West Susitna Access Reconnaissance Study
West Susitna Access to Resource Development

Transportation Analysis Report

5 ENGINEERING OF RESOURCE ACCESS ROUTES

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Acronyms

AAC	Alaska Administrative Code
AASHTO	American Association of State Highway and Transportation Officials
ADF&G	Alaska Department of Fish and Game
ADL	Alaska Division of Land
AEA	Alaska Energy Authority
AIDEA	Alaska Industrial Development and Export Authority
AMHT	Alaska Mental Health Trust
ANCSA	Alaska Native Claims Settlement Act
ARDF	Alaska Resource Data File
ARTEC	Alaska Railbelt Transmission and Electric Company
AS	Alaska Statute
ASCMCRA	Alaska Surface Coal Mining Control and Reclamation Act
ATV	all-terrain vehicle
bbl	barrels
BIF	best interest finding
BLM	U.S. Bureau of Land Management
bpd	barrels per day
CEA	Chugach Electric Association
CBM	Coalbed Methane
CIE	Cook Inlet Energy, LLC
CIRI	Cook Inlet Region, Inc.
CWA	Clean Water Act
DEM	digital elevation model
DGGS	Division of Geologic and Geophysical Surveys
DNR	Alaska Department of Natural Resources
DOF	Division of Forestry
DOG	Division of Oil and Gas
DOT&PF	Alaska Department of Transportation and Public Facilities
DPOR	Department of Parks and Outdoor Recreation
EIS	environmental impact statement
FAA	Federal Aviation Administration
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FMU	Forest Management Unit
GIS	Geographic Information System
GMU	Game Management Unit
KPB	Kenai Peninsula Borough

KPEDD	Kenai Peninsula Economic Development District
LNG	liquid natural gas
mcf	million cubic feet
MEA	Matanuska Electric Association
Mgal	million gallons
ML&P	Municipal Light and Power
MLW	Mining, Land and Water
MOA	Municipality of Anchorage
MSB	Matanuska-Susitna Borough
MW	megawatt
NHCC	National Highway Construction Cost Index
NPR-A	National Petroleum Reserve – Alaska
NWI	National Wetlands Inventory
OPMP	Office of Project Management and Permitting
PGDHS	A Policy on Geometric Design of Highways and Streets
PGE	platinum group elements
ROD	Record of Decision
RM	river mile
SRR	State Recreation River
SRS	State Recreational Site
syngas	synthetic gas
UCG	underground coal gasification
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

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5 ENGINEERING OF RESOURCE ACCESS ROUTES

Ten preliminary corridor segments were developed based on previously identified alignments, the constraints analysis, and engineering and environmental considerations, as detailed in Section 4. Further refinement of the preliminary corridor segments resulted in seven individual corridor alignments. For purposes of this study and determining access routes to identified termini, these alignments have been combined and refined, resulting in four access routes and one variant option, as presented in Section 4.5.3. Depending on the priority, funding, and timing of access needs, multiple routes could be chosen and combined or added to other routes in subsequent phases.

5.1 Preliminary Design Criteria

The road design criteria for the West Susitna access study were generated from the following published guidelines (in addition to professional engineering judgment):

- American Association of State Highway and Transportation Officials (AASHTO) 2004 *A Policy on Geometric Design of Highways and Streets* (PGDHS), as supplemented by the current edition of the Alaska DOT&PF's *Highway Preconstruction Manual* (PCM)
- AASHTO's 2001 Guidelines for Geometric Design of Very Low-Volume Local Roads
- U.S. Forest Service's Roadway Preconstruction Handbook

Table 5-1 summarizes the design criteria assumed at this time for a West Susitna access road. Anticipating the myriad of uses and vehicles that this new access road could see (e.g., public access for recreation, resource recovery, etc.), a 24-foot-wide, two-lane gravel access road (2'-10'-10'-2') was considered the facility, with the idea that the ultimate facility may be significantly wider based on further investigations or interest in the Study Area. See Appendix A for more details, as included in the Preliminary Design Criteria report. The dimension guidelines in Table 5-1 include the needs for both resource recovery and providing public access.

Table 5-1. West Susitna Access Design Criteria Summary

Functional classification	Rural Resource Recovery Road
Purpose:	Provide resource transport
Traffic volume	< 400 AADT
Number of Lanes	Two lanes
Design Vehicle	Tractors with double (belly-dump) trailers (WB-120 Trucks)
Design Speed	20-40 MPH depending on terrain
Surface	Unpaved
Traveled way width	10 feet (for two lanes)
Shoulder width	2 feet
Bridge width	Two lanes
Maximum Grade	7-16% (depending on terrain)
Curve Radius	380-feet @ 40 MPH
Stopping Sight Distance	250-feet @ 40 MPH
Vertical curves	Crest K = 29 @ 40 MPH Sag K = 35 @ 40 MPH
Clear Zone	0 to 6 feet or more up to 10 feet
Sideslopes	Foreslopes 4:1 Backslopes 2:1
Turnouts	n/a

AADT = Annual average daily traffic; MPH = miles per hour

5.1.1 Functional Classification

The suggested functional classification of an access road into the West Susitna basin would be a two-lane gravel **Rural Resource Recovery Road**.[147] The corridor would initially be considered a very low-volume local road. The PGDHS defines a very low-volume local road as one with an average annual daily traffic volume of 400 PVD or less.

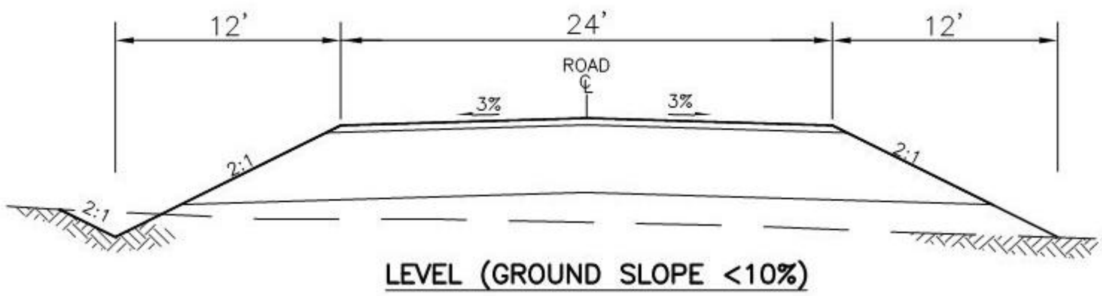
The dimensions of a Rural Resource Recovery Road would more than meet the roadway dimensions and needs required for a **Rural Local Road**[148] or **Rural Minor Access Road**[149]. The Rural Local Road classification is included here to highlight that this type of roadway could serve as pioneer access for initial exploratory investigations for natural resources. With minimal traffic, such an initial phase access would be classified as a Rural Local Road with the understanding that it will eventually function as and become a Rural Resource Recovery Road. However, Rural Local Road dimensions do not satisfy the design criteria needs (e.g., total roadway width) required for providing public access, per the Rural Minor Access Road classification. Therefore, the Rural Resource Recovery Road is the most reasonable functional classification for the West Sustina access route corridors at this time. Also, design criteria appropriate for a Rural Resource Recovery Road in many areas are

[147] AASHTO. 2004. A Policy on Geometric Design of Highways and Streets (PGDHS), page 414
[148] PGHDS, page 416
[149] AASHTO. 2001. Guidelines for Geometric Design of Very Low-Volume Local Roads, page 6

not significantly different from those for recreational roads.[150] Oftentimes, resource development roads are ultimately used for other (e.g., recreational) purposes, assuming the volumes are still below 400 VPD. The Rural Resource Recovery Road classification for West Susitna access takes into account these varying usages.

The recommended road typical cross-section is a 24-foot-wide embankment (gravel, two lanes [2'-10'-10'-2']), as depicted in Figure 5-1. It is possible a wider road would ultimately be needed, depending on the type of vehicles used to transport the resource and access needs. At this time, it is not known which resources or equipment may be transported on this road, so we have assumed the road profile would suffice based on this reconnaissance-level effort.

