AMBLER MINING DISTRICT INDUSTRIAL ACCESS PROJECT

SUMMARY REPORT ADDENDUM

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (cont)

Page

TABLE OF CONTENTS (cont)

FIGURES **Page**

TABLES

TABLE OF CONTENTS (cont)

APPENDIX

LIST OF ACRONYMS

ACEC ..... Areas of Critical Environmental Concern
ADF&G ..... Alaska Department of Fish and Game
AHRS ..... Alaska Heritage Resource Survey
ANILCA ..... Alaska National Interest Lands Conservation Act
ARRC ..... Alaska Railroad Corporation
AWC ..... Anadromous Waters Catalog
BLM ..... Bureau of Land Management
CD ..... compact disk
CCT ..... Construction Cost Trends
CPI ..... Consumer Price Index
CSU ..... Federal Conservation System Units
DEC ..... Alaska Department of Environmental Conservation
DMTS ..... Delong Mountain Transportation System
DNR ..... Alaska Department of Natural Resources
DOT&PF ..... Alaska Department of Transportation and Public Facilities
FY ..... Fiscal Year
GAAR ..... Gates of the Arctic National Park and Preserve
KVNP ..... Kobuk Valley National Park
NHCCI ..... National Highway Construction Cost Index
NRHP ..... National Register of Historic Places
NWR ..... National Wildlife Refuge
USACE ..... United States Army Corps of Engineers
USCG ..... United States Coast Guard
USFWS ..... United States Fish and Wildlife Service
WACH ..... Western Arctic Caribou Herd
WSR ..... Wild and Scenic Rivers

EXECUTIVE SUMMARY

The Ambler Mining District Industrial Access Project proposed to identify, design, and construct a transportation corridor from the Ambler mineral belt to the surface transportation system in Alaska's Interior via the Dalton Highway. Three road corridor alternatives are currently being evaluated as part of the Ambler Road Environmental Impact Statement. The selected corridor is intended to provide surface transportation access to state lands and facilitate exploration and development of mineral resources along the Ambler mining belt.

The original project study area extends from the Ambler mineral belt south to Nenana and from the Dalton Highway to the west coast of Alaska. Initially, eight potential corridors were identified within the project study area. Following desktop studies, field studies, community meetings, and agency coordination, these eight options were reduced to a proposed road corridor (Alternative A) and an alternative road corridor (Alternative B) as presented in the Revised SF299 Consolidated Permit Application submitted June 30, 2016. A third roadway alternative (Alternative C) was subsequently developed through the Ambler Road Environmental Impact Statement process.

This addendum to the Ambler Mining District Access Summary Report prepared by DOWL HKM in 2012 provides comparison of the three roadway alternatives in response to a request for additional data submitted to the Alaska Industrial Development and Export Authority from the Bureau of Land Management on October 18, 2018. As recommended in the data request letter, this document provides a comparison between the three alternatives consistent with the level of effort completed in 2011 and 2012 in support of the Amber Mining District Industrial Access Road. This document evaluates the three corridor alternatives based on the criterion and scoring system used for in the 2012 Summary Report, updated as appropriate based on changes to the proposed roadway design and to reflect current construction costs, based on data collected to date.

Twelve criteria were selected for evaluation based on community discussions and project team preliminary research. These criteria include 1) Corridor Length; 2) Federal Conservation System Units; 3) Wild and Scenic Rivers; 4) Salmon/Sheefish Rivers; 5) Caribou Habitat; 6) Threatened and Endangered Species/Critical Habitat Areas; 7) Wetland Habitats; 8) Availability of Material Sites; 9) Large Bridges; 10) Construction Cost; 11) Maintenance Costs; and 12) Special Considerations. The Wetland Habitats criterion has been left blank pending final mapping of Alternative C. The results of this evaluation are summarized in Tables ES-1 through ES-8.

The preferred road corridor presented in the Revised SF299 Consolidated Permit Application (Alternative A) rates the highest, due to the shorter length, lower presence of anadromous waters, material site availability, and lower construction and maintenance costs. The alternative corridor presented in Revised SF299 Consolidated Permit Application (Alternative B) rates the second highest, again due to the relatively shorter length, lower presence of anadromous waters, material site availability, and lower construction and maintenance costs. The alternative developed out of the Ambler Road Environmental Impact Statement (Alternative C) ranks the lowest due to the longer length, higher presence of anadromous waters, reduced material site availability, and higher construction and maintenance costs.

Table ES- 1: Roadway Corridor Evaluation Summary

Criterion	Alternative A	Alternative B	Alternative C
Corridor Length (miles)	211	228	332
Federal CSU (unit/miles/percentage of corridor)	GAAR/ 26 miles/12%[1]	GAAR/ 18 miles/8%[1]	None
Wild and Scenic Rivers	Kobuk WSR[1]	Kobuk WSR[1]	None
Salmon/Sheefish Rivers Total Mapped Anadromous Assumed Anadromous	28 5 23	31 6 25	251 13 238
Caribou Habitat	Less	Less	Less
Threatened/Endangered Species/Critical Habitat	None	None	None
Wetland Habitats (miles) [4]	-	-	-
Material Site Availability (percent of corridor with material site within 10 miles)	93%	95%	84%
Total Large Bridges (number/length in ft) Bridges Over 1,500 ft Major Stream Crossings	11/4,920 ft None 63	11/4,870 ft None 50	14/5,150 ft None 523
Construction Cost[2] (in millions)	$447	$481	$880
Annual Maintenance Cost[3] (in millions)	$10.1	$10.6	$15.7
Special Considerations Port Construction Very Large River Crossings	 No None	 No None	 No None

1. Access through GAAR was specifically permitted in ANILCA.
2. Cost rounded to tens of millions.
3. Annual maintenance cost for road and maintenance camps.
4. Wetland mapping is not yet complete.

Table ES- 2: Roadway Corridor Scoring Summary

Criterion	Alternative A	Alternative B	Alternative C
Corridor Length	5	5	3
Federal CSU	5	5	5
Wild and Scenic Rivers	5	5	5
Salmon/Sheefish Rivers	5	5	0
Caribou Habitat	5	5	5
Threatened/Endangered Species/Critical Habitat	5	5	5
Wetland Habitats	-	-	-
Material Site Availability	5	5	4
Total Large Bridges	5	5	5
Construction Cost	5	5	4
Annual Maintenance Cost	5	4	2
Total Score	**50**	**49**	**38**

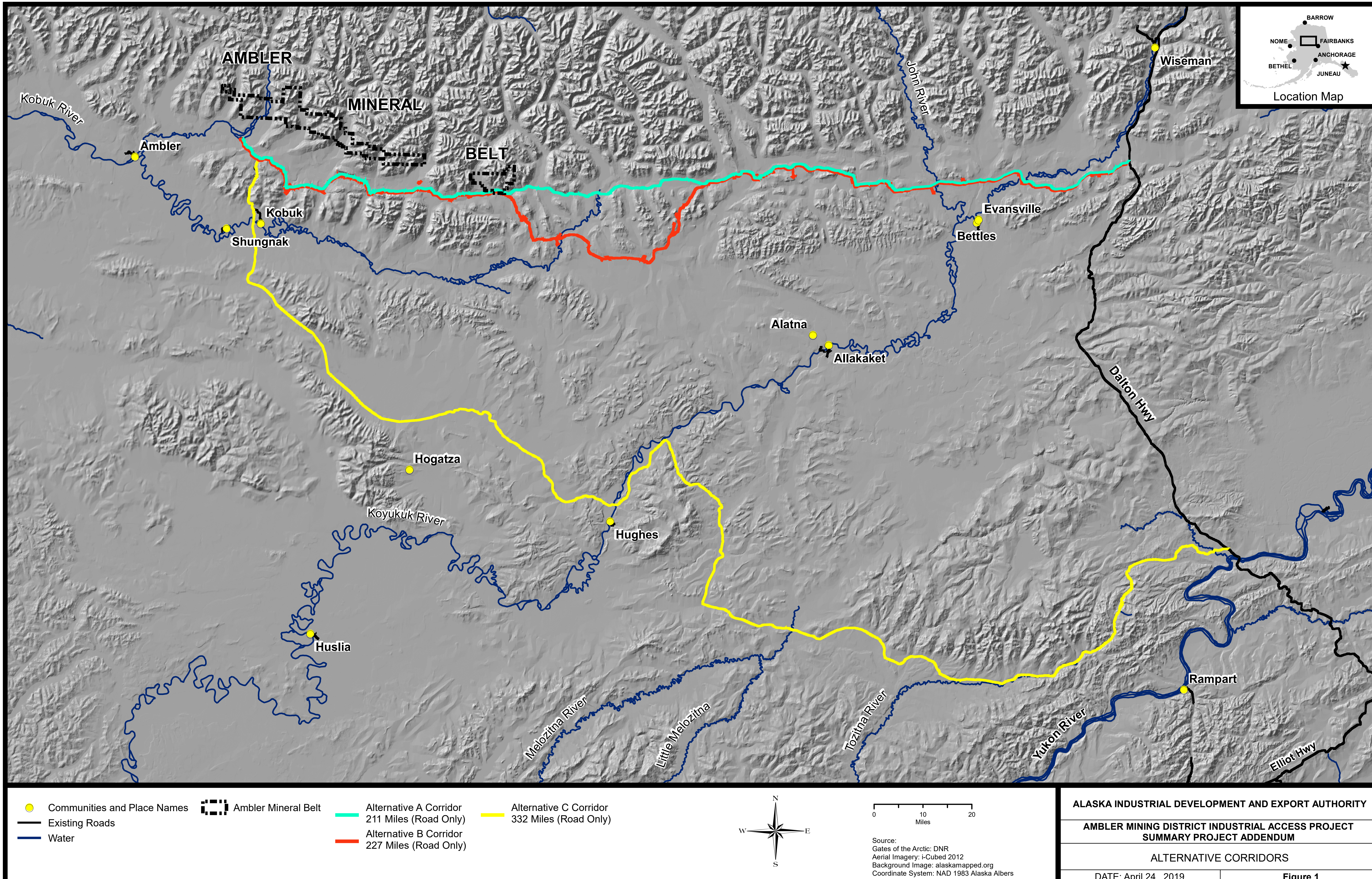
1.0 INTRODUCTION

This Summary Report Addendum was prepared in response to the Bureau of Land Management's (BLM) request for additional data regarding the Ambler Road Environmental Impact Statement (EIS), per the letter to the Alaska Industrial Development and Export Authority (AIDEA) dated October 18, 2018. The addendum builds upon methodologies, evaluation criteria, and data presented in the Ambler Mining District Access Summary Report (DOWL HKM, 2012b) as well as the separate technical memoranda that address design criteria, construction cost, hydrology, geotechnical, and environmental considerations (DOWL HKM, 2011a through 2011f) completed in support of the Ambler Mining District Access Summary Report. This addendum evaluates three corridor alternatives (Figure 1):

- Alternative A: the Preferred Corridor as submitted in the Revised SF299 Consolidated Permit Application, submitted June 30, 2016.
- Alternative B: the Alternative Corridor as submitted in the Revised SF299 Consolidated Permit Application, submitted June 30, 2016.
- Alternative C: the new route alternative developed during the EIS; the final alignment for evaluation was prepared by HDR and provided by BLM on February 13, 2019.

This Summary Report Addendum ranks the three corridors based on the same 5-point scoring system for criteria presented in the 2012 Summary Report. Specific revisions to the evaluation criterion are discussed in relevant sections within this report. The criterion evaluated and the scores assigned for each corridor are based on analysis of existing published information and field studies completed in support of the Ambler Mining District Industrial Access Project (AMDIAP).

The most recent construction cost estimates for Alternatives A and B were developed using earthwork volumes for excavation (cut) and borrow (fill) quantities determined through AutoCAD Civil3D, based on the preliminary roadway designs developed in support of the Revised SF299 Consolidated Permit Application. The available data and schedule for the Ambler Road EIS does not allow for determining comparable earthwork volumes for Alternative C in support of this Summary Report Addendum. Therefore, to provide a consistent cost comparison between the three alternatives, construction cost estimates presented in this addendum were prepared assuming the entire roadway embankment will be constructed with borrow (fill) material at uniform depths ranging from 3 feet to 7 feet, with the embankment thickness dependent on the identified subsurface soil conditions. The presented construction cost estimates are considered conservative since they do not account for usable excavation (cut) material that can be incorporated into the roadway embankment at a lower unit cost and have not been adjusted for varying topography to reduce material required. The presented construction cost estimates are for full-embankment, two-lane road corridors with a 32-foot-wide roadway surface (two 12-foot lanes with 4-foot shoulders). All bridges are assumed to be one lane (23-foot-wide deck surface) consistent with the Revised SF299 Consolidated Permit Application.



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2.0 CORRIDOR MATRIX CRITERIA

Evaluation criteria were developed during completion of the 2012 Summary Report and include: 1) Corridor Length; 2) Federal Conservation System Units; 3) Wild and Scenic Rivers; 4) Salmon/Sheefish Rivers; 5) Caribou Habitat; 6) Threatened and Endangered Species/Critical Habitat Areas; 7) Availability of Material Sites; 8) Large Bridges; 9) Construction Cost; 10) Maintenance Costs; and 11) Special Considerations. The three corridor alternatives were evaluated using the same criteria described in the 2012 Summary Report, unless noted in the individual sections below.

The following sections describe these criteria and the relative scores of the three alternatives evaluated. The scoring criteria as presented in the 2012 Summary Report is included for each section for reference.

2.1 Evaluation Criteria Descriptions and Alternative Scores

2.1.1 Corridor Length

Scoring Considerations

Each corridor is evaluated and scored based on its length. The corridors were scored using the following scale:

- Corridors of ≤250 miles = 5
- Corridors of 251-300 = 4
- Corridors of 301-350 = 3
- Corridors of 351-400 = 2
- Corridors of 401-450 = 1
- Corridors >450 miles = 0

The corridor alternative lengths vary from 211 to 332 miles, as shown in Table 1.

Table 1: Corridor Alternative Lengths

Corridor	Length (miles)	Score
Alternative A	211	5
Alternative B	228	5
Alternative C	332	3

2.1.2 Federal Conservation System Units

Scoring Considerations

Each corridor is evaluated and scored based on whether it crosses a Federal Conservation System Units (CSU), shown in Figure 2. The Alaska National Interest Lands Conservation Act (ANILCA) recognized the need for access to the Ambler mineral belt and included a provision permitting access through Gates of the Arctic National Park and Preserve (GAAR). Corridors that do not run through a CSU, or corridors that cross GAAR, are given a score of 5. Corridors crossing a CSU other than GAAR are given a score of 0 due to the time and costs associated with obtaining approval to cross through CSUs.

Alternatives A and B cross through GAAR; these corridor options are consistent with language permitting a transportation corridor through GAAR in ANILCA. Alternative C does not cross through a CSU. All three corridor alternatives are given a score of 5.

2.1.3 National Wild and Scenic Rivers

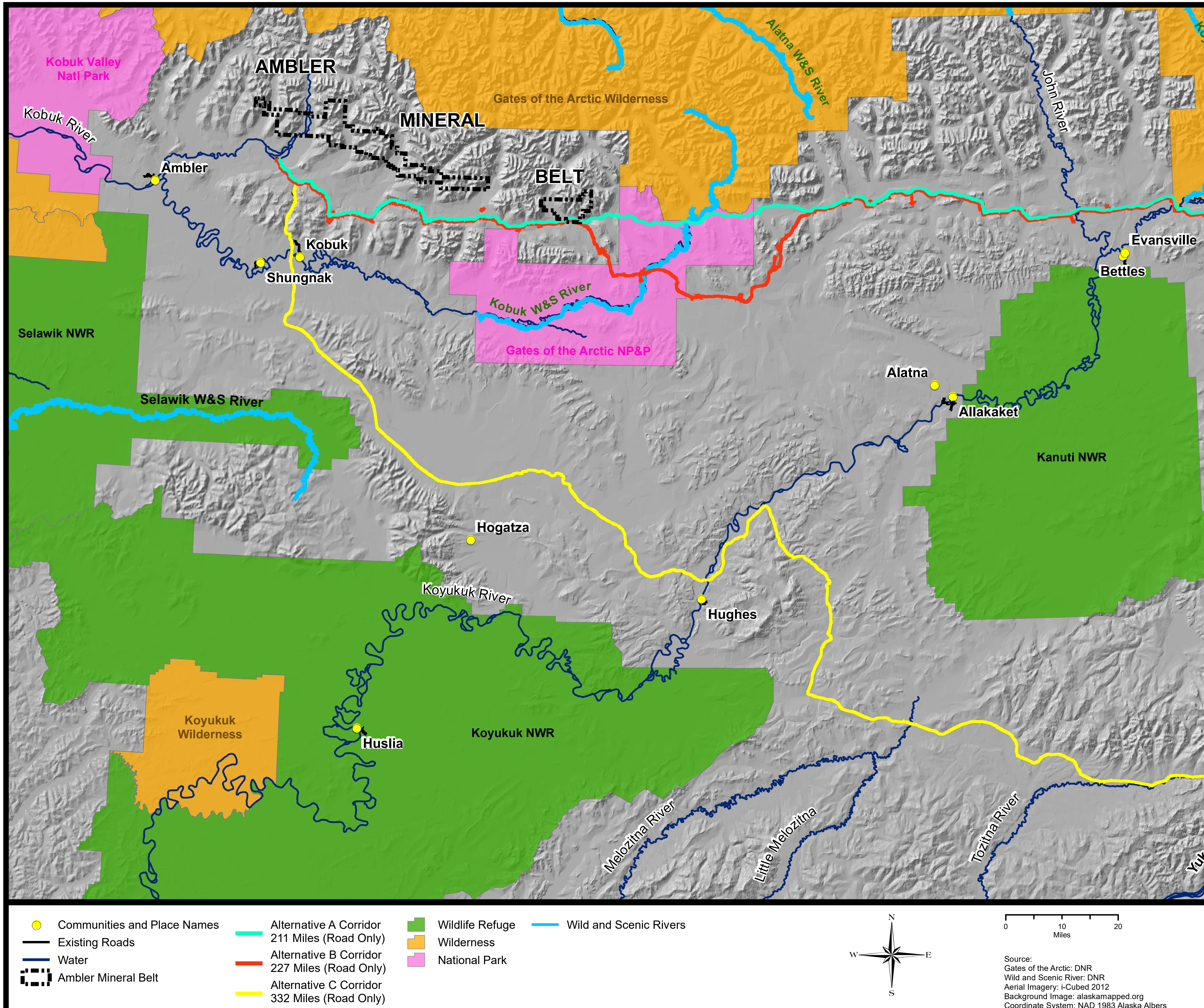
Scoring Considerations

Each corridor is evaluated and scored on whether it crosses a National Wild and Scenic River (WSR), shown in Figure 2. The corridors that cross a WSR are given a score of 0 and the corridors with no crossings are given a score of 5. Again, because ANILCA recognized the need for a corridor and permitted a corridor through GAAR and across the Kobuk WSR, corridors that cross the Kobuk WSR in GAAR are given a score of 5.

Although Alternatives A and B cross the Kobuk WSR in GAAR, these options are also consistent with the provisions for access established in ANILCA and are given a score of 5. Alternative C does not cross any WSRs and is also given a score of 5.

2.1.4 Salmon/Sheefish Rivers

The Alaska Department of Fish and Game's (ADF&G's) Anadromous Waters Catalog (AWC) was reviewed on to identify anadromous waters crossed by the three alternatives. Data files for the Arctic Region of the AWC were last updated on January 26, 2018. Data files for the Interior Region of the AWC were last updated on June 5, 2018. Since limited mapping of anadromous waters has occurred in the project study area, it is likely that there are other anadromous waters in this area that have not been mapped in the AWC. To account for this, unmapped streams with gradients of 8% or less in direct connection with mapped anadromous waters were assumed to have a high likelihood of supporting anadromous fish and are counted as anadromous waters. Mapped and assumed anadromous waters are shown in Figure 3.



