ALASKA
PipelineProject

Draft Resource Report 7 – Rev 0
Soil Resources

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TransCanada ExxonMobil

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Notes:

Yellow highlighting is used throughout this draft Resource Report to highlight selected information that is pending or subject to change in the final report.

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ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
§	Section
ADNR	Alaska Department of Natural Resources
AMP	Alaska Mainline milepost
ANGTS	Alaska Natural Gas Transportation System
APP	Alaska Pipeline Project
ATWS	Additional Temporary Work Space
BLM	U.S. Bureau of Land Management
BMP	Best Management Practices
cm	centimeter
C.F.R.	Code of Federal Regulations
DEM	Digital Elevation Model
DOD	U.S. Department of Defense
FERC	Federal Energy Regulatory Commission
GIS	geographic information system
GTP	Gas Treatment Plant
HEL	highly erodible land
LiDAR	light detection and ranging
MLBV	mainline block valve
MLRA	Major Land Resource Area
MP	milepost
NRCS	Natural Resources Conservation Service
PT Pipeline	Point Thomson Gas Transmission Pipeline
PTU	Point Thomson Unit
SCL	Land Capability Subclass
SCS	Soil Conservation Service
SSURGO	Soil Survey Geographic GIS database
STATSGO	State Soil Survey Geographic GIS database
TAPS	Trans-Alaska Pipeline System
USC	Unified Soil Classification
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WEG	Wind Erodibility Group

7.0 RESOURCE REPORT 7 – SOILS

The location information, facility descriptions, resource data, construction methods, and mitigation measures presented in this report are preliminary and subject to change. APP is conducting engineering studies, environmental resource surveys, agency consultations, and stakeholder outreach efforts to further refine and define the details of the Project.

The Project described in this resource report is being designed and developed based on estimated volumes of natural gas from projected shipper commitments. If final shipper commitments are significantly different from those estimated, the Project may be adjusted accordingly.

7.1 INTRODUCTION

TransCanada Alaska Company, LLC and Foothills Pipe Lines Ltd., working with ExxonMobil Alaska Midstream Gas Investments LLC, are developing a joint project to treat, transport, and deliver natural gas from the Alaska North Slope (ANS) to pipeline facilities in Alberta, Canada for markets in the contiguous United States and North America. This joint project is referred to as the Alaska Pipeline Project (APP or Project)[1].

As required by Title 18 Code of Federal Regulations (C.F.R.) Section (§) 380.12 and consistent with the Alaska Natural Gas Pipeline Act of 2004 (ANGPA), APP has prepared this draft resource report in support of its application to the U.S. Federal Energy Regulatory Commission (FERC) for a Certificate of Public Convenience and Necessity (CPCN) under Section 7(c) of the Natural Gas Act (NGA) to construct, own, and operate the portion of the Project in Alaska. This draft resource report pertains only to that portion of the Project in Alaska, and unless the context otherwise requires, references in this draft resource report to APP refer only to the Alaska portion of the Project[2].

As shown in Figure 1.1-1 of Resource Report 1, APP will comprise the following major components[3,4]:

- The Point Thomson Gas Transmission Pipeline (PT Pipeline)[5], consisting of approximately 58.4 miles of buried 32-inch-diameter pipeline from the Point Thomson Unit (PTU) to an APP Gas Treatment Plant (GTP) and associated facilities near Prudhoe Bay;

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1 Depending on the context, the term APP refers to the joint project or, collectively, to the sponsoring entities.

2 The Canadian Section refers to the portion of the Project from the Yukon border to the pipeline facilities in Alberta, Canada.

3 In previous FERC filings, the Point Thomson Gas Transmission Pipeline was referred to as Zone 1, the Gas Treatment Plant was referred to as Zone 2, and the Alaska Mainline was referred to as Zone 3 of the Alaska-Canada Pipeline.

4 As part of the Project, APP proposes to construct compressor stations, meter stations, various mainline block valves (MLBV), pig launcher and receiver facilities, as well as associated ancillary and auxiliary infrastructure, including additional temporary workspace, access roads, helipads, construction camps, pipe storage areas, contractor yards, borrow sites, and dock modifications at Prudhoe Bay.

5 The origin of the PT Pipeline is assumed to be located at an outlet from the PTU. The final length may vary depending on the final gas development plan for the PTU.

- The GTP, which will have the capacity to process gas received from the PTU and the existing Central Gas Facility (CGF) on the Prudhoe Bay Unit (PBU) in order to deliver an annual average capacity up to 4.5 billion standard cubic feet per day (bscfd) (standard conditions: 14.73 pounds per square inch absolute and 60 degrees Fahrenheit [ºF]) of sales quality gas; and
- The Alaska Mainline, consisting of approximately 745.1 miles of 48-inch-diameter pipeline, all of which is buried except as otherwise described in this Resource Report. The Alaska Mainline extends from the GTP to the Alaska-Yukon border east of Tok, Alaska, and includes provisions for intermediate gas delivery points within Alaska.

Table 7.1-1 lists the FERC's filing requirements and additional information applicable to Resource Report 7 taken from FERC's Guidance Manual for Environmental Report Preparation.

TABLE 7.1-1

Alaska Pipeline Project
Resource Report 7 Filing Requirements Checklist

Requirement	Where Found in Document
FERC REQUIREMENTS FROM 18 C.F.R. § 380.12	
1. Identify, describe, and group by milepost (MP) the soils affected by the proposed pipeline and Aboveground Facilities. (§ 380.12 [I][1]) • List the soil associations by MP and describe their characteristics.	Sections 7.3, 7.4, 7.5, and Appendices 7A and 7B
2. For Aboveground Facilities that would occupy sites over 5 acres, determine the acreage of prime farmland soils that would be affected by construction and operation. (§ 380.12 [I][2]) • List the soil series, describe their characteristics and percentages within the site. • Indicate the on-site percentage of each soil series that would be permanently affected. • Indicate which series are considered "prime or unique farmland."	Sections 7.5.2 and 7.5.3
3. Describe by MP potential impacts on soils. (§ 380.12 [I][3,4])	Section 7.5.1 and Appendices 7A and 7B.
4. Identify proposed mitigation to minimize impact on soils and compare with the FERC staff's Upland Erosion Control, Revegetation, and Maintenance Plan (Plan). (§ 380.12 [I][5]) • Identify any measures of the Plan that are deemed unnecessary, technically infeasible, or unsuitable and describe alternative measures that will ensure an equal or greater level of protection.	Sections 7.5, 7.6, and 7.7 (refer to Resource Report 1, Appendix 1J)

Mileposts (MPs) are commonly used markers along linear projects, such as APP. Where necessary to distinguish the PT Pipeline from the Alaska Mainline, APP has prefixed its MP identifier with a PT Pipeline MP (PMP) or an Alaska Mainline MP (AMP). This convention is used in APP's application and supporting maps and alignment sheets (refer to Appendix 1O of Resource Report 1) to identify resources and features along the respective pipeline routes.

The purpose of Resource Report 7 is to describe the soil resources crossed by the Project or that are in the Project area[6], and the potential impacts and mitigation measures that will be implemented to reduce impacts on these resources.

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6 The terms "Project area" and "Project footprint" are defined to include the project facilities and land requirements for construction and operation. The term "Project vicinity" is used to mean the area or region near or surrounding the Project area, and is subject to the context in which the term is used.

7.2 BACKGROUND AND METHODOLOGY

In Alaska, due to the lack of intensive land use, the rugged nature of the landscape, and general inaccessibility, few detailed and comprehensive U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) soil surveys exist for the Project area. In addition, due to the presence of permafrost and other unique Arctic and high-latitude conditions in Alaska, NRCS soil surveys alone are insufficient to characterize route conditions and associated Project construction-related effects.

Attributes of the existing NRCS datasets for Alaska are listed below.

- Three distinctly different versions of a General Soil Survey for Alaska exist. The original Exploratory Soil Survey of Alaska (USDA Soil Conservation Service [SCS] 1979) was updated to the State Soil Survey Geographic Database (STATSGO) in 1993, and was again updated in 2002 to the current version (STATSGO2).
- The three General Soil Survey products are not interchangeable. The soil classifications originally provided in the 1979 Exploratory Soil Survey have been updated to account for the development of a new soil order (Gelisols) to characterize and map permafrost soils. The legend indicating soil map units for the hardcopy 1979 Exploratory Soil Survey has changed in each subsequent version of the issued digital maps. The map units are not directly correlatable between the 1979 Survey, the interim STATSGO product (USDA NRCS 1998), and the newer STATSGO2 General Soils Map of Alaska (USDA NRCS 2011).
- The scale of mapping at 1:1,000,000 for all three General Soil Survey products is not detailed enough to accurately describe local soil conditions and potential construction limitations for the Project. The proposed Alaska Mainline and PT Pipeline are cumulatively approximately 803 miles in length and cross 139 distinct STATSGO2 map unit polygons and 24 map unit classifications.

  The average width of the map units is 5 miles and each map unit contains an average of 10 to 15 distinct component soils. At this scale, the range in characteristics for most soil properties of interest provides a generalized perspective, however, it is too broad to provide meaningful interpretations for soil resources and potential construction limitations. For example, slope ranges do not incorporate site-specific data, but represent average values for soils within a soil component of a mapping unit.
- Soil interpretations are generally developed to assess potential impacts to agricultural/silvicultural soils. Prime farmland, highly erodible soils, compaction-prone soils, and topsoil preservation to maintain agricultural soil quality are applicable to only a small portion of the Project area in Alaska.
- Soil interpretations and descriptions relate to the top 3 to 6.5 feet of the geological sediment. These data limit assessment of pipeline construction-related effects in permafrost soils where permafrost conditions extend deeper.

In part, to overcome the limitations of existing published data, APP conducted geotechnical engineering analyses using various combined geological/geotechnical datasets to evaluate soil resources and associated known hazards in the Project area. The use of these combined datasets is more appropriate for evaluating key soil properties than utilizing the existing general soils data for Alaska (Clark 2011).

These datasets were derived from the following data sources:

- Digital terrain maps covering the Alaska Mainline and the PT Pipeline (Rawlinson 1990);
- Digital elevation models (DEMs) of the Project area obtained in 2010 using light detection and ranging (LiDAR)[7] methods, supplemented with other available digital elevation datasets to fill data gaps;
- Terrain, landform, geothermal, bedrock, borehole, and soil properties data publicly available from legacy projects including the Trans-Alaska Pipeline System (TAPS) and the Alaska Natural Gas Transportation System (ANGTS); and
- Publicly available digital maps of Physiographic Provinces and Ecoregions in Alaska (Nowacki et al. 2001), bedrock geology maps (various U.S. Geological Survey [USGS] map series), various surficial geology and engineering geology maps produced by the Alaska Department of Natural Resources (ADNR), Division of Geological and Geophysical Surveys, permafrost maps (Jorgenson et al. 2008), and related reports and publications.

Specific characteristics of data used in the assessment of soil resources follow.

7.2.1 MAJOR LAND RESOURCE AREAS

Broad-scale soil interpretations utilized in this report are based on Major Land Resource Areas (MLRAs) (USDA NRCS 2004). MLRAs consist of geographically associated land resource units, mapped at a scale of 1:2,000,000 that are extensively used by the NRCS in state-wide planning within Alaska. For a given MLRA there are relatively consistent geomorphic patterns (e.g., soils, surficial geologic and soil parent materials, geomorphic and soil forming processes), sub-regional physiographic landforms; and predominant vegetation types and structure. For each MLRA, the NRCS has described the dominant land uses, soils, and surficial geological features that are important for land use planning. The MLRAs are similar, but not identical, to physiographic provinces and the Level 3 ecoregions described in Section 6.2 of Resource Report 6. The six MLRAs crossed by APP are discussed in detail along with their dominant soils and landforms in Section 7.3:

[Note: At the time of the development of this draft resource report, the State of Alaska is revising its MLRA map units and general digital soil survey products. If this information is publically released in time, this information will be updated in the final report.]

7.2.2 SOIL MAPPING

APP reviewed project-specific soil and terrain mapping information derived from the General Soils Map (STATSGO2) Geographic Information System (GIS) database (USDA NRCS 2011) in order to identify soil properties, interpretations, and limitations for areas that lacked detail.

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7 LiDAR is a remote sensing technology that uses laser scanning to collect height or elevation data from an airplane whose position at any given time is known using extremely accurate global positioning. Point clouds are reflections from objects the laser hits after it is emitted from the scanner. After capturing the raw point cloud, each point can be classified into different layers (e.g., vegetation and ground surface). The ground surface is the "floor" of the point cloud. The final output from the point cloud is a DEM. The DEM associated with the ground surface is referred to as a "bare earth model."

The STATSGO2 dataset was developed at a scale of 1:1,000,000 from the Alaska Exploratory Soil Survey (USDA SCS 1979). Because detailed soil surveys are available only for a small portion of Alaska, Alaska STATSGO2 data do not represent the compilation and generalization of a comprehensive state-wide soil survey. Alaska STATSGO2 map units are based on aerial observations of distinctive landscape patterns augmented by field verification and documentation of soils along transects representative of a set of specific, related landforms. Similar landforms identified from the air and delineated on the map as soil associations consist of component soils classified at the subgroup level of Soil Taxonomy (Soil Survey Staff 1975). Percentages of map unit component soils were estimated based on aerial observations augmented with field transecting. Each map unit in the Alaska STATSGO2 database represents an association of soils identified to the suborder level that are arranged in a consistent pattern associated with broad landforms. However, individual soil boundaries are not shown, and soil series are not identified as map unit components.

The Alaska NRCS produces detailed, large-scale Soil Survey Geographic GIS database (SSURGO2) soil maps for areas with special needs for detailed soil surveys to facilitate land use planning. Detailed soil surveys prepared at a scale of approximately 1:20,000 are available along approximately 158 miles of the Alaska Mainline from Fairbanks to Delta Junction (refer to Table 7.2.2-1). APP evaluated soils using the STATSGO2 soil mapping and the terrain mapping because the scale of the SSURGO2 mapping is similar to that of the terrain data (discussed in Section 7.2.3).

TABLE 7.2.2-1

Alaska Pipeline Project
Detailed Soil Survey Coverage along the Alaska Mainline

Borough/Census Area	Soil Survey Area Name	Soil Survey Area Symbol	AMP Start	AMP End	Segment Length
Fairbanks North Star	North Star Area [a]	AK642	430.1	460.6	30.4
			498.0	501.7	3.8
			504.5	518.3	13.7
	Greater Fairbanks Area [b]	AK610	460.6	476.6	16.1
	Fort Wainwright Area [c]	AK650	476.6	490.5	13.9
			490.6	490.8	0.2
	Greater Delta Area [d]	AK657	490.5	490.6	0.1
			490.8	498.0	7.1
			501.7	504.5	2.8
Subtotal					88.1
Southeast Fairbanks	Greater Delta Area	AK657	522.5	575.9	53.4
	Gerstle River Area [e]	AK615	575.9	592.0	16.1
Subtotal					69.5
Total					157.6

Portions of the Project outside of the AMP ranges provided in this table are not covered by SSURGO2 data.
[a] North Star Area (USDA NRCS 2000) mapped at a scale of 1:24,000.
[b] Greater Fairbanks Area (USDA NRCS 2004) mapped at a scale of 1:31,680.
[c] Fort Wainwright Area (USDA NRCS 2006) mapped at a scale of 1:25,000.
[d] Greater Delta Area (USDA NRCS 2008) mapped at a scale of 1:31,680.
[e] Gerstle River Area (USDA NRCS 2001) mapped at a scale of 1:24,000.

7.2.3 TERRAIN MAPPING

Terrain mapping is a systematic method for identifying, classifying, and mapping soil, rock, and geomorphologic features using signatures observed on stereo aerial photography. It provides a continuous interpretation of surface and implied subsurface conditions along a mapped corridor.

The terrain unit is a three-dimensional landform feature or suite of related landform features expected to occur from the ground surface to a typical depth of 20 feet. Terrain units may comprise one or more landforms. Several types of terrain units with compound landforms are possible. Layered terrain units indicate variable sediments or rock layers with depth, with the surface material having a thickness of at least 3 feet over contrasting sediments. Mosaic terrain units are mapped when two landforms occur within an area but the limits of the landforms cannot be resolved at the mapping scale. Complex terrain units are a combination of layered and/or mosaic terrain units. Terrain units represent the smallest length division along the pipeline route for which many soil attributes are mapped, however, when combined with landform, slope, geothermal or other datasets, further segmentation of the route is possible to identify specific soil-related limitations and potential hazards.