Figure 5-1. West Susitna Access Typical Cross Section for a Rural Resource Recovery Road



The study team assumes the West Susitna access road could initially be classified as a very low-volume roadway (less than an average of 400 vehicles per day) to serve as a pioneer access route for exploratory investigations for natural resources. It is assumed that the roadway would be open to the public. In terms of public access, the road could also provide access to communities and recreational or hunting sites along the road. At this time and phase in the study, traffic volumes are assumed to still be below 400 vehicles per day and the road could meet the needs of a **Rural Resource Recovery Road**[151] classification. Depending on resource development needs and public interest in accessing the lands found within the Study Area, traffic volumes could be more than 400 vehicles per day. With the uncertainty of resource development needs and public interest, it is difficult at this time to know with certainty traffic volumes. It is also possible a toll road could be a feature of the road, though there would not be limitations on the type of people who use it.

5.1.2 Other Design Considerations based on Interview-Identified Needs

While the data collection and resource industry interviews provided additional information, at this reconnaissance-level study, it is too early to project traffic generation and demand because not enough information exists about resource extraction quantities and transport needs. At this present time the amount, type, and schedule of concentrate removal and transport needs is not known. However, during the interviews conducted in early 2013 as part of the resource inventory task described in Section 2, the interviewees were asked the six transportation-specific questions listed below. Some of the answers provided, as they pertain to design criteria requirements, have been excerpted and included.

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[150] PDGHS, page 414

Selected Questions:

- What transportation needs to do you have for construction, fuel and mining equipment?
- Have access plans been explored? What kinds of modes have been considered or ruled out (rail, barge, air, pipeline, etc.)?
- What logistical challenges that you have experienced would be resolved by road access from the existing road system?
- What are typical vehicle types and/or sizes? Are there large, non-divisible loads that are overweight or over-sized?
- What type of concentrate or finished product will be taken from the site (estimated quantities and likely schedule)?
- What is the anticipated traffic (vehicle trips per day)? Will the workforce access the site by road or air?

Selected Answers:

- **Kiska** indicated they will need an all-season road for construction material, mining fleet and fuel delivery, and concentrate removal. Four concentrate-removal round trips and three light-service vehicle trips per day are expected. Kiska said pick-up trucks and standard tractor-trailers would be used to carry commercial loads. During production, vehicle traffic would include concentrate haul trucks. Kiska said their initial modeling suggests a single lane could be feasible, but a two-lane road is preferable. Kiska said their engineers suggest that occasional large, non-divisible loads are possible during construction, but during operation such loads would be less likely. Kiska said the Whistler mine would produce a gold-bearing copper sulphide concentrate. Daily concentrate production is estimated at 200 tonnes, requiring four daily round-trips using 52-tonne capacity concentrate haul trucks. For their workforce, Kiska estimates three light service trips daily. Crew changes would be either by road or by air.
- According to **On-Line**, the road would need to accommodate truck traffic, fuel haulage, and tractor-trailer rigs (standard commercial loads). If On-Line's project reached production, vehicle traffic would increase and include crew transportation vehicles and possibly larger concentrate haul trucks. On-Line said at present, during exploration, no product is produced from the site. If the project goes into production, concentrate removal down the access road will likely be required, depending on the commodities present. It is not possible at the present time to know the amount, type, and schedule of concentrate removal. For their workforce, On-Line anticipates remote sites, requiring on-site accommodations with fly-in crew changes. Possibly their Beaver Creek site could be a daily commute by crew bus.
- **PacRim** is planning to use air and barge for the Chuitna coal project. Rail and road links were considered, but are uneconomical if self-financed. Due to the project location, PacRim would use a barge option for large equipment. PacRim said coal would not be transported on the road system for export; all coal would be exported directly to ships from the mine site. PacRim said they anticipated 4 to 5 trucks per day for operations purposes. Workforce would be brought in by road and would require 150 round trips per week if private vehicles were allowed, far fewer if crew buses were used.
- **Apache** suggested giving the road an industrial classification. Apache said they have no concentrate or finished product, but they would hope to transport gas and oil by pipeline. There are no estimated volumes at this time. Operations would be years away.

- **Millrock** said during the exploration phase, typical vehicles on a roadway would be pick-up trucks and standard commercial loads. If the project reached production, vehicle traffic would increase and include crew transportation vehicles and possibly larger concentrate haul trucks. Millrock said at present, during exploration, no product is produced from the site. If the project goes into production, concentrate removal down the access road will likely be required, depending on the commodities present. For workforce access, Millrock anticipates an operation like Red Dog, with fly-in crew changes.
- **Linc Energy** said standard vehicles would be used for the bulk of their operations. Linc Energy said during construction of their plant facilities, there would be an expected need for large, non-divisible overweight loads; however, many of these would be brought by ocean-going ships and off-loaded close to the project area, minimizing distance traveled over the road system. Linc Energy said three products will be produced and all are expected to be transported off site by pipeline. The first product is UCG syngas transported to processing facilities on site or put into existing pipelines. Approximately 50 bcf/yr production is anticipated. The second product will be a synthetic fuel produced from the syngas, with estimated production ranging from 5,000 to 20,000 bbl/day. Final product would be CO2 gas for enhanced oil recovery on the order of 7,000 or more tonnes per day. Linc Energy said they would prefer site access by road. During the peak construction phase, they said they could potentially have 1,000 people on site, but even during operations they would expect 200 persons on site. Access likely would be by crew cabs, rather than individual vehicles, but they said nothing is definite at present. Anticipated traffic is a function of number of persons on site and means of access.
- **Aurora** said the rig they move requires permit loads with a safety index of at least 200,000 load capacity for a single load.
- **Cook Inlet Energy** said typical vehicle types include tank trucks, drill rigs, cat machinery, and pick up trucks. Cook Inlet Energy said their drill rigs are at 95,000 pounds load weight. Cook Inlet Energy said their natural gas and/or oil would be transported by pipeline. Drilling waste would leave in sacks or bags. Cook Inlet Energy said the drilling and construction phases will have more traffic than the operations phase. Crews will either be local or arrive via air. But, if a road were available, they may drive in from Tyonek or the Matanuska-Susitna Valley. Cook Inlet Energy has been actively improving and expanding a gravel road and pad system in the Olson Creek / Otter area, including a gravel pit and a new bridge across Olsen Creek.