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SUMMARY PROJECT ADDENDUM

FEDERAL CONSERVATION SYSTEM UNITS AND
WILD AND SCENIC RIVERS

DATE: April 24, 2019 | Figure 2

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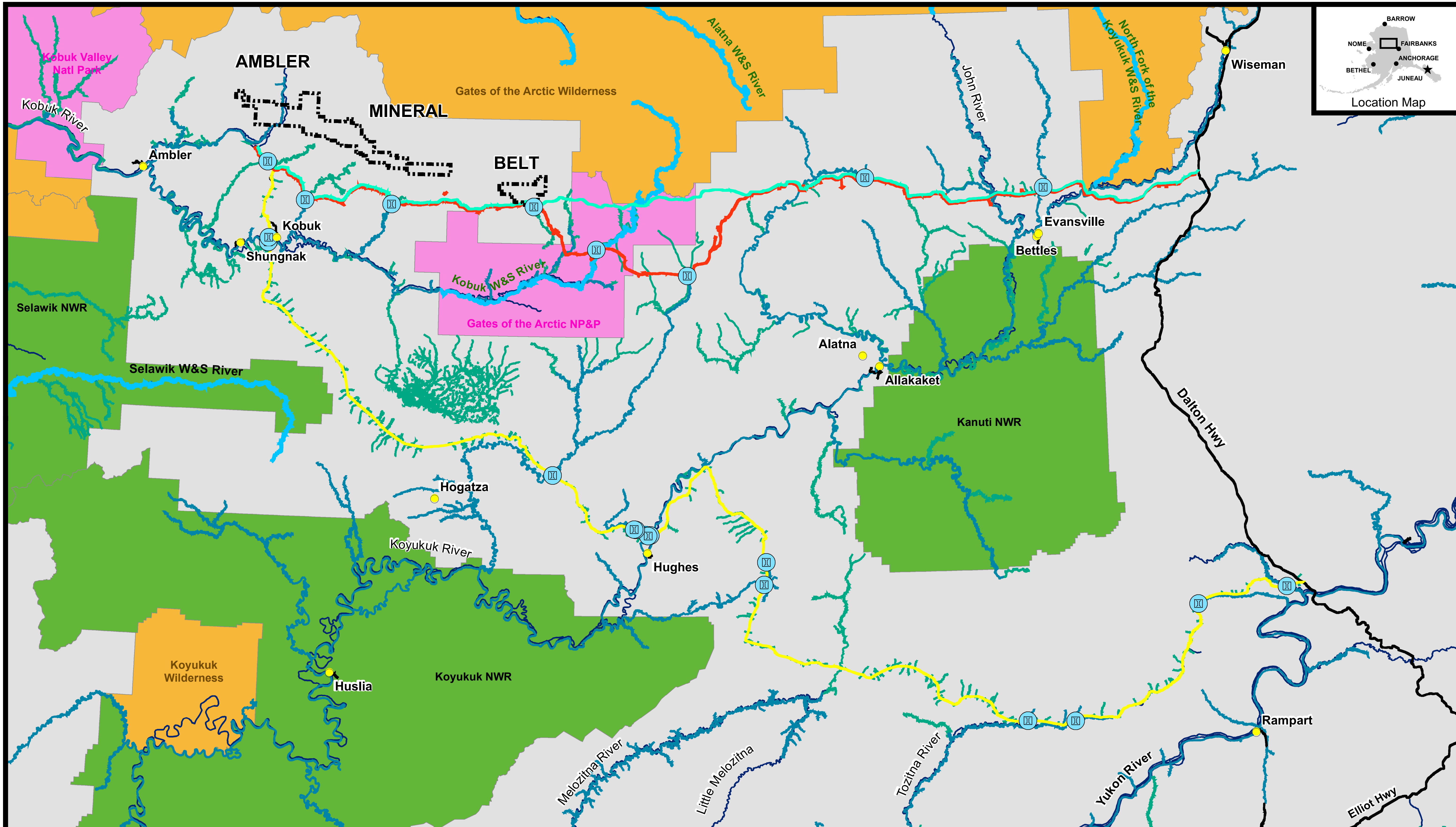

Communities and Place Names
Existing Roads
Water
Ambler Mineral Belt

Alternative A Corridor
211 Miles (Road Only)
Alternative B Corridor
227 Miles (Road Only)
Alternative C Corridor
332 Miles (Road Only)

Wildlife Refuge
Wilderness
National Park

Wild and Scenic Rivers
Cataloged Anadromous Streams
Assumed Anadromous Streams

Large Bridges

N
W E
S

0 10 20
Miles

Note: There is no designated critical habitat in the eastern and southeastern portion of the study area.

Source:
Gates of the Arctic: DNR
Wild and Scenic River: DNR
Catalogued Anadromous Streams: ADF&G
Coordinate System: NAD 1983 Alaska Albers

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ANADROMOUS STREAMS AND LARGE BRIDGES

DATE: April 24, 2019 | **Figure 3**

Q:\33\60693-10\60GIS\SR Addendum Figure 3 - Critical Habitat, Anadromous, and Lg Bridges.mxd Apr 24, 2019 9:22:34 AM User: tjameson

Scoring Considerations

Each corridor is evaluated and scored on the number of anadromous waters crossed. The corridors were scored using the following scale:

- Corridors with ≤50 crossings = 5
- Corridors with 51 - 60 crossings = 4
- Corridors with 61 - 70 crossings = 3
- Corridors with 71 - 80 crossings = 2
- Corridors with 81 - 90 crossings = 1
- Corridors with ≥91 crossings = 0

The numbers of mapped or assumed anadromous streams crossed by the three alternatives are shown in Table 2.

Table 2: Corridor Alternative Anadromous Stream Crossings

Corridor	Mapped	Assumed	Total	Score
Alternative A	5	23	28	5
Alternative B	6	25	31	5
Alternative C	13	238	251	0

2.1.5 Caribou Habitat

Five caribou herds are known to sometimes use portions of the original 2011 study area: (1) Western Arctic Caribou Herd (WACH); (2) Teshekpuk Lake Caribou Herd; (3) Galena Mountain Herd; (4) Wolf Mountain Herd; and (5) Ray Mountain Herd. All three alternatives cross through portions of the WACH habitat used for wintering and migration. The other caribou herds are smaller and tend to occupy smaller portions of the original project study area for shorter time periods. Although available information on the WACH is dated, WACH range maps published in the WACH Cooperative Management Plan and caribou range maps in the Bureau of Land Management's Kobuk-Seward Peninsula Resource Management Plan indicate that caribou use is more concentrated in the western portion of the project study area.

Scoring Considerations

Each corridor is evaluated and scored on caribou habitat crossed. Corridors that proceed east from the Ambler mineral belt and that cross relatively less caribou habitat are given 5 rating. Corridors that proceed west from the Ambler mineral belt and that cross relatively more caribou habitat are given a 0. All three alternatives head east from the Ambler mineral belt and cross less caribou habitat than those previously considering that head west, so all three alternatives are given a score of 5 for this criterion. The length of WACH range maps crossed by each alternative are shown in Table 3.

Table 3: Corridor Alternative Caribou Habitat

Corridor	Length of WACH Habitat Crossed (miles)	Percentage of Total Corridor Length	Score
Alternative A	193	91%	5
Alternative B	209	92%	5
Alternative C	178	54%	5

2.1.6 Threatened and Endangered Species and Critical Habitat Areas

Scoring Considerations

Corridors that are not expected to affect any threatened or endangered species or their habitat are given a score of 5. Corridors that may affect one threatened or endangered species or its critical habitat are given a score of 3. Corridors that may affect more than one species are given a score of 0.

None of the corridor alternatives cross through areas where threatened or endangered species are found. Therefore, none of these alternatives cross through areas designated as critical habitat for threatened or endangered species. All three alternatives are given a score of 5 for this criterion.

2.1.7 Wetland Habitats

The updated extent of wetland coverage and length of corridor intersection with wetland habitats is being evaluated for each alternative; results will be provided in May 2019.

Scoring Considerations

Each corridor is evaluated and scored based on its length of intersection with wetland habitats. The corridors were scored using the following scale:

- Intersection of ≤30 miles = 5
- Intersection of 31-60 miles = 4
- Intersection of 61-90 = 3
- Intersection of 91-120 = 2
- Intersection of 121-150 = 1
- Intersections of >150 miles = 0

The length of intersection with wetland habitats and corresponding score for each alternative are shown in Table 4.

Table 4: Corridor Alternative Wetland Habitats

Corridor	Length of Corridor Intersection with Wetland Habitats (miles)	Score
Alternative A	To Be Determined	-
Alternative B	To Be Determined	-
Alternative C	To Be Determined	-

2.1.8 Availability of Material Sites

In support of the Revised SF299 Consolidated Permit Application, material site locations were identified along the Alternatives A and B corridors. Distances between the proposed material sites were used to evaluate the percentage of the corridors that have material sites at least every 10 miles for Alternatives A and B (Figure 4).

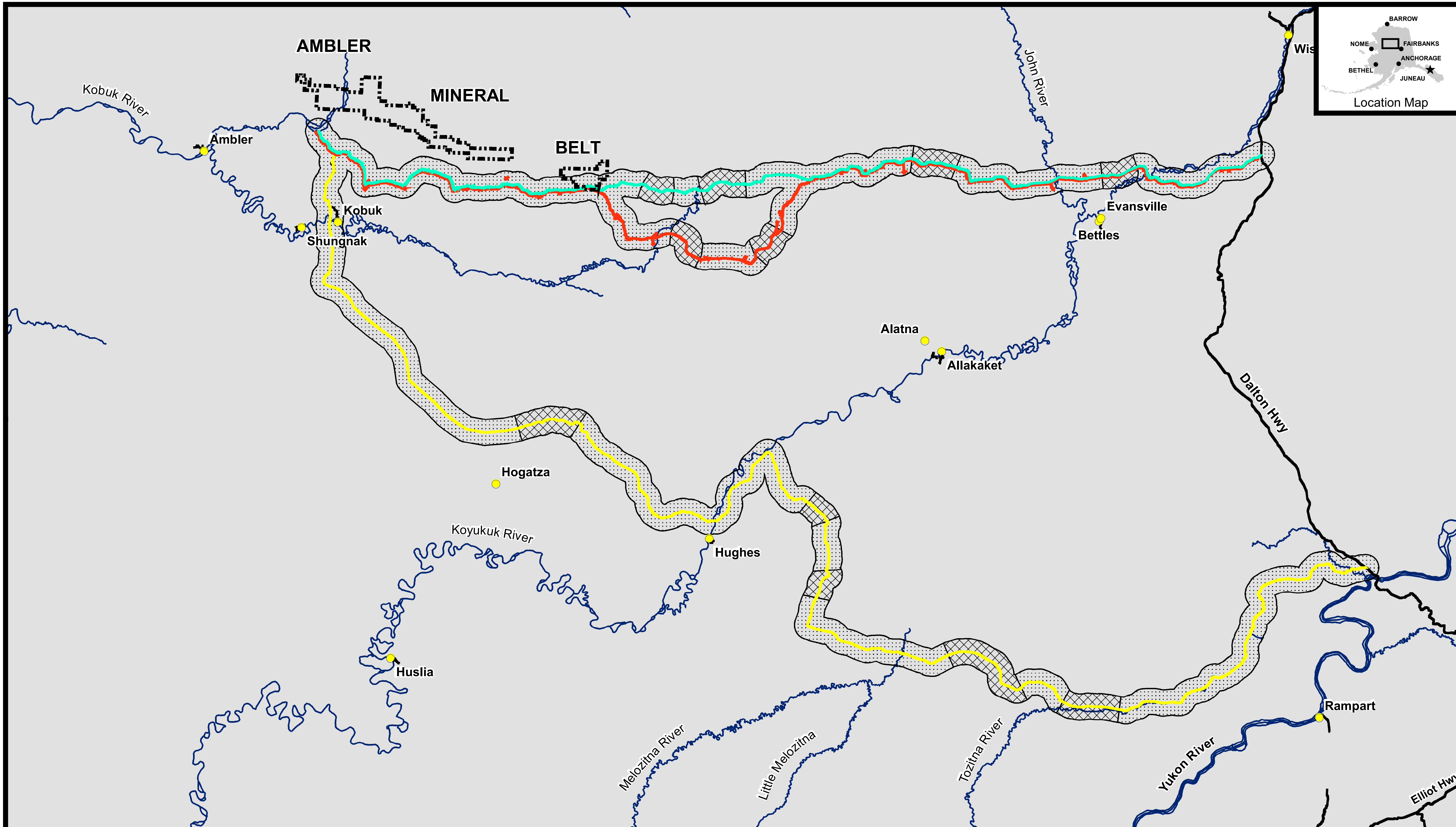
As part of the Ambler Road EIS, Shannon and Wilson identified potential material sites along the Alternative C corridor. As part of the geotechnical investigation completed by DOWL for the Alternative C corridor, as discussed in more detail in Sections 4 and 5 of this report, DOWL confirmed that material sites identified by Shannon and Wilson appear feasible for use in support of Alternative C. Distances between the identified material sites were used to evaluate the percentage of the corridors that have material sites at least every 10 miles for Alternative C (Figure 4).

Scoring Considerations

Each corridor is evaluated and scored on the percent of the corridor that has a material site within 10 miles. Corridor scoring is based on the following:

- >90% of corridor has material sites every 10 miles = 5
- 81%-90% of corridor has material sites every 10 miles = 4
- 71%-80% of corridor has material sites every 10 miles = 3
- 61%-70% of corridor has material sites every 10 miles = 2
- 51%-60% of corridor has material sites every 10 miles = 1
- ≤50% of corridor has material sites every 10 miles = 0

Approximately 93% (197 miles) of Alternative A is within 10 miles of a proposed material site and this corridor is given a score of 5 for this criterion (Table 4). Approximately 95% (217 miles) of Alternative B is within 10 miles of a proposed material site and this corridor is given a score of 5 for this criterion. Approximately 84% (279 miles) of Alternative C is within 10 miles of an identified material site and this corridor is given a score of 4 for this criterion.



Communities and Place Names
Existing Roads
Water
Ambler Mineral Belt
Alternative A Corridor 211 Miles (Road Only)
Alternative B Corridor 227 Miles (Road Only)
Alternative C Corridor 332 Miles (Road Only)
Corridor Segments with Material Sites at Less than 10 Mile Intervals
Corridor Segments with Material Sites at Greater than 10 Mile Intervals

Source:
Gates of the Arctic: DNR
Aerial Imagery: i-Cubed 2012
Background Image: alaskamapped.org
Coordinate System: NAD 1983 Alaska Albers

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MATERIAL SITE AVAILABILITY

DATE: April 24, 2019 | **Figure 4**

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Table 5: Corridor Alternative Material Site Availability

Corridor	Percent of Corridor w/Material Sites within 10 miles	Score
Alternative A	93%	5
Alternative B	95%	5
Alternative C	84%	4

2.1.9 Large Bridges

Scoring Considerations

Each corridor is evaluated and scored on the total length of large bridges needed (Figure 3). Corridor scoring is based on the following:

- Corridors with <5,500 ft = 5
- Corridors with 5,501- 6,000 ft = 4
- Corridors with 6,001 - 7,000 ft = 3
- Corridors with 7,001 - 8,000 ft = 2
- Corridors with 8,001- 9,000 ft = 1
- Corridors with >9,000 ft = 0

The number of large bridges crossed and the total combined length of estimated large bridge spans for the three alternatives are shown in Table 6. Both Alternative A and B have 11 large bridges and less than 5,000 feet of total length, so are given a score of 5. Alternative C has 14 large bridges with a total length of 5,290 feet, so is also given a score of 5.

Table 6: Corridor Alternative Large Bridges

Corridor	Large Bridges	Length of Large Bridge Spans (feet)	Score
Alternative A	11	4,920	5
Alternative B	11	4,870	5
Alternative C	14	5,150	5

2.1.10 Construction Costs

The most recent construction cost estimates for Alternatives A and B were developed using earthwork volumes for excavation (cut) and borrow (fill) quantities determined through AutoCAD Civil3D, based on the preliminary roadway designs developed in support of the Revised SF299 Consolidated Permit Application. The available data and schedule for the Ambler Road EIS does not allow for determining comparable earthwork volumes for Alternative C in support of this Summary Report Addendum. Therefore, to provide a consistent cost comparison between the three alternatives, construction cost estimates presented in this addendum were prepared assuming the entire roadway embankment will be constructed with borrow (fill) material at uniform depths ranging from 3 feet to 7 feet, with the embankment thickness dependent on the identified subsurface soil conditions. The presented construction cost estimates are considered conservative since they do not account for usable excavation (cut) material that can be incorporated into the roadway embankment at a lower unit cost and have not been adjusted for varying topography to reduce material required. The presented construction cost estimates are for full-embankment, two-lane road corridors with a 32-foot-wide roadway surface (two 12-foot lanes with 4-foot shoulders). All bridges are assumed to be one lane (23-foot-wide deck surface) consistent with the Revised SF299 Consolidated Permit Application.

Unit Prices

Construction costs for each corridor alternative were generally evaluated using the design criteria documented in the Design Criteria Memorandum (DOWL HKM, 2011a) and unit prices documented in the Baseline Cost Memorandum (DOWL HKM, 2011b). The unit prices listed in the 2011 Baseline Cost Memorandum are in fiscal year 2010 (FY10) dollars. To update the unit prices to current values, the unit costs were escalated up to FY18 dollars using the following factors:

- The Consumer Price Index (CPI) for the Municipality of Anchorage, published by the State of Alaska Department of Labor and Workforce Development, was used to calculate the average rate of inflation from 2011 through 2018. The average rate of inflation was applied to the FY10 unit prices to determine FY18 values.
- The Federal Highway Administration's National Highway Construction Cost Index (NHCCI) 2.0 was used to determine the difference in costs between September 2010 and September 2018. The ratio of the 2018 cost index over the 2010 cost index was applied to the FY10 unit prices to determine FY18 values.
- The Bureau of Reclamation's Construction Cost Trends (CCT) for "secondary roads" was used to determine the difference in costs between October 2010 and October 2018. The ratio of the 2018 cost index over the 2010 cost index was applied to the FY10 unit prices to determine FY18 values.

The FY18 costs determined using the CPI, NHCCI, and CCT were in close agreement; the results were averaged to determine the FY18 unit prices used for developing the construction cost estimates for the three alternatives. Note that costs were not updated to FY19 values due to the lack of published data for inflation rates and price indices for 2019.

Material Costs

Roadway construction cost estimates include clearing, aggregate surface course, embankment, and mobilization. Construction costs for road embankment are based on assumed embankment heights based on anticipated soil conditions as discussed in the 2011 Baseline Cost Memorandum; three typical sections were developed including:

- Typical “A” is applicable to soils classified as “poor” and has an 84-inch embankment height.
- Typical “B” is applicable to soils classified as “fair” and has a 60-inch embankment height.
- Typical “C” is applicable to soils classified as “good” and has a 36-inch embankment height.

Soil classification is derived from terrain unit mapping completed in support of the 2012 Summary Report and Revised SF299 Consolidated Permit Application, as discussed in the Geotechnical Memorandum (DOWL HKM, 2011e) and Sections 4 and 5 of this addendum. Terrain unit mapping was previously completed for areas encompassing Alternatives A and B. Terrain unit mapping for Alternative C was completed in support of the addendum. Table 7 shows the estimated percentages and lengths of poor, fair, and good soil conditions used in the cost estimate for the three alternatives.

Table 7: Corridor Alternative Estimated Construction Costs

Corridor	Poor Soils (%)	Poor Soils (mi)	Fair Soils (%)	Fair Soils (mi)	Good Soils (%)	Good Soils (mi)
Alternative A	35%	74	49%	103	16%	34
Alternative B	39%	89	49%	112	12%	27
Alternative C	41%	134	21%	68	39%	130

Haul costs were factored into developing composite unit prices for embankment for the three alternatives, based on the spacing of identified material sites along each corridor. Haul costs were estimated for roundtrip haul distances of 10, 15, and 20 miles based on identified material site locations as discussed in Subsection 2.1.8. Royalty costs of $5 per cubic yard are added where appropriate to reflect the cost of materials coming from non-state lands.

Also included in the roadway construction cost are truck turnouts, which are assumed to be located every 10 miles within each corridor. Turnouts for Alternatives A and B were located in support of the Revised SF299 Consolidated Permit Application. Alternative A has 20 turnouts and Alternative B has 22 turnouts, which roughly equate to one every 10 miles. Alternative C was assumed to have 33 turnouts.

<u>Hydrologic Costs</u>

Cost estimates for drainage structures along road and rail corridors were developed using the hydraulic design assumptions described in the Preliminary Hydrology Reconnaissance Memorandum (DOWL HKM, 2011d) and 2012 Summary Report. Historical bid tabulations for Dalton Highway projects and other Northern Region projects were used to estimate unit costs, which were then escalated to FY18 dollars.

For Alternatives A and B, the number and size of drainageway/stream/river crossings was determined during preliminary engineering efforts in support of the Revised SF299 Consolidated Permit Application. Wetlands/stream mapping, LiDAR data, aerial imagery, and field investigations were used to estimate the number and size of stream crossings along the two corridors. The size of bridge and culvert crossing was determined based on the estimated stream characteristics determined.

For Alternative C, available aerial imagery and hillshade datasets were used in ArcGIS to estimate the number and size of drainageway/stream/river crossings along the corridor. Data limitations for sections of the Alternative C corridor result in less confidence in stream classification compared to Alternatives A and B.

<u>Bridge Costs</u>

Bridge costs assume a one-lane bridge with a 23-foot wide deck. Crossing structures for larger streams and rivers with estimated bankfull channel widths greater than 20 feet were categorized into one of three bridge classes:

- Small bridges are assumed for bankfull channel width of 21 feet to 30 feet. The assumed bridge length is 50 feet, allowing room for abutments outside of the stream channel. The unit price for small bridges is $372,500, which include riprap, bridge abutments and substructure, girders, deck, and rail for a complete bridge in place.
- Medium bridges are assumed for bankfull channel width of 31 feet to 100 feet. The assumed bridge length is 140 feet, allowing room for abutments outside of the stream channel. The unit price for small bridges is $720,900 for a complete bridge in place.
- Large bridges are assumed for bankfull channel widths exceed 100 feet and costs are estimated on a linear foot basis at $7,100 per linear foot for a complete bridge in place. The assumed bridge length includes 40 feet on each side of the estimated bankfull channel (80 feet total) to account for abutments.

<u>Culvert Costs</u>

Crossing structures for smaller stream crossings with estimated bankfull widths of 20 feet or less were categorized into one of three culvert classes:

- Minor Culverts include drainageways with bankfull channel widths of 3 feet or less and generally include smaller ephemeral channels, swales, rills, and localized drainage. The assumed culvert diameter for minor culverts is 3 feet. The unit price for minor culverts is

$25,300, which includes culvert pipe, riprap, culvert marker posts, thaw pipe, insulation board, equipment, and labor for a complete culvert in place.

- Moderate culverts include streams with bankfull widths from 4 feet to 10 feet. The assumed culvert diameter for moderate culverts is 10 feet. The unit price for moderate culverts is $102,200 for a complete culvert in place.
- Major culverts include streams with bankfull widths from 11 feet to 20 feet. The assumed culvert diameter for major culverts is 20 feet. The unit price for major culverts is $242,700 for a complete culvert in place.

Data limitations did not allow for accurately estimating the number of minor culverts for Alternative C through ArcGIS. As a result, the number of minor culverts assumed for Alternative C was estimated at a per mile basis. Alternative A has on average 13.6 minor culverts per mile and Alternative B has on average 11.0 minor culverts per mile, for a combined average of 12.3 minor culverts per mile. This 12.3 minor culverts per mile value was applied to Alternative C to estimate the number of minor culverts along the corridor.

