Ambler Mining District Access

Design Criteria Memorandum

September 2011

AMBLER MINING DISTRICT ACCESS

DESIGN CRITERIA MEMORANDUM

AKSAS 63812

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1.0 INTRODUCTION

1.1 Project Overview and Purpose

The Ambler Mining District Access project proposes to identify, design, and construct a transportation corridor from the Ambler mineral belt to either a port location on the west coast of Alaska or the surface transportation system in the Alaska Interior. The corridor is intended to provide surface transportation access to state lands and facilitate exploration and development of mineral resources along the Ambler mineral belt.

The South Flank of the Brooks Range contains extensive mineral resources. Limited exploration efforts since the 1950s have identified significant resources of copper and other base metals (Hawley and Vant, 2009) (Figure 3). Exploration and development of these deposits has been economically and logistically curtailed by the lack of transportation infrastructure.

1.2 Project Study Area

The project study area extends from Ambler mineral belt south to Nenana and from the Dalton Highway to the west coast (Figure 1). Four potential corridors have been identified from the Ambler mineral belt to the west coast of Alaska, and four potential corridors head east from the Ambler mineral belt to the Dalton Highway or the Alaska Railroad (Figure 2).

1.3 Objectives

This Design Criteria Memorandum documents the initial review of road and rail corridors that could potentially access the Ambler mineral belt. The objectives for documenting the development of the corridors for this project are:

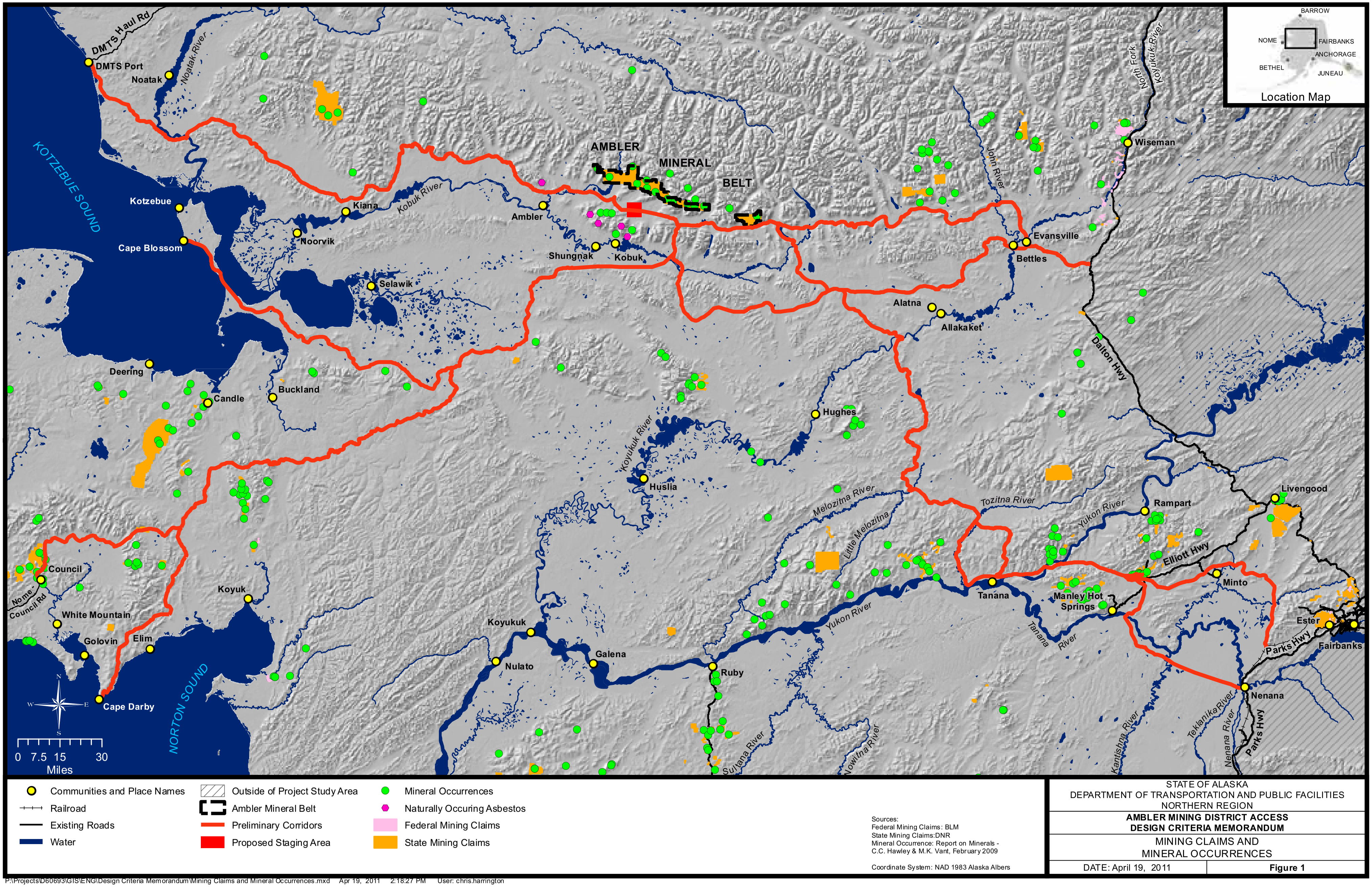
- Protect transportation corridor infrastructure and reduce the risks of failure;
- Establish consistency within the corridor;
- Minimize impacts to environmental resources; and
- Minimize long-term maintenance costs.

The design criteria set forth in this memorandum targets these objectives by:

- Documenting roadway and railway criteria that will guide design decisions for the entire the corridor;
- Identifying criteria that provide designers with geometric flexibility to minimize environmental impacts; and
- Developing predominantly fill cross-sections with depth that addresses thermal modeling, snow drifting, and settlement issues.

1.4 General Corridor Description

A Corridor Development Memorandum (DOWL HKM, 2011) was prepared to document the selection of eight potential road and rail transportation access corridors. These eight potential corridors were developed based on historic transportation corridors (e.g., winter trails, tractor trails, etc.) previous, access studies, topographic information, slope analysis, and aerial imagery. Four corridors start in the Ambler mineral belt and head west or southwest to existing or potential port sites on the Alaskan coast. Four corridors head east or southeast to the Dalton Highway or to the existing Alaska Railroad facilities near Nenana (See Figure 2).


DMTS Haul Rd
DMTS Port
Noatak
Noatak River
KOTZEBUE SOUND
Kotzebue
Cape Blossom
Kiana
Kobuk River
Noorvik
Selawik
Ambler
Shungnak
Kobuk
AMBLER
MINERAL
BELT
John River
Wiseman
North Fork
Koyukuk River
Evansville
Bettles
Alatna
Allakaket
Dalton Hwy
Deering
Candle
Buckland
Hughes
Koyukuk River
Huslia
Melozitna River
Little Melozitna
Tozitna River
Yukon River
Rampart
Livengood
Elliott Hwy
Minto
Tanana
Manley Hot
Springs
Tanana
River
Ester
Fairbanks
Parks Hwy
Nenana
Teklanika River
Nenana River
Kantishna River
Council
Nome
Council Rd
White Mountain
Golovin
Elim
Koyuk
Cape Darby
NORTON SOUND
Koyukuk
Nulato
Galena
Ruby
Sulatna River
Nowitna River
0 7.5 15 30
Miles
BARROW
NOME
FAIRBANKS
ANCHORAGE
BETHEL
JUNEAU
Location Map
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Railroad
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Proposed Staging Area
Mineral Occurrences
Naturally Occuring Asbestos
Federal Mining Claims
State Mining Claims
Sources:
Federal Mining Claims: BLM
State Mining Claims:DNR
Mineral Occurrence: Report on Minerals -
C.C. Hawley & M.K. Vant, February 2009
Coordinate System: NAD 1983 Alaska Albers
STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
NORTHERN REGION
AMBLER MINING DISTRICT ACCESS
DESIGN CRITERIA MEMORANDUM
MINING CLAIMS AND
MINERAL OCCURRENCES
DATE: April 19, 2011
Figure 1
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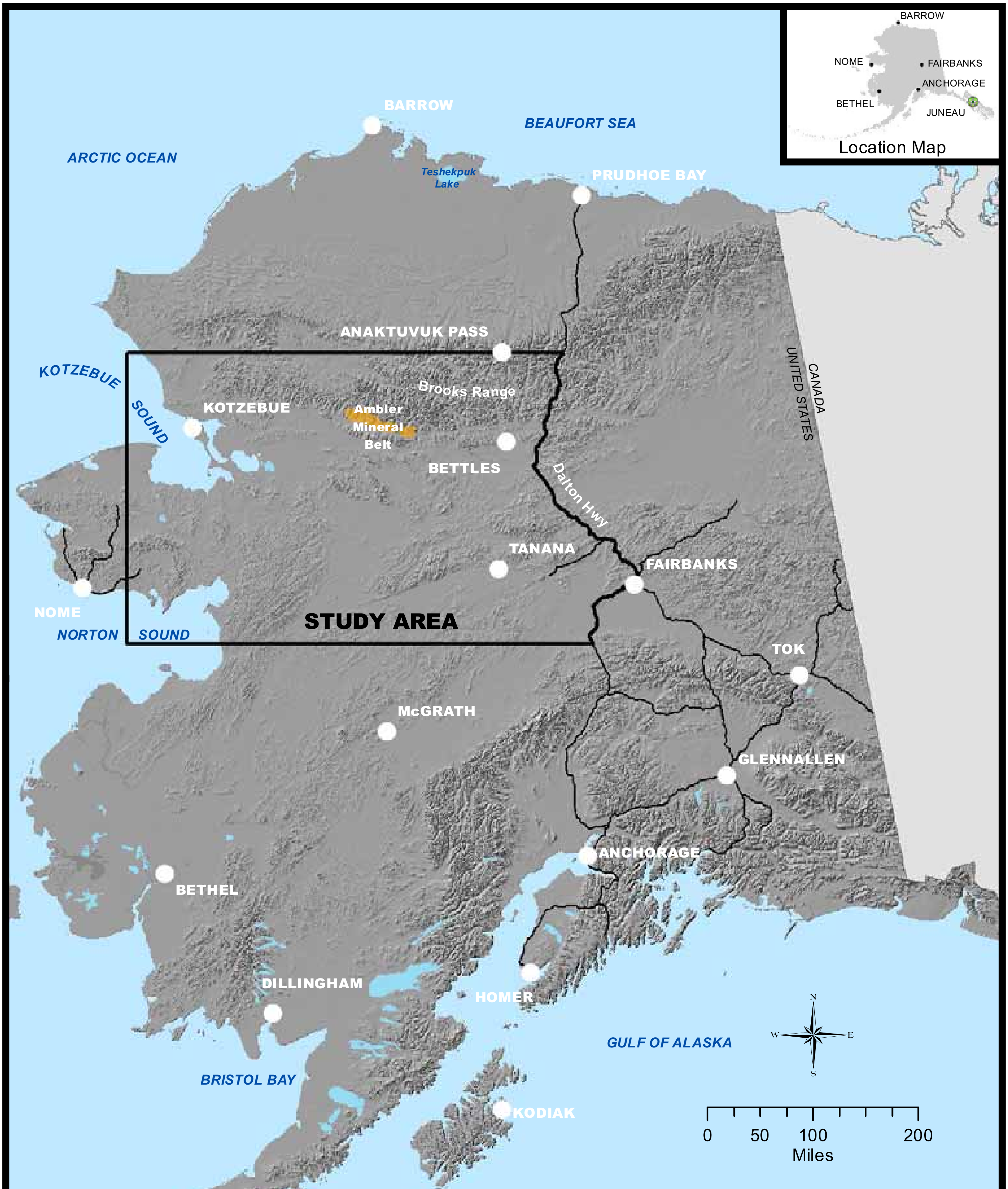