The landform is the most significant recognizable unit that can be seen or inferred from stereoscopic analysis of aerial photograph stereo pairs. Each landform group described in a landform map legend has a common geological origin, geomorphic expression (surface topography), texture (grain size), and other engineering characteristics mapped according to Project needs. Individual landforms are mapped as polygons on the terrain maps. Because soils are distributed on the landscape in close association with specific landforms, terrain mapping is a useful surrogate for soil mapping as it was completed at a suitable mapping scale and captures relevant attribute data for each mapping unit.

Terrain mapping along the Alaska Mainline was conducted at a scale of 1:24,000 for areas within 0.9 mile of an earlier route version. In combination with legacy terrain mapping along the nearby ANGTS route, a complete terrain profile along the Alaska Mainline route was developed. Similar terrain mapping information (Rawlinson 1990) was used to develop a terrain profile for the PT Pipeline route. The terrain maps and associated landform attribute legends were incorporated into a GIS spatial and attribute database. Important soil characteristics for individual terrain polygons were generalized by landform and physiographic region by considering individual map unit components or layers.

Attributes included in terrain mapping legends are in Table 7.2.3-1.

Terrain mapping provides a qualitative characterization of conditions along the Alaska Mainline that may suffice for a high-level evaluation of soil resources. For geotechnical engineering assessments, terrain mapping is used in combination with other datasets to generate route-specific characterization of soil properties, permafrost conditions, topography and related potential hazards such as erosion, slope instability, ground freezing, and thawing of permafrost.

TABLE 7.2.3-1

Alaska Pipeline Project
Description of Terrain Attributes

APP Terrain Attribute	Description
Material Texture Description [a]	Textures of the contained soils within terrain units are described in general terms based on definitions in the Unified Soil Classification (USC) system. Cobbles are granular particles with a grain size of 3 to 12 inches, while boulders are greater than 12 inches in diameter. The weathered nature of bedrock is described for bedrock terrain units.
Primary and Secondary Material Types	The primary material type is the most dominant material in a terrain unit. A range of USC soil types is assigned to the primary and secondary material types in each terrain unit. When two or more soil types are associated with a material type, the order in which they are listed indicates relative occurrence proportion.
Thickness	Each landform is assigned a range of estimated depth in feet (e.g., 3 to 20). To be mapped as a terrain unit, the landform and contained material must be at least 3 feet thick. The terrain analysis interpretation extends to a maximum depth of 20 feet.
Slope [b]	The characteristic slope of each terrain unit is described in general terms as Flat, Moderate, or Steep. For terrain units with variable topography, generalized slope ranges are used (e.g., Flat to Moderate).
Surface Drainage	Surface drainage represents the general "wetness" of the terrain unit, taking into account a combination of permeability, slope, topographic position, and proximity to the water table. Surface drainage is described qualitatively as Poor, Moderate, or Good.
Permeability	The intrinsic permeability or hydraulic conductivity refers to the rate at which water can flow through a soil. This property is controlled primarily by the grain size distribution of the soil. Permeability is described qualitatively as Low, Moderate, or High.
Soil Erodibility [c]	Erodibility considers the propensity of soils comprising the terrain unit to be removed by eolian, colluvial and fluvial processes such as sheetwash, rill and gully erosion, and channelized flow. In general, erodibility relates to the particle size of the soil independent of slope, permafrost conditions, and other driving factors in the terrain polygon[d]. Erodibility is described qualitatively as Low, Medium, or High.
Depth to Groundwater Table	Depth to groundwater table is described qualitatively as Surface, Shallow, Intermediate, or Deep as inferred from visual observations of surface conditions.
Thermal Condition and Permafrost Characteristics	General characterization of each landform includes assigning a set of symbols describing permafrost as Continuous, Discontinuous, Sporadic, Isolated, or Absent, and ice-richness of the landform where frozen as Low, Moderate, or High. The generalized description by terrain unit does not allow characterization of smaller segments within the polygon affected by variability in slope, vegetation, or other factors.

[a] Cobbles and boulders are defined by the same size classification in the USDA classification system for stones and rocks (Section 7.5.1.5) that considers stones and rocks to be greater than 3 inches in any dimension.

[b] Slope as determined for the APP terrain mapping was too general to use for erosion characterization. APP determined slopes in more detail using high-resolution DEM-based LiDAR methods (Section 7.2.4).

[c] Soil erodibility as determined for the terrain mapping along the Alaska Mainline was considered too general to determine erosion issues. Soil erodibility along the Alaska Mainline was determined using the detailed LiDAR slope data combined with terrain unit texture and thermal condition.

[d] Soil erodibility from terrain mapping may be used as one of several inputs in assessing erosion potential and associated mitigations along the pipeline route. Other important inputs to assess erosion include quantitative profiles of right-of-way slope, frozen state, and ground ice along the route.

7.2.4 TOPOGRAPHIC DATA

Detailed topographic information is important for pipeline routing and for assessing potential effects of right-of-way preparation, construction, and long-term operation of the pipeline on soils. Topographic information allows evaluation of slopes and slope morphology at a scale that is more detailed and appropriate than slope data present in the existing STATSGO2 dataset. Topographic information along the pipeline route is resolved into longitudinal and cross slope components (i.e., components parallel and perpendicular to the pipeline centerline, respectively).

A DEM is a set of regularly spaced elevation values, based on horizontal geographic coordinates, that provides a digital representation of ground-surface topography or other features on the ground surface such as vegetation. Geographically referenced elevation values can be determined from digitized topographic maps or directly using LiDAR technology. The following three digital elevation datasets were evaluated for the Project area:

- LiDAR data collected was post-processed to provide a resolution of 3.3 feet (1 meter). Absolute and relative vertical accuracy is 6 inches (15 centimeters [cm]) and 2 inches (5 cm), respectively. Absolute and relative horizontal accuracy is 20 inches (50 cm) and 6 inches (15 cm), respectively. These data were used to derive 1-foot and 5-foot contours along the pipeline corridor;
- Topographic information for the Project obtained from digitized 1:24,000 scale aerial photography. The resulting DEM, with a resolution of 16.4 feet and an accuracy of 8.2 feet, was used to derive 16.4-foot contours; and
- In certain areas where no Project-specific topographic information exists, coarser resolution DEMs are available from the USGS National Elevation Database for Alaska at a resolution of approximately two arc-seconds (200 feet).

The final composite APP DEM, derived from the sources described above, was used to generate the cross slope and longitudinal slope profiles summarized in this report. Longitudinal and cross slope angles were calculated every 30 feet along the right-of-way; cross slope angle at each fixed point represents the average slope angle over a 360-foot transect centered on the right-of-way. Calculated slope-angle data were filtered to segment the route into a continuous set of slope-class intervals. Slope classes and associated slope-angle ranges are shown in Table 7.2.4-1.

TABLE 7.2.4-1

Alaska Pipeline Project
Slope Classes and Slope Angle Ranges Used for Topographic Datasets

Slope	Slope Angle Range (percent)	
Class [a]	Lower Limit	Upper Limit
0	0	< 2
1	≥ 2	< 5
2	≥ 5	< 10
3	≥ 10	< 14
4	≥ 14	< 20
5	≥ 20	< 25
6	≥ 25	< 36
7	≥ 36	< 50
8	≥ 50	

[a] Slope class may be positive or negative; a positive longitudinal slope rises in direction of gas flow; a positive cross slope rises to right or falls to left looking in direction of gas flow.

7.2.5 OTHER ROUTE DATA

The Project closely follows portions of other existing or proposed pipeline project routes. Extensive geotechnical data currently available from legacy projects (TAPS and ANGTS) were used to create geotechnical datasets for route characterization and engineering analyses. These derived datasets in the Project area include the following:

- A continuous landform cross-section to 50-foot depth showing the type and thickness of each landform associated with ANGTS terrain-mapping;
- A continuous geothermal cross-section to 50-foot depth showing the active layer thickness, frozen state of the ground, and associated permafrost designation;
- A continuous bedrock cross-section to 50-foot depth showing the depth to top of bedrock, bedrock type, and degree of weathering for various bedrock layers;
- A borehole database containing over 8,000 spatially located boreholes, with over 4,500 of these boreholes containing soil samples and associated laboratory testing data. Layers in each borehole are associated with landforms, allowing complex queries of soil properties to generate corresponding cross-sections of soil conditions; and
- Observations of ground ice conditions and other features.

In addition to these datasets, publicly available maps and digital files of Physiographic Provinces and Ecoregions in Alaska (Nowacki et al. 2001), regional permafrost distribution (Jorgenson et al. 2008), and bedrock geology (various USGS publications at a range of scales) were used in a GIS environment to generate other route-specific datasets. A suite of digital maps and reports on surficial geology, active faulting, bedrock geology, permafrost distribution, and engineering geology along the Alaska Highway Corridor between Delta Junction and the U.S.-Canada border, and other publications and preliminary information from various sources were used to confirm route conditions.

7.2.6 DATA ANALYSIS APPROACH

Based on the different data sources described above, GIS methods were used to obtain mileposted route-specific datasets for use in characterization and engineering analyses. Specific conditions related to soil properties (erosion, slope instability, permafrost thawing, and ground freezing) were identified by merging various datasets according to APP-developed algorithms. To estimate areal extent of specific soil conditions, the right-of-way footprint was used to estimate a width for specific length intervals.

For Aboveground Facilities[8] and workspaces outside the right-of-way not covered by detailed route-specific datasets, terrain mapping in combination with available NRCS soils data and topographic maps were used to assess soil properties, and related effects. The footprint of these off-right-of-way features was used directly to estimate affected soils.

Pertinent soil-related properties and limitations are summarized in tables later in the report, and discussed in text by borough/census area and MLRA (if applicable).

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[8] Aboveground Facilities include the GTP, eight compressor stations, three custody meter stations, various MLBV, pig launchers, pig receivers, provisions for intermediate gas delivery points, and cathodic protection facilities as discussed in Section 1.3.2 of Resource Report 1.

7.3 RESOURCE AREAS

Selected physical and interpretative characteristics of terrain and soils map units are provided in Appendix 7A, Table 7A-1 (Alaska Mainline terrain units), Table 7A-5 (Point Thomson Gas Transmission Pipeline terrain units), Table 7B-1 (Point Thomson Gas Transmission Pipeline and Alaska Mainline STATSGO2 soils). Existing soil resources are discussed by MLRA, below. For further information on soil and terrain mapping conventions refer to Sections 7.2.2 and 7.2.3. The following information on soils, geology, land use, and climate was taken from “Land Resource Regions and Major Land Resource Areas of Alaska” (NRCS Staff 2004).

From north to south, the Project area lies within six MLRAs recognized by the NRCS (refer to Figure 7.3-1):

- The Arctic Coastal Plain (MLRA 246);
- Arctic Foothills (MLRA 245);
- Northern and Interior Brooks Range Mountains (MLRAs 244 and 234, respectively);
- Upper Kobuk and Koyukuk Hills and Valleys (MLRA 233);
- Interior Alaska Highlands (MLRA 231); and
- Interior Alaska Lowlands (MLRA 232).

Discussion relating the MLRAs crossed to their Wahrhaftig (1965) physiographic provinces and Nowacki et al. (2001) ecoregions is contained in Section 6.2 of Resource Report 6, and in Table 7.3-1.

TABLE 7.3-1

Alaska Pipeline Project
Boundaries of Major Land Resource Regions and their Relationship to Other Ecological and Geological Classification Systems [a]

Borough/ Census Area	Major Land Resource Area	Begin	End	Wahrhaftig Physiographic Region[b]	Nowacki Ecoregion Equivalent[c]
North Slope	Arctic Coastal Plain	0.0	62.9	Arctic Coastal Plain	Beaufort Coastal Plain
	Arctic Foothills	62.9	145.8	Arctic Mountains	Brooks range Foothills
	Northern Brooks Range Mountains	145.8	172.6	Arctic Mountains	Brooks Range
	Interior Brooks Range Mountains	172.6	185.2	Arctic Mountains	Brooks Range
Yukon-Koyukuk	Interior Brooks Range Mountains	185.2	254.6	Arctic Mountains	Brooks Range
	Upper Kobuk and Koyukuk Hills and Valleys	254.6	259.8	Interior Lowlands and Uplands	Kobuk Ridges and Valleys
	Interior Alaska Highlands	259.8	430.2	Interior Lowlands and Uplands	Ray Mountains Yukon Tanana Uplands
Fairbanks North Star	Interior Alaska Highlands	430.2	470.1	Interior Lowlands and Uplands	Ray Mountains Yukon Tanana Uplands
	Interior Alaska Lowlands	470.1	472.8	Interior Lowlands and Uplands	Tanana-Kuskokwim Lowlands
	Interior Alaska Highlands	472.8	474.0	Interior Lowlands and Uplands	Yukon-Tanana Uplands
	Interior Alaska Lowlands	474.0	487.2	Interior Lowlands and Uplands	Tanana-Kuskokwin Lowlands
	Interior Alaska Highlands	487.2	518.2	Interior Lowlands and Uplands	Yukon-Tanana Uplands

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TABLE 7.3-1

Alaska Pipeline Project
Boundaries of Major Land Resource Regions and their Relationship to Other Ecological and Geological Classification Systems [a]

Borough/ Census Area	Major Land Resource Area	Begin	End	Wahrhaftig Physiographic Region[b]	Nowacki Ecoregion Equivalent[c]
Southeast Fairbanks	Interior Alaska Highlands	518.2	526.3	Interior Lowlands and Uplands	Yukon-Tanana Uplands
	Interior Alaska Lowlands	526.3	577.2	Interior Lowlands and Uplands	Tanana-Kuskokwin Lowlands
	Interior Alaska Highlands	577.2	579.5	Interior Lowlands and Uplands	Yukon-Tanana Uplands
	Interior Alaska Lowlands	579.5	667.7	Interior Lowlands and Uplands	Tanana-Kuskokwin Lowlands
	Interior Alaska Highlands	667.7	685.1	Interior Lowlands and Uplands	Yukon-Tanana Uplands
	Interior Alaska Lowlands	685.1	714.1	Interior Lowlands and Uplands	Tanana-Kuskokwin Lowlands
	Interior Alaska Highlands	714.1	715.5	Interior Lowlands and Uplands	Yukon-Tanana Uplands
	Interior Alaska Lowlands	715.5	717.5	Interior Lowlands and Uplands	Tanana-Kuskokwin Lowlands
	Interior Alaska Highlands	717.5	745.1	Interior Lowlands and Uplands	Yukon-Tanana Uplands
PT Pipeline	Arctic Coastal Plain	0.0	58.4	Arctic Coastal Plain	Beaufort Coastal Plain

[a] Major Land Resource Regions as provided in NRCS Staff (2004).
[b] Physiographic Divisions of Alaska (Wahrhaftig 1965). Also refer to Section 6.2 of Resource Report 6.
[c] Unified Ecoregions of Alaska (Nowacki et al. 2001). Also refer to Section 6.2 of Resource Report 6.

Each MLRA is discussed in detail below, and descriptive summaries of all soils and terrain units crossed by the Project area are provided in Appendix 7A, Table 7A-1 for terrain mapping, and in Appendix 7B, Table 7B-1 for soils.