5.2 Additional Engineering Considerations

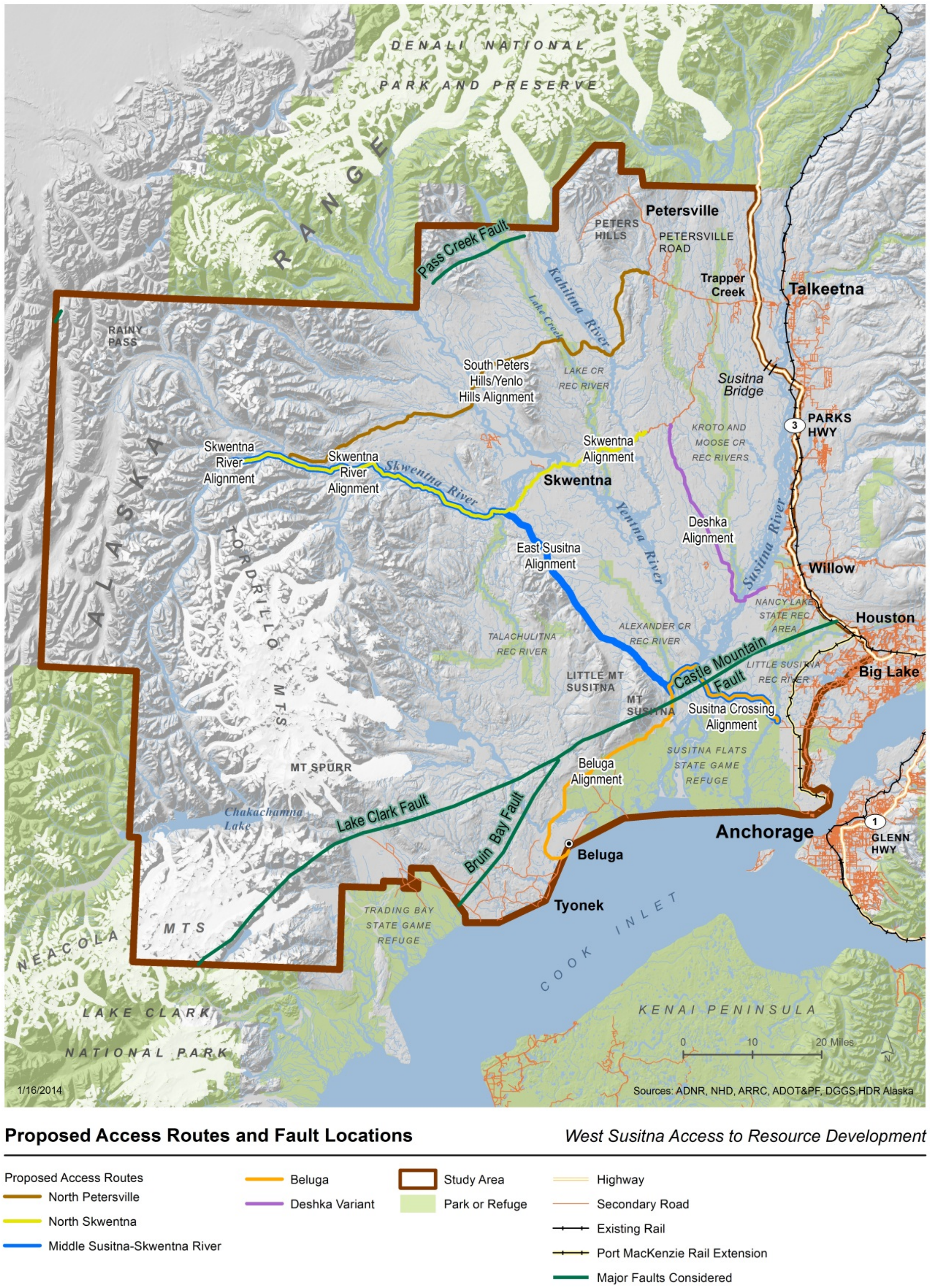
5.2.1 Seismicity

The Study Area is located in one of the most seismically active areas in the U.S. and is historically subject to relatively large earthquakes. Figure 5-2 depicts the fault locations in the Study Area. Within the Study Area, the Castle Mountain fault is located on the southern end of the Susitna lowlands. The Bruin Bay fault is also found in the Study Area; however, it is not considered an active fault system. The Bruin Bay fault is located along the base of Mount Susitna and trending northwest toward Beluga Mountain along the mountain front. The Lake Clark fault runs along the southeastern portion of the Study Area; it is not considered to be active. The relatively recent Pass Creek fault is centrally located in the Susitna lowlands with northeast to southwest trending surface expressions mapped west of Mt. Yenlo and the Kahiltna River.

If faulting is present and becomes active, seismicity could cause displacement along the roadway or associated structures. The potential for strong ground motions or associated liquefaction and slope failure should be a consideration in road location because some of these faults are considered to be Quaternary and active and are relevant to development and hazards mitigation. Additional explorations and evaluation should be conducted to more accurately locate or identify a fault in this location so that the alignment and associated features can be positioned so as not to straddle both sides of the fault's surface expression. Additionally, DNR-DGGS recommends that a neotectonic study may be required to map active surface traces of faults and to evaluate the local ground motions that may be generated by significant events. DGGS also recommends the scope of such a study should cover liquefaction, tectonic folding or warping of the ground surface, as well as secondary tectonic ground deformation (i.e., slope stability, lateral spread, and rock fall).[152]

[152] DNR-DGGS. October 8, 2013. Comments provided during a review of a draft of this report.

Figure 5-2. Proposed Access Routes and Fault Locations



5.2.2 Hydrologic Considerations

Hydrology data are limited for the Study Area (other than near the Susitna River), likely a result of the relatively undeveloped and remote nature of the area. The Susitna River aside, creek crossings were identified from USGS mapping and Google Earth™. Bridge lengths were measured off Google Earth™, and quite often the imagery was fuzzy, so the bank-to-bank widths are estimates. Also, many of the small rivers or creeks are in a braided channel; the actual river or creek may only occupy a small fraction of the width of the channel. Bank-to-bank width was measured for the braided channels. Each proposed access route crosses major rivers and numerous drainages, requiring multiple bridge structures and culverts.

The hydrology of the Susitna River is fairly well documented. The location of the crossing over the Susitna River considered a number of hydrological factors, as discussed earlier in Section 4.3. The crossing of the Susitna River considered the floodplain extent. However, due to the hydrologically active nature of the region, the DNR-DGGS recommends obtaining current imagery and LIDAR to conduct a cursory flood hazard evaluation. Though beyond the scope of this reconnaissance-level study, additional hydrologic considerations that should be further considered include potential basin responses to intense storms, glacio-fluvial controls, sediment mobilization, and landslide and debris flows, particularly in regard to how these might affect road infrastructure.[153]

Construction, and likely maintenance, of the road will require nearby water sources. During construction of the access road, water will be necessary for both dust control and aggregate compaction. The construction contractor will request a permit to pump water from a waterbody (such as a nearby creek or lake) that can sustain the draw-off of the water. After the road is constructed, the need for water will no longer exist unless a large repair area forms and the maintenance crew does not have its own source of water needed to compact the aggregate. If the road design requires seeding the sideslopes of the road, water would be required to keep the grass growing until it is accepted as self-sustaining. In the event that ice roads are used, sprayers would be required to build up the ice thickness until there is enough to support the anticipated loads. Maintenance would only be required after the ice road is damaged through melting.

5.2.3 Geological and Geotechnical Considerations

Numerous glaciers are found in the Alaska Range and extend down valleys to near the edges of the lowlands. Glacially carved bedrock, moraines, drumlins, and kettle lakes are some of the landforms in the Study Area that are constantly being reshaped by continuous erosional processes.

Regional geologic processes will have a substantive impact on the design and performance of transportation infrastructure in the Study Area. Such processes include stream icing, slope instability, flooding (through precipitation, liquefaction, lateral spreading, etc.). Many of these processes are complementary and should be evaluated separately as well as in relation to each other. The Study Area is likely subject to most, if not all, of these regional processes; however, some areas may be more prone than others. In general, the flooding, icing, and seismic influences will be more prevalent in low-lying areas and in areas near streams and floodways. Glacial outburst flooding will be difficult to predict, but can influence areas well outside of natural river floodways for relatively large distances below existing glaciers. Seismic influences will also more significantly impact areas adjacent to or on sloping ground, with greater severity on steeper gradients.

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[153] DNR-DGGS. October 8, 2013. Comments provided during a review of a draft of this report.

Rock Borrow Availability

Rock material source 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, including embankment development, concrete and/or asphalt aggregate, revetment, and surfacing material. The proximity of the rock materials is important because the distance that the material will need to 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 reach potential sources, which would also have an impact on the cost of the improvements and 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 require minimal development of branch roads to access them.

Rock Borrow Quality

Borrow rock quality addresses the rock material types available along each corridor for construction of the road and associated facilities. Rock material quality is important to the project because some of the uses for the material will require it to be durable (i.e., resistant to mechanical degradation). In general, rock material used in the construction of this project will need to meet the various durability requirements set forth in DOT&PF standards, depending on its application (aggregate, rip-rap, etc.). 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, as well as 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 construction costs by reducing the need to import higher durability materials from long distances.

Soil Borrow Availability

Soil borrow source 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, bridges, and in utility trenches. As with rock material sources, the proximity of the soil borrow sources 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 so that additional branch roads are not needed for access.