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LOCATION & VICINITY MAP

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Figure 2

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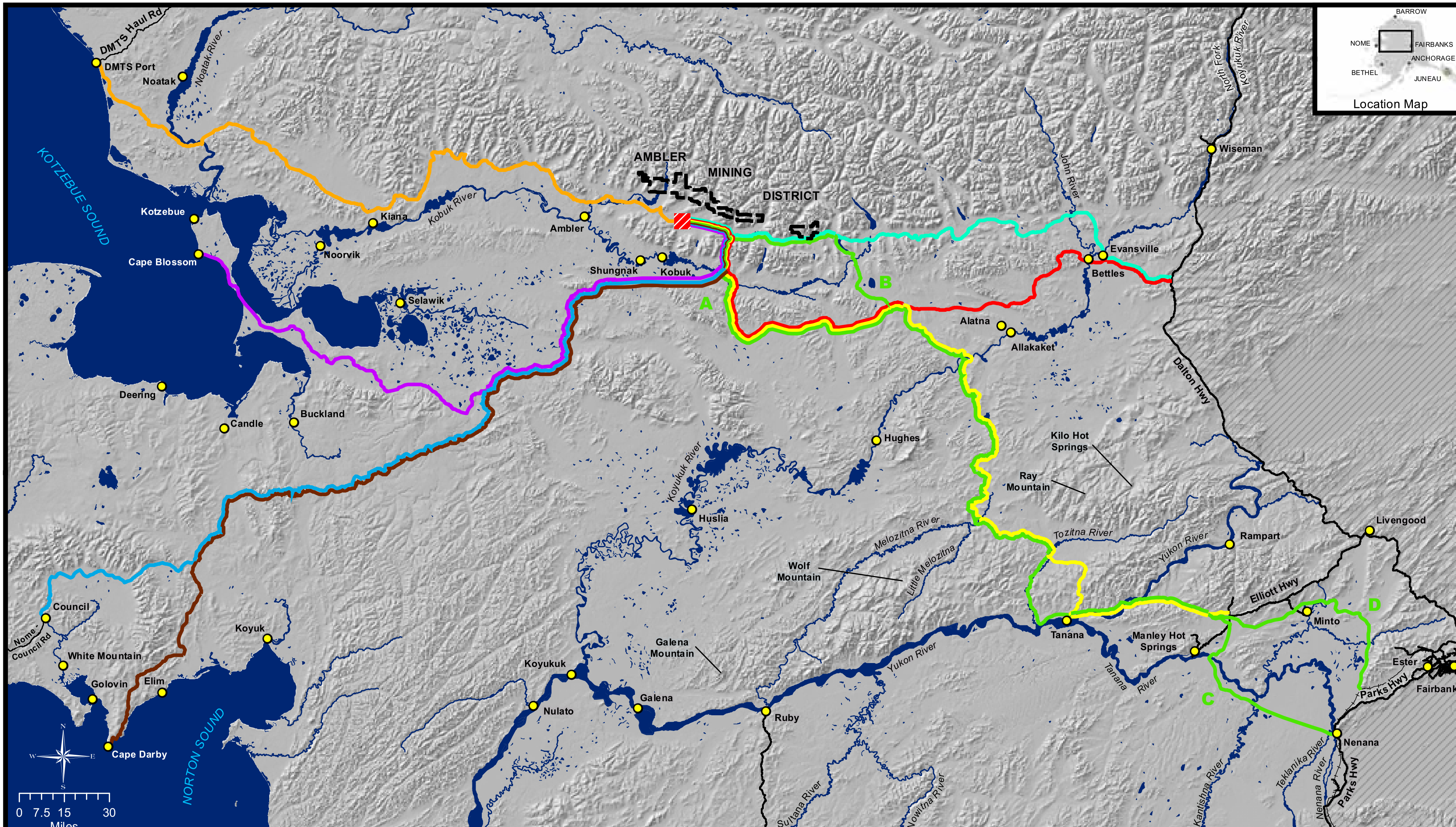

- Communities and Place Names
- Railroad
- Existing Roads
- Water
- Outside of Project Study Area
- Ambler Mineral Belt
- Proposed Staging Area
- 1-Brooks East Corridor 216 Miles (Road Only)
- 2-Kanuti Flats Corridor 241 Miles (Road Only)
- 3-Elliott Hwy Corridor 365 Miles (Road Only)
- 4-Parks Hwy RR Corridor 420-450 Miles (Rail Only)
- 5-DMTS Port Corridor 257 Miles (Road & Rail)
- 6-Cape Blossom Corridor 245 Miles (Road & Rail)
- 7-Selawik Flats Corridor 340 Miles (Road & Rail)
- 8-Cape Darby Corridor 331 Miles (Road & Rail)

Sources:
Commmunities and Place Names: DNR, DOT&PF
Existing Roads: DOT&PF
DMTS Haul Road: NANA
Railroad: DNR

Coordinate System: NAD 1983 Alaska Albers

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PRELIMINARY CORRIDORS

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Figure 3

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2.0 ROADWAY DESIGN CRITERIA

2.1 General Criteria

Design criteria for the Ambler mineral belt were generated from published guidelines from the American Association of State Highway and Transportation Officials (AASHTO). Additional design criteria were developed from State of Alaska Department of Transportation and Public Facilities (DOT&PF) bridge designers, private bridge fabricators, professionals with heavy-haul design experience, and past planning reports on similar DOT&PF Northern Region road and bridge projects.

The design criteria, comparison data, and criteria source or rationale are presented in Table 1. A detailed explanation of the criteria follows.

2.1.1 Functional Classification

Ambler mineral belt corridors are classified as Very Low-Volume Local Roads with the sub-classification of Rural Resource Recovery Roads. The Guidelines for Geometric Design of Very Low-Volume Local Roads (GDVLVLR) states that this type of road is "functionally classified as a local road and has a design average daily traffic volume of 400 vehicles per day or less." Rural Resource Recovery Roads are defined as "local roads serving logging or mining operations." Their intended use is "primarily or exclusively by professional drivers with large vehicles."

Table 1: Initial Roadway Design Criteria Comparison

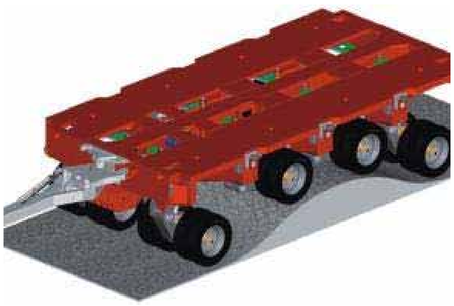
Element	This Project	Criteria Source/Rationale
Project Type	New Construction	Scope of Services
Functional Classification	Very Low-Volume Local Road (Special Purpose)	GDVLVLR, page 7
Functional Sub classification	Rural Resource Recovery Road	GDVLVLR, page 7
Functional Classification As defined by AASHTO	Local roads serving logging or mining operations. They are primarily used by vehicles involved with resource recovery and the driving population primarily consists of professional drivers with large vehicles.	GDVLVLR, page 7-8
Design Vehicle **Maximum Axle Loadings**	22,000 lbs/standard axle 22,000 lbs/trunnion axle (winter only)	A 22,000 lb axle loading should cover a wide range of transportation needs including moving heavy mining equipment to the site on multi-axle heavy haul trailers. The basic truck/trailer would be the standard 8'6" wide, but loads considerably wider (such as modularized equipment) could be carried on the proposed 32-foot typical section.
Number of Lanes	2	Scope of Services
Grade Limitations	50 mph - Level, 0-4% 40 mph - Level, 4-7% 40 mph - Rolling, 7-9% 40 mph -Mountainous, 9-12%	American Association of State Highway and Transportation Officials, A Policy on Geometric Design of Highways and Streets, 5th Edition, 2004, (AASHTO) page 235& 409, 414. AASHTO, page 446 (Steeper grades may necessitate lower design speeds)
Clear Zone	6 ft Recommended (4H:1V sides slopes) 0 ft Allowed (Can be 3:1 or steeper, slope stability dependent)	GDVLVLR, page 48 and 50.
Projected AADT **% Truck**	≤ 400 80%	2007-2009 Annual Daily Traffic Report, Northern Region for Dalton Highway (2009 AADT=300) Truck traffic: 2007-2009 Annual Daily Traffic Report, Northern Region for Dalton Highway.
Maximum Design Speed	50 mph	AASHTO, page 415 The design speed will be dependent on the terrain.
Surfacing, Lanes	Unpaved	GDVLVLR, page 6
Minimum Traveled Way Width Lane Shoulder	 32 feet 12 feet 4 feet	GDVLVLR, page 18 Exhibit 1 Page 19 discretion A wider typical section was chosen due to the anticipated high amount of heavy haul truck traffic within the Ambler mineral belt corridor.
Design Flood	50-year return period (2% exceedance probability)	Alaska Highway Preconstruction Manual (HPM) and Alaska Highway Drainage Manual (HDM).

Element	This Project	Criteria Source/Rationale
Scour Protection	Designed for 100-year return period (1% exceedance probability) Checked at 500-year return period (0.2% exceedance probability)	HPM and HDM
Cross-Drainage Culvert	24-inch or greater	HPM
Culverts > 100 feet	36-inch or greater	HPM
Headwater to depth ratio (HW/D)	1.0 at design flow	HDM
Minimum and Maximum Cover over culverts	Varies	In accordance with DOT&PF Standard Drawing D-04.21 pipe and Arch Tables.
Fish Passage	Tier 1. Stream Simulation Design	2001 Memorandum of Understanding (MOU) between ADF&G and DOT&PF for the Design, Permitting, and Construction of Culverts for Fish Passage
Bridge Live Load	AASHTO HL-93	HPM

2.1.2 Design Vehicle

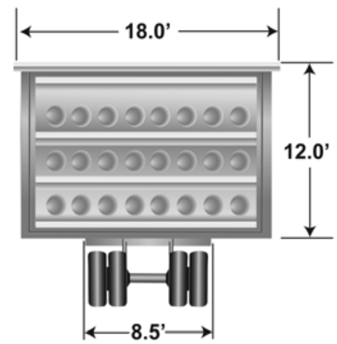
The majority of the anticipated traffic will be heavy haul vehicles. Typical vehicles beyond the "low boys" used to haul common earth moving machines are generally found in two general configurations. The first would be the multi-axle, flatbed hauler such as the Goldhofer modular trailers, which are, in essence, a flat table with an axle about every five feet, often with eight wheels per axle. These haulers can be either self-propelled or towed with a large tractor and can be joined together both end-to-end and side-to-side to haul enormous loads. The second configuration is a complex trailer with multi-axle "trucks" both in front of and behind the load (See Figure 4). Selection of the particular type of heavy haul vehicle is based on various reasons including size and configuration of the load, terrain, and span length of crossings.

