obtained, further study will be needed to identify if the Kettle Lake variant or the Deadman East variant of the Seattle Creek (North) alternative should be used or if the primary alignment shown in this report should be the selected route. Further engineering and environmental analysis may be required before an access corridor is selected.

Table 5-1. Summary of alternatives analysis

Category	Criteria	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Engineering	New road (miles)	54.8	51.7	43.3	42.5
	Upgrades to Denali Highway (miles)	0.0	0.0	20.0	53.0
	Total length (including Denali Highway; miles)	54.8	51.7	63.3	95.5
	Highest elevation (feet)	3,450	3,250	4,100	3,200
	New road above 3,000 feet (miles)	5.0	12.5	32.0	6.4
	Travel time from Hurricane to Watana Dam (hours)	N/A	1.5	2.4	3.1
	Distance from Hurricane to Watana Dam (miles)	N/A	51.7	102.6	134.7
	Travel time from Cantwell to Watana Dam (hours)	N/A	2.1	1.8	2.7
	Distance from Cantwell to Watana Dam (miles)	N/A	91.0	63.4	95.5
	Travel time from railroad siding to Watana Dam (hours)	1.6	1.5	1.9	2.8

Table 5-1. Summary of alternatives analysis

Category	Criteria	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Engineering (cont.)	Distance from railroad siding to Watana Dam (miles)	54.8	52.3	65.3	97.4
	Potential transmission line in close proximity	Yes	Yes	Yes	No
Geologic and Geotechnical Conditions	Borrow soil quality[a]	4	4	3	1
	Borrow rock quality[a]	2	4	3	2
	Subgrade support[a]	2	2.5	2	1.5
	Soil slope stability[a]	3	3	2	1
	Permafrost conditions[a]	2	2	3	1
Hydrology and Hydraulics	Number of bridges on new roadway	4	6	4	4
	Linear feet of bridge on new roadway	1,000	800	200	300
	Drainage culverts on new roadway	0	2	4	0
	Small fish culverts on new roadway	15	25	3	23
	Large fish culverts on new roadway	4	2	4	2

Table 5-1. Summary of alternatives analysis

Category	Criteria	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Hydrology and Hydraulics (cont.)	New/ replacement bridges on Denali Highway	0	0	1	2
	Replacement of small fish culverts along the Denali Highway	0	0	6	13
	Replacement of large fish culverts along the Denali Highway	0	0	0	1
Fisheries and Aquatics	Salmon stream crossings	8	4	0	0
	Stream crossings requiring fish passage	23	32	15	29
Terrestrial	Caribou habitat[a]	2	2	3	3
	Moose habitat [a]	2.5	2	3	3
	Migratory duck habitat (acres)	763.5	965.3	322.1	744.7
	Swan habitat (acres)	166.4	163.6	0.0	71.3
	Bear habitat (acres)[a]	3.5	3	2.5	2
Wetlands	Category 2, 3 and 4 wetlands (acres)	226.8 [b]	553.9	699.2	544.1[b]
Fish and Wildlife Use	Sport fishing[a]	2	3	2	2.5
	Sport and subsistence hunting[a]	2	2	3	3

Table 5-1. Summary of alternatives analysis

Category	Criteria	South Road	Hurricane (West)	Seattle Creek (North)	Butte Creek (East)
Land Status	Corridor (acres)				
	Federal lands	0	14,817	6,613	10,238
	State lands	13,719	19,443	36,042	50,634
	Native	40,828	9,521	896	896
	Private or Borough	1,692	5,160	0	818
	ROW (acres)				
	Federal lands	0	771	357	255
	State lands	417	749	1,174	1,230
	Native	1,466	300	45	45
	Private or Borough	112	66	0	0
Socioeconomics	Distance between Parks Highway junction and Cantwell (miles)	N/A	39	0	0
Costs	New road construction ($ millions)	251.2	211.5	149.1	144.0
	Denali Highway upgrades ($ millions)	0	0	14.6	31.7
	Total roadway ($ millions)	251.2	211.5	163.7	175.7

Red: Not preferable **Green: Favorable**

[a] Criteria evaluated on a qualitative basis

[b] Wetland information was only available for a portion of the corridor. However, based on existing aerial photography and other information, it is believed that the unmapped portion of the corridor also contains a substantial amount of wetland.