Soil Borrow Quality

Borrow soil quality addresses the soil material types available in the soil borrow sources along each corridor. While soil availability is important, the quality of the available material will also impact the cost of the project. Ideally, soil borrow used for this project will consist of clean (low fines content), well-graded sand and gravel. Such 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 deposits) may also be utilized, but their applications will be limited to deep embankment development. Regardless of the gradation of the soil fill used, it should not contain free ice, organic detritus, or a significant amount of plastic fines. Higher quality soil borrow resources along the project corridor will help reduce 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.

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, the deeper the foundation systems must 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 fewer materials and less 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.

Permafrost Conditions

Permafrost 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 under and around the new road. Based on the location of this project, it is likely that the majority of the ground beneath each alignment is not frozen continuously throughout the year. If permafrost conditions exist in a given area, it is more favorable if the soil consists of materials that do not lose a significant amount of strength when 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 no measures (such as insulation and refrigeration) will need to be taken to maintain the thermal balance under the roadway and associated structures.

Subgrade Support

Subgrade support addresses the general support capabilities of the subsurface materials along each corridor considered for this project. 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.

Drainage

Drainage addresses the general surface and near-surface drainage characteristics of each corridor considered for this project. 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.

5.3 Proposed Access Routes

The proposed access routes are described in this section and engineering considerations are summarized in Table 5-2. Depending on the priority, availability and timing of access needs, multiple routes could be chosen and combined or added to other routes in subsequent phasing. For example, the destination for the Middle Susitna-Skwentna River route is the mining area in the Tordrillo Mountains. If this route was selected and then later access to Beluga was desired, an approximate 38-mile alignment branching from the Middle Susitna-Skwentna River route could be added for an additional approximate $103 million.

Table 5-2. Proposed Access Routes Engineering Considerations Summary

	North Petersville Road	North Skwentna	Middle Susitna-Skwentna River	Beluga	Deshka Variant
Alignment combination	South Peters Hills/ Yenlo Hills	Skwentna Skwentna River	Susitna Crossing East Susitna Skwentna River	Susitna Crossing Beluga	Deshka
General origin	Petersville Rd	Oil Well Rd	Little Su River Rd	Little Su River Rd	Willow area
General destination	Upper Skwentna mineralized area	Upper Skwentna mineralized area	Upper Skwentna mineralized area	Beluga/ Tyonek	Area south of Oil Well Rd
Length (miles)	78.8	71.6	107.9	63.8	33.5
Bridges (#)					
Conventional [1]	9	12	20	11	1
Long Span[2]	4	6	4	2	2
Total	13	18	24	13	3
Bridges (>1,000 feet)	1,150 (Yentna)	1,200 (Yentna) 1,200 (Hayes)	1,200 (Hayes) 1,640 (Susitna)	1,640 (Susitna)	1,200 (Susitna)
Culverts (#)					
Large [3]	12	12	14	6	2
Small [4]	37	26	40	12	11
Minor Drainage [5]	316	292	440	260	136
Cost Estimate (millions)					
Subtotal[6]	$147.6	$188.3	$187.4	$106.9	$72.2
Total [7]	$376.4	$504.3	$453.2	$257.8	$216.9
Total per mile [8]	$4.6	$6.3	$4.2	$4.0	$5.2

Assumptions:

[1] Conventional bridges are considered less than 300 feet in length.

[2] Long span bridges are 300 feet or longer.

[3] A culvert approximately 96 feet or longer.

[4] Small culverts and minor drainage culverts have an assumed length of approximately 50 feet.

[5] An additional four culverts per mile to accommodate minor drainage patterns.

[6]Subtotal cost estimate for new proposed roadways includes clearing, earthwork, structures, stream and river crossings (including culverts), guardrail and retaining walls, and miscellaneous items such as topsoil, seeding, geotextile and signing.

[7] Total cost estimate includes drainage measures, erosion and pollution, surveying, environmental studies and permits, existing road upgrades, construction, mobilization, ROW acquisition, contingency, design, and utilities.

[8] Total per mile cost includes only the proposed access routes and does not include existing roadways or cost to upgrade them.

5.3.1 North Petersville Access Route

The 78.8-mile North Petersville access route would originate from the existing Petersville Road and end in the mining area north of the Tordrillo Mountains. See Figure 5-3. This route consists of the South Peters Hills/Yenlo Hills alignment, as described in Section 1.1.1. From Petersville Road, the route would cross a number of major rivers and travel through the Lake Creek and Kroto and Moose Creek Recreation Rivers.

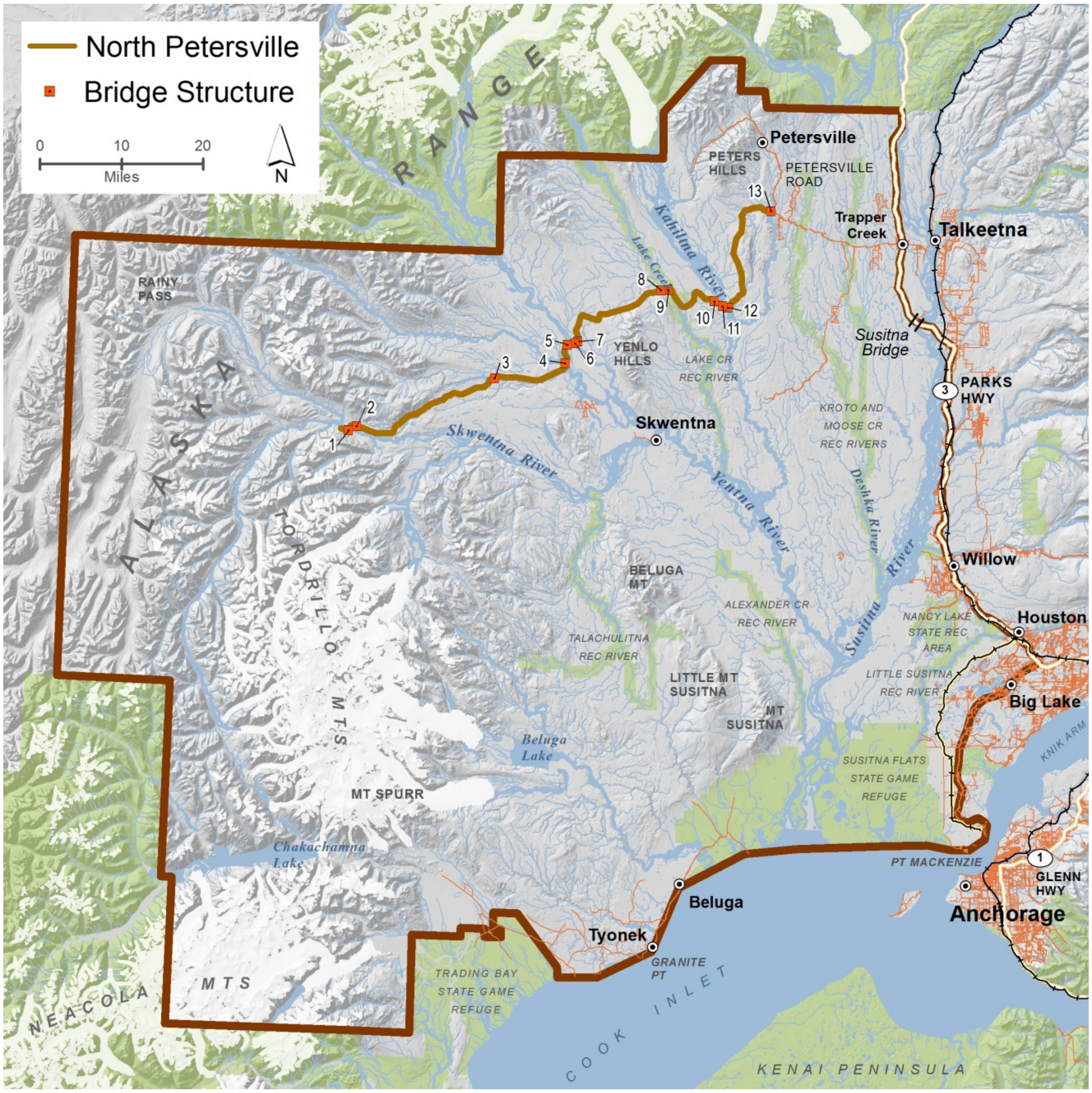
The North Petersville access route generally trends east to west and typically follows topographic highs where possible. Much of the eastern two-thirds of the route is characterized by low (less than 100 feet tall) topographical highs, separated by low, poorly drained, boggy areas. Given the variable terrain, it is anticipated that drainage along the route is generally good except for the interspersed wetland areas that will be crossed. The potential for permafrost along this route is likely the greatest in comparison to other routes in this study. Permafrost soils can be expected in higher elevations and on the north side of topographic high areas. Some of the low, poorly drained, boggy areas may also be underlain by permafrost soils.