AASHTO does not define dimensions or turning radii specifically for heavy haul vehicles. Since several of the access corridors connect to existing rural roadways, vehicles using the new corridor must also be consistent with criteria governing existing highways. Thus, the design vehicle is a WB-62 to be compatible with the turning radii and the geometric of the existing road network. Given the anticipated type of road, lack of intersections, and 50 mph design speed, few design elements will be governed by WB-62 criteria. A more relevant criteria for evaluating the design vehicle on this rural resource recovery road is to set the recommended design vehicle loading based on allowable loading. Establishing the loading requirements enables the road cross-section to be designed to carry this load based on depth of section and available materials. For a resource recovery road, the recommended design vehicle loading is a 22,000 pound (lb) load per axle with standard axles. A 22,000-lb axle loading will cover a wide range of transportation needs, including moving heavy mining equipment using multi-axle, heavy-haul trailers. The basic truck/trailer would be the standard 8-foot-6-inch width, but loads considerably wider (such as modularized equipment that can be 18 feet in width) could be carried on the proposed typical section (12-foot travel lanes and 4-foot shoulders). The use of trunnion axles will accommodate significantly higher axle capacity and are also recommended, but should be prohibited from use when the ground is not frozen to minimize impacts to the structural section.



Basic Flat Bed Truck

Complex Trailer



Typical Modularized Equipment

Figure 4: Multi Axle Module Trailers

Bridges require additional loading considerations. The length of a bridge is important in determining the total load weight that it can carry. Shorter bridge spans may only carry part of the total load at any one time, whereas longer bridge spans will carry the entire load at once, so the gross vehicle weight must be considered. A CAT D11 dozer shipping weight is about 165,000 lbs; gross weight of the rig and load can exceed 220,000 lbs.

2.1.3 Design Speed and Grade Limitations

The design speed of a Rural Resource Recovery Road in the GDVLVLR is 35 miles per hour (mph). AASHTO states "design criteria appropriate for [Rural Resource Recovery Roads] in many areas are not significantly different from those of recreational roads. For this reason, the criteria developed for recreational roads should be followed to the extent they are applicable." However, Rural Resource Recovery Roads are typically longer and have higher potential for long, straight, stretches of roadway compared to recreational roads. Furthermore, it is important for the design speed to closely match the speed at which the majority of the drivers are comfortable traveling, while adapting to visual and physical cues such as sight distance, lane width, and road gradient. Due to the rural and predominantly flat terrain of the access corridors, 35 mph was deemed to be unrealistically slow. A design speed of 50 mph was selected for this project. This design speed is similar to the Dalton Highway and other rural roads in Alaska. During future design phases, this design speed may be reduced in rolling and mountainous terrain at the discretion of DOT&PF.

2.1.4 Clear Zone

Provision for roadside clear zones, flatter slopes, or traffic barriers is generally inconsistent with the economic decision to build and maintain an unpaved surface (GDVLVLR, 2001). The GDVLVLR design guidelines for roadside clear zone width is a 6-foot or more clear recovery area if the clear zone is considered low cost (right-of-way needed, terrain, etc.) and has minimum environmental impacts. If the impacts are considered impractical, clear zones from 0 to 6 feet may be used.

In areas where clear zone width is not deemed practical, side slopes can be reduced to 3H:1V or steeper depending on the slope stability. Where horizontal curves are sharp or where engineering judgment determines a clear zone is needed, the slopes will be 4H:1V or flatter.

2.1.5 Projected Average Annual Daily Traffic (AADT)

Dalton Highway AADT was considered in developing the design criteria for this project. Based on the current DOT&PF traffic report (Northern Region, DOT&PF *Annual Daily Traffic Report, 2007-2009*), Dalton Highway AADT is about 300. A corridor from Ambler mineral belt east to Dalton Highway is estimated to have a traffic volume equal to or less than the Dalton Highway. Since the estimated AADT is less than 400, the GDVLVLR was used to establish basic design criteria.

2.1.6 Typical Section

For a low-volume local road with a 50 mph design speed, the minimum required roadway surface width for new construction with two-way traffic varies from 20 to 24.5 feet. This minimum standard is not recommended for the access corridors due to safety and maintenance concerns for such a narrow road operating in Arctic condition with large resource recovery vehicles. Similar Northern Region roads and the need to accommodate wide loads for modularized equipment dictate a wider road surface. A 32-foot typical section (12-foot travel lanes and 4-foot shoulders) which matches the Dalton Highway width is proposed. See Figure 5 for the recommended typical section. This width uses a traveled way width that matches the minimum requirements, and adds a 4-foot shoulder to resolve the safety and maintenance concerns.

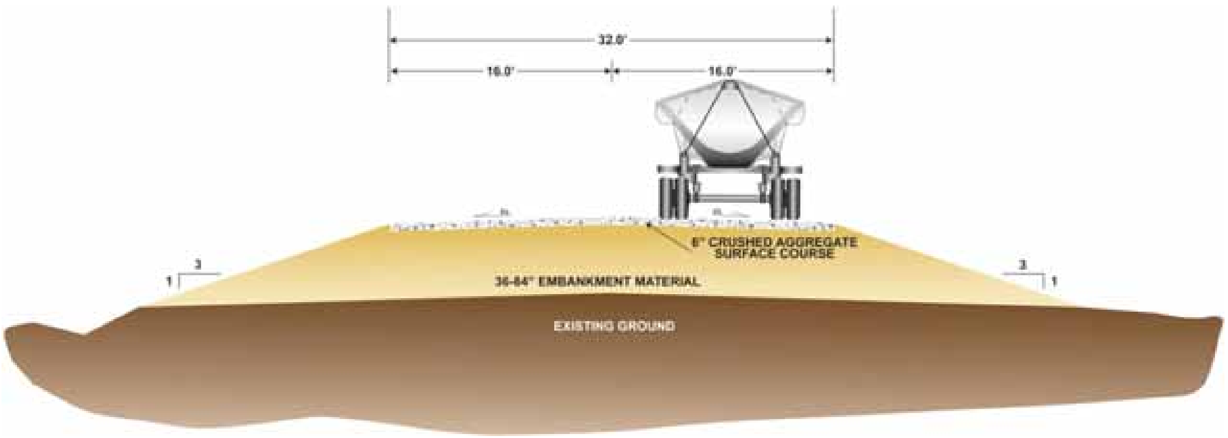


Figure 5: Ambler Mining District Access Typical Section

2.1.7 <u>Turnouts</u>

The proposed corridor will consist of 32-foot gravel width wide enough in an emergency for a standard 8-foot-6-inch wide truck to pull over to the side of the road and maintain clear space for two-way traffic. To also accommodate non-emergency use, wider turnouts are needed throughout the corridor to provide sufficient space for vehicles to safely pull off the road if repairs are is required, chains need to be installed, maintenance performed or simply for a rest stop (Figure 6). Turnouts may also be used when hauling a significantly over width load that is wide enough to prohibit an oncoming vehicle to pass. Turnout spacing is recommended at ten-mile intervals and the dimensions should match the DOT&PF Highway Preconstruction Manual (HPM) for truck emergency turnouts at least 150 feet long by 20 feet wide with a minimum 50-foot long approach and 50-foot long exit taper.

The HPM also recommends that turnouts be "provided at the beginning of passes to install tire chains or at the top of steep grades to check brakes." Placement of the turnouts should b e adjusted to fulfill this requirement as well.

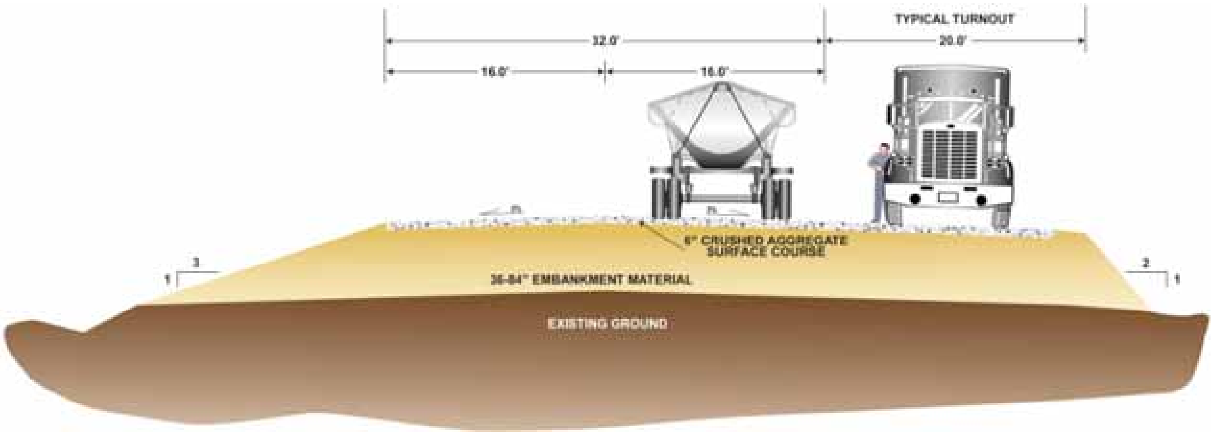


Figure 6: Ambler Mining District Typical Section

2.1.8 Structural Section

Due to various levels of permafrost in the study area and the lack of geotechnical data to determine areas where excavation is an option, it was assumed that no excavation below the existing ground surface would be included in the baseline cost estimates. In addition, varying stability in subsurface conditions in the corridors will require varying heights of fill. Initially, three structural sections were assumed as shown in Table 2.

Table 2: Structural Section Summary

Typical Section	Embankment Thickness	Remarks
A	84 inches	Areas with high potential for frost heave and thaw settlement.
B	60 inches	Areas with potential for wind and snow drifting (low to no potential for frost heave and thaw settlement.
C	36 inches	Areas with low to no potential for frost heave and thaw settlement and low potential for wind and snow drifting.

The assumed structural sections used in approximating quantities were further analyzed using the program TEMP/W; a component of the GeoStudio 2004 suite products. TEMP/W is a finite element software product used to model thermal changes in the ground due to the environment, or construction of roadways. Several configurations were evaluated that included varying thicknesses of embankment material, with and without insulation, and transient air temperatures.