6 Airport

Given the remoteness of the area, an airport is proposed for the project in order to be able to start construction on the dam prior to the road being complete, and to support future dam operations. It is anticipated that the airport will be used to transport construction materials and passengers to the Watana dam site. This section examines two potential airport locations identified in previous studies to validate that they are feasible. The evaluation considered the design demands of the anticipated aircraft to use the facility (the design aircraft) and examined the site's ability to accommodate an airport meeting these dimensional standards. In addition, the team examined the location to verify that approach surfaces and wind coverage would be suitable and that an airport at the location would be constructible. Finally, a cost estimate was prepared.

6.1 Airport Location and Conditions

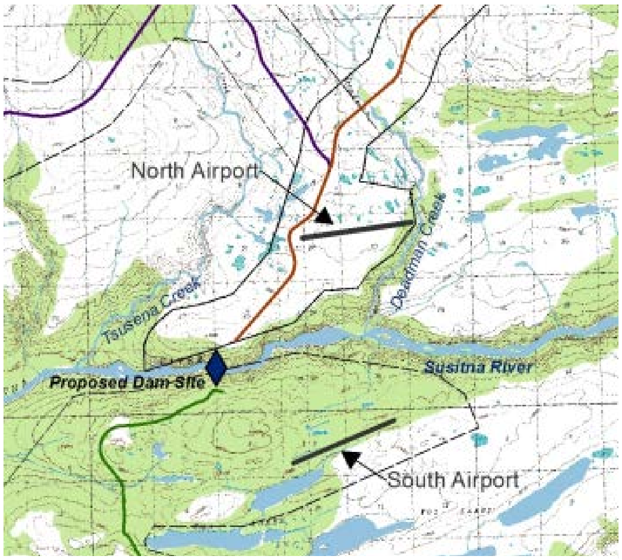

Figure 6-1. Airport alternatives

The Alaska Energy Authority (AEA) provided the project team with two potential runway alignments for validation based on work done in the 1980s: one on the north side of the Susitna River and one on the south side (see Figure 6-1). As part of the Watana Transportation Access Study, the project team identified the runway south of the Susitna River as the primary airport for the South Road alignment. This proposed location is on relatively level terrain at approximately 2,300 feet of elevation (see Figure 6-1). The site is relatively unconstrained but there are some wetlands and ponded water in the area.

The runway north of the Susitna River was identified as the primary airport for the Hurricane (West), Seattle Creek (North), and Butte Creek (East) alternatives. This site is on relatively level terrain and the proposed airport would be located on a relatively flat bench of tundra at roughly 2,300 feet of elevation (see Figure 6-3). The site is constrained by Deadman Creek on the east and wetland areas to the west.

Figure 6-2 Proposed South Airport Location Wet tundra, relatively flat, with mountainous terrain in the distance

6.2 Design Aircraft and Airport Features

Design Aircraft. The team first selected a design aircraft and determined the required runway length and dimensions required to accommodate that aircraft. AEA suggested a Lockheed L-382 aircraft as the design aircraft, and DOT&PF asked the project team to evaluate a Boeing 737-200 aircraft.

Runway Dimensions. Based on Federal Aviation Administration (FAA) runway length criteria, a gravel runway that is 6,500 feet long by 100 feet wide would accommodate both of these aircraft types.[36] The runway safety area would need to be 8,500 feet long by 500 feet wide to meet FAA requirements (see Figure 6-4 and Figure 6-5).

Figure 6-3. Proposed North Airport location
Wet tundra terrain, relatively flat, with mountainous terrain far enough from the site to proved safe approaches into the airport.

Apron Dimensions. A 400-foot-long by 200-foot-wide apron (8,000 square feet) is recommended as a reasonable, workable apron size, based on the anticipated need of having two aircraft unloading/loading supplies or personnel at the same time[37]. The proposed apron could easily accommodate two lease lots in the proposed 400-foot by 200-foot configuration. The apron could be expanded for additional lease lots if needed or desired in the future. The apron would be set back 500 feet from the runway centerline in accord with FAA requirements.

Parallel Taxiway. A parallel taxiway is a desired feature of:

- Airports that use instrument approaches and generally have less than one mile visibility
- Airports where aircraft landings and takeoffs are often delayed by aircraft taxiing on the runway

The current proposal does not include the construction of a parallel taxiway and one is not recommended at this time.

A runway with these specifications meets all FAA design criteria for these aircraft.

[36] A runway of this size would accommodate aircraft currently being used by at least three cargo carriers (Lyndon, Northern Air Cargo, and Everett).
[37] This was not based on a specific logistics study, but rather was based on experiences of constructing the Trans Alaska Pipeline. The apron size should be re-evaluated after a logistics plan is developed for the project.