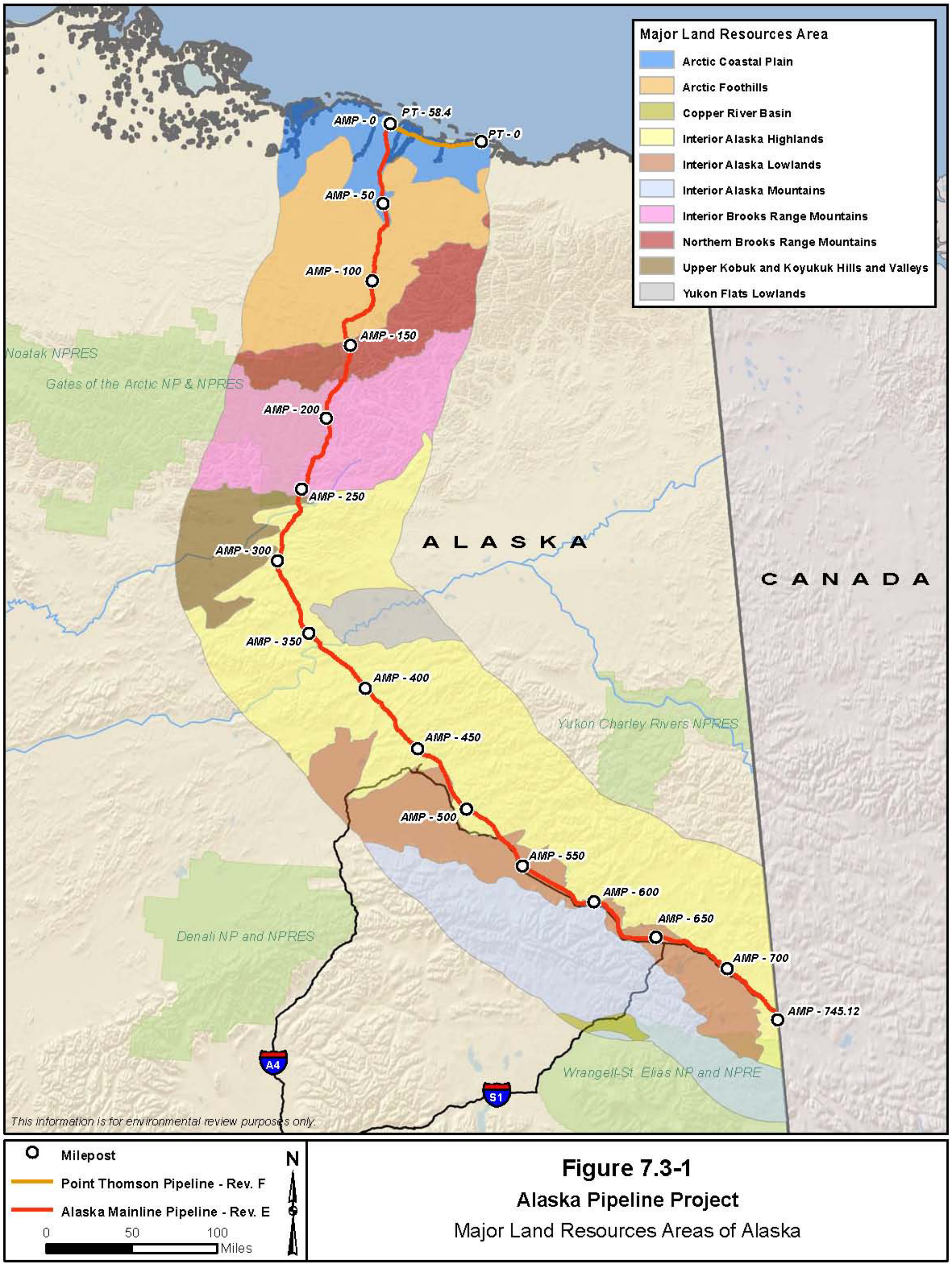

Figure 7.3-1
Alaska Pipeline Project
Major Land Resources Areas of Alaska

Source: USDA NRCS 2004

Arctic Coastal Plain (MLRA 246)

The soils in the area have a pergelic soil-temperature regime, indicating they have a mean soil temperature less than 32°F. All soils are underlain by permafrost, and most soils usually are saturated above the permafrost table throughout the summer. Nearly all areas exhibit strongly patterned ground with frost features common to the Arctic tundra. The majority of the soils consist of poorly and very poorly drained, loamy stratified sediments with thaw-sensitive ground ice below 10 inches. Upon thaw, these soils are subject to subsidence in level areas and to fluid and plastic deformation on steeper slopes near the transition to the Arctic Slope MLRA. Sandy, well-drained soils have formed on dunes, and soils with gravelly and cobbly substrates are present in broad floodplains and deltas. Very poorly drained fibrous peats occupy the borders of lakes, shallow depressions on terraces, and small drainages. Well-drained, gravelly soils on low terraces bordering major streams do not retain enough moisture for ground-ice formation and are thaw-stable.

Soils that occupy low terraces and braided floodplains bordering the Sagavanirktok River are somewhat poorly drained and gravelly. Low terraces are commonly flooded by runoff from spring snowmelt and heavy summer rainstorms in the mountainous watershed areas. Gravelly permafrost soils with exceptionally good surface drainage are present near escarpment edges on low terraces, slightly above the floodplains. Permafrost soils with gravelly and very gravelly substrates are not likely to be substantially affected by subsidence or mass movement and are typically thaw-stable. These soils are among the most suitable soils for building sites, roads, and other intensive uses.

Arctic Foothills (MLRA 245)

The pipeline route through the Arctic Foothills is underlain by permafrost, and near-surface soils with thin peat layers are typically wet during summers. Discontinuous gravelly soils with thicker active layer are present on floodplains. Permafrost may be absent under larger perennial rivers. Loamy soils underlain by permafrost are common on hills bordering the Brooks Range, and gravelly, well-drained soils mantle ridges and hills. Hydric (wet) soils with thin surface peats, are present along small streams and in shallow depressions. Gravel terraces border the floodplains of major streams. Shallow bedrock, rubbly slopes, and rough mountainous terrain become more common along the route southward toward the Brooks Range.

All poorly and very poorly drained soils are thaw-sensitive and may be subject to subsidence and thermal erosion[9] on shallow slopes. On steeper slopes, thermal erosion, subsidence, and mass wasting are active. Well-drained, gravelly soils adjacent to larger streams and on alluvial fans are generally thaw-stable.

Northern Brooks Range (MLRA 244) and Interior Brooks Range (MLRA 234)

Terrain in the area is expected to be underlain by permafrost, with the exception of soils on some steep, forested south-facing slopes, and under perennial streams. Most of the Brooks Range is barren of vegetation. Forests of white spruce, paper birch, and quaking aspen or black spruce cover some southern slopes and southern valleys. Alpine tundra covers intermediate slopes. Soils are extremely thin or absent in more than 70 percent of the area, however, because the route preferentially follows river valleys, thin shallow-to-bedrock soils and soils with thin surface peat cover colluvium and alluvium are dominant on steep lower slopes.

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9 Prime farmland is absent in the Project area and is not discussed in this report.

Thin peats and wet mineral soils with shallow permafrost are present where the route traverses valley bottoms along the Dietrich and Koyukuk rivers.

Frozen slopes that are well to excessively drained are expected to be thaw-stable. The remaining soils are loamy, with drainage classes varying from somewhat poor to very poor, and/or have permafrost at shallow depths. Upon thawing, some soils could be subject to mass wasting on steeper slopes or subsidence on level and nearly level surfaces.

Kobuk and Koyukuk Hills and Valleys (MLRA 233)

A small, 5.2-mile-long segment of the Alaska Mainline traverses the Kobuk and Koyukuk Hills and Valleys (Table 7.3-1) across the transition between the Interior Brooks Range Mountains and the Interior Alaska Highlands. The geology, climate, physiography, and soils are similar to the Interior Alaska Highlands, discussed below.

Interior Alaska Highlands (MLRA 231)

Well-drained soils usually are deficient of moisture in mid-summer. Most valley bottoms, north- and east-facing slopes, and hills with summits elevation above 2,600 feet are underlain by permafrost. Soils above the perennially frozen ground are typically poorly and very poorly drained. The principal soils under white-spruce-birch-aspen forests on uplands lack surface peats. Soils under black spruce forest and sedge-dominated tundra vegetation typically have thin surface peats underlain by shallow to deep, continuous to sporadic permafrost. Shallow, stony soils are in alpine areas with tundra vegetation characterized by sparse, shrubby plants.

Somewhat poorly drained to very poorly drained soils on north- and east-facing slopes or valley bottoms have permafrost at varying depths, however, several permafrost soils are well to excessively drained and should be thaw-stable. Several soils associated with stream terraces and south- and west-facing slopes are permafrost-free.

Several soils with shallow permafrost are characterized by loamy textures, and drainage classes vary from somewhat poor to very poor. Permafrost ranges from continuous to absent within this MLRA. Depths to permafrost typically increase in recently burned areas on north- and east-facing slopes. Fine-grained thawing permafrost terrain may be subject to mass wasting on steeper north- and east-facing slopes, and may be subject to subsidence on level and nearly level surfaces.

Well-drained, coarse-grained permafrost terrain is typically thaw-stable.

Interior Alaska Lowlands (MLRA 229)

Silty loess of varying thickness overlie loamy, sandy, and gravelly alluvium and colluvium. Peats have typically developed in poorly drained depressions on stream terraces, outwash plains, and moraines. Poorly or very poorly drained Gelisols are shallow to moderately deep over permafrost. Periodic wildfires remove protective vegetation and disturb the insulating organic surface mat, lowering the permafrost table and eliminating perched water tables. Depending on fire frequency, landform position, and particle size, these thawed soils may or may not revert back to Gelisols. Poorly developed non-permafrost-affected soils occur in stratified silty, sandy, and gravelly alluvium on the same landforms and are formed in the same materials as the Gelisols, with drainage characteristics ranging from very poorly drained to extremely well-drained. They are found in depressions on floodplains and low, stream terraces. Those soils in higher positions adjacent to streams range from moderately well-drained to excessively drained. Peats form in floating fibrous organic mats around the margins of lakes and in shallow basins.

7.4 SOIL PROPERTIES

The following soil properties, are discussed in detail in the sections that follow:

- The presence of continuous, discontinuous, and sporadic permafrost and permafrost temperature[10]. Specific permafrost impacts relate to thaw-settlement, slope instability, and soil compaction and rutting during construction and post-construction reclamation;
- Highly erodible soils are not a listed feature of map unit component soils in the NRCS STATSGO2 database for Alaska. As part of engineering evaluations of the Project, a methodology (Terrain Erodibility Index) has been adopted specifically for pipeline construction in Arctic and sub-Arctic areas to identify erosion potential and associated mitigation measures;
- Estimates of hydric soils, compaction-prone soils, and topsoil depth are developed from the NRCS soil maps;
- Topsoil thickness is evaluated using NRCS STATSGO2 soil data. The active layer thickness is an important component of permafrost soils and is discussed with topsoil; and
- Slope classes were developed using digital elevation data for the Alaska Mainline and the PT Pipeline for this draft resource report. Slopes associated with other related Aboveground Facilities are assessed using the NRCS STATSGO2 data and available topographic DEMs.

7.4.1 PERMAFROST

Permafrost soils are found at high latitudes and at high altitudes in many of the world's mountain ranges. Permafrost soils as mapped by the NRCS in Alaska are characterized by the presence of permanently frozen soil within 3 to just over 6 feet (1 to 2 meters) of the surface depending on the nature of the frozen substrate. Soil taxonomy does not recognize soils where the top of the permafrost layer is deeper than 6.6 feet as permafrost soils[11]. The current USDA system of soil taxonomy recognizes permafrost soils at the highest order level as "Gelisols," and provides a classification scheme that is based on the nature of the active layer, soil drainage, the presence of massive ground ice within the permafrost layer, landscape position, soil mineralogy and chemistry, and grain size.

Permafrost conditions in the Project area have been characterized as part of terrain mapping. These datasets provide a detailed delineation of permafrost to a depth of 50 feet.

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10 Cold permafrost remains below 30°F and can absorb considerable heat without thawing. Warm permafrost on the other hand remains at or just below freezing and may thaw with the addition of very little heat (Alyeska Pipeline 2011).

11 Permafrost is defined by the thermal regime (sediment continuously frozen for more than two years), not depth, however, permafrost soils are defined by NRCS as those soils that have permafrost above 1 to 2 meters depending on the presence of soil material that has been mixed by frost churning. Thus, soil with permafrost below the required soil depths would not be recognized as permafrost soils by the NRCS.

The literature on permafrost soils uses many specialized terms that are specific to its genesis, setting, landforms, and physical and thermodynamic characteristics (van Everdingen 2005). Permafrost soils feature a dynamic “active layer” that varies from a few inches to a few feet thick and is characterized by seasonal freeze-thaw cycles (Figures 7.4.1-1 and 7.4.1-2). The active layer is a dynamic zone whose thickness is influenced by micro- and macroclimatic factors, as well as hydrologic and physical factors that affect the balance between heat entering and leaving the soil system (Goodrich and Gould 1981; Johnston et al. 1981; Roth and Boike 2001; Williams and Smith 1989). Important soil features that influence the dynamic equilibrium within the active layer include the presence and thermal properties of the overlying insulating layer and snow depth. The surface layer typically consists of growing vegetation, undecomposed plant remains (i.e., loose surface material), and peat in varying stages of decomposition and thickness that act to dampen the variability in heat exchanges between the active layer and the atmosphere (Harris 1986). Roth and Boike (2001) present a quantitative assessment of the dynamic thermal equilibrium stressing conductive heat fluxes, generation of sensible and latent heat from phase transformation of water, and migration of water vapor. Harris (1986) emphasized the importance of the surface layer on maintaining the thermal equilibrium in permafrost soils impacted by winter ice road and snow pad construction. Douglas et al. (2008) reviewed research plots established by Linell (1973) to show the slow deepening (near surface to over 22 feet) of the permafrost table in test plots that had been removed of vegetation for several decades.

Freeze-thaw cycles in poorly drained permafrost soils can result in the temporary development of ice lenses in the active layer that produce frost-churning (cryoturbation), which in turn mixes soil horizons (Soil Survey Staff 2010). This mixing is recognized in soil classification schemes at the suborder level as “Turbels.” These mixed materials are called “gelic” material by soils scientists. Typical cross-sections of Turbel soils are provided in Figure 7.4.1-3.

Except in areas of taliks (permanently unfrozen zones within permafrost terrain) or non-permafrost terrain, permafrost lies immediately under the active layer, and may consist of ice, organic matter, fine- to coarse-textured soil material and rock, or mixtures of these materials, which remain below 32°F for multiple years. Moisture content in the permafrost may vary from dry to very wet conditions. Significant quantities of segregated ice in the soil can result in soil water content well above the total pore volume of the soil. Characteristics of permafrost soils that are considered in construction assessments include the frozen state, the water content of the soil, the presence and morphology of included ice, and permafrost temperature. Segregated ice found in the soil profile is often called “ground ice” and is typically associated with fine-textured, water-saturated sediments in poorly drained landscape features. Occasionally, ground ice consisting of relict buried glacial ice may be present in both fine-grained and coarse-grained sediments.

Thaw-Stable and Thaw-Sensitive Soils

Thaw-stable permafrost soils are soils that, upon thawing, would not experience either substantial thaw-settlement or loss of strength (van Everdingen 2005). Soil characteristics that typically favor thaw-stable permafrost soils include the presence of coarse-textured soils (e.g., gravel) in better-drained landscape positions on low-gradient slopes, and soils with a south and west aspects (Brown et al. 1981; Hunter et al. 1981; USDA NRCS 2001; Williams and Smith 1989).