2.1.8.1 Thermal Modeling - Transient Analysis

The model assumes winter construction for fill placement, and models conditions for 9,000 hours (approximately one year). The model ran thaw calculations at five-day increments (120 hours). Each of the 75 calculations created under each model indicated depth of thaw (where occurring) and a summary of the thaw depths over the model year is shown in Appendix A. Each blue line shown represents depth of thaw during a 5-day increment.

2.1.8.2 Thermal Modeling - Corridor Soil Profile

Soil profiles within each corridor vary greatly. For this preliminary engineering effort, a generic profile was created. The profile assumes four existing layers extending a total depth of 20 feet below the original ground surface; a point at which it was assumed the soil temperatures would remain constant year-round and maintain temperatures of 30° F below a depth of 20 feet for both steady-state and transient heat flow analysis. The profile assumptions are:

- Gravel fill material of varying depth, overlying
- Three feet of peat, overlying
- Seven feet of silt, overlying
- Ten feet of silty sands and gravels.

After the initial analyses were completed, the soil profile was modified to observe the variation in thaw depths. In one profile, the peat layer was decreased to one foot thick, increasing the silt layer to nine feet. In a subsequent profile, the water content of the peat was decreased to indicate drier conditions and a tendency for greater thaw depths.

2.1.8.3 Thermal Modeling - Air Temperature

TEMP/W allows the air temperature (surface boundary condition) to vary over time. Average monthly temperatures were obtained from the Western Regional Climate Center for Bettles, Alaska (see Appendix A).

Average monthly temperatures were assigned to occur in the middle of the month. The model calculated a temperature for each five-day time increment using the average monthly temperatures.

2.1.8.4 Thermal Modeling - Thermal Properties of Soils

The thermal properties of the materials used in the model are critical to the analyses. Average thermal properties for each material were assumed based on the general knowledge of soil conditions within the corridors and published data. Table 3 details the material properties assumed in the analysis.

Table 3: Assumed Thermal Properties of Materials

Material Name	Frozen Thermal Conductivity (BTU/ft/hr/F)	Unfrozen Thermal Conductivity (BTU/ft/hr/F)	Frozen Volumetric Heat Capacity (BTU/ft^3/F)	Unfrozen Volumetric Heat Capacity (BTU/ft^3/F)	Volumetric Water Content %
Organic, Wet Peat	1.05	0.2	30	55	2.1
Silt	1.04	0.81	29.6	43.5	0.93
Silty Sand w/Gravel	1.27	1.04	26.4	32.4	0.66
Gravel Fill	1.25	1.15	25	28.8	0.13
Insulation	0.02	0.02	3	3	0

2.1.8.5 Thermal Modeling - Boundary Conditions

The model uses boundary conditions to control external forces that enter and leave the model area. For 2D models typically upper and lower boundary conditions are assumed. The upper boundary was assumed to be the ground surface and would be controlled by air temperatures. TEMP/W allows the air temperature to vary over time.

The lower boundary layer for soil models is generally the depth at which the ground temperatures are constant and unaffected by seasonal air temperatures. We assumed the soil temperatures remained constant 20 feet below the existing surface at 30° F.

2.1.8.6 Thermal Modeling - Analysis

Seven different analyses were completed and are outlined in Table 4. These analyses were used to develop the proposed structural section details. For each of the analyses, a summary of the thaw depths that occurred over a 1-year duration is shown in Appendix A.

Table 4: Structural Section Summary

Model	Soil Profile of Original Ground	Embankment Depth (ft)	Rigid Insulation Thickness (in)
1	3’ peat/7’ silt	NA	---
2	3’ peat/7’ silt	3	---
3	3’ peat/7’ silt	3	2
4	3’ peat/7’ silt	6	---
5	3’ peat/7’ silt	6	2
6	3’ peat/7’ silt	8	---
7	3’ peat/7’ silt	8	2

2.2 Roadway Bridge and Culvert Criteria

Bridges, culverts, and hydrologic calculations in support of crossing structures will be consistent with the Alaska Highway Preconstruction Manual (HPM) and the Alaska Highway Drainage Manual (HDM).

2.2.1 Design Flood

The HPM and HDM list a 50-year return period (2% exceedance probability) as the design flood for bridges on all highways and culverts on primary highways and secondary highways of high importance. Culverts and bridges in designated flood hazard areas are designed for the 100-year return period (1% exceedance probability); however, no Flood Hazard areas are mapped in the project study area. Scour protection will be designed for the 100-year return period and checked at the 500-year return period (0.2% exceedance probability) as required by the HPM and HDM.

2.2.2 Culvert Sizing

The APCM requires 24-inch or greater diameters for cross-drainage culverts and 36-inch or greater for culverts over 100 feet long. A minimum diameter of 36 inches is also recommended where icing is likely. Culverts shall be designed for a maximum headwater to depth (HW/D) ratio of 1.0 at the design flood flow per the HDM.

2.2.3 Design Live Load

The design live load is based on the AASHTO HL-93 live load and the design vehicle and loading discussed in Section 2.1.2. The bridge designs for roadway corridors should assume a project-specific inventory (or permit) load. Span lengths and total length of bridges are important parameters in evaluating capacity to support inventory loading. Shorter bridge spans may carry only part of the total load at any one time, whereas longer bridge spans carry the entire load at once; thus, gross vehicle weight and geometry must be considered. Regardless of gross weight, load geometry is critical for completing any analysis and or design. DOT&PF's bridge design group recommended evaluating bridges for an inventory load multiplied by a 1.35 load factor (verbal communication, Elmer Marx, DOT&PF). In the absence of a specific inventory load, or as a comparison to the inventory load, the HL-93 loading multiplied by a 1.75 load factor could be used in evaluating any bridge of any size (verbal communication, Elmer Marx, DOT&PF). Bridges should be designed for whichever load is greater.

3.0 RAILWAY DESIGN CRITERIA

3.1 General Criteria

The railway design criteria for the Ambler Mining District Access were developed from three primary sources: the Alaska Railroad Corporation (ARRC), the American Railway Engineering and Maintenance-of-way Association (AREMA), and the Federal Railroad Administration (FRA). If a rail option is selected by DOT&PF as the preferred corridor, it is unknown who will own, maintain, and operate the rail facilities. In the absence of any other criteria, the evaluation of the rail alignment is based primarily on ARRC design standards because ARRC has specialized experience in design, operation, construction, and maintenance of railroad facilities in Alaska. ARRC assets include track, bridges, signalization equipment, maintenance facilities, loading/unloading equipment, locomotives, and a fleet of railcars. Additionally, the State of Alaska owns the ARRC. For criteria that ARRC guidelines do not address, AREMA guidelines may apply. The ARRC uses AREMA's recommended practices as a foundation for their design standards, similar to large North American Class I Railroad companies (Class I railroad companies have operating revenues in excess of $346.8 million). A summary of the initial design criteria appears in Table 5.

Table 5: Initial Railway Design Criteria

Element	This Project	Criteria Source/Rationale
Project Type	New construction	Scope of services
Track Classification	Class 3, non-mainline	FRA Federal Track Safety Standards
Freight Car Weight	286,000-lb (143 tons) rail cars	North American heavy-rail standard
Annual Tonnage	Less than 10,000,000 gross tons	Assume less than 700 trains annually, or 1.92 trains daily, see Section 3.1.1.
Maximum Design Speed	40 mph for freight traffic	FRA Class 3 Track; see Section 3.1.2.
Grade Limitations	Level, 0-0.5% Rolling, 0.5-1.0% Mountainous, 1.0-1.5%	ARRC standard practice
Track Components	141RE Continuously Welded Rail ARRC Standard Concrete Ties	ARRC standard practice for new construction ARRC Standard Drawing 1.4-05
Track Section	Rail, Ties, Ballast	
Structural Section	48-inch or 84-inch total section, ballast not included	ARRC Standard Drawings 2.3-03 and 2.1-04
Subballast	12 inches Aggregate Base Course Grading C-1	ADOT&PF Standard Specifications for Highway Construction
Embankment in permafrost areas	36 inches Selected Material Type A 36 inches Compacted Embankment (Selected Material Type C or better)	Type A requirement from recent ARRC projects
Embankment in non-permafrost areas	36 inches Selected Material Type A	
Siding Tracks	Length: approximately 8,500' (8,000' clear length) Spacing: 15' between track centerlines Longitudinal Spacing: approximately every 20 miles #15 Turnouts (hand-thrown)	ARRC standard practice for new construction; see Section 3.1.4. ARRC Standard Drawing 2.11-05 ARRC standard practice for new construction; see Section 3.1.4. ARRC standard practice for new construction; assume non-electrified track, see Section 3.1.4.
Maximum Degree of Curvature	6^{o} (Radius = 955.36'), Chord Defined 5^{o} (Radius = 1146.28') preferred	AREMA Manual for Railway Engineering ARRC Track Chart
Superelevation	Maximum: 4.75 inches (6^{o} curve) Preferred: 3.75 inches (5^{o} curve) Unbalance: 2 inches	ARRC Track Chart FRA Federal Track Safety Standards
Fish Passage	Tier 1. Stream Simulation Design	2001 Memorandum of Understanding (MOU) between ADF&G and DOT&PF for the Design, Permitting, and Construction of Culverts for Fish Passage
Bridge Loading	Cooper E-80	AREMA Manual for Railway Engineering

3.1.1 Classification and Estimated Traffic

The track classification for a railroad line into the Ambler mineral belt will depend on several factors; ultimately, the classification dictates the design speed and maintenance requirements of the track. The FRA establishes track classes with progressively increasing standards for track quality and inspection timelines.

Table 6: FRA Classes of Railroad Track

Class of Track	Maximum Speed, Freight Traffic	Maximum Speed, Passenger Traffic	Minimum Track Inspection Frequency
Class 1*	10 mph	15 mph	Non-mainline: Monthly Mainline: twice weekly
Class 2*	25 mph	30 mph	
Class 3*	40 mph	60 mph	
Class 4	60 mph	80 mph	Twice weekly
Class 5	80 mph	90 mph	
Class 6	NA	110 mph	
Class 7	NA	125 mph	
Class 8	NA	150 mph	
Class 9	NA	200 mph	Three times weekly

* Note: for Classes 1 through 3, track is considered mainline if it carries passenger traffic or more than 10 million gross tons during the preceding year.

As shown in Table 6, track with a higher classification can travel at greater speeds, but the inspection requirements become more rigid. Railroad companies determine their own class of track based on FRA guidelines for track structure, track geometry, and the FRA enforces maintenance standards for the specified track classification. Track structure refers to rails, crossties, track switches, tie plates, and rail fastening systems. Track geometry is the gage (the distance between individual rails), alignment, super-elevation, and curvature. If any of these structure or geometric elements are inadequate, or if track maintenance is inadequate, then the track classification must be downgraded, thus reducing the allowable track speed.

Class 3 (non-mainline) track is recommended for access to the Ambler mineral belt. This classification allows reduced maintenance costs by requiring monthly track inspections rather than twice-weekly inspections.