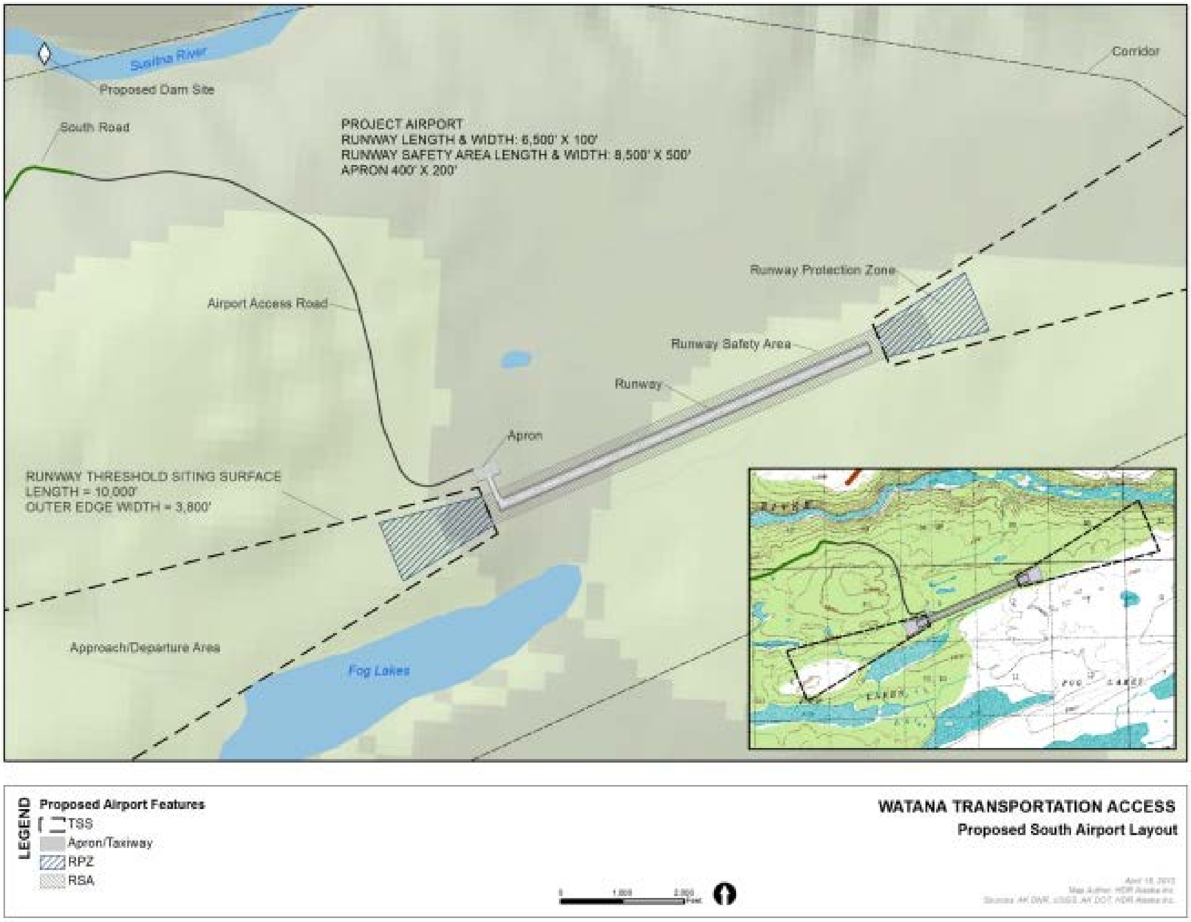

Figure 6-4. Proposed South Airport layout

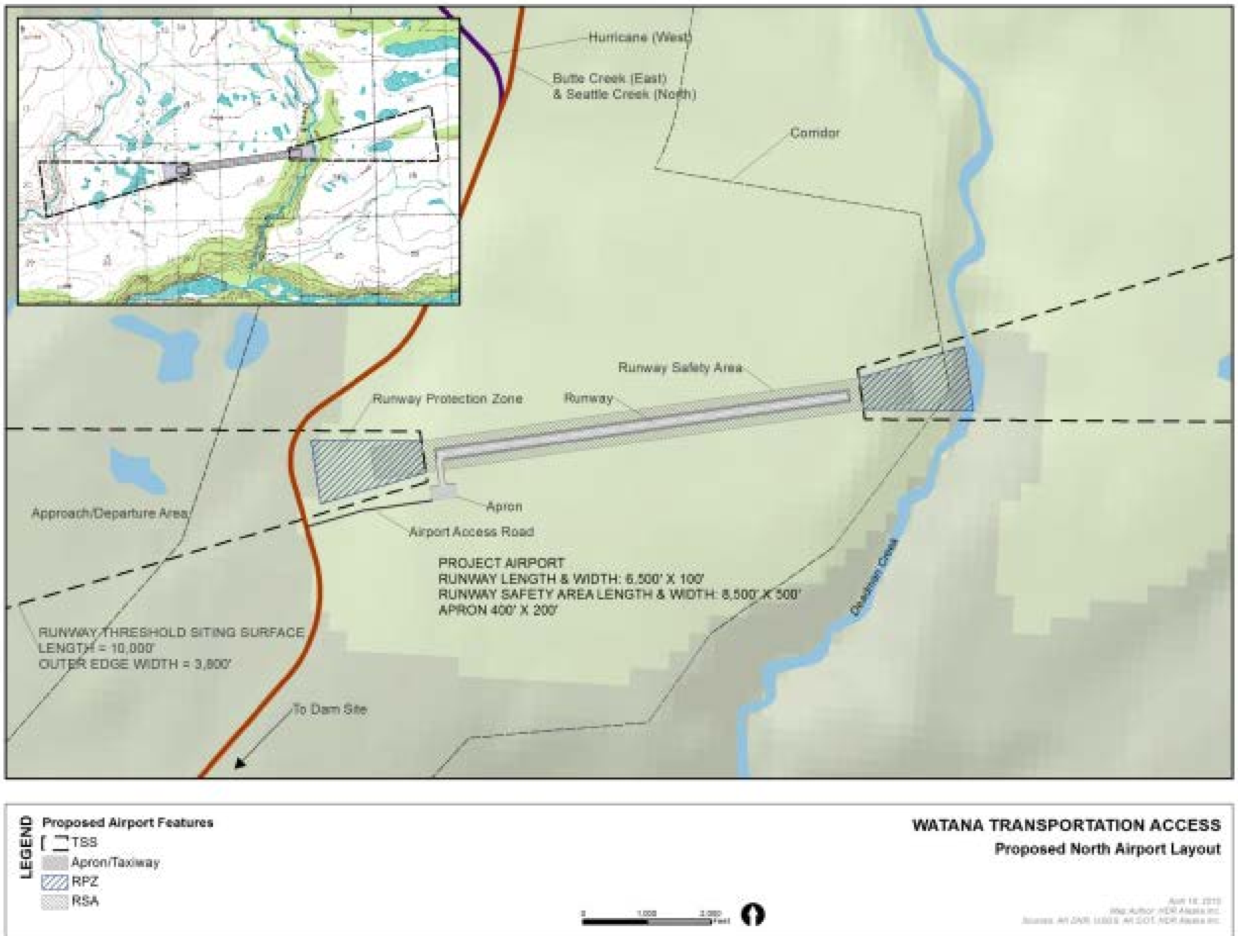

Figure 6-5. Proposed North Airport layout

Passenger Facilities. It is anticipated that typical passenger aircrafts include Beech 1900, De Havilland Twin Otter, and CASA 212. As these aircraft hold fewer than 30 seats, it is anticipated that the airport should not require an Airport Operating Certificate under 14 CFR 139.[38] As a non-certified airport, it will not require fire fighting and rescue equipment.

Airport Access Road. An airport access road will be needed to connect each alignment to the airport. The airport access road is anticipated to have the same design criteria as the alignment.

[38] Alaskan airports that serve aircraft with fewer than 30 seats are exempt from Federal airport certification requirements (FAA 2011)

6.3 Runway Approaches

In addition, the project team evaluated the runway approaches to verify the approaches have sufficient clearances for safe operations.

6.3.1 South Airport

The runway elevation will be approximately 2,350 feet. With the proposed runway orientation, there are no object penetrations to the threshold siting approach slope as defined by FAA Advisory Circular 150/5300-13 CHG 12 (Line 9 of Table A2-1 in Appendix 2).

When approaching the runway from the west (landing to the east), there is a hill with an elevation of 2,630 feet and 3.4 miles out from the airport, along the runway centerline; and a second hill 2,500 feet in elevation and 1.5 miles out from the airport. Both of these hills are below the threshold siting approach slope in Table A2-1. The precision instrument imaginary surface extends 9.5 miles (50,000 feet) from the runway. The 2,630-foot hill will be approximately 250 feet below the specified approach slope; and the 2,500-foot hill will be approximately 85 feet below the specified approach slope used to land at the runway under instrument conditions. Consequently, the hills should not be a factor for establishing an instrument approach on the west side of the runway. Should a more detailed survey or the final design of the runway change any of the parameters, the hills could be modified to eliminate the approach slope penetration.