Fish Passage Culvert Costs

Fish passage culverts were assumed to incur additional costs associated with fish passage design efforts, in-channel structures and material, bank stabilization, and labor for reconstruction of channel beds. An additional cost of $156,200 was applied to any moderate or major culverts on mapped or assumed anadromous waters to cover the additional cost associate with providing fish passage.

Scoring Considerations

Each corridor is evaluated and scored based on estimated construction cost (rounded to tens of millions). The range of costs used for scoring were escalated up to FY18 dollars from the values listed in the 2012 Summary Report. Corridors were scored using the following scale:

- Cost ≤$600 Million = 5
- Cost >$600-900 Million = 4
- Cost >$900-1,200 Million = 3
- Cost >$1,200-1,500 Million = 2
- Cost >$1,500-1,800 Million =1
- Cost ≥$1,801 Million = 0

The total estimated construction cost for the three alternatives range from $447 million to $880 million, as shown in Table 8 and Appendix A.

Table 8: Corridor Alternative Estimated Construction Costs

Corridor	Construction Cost (in millions)	Score
Alternative A	$447	5
Alternative B	$481	5
Alternative C	$880	4

2.1.11 Maintenance Costs

Roadway Maintenance Costs

Maintenance costs are assumed to be similar to Dalton Highway maintenance costs. A cost per mile for roadway maintenance was derived from data provided by DOT&PF's Dalton Highway maintenance section for FY10 and escalated up to FY18 dollars. The resultant $31,400 per mile cost for roadway maintenance is applied to each corridor alternative.

Roadway Maintenance Camp Costs

Additional costs are added to each alternative for initial construction and annual maintenance of road maintenance camps. Maintenance camps are assumed to be required approximately every 50 to 60 miles. For the Revised SF299 Consolidated Permit Application, three maintenance stations were proposed for Alternatives A and B. Subsequently it was identified that an additional maintenance station is likely needed near the Dalton Highway, resulting in four maintenance stations for Alternatives A and B. Based on the per 50- to 60-mile criteria, six maintenance stations are assumed for Alternative C.

Initial construction cost for each maintenance camp is estimated at $6.6 million, based on FY10 construction costs for a new maintenance facility at East Fork along the Dalton Highway and escalated up to FY18 dollars. Estimated annual maintenance cost per camp is $507,000. This annual cost is estimated using FY10 costs for several existing maintenance camps provided by DOT&PF, escalated up to FY18 dollars.

For the Revised SF299 Consolidated Permit Application, landing strips were proposed at each of the three maintenance stations farthest from the Dalton Highway for Alternatives A and B. A landing strip is not anticipated to be needed at the maintenance station closest to the Dalton Highway. Using the same assumptions for Alternative C, the need for landing strips at each of the five maintenance stations farthest from the Dalton Highway are included in the maintenance cost estimates. Initial construction costs for a landing strip at each maintenance camp were estimated based on clearing, embankment fill, and surface course needs assuming a 3,000-foot-long landing strip. FY10 unit costs were escalated up to FY18 dollars, resulting in an estimated construction cost of $838,000 per landing strip.

The life-cycle for each maintenance camp is assumed to be 20 years, which includes the initial camp construction cost and the annual cost to maintain the camp for the 20-year duration without major upgrades or renovations. The 20-year life-cycle cost for individual alternatives is included in Appendix A.

Scoring Considerations

Each corridor is evaluated and scored based on estimated annual maintenance cost determined from the 20-year life-cycle costs and factoring in initial capital construction and annual maintenance. The range of costs used for scoring were escalated up to FY18 dollars from the values listed in the 2012 Summary Report. Corridors were scored using the following scale:

- Cost ≤$10.3 Million = 5
- Cost $10.4-12.7 Million = 4
- Cost $12.8-15.1 Million = 3
- Cost $15.2-17.5 Million = 2
- Cost $17.6-19.9 Million = 1
- Cost ≥$20.0 Million = 0

Estimated annual maintenance costs for each alternative and corresponding scores for this criterion are shown in Table 9. Initial maintenance camp construction and annual maintenance are summarized in Appendix A.

Table 9: Corridor Alternatives Estimated Maintenance Costs

Corridor	Annual Maintenance Cost (in millions)	Score
Alternative A	$10.1	5
Alternative B	$10.6	4
Alternative C	$15.7	2

2.1.12 Special Considerations

None of the three alternatives include port construction or very large river crossings (i.e., Yukon or Noatak Rivers). Therefore, no special considerations apply to the three alternatives.

3.0 INDIVIDUAL CORRIDOR ANALYSIS

The following sections summarize each corridor in relation to the 11 criteria identified earlier.

3.1 Alternative A

3.1.1 General Route Description

The Alternative A corridor is the shortest option, measuring approximately 211 miles from the Ambler mineral belt to the Dalton Highway. The corridor heads southeast away from the Ambler River and then east along the north side of the Cosmos Hills towards GAAR. The corridor continues east through GAAR to the north of Nutuvukti Lake and to the south of Walker Lake. It proceeds to travel east, remaining north of the Helpmejack Hills, Alatna Hills, and Ninemile Hills, crossing the Koyukuk River to the northeast of Evansville/Bettles. The corridor continues east along the north side of the Jack White Range, near the southern boundary of GANNP, to mile 161 on the Dalton Highway.

The evaluation of this corridor is summarized in Table 10.

Table 10: Alternative A Corridor Evaluation

Criterion	Value	Score
Corridor Length (miles)	211	5
Federal CSU (unit/miles/percentage of corridor)	GAAR/26/12%	5[1]
Wild and Scenic Rivers	Kobuk WSR	5[1]
Salmon/Sheefish Rivers Total Mapped Anadromous Assumed Anadromous	28 5 23	5
Caribou Habitat	Less	5
Threatened/Endangered Species/Critical Habitat	None	5
Wetland Habitats (miles)	To Be Determined	-
Material Site Availability (percent of corridor with material site within 10 miles)	93%	5
Total Large Bridges (number/length in ft) Bridges Over 1,500 ft Major Stream Crossings	11/4,920 ft None 63	5
Construction Cost[2] (in millions)	$447	5
Annual Maintenance Cost (in millions)	$10.1	5
Special Considerations ANILCA Corridor through GAAR	NA	NA
Total Score		50

1. Access through GAAR and across the Kobuk WSR was permitted under ANILCA.
2. Costs rounded to tens of millions.

3.1.2 Corridor Length

This corridor is 211 miles long; the shortest of the potential corridors. The corridor is given a score of 5 for this criterion.

3.1.3 Federal Conservation Systems

This corridor crosses through the preserve portion of GAAR. The length of the corridor within the CSU is approximately 26 miles, or 12% of the corridor length. Although this corridor goes through GAAR, it also is given a score of 5 for this criterion since access through GAAR was permitted in ANILCA.

3.1.4 Wild and Scenic Rivers

This corridor crosses the Kobuk WSR. The crossing is approximately 430 feet long. This corridor is given a score of 5 for this criterion, given the recognition of access through GAAR in ANILCA.

3.1.5 Salmon/Sheefish Rivers

This corridor crosses 5 mapped anadromous streams and 23 streams assumed to be anadromous, for a total of 28. This is the lowest number of anadromous streams crossed by any alternative and Alternative A is given a score of 5 for this criterion.

3.1.6 Caribou Habitat

This alternative crosses through migratory areas and the outer range of the WACH. This alternative heads east from the Ambler mineral belt and crosses less WACH habitat than corridors previously considered that head west and is given a score of 5 for this criterion.

3.1.7 Threatened and Endangered Species and Critical Habitat Areas

This corridor does not cross through areas where threatened or endangered species, or critical habitat areas are found. Hence, the corridor is given a score of 5 for this criterion.

3.1.8 Wetland Habitats

To be determined.

3.1.9 Availability of Material Sites

This alternative has material sites available every 10 miles for approximately 93% of the length of the corridor and is given a score of 5 for this criterion.

3.1.10 Large Bridges

This corridor has 63 major stream crossings, including 11 large bridges with a total combined length of approximately 4,920 linear feet. This corridor has the second lowest total length of large bridges and is given a score of 5 for this criterion.

3.1.11 Construction Cost

The total estimated construction cost for this corridor is $447 million (Appendix A). This is the lowest construction cost of the three alternatives evaluated and the corridor is given a score of 5 on this criterion.

3.1.12 Maintenance Cost

Estimated annual maintenance cost for Alternative A is approximately $10.1 million. Initial maintenance camp construction and annual maintenance are summarized in Appendix A. This is the lowest annual maintenance cost for the alternatives evaluated and the corridor is given a score of 5 on this criterion.

3.1.13 Special Considerations

No special considerations are relevant to this corridor.

3.2 Alternative B

3.2.1 General Route Description

This Alternative B corridor is approximately 228 miles long and follows the same general path as the Alternative A corridor, except it diverges to the south when crossing GAANP. The corridor heads southeast away from the Ambler River and then east along the north side of the Cosmos Hills towards GAAR. To the east of the Beaver Creek crossing, the corridor diverges southeast from the Alternative A alignment until entering GANNP. The corridor proceeds east across GAAR and exits GAAR to the north of Norutak Lake. It proceeds east, crossing the Hogatza River, and then heads northeast through the Helpmejack Hills. From this point the corridor follows the Alternative A alignment east to mile 161 of the Dalton Highway.

The evaluation of this route is summarized in Table 11.

3.2.2 Corridor Length

This corridor is 228 miles long and is given a score of 5 for this criterion.

3.2.3 Federal Conservation Systems

This corridor crosses through the preserve portion of GAAR. The length of the corridor within the CSU is approximately 18 miles, or 8% of the corridor length. Although this corridor goes through GAAR, it also is given a score of 5 for this criterion since access through GAAR is permitted in ANILCA.

3.2.4 Wild and Scenic Rivers

This corridor crosses the Kobuk WSR. The crossing is approximately 480 feet long. This corridor is given a score of 5 for this criterion, given the recognition of access through GAAR in ANILCA.

Table 11: Alternative B Corridor Evaluation

Criterion	Value	Score
Corridor Length (miles)	228	5
Federal CSU (unit/miles/percentage of corridor)	GAAR/18/8%	5
Wild and Scenic Rivers	Kobuk WSR	5
Salmon/Sheefish Rivers Total Mapped Anadromous Assumed Anadromous	31 6 25	5
Caribou Habitat	Less	5
Threatened/Endangered Species/Critical Habitat	None	5
Wetland Habitats (miles)	To Be Determined	-
Material Site Availability (percent of corridor with material site within 10 miles)	95%	5
Total Large Bridges (number/length in ft) Bridges Over 1,500 ft Major Stream Crossings	11/4,870 ft None 50	5
Construction Cost[1] (in millions)	$481	5
Annual Maintenance Cost (in millions)	$10.6	4
Special Considerations ANILCA Corridor through GAAR	NA	NA
	Total Score	**49**

1. Costs rounded to tens of millions.

3.2.5 Salmon/Sheefish Rivers

This corridor crosses 6 mapped anadromous streams and 25 streams assumed to be anadromous, for a total of 31. This is the second lowest number of anadromous streams crossed by an alternative evaluated and this corridor is given a score of 5 for this criterion.

3.2.6 Caribou Habitat

This alternative crosses through migratory areas and the outer range of the WACH. This alternative heads east from the Ambler mineral belt and crosses less WACH habitat than corridors previously considered that head west and is given a score of 5 for this criterion.

3.2.7 Threatened and Endangered Species and Critical Habitat Areas

This corridor does not cross through areas where threatened or endangered species and critical habitat areas are found and is given a score of 5 for this criterion.

3.2.8 Wetland Habitats

To Be Determined

3.2.9 Availability of Material Sites

This alternative has material sites available every 10 miles for approximately 95% of the length of the corridor and is given a score of 5 for this criterion.

3.2.10 Large Bridges

This corridor has 50 major stream crossings, including 11 large bridges with a total combined length of approximately 4,870 linear feet. This alternative has the lowest total length of large bridges and is given a score of 5 for this criterion.

3.2.11 Construction Cost

The total estimated construction cost for this corridor is $481 million (Appendix A). This is the second lowest construction cost of the three alternatives evaluated and the corridor is given a score of 5 on this criterion.

3.2.12 Maintenance Cost

Estimated annual maintenance cost for Alternative B is approximately $10.6 million. Initial maintenance camp construction and annual maintenance are summarized in Appendix A. This is the second lowest annual maintenance cost for the alternatives evaluated and this corridor is given a score of 4 on this criterion.

3.2.13 Special Considerations

No special considerations are relevant to this corridor.

3.3 Alternative C

3.3.1 General Route Description

This Alternative C corridor is the longest option at approximately 332 miles. This corridor heads east from the Ambler River and then south through the Cosmos Hills, crossing the Kobuk River near the community of Kobuk. The corridor then heads southeast to the south of the Lockwood Hills and crosses to the south of the Pah River Flats along the north side of the Zane Hills. It heads east to the north of Hogatza and then runs southeast to cross the Koyukuk River near the community of Hughes. The corridor heads northeast along the Koyukuk River before proceeding southeast through the Indian Mountains. The corridor heads south along the Indian River and then proceeds southeast along the south flank of the Ray Mountains. The corridor follows the Tozitna River east and then proceeds northeast through the Ray Mountains. It then heads east to mile 59.5 of the Dalton Highway to the north of the Yukon River.

The evaluation of this route is summarized in Table 12.

3.3.2 Corridor Length

This alternative is 332 miles long and is the longest of the corridors evaluated. The corridor is given a score of 3 for this criterion.

3.3.3 Federal Conservation Systems

This corridor does not cross through any CSUs. The corridor is given a score of 5 for this criterion.

Table 12: Alternative C Corridor Evaluation

Criterion	Value	Score
Corridor Length (miles)	332	3
Federal CSU (unit/miles/percentage of corridor)	None	5
Wild and Scenic Rivers	None	5
Salmon/Sheefish Rivers Mapped Anadromous Assumed Anadromous	251 13 238	0
Caribou Habitat	Less	5
Threatened/Endangered Species/Critical Habitat	None	5
Wetland Habitats (miles)	To Be Determined	-
Material Site Availability (percent of corridor with material site within 10 miles)	84%	4
Total Large Bridges (number/length in ft) Bridges Over 1,500 ft Major Stream Crossings	14/5,150 ft None 523	5
Construction Cost [1] (in millions)	$880	4
Annual Maintenance Cost (in millions)	$15.7	2
Special Considerations None	NA	NA
Total Score		**38**

1. Costs rounded to tens of millions.

3.3.4 Wild and Scenic Rivers

This corridor does not cross any WSRs. The corridor is given a score of 5 for this criterion.

3.3.5 Salmon/Sheefish Rivers

This alternative crosses 13 mapped anadromous streams and 238 streams assumed to be anadromous, for a total of 251. This is the highest value of anadromous streams crossed by any of the alternatives and this corridor is given a score of 0 for this criterion.

3.3.6 Caribou Habitat

This alternative crosses through migratory areas and the outer range of the WACH. This alternative heads east from the Ambler mineral belt and crosses less WACH habitat than corridors previously considered that head west and is given a score of 5 for this criterion.

3.3.7 Threatened and Endangered Species and Critical Habitat Areas

This corridor does not cross through areas where threatened or endangered species or critical habitat areas are found, and it is given a score of 5 for this criterion.

3.3.8 Wetland Habitats

To be determined.

3.3.9 Availability of Material Sites

This alternative has material sites available every 10 miles for approximately 84% of the length of the corridor and is given a score of 4 for this criterion.

3.3.10 Large Bridges

This corridor has 523 major stream crossings, including 14 large bridges with a total of 5,150 feet of large bridge spans. This alternative has the highest numbers of large bridges and the greatest total length of large bridges, but the total length is still below 5,500 linear feet so the corridor is given a 5 for this criterion.

3.3.11 Construction Cost

The total estimated construction cost for this corridor is $880 million (Appendix A). This alternative has the highest construction cost of the three alternatives considered and is given a score of 4 on this criterion.

3.3.12 Maintenance Cost

Estimated annual maintenance cost for Alternative C is approximately $15.7 million. Initial maintenance camp construction and annual maintenance are summarized in Appendix A. This is the highest annual maintenance cost of the alternatives evaluated and this corridor is given a score of 2 on this criterion.

3.3.13 Special Considerations

No special considerations are relevant to this corridor.

4.0 ALTERNATIVE C GEOLOGIC ASSESSMENT

4.1 Introduction

This geotechnical analysis serves as an addendum to the DOWL Geotechnical Memorandum (2011). The objective of this analysis is to characterize the geology and geotechnical material properties along the Alternative C corridor. This was accomplished by using a landform-derivative classification process based on data collected from published geologic literature and maps and limited satellite imagery interpretation. A preliminary terrain unit map (PTUM) was created from the geologic references and satellite imagery, which was then used to complete the data analysis leading to the results and interpretations presented within this section.

4.2 Methods

4.2.1 Landform Derivative Analysis Overview

The terrain unit mapping and geological properties analysis was based on a landform derivative process. The fundamental premise of this technique is that landforms generated from similar physical processes (e.g. glaciers, wind, flowing water, etc.) generally have similar physical properties (e.g. grain size distribution of particulate, hazard potential, propensity for ice formation, etc.). Thus, if a landform can be identified and classified then the general physical characteristics of that landform can be derived. This analysis followed the methodology applied in the 2011 Geotechnical Memorandum and follows the process described in detail within the State of Alaska Department of Natural Resources Division of Geological and Geophysical Surveys (DGGS), Miscellaneous Publication 129 (MP 129), Survey of Geology, Geologic Materials, and Geologic Hazards in Proposed Access Corridors, Alaska (Reger et al. 2003). The 2011 Geotechnical Report and MP 129 should be reviewed for a thorough understanding of the methods applied in this analysis.

Some differences in approach were necessary between the work done for the 2011 Geotechnical Memorandum and this analysis. The 2011 study was focused on a very large study area and many of the analyzed corridors overlapped with the corridors mapped within MP 129; therefore limited additional mapping was required outside of what is presented in MP 129. Where there was no corridor coverage from MP 129, the 2011 mapping was completed using large scale (1:500,000 or greater) state-wide geologic maps and the satellite imagery available at the time, which was considerably lower quality than currently available. The Alternative C corridor contains almost no overlap with the corridors presented within MP 129 and additional geologic references were needed to complete the PTUM.

4.2.2 Preliminary Terrain Unit Mapping

Publicly available geologic maps were obtained from the DGGS and United States Geological Survey (USGS) which covered the alignment area (see the References for a full list of all maps used in this study). Most of these maps are displayed on a 1:250:000 scale and thus only landforms identifiable at this scale are generally mapped. Surficial geologic maps were used where possible, but there are a few sections of the alignment where surficial geologic maps have not been published or available maps do not delineate surface landforms. This was the case for portions of the Shungnak and Melozitna quadrangles. The geologic reference maps were georeferenced with ArcGIS and the mapping was digitized within 2.5-miles on either side of the Alternative C corridor. This digitized map formed the basis of the PTUM.

As many of the published geologic maps use different terminology and symbology for different landform units, the geologic map unit descriptions and the associated reports were reviewed and an interpretation was made to classify all of the mapped units into one of the classifications presented in MP 129. These classifications were assigned as an attribute for each landform within the PTUM. This was necessary so that the derivative interpretations and classification presented in MP 129 could be uniformly applied to all mapped units across the corridor regardless of the variation in the published geologic map terminology or symbology.

Where no surficial mapping was available, some limited satellite imagery interpretation was done. Satellite imagery was also used to refine the boundaries and verify the mapped units. Satellite imagery quality varied with location. Where there was a discrepancy or ambiguity between the mapped landform and the project geologist's interpretations of satellite imagery, the published geologic classification was applied.

Once all the landforms were mapped and classified into one of the landform types described in MP 129, the derivative interpretations were applied. These derivative characteristics included grain size distribution, propensity for ice formation, generalized geologic hazards, and bedrock classification. This data was then reduced by similar methods used in the 2011 Geotechnical Report to arrive at interpreted embankment foundation conditions and relative suitability of material for borrow.

Differences in mapping from the 2011 Geotechnical Memorandum include:

- classifying alluvium deposits with combined geologic hazards of significant liquefaction and potential seasonal flooding as a minor hazard (previously mapped as a significant hazard) for possible material site classification, and
- classifying the geologic unit “Qsm” as an SM material as opposed to a GS material.

4.2.3 General Embankment Foundation Conditions

The general embankment foundation conditions were derived from each geologic landform within the PTUM in accordance with the methods described in the 2011 Geotechnical Memorandum. A landform was assigned a classification of rating from poor, fair, or good based on the grain size distribution, propensity for ice content, and estimated thaw stability. The assessment was a direct correlation of the material type and hazard classification derived from the landform classification. This method only generates a very generalized assessment of embankment foundation conditions. Local variations can occur rapidly over short distances and can be affected by a wide variety of local climate and geographic features. The expected material types and corresponding general embankment foundation conditions for each portion of Alternative C are presented in Table B-1 in Appendix B.

4.2.4 Material Sites

Material site locations provided by HDR were reviewed with respect to the mapped geology and the interpretation of geological conditions by DOWL’s project geologist. In general, the selected material sites appear to be suitable; however, some of the supplied boundaries may need to be enlarged to yield enough material for construction. The provided material site boundaries were used to determine the general material availability along the alignment. The average distance between these provided material sites for each section of Alternative C is shown graphically in Figure 1 in Appendix B and presented in Table B-1.

Additional potential material source landforms were identified during creation of the PTUM using the methods described in the 2011 Geotechnical Memorandum. These additional landforms could potentially serve as material sources and result in shorter haul distances between material sites than shown in Figure 1 (Appendix B) or tabulated in Table B-1. The potentially suitable material source landforms identified by the PTUM mapping processes are shown in Figure 2 in Appendix B. Material sites and suitability of material for borrow is discussed in further in Section 5.0 Alternative C Geologic Description.