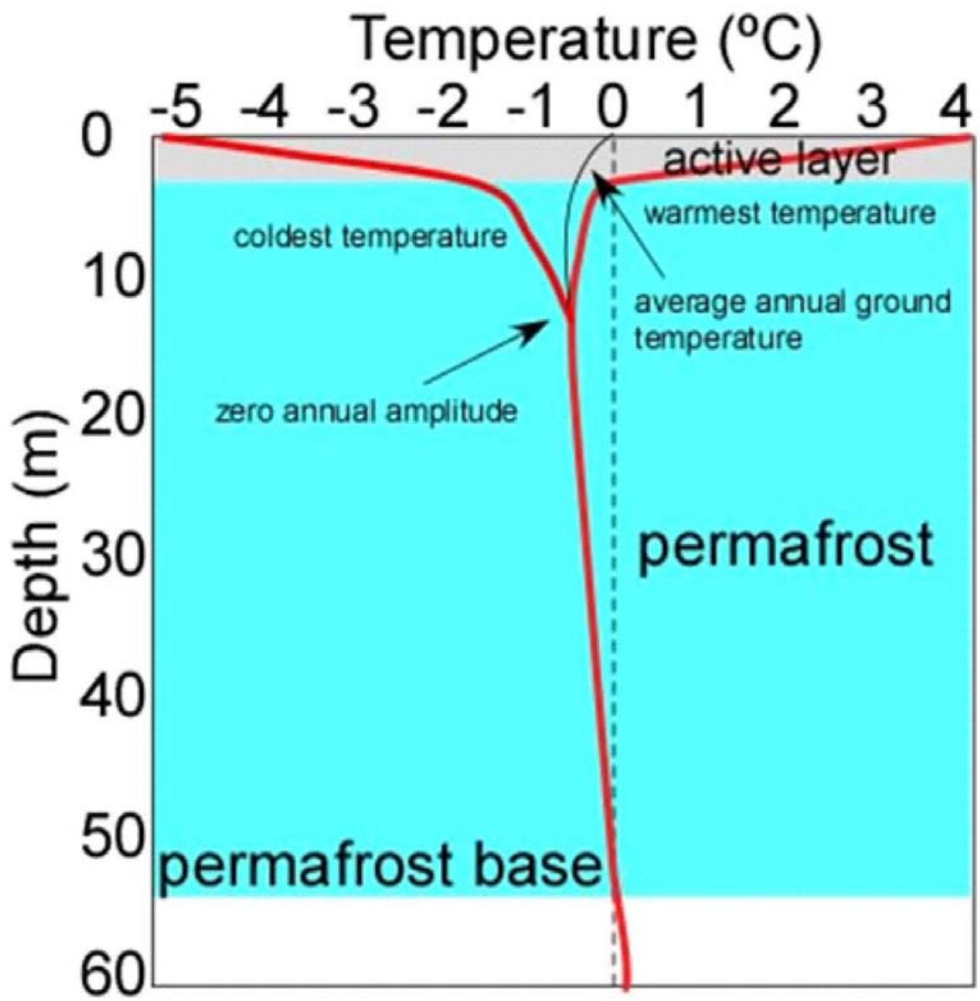
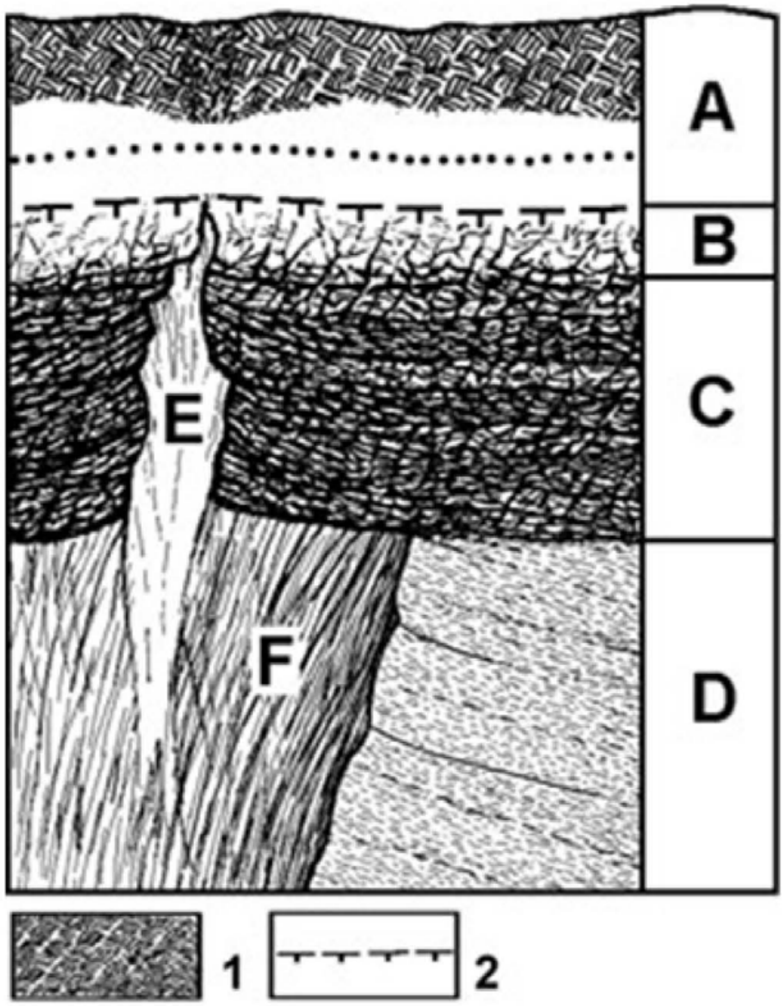


Figure 7.4.1-1
Alaska Pipeline Project
An Illustration of the Range inTemperatures Experienced at Different Depths in Permafrost Ground During the Year

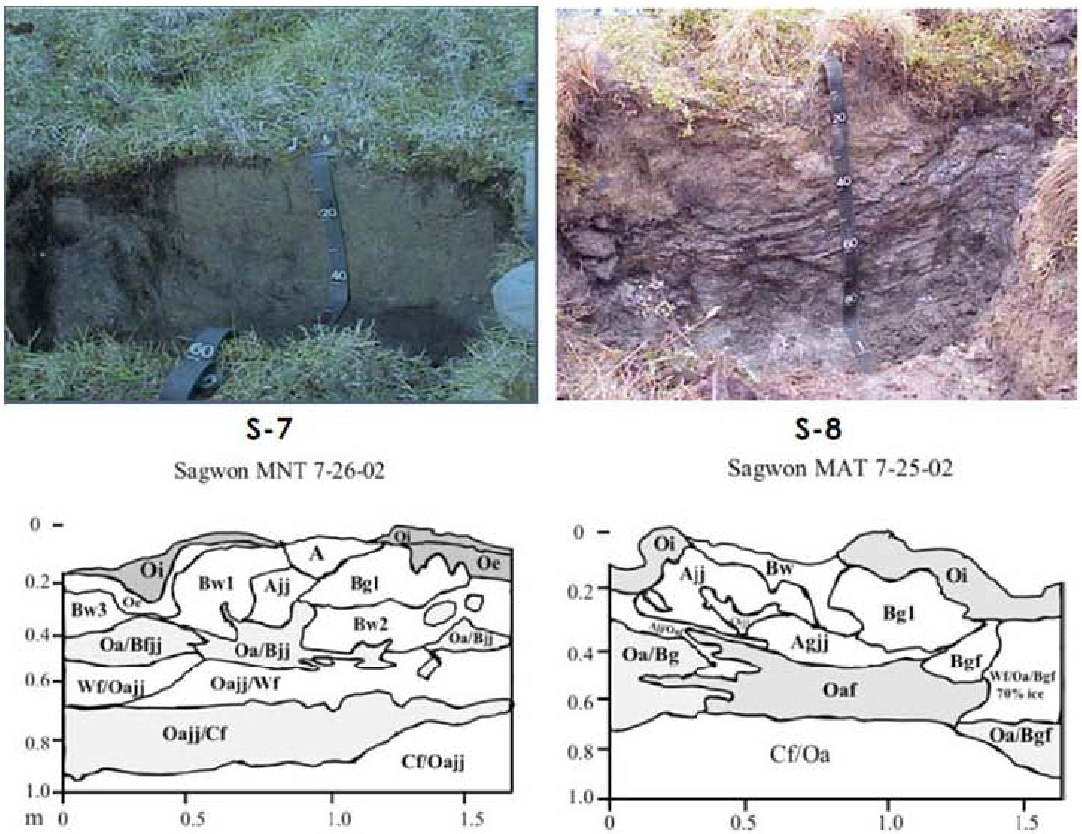
Source: http://research.iarc.uaf.edu/permafrost/dic_permafrost.htm



A – Active Layer
B – Transition Layer
C – Intermediate layer with soil embedded in a ice matrix.
D – Deeper permafrost with lenticular ice layers
E – Young ice wedge
F – Older ice wedge
1 – The organic layer
2 – Permafrost table.

Figure 7.4.1-2
Alaska Pipeline Project
Idealized Stratigraphy of Soil and Ice Morphology
in Fine-Grained, Ice-Rich Permafrost

Source: Jorgenson and Shur 2011.



O - Organic surface soil

A - Mineral surface soil

B - Mineral subsurface soil

C - Mineral parent material (sediment)

a - Well decomposed

e - Intermediate decomposition

g - Gleyed (reduced, indicative of hydric soil)

i - Poorly decomposed

f - Permanently frozen soil (ice rich)

ff - Permanently frozen soil (ice poor)

jj - Cryoturbated (frost churned, mixed)

Figure 7.4.1-3

Alaska Pipeline Project

Turbels Represent Soils That Have Naturally Mixed Surface Horizons and Active Layers

Source: Ping 2006

Thaw-sensitive soils are soils that, upon thawing, may experience substantial thaw-settlement and reduced strength to a value much lower than that for similar material in an unfrozen condition (van Everdingen 2005). Soil characteristics that result in thaw-sensitive soils include the presence of stratified, fine-textured sediments in poorly drained positions, thin soils on steeply sloping ground, and soils with a north and east aspect (Brown et al. 1981; Hunter et al. 1981; Jorgenson et al. 2008; USDA NRCS 2001; Williams and Smith 1989).

Additional Permafrost Characteristics

Characteristics of permafrost soil may be extremely variable in soils with a dynamic active layer. Virtually all of the soil considerations related to permafrost that are associated with construction in the Arctic are common. Surface expressions of permafrost dynamics on the landscape, such as solifluction lobes, frost blisters, patterned ground, and thermokarst features, are indicative of permafrost soil terrain. Natural occurrences such as fire, flood, unusually wet periods, and drought directly and indirectly affect both the longevity of permafrost and the characteristics present.

Thermal disturbance of the upper portions of permafrost soil results in deepening of the active layer. When the affected portions of the permafrost contain substantial amounts of ground ice, thaw-induced subsidence, solifluction, soil creep, and mudflows may occur depending on site-specific conditions. The presence of ground ice frequently indicates the presence of moisture contents in the frozen soil that exceed the total pore volume of the unfrozen soil (referred to as excess ice). Thaw-induced subsidence of these soils reflects the volume decrease due to the phase change from ice to water as well as the drainage of water that was ground ice in the soil matrix. Slope instability related to thawing of permafrost may reflect the characteristics of viscous flow in the downslope direction, or may result from sudden thawed layer detachments. These slope-related effects may occur in areas characterized by thick unconsolidated sediments as well as areas with thin permafrost soils over bedrock.

Fire is a naturally occurring alteration that affects extensive areas in the Interior. Fire removes or reduces the effectiveness of the surface insulating layer, which in the long-term allows more heat to enter the soils. The loss of, or disturbance to, the surface vegetation deepens the active layer at the expense of the underlying permafrost and may lead to thaw-induced subsidence, erosion, or slope instability depending on site-specific conditions. Typically, Gelisols can be converted to Entisols and develop better drainage after fire removes the insulating and shading layers (Figure 7.4.1-4). Though variable, Alaska wildfires have consumed roughly 1 million acres annually since 1939, with a maximum of 6.6 million acres consumed in 2004 (Anchorage Daily News 2011).

Anthropogenic alterations common to a construction project, including land clearing, compaction, excavation, and filling can simulate the natural effects of fire on the dynamics of active layer presence and thickness (Linell 1973; Douglas et al. 2008).

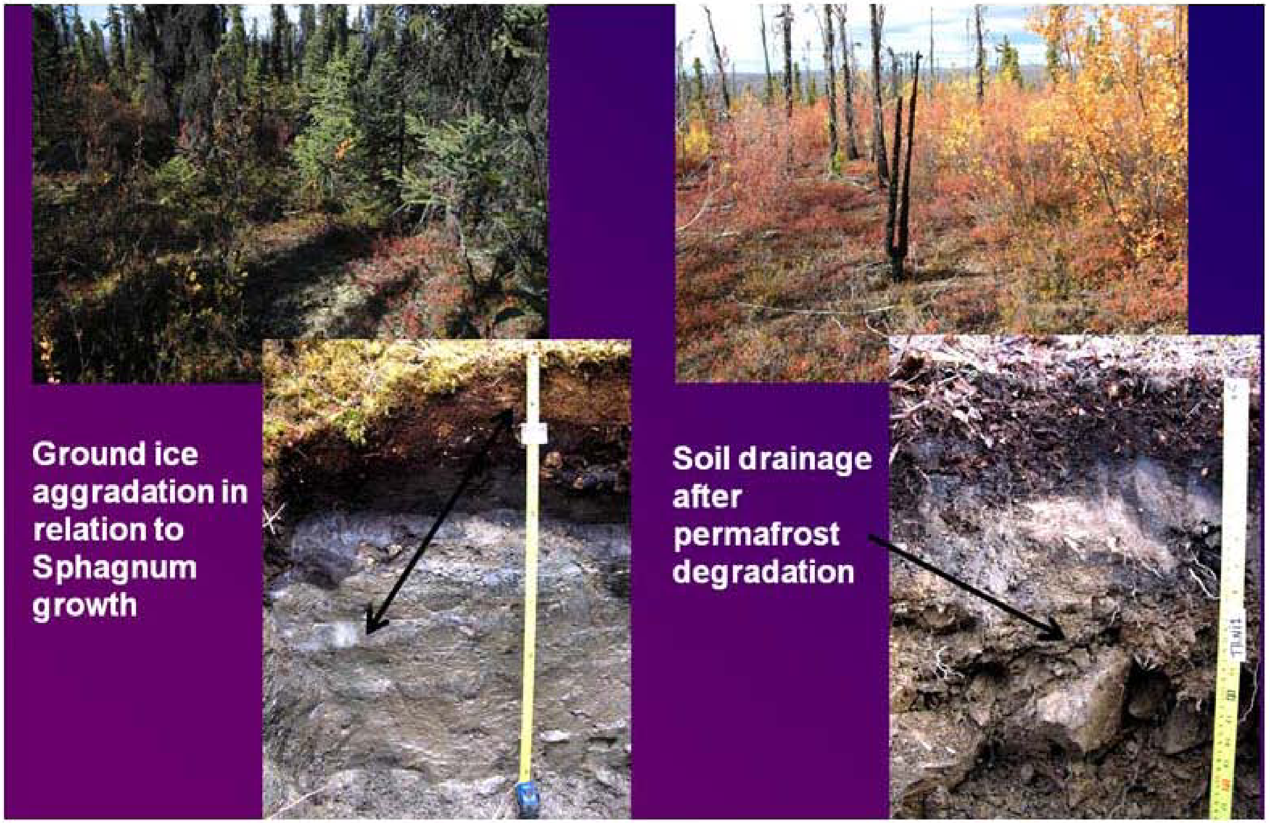


Figure 7.4.1-4
Alaska Pipeline Project
Effects of Fire on Permafrost Dynamics in Interior Alaska

Source: Jorgenson et al. 2011.

Assessment of Permafrost in the Project Area

On a macroclimatic scale, the Project area traverses areas of continuous and discontinuous permafrost. Continuous and discontinuous permafrost have been qualitatively defined since the early 1900s (Nikiforoff 1928). However, more recent studies have attempted to quantify and categorize permafrost-affected lands by their areal extent. Jorgenson et al. (2008) and van Everdingen (2005), characterized zones of continuous, extensive discontinuous, intermittent discontinuous, sporadic, and isolated categories as having areal extents of greater than 90, 65-90, 35-65, 10-35, and less than 10 percent permafrost, respectively. However, because few studies exist regarding the actual extent of permafrost in Alaska, most maps depicting the distribution of continuous and discontinuous permafrost are based on mean annual air temperatures correlated to limited ground sampling (Brown et al. 1981; Harris 1983).

Jorgenson et al. (2008), provides the most current regional presentation of permafrost distribution in Alaska. The authors describe permafrost distribution semi-quantitatively by relating permafrost distributions to mean annual air temperature, climate, and surficial geology (terrain units) verified with known information on ground ice and the presence of permafrost-related landforms. Their methodology provides a framework to use readily available parameters to predict the presence and nature of permafrost.

The geothermal cross-section interpreted from available ANGTS data provides the most detailed estimate of permafrost conditions in the Project area. The permafrost attributes associated with APP terrain mapping provide additional information on permafrost, but are not as detailed as the geothermal cross-section and do not incorporate information from boreholes and geophysical surveys. Permafrost conditions in the Project area have been characterized through terrain mapping and interpretation and extrapolation of legacy ANGTS route analysis. The ANGTS data was based on terrain mapping, borehole drilling, and geophysical surveys. To differentiate thaw-stable and thaw-sensitive permafrost in the Project area data sets were merged. The datasets included the following attributes: terrain mapping and associated soil groups based on textural and ice-richness, continuous geothermal cross-section indicating locations of permafrost, and right-of-way footprint. These datasets provide a detailed delineation of permafrost to a depth of 50 feet along the route.