The non-mainline designation is dependent upon the annual tonnage hauled over the rail line. The assumed traffic carried by the track will be less than 10 million gross tons annually. Since the primary purpose for constructing a rail line to the Ambler mineral belt is for hauling bulk commodities, resources extracted from the Ambler area will likely be hauled away on unit trains. All rail cars in a "unit train" have the same point of origin and the same destination. Unit trains do not need to be divided and reclassified in rail yards, thus improving operational efficiency and reducing costs. Unit trains typically carry only one commodity and therefore consist of the same type of rail cars. Across North America, unit trains typically consist of approximately 100 rail cars, and the maximum weight of each car is 286,000 pounds (143 tons) each. Therefore, the non-mainline threshold of 10 million tons equates to 700 unit trains annually or 1.92 unit trains daily. As a comparison, the 2008 production from Red Dog mine was 703,289 tons (567,911 tons of zinc and 135,144 tons of lead, and 234 tons of silver), which would require only 49 unit trains.

3.1.2 Design Speed

Freight traffic and passenger traffic can travel at different speeds over the same track. However, for the purposes of accessing the Ambler mineral belt, freight guidelines are more economically feasible and meets the project objective to haul bulk commodities from the Ambler mineral belt.

Freight traffic on FRA Class 3 track (non-mainline) can travel at 40 mph, which is appropriate since time-sensitive intermodal traffic is not expected. In addition, this speed is commonly used for regional railroads and secondary mainlines for large Class I railroad companies.

3.1.3 Grade Limitations

ARRC prefers grades between 0 and 0.50% to maximize operational efficiency. ARRC accepts grades of 0.50-1.00%, but these should be limited to the extent possible. Grades of 1.00-1.50% are not advisable for the heavy loads expected from the Ambler mineral belt and, if ARRC were to own/operate the track, would require approval from the ARRC Chief Engineer.

3.1.4 Typical Section

The track structure consists of a minimum of 1-foot (minimum) of ballast below the base of concrete ties and 141-lb RE continuously-welded rail. "RE" denotes an AREMA standard rail section, see Figure 7. Continuously-welded rail (CWR) is manufactured in 39-foot lengths, which can be welded into lengths up to 1,600 feet long for construction. This is consistent with ARRC's standard practices for new track construction elsewhere in Alaska.

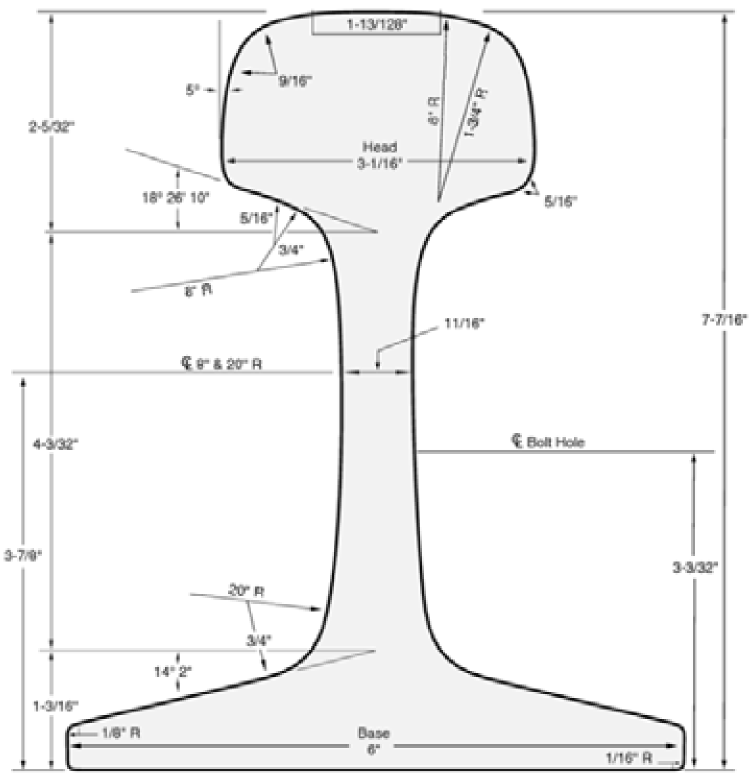


Figure 7: 141-lb RE Rail Section

Using other lower-quality track components could reduce construction costs, but other costs may increase as a result. 115-lb. rail is less expensive, but will experience more wear than 141-lb. rail. Additionally, substituting CWR for jointed rail could reduce construction costs, but the maintenance costs are higher. Similarly, wooden ties are cheaper than concrete ties, but they also require more maintenance and have a shorter lifespan. Another consideration is that the use of lower-quality materials may reduce the overall stiffness of the track structure. Significant reductions in stiffness could require a thicker subgrade section, enhanced subgrade preparation, reduced tie spacing (and therefore more ties), and increased maintenance or inspection requirements, but these items should be evaluated during future design tasks.

Two different track embankment sections were evaluated: one for use when information indicates the presence of wetlands, and one for locations without wetlands. The bottom portion of the typical section in wetlands areas consists of 36-inches of compacted embankment material meeting a minimum quality standard comparable to Selected Material Type C (note: ARRC uses DOT&PF material specifications because it does not have specifications for non-rail elements). Above this layer is a 36-inch layer of Selected Material Type A. This is consistent with the thermal modeling for the roadway. A 12-inch layer of subballast lies directly above the Select Material Type A (see Figure 8). Subballast should meet specifications for Aggregate Base Course Grading C-1. This embankment is consistent with new construction practices for the ARRC in wetland areas, but the project geotechnical engineer should reevaluate the material type, depth, and availability during the design phase of the project. Railroad embankments may have higher compaction required than roadway embankments; again, this should be confirmed with the project geotechnical engineer during the design phase.

In areas that do not contain wetlands, the 36-inch layer of Selected Material, Type A can be placed directly upon an adequately prepared subgrade, followed by 12 inches of subballast.

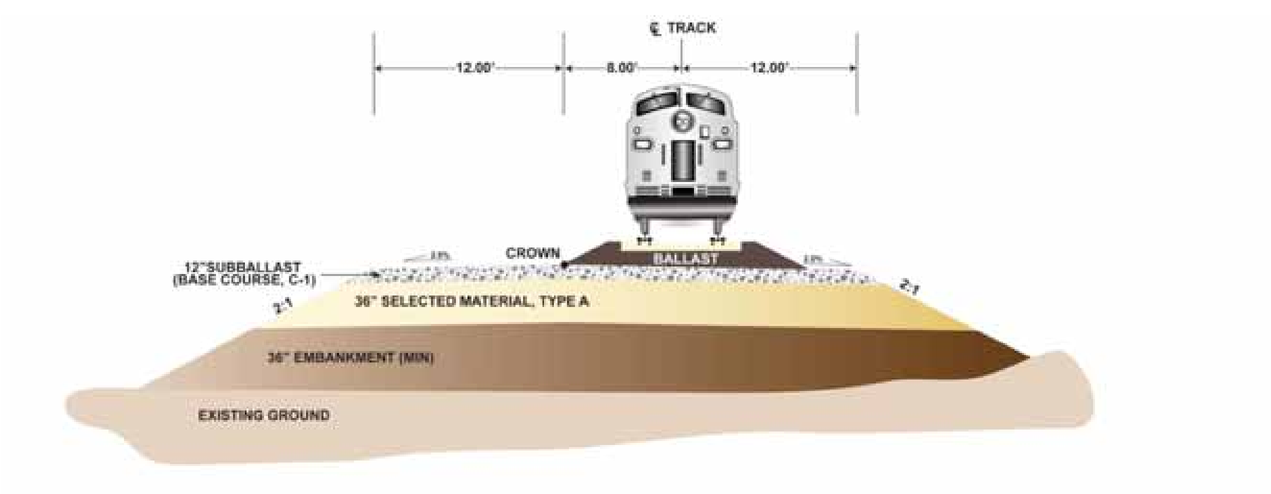


Figure 8: Railway Mainline Typical Section

To facilitate railroad operations, the Ambler mineral belt corridor incorporates a series of siding tracks. Separated from the main line, siding tracks generally serve an auxiliary purpose, such as loading, unloading, passing, and staging or storing rail cars while traffic continues using the primary track. For new routes that anticipate having two trains daily and the potential for additional future trains, ARRC plans to have sidings at 10-mile intervals. Due to the lower traffic volume expected along the Ambler mineral belt corridor, sidings are suitable at 20-mile intervals; however, designers should accommodate additional future sidings during the design phase. Each siding will require a #15 turnout at each end of the siding to allow trains to pass from the mainline to the siding. The turnouts along the Ambler mineral belt corridor are hand-thrown, meaning the train operator must exit the train and operate the switch in order to occupy the siding track. Electric switches would not be practical along this corridor due to the low volume of traffic and the lack of other signalization requirements along the corridor. The ARRC guideline for the spacing between the centerline of the siding and the centerline of the main line is 15 feet see Figure 8. Sidings 8,500 feet long have over, 8,000 feet of track at the full 15-foot separation. This length can easily accommodate a unit train consisting of 100 "hopper" rail cars filled with bulk commodities, or a unit train hauling roughly 80 flat cars (flat cars are generally longer than hopper cars).

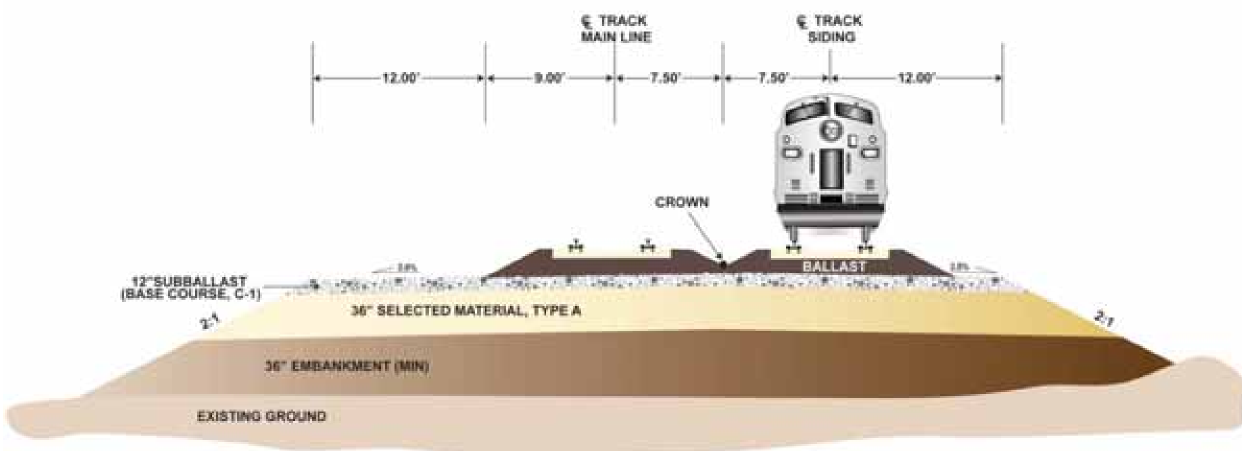


Figure 9: Railroad Typical Section with Siding Track

3.1.5 Geometric Criteria

The geometric criteria are based on the design speed of the track. The maximum degree of curvature for a 40 mph design speed is 6 degrees, but this requires 4.75 inches of superelevation. The minimum radius of a 6-degree curve is 955.36 feet. (note: that curves in railroad alignments use the chord definition, not the arc definition used in roadway design. By comparison, an arc-defined 6-degree curve has a radius of 954.93 feet). In addition, the 4.75-inch superelevation mentioned above is not the equilibrium elevation. Rather, ARRC unbalances the equilibrium elevation by 2 inches to reduce the wear on the inside rail when train speeds are less than the design speed. Minimizing the number of curves and maximizing the degree of curvature when possible will also reduce wearing on rails and extend the life of the track.