4.3 Regional Geologic Setting

4.3.1 Physiography

The Alternative C corridor traverses through six physiographic provinces of Alaska as described by Wahrhaftig (1965). Each physiographic province is defined by general topography, drainage, lakes, glaciers, permafrost conditions, and geology. The Alternative C route has been subdivided along each of these physiographic provinces as they serve as reasonable divisions for discussion and each section has some generally shared characteristics. A map of the physiographic divisions is shown in Figure 3 in Appendix B. The physiology (physical geography) of each segment is discussed individually in Section 5.0 Alternative C Geologic Description.

4.3.2 Permafrost

As noted in the 2011 Geotechnical Memorandum, permafrost can be extremely variable in distribution, thickness, temperature, and thaw settlement/heave potential and thaw strength properties. The Alternative C route traverses across almost all the permafrost conditions mapped across Alaska by Ferrians (1998). This includes:

- Mountainous area underlain by discontinuous permafrost
- Mountainous area underlain by continuous permafrost
- Lowland and upland area underlain by moderately thick to thin permafrost
- Lowland and upland area underlain by continuous permafrost

Within some satellite imagery, prominent permafrost features are observable (e.g. ice-wedge polygons and thaw lakes). Where observable, these features are noted within the section description in Section 5.0 Alternative C Geologic Description. A generalized permafrost distribution map of Alternative C is provided as Figure 4 in Appendix B.

4.3.3 Naturally Occurring Asbestos

Naturally occurring asbestos (NOA) minerals have been documented in mafic and ultramafic igneous and metamorphic rocks in the region. Typical asbestos-bearing or potentially asbestos-bearing minerals include asbestos, chrysotile, tremolite, actinolite, talc, soapstone, nephrite (jade), magnesite, nemalite, and serpentine. The Alaska Department of Transportation and Public Facilities has determined that the Ambler region has significant exposures of ultramafic rocks that contain both serpentine and amphibole mineral forms that contain asbestos (Perkins et al. 2009). The DGGS has published a report documenting the distribution of relative NOA potential in bedrock units across Alaska (Solie and Athey 2015). Abundance of NOA-favorable lithology was assigned according to estimated percentage of total rock volume in a geologic bedrock unit as follows: trace (less than 1%), minor (1-10%), moderate (11-50%), and major (greater than 50%). These estimated percentages were then used to classify a geologic bedrock unit into NOA potential classifications. These classifications by Solie and Athey are as follows:

- High to Known – Map units consisting entirely of or containing a major amount (>50%) of rock types known to host asbestos elsewhere in the world.
- Medium – Map units consisting of more than one rock type, where at least one rock type within the unit is favorable, or a unit including the types of rocks that could host NOA in areas affected by metamorphism or deformation.
- Zero to Low – Map units containing zero to trace (<1%) amounts of highly NOA-favorable rock types, minor (1-10%) to major (>50%) amounts of low-NOA-favorable rock types and rock types that are unfavorable for NOA.
- Surficial Deposits – Map units consisting of unconsolidated surficial deposits. These units have not been evaluated for NOA potential and could contain asbestos depending on origin of sediments.

However, it is important to understand that NOA minerals usually constitute only a part of the rock in which they occur and form as secondary alteration products requiring specific conditions for growth (Solie and Athey 2015). Therefore, rock types rated as having higher NOA potential do not necessarily contain NOA and bodies of rock rated as low potential could include localized NOA.

Glaciation, weathering, and surficial processes can erode NOA containing bedrock and mobilize the NOA minerals so that they may be present in gravels and other deposits that may be used in road base and construction. The airborne dust associated with use of this material adds to the risk of inhalation of asbestos-rich dust. Higher NOA potential in surficial deposits will generally be found close to bedrock with the highest potential for NOA but different surficial deposits may inherit different amounts of NOA minerals based on the process in which the deposit is formed (Solie and Athey 2015).

Within this analysis, each segment of Alternative C was compared with the DGGS study and the relative NOA-bearing probability of the bedrock units was determined. The relative likelihood of bedrock bearing NOA is discussed for each segment within Section 5.0 Alternative C Geologic Description.

4.3.4 Acid Rock Drainage

Acid rock drainage (ARD) is acidic runoff caused by the oxidation of sulfide minerals during which sulfur is converted to sulfuric and sulfurous acid. This commonly occurs when volcanogenic massive sulfides are exposed to air and water; although, it may occur in other rock types as well. The prediction of the occurrence of ARD susceptible rocks from satellite photography can often be misleading (what may appear to be iron staining may in fact only be seasonal vegetation coloration) and, like NOA, a formation having the potential to generate ARD does not indicate that it will definitively occur. Currently, DOWL is not aware of any publications which delineate the ARD potential of bedrock units across the Alternative C corridor. For these reasons, an assessment of ARD potential was not conducted in this study as the results of such an assessment would not be meaningful. At the time of route development, if a bedrock material site is determined to have minerology which could lead to ARD, a panel of acid/base tests should be conducted to determine the rocks ARD potential definitively. If a source were to be determined to have ARD potential, methods could be implemented to prevent ARD, or an alternative site could be selected.

5.0 ALTERNATIVE C GEOLOGIC DESCRIPTION

5.1 Typical Geology

From west of the Dalton Highway, the alignment traverses eolian silt before crossing through the Ray Mountains. The Ray Mountains are composed of bedrock which could generate suitable borrow material. After exiting the west side of the Ray Mountains, the alignment traverses across the north side of the Tozitna River drainage where it is underlain by eolian silt and colluvium covering older alluvium. This section displays polygonal ice-wedge pattering and thaw lakes near the Melozitna River. Shallow bedrock may be possible along the alignment as it wraps around the north side of Indian Mountain toward Hughes, but upland silt and glacial lake sediments are also present on the east side of Indian Mountain.

After crossing the Koyukuk River, the alignment passes through the Hogatza River Flats and along the southern edge of the Pah River Flats on the north flank of the Zane Hills. Material sites are not abundant nor advantageous in this portion of the alignment. Where the alignment realigns to the northwest and traverses the south of Lockwood Hills, the underlying soils are composed of glacial drift, eolian silt, and colluvium. Massive ice structures and thaw lakes are present as the alignment enters into the Kobuk Lowlands. The southside of the Kobuk Lowlands contain a mixture of thaw lake deposits, reworked eolian sand, and fine-grained alluvium; the Kobuk River floodplain is composed of alluvial gravel and sand. The final stretch of the alignment traverses along the existing road between Kobuk and Bornite through the Cosmos Hills range before exiting the range on the north side and entering the Ambler Lowlands. These lowlands are composed of alluvium, reworked eolian sand, glacial drift, and Ambler River alluvium.

5.1.1 Section 1 – Mile 0 to 62 – Dalton Highway through Ray Mountains

This portion of the corridor is located in the Kokrine-Hodzana Highlands physiographic province which is typified by mountains with even-topped rounded ridges and isolated areas of rugged mountains with glacial cirques (Wahrhaftig 1965). In this section the alignment traverses from the Dalton Highway through the Ray Mountains. The first 20 miles of the alignment is generally underlain by eolian silt outside of the Ray River alluvial valley. The next portion of the alignment generally follows narrow alluvial valleys with mountain slopes rising on both sides of the corridor before existing the Ray Mountains near the headwaters of the Tozitna River.

The bedrock is composed of variably altered/metamorphosed, mafic igneous (basalt, gabbro, and rare ultramafic) and sedimentary (argillite, phyllite, chert, slate, graywacke, and carbonate) rocks (Chapman 1982, Patton 2009). The bedrock could be suitable for borrow source material. This bedrock in this portion of the Ray Mountains has been classified as having medium potential for

NOA occurrence indicating it could possibly contain NOA in localized portions of the unit (Solie and Athey 2015). These localized portions would likely occur near ultramafic occurences. Ultramafic occurences have been described as rare in the area (Chapman 1982).

The foundation soils are composed of silt, bedrock, and narrow alluvium deposits. The narrow alluvial valleys may be a source for clean sand and gravel, but the limited extent of the deposits may limit the yield of any individual site and multiple sites would likely be needed at shorter intervals along the alignment to obtain an adequate volume of material. This portion of the alignment is generally underlain by discontinuous permafrost (Ferrians 1998).

5.1.2 Section 2 – Mile 62 to 127- Ray Mountains across Tozitna River and Melozitna Drainages to Indian River Uplands

This portion of the alignment is located with Tozitna-Melozitna Lowland physiographic province composed of a narrow rolling plain at the heads of the Tozitna and Melozitna Rivers (Wahrhaftig 1965). The alignment traverses north of the Tozitna River along the lower slopes of the Ray Mountains before crossing over the Melozitna River. The foundation soils are generally composed of older alluvial deposits capped by and intermixed with eolian silt. Very little of the unconsolidated sediments would generate suitable borrow sites aside from alluvium adjacent to the Melozitna River. Borrow materials would likely be obtained from bedrock sources in the Ray Mountains to the north and possibly an isolated outcrop near the Melozitna River. Bedrock in this portion of the alignment is generally classified as zero to low probability of NOA occurrence (Solie and Athey 2015).

The bedrock to the north of alignment in the lower portions of the Ray Mountains is generally composed of schist with some carbonate rocks, but some mafic igneous rocks and granitic outcrops may be accessible (Chapman 1982, Patton 2009). The quality of any bedrock borrow source would need to be accessed for viability and may result in a longer access road required to access higher quality rock material.

This portion of the alignment is underlain by discontinuous and continuous permafrost (Ferrians 1998). Massive ice structures (ice wedge polygons) are visible in satellite imagery in the portion of the alignment north of the Tozitna River and numerous thaw lakes are present near the Melozitna River. These indicate the sediment is ice rich and may require a thicker embankment in this portion of the alignment where bedrock is not near the surface. Some of these ice-rich features are visible in deposits overlying areas mapped as bedrock by Chapman (1982). The thickness of these overlying deposits would need to be determined through field investigation and could result in the need for thicker embankments than implied by the landform derivative method applied within this study.

5.1.3 Section 3 – Mile 127 to 218 – Indian River Uplands past Hughes to Hogatza River Flats.

This section of the corridor passes through the Indian River Upland physiographic province which can be generalized as a group of low ridges surrounding the Indian Mountains interspersed with lowlands and broad flat divides with drainage flowing to the Koyukuk River (Wahrhaftig

1965). The alignment traverses north from the Melozitna drainage before wrapping around the north side of the Indian Mountains and realigning south toward Hughes along the Koyukuk River alluvial floodplain. From near Hughes, the corridor realigns to the west, crosses the Koyukuk and traverses up the Hughes Creek drainage toward the west.

The majority of the bedrock underlain and adjacent to this section of the alignment is composed of graywacke and mudstone (Patton 2009). This formation will likely yield borrow of varying quality and portions of the formation composed of graywacke may yield suitable borrow material. Extrusive volcanic rocks composed of dacite and rhyolite flows are also present near mile points 124 to 125 which may yield suitable borrow (Patton 1978, Patton 2009). The Indian Mountains are cored by a large granitic pluton which outcrops near the alignment and should generate excellent borrow material. Bedrock in this portion of the alignment is classified as zero to low probability of NOA occurrence (Solie and Athey 2015).

The foundation soils are generally composed of bedrock, silt deposits, and alluvial deposits. The alluvium along the Koyukuk River could yield clean sand a gravel. This segment of the of the alignment is underlain by discontinuous and continuous permafrost (Ferrians 1998). Several sections (mile points 153.5-158, 181-182, and 208-218) have ice wedge polygons and thaw lakes visible within satellite imagery.

The USGS has not published a surficial geology map for the Melozitna quadrangle (quad) and the available satellite imagery over this area of the alignment is relatively poor. Unconsolidated sediments were delineated in detail within the available bedrock geology maps (Patton 1978, Patton 2009). As such, little is known about the surficial geology in the mountainous areas in the Melozitna quad portion of the alignment. It is possible that much of the mapped bedrock is mantled by upland eolian silt and colluvium as identified in the Hughes quad to the north (Hamilton 2002). If so, a thicker embankment may be necessary where the bedrock is not near the surface.

5.1.4 Section 4 – Mile 218 to 302 – Hogatza River Flats to Kobuk River Lowlands

This segment of the alignment passes through the Pah River Section physiographic province which is composed of a diverse topography typified by a series of rolling ridges and mountains surrounding lowland sections (Wahrhaftig 1965). The alignment traverses from the east through the Hogatza River lowlands, skirts to the south of the Pah River Flats on the northern flank of the Zane Hills and realigns toward the northwest along the Pick River drainage between the Kiliovilik and Sheklukshuk Ranges and Lockwood Hills.

Bedrock outcrops near the alignment are infrequent between mile points 218 to 252. Where the alignment traverses north of the Zane Hills, bedrock outcrops occur approximately 1 to 2 miles south of the alignment. If a source were developed, the bedrock is composed of andesite and basalt lava flows which would likely generate suitable borrow (Patton 2009). However, the bedrock outcrops rises steeply in many places which could make developing an access road and bedrock quarry within these resources disadvantageous. This same unit composes the Lockwood Hills further north along the alignment where it is more accessible for development.

This segment of the of the alignment is underlain by discontinuous and continuous permafrost (Ferrians 1998). The foundation soils in this portion of the alignment are generally the least desirable of any segment of the alignment. From mile points 218 to 253, the alignment traverses through muskeg and thaw deposits expected to contain a thick organic layer. Throughout this muskeg/thaw section there is little suitable borrow available beyond alluvial deposits located adjacent to the Hogatza River. These deposits are generally limited in extent and multiple material sites would likely need to be developed to accommodate the material demands. North of the Zane Hills, the alignment traverses through a mixture of reworked eolian silt, alluvial fan deposits, drift, and several small drainages in which the alluvium is expected to be a variable consistency. Where the alignment parallels the Pick River the underlying soils are composed of eolian silt and colluvium. Massive ice and thaw structures are visible in satellite photography, particularly near mile points 296 to 302.

The USGS has not published a surficial geology map of the Shungnak quad for the portion of the alignment north of the Zane Hills and satellite photograph interpretation was conducted where possible. Some of the alluvial drainages and alluvial fans may contain suitable borrow material locations to supplement the lack of advantageous material sites currently identified within this segment but it is difficult to determine without additional investigation.

5.1.5 Section 5 – Mile 302 to 315 – Kobuk River Lowlands

This shorter section of the alignment is within Kobuk-Selawik Lowland physiographic province which is characterized by the broad Kobuk River floodplain and lake-dotted lowland (Wahrhaftig 1965). The floodplain is bordered on the south by a complex terrace and fan deposit that consists of fine gravel, sand, and silt with mixtures of organic material. In some areas, the material has been redeposited by migrating thaw lakes and in other places a cover of dune sand is present (Fernald 1964). To the north of the Kobuk floodplain, the alignment rises in elevation through glacial drift and eolian sand before arriving at the base of the Cosmos Hills.

The foundation soils between mile points 302 and 309 are composed of the complex terrace and fan deposit described above. Numerous thaw lakes are present throughout the deposit and the alignment crosses an approximately 1-mile long wide thaw lake deposit near mile points 303 to 304. Foundation soils are expected to be poor for this interval and the material would not be suitable for borrow. Foundation soils are expected to be good within the Kobuk River floodplain and clean sand and gravel may be obtained from these alluvial deposits. The drift and eolian sand deposits north of the Kobuk river should provide fair foundation conditions but may not be suitable borrow. This section is underlain by discontinuous to continuous permafrost (Ferrians 1998).

Bedrock does not outcrop in this section of the alignment.

5.1.6 Section 6 – Mile 315 to 332.3 – Kobuk River Lowlands to Ambler River

In this section the alignment passes through Ambler – Chandalar Ridge and Lowland Section physiographic province which is typified by a southern ridge of mountains (Cosmos Hills at this location) separated from the southern edge of the Brooks Range by a lowland (Wahrhaftig 1965). The alignment follows the established road between Kobuk and Bornite through the Cosmos Hills before continuing north into the Ambler Lowlands and ultimately arriving at the Ambler River.

The bedrock beneath the alignment in the Cosmos Hill range is composed of sedimentary (sandstone, conglomerate, carbonate) and metasedimentary (phyllite and schist) rocks. Mafic volcanic (basalt and diabase) and ultramafic complex (serpentinite) are located nearby within the Cosmos Hills (Patton 1968, Patton 2009). The sedimentary rocks and mafic volcanic rocks could be suitable borrow sources. The Cosmos Hills area has been classified as a medium to high probability of NOA occurrence with known occurences in the range (Solie and Athey, 2015).

The foundation soils in the portion of the alignment are composed of bedrock and existing road material through the Cosmos Hills. To the north the alignment traverses reworked eolian sand, glacial drift, and alluvium. The alluvium and drift could yield adequate borrow materials. This portion of the alignment is underlain by continuous permafrost (Ferrians 1998).

6.0 SUMMARY AND CONCLUSIONS

The three roadway alternatives, as they are described by 12 specific evaluation criteria, are summarized in Tables 13 and 14.

Based on the evaluation of the 12 criteria, Alternatives A and B both rank more favorably than Alternative C, with Alternative A having the highest score due to the lower annual maintenance costs. Alternative C scores notably lower than the other two alternatives due to the longer length of the corridor, the significantly higher number of salmon/sheefish rivers crossed, less material site availability, a higher construction cost, and a higher annual maintenance cost.

Table 13: Corridor Evaluation Summary

Criterion	Alternative A	Alternative B	Alternative C
Corridor Length (miles)	211	228	332
Federal CSU (unit/miles/percentage of corridor)	GAAR/ 26 miles/12%[1]	GAAR/ 18 miles/8%[1]	None
Wild and Scenic Rivers	Kobuk WSR[1]	Kobuk WSR[1]	None
Salmon/Sheefish Rivers Total	28	31	251
Mapped Anadromous	5	6	13
Assumed Anadromous	23	25	238
Caribou Habitat	Less	Less	Less
Threatened/Endangered Species/Critical Habitat	None	None	None
Wetland Habitats (miles)	-	-	-
Material Site Availability (percent of corridor with material site within 10 miles)	93%	95%	84%
Total Large Bridges (number/length in ft)	11/4,920 ft	11/4,870 ft	14/5,150 ft
Bridges Over 1,500 ft	None	None	None
Major Stream Crossings	63	50	523
Construction Cost[2] (in millions)	$447	$481	$880
Annual Maintenance Cost[3] (in millions)	$10.1	$10.6	$15.7
Special Considerations			
Port Construction	No	No	No
Very Large River Crossings	None	None	None

1. Access through GAAR was permitted in ANILCA.
2. Cost rounded to tens of millions.
3. Annual maintenance cost for road and maintenance camps.

Table 14: Corridor Scoring Summary

Criterion	Alternative A	Alternative B	Alternative C
Corridor Length	5	5	3
Federal CSU	5	5	5
Wild and Scenic Rivers	5	5	5
Salmon/Sheefish Rivers	5	5	0
Caribou Habitat	5	5	5
Threatened/Endangered Species/Critical Habitat	5	5	5
Wetland Habitats	-	-	-
Material Site Availability	5	5	4
Total Large Bridges	5	5	5
Construction Cost	5	5	4
Annual Maintenance Cost	5	4	2
Total Score	**50**	**49**	**38**

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APPENDIX A

Construction and Maintenance Cost Estimates by Alternative

APPENDIX A

CONSTRUCTION AND MAINTENANCE COST ESTIMATES BY CORRIDOR

The most recent construction cost estimates for Alternatives A and B were developed using earthwork volumes for excavation (cut) and borrow (fill) quantities determined through AutoCAD Civil3D, based on the preliminary roadway designs developed in support of the Revised SF299 Consolidated Permit Application. The available data and schedule for the Ambler Road EIS does not allow for determining comparable earthwork volumes for Alternative C in support of this Summary Report Addendum. Therefore, to provide a consistent cost comparison between the three alternatives, construction cost estimates presented in this addendum were prepared assuming the entire roadway embankment will be constructed with borrow (fill) material at uniform depths ranging from 3 feet to 7 feet, with the embankment thickness dependent on the identified subsurface soil conditions. The presented construction cost estimates are considered conservative since they do not account for usable excavation (cut) material that can be incorporated into the roadway embankment at a lower unit cost and have not been adjusted for varying topography to reduce material required. The presented construction cost estimates are for full-embankment, two-lane road corridors with a 32-foot-wide roadway surface (two 12-foot lanes with 4-foot shoulders). All bridges are assumed to be one lane (23-foot-wide deck surface) consistent with the Revised SF299 Consolidated Permit Application.

1.0 ALTERNATIVE A

1.1 Roadway Construction Costs

Total Construction cost for the 211-mile-long corridor is estimated at **$447,000,000** and consists of the following:

Table A-1: Alternative A Construction Cost

Component	Cost/mile (million/mile)
Roadway	$1.51
Water Crossings	$0.61
Corridor Cost/mile	**$2.12**
Total Corridor Cost	**$447,000,000**
Corridor Length = 211 miles	
Truck turnouts = 20 each	

- Roadway construction cost assumes clearing, gravel surfacing, embankment, a widened roadway surface every ten miles for truck turnouts, and mobilization.

- Embankment material cost assumed approximately 61% of material would be used from state lands at a unit price of $8.48/ton. The remaining 39% of the embankment material was assumed to have a $5/cubic yard royalty added for non-state land material for a unit price of $10.98/ton.

1.2 Estimated Maintenance Costs

Roadway Maintenance Costs

Estimated annual road maintenance cost for Alternative A is approximately $6,625,400.

Roadway Maintenance Camp Costs

Initial maintenance camp construction and annual maintenance are summarized in Table A-2.