For Project facilities and infrastructure not covered by other datasets, the STATSGO2 dataset was used to assess potential hazards. The STATSGO2 GIS dataset includes attribute data for each component soil within each soil map unit, including:

- Component percentage of the map unit. Component percentages were developed by transecting representative map units and determining the representative percentage of each component soil in the map unit. The database is designed so that for any given map unit, the percentages for all component soils sum to 100 percent;
- Low, representative, and high-slope percentage ranges for each component soil;
- Drainage class ranging from excessively drained to very poorly drained; and
- USDA taxonomic classification of all of the soils.

In general, permafrost soils that are somewhat poorly to very poorly drained have high ice-contents and could potentially be subject to subsidence due to thawing and slope instability when on slopes. All STATSGO2 map unit soil components that were classified into the Gelisols soil order and have somewhat poor, poor, and very poor drainage classes were considered thaw-sensitive permafrost soils. All soils not meeting these criteria were considered thaw-stable permafrost soils or non-permafrost soils.

Thaw-sensitive permafrost soils are identified and discussed for the PT Pipeline and Alaska Mainline in Section 7.5.1.1, for Aboveground Facilities (i.e., GTP, compressor stations) in Section 7.5.2, and for Associated Infrastructure[12] (e.g., access roads, construction camps) in Section 7.5.3.

7.4.2 EROSION

For the Project area, soil erodibility was determined based on textural characteristics of soils associated with APP terrain mapping in conjunction with the terrain profile along the pipeline route. Landforms were assigned unified soil classification codes based on qualitative descriptions of soil characteristics, from which grain size distribution was estimated. The grain size and soil type were then used to classify soil erodibility within the respective terrain polygon. When considered in combination with route-specific slope datasets and geothermal conditions, erosion potential along the route, as well as appropriate mitigation measures, can be assessed[13]. Although coarse sediments of floodplains have been rated as having high erodibility because of their proximity (by virtue of their origin) to streams, known watercourse-related geohazards such as vertical scour and channel migration are considered separately from erosion (i.e., erosion potential is considered only for overland segments of the route). Erosion potential in the Project area was assessed using the route-specific datasets described in Section 7.2.

The Pipeline Facility locations were assessed for erodible soils by utilizing the STATSGO2 database. Highly erodible land (HEL), as designated by NRCS, includes both water and wind as agents of erosion. NRCS has defined HEL at a scale that precludes its inclusion in the STATSGO2 attribute database. Consequently, highly erodible soils at specific facility locations were identified based on three soil parameters present in the STATSGO2 database that are directly related to the susceptibility of a soil to erosion by water or wind: Slope class; Wind Erodibility Group (WEG)[14]; and Land Capability Subclass (SCL) (Tables 7.4.2-1 and 7.4.2-2). The assessment of Alaska soils susceptible to water erosion is complicated by the broad slope class categories used for many Alaska soils combined with the absence of SCL designations for many non-agricultural soils.

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[12] Associated Infrastructure and land required to construct and operate APP include additional temporary workspace (ATWS), access roads, helipads, airstrips, construction camps, pipe storage areas, contractor yards, borrow sites, and dock modifications, as discussed in Section 1.3.3 of Resource Report 1.

[13] Data for soil erodibility, right-of-way slope, and frozen moisture content can be used in a semi-quantitative index-based assessment of erosion potential to calculate a Terrain Erodibility Index, which can be incorporated as part of a route-specific engineering assessment.

[14] A WEG is a grouping of soils that have similar surface-soil properties affecting their resistance to soil blowing, including texture, organic matter content, and aggregate stability.

TABLE 7.4.2-1

Alaska Pipeline Project
Description of the Natural Resources Conservation Service's Land Capability Classification System [a]

Class or Group	Description
Land Capability Class [b]	
1	Soils with slight limitations that restrict their use.
2	Soils with Moderate Limitations that restrict the choice of plants (used for revegetation) or that require moderate conservation practices.
3	Soils have severe limitations that restrict the choice of plants or that require special conservation practices, or both.
4	Soils have very severe limitations that restrict the choice of plants or that require very careful management, or both.
5	Soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.
6	Soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.
7	Soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat.
8	Soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.
Land Capability Subclass Modifiers [c]	
e	Soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass.
w	Soils for which excess water is the dominant hazard or limitation affecting their use. Poor soil drainage, wetness, a high watertable, and overflow are the factors that affect soils in this subclass**.**
s	Soils that have soil limitations within the rooting zone, such as shallowness of the rooting zone, stones, low moisture-holding capacity, low fertility that is difficult to correct, and salinity or sodium content.
c	Soils for which the climate (the temperature or lack of moisture) is the major hazard or limitation affecting their use.

[a] Land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time. The Land Capability Classification system is described in detail in the National Soils Handbook (USDA NRCS 2011).

[b] Capability class is the broadest category in the land capability classification system. Class codes I (1), II (2), III (3), IV (4), V (5), VI (6), VII (7), and VIII (8) are used to represent both irrigated and non-irrigated land capability classes.

[c] Capability subclass is the second category in the land capability classification system. Class codes e, w, s, and c are used for SCLs and are appended to the Land Capability Class. SCL 4e indicates a soil with very severe restrictions due to erosion hazards. Soil in this class would be considered HEL.

Soils in SCL 4e or higher have severe to extreme erosion limitations for agricultural use and are usually classified as HEL. A component soil was considered to be generally highly erodible by water if the soil is in SCL 4e through 8e. The STATSGO2 data indicate the most common slope categories for soils in the Project area other than nearly level positions are defined across a wide range of potential slope percents[15]. Because soils with average slopes less than and greater than nine percent are placed in SCL 3e (not highly erodible) and SCL 4E (highly erodible), respectively, soils with average slopes greater than nine percent are considered highly erodible consistent with their SCL classification (when one is provided for the map unit component in the STATSGO2 database).

[15] STATSGO2 data include broad intermediate slope classes (e.g., 1-12, 1-15, 1-16, 3-16, and 3-20 percent). Soils in the 1-16 percent slope categories have an average slope of 8.5 percent, are not considered highly erodible, and when placed in a SCL are placed into the 3E category. Soils in the 3-20 percent slope category have an average slope of 11.5 percent and would be considered highly erodible and are typically placed into SCL 4E or higher.

Soils in WEG 1 and 2 include coarse-textured soils with poor aggregation that are particularly susceptible to wind erosion (Table 7.4.2-2). Because management and construction mitigation techniques used to control wind erosion hazards are different from those used to control water erosion, APP developed a separate grouping for wind erosion based on the WEG. A component soil was considered to be highly erodible by wind if it is in WEG 1 or 2. Most soils in in the Project area fall into WEG 2 and 8. Soils in WEG 8 are not wind-erodible due to the presence of coarse fragments or persistent wetness of the soil surface.

TABLE 7.4.2-2

Alaska Pipeline Project
Description of Natural Resources Conservation Service Wind Erodibility Group and Index System [a]

Wind Erodibility Group [a]	Properties of the Surface Layer [b]	Wind Erodibility Index [c] (tons/acres/year)
1	Coarse sands, sands, fine sands, and very fine sands.	160 - 310
2	Loamy coarse sands, loamy sands, loamy fine sands, loamy very fine sands, ash material, and sapric soil material.	134
3	Coarse sandy loams, sandy loams, fine sandy loams, and very fine sandy loams.	86
4L	Calcareous loams, silt loams, clay loams, and silty clay loams.	86
4	Clays, silty clays, non-calcareous clay loams, and silty clay loams that are more than 35 percent clay.	86
5	Non-calcareous loams and silt loams that are less than 20 percent clay and sandy clay loams, sandy clays, and hemic soil material.	56
6	Non-calcareous loams and silt loams that are more than 20 percent clay and non-calcareous clay loams that are less than 35 percent clay.	48
7	Silts, non-calcareous silty clay loams that are less than 35 percent clay, and fibric soil material.	38
8	Soils that are not subject to wind erosion because of coarse fragments or bedrock exposures on the surface or because of surface wetness.	0

[a] WEGs are made up of soils that have similar surface properties affecting their susceptibility to wind erosion in cultivated and/or disturbed areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. Most Alaska soils in the Project area fall into groups 2 and 8.

[b] Texture and structure of the surface layer are the important considerations. This list is simplified from that available in the National Soils Handbook (USDA NRCS 2011).

[c] Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Occasionally soils in WEG 3 and SCL 3E are considered HEL by the NRCS. These soils, however, would not be considered highly erodible using the STATSGO2 data as inclusion of WEG 3 and SCL 3E in the groupings would include a much larger number of non-highly erodible soils than highly erodible soils.

The two classification schemes for highly erodible soils, presented above, provide a preliminary estimate of the magnitude of erosion-sensitive soils in areas potentially affected by Project construction and not covered by the route-specific assessment.

Highly erodible soils are identified and discussed for the PT Pipeline and Alaska Mainline in Sections 7.5.1.2 and 7.5.1.7, for Aboveground Facilities (e.g., GTP, compressor stations) in Section 7.5.2, and for Associated Infrastructure (e.g., access roads, construction camps) in Section 7.5.3.

7.4.3 HYDRIC SOILS

Hydric soils are defined as "soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part" (USDA SCS 1994). Soils that are artificially drained or protected from flooding are still considered hydric if the soil in its undisturbed state meets the definition of a hydric soil. Generally, hydric soils are those soils that are poorly and very poorly drained, and are one of three defining characteristics of wetland habitat conditions (refer to Section 2.4 of Resource Report 2 for a discussion of wetlands).

Hydric soils are extensive in Alaska. The presence of permafrost in many Alaska soils acts as an impermeable layer that deters deep infiltration, resulting in the formation of a "perched" water table. Permafrost combined with low evapotranspiration results in extensive hydric soils in level areas as well as on sloping ground. Hydric soil designations are component soil attributes in the STATSGO2 database. Percentage and acreage of hydric soils in the Project area were determined by a query of the database for all map unit components, and were then summarized by map unit crossing length and area within pipeline and facilities footprints.

Hydric soils are identified and discussed for the PT Pipeline and Alaska Mainline in Section 7.5.1.3, for Aboveground Facilities (e.g., GTP, compressor stations) in Section 7.5.2; and for Associated Infrastructure (e.g., access roads, construction camps) in Section 7.5.3.

7.4.4 COMPACTION-PRONE SOILS

Compaction-prone soils in the Project area in Alaska were identified by querying the STATSGO2 database for component soils that have a histic epipedon[16], a surface texture of sandy clay loam or finer, and/or a drainage class of somewhat poorly drained through very poorly drained.

Compaction is not likely to be an issue where winter construction is planned; however, compaction may be an issue in areas proposed for summer construction.

Compaction-prone soils are identified and discussed for the PT Pipeline and Alaska Mainline in Section 7.5.1.4, for Aboveground Facilities (e.g., GTP, compressor stations) in Section 7.5.2, and for Associated Infrastructure (e.g., access roads, construction camps) in Section 7.5.3.

7.4.5 STONY/ROCKY SOILS

Alaska has extensive areas of gravelly and stony/cobbly soils based on the genesis of the surficial parent material. Stones and cobbles include rock components of the soil matrix that are greater than 3 inches in any dimension and are components of many geomorphic map units such as colluvium located at the base of steep slopes, those associated with the active and lower terraces of high-gradient streams, and till developed from bedrock.

Blasting may be required in areas where shallow bedrock or boulders and permafrost are encountered that cannot be removed by conventional mechanical excavation equipment. Areas requiring blasting have been evaluated by APP and are discussed in Section 6.5 of Resource Report 6.

[16] A histic epipedon is a surface soil horizon between 8 and 16 inches thick that is high in organic carbon, and saturated with water for some part of the year.

For the pipeline, terrain-mapped soil groups were developed based on the texture, layering, and stratigraphic unit description associated with the surface strata characteristics. The soil units were given a modifier of "no," "few," or "frequent" to qualitatively represent cobble and boulder content. Queries of bedrock and cobble/boulder soil groups extending to the depth of the pipe trench bottom, in combination with permafrost conditions, were used to identify potential blasting areas.

Stony and rocky soils are identified and discussed for the PT Pipeline and Alaska Mainline in Section 7.5.1.5; for Aboveground Facilities (e.g., GTP, compressor stations) in Section 7.5.2; and for Associated Infrastructure (e.g., access roads, construction camps) in Section 7.5.3.

7.4.6 TOPSOIL

There is limited agricultural land in the Project area, however, topsoil depth and characteristics may be relevant in planning right-of-way preparation, construction, and reclamation activities along the right-of-way and in off-right-of-way work areas. Topsoil depth was determined using the NRCS STATSGO2 dataset described in Section 7.2.2.

Topsoil depth and character (e.g., mineral soil versus peat) in the Project area were quantified by grouping the lower limit of the component soil A horizons into one of five thickness ranges: 0-6 inches, greater than 6-12 inches, greater than 12-18 inches, greater than 18-24 inches, and greater than 24 inches, respectively. Histic epipedons are separated from soils with mineral topsoils. Acreage and percentages of soils within each topsoil group were then summarized by map unit. When the component soil could be inferred by aerial photographic interpretations in the context of the terrain unit, the topsoil depths characteristic of the component soil series was used.

Topsoil depth is identified and discussed for the PT Pipeline and Alaska Mainline in Section 7.5.1.6; for Aboveground Facilities (e.g., GTP, compressor stations) in Section 7.5.2; and for Associated Infrastructure (e.g., access roads, construction camps) in Section 7.5.3.

7.4.7 SLOPE

As described in Section 7.2.4, publicly available and Project-specific DEM data were used to identify slope-related characteristics along the Alaska Mainline and PT Pipeline. Modeling based on GIS data was used to derive slope datasets. Topographic information along the pipeline route is resolved into longitudinal and cross slope components (e.g., components parallel and perpendicular to the pipeline centerline, respectively). Slope classes for both longitudinal and cross slopes are defined in Table 7.2.4-1.

In addition to the detailed slope components calculated along the route, generalized slope classes were included as an attribute in APP terrain mapping, however, these are difficult to use in combination with other data as they represent qualitative descriptions that are too general to assess route-specific conditions.

Slope issues are identified and discussed for the PT Pipeline and Alaska Mainline in Section 7.5.1.7; for Aboveground Facilities (e.g., GTP, compressor stations) in Section 7.5.2; and for Associated Infrastructure (e.g., access roads, construction camps) in Section 7.5.3.

7.4.8 DROUGHTY SOILS AND POOR REVEGETATION POTENTIAL

The most common soil property influencing germination and initial growth of vegetation is droughty soils. Droughty soils in the Project area were identified by querying the STATSGO2 database for component soil series that have: 1) a surface texture of sandy loam or coarser, and 2) are moderately well to excessively drained.

Droughty soils are discussed for the Pipeline Facilities[17] in Section 7.5.1.8 and in Section 7.5.2 for Aboveground Facilities.

7.4.9 DETAILED TERRAIN UNIT AND STATSGO2 SOILS DATA: POINT THOMSON GAS TRANSMISSION PIPELINE AND ALASKA MAINLINE

[Note: Soils information for the Aboveground Facilities and Associated Infrastructure will be developed for the final report. The information in this section is preliminary and will be updated in the final report.]

Data for the PT Pipeline and the Alaska Mainline are provided by MP in Appendices 7A and 7B.

Appendix 7A includes summary and raw data for the analysis of soil resources using APP Terrain Data. Several tables are provided that document the attributes and distribution of the data used by APP in the terrain analysis of soil resources along the PT Pipeline and the Alaska Mainline.

- Table 7A-1 provides the cumulative area (acres) and selected interpretative and physical data associated with terrain units along the Alaska Mainline. Data are provided alphabetically by symbol for ease in identifying information for a specific terrain unit.
- Table 7A-2 provides the cumulative area (acres) and the areal distribution of longitudinal and cross slope classes associated with terrain units along Alaska Mainline. Data are provided alphabetically by symbol for ease in identifying slope information for a specific terrain unit.
- Table 7A-3 provides selected interpretative and physical data associated with each mileposted terrain unit along the Alaska Mainline.
- Table 7A-4 provides the acreage of longitudinal and cross slopes associated with each mileposted terrain unit along the Alaska Mainline.
- Table 7A-5 provides the cumulative length (miles) and selected interpretative and physical data associated with terrain units along the PT Pipeline. Data are provided alphabetically by symbol for ease in identifying information for a specific terrain unit.
- Table 7A-6 provides selected interpretative and physical data associated with each mileposted terrain unit along the PT Pipeline.