3.2 Railway Bridge Criteria

Design criteria for rail drainage structures, including bridges, culverts, and hydrologic calculations used in sizing crossing structures, are consistent with the ARRC design practice and the AREMA engineering guidelines. HPM and HDM criteria were also considered, with priority given to the most restrictive criteria when there were conflicts.

3.2.1 Design Flood

A 100-year recurrence interval (2% exceedance probability) was assumed for sizing structures at stream crossings, as recommended by AREMA. Scour at bridges will be designed for the 100-year return period and checked at the 500-year return period (0.2% exceedance probability).

3.2.2 Design Live Load

The design live load is based on a Cooper E-80 load or the Alternative Live Load, which are represented by number of axles of a given spacing and load values.

3.2.3 Culvert Sizing and Cover Heights

Culvert designs will comply with the HPM and HDM using a 100-year design flood frequency. Minimum and maximum cover heights for culverts will comply with Table 1-4-29 Minimum and Maximum Height of Cover in Feet of the AREMA Manual for Railway Engineering.

4.0 FISH PASSAGE CRITERIA

The proposed corridors cross a number of water bodies containing anadromous and/or resident fish (ADF&G 2010). Crossing anadromous or resident fish-bearing streams and rivers will require ADF&G fish habitat permits and may require fish passage culverts.

The 2001 Memorandum of Understanding (MOU) between ADF&G and DOT&PF for the Design, Permitting, and Construction of Culverts for Fish Passage details the state's commitment to maintenance and conservation of its fisheries resources and outlines specific guidelines for fish passage culverts. Culvert design guidelines in the MOU are tiered to encourage use of stream simulation design principles over hydraulic design principles. The tiers are summarized below.

Tier 1. Stream Simulation Design. Tier 1 applies to new or replacement structures and calls for replicating natural stream conditions by maintaining the existing form and function of the stream channel. This design method applies to streams with gradients of 6 percent or less. Culvert widths must be 90 percent or more of OHW width, or 75 percent or more if the stream gradient is less than one percent and the culvert is installed at 0.5 percent or less. Culverts must be embedded and filled with dynamically-stable substrate at the 50-year flood discharge.

Tier 2. FISHPASS Program Design. ADF&G's review process for Tier 2 is more complex than for Tier 1. Tier 2 applies to retrofitting existing culverts (not applicable for this project) or crossings where Tier 1 is not preferred. This design method is applicable for gradients up to 10 percent with use of baffled culverts. Typically, this design approach is applicable for steeper channels or where habitat upstream is limited. The culvert design must be evaluated with FISHPASS for a design fish species (agreed upon by ADF&G and DOT&PF) at a fish passage design flow.

Tier 3. Hydraulic Engineering Design. Tier 3 is used when site-specific conditions (including gradient, upstream habitat value, and species present) preclude the use of Tier 1 or Tier 2 guidelines. This design method can be used for gradients exceeding 10 percent in conjunction with baffled culverts. Hydraulic calculations must support the ability of the design fish to pass upstream at the fish passage design flow. This level of design requires the most detailed evaluation of the crossing parameters during the ADF&G permit review.

Fish passage culverts are assumed to be required for AWC-mapped anadromous streams and streams assumed to be anadromous. Design Criteria set for both road and rail corridors recommend fish passage culverts designed to Tier 1 guidelines.

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APPENDIX A

Thermal Modeling-Thaw Depth Figures

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NOTE:
To print data frame (right side), click on right frame before printing.

1971 - 2000

- Daily Temp. & Precip.
- Daily Tabular data (~23 KB)
- Monthly Tabular data (~1 KB)
- NCDC 1971-2000 Normals (~3 KB)

1961 - 1990

- Daily Temp. & Precip.
- Daily Tabular data (~23 KB)
- Monthly Tabular data (~1 KB)
- NCDC 1961-1990 Normals (~3 KB)

Period of Record

- Station Metadata
- Station Metadata Graphics

General Climate Summary Tables

- Temperature
- Precipitation
- Heating Degree Days
- Cooling Degree Days
- Growing Degree Days

Temperature

- Daily Extremes and Averages
- Spring 'Freeze' Probabilities
- Fall 'Freeze' Probabilities
- 'Freeze Free' Probabilities
- Monthly Temperature Listings
  - Average
  - Average Maximum
  - Average Minimum

Precipitation

- Monthly Average
- Daily Extreme and Average
- Daily Average

BETTLES FAA AIRPORT, ALASKA

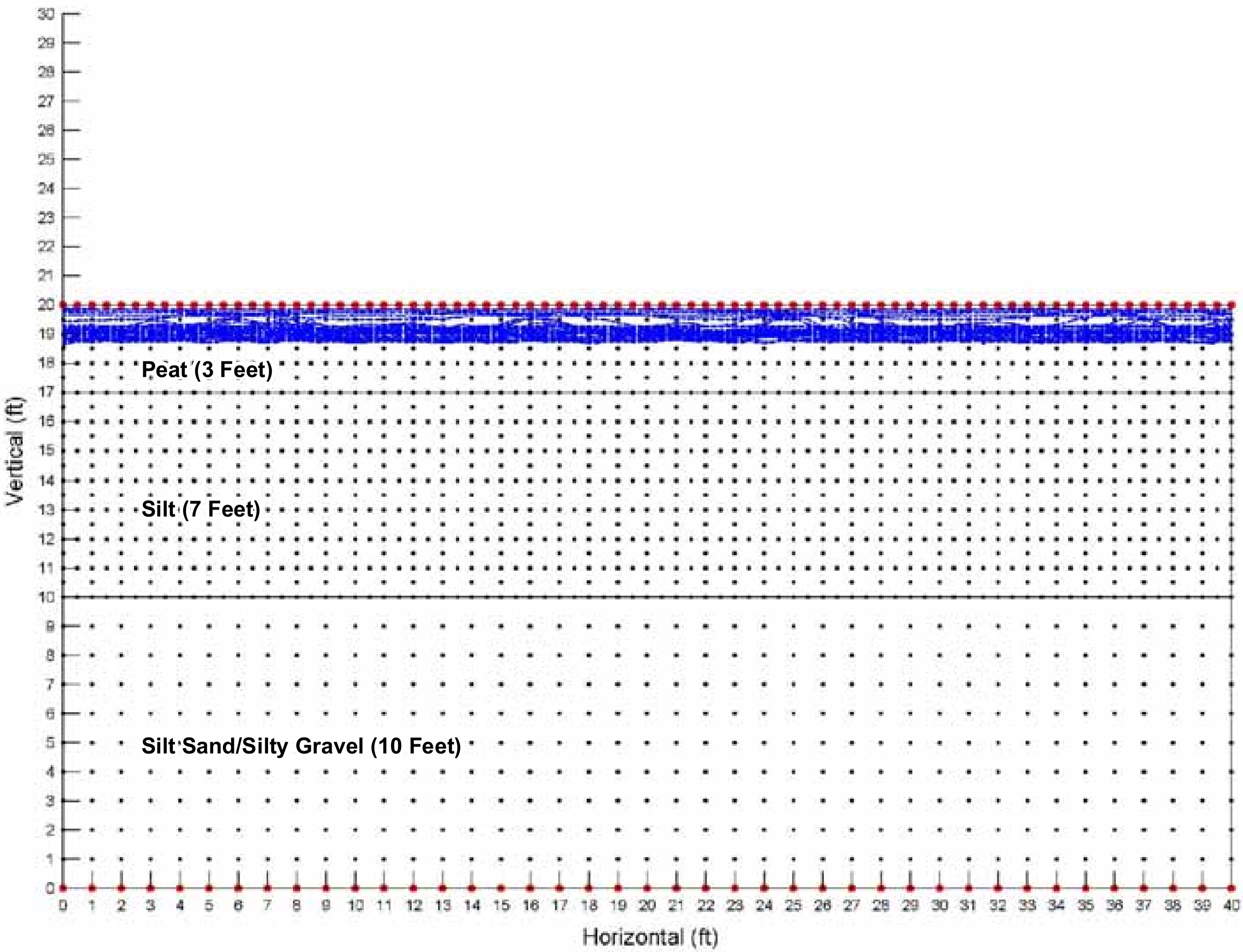
Period of Record General Climate Summary - Temperature

Station:(500761) BETTL

From Year=1951 T

	Monthly Averages			Daily Extremes			
	Max.	Min.	Mean	High	Date	Low	Date
	F	F	F	F	dd/yyyy or yyyymmdd	F	dd/yyy or yyyymm
January	-4.3	-20.2	-12.1	48	01/1980	-70	04/19
February	1.7	-16.7	-7.5	40	21/1977	-64	09/19
March	14.9	-8.8	3.0	49	22/1998	-56	14/19
April	32.5	10.1	21.3	63	30/1995	-37	07/19
May	53.1	33.5	43.3	86	31/1983	-10	03/19
June	68.3	46.9	57.6	92	16/1969	27	01/19
July	69.4	48.8	59.1	93	06/1986	29	14/19
August	62.4	43.5	52.9	88	06/1994	22	30/19
September	48.4	32.1	40.3	79	05/1957	0	23/19
October	25.4	12.4	19.0	57	02/2003	-35	31/19
November	5.9	-8.1	-1.1	45	13/1976	-57	25/19
December	-1.4	-16.5	-9.0	38	09/1960	-59	25/19
Annual	31.4	13.1	22.2	93	19860706	-70	197501
Winter	-1.3	-17.8	-9.5	48	19800101	-70	197501
Spring	33.5	11.6	22.5	86	19830531	-56	196403
Summer	66.7	46.4	56.5	93	19860706	22	196808
Fall	26.6	12.1	19.4	79	19570905	-57	197411

Cumulative Thaw Depth
(1-year duration)