Table A-2: Alternative A Maintenance Camp Cost

Component	Cost/each	Total Corridor Cost
Four new maintenance camps	$6,608,000/each	$26,432,000
Three new landing strips	$838,000/each	$2,514,000
Annual maintenance of **four** camps	$507,000/camp	$2,028,000/yr

Maintenance costs for a 20-year period would consist of the following costs:

Table A-3: Alternative A Maintenance Cost Summary

Component	Total Corridor Cost
Annual Road Maintenance Cost (20 years)	$132,508,000
Maintenance Camps	$26,432,000
Landing Strips	$2,514,000
Annual Camp Maintenance (20 years)	$40,560,000
Total 20-Year Maintenance Cost	$202,014,000
Estimated Annual Maintenance	**$10,100,700**

2.0 ALTERNATIVE B

2.1 Roadway Construction Costs

Total Construction cost for the 228-mile-long corridor is estimated at **$481,000,000** and consists of the following:

Table A-4: Alternative B Corridor Construction Cost

Component	Cost/mile (million/mile)
Roadway	$1.53
Water Crossings	$0.58
Corridor Cost/mile	**$2.11**
Total Corridor Cost	**$481,000,000**
Corridor Length = 228 miles	
Truck Turnouts = 22 each	

- Roadway construction cost assumes clearing, gravel surfacing, embankment, a widened roadway surface every ten miles for truck turnouts, and mobilization.
- Embankment material cost assumed approximately 67% of material would be used from state lands at a unit price of $8.43/ton. The remaining 33% of the embankment material was assumed to have a $5/cubic yard royalty added for non-state land material for a unit price of $10.93/ton.

2.2 Estimated Maintenance Costs

Roadway Maintenance Costs

Estimated annual road maintenance cost for Alternative B is approximately $7,159,200.

Roadway Maintenance Camp Costs

Initial maintenance camp construction and annual maintenance are summarized in Table A-5.

Table A-5: Alternative B Corridor Maintenance Camp Cost

Component	Cost/each	Total Corridor Cost
Four new maintenance camps	$6,608,000/each	$26,432,000
Three new landing strips	$838,000/each	$2,514,000
Annual maintenance of **four** camps	$507,000/camp	$2,028,000/yr

Maintenance costs for a 20-year period would consist of the following costs:

Table A-6: Alternative B Corridor Maintenance Cost Summary

Component	Total Corridor Cost
Annual Road Maintenance Cost (20 years)	$143,184,000
Maintenance Camps	$26,432,000
Landing Strips	$2,514,000
Annual Camp Maintenance (20 years)	$40,560,000
Total 20-Year Maintenance Cost	$212,690,000
Estimated Annual Maintenance	**$10,634,500**

3.0 ALTERNATIVE C

3.1 Roadway Construction Costs

Total Construction cost for the 332-mile-long corridor is estimated at **$880,000,000** and consists of the following:

Table A-7: Alternative C Corridor Construction Cost

Component	Cost/mile (million/mile)
Roadway	$1.62
Water Crossings	$1.03
Corridor Cost/mile	**$2.65**
Total Corridor Cost	**$880,000,000**
Corridor Length = 332 miles	
Truck Turnouts = 33 each	

- Roadway construction cost assumes clearing, gravel surfacing, embankment, a widened roadway surface every ten miles for truck turnouts, and mobilization.

- Embankment material cost assumed approximately 5% of material would be used from state lands at a unit price of $8.63/ton. The remaining 95% of the embankment material was assumed to have a $5/cubic yard royalty added for non-state land material for a unit price of $11.13/ton.

3.2 Estimated Maintenance Costs

Roadway Maintenance Costs

Estimated annual road maintenance cost for Alternative C is approximately $10,424,800.

Roadway Maintenance Camp Costs

Initial maintenance camp construction and annual maintenance are summarized in Table A-8.

Table A-8: Alternative C Corridor Maintenance Camp Cost

Component	Cost/each	Total Corridor Cost
Six new maintenance camps	$6,608,000/each	$39,648,000
Five new landing strips	$838,000/each	$2,514,000
Annual maintenance of **six** camps	$507,000/camp	$3,042,000/yr

Maintenance costs for a 20-year period would consist of the following costs:

Table A-9: Alternative C Corridor Maintenance Cost Summary

Component	Total Corridor Cost
Annual Road Maintenance Cost (20 years)	$208,496,000
Maintenance Camps	$39,648,000
Landing Strips	$4,190,000
Annual Camp Maintenance (20 years)	$60,840,000
Total 20-Year Maintenance Cost	$313,174,000
Estimated Annual Maintenance	**$15,658,700**

http://live.laborstats.alaska.gov/cpi/index.cfm

Consumer Price Index, Average Annual Inflation

Ave Δ CPI 2010-2018, Anchorage 1.81%

https://www.fhwa.dot.gov/policy/otps/nhcci/pt1.cfm

FHWA Construction Cost Index

September 2010	1.4465
September 2018	1.8468
Increase	1.277

https://www.usbr.gov/tsc/techreferences/mands/cct.html

Bureau of Reclamation Construction Cost Trends (Secondary Roads)

October 2010	416
October 2018	488
Increase	1.173

Haul Costs

RT Operating Cost per CY		CPI	FHWA	BOR	Average	Unit Cost FY18
1 mile	$3.00	$3.46	$3.83	$3.52	$3.60	**$3.60**
2 mile	$3.65	$4.21	$4.66	$4.28	$4.39	**$4.39**
3 mile	$4.25	$4.91	$5.43	$4.99	$5.11	**$5.11**
4 mile	$4.80	$5.54	$6.13	$5.63	$5.77	**$5.77**
5 mile	$5.30	$6.12	$6.77	$6.22	$6.37	**$6.37**
10 mile	$8.45	$9.75	$10.79	$9.91	$10.15	**$10.15**
15 mile	$11.35	$13.10	$14.49	$13.31	$13.64	**$13.64**
20 mile	$14.20	$16.39	$18.13	$16.66	$17.06	**$17.06**

Material RT Prep Costs

RT Prep Cost per CY		CPI	FHWA	BOR	Average	Unit Cost FY18
Excavation and Loading	$3.00	$3.46	$3.83	$3.52	$3.60	**$3.60**
Placement & Grading	$0.45	$0.52	$0.57	$0.53	$0.54	**$0.54**
Compaction	$0.35	$0.40	$0.45	$0.41	$0.42	**$0.42**
Watering	$1.65	$1.90	$2.11	$1.94	$1.98	**$1.98**
Total	$5.45	$6.29	$6.96	$6.39	$6.55	**$6.55**

Water Crossings

Description	Unit Cost FY10	Unit	CPI	FHWA	BOR	Average	Unit Cost FY18
Minor Crossing	$21,000	EA	$24,241	$26,811	$24,635	$25,229	**$25,300**
Culvert Small	$85,000	EA	$98,117	$108,523	$99,712	$102,117	**$102,200**
Culvert Large	$202,000	EA	$233,171	$257,901	$236,962	$242,678	**$242,700**
Fish Passage	$130,000	EA	$150,061	$165,976	$152,500	$156,179	**$156,200**
Bridge Small	$310,000	EA	$357,837	$395,788	$363,654	$372,426	**$372,500**
Bridge Medium	$600,000	EA	$692,588	$766,042	$703,846	$720,825	**$720,900**
Bridge Large	$5,900	LF	$6,810	$7,533	$6,921	$7,088	**$7,100**

Maintenance Costs

Description	Unit Cost FY10	Unit	CPI	FHWA	BOR	Average	Unit Cost FY18
Road Maintenance	$26,100	/MILE	$30,128	$33,323	$30,617	$31,356	**$31,400**
Maintenance Camp	$5,500,000	EA	$6,348,720	$7,022,053	$6,451,923	$6,607,566	**$6,608,000**
Landing Strip	$697,000	EA	$804,556	$889,886	$817,635	$837,359	**$838,000**
Camp Maintenance	$422,000	/EA	$487,120	$538,783	$495,038	$506,980	**$507,000**

Construction Costs

Description	Unit Cost FY10	Unit	CPI	FHWA	BOR	Average	Unit Cost FY18
Clearing	$9,500	ACRE	$10,966	$12,129	$11,144	$11,413	**$11,500**
Agg. Surface Course	$35	TON	$40.40	$44.69	$41.06	$42.05	**$42**
Turnout, Typical A	$22,992	EA	$26,540	$29,355	$26,971	$27,622	**$27,700**
Turnout, Typical B	$19,101	EA	$22,049	$24,387	$22,407	$22,947	**$23,000**
Turnout, Typical C	$14,824	EA	$17,112	$18,926	$17,390	$17,809	**$17,900**
Turnout Borrow	$8	TON	$9	$10	$9	$10	**$10**

Maintenance Costs

Scoring Range	Unit Cost FY10	Unit	CPI	FHWA	BOR	Average	Unit Cost FY18
5	$8,500,000	Total	$9,811,659	$10,852,264	$9,971,154	$10,211,692	**$10,300,000**
4	$10,500,000	Total	$12,120,284	$13,405,738	$12,317,308	$12,614,443	**$12,700,000**
3	$12,500,000	Total	$14,428,910	$15,959,212	$14,663,462	$15,017,194	**$15,100,000**
2	$14,500,000	Total	$16,737,535	$18,512,686	$17,009,615	$17,419,945	**$17,500,000**
1	$16,500,000	Total	$19,046,161	$21,066,160	$19,355,769	$19,822,697	**$19,900,000**
0	$16,600,000	Total	$19,161,592	$21,193,833	$19,473,077	$19,942,834	**$20,000,000**

Construction Costs

Scoring Range	Unit Cost FY10	Unit	CPI	FHWA	BOR	Average	Unit Cost FY18
5	$500,000,000	Total	$577,156,384	$638,368,476	$586,538,462	$600,687,774	**$600,000,000**
4	$750,000,000	Total	$865,734,576	$957,552,713	$879,807,692	$901,031,661	**$900,000,000**
3	$1,000,000,000	Total	$1,154,312,768	$1,276,736,951	$1,173,076,923	$1,201,375,548	**$1,200,000,000**
2	$1,250,000,000	Total	$1,442,890,960	$1,595,921,189	$1,466,346,154	$1,501,719,434	**$1,500,000,000**
1	$1,500,000,000	Total	$1,731,469,152	$1,915,105,427	$1,759,615,385	$1,802,063,321	**$1,800,000,000**
0	$1,501,000,000	Total	$1,732,623,465	$1,916,382,164	$1,760,788,462	$1,803,264,697	**$1,800,000,000**

Consumer Price Index for the Municipality of Anchorage and the U.S.

http://live.laborstats.alaska.gov/cpi/index.cfm

	Anchorage						U.S.					
Year	1st Half	Percent Change	2nd Half	Percent Change	Annual	Percent Change	1st Half	Percent Change	2nd Half	Percent Change	Annual	Percent Change
2018	223.099	2.1	227.992	4	225.545	3	250.089	2.5	252.125	2.4	251.107	2.4
2017	218.616	0.7	219.131	0.2	218.873	0.5	244.076	2.2	246.163	2	245.12	2.1
2016	216.999	-0.1	218.66	0.9	217.83	0.4	238.778	1.1	241.237	1.5	240.007	1.3
2015	217.111	1.1	216.706	-0.1	216.909	0.5	236.265	-0.1	237.769	0.3	237.017	0.1
2014	214.777	1.9	216.833	1.4	215.805	1.6	236.384	1.7	237.088	1.5	236.736	1.6
2013	210.853	2.7	213.91	3.5	212.381	3.1	232.366	1.5	233.548	1.4	232.957	1.5
2012	205.215	2.5	206.617	2	205.916	2.2	228.85	2.3	230.338	1.8	229.594	2.1
2011	200.278	2.8	202.576	3.6	201.427	3.2	223.598	2.8	226.28	3.5	224.939	3.2
2010	194.834	2.5	195.455	1	195.144	1.8	217.535	2.1	218.576	1.2	218.056	1.6
2009	190.032	1.3	193.456	1.1	191.744	1.2	213.139	-0.6	215.935	-0.1	214.537	-0.4
2008	187.659	4.6	191.335	4.5	189.497	4.6	214.429	4.2	216.177	3.4	215.303	3.8
2007	179.394	1.5	183.08	2.9	181.237	2.2	205.709	2.5	208.976	3.1	207.342	2.8
2006	176.7	4.2	177.9	2.2	177.3	3.2	200.6	3.8	202.6	2.6	201.6	3.2
2005	169.6	2.4	174.1	3.8	171.8	3.1	193.2	3	197.4	3.8	195.3	3.4
2004	165.6	2.8	167.8	2.4	166.7	2.6	187.6	2.3	190.2	3	188.9	2.7
2003	161.1	2.3	163.9	3.1	162.5	2.7	183.3	2.5	184.6	2	184	2.3
2002	157.5	2	159	1.9	158.2	1.9	178.9	1.3	180.9	1.9	179.9	1.6
2001	154.4	2.9	156	2.7	155.2	2.8	176.6	3.4	177.5	2.2	177.1	2.8
2000	150	0.9	151.9	2.4	150.9	1.7	170.8	3.3	173.6	3.5	172.2	3.4
			Annual Average 2010-2018:			1.81				Annual Average 2010-2018:		1.79

Corridors	Length	Estimated Annual Road Maintenance Cost	Maintenance Camp Costs					20 yr Life Cycle Costs			ANNUAL TOTAL
	Miles		Each		Landing Strip		Main	Annual Road Main 20 yrs	Annual Camp Main 20 yrs	20 YR TOTAL	
Alternative A	**211**	$6,625,400	4	$26,432,000	3	$2,514,000	$2,028,000	$132,508,000	$40,560,000	$202,014,000	$10,100,700
Alternative B	**228**	$7,159,200	4	$26,432,000	3	$2,514,000	$2,028,000	$143,184,000	$40,560,000	$212,690,000	$10,634,500
Alternative C	**332**	$10,424,800	6	$39,648,000	5	$4,190,000	$3,042,000	$208,496,000	$60,840,000	$313,174,000	$15,658,700

Road maintenance per mile per year:	$31,400
Maintenance camp capital cost:	$6,608,000
Landing strip capital cost:	$838,000
Camp maintenance per year:	$507,000

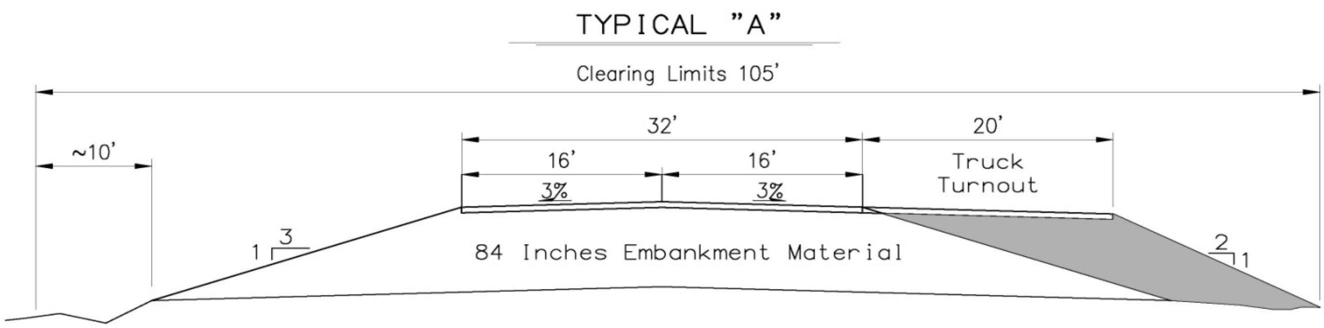
Alternative Baseline Cost Estimate Summary					
Corridors	Length	Roadway			
	Miles	Roadway Cost/mile* (million/mile)	Water Crossing Cost/mile (million/mile)	Baseline Cost Per Mile (million/mile)	Total Corridor Cost (in millions)
Alternative A	**211**	$1.51	$0.61	**$2.12**	**$447**
Alternative B	**228**	$1.53	$0.58	**$2.11**	**$481**
Alternative C	**332**	$1.62	$1.03	**$2.65**	**$880**

***Does NOT include maintenance costs.**

Corridor Haul Cost Summary			
Corridors	Miles	Road	
		State Land Haul Cost/TON	Royalty for BLM/Native Owned Land Haul Cost/TON
Alternative A	**211**	$8.48	$10.98
Alternative B	**228**	$8.43	$10.93
Alternative C	**332**	$8.63	$11.13

Truck Turnout Estimates

SUMMARY OF TURNOUT COST (EACH)		
A	B	C
$17,136	$14,459	$11,571



~ 150 Foot turnout

TURNOUT BASELINE PER- EACH COSTS - TYPICAL SECTION "A"					
PAY ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	0.00	$11,500	$50
301	AGGREGATE SURFACE COURSE	TON	111	$42	$4,662
203	EMBANKMENT	TON	1,207	$9.00	$10,867
+ Mobilization				10%	$1,558
				TOTAL COST EACH TURNOUT	$17,136

CROSS SECTIONAL AREA - TYPICAL "A"		TOTAL QUANTITY	
CLEARING	WIDTH (ft)	5	FT
AGGREGATE SURFACE COURSE		10	SF
EMBANKMENT		111	SF

SUMMARY OF QUANTITIES PER TURNOUT					Reduced / less Vegetation
CLEARING	750	SF	0.02	ACRES	0.00
AGGREGATE SURFACE	56	CY	111	TONS	
EMBANKMENT	617	CY	1,207	TONS	

ASSUMPTIONS:

1. Areas determined using AutoCAD.
2. Aggregate Surface Course conversion factor assumed to be 1.998 Tons per CY.
3. Embankment conversion factor assumed to be 1.958 Tons per CY.
4. Embankment unit price assumes an average corridor haul cost of $9.00.

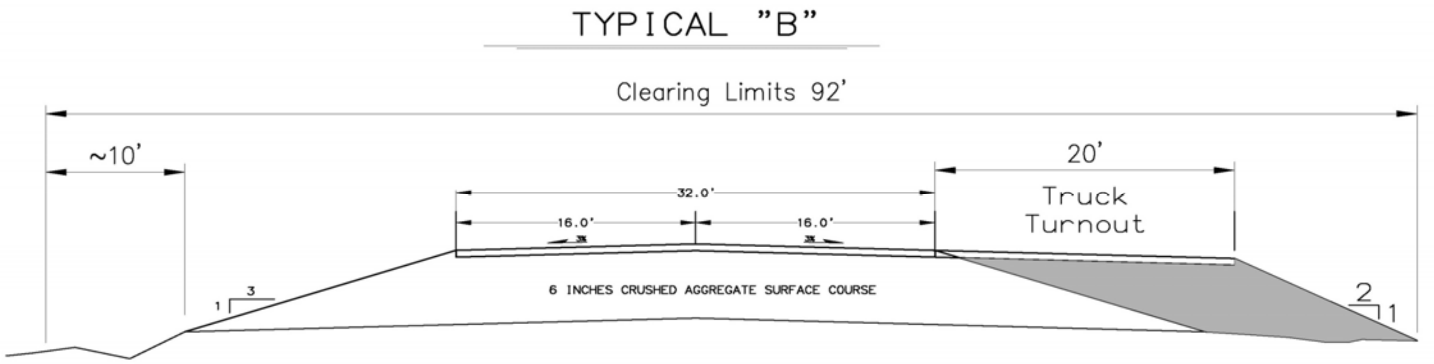
Turnout 150 ft

I ACRE = 43,560 SF

* Quantities must be input into cells with RED lettering.

Truck Turnout Estimates

SUMMARY OF TURNOUT COST (EACH)		
A	B	C
$17,136	$14,459	$11,571



~ 150 Foot turnout

TURNOUT BASELINE PER- EACH COSTS - TYPICAL SECTION "B"					
PAY ITEM	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	0.0	$11,500	$63
301	AGGREGATE SURFACE COURSE	TON	111	$42	$4,662
203	EMBANKMENT	TON	935	$9	$8,419
+ Mobilization				10%	$1,314
				TOTAL COST EACH TURNOUT	$14,459

CROSS SECTIONAL AREA - TYPICAL "B"		TOTAL QUANTITY	
CLEARING	WIDTH (ft)	4	FT
AGGREGATE SURFACE COURSE		10	SF
EMBANKMENT		86	SF

SUMMARY OF QUANTITIES PER TURNOUT					Reduced / less
CLEARING	600	SF	0.01	ACRES	0.0
AGGREGATE SURFACE	56	CY	111	TONS	
EMBANKMENT	478	CY	935	TONS	

ASSUMPTIONS:

1. Areas determined using AutoCAD.
2. Aggregate Surface Course conversion factor assumed to be 1.998 Tons per CY.
3. Embankment conversion factor assumed to be 1.958 Tons per CY.
4. Embankment unit price assumes an average corridor haul cost of $9.00.

Turnout 150 ft

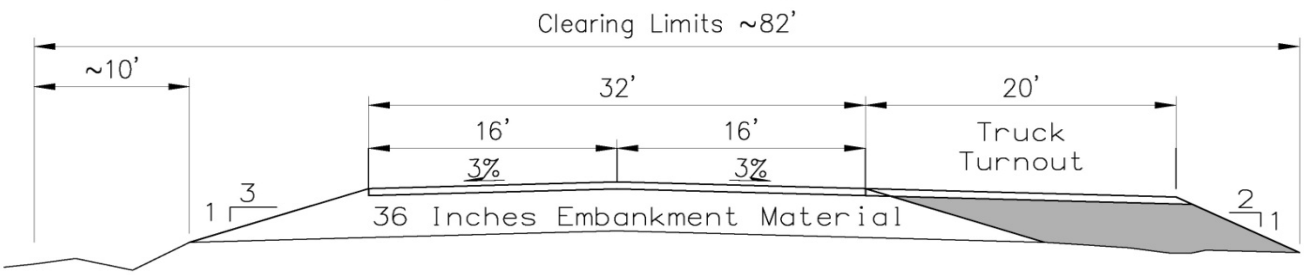
I ACRE = 43,560 SF

* Quantities must be input into cells with RED lettering.