The route would require the following 13 bridge structures, as numbered on the associated figure:

1. 500-ft over Skwentna River
2. 30-ft over an unnamed creek
3. 220-ft over Johnson Creek
4. 400-ft over Kitchatna River
5. 1,150-ft over Yentna River
6. 120-ft over Donkey Creek Slough
7. 80-ft over Donkey Creek
8. 40-ft over an unnamed slough
9. 280-ft over Lake Creek
10. 50-ft over Shovel Creek
11. 50-ft over an unnamed creek
12. 420-ft over Kahiltna River
13. 170-ft over Peters Creek

Compared to other route options, this route provides access to an average amount of resources, as shown in Table 6-1.

Figure 5-3. North Petersville Proposed Access Route



5.3.2 North Skwentna Access Route

The 71.6-mile North Skwentna access route would originate from the existing Oil Well Road and end in the mining area north of the Tordrillo Mountains. See Figure 5-4. This route combines the Skwentna and Skwentna River alignments, as detailed in Section 1.1.1. This route goes through the Lake Creek and Talachulitna Recreation Rivers.

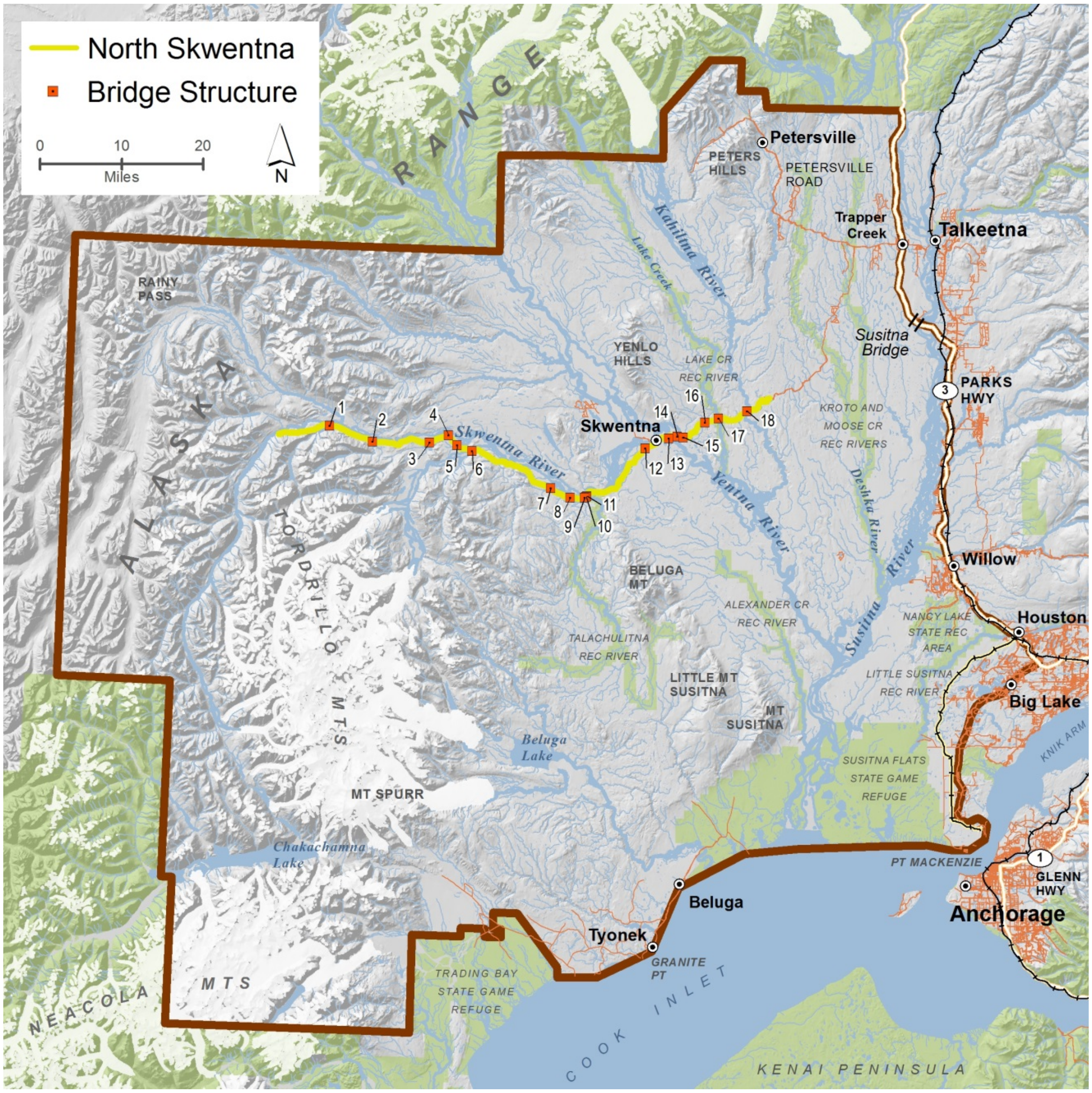
The eastern portion of this route (Skwentna alignment) generally runs east-west along lowlands around the Yentna and Skwentna Rivers. Low-lying, boggy areas are very prevalent along this portion. Subgrade support is anticipated to be highly variable, and drainage in the boggy areas may be a challenge in design and construction. The route crosses the Skwentna River and traverses well-drained, alluvial terraces between the Skwentna River and the mountainous terrain. Permafrost soils are not anticipated to be encountered along the eastern portion of the route, whereas they might be encountered as the route comes within close proximity to the mountainous terrain.

The route would require the following 18 bridge structures, as numbered on the associated figure:

1. 300-ft over Chickak River
2. 440-ft over Old Man Creek
3. 90-ft over Red Salmon Creek
4. 200-ft over an unnamed slough
5. 250-ft over an unnamed slough
6. 1,200-ft over Hayes River
7. 250-ft over Canyon Creek
8. 50-ft over an unnamed slough
9. 90-ft over an unnamed slough
10. 60-ft over an unnamed slough
11. 250-ft over Talachulitna River
12. 80-ft over Eightmile Creek
13. 1,200-ft over Yentna River
14. 80-ft over an unnamed creek
15. 320-ft over an unnamed slough
16. 160-ft over an unnamed slough
17. 270-ft over Lake Creek
18. 450-ft over Kahiltna River

Compared to other routes, this route provides access to the greatest number of acres of hardrock mineral resources. This route also provides access to a great number of forestry/timber resources.

Figure 5-4. North Skwentna Proposed Access Route



5.3.3 Middle Susitna-Skwentna River Access Route

The Middle Susitna-Skwentna River access route would originate from the existing Little Susitna River Road and end in the mining area north of the Tordrillo Mountains. See Figure 5-5. Nearly 108 miles long, this is the longest access route proposed in this study. This route combines three alignments (Susitna Crossing, East Susitna, and Skwentna River), as detailed in Section 1.1.1. This route goes near the Susitna Flats State Game Refuge and the Alexander Creek, Talachulitna, and Little Susitna Recreation Rivers.