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NORTHERN REGION

AMBLER MINING DISTRICT ACCESS
DESIGN CRITERIA MEMORANDUM

EXISTING CONDITIONS

DATE: April 18, 2011

Figure A-1

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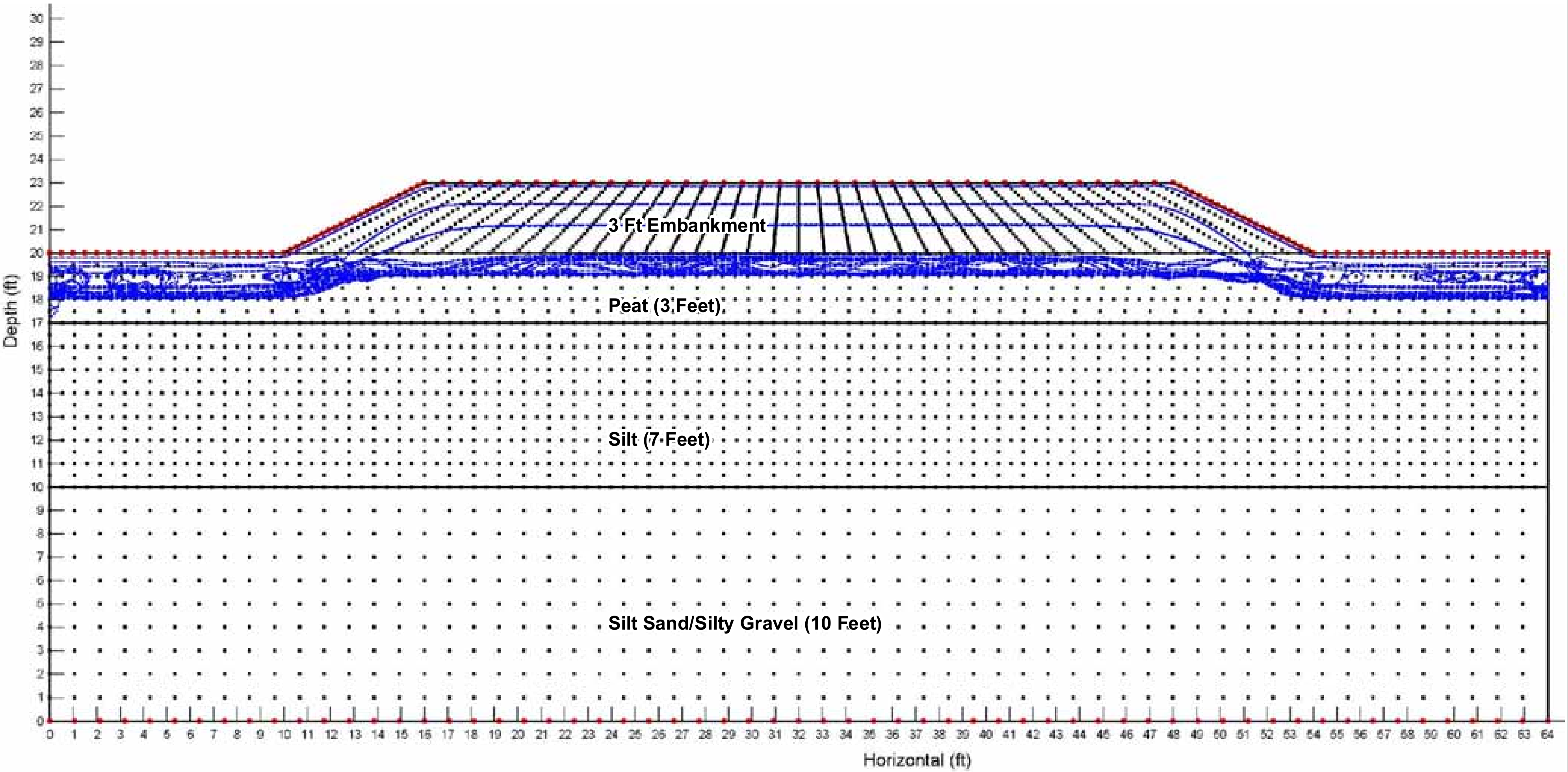
Cumulative Thaw Depth
(1-year duration)



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3' EMBANKMENT (NO INSULATION)

DATE: April 18, 2011	**Figure A-2**

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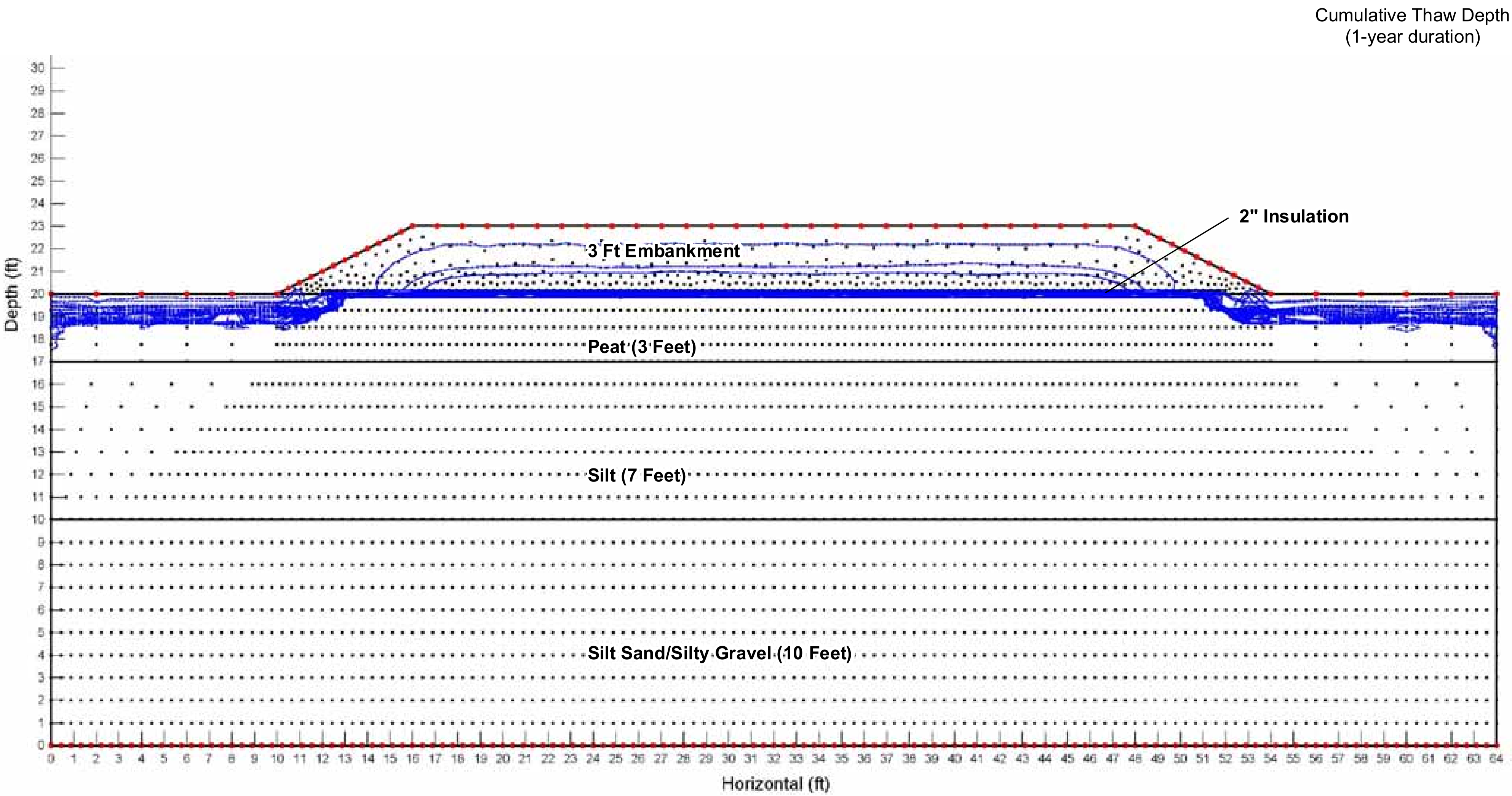

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3' EMBANKMENT (WITH 2" INSULATION)

DATE: April 18, 2011 | **Figure A-3**

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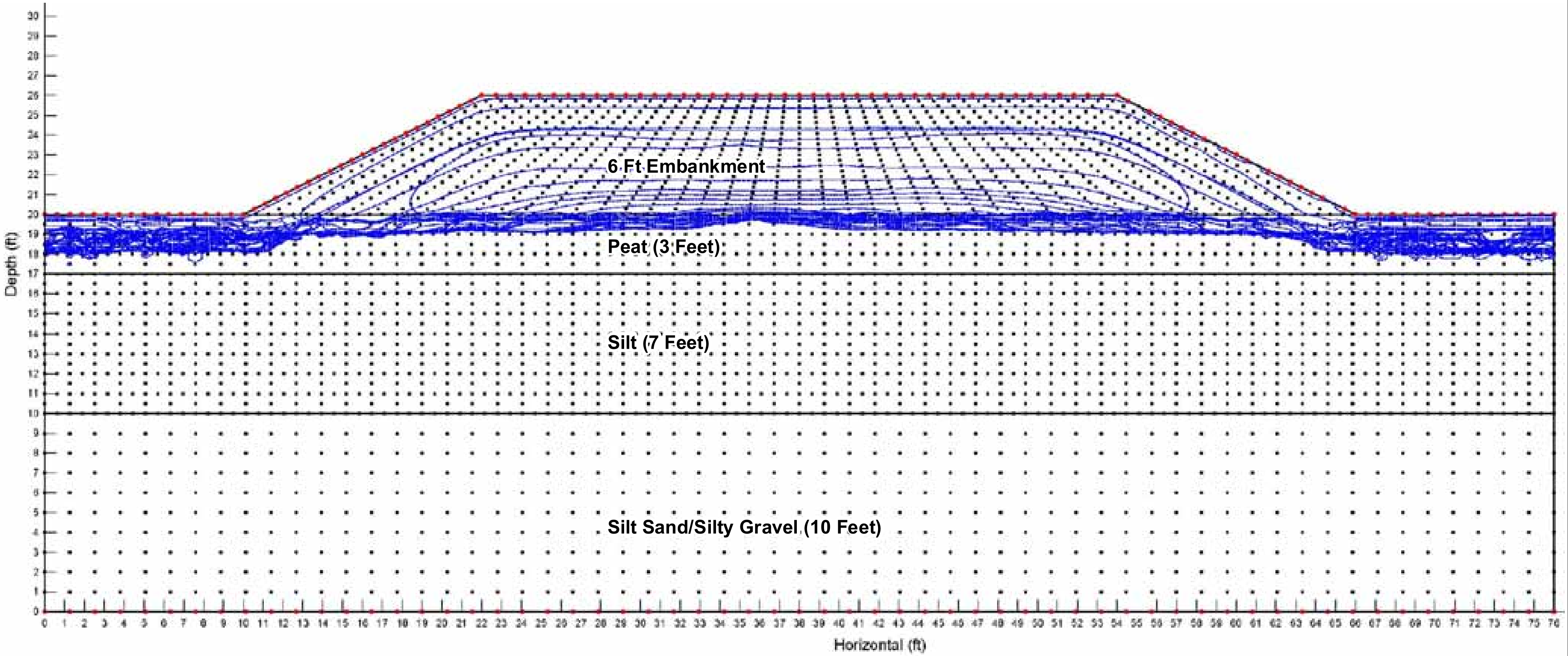
Cumulative Thaw Depth
(1-year duration)