Appendix 7B includes summary and raw data for the analysis of soil resources using NRCS STATSGO2 data. Several tables are provided that document the attributes and distribution of the data used in the STATSGO2 analysis of soil resources along the PT Pipeline and the Alaska Mainline.

- Table 7B-1 provides selected physical and interpretative characteristics of STATSGO2 soil map unit component soils along the PT Pipeline and the Alaska Mainline.

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[17] The Pipeline Facilities will consist of the PT Pipeline and the Alaska Mainline, as discussed in Section 1.3.1 of Resource Report 1.

- Table 7B-2 provides the miles of selected soil limitations for each STATSGO2 soil map unit polygon crossed by the PT Pipeline and the Alaska Mainline by MP.
- Table 7B-3 provides the mileposted breakdown of topsoil depth and slope class for the PT Pipeline and the Alaska Mainline.
- Table 7B-4 provides the length (in feet) of soil limitations for access roads planned for the PT Pipeline and the Alaska Mainline. [Note: Information on access roads is still being developed; therefore, the structure of Table 7B-4 is provided in Appendix 7B and the completed table will be provided in the final report.]
- Table 7B-5 provides the length (in feet) of topsoil depth and slope class for the access roads planned for the PT Pipeline and the Alaska Mainline. [Note: Information on access roads is still being developed; therefore, the structure of Table 7B-5 is provided in Appendix 7B and the completed table will be provided in the final report.]

7.5 CONSTRUCTION AND OPERATION IMPACTS AND MITIGATION

Soil impacts resulting from pipeline construction, and operations and maintenance activities are based on the assessment of soil properties. Soil impacts include reduction in the ability of the soil to support specific functions that benefit both human and natural environments, or have the potential to affect pipeline maintenance and operation.

Pipeline construction activities that have the potential to affect soils and reclamation efforts include:

- Clearing and grading along the right-of-way and within additional temporary workspace;
- Trenching, backfilling, and reclamation;
- Development of construction camps and access roads;
- Establishment of borrow areas; and
- Construction of various Aboveground Facilities including the GTP.

APP evaluated the following major soil characteristics to identify those that could affect construction or increase the potential for construction-related soil impacts: the distribution of thaw-stable and thaw-sensitive permafrost soils, erosion potential, hydric soils, compaction-prone soils, the presence of stony or rock soils (bedrock is discussed in Section 6.5 of Resource Report 6), and droughty soils with poor revegetation potential (refer to Section 7.4).

Generally, to reduce or avoid impacts on soils, APP will implement its Project-specific APP Upland Erosion Control, Revegetation, and Maintenance Plan (APP's Plan) and APP Wetland and Waterbody Construction and Mitigation Procedures (APP's Procedures). APP's Plan and Procedures are consistent with the 2003 versions of the FERC Upland Erosion Control, Revegetation, and Maintenance Plan (FERC Plan) and Wetland and Waterbody Construction and Mitigation Procedures (FERC Procedures), except where alternative measures to the FERC's Plan or Procedures are requested by APP and approved by the FERC (refer to Section 7.7). As a result, and as discussed with FERC, APP's Plan and Procedures will build upon the FERC Plan and applicable permit conditions using a "toolbox" approach. The toolbox will contain Best Management Practices (BMPs) available for selection and implementation based on site conditions during construction. APP's Plan and Procedures are presented in Resource Report 1, Appendices 1J and 1K, respectively.

APP will work with the appropriate land management agency (e.g., the U.S. Bureau of Land Management [BLM], the U.S. Department of Defense [DOD], and ADNR) to further define/develop appropriate mitigation measures to be employed on public lands.

The following discussion provides summaries of potential limitations based on soil properties and/or the setting in the landscape, and is referenced to borough/census area and MLRA (where applicable). Mitigation measures are also proposed relative to potential impacts for APP facilities, Aboveground Facilities and Associated Infrastructure greater than 5 acres in size (refer to Section 1.3 in Resource Report 1 for descriptions of these facilities).

7.5.1 PIPELINE

7.5.1.1 Permafrost

Natural or human alterations in the physical and thermal properties of the surface insulating layer can impact the thickness of the active layer and affect soil properties that are in equilibrium with long-term climatic conditions.

The following freezing and thaw-related effects that could result from construction and/or operation were considered by APP during development of the Project facilities.

- Freezing of unfrozen ground leading to frost-bulb formation and potential frost heave. Frost heave is a common feature of some freezing soils. It is defined as the upward or outward movement of the ground surface (or objects on, or in the ground) caused by the formation of ice in the soils (van Everdingen 2005). A frost bulb is a zone of frozen ground formed around a buried pipeline or beneath or around a structure maintained at a mean annual temperature below 32°F (van Everdingen 2005).
- Thawing of frozen ground induce potential in-situ effects including subsidence and thaw consolidation, thermokarsting, and thaw bulb formation. With respect to permafrost, thaw-induced subsidence is the lowering of the ground surface associated with a reduction in volume due to the melting of ice in ice-rich permafrost and the resulting drainage of the liquid water. Thaw consolidation is the time-dependent compression of soil resulting from thawing of frozen ground and subsequent drainage of excess water in soils.

  If during thaw, the flow of water from the thawing ground is unimpeded, then the variation of thaw-settlement with time is controlled by the position of the thawing front. If the thawed ground is not sufficiently permeable and flow is impeded, the rate of settlement with time is also controlled by the compressibility and permeability of the thawed ground. For thawing fine-grained soils with low hydraulic conductivity, pore-water pressures in excess of hydrostatic conditions may be generated at the thaw front by rapid thawing. These excess pore pressures may contribute to instability of slopes and foundation soils, and are therefore considered in pipeline construction and mitigation.

  Thermokarsting is the process by which characteristic landform elements (patterned lakes and mounds) result from the thawing of ice-rich permafrost or the melting of massive ice (van Everdingen 2005). Thermokarst is common in areas of the Interior where natural fires result in the partial or complete removal of trees, organic loose surface material, and moss that insulates the active layer in areas of massive ground ice.

A thaw bulb is a zone of thawed ground below or surrounding a man-made structure placed on or in permafrost and maintained at mean annual temperatures above 32°F (van Everdingen 2005). Thaw bulbs can occur where the pipeline traverses permafrost terrain and operates at temperatures above freezing. Thaw bulbs may also form beneath cleared rights-of-way.

Taliks are portions of ground within permafrost that remain unfrozen. These typically occur beneath major watercourses and lakes where the heat associated with the flowing water or water depth prevents freezing to the waterbody bottom and maintains an unfrozen zone. In the context of the Project area, a talik may form as an unfrozen zone of ground between the seasonal freeze-thaw layer at the ground surface and the top of the permafrost layer as the thaw front advances downward with time in response to clearing, and disturbance or removal of the surface insulating layer.

- Thawing of frozen ground inducing potential ex-situ thaw instability effects including solifluction, slope creep, and thawed layer detachment. In permafrost terrain, the removal of the vegetation cover or disturbance of the surface organic layer along the right-of-way will increase the depth of annual thaw, which may cause temporary to longer-term thaw instability on some slopes if not mitigated during construction or operations.

  Solifluction and soil creep are both slow downslope movements of saturated and unsaturated earth materials and can occur in frozen and unfrozen ground (van Everdingen 2005). Rates of soil movement can vary widely and are subject to many influences such as the presence/absence of vegetation, moisture content, and the nature of the substrate.

  Thawed layer detachment is usually applied to more-rapid downslope flows resulting from detachment of the thawed layer from the underlying permafrost stratum.

Potential impacts to the Project facilities were assessed using criteria developed by both APP and NRCS. For the preliminary Project definition phase, APP used the various datasets described in Section 7.2 to identify geographic locations associated with permafrost-related effects. Potentially thaw-sensitive permafrost was initially identified from terrain mapping attributes to include landforms in permafrost with a fine-grained soil component and moderate to high ice-content (indicated by the ice-richness index in the terrain mapping legend). Terrain mapping and associated soil groups' datasets were merged with geothermal datasets. The threshold ice-richness index was calibrated using aboveground installation of TAPS as a surrogate for areas of thaw-sensitive terrain. Terrain units with an ice-richness index below the threshold value were considered thaw-stable. For future engineering assessments, the landform cross-section and associated soils properties database will be used in conjunction with the geothermal cross-section, and possibly other route data, to identify thaw-sensitive soils in the Project area.

Criteria developed to identify areas with potential thaw-induced instability on longitudinal slopes include one or more of the following:

- The area is permafrost with a medium to high ice-content;
- The area is near existing thaw instabilities; and

- The area is underlain by silty or clayey soil.

Low, medium, and high thaw instability categories relate to areas identified using the above criteria as being potentially thaw-sensitive areas with less than 14, between 14 and 25, and greater than 25 percent slopes, respectively.

The majority of the soils and terrain units within the construction footprint of the PT Pipeline are permafrost soils that are thaw-sensitive in terms of thaw-settlement and loss of strength on thawing. The majority of these soils developed in fine-textured, nearly-level alluvial and lacustrine sediments. However, given the low-relief nature of the PT Pipeline and the fact that the entire route will be constructed in winter, it is unlikely that solifluction, soil creep, or thawed layer detachment will be issues either during construction, reclamation, or for operations and maintenance. A consideration is the potential for thaw-induced subsidence depending on site-specific conditions such as natural drainage patterns.

Thaw-sensitive permafrost soils associated with summer construction on the Alaska Mainline are tabulated in Tables 7.5.1-1 and 7.5.1-2. Winter construction provides inherent protection to thaw-sensitive permafrost soils because the ambient air temperature will be below freezing and, therefore, are not presented in Tables 7.5.1-1 and 7.5.1-2. A detailed presentation of thaw-sensitive and thaw-stable soils by MP in the Project area is provided in Appendix 7A, Table 7A-4.

TABLE 7.5.1-1

Alaska Pipeline Project
Distribution of Thaw-Sensitive and Thaw-Stable Soils Associated with Summer Construction along the Alaska Mainline

Pipeline/Season	Borough/Census Area	Major Land Resource Area	Thaw-Sensitive and Thaw-Stable Soils (acres) [a b]		
			Thaw-Sensitive	Thaw-Stable	Total
Alaska Mainline Summer	North Slope Borough	N. Brooks Range Mtns	28.5	174.8	203.2
		Interior Brooks Range Mtns	19.3	286.6	305.9
		Total	47.8	461.4	509.1
	Yukon-Koyukuk Census Area	Interior Brooks Range Mtns	396.9	681.3	1078.2
		Interior Alaska Highlands	614.6	1219.7	1834.3
		Total	1011.5	1901.0	2912.5
	Fairbanks North Star Borough	Interior Alaska Highlands	62.5	100.0	162.5
		Total	62.5	100.0	162.5
	Southeast Fairbanks Census Area	Interior Alaska Highlands	115.0	324.9	439.8
		Interior Alaska Lowlands	332.1	2165.7	2497.8
		Total	447.1	2490.6	2937.6
Total			1568.8	4952.9	6521.7

[a] Area of thaw-sensitive and thaw-stable soils within the construction footprint (right-of-way plus Additional Temporary Workspace [ATWS]) of the PT Pipeline and the Alaska Mainline was determined by APP geotechnical engineers based on terrain data, best professional opinion, and comparisons with known permafrost areas along the TAPS corridor as discussed in Section 7.4.1.

[b] Acreage subtotals and totals may not exactly equal the sum of the constituent values due to rounding errors.

TABLE 7.5.1-2

Alaska Pipeline Project
Permafrost Thaw Sensitivity[a] along the Alaska Mainline During the Summer Construction Season by Borough/Census Area and Geologic Material

Pipeline/ Sensitivity/ Const. Season	Borough/Census Area	Total Acres	Geologic Nature of Surface Material									
			Eolian	Colluvial	Alluvial	Moraine	Glacio-fluvial	Rock	Lacus-trine	Organic	Water	Drift
		Acres [b]										
Alaska Mainline Thaw-sensitive Summer	North Slope Borough	47.7	0.0	45.9	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Yukon-Koyukuk Census Area	1011.6	295.6	524.1	187.5	0.0	0.0	0.0	0.0	4.4	0.0	0.0
	Fairbanks North Star Borough	62.5	49.4	13.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Southeast Fairbanks Census Area	447.0	58.8	268.4	101.5	0.0	0.0	0.0	0.0	18.4	0.0	0.0
	Total Summer	1568.8	403.8	851.5	290.8	0.0	0.0	0.0	0.0	22.8	0.0	0.0
Alaska Mainline Thaw-stable Summer	North Slope Borough	461.4	0.0	7.7	250.4	37.1	0.0	166.1	0.0	0.0	0.0	0.0
	Yukon-Koyukuk Census Area	1900.9	47.6	6.2	426.6	39.3	2.7	1378.0	0.0	0.0	0.6	0.0
	Fairbanks North Star Borough	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
	Southeast Fairbanks Census Area	2490.6	614.5	46.7	902.9	265.7	321.6	322.6	0.0	16.0	0.6	0.0
	Total Summer	4952.9	662.1	60.6	1579.9	342.1	324.3	1966.7	0.0	16.0	1.2	0.0
Total		6521.7	1065.9	912.1	1870.7	342.1	324.3	1966.7	0.0	38.8	1.2	0.0

[a] Area in acres of thaw-sensitive and thaw-stable soils by surface geologic unit within the construction footprint (right-of-way plus ATWS) of the Alaska Mainline was determined by APP geotechnical engineers based on terrain data, best professional judgment, and comparisons with known permafrost areas along the TAPS corridor as discussed in Section 7.4.1.

[b] Acreage subtotals and totals may not exactly equal the sum of the constituent values due to rounding errors.

For the Alaska Mainline portion of the route, approximately half of the route crosses thaw-stable soils. The majority of these soils are eolian, colluvial, and alluvial in nature. These soils should have few limitations due to effects of pipeline construction on permafrost characteristics. Where the Alaska Mainline crosses thaw-sensitive soils, there is the potential for problems with thaw-induced subsidence, solifluction, and soil creep, or thawed layer detachment. The majority of the thaw-sensitive soils along the Alaska Mainline will be crossed by construction during winter and approximately 10 percent will be crossed by construction during summer.

Numerous studies have investigated the dynamics and characteristics of permafrost near TAPS and the Alaska Highway that are directly applicable to a discussion of permafrost along the Alaska Mainline. Kreig and Reger (1976) performed a preconstruction terrain evaluation along the proposed route of TAPS. Kreig and Reger (1982) discussed the use of air photo analysis of Arctic terrains and applied their analysis to summarize soil and landform properties along the TAPS route. Brown and Kreig (1983) developed a guidebook for the Fourth International Conference on Permafrost that described mileposted, representative permafrost features along portions of the TAPS route that followed the Elliot and Dalton highways. Walker et al. (2009) updated this guidebook for the Dalton Highway Field Trip Guide for the Ninth International Conference on Permafrost fieldtrip that also included a detailed assessment of permafrost soils (Gelisols). More specifically, Kreig and Metz (2004, 1989) summarized lessons learned from terrain evaluation and applied terrain and permafrost concepts to major pipeline construction and pipeline route selection. The following information is based in large part on information contained in these reports.

Construction and reclamation issues associated with thaw-sensitive soils differ between the zones of continuous and discontinuous permafrost. The presence of permafrost and associated construction limitations is predictable in certain landforms and unpredictable in others. Thaw-sensitive permafrost subject to thaw-induced subsidence are generally present along the route in the Arctic Coastal Plain, and the Arctic Foothills in areas characterized by relatively fine-textured sediments and level to nearly level relief, however, permafrost may be thaw-stable or absent in localized areas adjacent to major rivers as well as gravelly, cobbly areas on alluvial fans, ridgetops, and elevated terraces along floodplains due to the presence of good drainage combined with coarse-textured subsoils.

Permafrost is either not present or is thaw-stable on non-soil rubble land and rock outcrops, which are common in the Northern and Interior Brooks Range MLRAs. Much of the soil along the Atigun River leading to Atigun Pass consists of rubble land associated with colluvium and coarse-textured, cobbly colluvial/alluvial fans above the Atigun River. Soils adjacent to the Atigun River with medium- to coarse-textured, gravelly and cobbly subsoils are likely to be permafrost-affected, although most of the coarser soils may be thaw-stable.