The western portion of this route (the Susitna Crossing alignment) travels east-west, with existing mapping showing the route crossing almost exclusively glacial moraine and kame deposits except for alluvial terrace deposits adjacent to Alexander Creek and the Susitna River. Based on USGS mapping, the land between the Little Susitna and Susitna Rivers contains many scattered, low-lying, poorly drained, boggy areas. To the west of the Susitna River crossing, mapping indicates the route (East Susitna alignment) goes through soil deposits that are variable ranging from glacial tills, outwash, and isolated alluvial deposits, which should yield a variety of soil materials with variable quality. The route then traverses well-drained, alluvial terraces between the Skwentna River and the mountainous terrain (Skwentna River alignment). Permafrost is not anticipated in the eastern portion of this route, but may be encountered in the mountainous terrain to the west of the Susitna River.

The route would require the following 24 bridge structures, as numbered on the associated figure:

1. 300-ft over Chickak River
2. 440-ft over Old Man Creek
3. 90-ft over Red Salmon Creek
4. 200-ft over an unnamed slough
5. 250-ft over an unnamed slough
6. 1,200-ft over Hayes River
7. 250-ft over Canyon Creek
8. 50-ft over an unnamed slough
9. 90-ft over an unnamed slough
10. 60-ft over an unnamed slough
11. 250-ft over Talachulitna River
12. 20-ft over an unnamed creek
13. 50-ft over Deep Creek
14. 50-ft over Clear Creek
15. 40-ft over Bear Creek
16. 50-ft over Upper Sucker Creek
17. 80-ft over Wolverine Creek
18. 200-ft over Alexander Creek
19. 150-ft over Anderson Creek
20. 1,640-ft over Susitna River
21. 30-ft over an unnamed slough
22. 30-ft over an unnamed slough
23. 30-ft over Fish Creek
24. 170-ft over Little Susitna River

Due to the length of this route, this route provides access to the greatest number of claims and acreages of a number of resources, including hardrock minerals, placer gold mining claims, and forestry/timber resources. See Table 6-1.

Figure 5-5. Middle Susitna-Skwentna River Proposed Access Route

5.3.4 Beluga Access Route

The Beluga access route would originate from the existing Little Susitna River Road and end near Beluga. Approximately 64 miles in length, this is the shortest access route proposed in this study (other than the Deshka variant, which is only 33.5 miles long). See Figure 5-6. This route combines the Susitna Crossing and Beluga alignments, as further described in Section 1.1.1. This route runs through the Susitna Flats State Game Refuge and the Alexander Creek and Little Susitna Recreation Rivers.

The western portion of this route (the Susitna Crossing alignment) travels east-west, with existing mapping showing the route crossing almost exclusively glacial moraine and kame deposits except for alluvial terrace deposits adjacent to Alexander Creek and the Susitna River. Based on USGS mapping, the land between the Little Susitna and Susitna Rivers contains many scattered, low-lying, poorly drained, boggy areas. Once west of the Susitna River, the ground traversed by the route appears to be relatively well-drained, except for the far southwest end of the alignment near the Beluga River. The Castle Mountain fault is mapped in this area and appears to follow a significant portion of the route west of the Susitna River. Permafrost soils are not anticipated along this route.

The route would require the following 13 bridge structures, as numbered on the associated figure:

1. 650-ft over Beluga River
2. 50-ft over Olson Creek
3. 150-ft over Theodore River
4. 210-ft over Lewis River
5. 40-ft over Granite Creek
6. 40-ft over Pierce Creek
7. 200-ft over Alexander Creek
8. 150-ft over Anderson Creek
9. 1,640-ft over Susitna River
10. 30-ft over an unnamed slough
11. 30-ft over an unnamed slough
12. 30-ft over Fish Creek
13. 170-ft over Little Susitna River

Compared to other routes, this route provides access to the highest number of acres of coal resources and second highest acreage of oil and gas resources.

Figure 5-6. Beluga Proposed Access Route

5.3.5 Deshka Variant Access Route

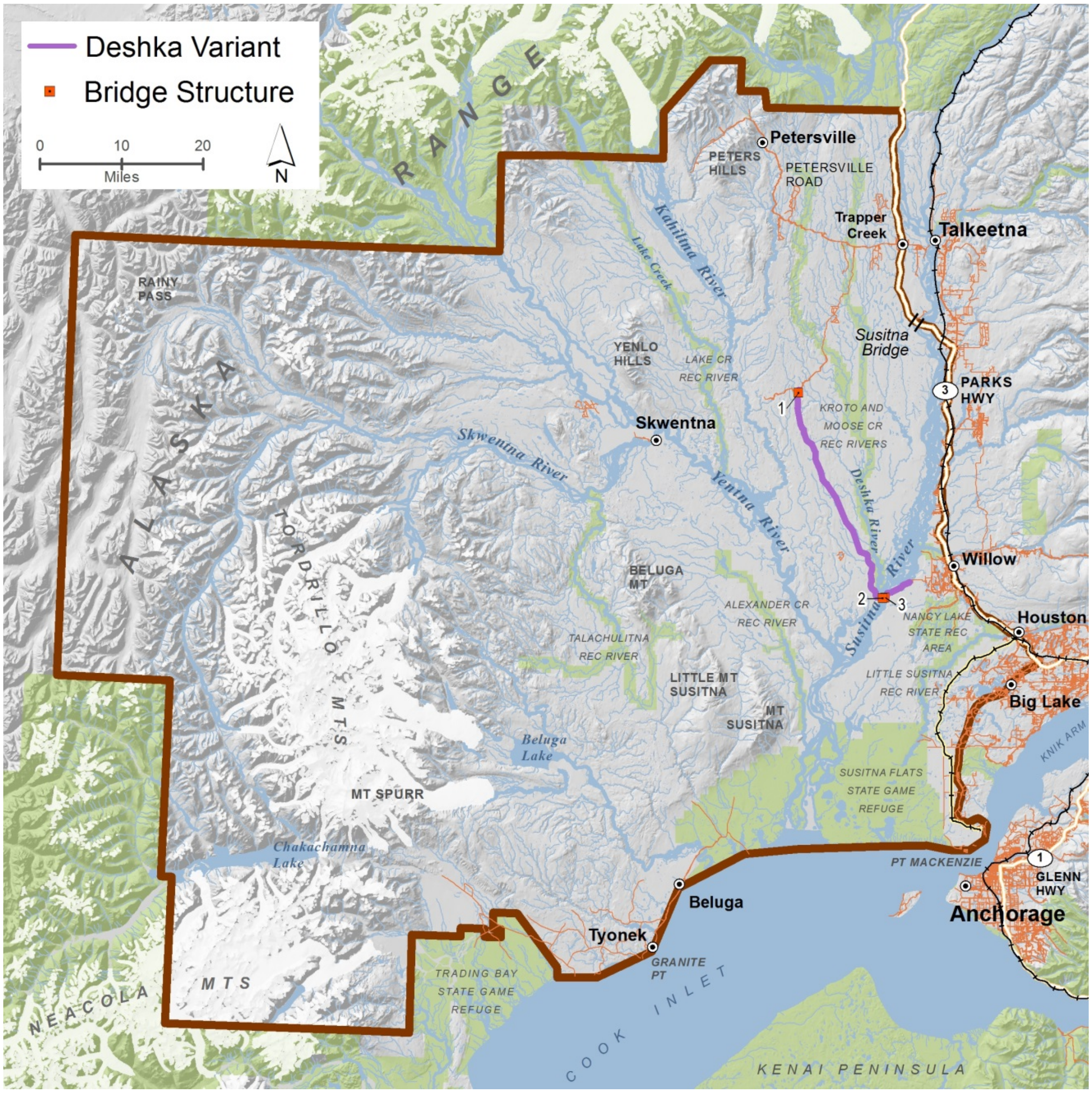
The 33.5-mile Deshka variant access route was included to provide access near existing infrastructure and specifically to potential agricultural and timber lands. See Figure 5-7. This variant originates near Deshka Landing, west of Willow, and traverses north to the existing Oil Well Road. Section 1.1.1 details this further. This route runs near the Kroto and Moose Creek Recreation Rivers as well as the Nancy Lake and Willow Creek State Recreation Area.