Truck Turnout Estimates

SUMMARY OF TURNOUT COST (EACH)		
A	B	C
$17,136	$14,459	$11,571

TYPICAL "C"



~ 150 Foot turnout

TURNOUT BASELINE PER- EACH COSTS - TYPICAL SECTION "C"					
PAY ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	0.02	$11,500	$277
301	AGGREGATE SURFACE COURSE	TON	111	$42	$4,662
203	EMBANKMENT	TON	620	$9.00	$5,580
+ Mobilization				10%	$1,052
				TOTAL COST EACH TURNOUT	$11,571

CROSS SECTIONAL AREA - TYPICAL "C"		TOTAL QUANTITY	
CLEARING	WIDTH (ft)	7	FT
AGGREGATE SURFACE COURSE		10	SF
EMBANKMENT		57	SF

SUMMARY OF QUANTITIES PER TURNOUT					Reduced / less Vegetation
CLEARING	1,050	SF	0.02	ACRES	0.00
AGGREGATE SURFACE	56	CY	111	TONS	
EMBANKMENT	317	CY	620	TONS	

ASSUMPTIONS:

1. Areas determined using AutoCAD.
2. Aggregate Surface Course conversion factor assumed to be 1.998 Tons per CY.
3. Embankment conversion factor assumed to be 1.958 Tons per CY.
4. Embankment unit price assumes an average corridor haul cost of $9.00.

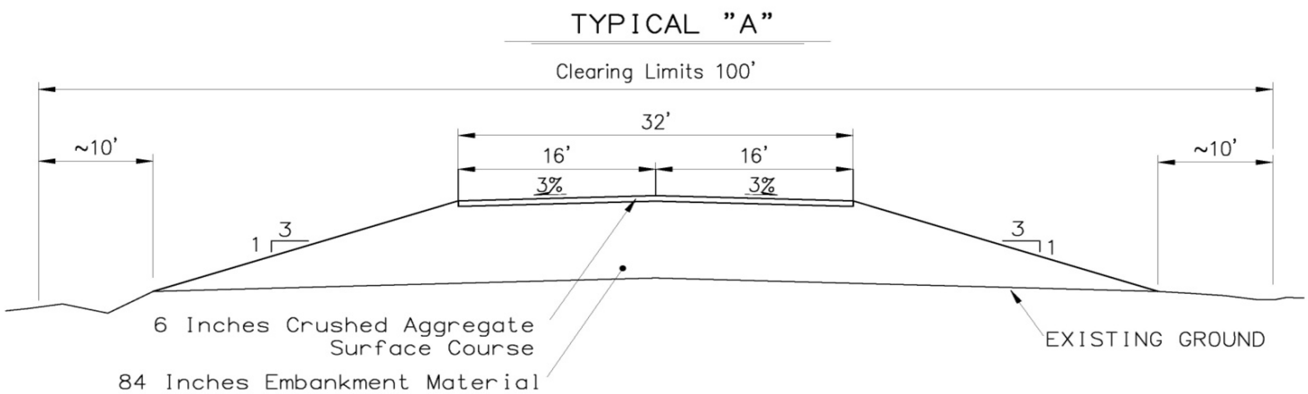
Turnout 150 ft

I ACRE = 43,560 SF

* Quantities must be input into cells with RED lettering.

Alternative A

SUMMARY OF UNIT COSTS (MILLION $/MILE)				
A	B	C	per mile	TOTAL
$144,866,874	$142,110,366	$32,181,812	$1,512,602	$319,159,052



~ 74 Miles

ROADWAY BASELINE PER-MILE COSTS - TYPICAL SECTION "A"					
PAY ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	224.2	$11,500	$2,578,788
301	AGGREGATE SURFACE COURSE	TON	462,612	$42	$19,429,724
203A	EMBANKMENT	TON	7,069,158	$8.48	$59,944,473
203B	EMBANKMENT	TON	4,519,626	$10.98	$49,624,219
	TURNOUTS	EACH	7	$17,136	$119,954
+ Mobilization				10%	$13,169,716
				TOTAL COST 74 MILES	$144,866,874

CROSS SECTIONAL AREA - TYPICAL "A"		TOTAL QUANTITY	
CLEARING	WIDTH (ft)	100	FT
AGGREGATE SURFACE COURSE		16	SF
EMBANKMENT		409	SF

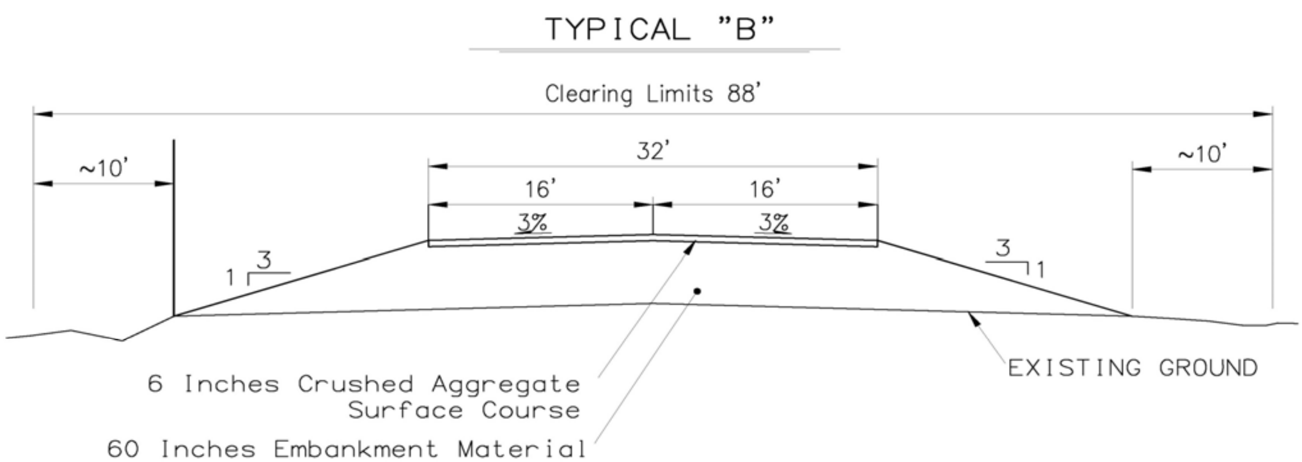
SUMMARY OF QUANTITIES PER UNIT MILE					Reduced / less Vegetation
CLEARING	528,000	SF	12.12	ACRES	3.0
AGGREGATE SURFACE	3,129	CY	6,252	TONS	**Total of 203**
EMBANKMENT	79,982	CY	156,605	TONS	**11,588,784**

ROYALTIES APPLIED TO MATERIAL COSTS			
Item 203A	= Material from state owned land.	**61%**	Percentage of ownership within corridor.
Item 203B	= Material from BLM/Native owned land.	**39%**	

* Quantities must be input into cells with RED lettering.

Alternative A

SUMMARY OF UNIT COSTS (MILLION $/MILE)				
A	B	C	per mile	TOTAL
$144,866,874	$142,110,366	$32,181,812	$1,512,602	$319,159,052



~ 103 Miles

ROADWAY BASELINE PER-MILE COSTS - TYPICAL SECTION "B"					
PAY ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	439.5	$11,500	$5,053,867
301	AGGREGATE SURFACE COURSE	TON	643,907	$42	$27,044,076
203A	EMBANKMENT	TON	6,254,942	$8.48	$53,040,144
203B	EMBANKMENT	TON	3,999,061	$10.98	$43,908,564
	TURNOUTS	EACH	10	$14,459	$144,592
+ Mobilization				10%	$12,919,124
				TOTAL COST 103 MILES	**$142,110,366**

CROSS SECTIONAL AREA - TYPICAL "B"		**TOTAL QUANTITY**	
CLEARING	WIDTH (ft)	**88**	FT
AGGREGATE SURFACE COURSE		**16**	SF
EMBANKMENT		**260**	SF

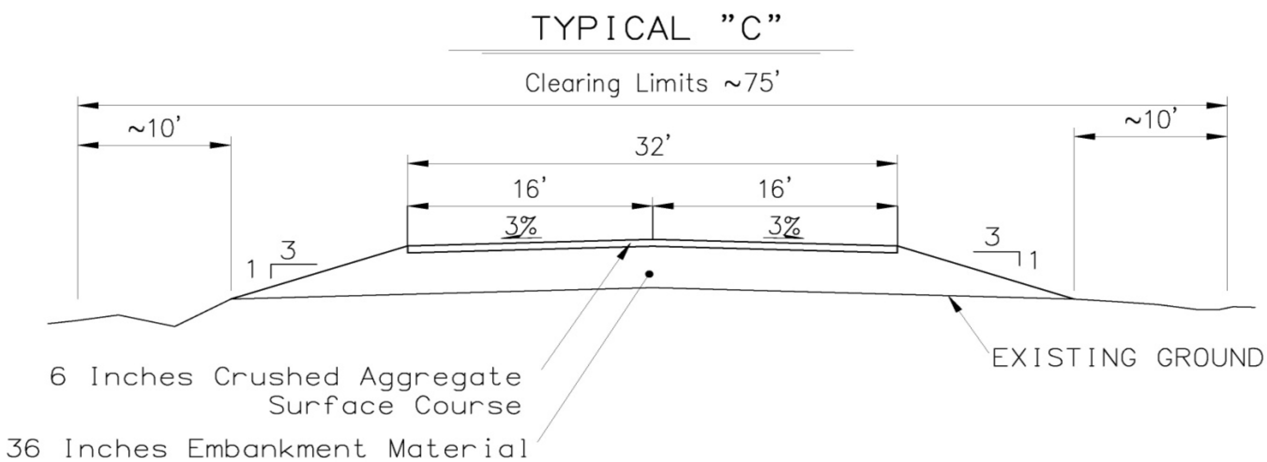
SUMMARY OF QUANTITIES PER UNIT MILE					Reduced / less
CLEARING	**464,640**	SF	**10.67**	ACRES	**4.3**
AGGREGATE SURFACE	**3,129**	CY	**6,252**	TONS	**Total of 203**
EMBANKMENT	**50,844**	CY	**99,553**	TONS	**10,254,002**

ROYALTIES APPLIED TO MATERIAL COSTS			
Item 203A	= Material from state owned land.	**61%**	Percentage of ownership within corridor.
Item 203B	= Material from BLM/Native owned land.	**39%**	

* Quantities must be input into cells with RED lettering.

Alternative A

SUMMARY OF UNIT COSTS (MILLION $/MILE)				
A	B	C	per mile	TOTAL
$144,866,874	$142,110,366	$32,181,812	$1,512,602	$319,159,052



~ 34 Miles

ROADWAY BASELINE PER-MILE COSTS - TYPICAL SECTION "C"					
PAY ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	309.1	$11,500	$3,554,545
301	AGGREGATE SURFACE COURSE	TON	212,552	$42	$8,927,171
203A	EMBANKMENT	TON	1,080,017	$8.48	$9,158,238
203B	EMBANKMENT	TON	690,503	$10.98	$7,581,524
	TURNOUTS	EACH	3	$11,571	$34,714
+ Mobilization				10%	$2,925,619
				TOTAL COST 34 MILES	**$32,181,812**

CROSS SECTIONAL AREA - TYPICAL "C"		**TOTAL QUANTITY**	
CLEARING	WIDTH (ft)	**75**	FT
AGGREGATE SURFACE COURSE		**16**	SF
EMBANKMENT		**136**	SF

SUMMARY OF QUANTITIES PER UNIT MILE					Reduced / less Vegetation
CLEARING	**396,000**	SF	**9.09**	ACRES	**0.0**
AGGREGATE SURFACE	**3,129**	CY	**6,252**	TONS	**Total of 203**
EMBANKMENT	**26,596**	CY	**52,074**	TONS	**1,770,519**

ROYALTIES APPLIED TO MATERIAL COSTS			
Item 203A	= Material from state owned land.	**61%**	Percentage of ownership within corridor.
Item 203B	= Material from BLM/Native owned land.	**39%**	

* Quantities must be input into cells with RED lettering.

Borrow Site Summary (as referenced in Geotechnical Addendum)		
Miles	Miles	Occurrence
15 to 20 mile intervals	2 miles	15.0 miles
10 to 15 mile intervals	12 miles	10.0 miles
Less than 10 mile intervals	197 miles	5.0 miles
Total	211 miles	
Total Borrow (tons)	34,524,361	163,623 (~per average per mile)

Alternative A

RT Operating Cost per CY	
1 mile	**$3.60**
2 mile	**$4.39**
3 mile	**$5.11**
4 mile	**$5.77**
5 mile	**$6.37**
10 mile	**$10.15**
15 mile	**$13.64**
20 mile	**$17.06**

RT Prep Cost per CY	
	Per CY
Excavating and Loading =	$3.60
Placement & Grading =	$0.54
Compaction =	$0.42
Watering =	$1.98
In Addition to operating Cost	$6.55
(factored into Total Cost in Place)	

Alt A (soil type)	**Borrow (TON)**	**Borrow (CY)**	**Distance from Borrow Source (One Way)**	**Distance from Borrow Source (Round trip)**	**Haul Cost (CY)**	**Haul Cost**	**Total Cost in Place**
Miles			MILES				
197 miles	32,266,370	16,133,185	5.0 miles	10 miles	$10.15	$163,778,016	$269,409,991
12 miles	1,930,746	965,373	7.5 miles	15 miles	$13.64	$13,163,454	$19,484,231
2 miles	327,245	163,623	10.0 miles	20 miles	$17.06	$2,791,324	$3,862,643
Totals	34,524,361	17,262,181					$292,756,865

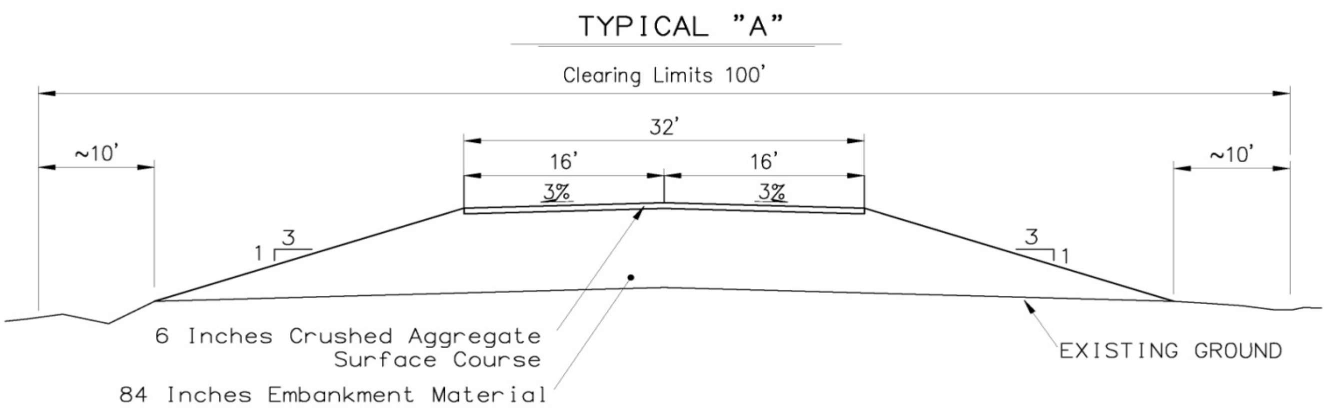
	State Land	**BLM / Native Royalties**
Base Cost/CY	16.96	$16.96
+ BLM/Native Royalties	$0.00	5.00
Adjusted Base Cost/CY	16.96	21.96
Adjusted Cost/Ton	**$8.48**	**$10.98**

ASSUMPTIONS:

1) Assumes additional $5/CY for material used from BLM or Native owned land.
2) Includes operations, haul, and placement.
3) Assumes 20 ton haul.
4) 2 tons/CY

Alternative B

SUMMARY OF UNIT COSTS (MILLION $/MILE)				
A	B	C	per mile	TOTAL
$171,224,256	$152,099,163	$25,259,513	$1,528,873	$348,582,932



~ 89 Miles

ROADWAY BASELINE PER-MILE COSTS - TYPICAL SECTION "A"					
PAY ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	269.7	$11,500	$3,101,515
301	AGGREGATE SURFACE COURSE	TON	556,385	$42	$23,368,182
203A	EMBANKMENT	TON	9,338,368	$8.43	$78,748,956
203B	EMBANKMENT	TON	4,599,494	$10.93	$50,285,535
	TURNOUTS	EACH	9	$17,136	$154,226
+ Mobilization				10%	$15,565,841
				TOTAL COST 89 MILES	$171,224,256

CROSS SECTIONAL AREA - TYPICAL "A"		TOTAL QUANTITY	
CLEARING	WIDTH (ft)	100	FT
AGGREGATE SURFACE COURSE		16	SF
EMBANKMENT		409	SF

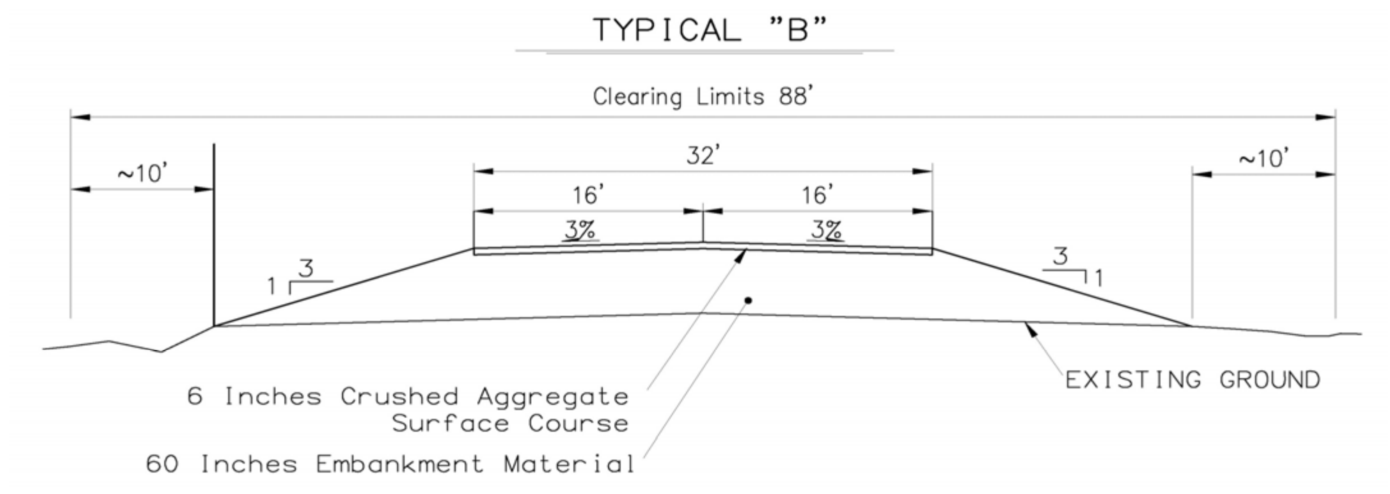
SUMMARY OF QUANTITIES PER UNIT MILE					Reduced / less Vegetation
CLEARING	528,000	SF	12.12	ACRES	3.0
AGGREGATE SURFACE	3,129	CY	6,252	TONS	**Total of 203**
EMBANKMENT	79,982	CY	156,605	TONS	**13,937,862**

ROYALTIES APPLIED TO MATERIAL COSTS			
Item 203A	= Material from state owned land.	**67%**	Percentage of ownership within corridor.
Item 203B	= Material from BLM/Native owned land.	**33%**	

* Quantities must be input into cells with RED lettering.

Alternative B

SUMMARY OF UNIT COSTS (MILLION $/MILE)				
A	B	C	per mile	TOTAL
$171,224,256	$152,099,163	$25,259,513	$1,528,873	$348,582,932



~ 112 Miles

ROADWAY BASELINE PER-MILE COSTS - TYPICAL SECTION "B"					
PAY ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	477.9	$11,500	$5,495,467
301	AGGREGATE SURFACE COURSE	TON	700,170	$42	$29,407,150
203A	EMBANKMENT	TON	7,470,489	$8.43	$62,997,434
203B	EMBANKMENT	TON	3,679,494	$10.93	$40,227,323
	TURNOUTS	EACH	10	$14,459	$144,592
+ Mobilization				10%	$13,827,197
				TOTAL COST 112 MILES	**$152,099,163**

CROSS SECTIONAL AREA - TYPICAL "B"		TOTAL QUANTITY	
CLEARING	WIDTH (ft)	88	FT
AGGREGATE SURFACE COURSE		16	SF
EMBANKMENT		260	SF

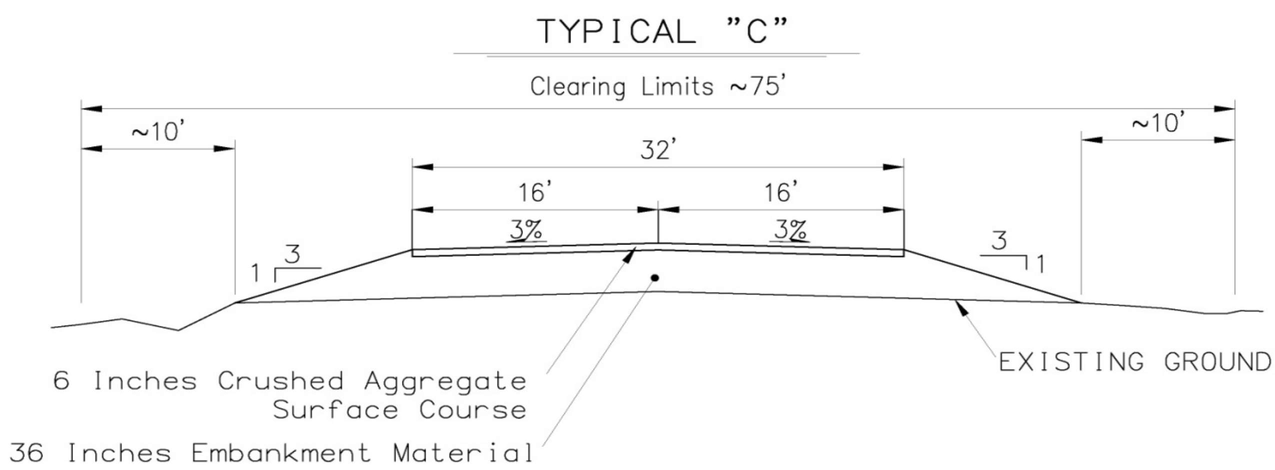
SUMMARY OF QUANTITIES PER UNIT MILE					Reduced / less
CLEARING	464,640	SF	10.67	ACRES	4.3
AGGREGATE SURFACE	3,129	CY	6,252	TONS	**Total of 203**
EMBANKMENT	50,844	CY	99,553	TONS	**11,149,983**

ROYALTIES APPLIED TO MATERIAL COSTS			
Item 203A	= Material from state owned land.	**67%**	Percentage of ownership within corridor.
Item 203B	= Material from BLM/Native owned land.	**33%**	

* Quantities must be input into cells with RED lettering.