The Atigun Pass area represents rock outcrop and rubble land. South of Atigun Pass, the route follows river drainages characterized by a complex of soils consisting primarily of nearly level to sloping foot and toe slopes adjacent to mountains and ridges, and nearly level landscape positions along the river floodplains. Thaw-sensitive permafrost characterizes all of the soils except those immediately adjacent to the rivers that are associated with the thaw bulb or talik of the river itself, and well-drained, coarse-textured soils on terraces above the floodplain. Permafrost soils on nearly level areas and the more level portions of foot and toe slopes above the active floodplains and higher terraces make thaw-sensitive soils subject to subsidence upon thaw. Permafrost soils on lower and mid-slope portions of toe and foot slopes could be potentially subject to slope instability upon thaw without adequate reclamation or mitigation.

The remainder of the route downstream of AMP 259 alternates between traversing the Interior Alaska Highlands and the Interior Alaska Lowlands. Similar soils characterize the different MLRA units; although, the relative percentages of component soils are different (Figure 7.5.1-1). The Interior Alaska Highlands are characterized by east- to west-trending steep ridges and low mountains separated by relatively broad to narrow valleys. The south sides of the ridges are generally dominated by soils that, though steep, are not permafrost-affected. The steep north sides of the ridges are generally dominated by shallow-to-bedrock, permafrost soils with thin peat surface layers over gravelly loams and weathered bedrock or frozen soil. Sloping soils transition to nearly level soils in the valleys. The presence of flowing water (i.e., streams, rivers, areas of active groundwater discharge, and larger lakes) retards the development of shallow permafrost (Jorgenson et al. 2008).

Nearly level soils in the valleys and broad, poorly drained flats frequently alternate between permafrost soils and permafrost-free soils. Permafrost soils on nearly level positions in areas of discontinuous permafrost are often indicated by the presence of ice-cored hummocks and raised peat areas (referred to as “palsas”). Hunter et al. (1981), distinguishes between “dry peat” and “wet peat” in discontinuous permafrost areas as being associated with thaw-sensitive permafrost and non-permafrost areas, respectively. Intervening very poorly drained “wet peat” areas frequently lack permafrost. Talik areas become more frequent as the route progresses south.

South of Fairbanks, the route generally follows the broad valley of the Tanana River. The distribution of permafrost soils, as described above, also applies to areas above the active floodplain and elevated terraces associated with the Tanana River. Where the route follows the elevated terraces of the Tanana River that are characterized by deep, coarse-textured sediments, soils are dominated by either permafrost-free or thaw-stable soils. Several broad, nearly level areas of coalescing alluvial fans south of the Tanana River and north of the Alaska Range have shallow, actively moving groundwater systems originating as melt water from the Alaska Range. This melt water recharges the groundwater system in foot and toe slope positions and from rivers originating in the Alaska Range (USDA NRCS 2001). Many of these areas have no permafrost.

APP has developed special pipeline construction protocols in thaw-sensitive permafrost that are provided in Section 1.6.3.10 of Resource Report 1. APP has considered construction effects in thaw-sensitive permafrost and has developed right-of-way configurations that reduce impacts of thaw-sensitive permafrost on the PT Pipeline and Alaska Mainline as graphically presented in Resource Report 1, Appendices 1E and 1H. During construction, APP will implement BMPs designed for thaw-sensitive permafrost as described in Resource Report 1 Section 1.6.3.10; and Resource Report 1, Appendix 1J, Sections IV(F) and V.

Winter construction in frozen soil conditions will be a primary means of mitigating adverse impacts of pipeline construction on potentially affected soils in thaw-sensitive terrain (e.g., tundra, ice-rich permafrost, muskegs, as well as other areas of permafrost and non-permafrost).

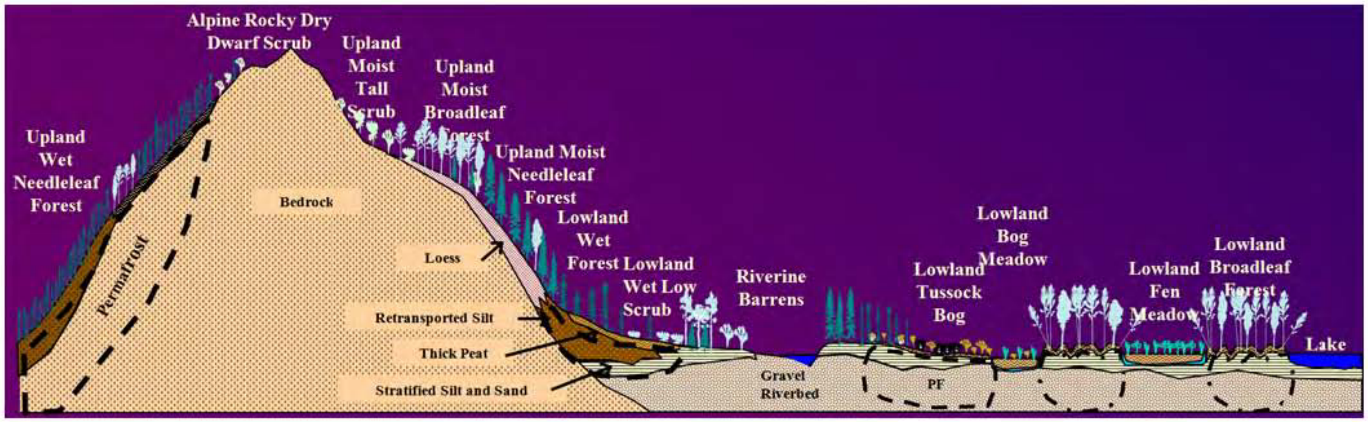

Figure 7.5.1-1
Alaska Pipeline Project
Typical Soil-Vegetation-Permafrost Relationships Associated with Characteristic Landforms of the Interior Alaska Highlands and Interior Alaska Lowlands MLRAs

Source: Jorgenson et al. 2008

DRAFT

The spread and seasons of construction configuration is provided in Figure 1.5-1 of Resource Report 1.

APP has developed construction protocols and right-of-way configurations to reduce to the extent practicable, adverse impacts on thaw-sensitive permafrost soil areas during winter construction. Resource Report 1, Appendix 1H provides details and a justification for the right-of-way configuration under various scenarios for winter construction, including:

- Winter construction south of the tree line (Resource Report 1, Appendix 1H, Section H1);
- Winter construction north of the tree line (Resource Report 1, Appendix 1H, Section H3);
- Winter construction PT Pipeline (Resource Report 1, Appendix 1H, Section H4);
- Winter construction on side slopes north of the tree line (Resource Report 1, Appendix 1H, Section H5); and
- Unfrozen wetland construction – winter construction (Resource Report 1, Appendix 1H, Section H6).

Additional drawings showing typical construction right-of-way configurations for winter and summer construction are in Resource Report 1, Appendix 1E, Drawings ROW-1 through ROW-22. Measures developed to construct the Alaska Mainline and PT Pipeline in thaw-sensitive permafrost are provided in Section 1.6.3.10 Resource Report 1.

Tundra in the Arctic Coastal Plain is a sensitive ecological community crossed by the Project area. Along with the Arctic Foothills and the Northern Brooks Range Mountains, virtually all of the tundra affected by the pipeline is in the zone of continuous permafrost. APP intends to construct the entire 58.4-mile-long PT Pipeline and the first 164.5 miles of the Alaska Mainline during winter to reduce impacts on tundra vegetation and the underlying soils within the continuous permafrost zone. Of the total 803.5 miles of Project pipeline construction, APP intends to construct 516 miles (64 percent of total) during winter.

7.5.1.2 Erosion

Erosion is a natural process that can be accelerated by human disturbance. Factors that influence the degree of erosion include soil texture, structure, length and percent of slope, vegetative cover, soil depth, thermal regime, and rainfall or wind intensity. Soils most susceptible to erosion by water are typified by bare or sparse vegetative cover, non-cohesive soil particles with low infiltration rates, moderate to steep slopes, and sloping soils with a thin active layer over permafrost. Clearing, grading, and equipment movement could accelerate the erosion process and, without adequate mitigation, result in discharge of sediment to waterbodies and wetlands. Soil loss due to erosion could also reduce soil fertility in agricultural land and impair natural revegetation.

APP has determined the water-driven erosion potential for the Alaska Mainline using terrain mapping in combination with route-specific slope data, and geothermal data, as discussed in Section 7.4.2. Although terrain mapping was performed for the PT Pipeline (Rawlinson 1990), no estimates of soil erodibility were determined. The soil erosion potential for the PT Pipeline was estimated using NRCS STATSGO2 data. No estimates of wind-driven soil erosion potential were made using terrain mapping; therefore, the magnitude of soil erosion potential by wind was determined using NRCS STATSGO2 methods.

PT Pipeline construction-related effects on soil erosion are expected to be temporary (lasting a few months after construction) to short-term (effects persisting for up to three years). The PT Pipeline is located entirely in the Arctic Coastal Plain, characterized by nearly level soils and continuous permafrost with generally thin active layers. The entire PT Pipeline will be constructed in the winter using construction techniques designed to reduce impacts on the tundra vegetation. Based on Table 7B-2 in Appendix 7B, salient features pertaining to water and erosion for the PT Pipeline include the following:

- There are no highly water-erodible soils along the entire length of the PT Pipeline that were identified using NRCS STATSGO2 data;
- Construction will occur in winter using ice pads. Soils outside of the trenched area will be subject to minimal disturbance;
- Isolated dunes and sandy areas exist that are wind-erodible according to the NRCS STATSGO2 data. Approximately 25 percent of total construction footprint of the route is wind-erodible, generally in dune areas and along stream crossings; and
- Wind erosion is not expected to be a problem because the pipeline will be constructed during winter. In areas where the trenching has exposed wind-erodible soils that are returned to the backfilled trench, APP will employ BMPs as indicated in APP's Plan to assist with minimizing wind erosion potential and to facilitate revegetation.

The Alaska Mainline route crosses steep to level ground, continuous, discontinuous and sporadic permafrost, and several different MLRAs reflecting a variety of landforms, vegetation communities, and macro- and micro-climates. The assessment of soil erosion potential during summer construction activities are summarized in Table 7.5.1-3. A detailed assessment of soil erosion potential by MP in Appendix 7A, Table 7A-3 (Alaska Mainline) and Table 7A-6 (PT Pipeline). Based on Table 7.5.1-3, salient features pertaining to water and wind erosion for the Alaska Mainline include the following:

- Of the entire construction footprint (16,213 acres), over half is planned for winter construction, and the remaining portion is planned for summer construction;
- Approximately one-third of the Alaska Mainline is considered highly water-erodible; and
- Approximately 25 percent of the Alaska Mainline is considered highly wind-erodible.

TABLE 7.5.1-3

Alaska Pipeline Project
Water- and Wind-Erodible Soils by Pipeline, Borough/Census Area, and Major Land Resource Area

Pipeline/ Season	Borough/ Census Area	Major Land Resource Area	Total Acres	Water Erodible [a] Not Highly Erodible	Water Erodible [a] Highly Erodible	Wind Erodible [b] Not Highly Erodible	Wind Erodible [b] Highly Erodible
				Acres [c]			
Alaska Mainline Summer	North Slope Borough	N. Brooks Range Mtns	203.2	159.3	44.0	203.2	0.0
		Interior Brooks Range Mtns	305.9	233.6	72.3	250.9	55.0
		Total	509.1	392.9	116.3	454.1	55.0
	Yukon-Koyukuk Census Area	Interior Brooks Range Mtns	1078.2	839.2	239.0	874.2	204
		Interior Alaska Highlands	1834.3	1127.3	707.0	1390.5	443.8
		Total	2912.5	1966.5	946.0	2264.7	647.8
	Fairbanks North Star Borough	Interior Alaska Highlands	162.5	95.7	66.8	141.4	21.1
		Total	162.5	95.7	66.8	141.4	21.1
	Southeast Fairbanks Census Area	Interior Alaska Highlands	439.8	225.0	214.8	309.4	130.4
		Interior Alaska Lowlands	2497.8	2035.0	462.8	1165.5	1332.3
		Total	2937.6	2260.0	677.6	1474.9	1462.7
Total			6,521.7	4,715.1	1,806.7	4,355.1	2,186.6

[a] Water erodibility limitations were determined using terrain unit mapping methods as described in Section 7.2.3. All values represent acres within the construction footprint (construction right-of-way and ATWS) for the PT Pipeline and the Alaska Mainline.
[b] Wind erodibility limitations were determined using NRCS STATSGO2 methods as described in Section 7.4.2.
[c] Acreage subtotals and totals may not exactly equal the sum of the constituent values due to rounding errors.

Most direct erosion-based impacts are expected to be temporary (lasting a few months after clearing and pipeline construction) to short-term (effects persisting for up to three years after clearing and pipeline construction). Persistent direct and indirect impacts will result in areas that were reclaimed to stable conditions that may not reflect pre-construction contours, however, the establishment of stable surfaces will represent the presence of an additional natural landform after the area has been stabilized and reclaimed, though different from pre-construction conditions.

To minimize or reduce potential impacts due to soil erosion and associated sedimentation, APP will use erosion and sedimentation control methods described in its Plan. APP's Plan has adapted and modified the FERC Plan to accommodate Alaska-specific conditions including permafrost and wide-spread silty soil deposits. APP's Plan will employ a toolbox approach containing BMPs available for selection and implementation based on site-specific conditions at the time of construction.

During operations, the effectiveness of revegetation and permanent erosion control devices will be monitored by APP. Except in actively cultivated agricultural areas, temporary erosion control devices will be maintained until the right-of-way is revegetated successfully, as defined in APP's Plan. Following successful revegetation of construction areas, temporary erosion control devices will be removed by APP, where appropriate.

7.5.1.3 Hydric Soils

The distribution of hydric soils, as determined by GIS query of the NRCS STATSGO2 dataset, is provided in Table 7.5.1-4, below. A detailed presentation of hydric soil by MP in the Project area is in Appendix 7B, Table 7B-2.

TABLE 7.5.1-4

Alaska Pipeline Project
Hydric Soil Distribution along the Pipeline Facilities

Pipeline/Season	Borough/Census Area	Major Land Resource Area	Distribution Hydric Soils (acres) [b]		
			Not Hydric	Hydric [a]	Total
PT Pipeline Winter	North Slope Borough	Arctic Coastal Plain	486.4	909.6	1396.0
		Total	486.4	909.6	1396.0
	Total		486.4	909.6	1396.0
Alaska Mainline Summer	North Slope Borough	N. Brooks Range Mtns	203.2	0.0	203.2
		Interior Brooks Range Mtns	238.6	67.3	305.9
		Total	441.8	67.3	509.1
	Yukon-Koyukuk Census Area	Interior Brooks Range Mtns	406.8	671.4	1078.2
		Interior Alaska Highlands	1120.0	714.3	1834.3
		Total	1526.8	1385.7	2912.5
	Fairbanks North Star Borough	Interior Alaska Highlands	102.4	60.1	162.5
		Total	102.4	60.1	162.5
	Southeast Fairbanks Census Area	Interior Alaska Highlands	213.0	226.9	439.9
		Interior Alaska Lowlands	1866.4	631.4	2497.8
		Total	2079.4	858.3	2937.7
	Total		4150.5	2371.3	6521.8

TABLE 7.5.1-4

Alaska Pipeline Project
Hydric Soil Distribution along the Pipeline Facilities

Pipeline/Season	Borough/Census Area	Major Land Resource Area	Distribution Hydric Soils (acres) [b] Not Hydric	Hydric [a]	Total
Alaska Mainline Winter	North Slope Borough	Arctic Coastal Plain	797.6	380.3	1177.9
		Arctic Foothills	764.4	989.7	1754.1
		N. Brooks Range Mtns	367.4	49.9	417.3
		Total	1929.4	1419.9	3349.3
	Yukon-Koyukuk Census Area	Interior Brooks Range Mtns	46.8	459.3	506.1
		Upper Kobuk and Koyukuk Hills and Valleys	30.1	81.3	111.4
		Interior Alaska Highlands	1043.4	822.1	1865.5
		Total	1120.3	1362.7	2483.0
	Fairbanks North Star Borough	Interior Alaska Highlands	930.0	468.7	1398.7
		Interior Alaska Lowlands	147.2	189.7	336.9
		Total	1077.2	658.4	1735.6
	Southeast Fairbanks Census Area	Interior Alaska Highlands	413.5	382.8	796.3
		Interior Alaska Lowlands	792.3	534.9	1327.2
		Total	1205.8	917.7	2123.5
	Total		5332.8	4358.8	9691.6
Alaska Mainline Total			9483.3	6730.1	16213.4
PT Pipeline and Alaska Mainline Total			9969.7	7639.7	17609.4

[a] Area of hydric soils contained within the construction footprint (right-of-way plus ATWS) was determined by a simple query of hydric soil status in the NRCS STATSGO2 database.
[b] Acreage subtotals and totals may not exactly equal the sum of the constituent values due to rounding errors.