In general, this route follows relatively low relief ridges (less than 50 to 100 foot tall) that parallel the Deshka River. The variant would require two bridge structures over the Susitna River and one additional structure over an unnamed creek, as depicted on the associated figure.

1. 20-ft over an unnamed creek
2. 1,200-ft over Susitna River (Susitna River Bridge #2)
3. 900-ft over Susitna River (Susitna River Bridge #1)

Compared to other routes, this variant provides access to the most amounts of acres of oil and gas permit/leases and potential agricultural areas. It provides access to the least amount of hardrock minerals and coal acres.

Figure 5-7. Deshka Variant Access Route



5.4 Preliminary Cost Estimates

Preliminary cost estimates were prepared using the reconnaissance-level engineering and DOT&PF bid tabs for the Northern Region. Where data for a particular item was not available, similar information from the DOT&PF Central Region was used. Using the National Highway Construction Cost Index (NHCC) published by the Federal Highway Administration (FHWA), the average unit prices were adjusted from their date of bidding to 2013 dollars. Once all of the average unit prices had been normalized to 2013 dollars, they were plotted to determine whether a trend existed within the data set. For many of the items, a distinct trend emerged and made it possible to estimate the unit price as a function of the item quantity. Due to the scale of the project, quantities for some items exceeded the quantities for any of the available historic bid tab data. In these cases, the unit price for the highest quantity on record was substituted as a conservative estimate. Unit prices were rounded to the nearest cent. Figure 5-8 and Table 5-3 presents the preliminary cost estimates with assumptions following the table. See Appendix D for additional cost estimate details.

Figure 5-8. Reconnaissance-Level Total Cost Estimate Comparison

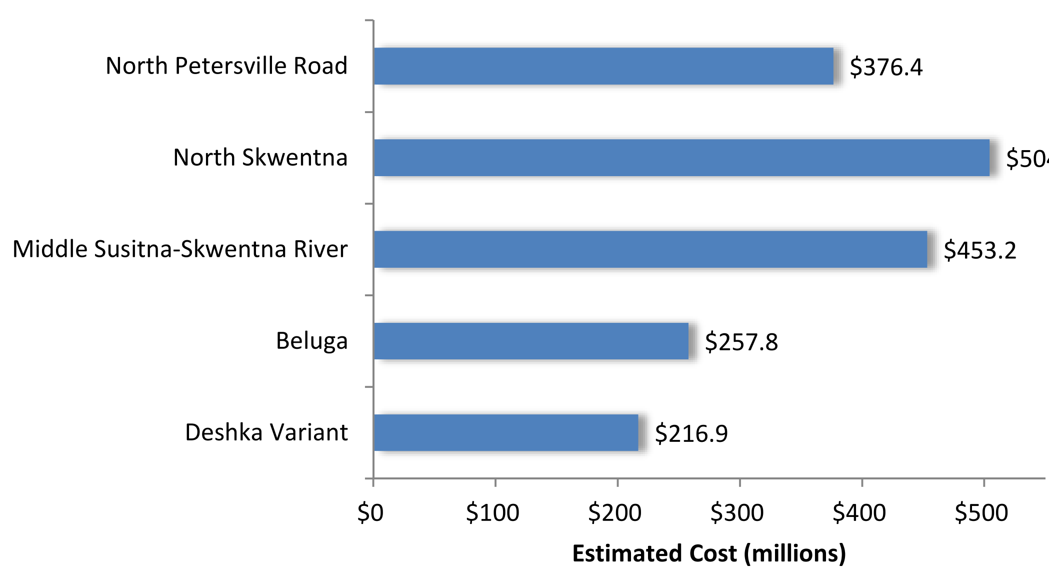


Table 5-3. Preliminary Cost Estimates (in millions)

	North Petersville Road	North Skwentna	Middle Susitna-Skwentna River	Beluga	Deshka Variant
Clearing	$2.2	$2.0	$2.7	$1.5	$0.73
Earthwork	$29.4	$29.3	$26.4	$9.9	$3.7
Structural Section	$15.9	$14.5	$21.9	$12.9	$6.8
Stream/River Crossings (includes bridges and culverts)	$83.7	$125.9	$119.4	$74.9	$57.3
Miscellaneous	$16.3	$16.6	$17.0	$7.6	$3.7
Subtotal	*$147.6*	*$188.3*	*$187.4*	*$106.9*	*$72.2*
Drainage Measures	$14.8	$18.9	$18.8	$10.7	$7.3
Erosion and Pollution	$4.5	$5.7	$5.7	$3.3	$2.2
Surveying	$4.5	$5.7	$5.7	$3.3	$2.2
Construction Traffic Control	$7.4	$9.5	$9.4	$5.4	$3.7
Contractor Furnished	$1.5	$1.9	$1.9	$1.1	$0.8
Mobilization (10%)	$14.8	$18.9	$18.8	$10.7	$7.3
Subtotal	*$195.1*	*$248.9*	*$247.7*	*$141.4*	*$95.7*
Contingency (30%)	$58.5	$74.7	$74.3	$42.4	$28.7
Construction Subtotal	*$253.6*	*$323.6*	*$322.1*	*$183.9*	*$124.5*
Environmental study/ permitting (3%)	$7.6	$9.7	$9.6	$5.5	$3.7
Construction Administration (15%)	$38.1	$48.6	$48.4	$27.6	$18.7
Project Camp (2%)	$5.1	$6.5	$6.5	$3.7	$2.5
Subtotal	*$304.4*	*$388.4*	*$386.7*	*$220.7*	*$149.4*
Design (10%)	$30.5	$38.9	$38.7	$22.1	$15.0
Utilities (0.5%)	$1.6	$2.0	$2.0	$1.2	$0.8
ROW	$5.7	$1.4	$4.2	$1.5	$0.05
Subtotal	*$342.2*	*$430.7*	*$431.6*	*$245.5*	*$165.3*
ICAP	$17.1	$21.5	$21.6	$12.3	$8.3
TOTAL for new access routes	**$359.4**	**$452.3**	**$453.2**	**$257.8**	**$173.6**
Existing road upgrades	$17.0	$52.0	$0	$0	$43.3
TOTAL	**$376.4**	**$504.3**	**$453.2**	**$257.8**	**$216.9**
*Total per mile for new roadway **	*$4.6*	*$6.3*	*$4.2*	*$4.0*	*$5.2*

* Total per mile includes only the proposed access routes and does not include existing roadways or cost to upgrade them.

5.4.1 Assumptions for Cost Estimate Development

Once the unit price-quantity relationships were established, they were applied to planning level quantities to calculate and estimate the cost for each item. Additional assumptions were made in applying engineering judgment to many items that will not be directly measured at this stage of the project. The assumptions for each item are as follows.

Clearing

Assuming an average embankment width of 40 feet plus an additional 10 feet on either side, the clearing quantity is estimated at 7.3 acres per mile for all three terrain classifications.

Unclassified Excavation

Due to the coarseness of the available terrain data, modeling earthwork over representative sections gives a rough estimate at best. Instead, representative cross sections were drawn for each terrain type. In each typical section the roadway template remains constant but the terrain cross slope is varied as follows; 10% for level, 25% for rolling, 40% for mountainous. The resulting excavation and embankment cross section areas were then used as the basis for the per mile quantity. The portions of the alignment crossing each terrain type were added together then were multiplied by the respective quantity in that terrain type to arrive at the total quantity.

Embankment Borrow C

The quantities for embankment were estimated for each terrain type as described above. The large embankment quantity is an example of an item where quantity relevant cost information was unavailable from the bid tab data. In this instance the unit price for the largest quantity on record was used as a conservative estimate. This item also varies per mile cost based on terrain.

Borrow A and Aggregate Surface Course

These items have a constant quantity per mile across all terrain types using a roadway top width of 24 feet. The depth of Borrow A is 48 inches and aggregate surface course was estimated at a thickness of 4 inches.