When approaching the runway from the east (landing to the west), there is no high terrain within 9.5 miles of the runway threshold along the extended runway centerline that would affect the approach siting surface meaning a precision instrument approach would also be established on the approach from the east. All the terrain encompassed by the Part 77 precision approach imaginary surface is below the runway elevation.

The runway location was also checked to determine the ability to better orient the runway for wind coverage. The proposed location provides some flexibility for changing the runway bearing or orientation before airspace penetrations would create issues. The runway can be rotated clockwise 15 degrees and counterclockwise 19 degrees from the orientation shown before encountering terrain penetration of the FAR Part 77 precision approach imaginary surfaces.

6.3.2 North Airport

The runway elevation will be approximately 2,400 feet. With the proposed runway orientation, there are no object penetrations to the threshold siting approach slope as defined by FAA Advisory Circular 150/5300-13 CHG 12 (Line 9 of Table A2-1 in Appendix 2).

When approaching the runway from the west (landing to the east), there is a hill with an elevation of 4,056 feet 11 miles out from the airport, along the runway centerline. This hill is beyond the outer edge of the precision instrument runway imaginary surface[39] used to define obstructions to navigable airspace. The precision instrument imaginary surface extends 9.5 miles (50,000 feet) from the runway. There are no other terrain penetrations to the imaginary surfaces to a precision approach from this direction. This 4,056-foot-high hill will be approximately 1,440 feet below the approach slope used to define obstructions for landing under instrument

[39]The runway imaginary surface is defined in 14 CFR 77.19of the Federal Aviation Regulations Part 77.

conditions and should not be a factor for establishing an instrument approach on the west side of the runway.

When approaching the runway from the east (landing to the west), the nearest high terrain is 13 miles from the runway threshold along the extended runway centerline (see Figure 6-6), meaning a precision instrument approach would also be established on the approach from the east. All the terrain encompassed by the Part 77 precision approach imaginary surface is below the defined obstruction elevation.

Figure 6-6. Ponded water and terrain west of the North Airport's western end

The runway location was also checked to determine the ability to better orient the runway for wind coverage. The proposed location provides some flexibility for changing the runway bearing or orientation before airspace penetrations would create issues. The runway can be rotated clockwise 17 degrees and counterclockwise 21 degrees from the orientation shown before encountering terrain penetration of the FAR Part 77 precision approach imaginary surfaces.

6.4 Runway Wind Coverage

To determine if the runway locations were feasible, the project team also looked at whether the proposed location and alignment can meet FAA wind criteria for an airport. For this analysis the project team conducted a wind analysis (based on AC 150/5300-13 Appendix 1) using wind data collected in the 1980s and FAA's wind rose program. The project team concluded that both of the proposed runways meets FAA's goal of 95 percent wind coverage and neither would require a cross-wind runway.

As noted above in section 6.3 runway approaches, mountainous terrain is far enough from the runway that mechanical turbulence caused by terrain is not anticipated to be a substantial concern. For more detailed discussion on the wind analysis, please see Appendix L.

6.5 Constructability

Both potential airport locations would be located on relatively flat, dry terrain. Standard arctic engineering principles for construction are anticipated. For the south airport, there are no limiting creeks or drainages, but there are some lakes that should be avoided. A more detailed mapping effort could allow the proposed runway to shift to miss wetland features that might be identified.

For the north airport, Deadman Creek to the east is a constraining feature. To the west, the proposed runway is wetter, with standing ponded water and wetlands. Wetland fill in the tundra area is anticipated to be required. Based on aerial reconnaissance of the proposed locations, the terrain and conditions appear to be suitable for a runway.

6.6 Cost

As both airports are the same size and have the same features, the cost is estimated to be the same for each airport. The estimated total construction cost is $36.7 million dollars and it is estimated to take between 1 and 2 years to construct.

6.7 Conclusion

Both potential airport locations near the proposed Watana Dam site appears feasible. An airport with a 6,500-foot-long by 100-foot runway would accommodate the likely design aircraft. Both sites have sufficient room and terrain conditions to accommodate this airport with standard construction techniques and would avoid and minimize involvement with streams and wetlands. Both sites have sufficient airspace for safe approach surfaces and wind coverage is good. Both sites offer flexibility to rotate the runway about its access during design, based on additional wind data and design and environmental information, and still provide for safe approaches.

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