Alternative B

SUMMARY OF UNIT COSTS (MILLION $/MILE)				
A	B	C	per mile	TOTAL
$171,224,256	$152,099,163	$25,259,513	$1,528,873	$348,582,932



~ 27 Miles

ROADWAY BASELINE PER-MILE COSTS - TYPICAL SECTION "C"					
PAY ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	245.5	$11,500	$2,822,727
301	AGGREGATE SURFACE COURSE	TON	168,791	$42	$7,089,224
203A	EMBANKMENT	TON	942,020	$8.43	$7,943,907
203B	EMBANKMENT	TON	463,980	$10.93	$5,072,621
	TURNOUTS	EACH	3	$11,571	$34,714
+ Mobilization				10%	$2,296,319
				TOTAL COST 7 MILES	$25,259,513

CROSS SECTIONAL AREA - TYPICAL "C"		TOTAL QUANTITY	
CLEARING	WIDTH (ft)	75	FT
AGGREGATE SURFACE COURSE		16	SF
EMBANKMENT		136	SF

SUMMARY OF QUANTITIES PER UNIT MILE					Reduced / less Vegetation
CLEARING	396,000	SF	9.09	ACRES	0.0
AGGREGATE SURFACE	3,129	CY	6,252	TONS	**Total of 203**
EMBANKMENT	26,596	CY	52,074	TONS	**1,406,001**

ROYALTIES APPLIED TO MATERIAL COSTS			
Item 203A	= Material from state owned land.	67%	Percentage of ownership within corridor.
Item 203B	= Material from BLM/Native owned land.	33%	

* Quantities must be input into cells with RED lettering.

Alternative B

Borrow Site Summary (as referenced in Draft Geotechnical Report)		
Miles	Miles	Occurrence
10 to 15 mile intervals	11 miles	10.0 miles
Less than 10 mile intervals	217 miles	5.0 miles
Total	228 miles	
Total Borrow (tons)	26,493,846	116,201 (~per average per mile)

RT Operating Cost per CY	
1 mile	**$3.60**
2 mile	**$4.39**
3 mile	**$5.11**
4 mile	**$5.77**
5 mile	**$6.37**
10 mile	**$10.15**
15 mile	**$13.64**
20 mile	**$17.06**

RT Prep Cost per CY	
	Per CY
Excavating and Loading =	$3.60
Placement & Grading =	$0.54
Compaction =	$0.42
Watering =	$1.98
In Addition to operating Cost	$6.55
(factored into Total Cost in Place)	

Alt B (soil type)	Borrow (TON)	Borrow (CY)	Distance from Borrow Source (One Way)	Distance from Borrow Source (Round trip)	Haul Cost (CY)	Haul Cost	Total Cost in Place
Miles			MILES				
217 miles	25,227,254	12,613,627	5.0 miles	10 miles	$10.15	$128,048,792	$210,636,474
11 miles	1,266,592	633,296	7.5 miles	15 miles	$13.64	$8,635,377	$12,781,880
Totals	26,493,846	13,246,923					$223,418,354

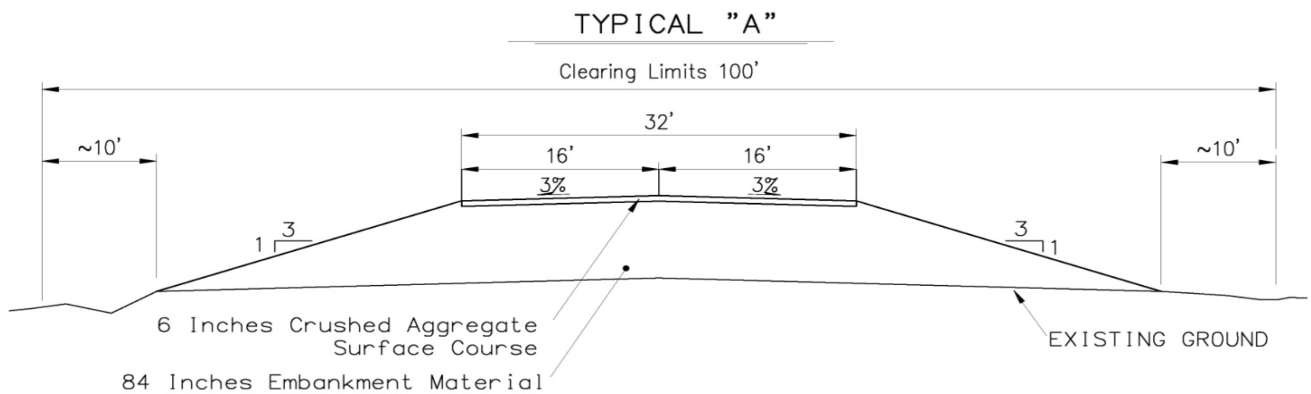
	State Land	BLM / Native Royalties
Base Cost/CY	16.87	$16.87
+ BLM/Native Royalties	$0.00	5.00
Adjusted Base Cost/CY	16.87	21.87
Adjusted Cost/Ton	**$8.43**	**$10.93**

ASSUMPTIONS:

1) Assumes additional $5/CY for material used from BLM or Native owned land.
2) Includes operations, haul, and placement.
3) Assumes 20 ton haul.
4) 2 tons/CY

Alternative C

SUMMARY OF UNIT COSTS (MILLION $/MILE)				
A	B	C	per mile	TOTAL
$298,064,443	$105,353,584	$134,594,387	$1,620,519	$538,012,414



~ 134 Miles

ROADWAY BASELINE PER-MILE COSTS - TYPICAL SECTION "A"					
PAY ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	406.1	$11,500	$4,669,697
301	AGGREGATE SURFACE COURSE	TON	837,704	$42	$35,183,555
203A	EMBANKMENT	TON	1,049,255	$8.63	$9,052,603
203B	EMBANKMENT	TON	19,935,841	$11.13	$221,839,050
	TURNOUTS	EACH	13	$17,136	$222,771
+ Mobilization				10%	$27,096,768
				TOTAL COST 134 MILES	$298,064,443

CROSS SECTIONAL AREA - TYPICAL "A"		TOTAL QUANTITY	
CLEARING	WIDTH (ft)	100	FT
AGGREGATE SURFACE COURSE		16	SF
EMBANKMENT		409	SF

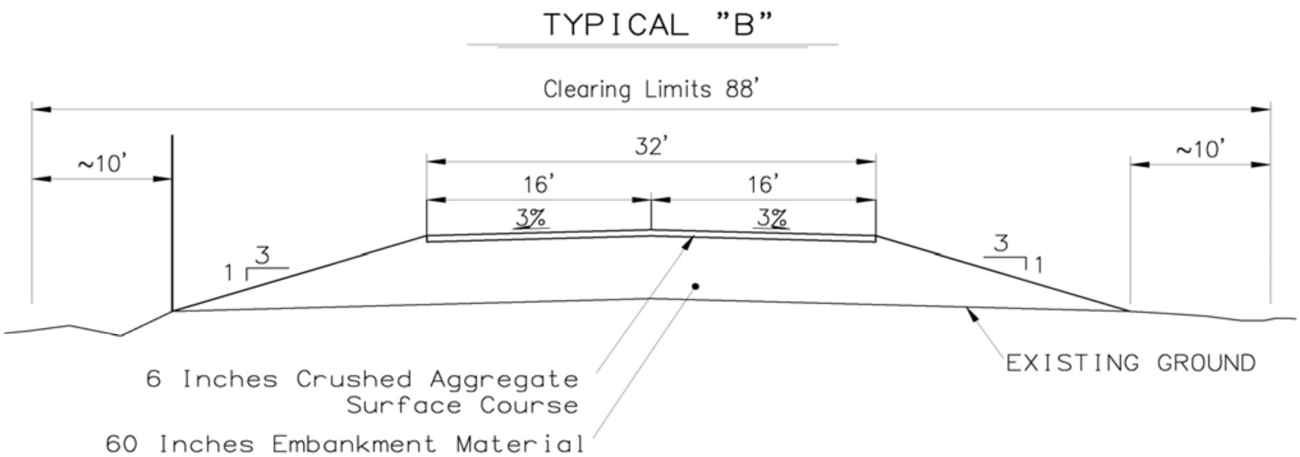
SUMMARY OF QUANTITIES PER UNIT MILE					Reduced / less Vegetation
CLEARING	528,000	SF	12.12	ACRES	3.0
AGGREGATE SURFACE	3,129	CY	6,252	TONS	Total of 203
EMBANKMENT	79,982	CY	156,605	TONS	20,985,096

ROYALTIES APPLIED TO MATERIAL COSTS			
Item 203A	= Material from state owned land.	5%	Percentage of ownership within corridor.
Item 203B	= Material from BLM/Native owned land.	95%	

* Quantities must be input into cells with RED lettering.

Alternative C

SUMMARY OF UNIT COSTS (MILLION $/MILE)				
A	**B**	**C**	**per mile**	**TOTAL**
$298,064,443	$105,353,584	$134,594,387	$1,620,519	$538,012,414



~ 68 Miles

ROADWAY BASELINE PER-MILE COSTS - TYPICAL SECTION "B"					
PAY ITEM NO.	**ITEM DESCRIPTION**	**UNIT**	**QUANTITY**	**UNIT COSTS**	**COST**
201	CLEARING	ACRE	290.1	$11,500	$3,336,533
301	AGGREGATE SURFACE COURSE	TON	425,103	$42	$17,854,341
203A	EMBANKMENT	TON	338,482	$8.63	$2,920,301
203B	EMBANKMENT	TON	6,431,151	$11.13	$71,563,595
	TURNOUTS	EACH	7	$14,459	$101,215
+ Mobilization				10%	$9,577,599
				TOTAL COST 68 MILES	**$105,353,584**

CROSS SECTIONAL AREA - TYPICAL "B"		**TOTAL QUANTITY**	
CLEARING	WIDTH (ft)	**88**	FT
AGGREGATE SURFACE COURSE		**16**	SF
EMBANKMENT		**260**	SF

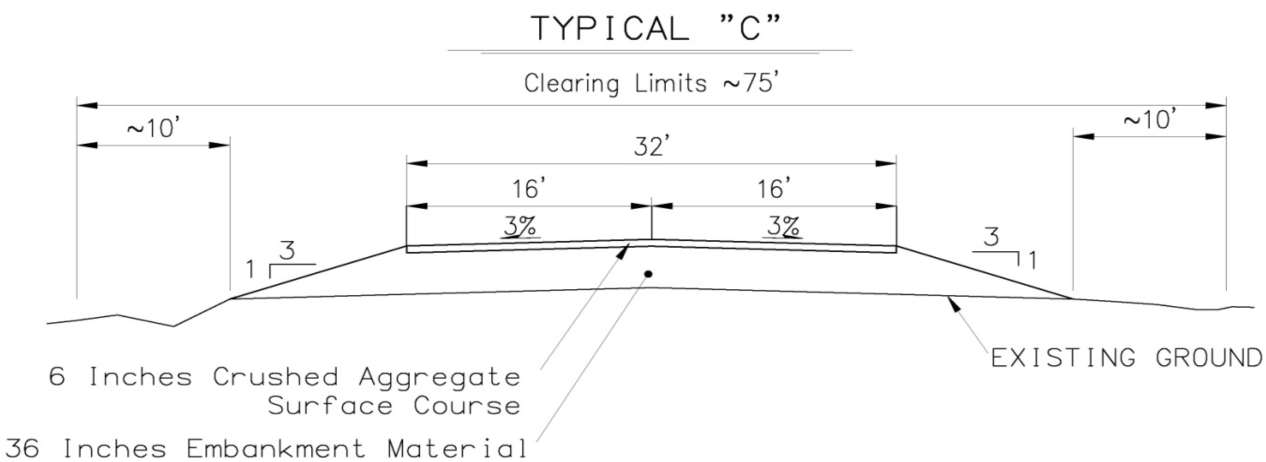
SUMMARY OF QUANTITIES PER UNIT MILE					Reduced / less
CLEARING	**464,640**	SF	**10.67**	ACRES	**4.3**
AGGREGATE SURFACE	**3,129**	CY	**6,252**	TONS	**Total of 203**
EMBANKMENT	**50,844**	CY	**99,553**	TONS	**6,769,633**

ROYALTIES APPLIED TO MATERIAL COSTS			
Item 203A	= Material from state owned land.	**5%**	Percentage of ownership within corridor.
Item 203B	= Material from BLM/Native owned land.	**95%**	

* Quantities must be input into cells with RED lettering.

Alternative C

SUMMARY OF UNIT COSTS (MILLION $/MILE)				
A	B	C	per mile	TOTAL
$298,064,443	$105,353,584	$134,594,387	$1,620,519	$538,012,414



~ 130 Miles

ROADWAY BASELINE PER-MILE COSTS - TYPICAL SECTION "C"					
PAY ITEM NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COSTS	COST
201	CLEARING	ACRE	1,181.8	$11,500	$13,590,909
301	AGGREGATE SURFACE COURSE	TON	812,698	$42	$34,133,299
203A	EMBANKMENT	TON	338,482	$8.63	$2,920,301
203B	EMBANKMENT	TON	6,431,151	$11.13	$71,563,595
	TURNOUTS	EACH	13	$11,571	$150,429
+ Mobilization				10%	$12,235,853
				TOTAL COST 130 MILES	$134,594,387

CROSS SECTIONAL AREA - TYPICAL "C"		TOTAL QUANTITY	
CLEARING	WIDTH (ft)	75	FT
AGGREGATE SURFACE COURSE		16	SF
EMBANKMENT		136	SF

SUMMARY OF QUANTITIES PER UNIT MILE					Reduced / less Vegetation
CLEARING	396,000	SF	9.09	ACRES	0.0
AGGREGATE SURFACE	3,129	CY	6,252	TONS	Total of 203
EMBANKMENT	26,596	CY	52,074	TONS	6,769,633

ROYALTIES APPLIED TO MATERIAL COSTS			
Item 203A	= Material from state owned land.	5%	Percentage of ownership within corridor.
Item 203B	= Material from BLM/Native owned land.	95%	

* Quantities must be input into cells with RED lettering.

Borrow Site Summary (as referenced in Geotechnical Addendum)		
Miles	Miles	Occurrence
10 to 15 mile intervals	53 miles	10.0 miles
Less than 10 mile intervals	279 miles	5.0 miles
Total	332 miles	
Total Borrow (tons)	34,524,361	103,989 (~per average per mile)

Alternative C

RT Operating Cost per CY	
1 mile	**$3.60**
2 mile	**$4.39**
3 mile	**$5.11**
4 mile	**$5.77**
5 mile	**$6.37**
10 mile	**$10.15**
15 mile	**$13.64**
20 mile	**$17.06**

RT Prep Cost per CY	
	Per CY
Excavating and Loading =	$3.60
Placement & Grading =	$0.54
Compaction =	$0.42
Watering =	$1.98
In Addition to operating Cost	$6.55
(factored into Total Cost in Place)	

Alternative C	**Borrow (TON)**	**Borrow (CY)**	**Distance from Borrow Source (One Way)**	**Distance from Borrow Source (Round trip)**	**Haul Cost (CY)**	**Haul Cost**	**Total Cost in Place**
Miles			MILES				
279 miles	29,012,942	14,506,471	5.0 miles	10 miles	$10.15	$147,264,230	$242,245,301
53 miles	5,511,419	2,755,710	7.5 miles	15 miles	$13.64	$37,575,787	$55,618,787
Totals	34,524,361	17,262,181					$297,864,088

	State Land	**BLM / Native Royalties**
Base Cost/CY	17.26	$17.26
+ BLM/Native Royalties	$0.00	5.00
Adjusted Base Cost/CY	17.26	22.26
Adjusted Cost/Ton	**$8.63**	**$11.13**

ASSUMPTIONS:

1) Assumes additional $5/CY for material used from BLM or Native owned land.
2) Includes operations, haul, and placement.
3) Assumes 20 ton haul.
4) 2 tons/CY

Water Crossing Summary Per Corridor			
Corridors	Length	Roadway	
	Miles	TOTAL COST (in millions)	Per Mile Cost (in millions)
Alternative A	**211**	**$128**	**$0.608**
Alternative B	**228**	**$131**	**$0.576**
Alternative C	**332**	**$341**	**$1.026**

Roadway Water Crossing Summary

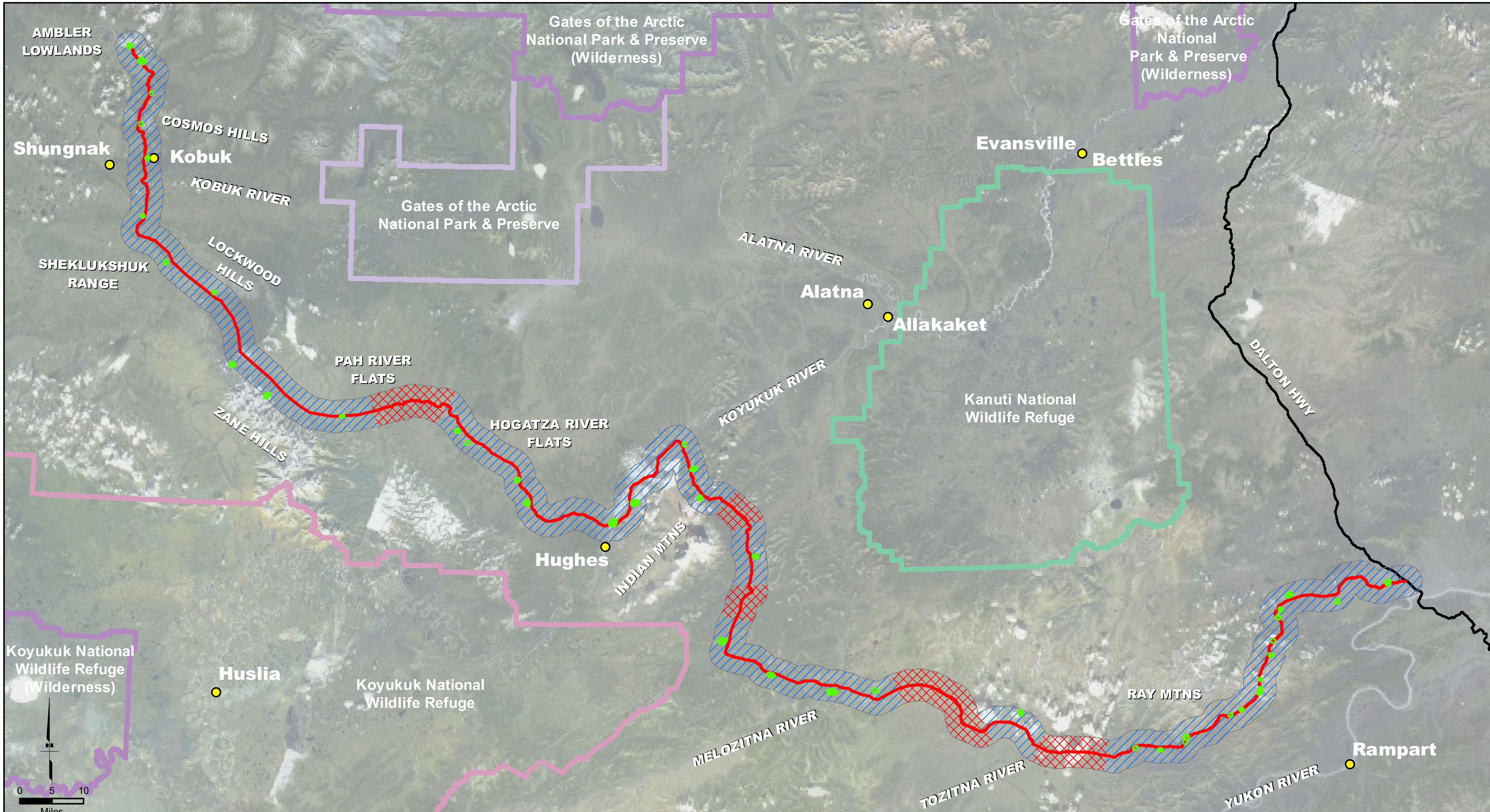
Corridors	CULVERTS							FISH PASSAGES		BRIDGES						TOTAL COST (in millions)
	Minor			Moderate/Small (<10')		Major/Large (10' to 20')				Bridge Small (<50')		Bridge Medium (50' to 140')		Bridge Large (>140')		
	QUANTITY (EA)	#/Mile	UNIT COST (EA)	QUANTITY (EA)	UNIT COST (EA)	QUANTITY (EA)	UNIT COST	QUANTITY (EA)	UNIT COST	QUANTITY (EA)	UNIT COST	QUANTITY (EA)	UNIT COST	QUANTITY (LF)	UNIT COST	
Alternative A	2,869	13.60	$25,300	15	$102,200	19	$242,700	17	$156,200	3	$372,500	15	$720,900	4,920	$7,100	**$128**
Alternative B	3,155	10.95	$25,300	12	$102,200	12	$242,700	19	$156,200	3	$372,500	12	$720,900	4,870	$7,100	**$131**
Alternative C	4,076	12.28	$25,300	131	$102,200	141	$242,700	65	$156,200	79	$372,500	158	$720,900	5,150	$7,100	**$341**