Bridges

A width of 26 feet was assumed for all roadway bridges to accommodate the 24-foot top and bridge railing. Bridges were subdivided into two categories; conventional and long span. Both unit prices were based on engineering construction experience with recent projects in Alaska and the Lower 48. Lengths for each structure were estimated from USGS topographic maps and aerial photography and the proposed crossing geometry. Conventional bridges assume deck bulb-T construction which is very common throughout Alaska at a cost of $350 per square foot. Bridges 300 feet or more are considered long span bridges. Recent national projects indicate that building such structures in fairly rugged conditions and remote areas warrants a cost of $1000 per square foot.

Culverts

Following a preliminary assessment of visible stream crossings using USGS topographic maps and aerial photography, culvert types were subdivided into three categories: large culverts, small culverts and minor drainage culverts. An assumed culvert length of approximately 50 feet to daylight on either side of a four foot embankment with 2:1 side slopes was used for both the minor drainage culverts and small culvert classification. To account for the deeper embankments associated with large culverts, a culvert length of approximately 96 feet was used to daylight on either side of a 20 foot embankment with 2:1 side slopes. The unit prices for the two categories of culvert are based on project experience in Southcentral Alaska.

ADF&G, Division of Habitat, provided the following initial input regarding culverts and bridges affecting anadromous fish streams. Pursuant to AS 16.05.841 and AS 16.05.871, (1) the preferred route should be sited to minimize the number of stream crossing(s) to the extent practical; (2) bridge construction is preferred over culvert installation for stream crossings greater than 20 feet in width; and (3) any culvert installation in fish-bearing waters should use a stream simulation design criteria to ensure the upstream and downstream movement of fish is maintained.

Retaining Walls

To reduce earthwork quantities in mountainous terrain gabion retaining walls were assumed. It is assumed that 0.25 of each mile in mountainous terrain will require walls on one side of the roadway. The average height of these walls is assumed to be 10 feet.

Guardrail

It is assumed that guardrail will only be needed along half of each mile of mountainous terrain. The number of end sections required is calculated on the assumption that the average length of each guardrail segment is 250 feet.

Topsoil and Seeding

Topsoil and seeding were estimated at 4.84 acres/mile. This represents an average of 20 feet of topsoil and seeding on either side of the edge of gravel.

Geotextile Fabric

Geotextile fabric will be required in areas with permafrost or soft soils. It has been assumed that permafrost and soft soils will be encountered in 25 percent of level terrain and 15 percent of rolling terrain areas.

Signing

Signing for this project is assumed to minimal due to its backcountry nature. $1000/lane-mile has been assumed to cover these costs.

ROW

An average cost per acre to acquire ROW was developed for each route based on comparable State sales closest to the proposed access routes. For each route, the road length was multiplied by a presumed 200 foot wide ROW to calculate the total number of acres needing to be acquired. (The 200-foot ROW width is a preliminary placeholder, and depending upon the route, access and staging needs, may require more or less than the 200 feet width). An average cost per acre based on comparative sales in the vicinity of the access route was multiplied by the total number of acres to get a ROW acquisition cost estimate for each route.

Table 5-4. Preliminary ROW Acquisition Cost Estimates

	North Petersville Road	North Skwentna	Middle Susitna-Skwentna River	Beluga	Deshka Variant
Acres to be acquired [1]	1910.3	1735.8	2615.8	1551.5	812.1
State sale comparable close to access route per acre	$3,100 $3,100 $1,943	$481 $960 $702	$1,943 $1,493 $962	 $962 $815	$1,143 $1,298 $1,159
Subtotal average cost per acre	$2,714	$715	$1,466	$889	$1,200
Total average cost per acre [2]	$3,000	$790	$1,600	$980	$1,320
Total ROW acquisition cost	$5.7 million	$1.4 million	$4.2 million	$1.5 million	$45,000

[1]Route length multiplied by a 200 foot ROW

[2]Total average cost per acre is rounded and includes 10% inflation.

A more detailed title search should be conducted in a subsequent phase should this project move forward. The acquisition cost does not take into account the cost (in time) to acquire the ROW.

Environmental/Permitting

A 3% line item was included to incorporate the costs to conduct some environmental baseline studies and coordinate permit acquisition.

Existing Road Upgrades

Two proposed West Susitna access routes would likely necessitate the need to upgrade two existing roadways: Petersville Road and Oilwell Road. The North Petersville Road access route branches off from milepost (MP) 18 of Petersville Road.[154] For the North Skwentna access route and Deshka Variant, Oilwell Road would need to be upgraded. Oilwell Road branches off from MP 6 of Petersville Road and continues for approximately 17 miles before becoming more of a trail than a road. Roadway conditions along these two roads vary greatly and are not fully known without field-verifying the conditions. Assumptions are inferred regarding these two roadways and required upgrades.

Petersville Road is classified as a minor collector road that is approximately 37 miles long. The DOT&PF maintains a portion of Petersville Road. Based on conversations with DOT&PF staff and professional judgment, we have assumed the first approximate 9.5 miles are paved and would require little to no upgrade. This paved portion is assumed to be 24-feet wide with gravel shoulders. No culvert information for this roadway segment is available at this time.

Between MP 9.5 and 18 of Petersville Road, the roadway is dirt and the road top ranges between 18-feet to 24-feet wide. For cost estimate purposes, we have assumed the existing roadway top averages 21-feet wide and would need to be widened to the proposed width of 24 feet. Along this 8.5-mile stretch, one 105-foot bridge would need to be replaced and we assumed six minor drainage culverts

[154] MP locations are approximate

would be needed per mile. Other assumptions include: no clearing; one-third of the existing embankment should be replaced with Borrow C and one-third of Borrow A would be replaced.

Oilwell Road conditions vary significantly and much of the existing conditions are unknown. The MSB maintains the first 12.5 miles of this roadway, with additional minor maintenance of the "trail" between MP 12.5 and MP 15, the site of the Kroto Creek bridge. According to MSB maintenance personnel, beyond MP 15 is a mere trail and how far it extends is unclear.[155]

To prepare cost estimates for upgrading this road, Oilwell Road was broken down into four segments: (1) MP 0-12.6, (2) 12.6-16.76, (3) a 5.1-mile extension, and (4) a second extension by 4.7 miles. The North Skwentna access route would require all four Oilwell Road segment upgrades, while the Deshka Variant branches off slightly early and would only require the three segment upgrades. Assumptions for upgrading the four Oilwell Road segments are as follows:

- **MP 0-12.6:**
    - The total cost estimate for upgrading this segment is approximately $20.7 million, or about $1.6 million per mile.
    - 25% of the length requires clearing
    - Includes rebuilding road, new embankment and all new structural section
    - Replaces three bridges that are the following length: one that is 65 feet and two that are 35 feet
    - Assumes six minor drainage culverts per mile
- **MP 12.6-16.76:**
    - The total cost estimate for upgrading this segment is approximately $11.3 million, or about $2.7 million per mile.
    - 50% of length requires clearing
    - Includes rebuilding road, new embankment and all new structural section
    - Replaces two bridges: one 75-feet long and one 45-feet long
    - Assumes six minor drainage culverts per mile
- **5.1-mile road extension**
    - The total cost estimate for upgrading this segment is approximately $11.3 million, or about $2.2 million per mile.
    - 50% of length requires clearing
    - Includes rebuilding road, new embankment and all new structural section
    - No bridges are needed along this segment
    - Assumes six minor drainage culverts per mile
- **4.7-mile road extension** *(required only for the North Skwentna access route)*
    - The total cost estimate for upgrading this segment is approximately $8.7 million, or about $1.8 million per mile.
    - 50% of length requires clearing
    - Includes rebuilding road, new embankment and all new structural section
    - No bridges are needed along this segment
    - Assumes six minor drainage culverts per mile

155 MSB. December 2013. Personal communication with MSB roads maintenance staff Mike Lachelt

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