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6' EMBANKMENT (NO INSULATION)

DATE: April 18, 2011

Figure A-4

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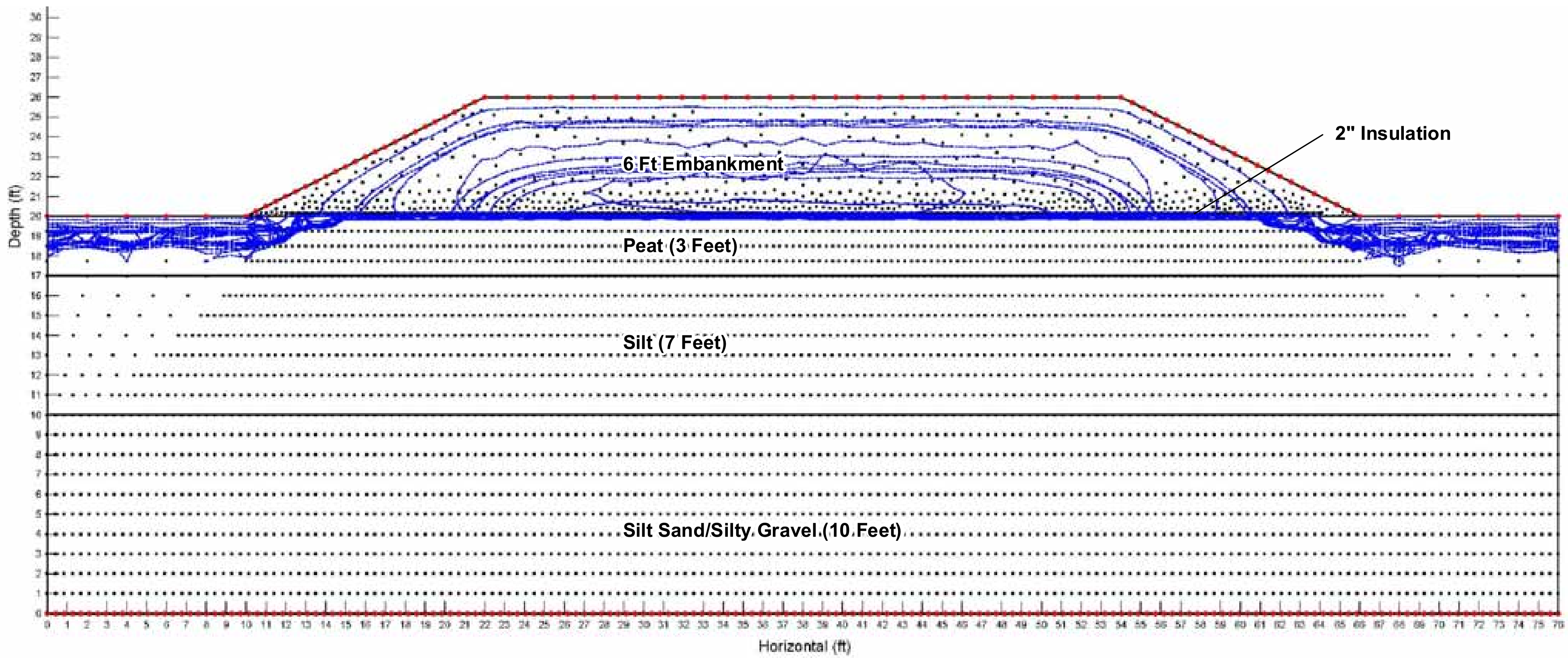
Cumulative Thaw Depth
(1-year duration)



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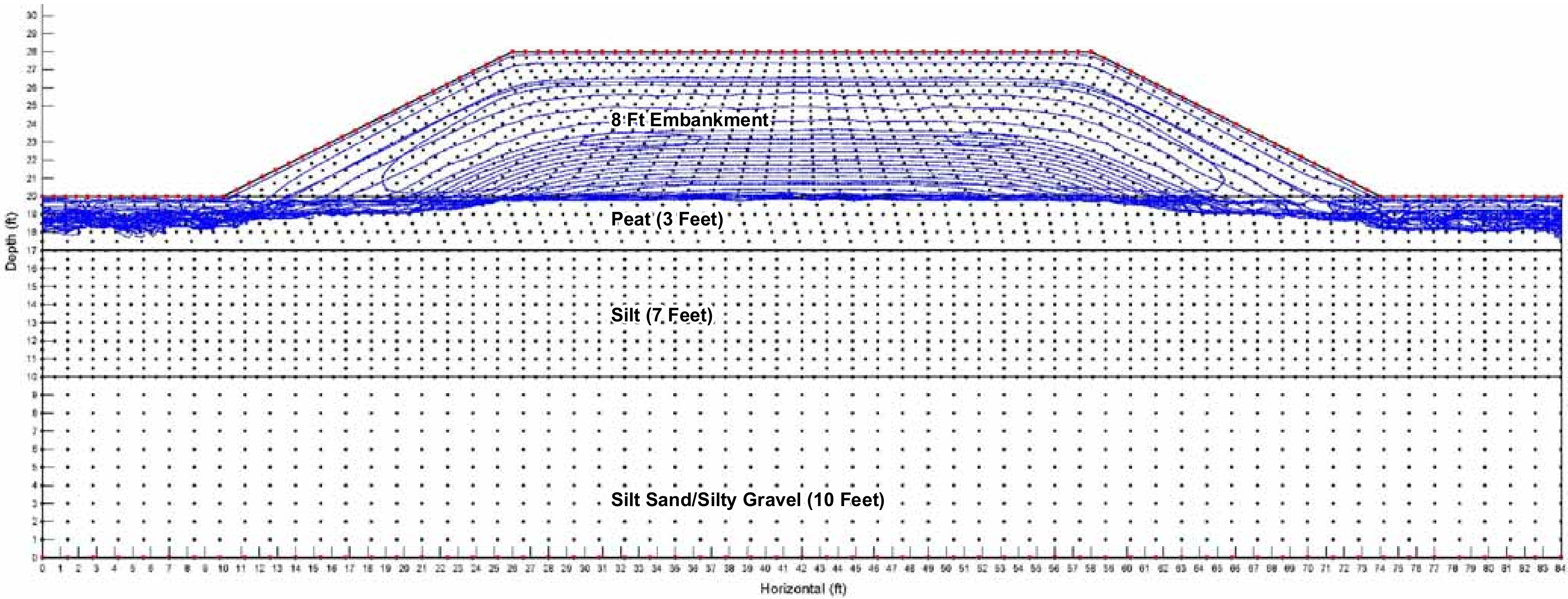
6' EMBANKMENT (WITH 2" INSULATION)

DATE: April 18, 2011 | **Figure A-5**

Cumulative Thaw Depth
(1-year duration)



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8' EMBANKMENT (NO INSULATION)

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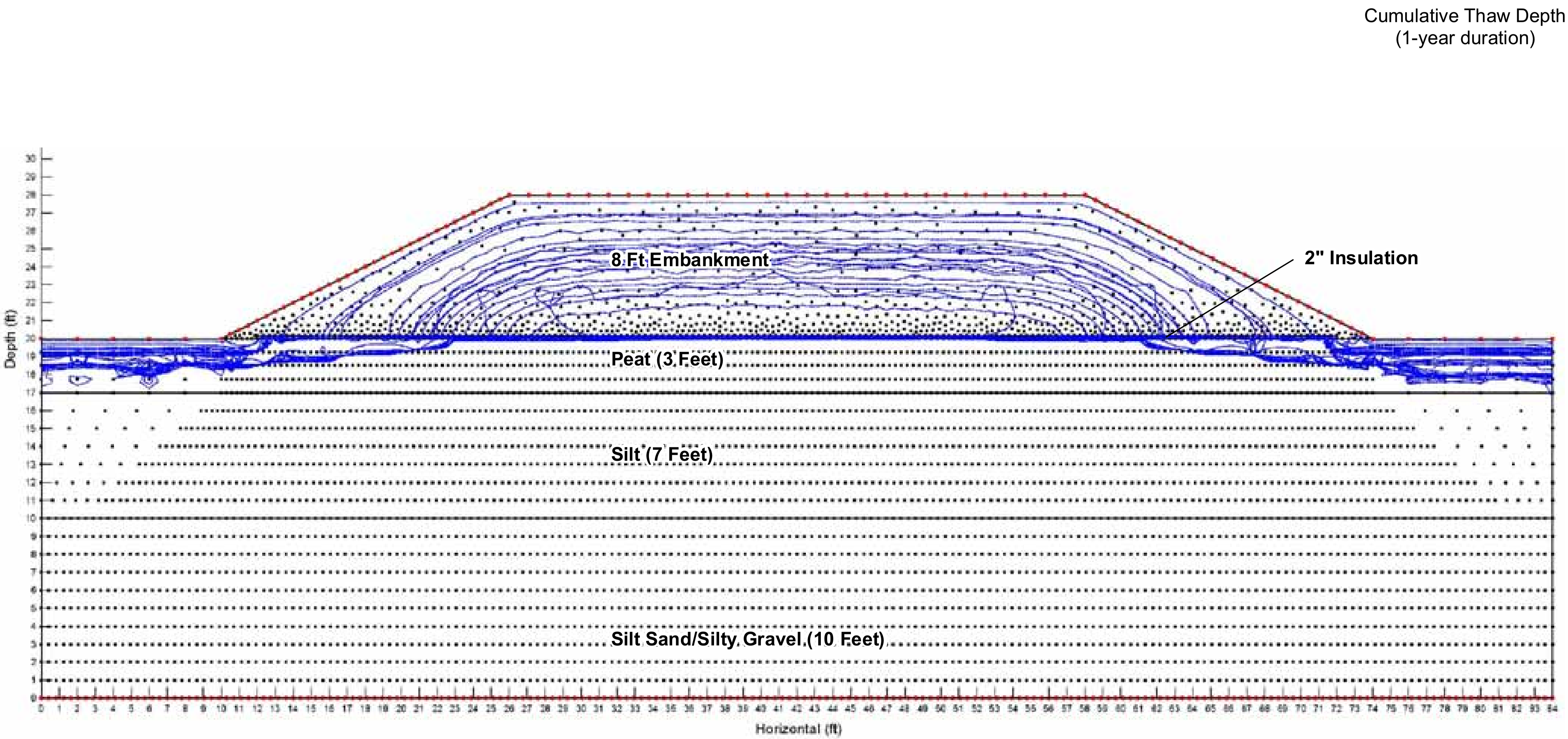

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8' EMBANKMENT (WITH 2" INSULATION)

DATE: April 18, 2011

Figure A-7

Ambler Mining District Access