APPENDIX B

Geotechnical Data

Table B-1: Alternative C Corridor Geotechnical Summary, 332 Miles

Material Type		Permafrost		General Foundation Conditions		Borrow Material Description	Miles Between Sites	NOA	Comments
Unit	**(mi)**	**Distribution**	**(mi)**	**Rating**	**(mi)**				
Section 1: Mile 0 to 62, Kokrine-Hodzana Highlands Section, 62 miles									
BU	2	Continuous, thick to thin	2	Good	41	Igneous and sedimentary bedrock in Ray Mountains. Narrow alluvium deposits present near rivers and streams in Ray Mountains.	5	Medium NOA potential	Corridor traverses silt, alluvium, and bedrock from the Dalton Highway through the Ray Mountains. *Intrusive mafic rocks with ultramafic zones may occur in Ray Mountains which may contain NOA.*
BV	23			Fair	5				
GS	16	Discontinuous	60	Poor	16				
GM	5								
SM	16								
Section 2: Mile 62 to 127, Tozitna-Melozitna Lowland Section, 65 miles									
BU	22	Continuous, thick to thin	37	Good	29	Sedimentary (possibly igneous) bedrock north of alignment and near Melozitna River. Potentially suitable alluvium in Tozitna River floodplain.	10 to 15	Zero to low NOA potenial	Alignment crosses through older alluvial deposits capped by and intermixed with eolian silt. Polygonal ice wedges and thaw lakes present in portions of alignment. Eolian silt may cap areas mapped as bedrock.
BV	3			Fair	19				
GS	4	Discontinous	28	Poor	17				
GM	19								
SM	17								
Section 3: Mile 127 to 218, Indian River Uplands Section, 91 miles									
BU	15	Continuous, thick to thin	60	Good	45	Igneous and sedimentary bedrock. Alluvium in Koyukuk River floodplain.	10	Zero to low NOA potenial	Corridor traverses over bedrock, silt mantled bedrock, glacial lake deposits, and alluvium. Massive permafrost ice structures are visible in portions of alignment.
BV	6			Fair	4				
GS	24	Discontinuous	31	Poor	42				
GM	2								
SA	2								
SM	37								
OR	5								
Section 4: Mile 218 to 302, Pah River Section, 84 miles									
BV	1	Continuous, thick to thin	38	Good	8	Smaller alluvial deposits occur near Hogatza River. Igneous rock in Zane Hills and Lockwood Hills.	10 to 15	Zero to low NOA potenial	Alignment crosses through a muskeg and thaw lake terrain before reaching Zane Hills area. Bedrock outcrops are rare until Zane Hills. Bedrock sources in Zane Hills may be difficult to access.
GS	7			Fair	31				
GM	31	Discontinuous	46	Poor	45				
SM	13								
OR	32								
Section 5: Mile 302 to 315, Kobuk River Lowland Section, 13 miles									
GS	4	Continuous	2	Good	4	Kobuk River floodplain alluvium.	10	Zero to low NOA potenial	Corridor traverses complex terrace deposit of gravel, sand, silt, and organic material dotted with thaw lakes and the Kobuk River floodplain alluvium. Bedrock does not outcrop in this section of the alignment.
GM	1			Fair	2				
SA	1	Discontinous	11	Poor	7				
SM	6								
OR	1								
Section 6: Mile 315 to 332, Ambler-Chandalar Ridge and Lowland Section, 17 miles									
BO	0.5	Continuous, thick to thin	11	Good	3	Sedimentary and metamorphic bedrock. Glacial drift, older alluvial terraces, and alluvium available.	5	Medium to high potential and known	Alignment crosses over Cosmos Hills along existing road before crossing into Ambler Lowlands where it is underlain by alluvium, drift, and reworked eolion sand and silt. *Rocks in the Cosmos Hills have medium and high potential and known occurrences of NOA in area.*
BM	1			Fair	7				
BC	0.5	Continuous	6	Poor	7				
GS	1								
GM	7								
SM	7								
Summary		Continuous	47%	Good	39%	Approximate Average Distance	10	Majority Zero to Low	
		Discontinuous	53%	Fair	21%	Material Site within 10 miles	84%		
				Poor	41%	Material Site greater 10 miles	16%		



Selected Material Sites and Proximity

- Selected Potential Material Site
- Corridor Segment with Material Site at less than 10 Mile Intervals
- Corridor Segment with Material Site at greater than 10 Mile Intervals

Alignment and Existing Infrastructure

- Alternative C Corridor
- Dalton Highway
- Community

AMBLER MINING DISTRICT INDUSTRIAL ACCESS PROJECT

DOWL

AIDEA Alaska Industrial Development and Export Authority

Selected Material Sites and Proximity

Ambler Mining District
Industrial Access Project

March 28, 2019

Figure 1

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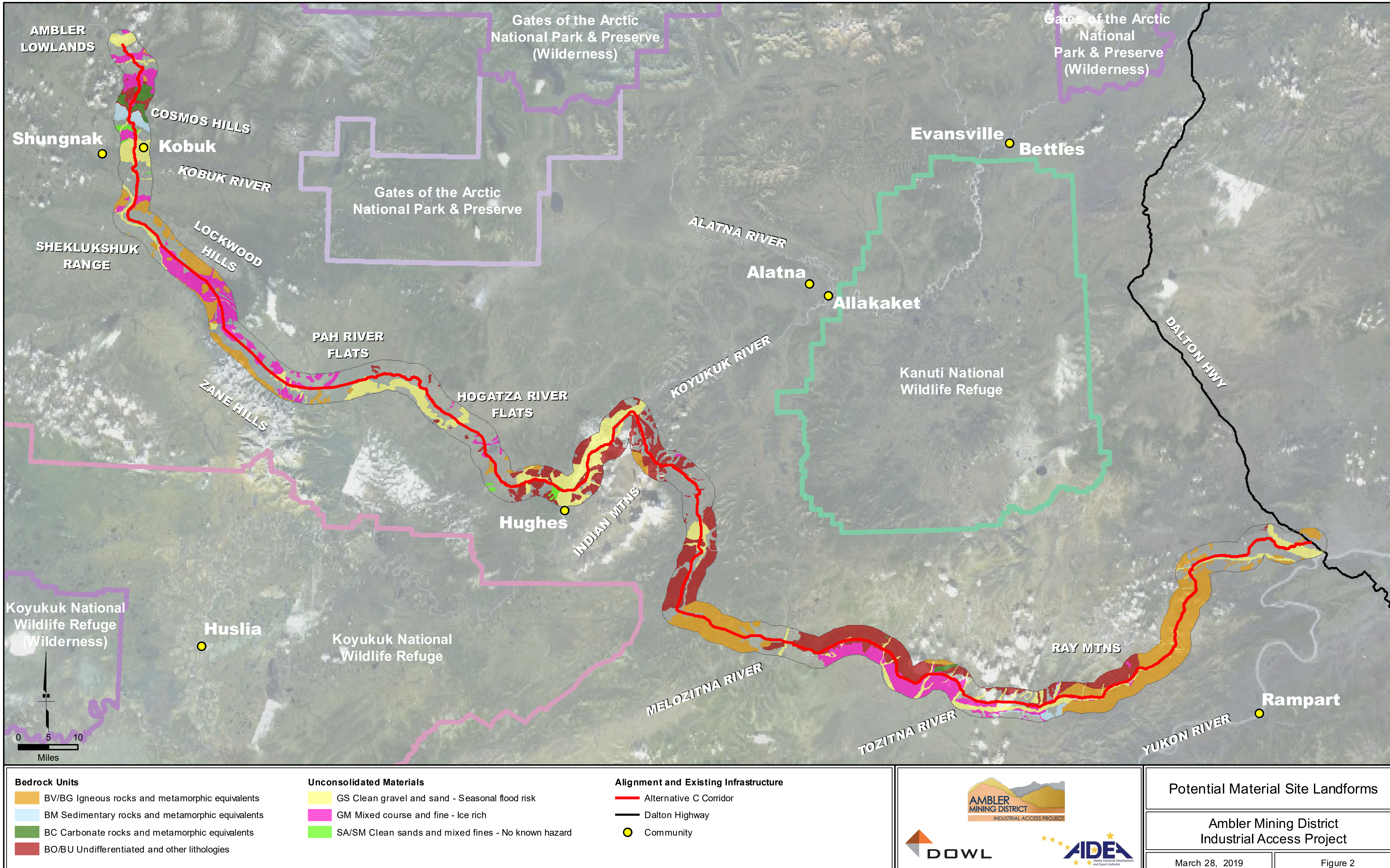

Potential Material Site Landforms

Ambler Mining District Industrial Access Project

March 28, 2019

Figure 2

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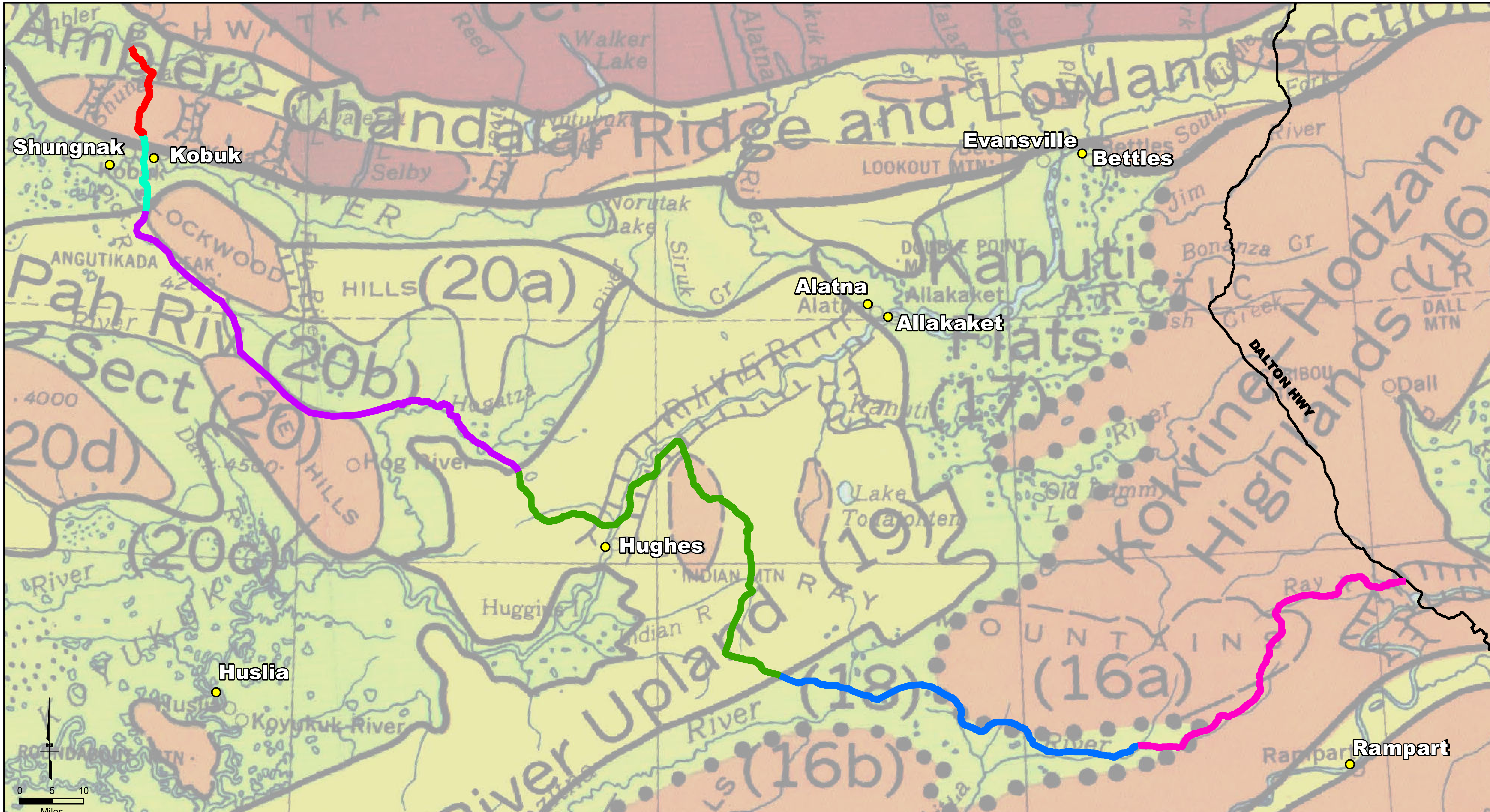

Alternative C - Sections as Discussed in Geologic Description

- Section 1
- Section 2
- Section 3
- Section 4
- Section 5
- Section 6

Existing Infrastructure

- Dalton Highway
- Community

Physiographic Provinces

Ambler Mining District
Industrial Access Project

March 28, 2019

Figure 3

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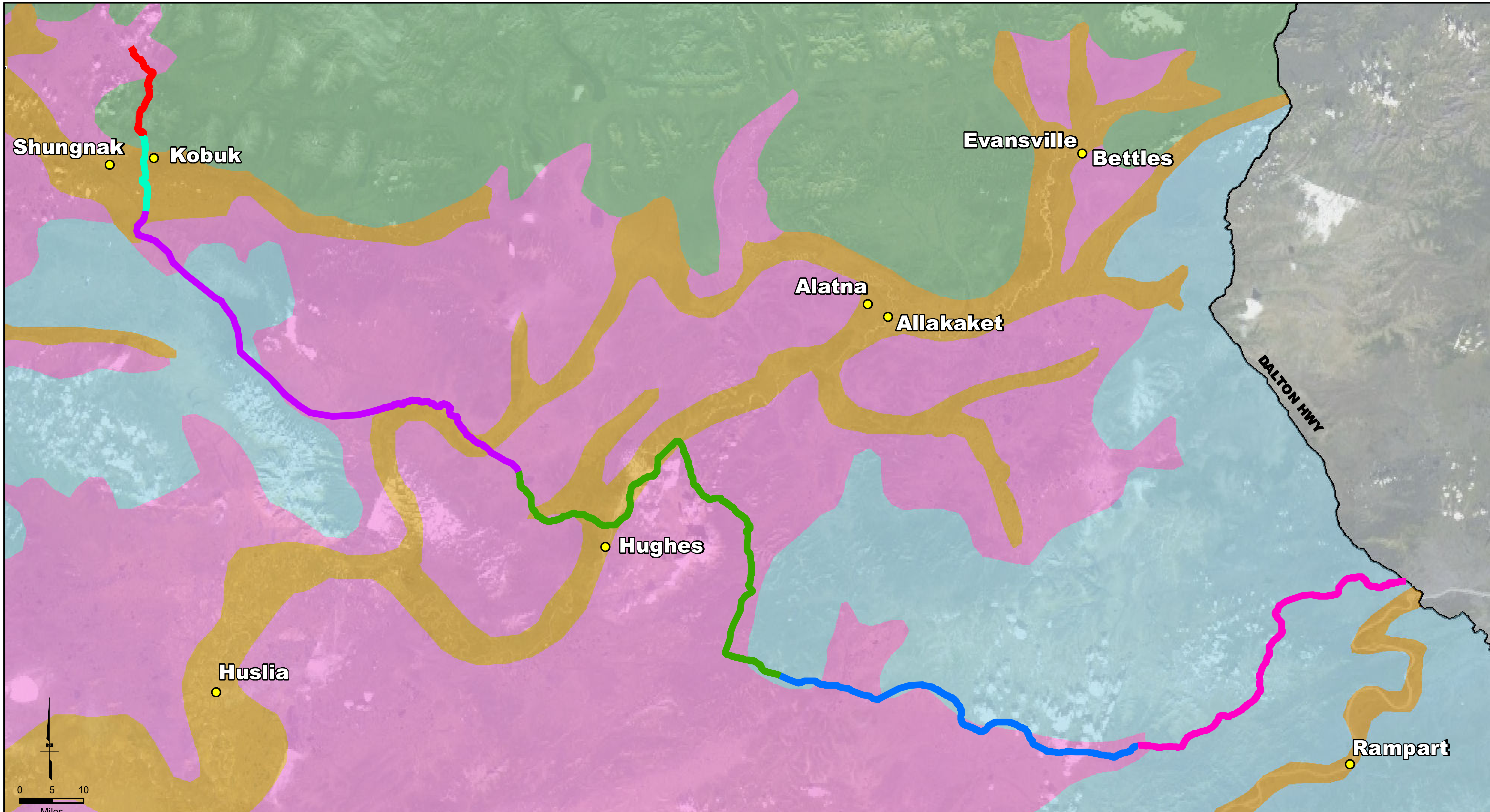

Permafrost

- Mountainous Area underlain by continuous permafrost
- Mountainous Area underlain by discontinuous permafrost
- Lowland and Upland Area underlain by thick permafrost
- Lowland and Updland Area underlain by moderately thick to thin permafrost
- Lowland and Upland Area underlain by discontinuous permafrost
- Lowland and Upland Area underlain by numerous isolated masses of permafrost

Alternative C - Sections as Discussed in Geologic Description

- Section 1
- Section 2
- Section 3
- Section 4
- Section 5
- Section 6

Existing Infrastructure

- Dalton Highway
- Community

AMBLER MINING DISTRICT INDUSTRIAL ACCESS PROJECT

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Permafrost Distribution

Ambler Mining District
Industrial Access Project

March 28, 2019

Figure 4

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APPENDIX C

Hydrologic Data

Ambler Mining District Industrial Access Project **Alternative A**

USACE Permit Application Data Deliverables

Updated by: RDP

Updated: 4/18/2016

Date Updated:	4/18/2016	4/18/2016	4/18/2016		
Project Teams:	**Team Shungnak**	**Team Alatna**	**Team Koyukuk**	**TOTAL**	**Unit**
Number of minor culverts (total #):				2,869	each
Number of moderate culverts (total #)				15	each
Number of major culverts (total #)				19	each
Number of small bridges (total #)				3	each
Number of medium bridges (total #)				15	each
Number of large bridges (total #)	4	4	3	11	each

Large Bridges				
River Name (if known)	**Length (ft)**	**Length (ft)**	**Length (ft)**	**Total (ft**
Reed River, North Crossing (Alatna Sta 298+90)		460		
Kobuk River, North Crossing (Alatna Sta 1043+00)		430		
Alatna River (Alatna Sta 2647+00)		400		
Malamute Fork of Alatna River (Alatna Sta 2921+60)		420		
Beaver Creek (Shungnak Sta 4402+00)	220			
Kogoluktuk River (Shungnak Sta 1875+00)	320			
Mauneluk River (Shungnak Sta 2974+90)	460			
Shungnak River (Shungnak Sta 1200+00)	380			
Koyukuk River			820	
Wild River			430	
John River			580	
Total	1380	1710	1830	**4920**

Cells in green taken from GIS data 4/18/2016; minor culverts revised 5/20/2016; see Data Totals spreadsheet

Cells in gray outdated; not used in estimate.

Ambler Mining District Industrial Access Project **Alternative B**

USACE Permit Application Data Deliverables
Updated by: RDP
Updated: 4/18/2016

Date Updated:	4/5/2016	4/18/2016	4/5/2016	4/5/2016		
Project Teams:	**Team Shungnak**	**Team Helpmejack**	**Team Alatna**	**Team Koyukuk**	**TOTAL**	**Unit**
Number of minor culverts (total #):					3,155	each
Number of moderate culverts (total #)					12	each
Number of major culverts (total #)					12	each
Number of small bridges (total #)					3	each
Number of medium bridges (total #)					12	each
Number of large bridges (total #)	4	2	2	3	11	each

Large Bridges					
River Name (if known)	**Length (ft)**	**Length (ft)**	**Length (ft)**	**Length (ft)**	**Total (ft**
Alatna River (Alatna Sta 2647+00)			400		
Malamute Fork of Alatna River (Alatna Sta 2921+60)			420		
Beaver Creek (Shungnak Sta 4402+00)	220				
Kogoluktuk River (Shungnak Sta 1875+00)	320				
Mauneluk River (Shungnak Sta 2974+90)	460				
Shungnak River (Shungnak Sta 1200+00)	380				
Koyukuk River				820	
Wild River				430	
John River				580	
Reed River, South Crossing		360			
Kobuk River, South Crossing		480			
Total	1380	840	820	1830	**4870**

Cells in green taken from GIS data 4/18/2016; minor culverts revised 5/20/2016; see Data Totals spreadsheet
Cells in gray outdated; not used in estimate.

Ambler Mining District Industrial Access Project **Alternative C**

Updated by: RDP

Updated: 4/22/2019

Date Updated:	4/22/2019	**Unit**
Number of minor culverts (total #):	4,076	each
Number of moderate culverts (total #)	131	each
Number of major culverts (total #)	141	each
Number of small bridges (total #)	79	each
Number of medium bridges (total #)	158	each
Number of large bridges (total #)	14	each

Large Bridges	
River Name (if known)	**Length (ft)**
Ray River	230
Big Salt Creek	210
Gishna Creek	260
McQuestion Creek	190
Indian River	230
Indian River	190
Koyukuk River	1280
Hughes Creek	200
Hughes Creek	200
Hughes Creek	220
Hogatza River	380
Kobuk River (side channel)	250
Kobuk River	930
Shungnak River	380
Total	5150

Minor culverts estimaed at 12.28 culvert/mile.

Number and sizes of crossing estimated through GIS available data 4/22/2019