Table 7.5.1-4 indicates the majority of the soils crossed by the PT Pipeline are hydric. Areas of soils that may not be hydric include dune areas, sand blankets, and the coarse-textured terraces adjacent to rivers. Construction during winter will be an effective mitigation measure when crossing hydric soils along the PT Pipeline.

Approximately 42 percent of soils crossed by the Alaska Mainline are assessed as being hydric. Of these, approximately 27 percent will be crossed during winter construction. Approximately 15 percent of hydric soils will be crossed during summer construction.

Hydric soils are not treated differently from upland soils unless they are components of delineated wetlands. Impacts on hydric soils are expected to be minimal in areas constructed during winter. Mitigation to impacts during summer construction is identified in APP's Procedures.

7.5.1.4 Compaction-Prone Soils

Soil compaction modifies the soil structure and reduces the porosity and moisture-holding capacity of soils. Soil compaction has primarily been a concern with soils that are intensively used for agriculture or silviculture. Construction equipment traveling over wet unfrozen soils could temporarily disrupt the native soil structure, reduce pore space, increase runoff potential, and cause rutting. The degree of compaction depends on thawed moisture content and soil texture. Fine-textured soils with poor internal drainage that are moist or wet during construction are the most susceptible to compaction and/or rutting. Coarse-textured and well-drained non-permafrost soils or permafrost soils that remain frozen during construction are not typically considered compaction-prone.

The majority of the soils crossed by the PT Pipeline (85 percent of total) are compaction-prone because they are poorly to very poorly drained, and they consist of relatively fine-textured eolian material overlying coarser-textured outwash and fluvial sediments; however construction will occur in the winter. In addition, the majority of the soils (53 percent of total) crossed by the Alaska Mainline are compaction-prone, however, 36 percent are crossed during winter from ice roads. Construction during winter construction in anticipated to limit compaction impacts on these soils.

The distribution of compaction-prone soils during summer construction on the Alaska Mainline, as determined by GIS query of the NRCS STATSGO2 dataset, is provided in Table 7.5.1-5, below. A detailed presentation of compaction-prone soils by MP is provided for the Project area during summer and winter construction in Appendix 7B, Table 7B-2.

TABLE 7.5.1-5

Alaska Pipeline Project
Distribution of Compaction-Prone Soils During Summer Construction along the Alaska Mainline

Pipeline/Season	Borough/Census Area	Major Land Resource Area	Distribution Compaction-Prone Soils (acres) [b]		
			Not Compaction-Prone	Compaction-Prone [a]	Total
Alaska Mainline Summer	North Slope Borough	N. Brooks Range Mtns	203.2	0.0	203.2
		Interior Brooks Range Mtns	215.7	90.1	305.8
		Total	418.9	90.1	509.0
	Yukon-Koyukuk Census Area	Interior Brooks Range Mtns	381.2	697.0	1078.2
		Interior Alaska Highlands	850.3	984.0	1834.3
		Total	1231.5	1681.0	2912.5
	Fairbanks North Star Borough	Interior Alaska Highlands	91.0	71.5	162.5
		Total	91.0	71.5	162.5
	Southeast Fairbanks Census Area	Interior Alaska Highlands	192.4	247.5	439.9
		Interior Alaska Lowlands	1729.2	768.6	2497.8
		Total	1921.5	1016.1	2937.7
Total			3663.0	2858.8	6521.8

[a] Area of compaction-prone soils within the construction footprint (construction right-of-way and ATWS) of the PT Pipeline and the Alaska Mainline was determined by a complex query of soil physical and hydrologic characteristics in the NRCS STATSGO2 database.

[b] Acreage subtotals and totals may not exactly equal the sum of the constituent values due to rounding errors.

Approximately 18 percent of the compaction-prone soils will be crossed by summer construction where compaction of the active layer in permafrost soils may occur. Removal of the topsoil and the loose surface material in actively-cultivated agricultural areas and non-agricultural areas as practicable will avoid or reduce the compaction typically associated with soils where the active layer is thin. Seasonal freezing and thawing of Turbels, the most common permafrost soils in Alaska, also serves as a self-mitigation for compaction to reduce the effects of compaction in non-agricultural soils.

APP will identify and mitigate adverse impacts of compaction on actively cultivated agricultural land as indicated in its Plan.

Because of compaction alleviation practices in APP's Plan, impacts are likely to be temporary to short-term in agricultural land. Similarly, impacts are expected to be negligible to short-term in areas constructed during winter. In undisturbed land that is crossed by construction during summer, most direct impacts are expected to be temporary (lasting a few months after construction) to short-term (effects persisting for up to three years) as freeze and thaw processes that are characteristic of the active layers in somewhat poorly drained to poorly drained soils naturally alleviates compaction. Better-drained soils that are crossed are not expected to have substantial compaction impacts.

7.5.1.5 Stony/Rocky Soils

Introducing additional stones or rocks (defined as stones or rocks greater than three inches along any dimension) into the plant rooting zone may reduce soil moisture-holding capacity, resulting in a reduction of soil productivity, particularly in agricultural soils. Additionally, some agricultural equipment may be damaged by contact with large rocks and stones. Rock fragments and stones at the surface and in the surface layer may be encountered during grading, trenching, and backfilling. The evaluation of stony and rocky soils typically emphasizes the surface soils, however, the presence of subsurface stones can have an impact as well.

The presence of cobbles, rocks, and boulders in the subsoil, and bedrock could affect the constructability and reclamation of the construction right-of-way. APP qualitatively ascribed the presence of subsurface cobbles and boulders to their trench soil designation as none, few, or frequent. Bedrock expected within the trench depth, or within the anticipated excavated profile of the right-of-way, was also identified as part of assessing potential blasting locations (refer to Section 6.5 of Resource Report 6).

APP terrain mapping in combination with route-specific cross slope data, a bedrock depth profile, and expected right-of-way configuration was used to identify locations of grade rock (i.e., rock expected to be intersected by the right-of-way excavation) and ditch rock (i.e., rock expected to be encountered in the pipe trench. The STATSGO2 dataset used to evaluate subsurface rocks is provided in Table 7.5.1-6.

The terrain mapping is more detailed than the NRCS STATSGO2 data and also provided estimates of stony/rocky subsoils and the presence of shallow bedrock and ditch rock. APP determined a soil group for each terrain unit that included estimates of cobbles and boulders in the subsoil based on the terrain unit map description and experience with Arctic construction on similar landforms. Bedrock is covered in more detail in Section 6.5 of Resource Report 6.

TABLE 7.5.1-6

Alaska Pipeline Project
Summary of the Distribution of Subsurface Cobbles and Boulders along the Pipeline Facilities using Alaska Pipeline Project Terrain Data

Pipeline/Season	Borough/Census Area	Major Land Resource Area	Rock Classes (relative frequency) [a] None	Few	Frequent	Total Acres
			Acres [b]			
PT Pipeline Winter	North Slope Borough	Arctic Coastal Plain	935.3	40.5	420.1	1396.0
		Total	935.3	40.5	420.1	1396.0
	Total		935.3	40.5	420.1	1396.0
Alaska Mainline Summer	North Slope Borough	N. Brooks Range Mtns	11.7	0.0	141.5	203.2
		Interior Brooks Range Mtns	25.8	0.0	164.0	305.9
		Total	37.5	0.0	305.5	509.1
	Yukon-Koyukuk Census Area	Interior Brooks Range Mtns	261.0	2.1	583.2	1078.2
		Interior Alaska Highlands	665.2	18.7	4.3	1834.3
		Total	926.2	20.8	587.5	2912.5
	Fairbanks North Star Borough	Interior Alaska Highlands	62.5	0.0	0.0	162.5
		Total	62.5	0.0	0.0	162.5
	Southeast Fairbanks Census Area	Interior Alaska Highlands	224.9	0.0	49.5	439.8
		Interior Alaska Lowlands	264.0	8.9	2067.7	2497.8
		Total	488.9	8.9	2117.2	2937.6
	Total		1515.1	29.7	3010.2	6521.7
Alaska Mainline Winter	North Slope Borough	Arctic Coastal Plain	731.9	18.5	427.5	1177.9
		Arctic Foothills	205.3	46.4	1368.9	1754.1
		N. Brooks Range Mtns	77.4		334.5	417.3
		Total	1014.6	64.9	2130.9	3349.3
	Yukon-Koyukuk Census Area	Interior Brooks Range Mtns	115.6	0.0	386.0	506.1
		Upper Kobuk and Koyukuk Hills and Valleys	0.0	0.0	111.4	111.4
		Interior Alaska Highlands	1078.2	27.7	528.2	1865.6
		Total	1193.8	27.7	1025.6	2483.1
	Fairbanks North Star Borough	Interior Alaska Highlands	958.1	36.3	79.1	1398.7
		Interior Alaska Lowlands	249.2	4.8	80.8	336.9
		Total	1207.3	41.1	159.9	1735.6
	Southeast Fairbanks Census Area	Interior Alaska Highlands	674.7	11.4	0.0	796.3
		Interior Alaska Lowlands	326.0	9.6	624.4	1327.3
		Total	1000.7	21.0	624.4	2123.5
	Total		4416.5	154.8	3940.7	9691.6
Alaska Mainline Total			5931.6	184.6	6951.0	16213.4
Project Total			6866.9	225.1	7371.1	17609.4

[a] None, Few, and Frequent Rock classes are estimates based on qualitative estimates of rock contents within the potential trench excavation that would be typical of the terrain unit identified and described by APP. Acres of subsurface stones determined by APP geotechnical engineers for the construction footprint (construction right-of-way and ATWS).

[b] Acreage subtotals and totals may not exactly equal the sum of the constituent values due to rounding errors.

For the PT Pipeline, based on the data summarized in Table 7.5.1-6 the terrain data suggests that most of the right-of-way has few or no subsurface stones greater than 3 inches in size.

For the Alaska Mainline, based on the data summarized in Table 7.5.1-6 subsurface rocks can be expected (frequent category) in 41 percent of the Alaska Mainline. Based on the data provided in Section 6.5 of Resource Report 6, bedrock can be expected along approximately 173 miles of the Alaska Mainline route.

Blasting may be required in areas where hard, shallow bedrock or boulders and permafrost are encountered that cannot be removed by conventional excavation with a trencher, backhoe, bulldozer, hydraulic hammer, or rock saw. Areas requiring blasting are addressed in Section 6.5 of Resource Report 6.

During construction, APP will mitigate adverse impacts due to the presence of stones and rocks in cultivated agricultural soils by following the mitigation protocols provided in its Plan. Similarly, impacts are expected to be negligible to short-term in areas constructed during winter. In undisturbed land that is crossed by construction during summer, and in areas of cross slopes and longitudinal slopes requiring cuts, most direct impacts are expected to be negligible in areas where topsoil and loose surface material are placed on the surface of the reclaimed area. There may be some areas outside agricultural land where excess blast rock and subsoil rock may be spread out along the right-of-way, however, because these areas are not in agricultural use, the impacts of stones and rocks on reclamation are not expected to be significant.

After reclamation these nonagricultural areas may not reflect pre-construction conditions. The establishment of stable surfaces will represent an additional natural landform after the area has been stabilized and allowed to revegetate.

7.5.1.6 Topsoil

APP used the NRCS STATSGO2 GIS to estimate topsoil depths along the right-of-way, however, topsoil is typically thin (less than 6 inches thick) in many non-organic Alaska soils and thin organic mats are common. The dominant soil type along the right-of-way is the Turbel soil order, which is characterized by frost-churning action during freezing that mixes the surface and subsurface soils within the active layer. These mixed materials are called “gelic” material by soil scientists. The treatment of the surface and loose subsurface materials, including organic material and loose subsoil is discussed below.

The majority of the soils (95 percent of total) crossed by the PT Pipeline have topsoils that are greater than 6 inches in thickness. This topsoil material includes loose surface material and organic-enriched surface mineral material that has been cryoturbated (churned up) within the active layer by frost action. Areas with very thin topsoil are on dune land, riverwash, and sand sheets. However, all of the PT Pipeline will be constructed during winter with minimal disturbance to the soils outside of the trenched area.

The distribution of topsoil depths in 6-inch increments on the Alaska Mainline, as determined by GIS query of the NRCS STATSGO2 dataset, is summarized for the APP in Table 7.5.1-7. A detailed mileposted-presentation of topsoil depths along the route is in Appendix 7B, Table 7B-3.

TABLE 7.5.1-7

Alaska Pipeline Project
Distribution of Topsoil Depths along the Alaska Mainline from AMP 505.0 – AMP 625.0

Pipeline/ Season	Borough/Census Area	MLRA	Representative Topsoil Depth Classes (inches) [a] 0-6	>6-12	>18 [b]	Total
			Acres [c]			
Alaska Mainline Summer	SE Fairbanks	Int. Alaska Highlands	32.2	4.0	13.3	49.5
		Int. Alaska Lowlands	980.6	217.9	239.7	1438.2
		Total	1012.8	221.9	253.0	1487.7
	Total		1012.8	221.9	253.0	1487.7
Alaska Mainline Winter	Fairbanks North Star	Int. Alaska Highlands	196.9	34.9	53.2	285.0
		Total	196.9	34.9	53.2	285.0
	Southeast Fairbanks	Int. Alaska Highlands	117.1	20.0	38.7	175.8
		Int. Alaska Lowlands	398.0	26.7	289.8	714.5
		Total	515.1	46.7	328.5	890.3
	Total		712.0	81.6	381.7	1175.3
Alaska Mainline Total AMP 505 - 624			1724.8	303.4	634.8	2663.1

[a] Topsoil depth classes are estimates based on a query of representative topsoil depths in soil map unit component soil series provided in the Alaska SSURGO2 GIS dataset. These depths were averaged and placed into 6-inch increments. Miscellaneous land types such as rubble land and rough mountainous land were placed into the 0-6 inch depth increment. Topsoil includes duff and underlying organic enriched surface soil. Topsoil depth determined for the area within the construction footprint (construction right-of-way and ATWS) for the PT Pipeline and the Alaska Mainline.

[b] Soils placed into the >18 inch topsoil depth class have a surface soil that is typically organic (> 80% peat by volume of the upper 20 inches (50 cm) and includes soils in the Histel suborder of the Gelisol soil order.

[c] Acreage subtotals and totals may not exactly equal the sum of the constituent values due to rounding errors.

Based on the STATSGO2 assessment, approximately half of the Alaska Mainline soils have thin topsoil that varies in thickness from 0 to 6 inches; however, the remainder of the route is relatively evenly split between the 6- to 12- and 12- to 18-inch increments. A minor amount of organic peat soils are also crossed.

The treatment of topsoil and loose surface material is illustrated for right-of-way construction configurations in Resource Report 1, Appendices 1E and 1H. During construction, APP will implement protocols for treatment of topsoil and loose surface material as indicated in APP's Plan.

No agricultural land is located along the PT Pipeline, and there is little agricultural land along the Alaska Mainline. No NRCS-designated Prime Farmland is present within the construction footprint. Approximately 17 miles of agricultural land consisting of actively cultivated cropland is located in 34 discontinuous parcels from AMP 538 to AMP 590 (Section 8.2.3.1 of Resource Report 8). Construction impacts (including additional temporary workspace) to agricultural land are expected to total approximately 341 acres.

The treatment of agricultural land is addressed in APP's Plan and in Section 1.6.3.7 of Resource Report 1. APP's Plan addresses aspects of pipeline construction and reclamation as it relates to farmlands (e.g., topsoil segregation, depth of cover, compaction, rock removal, weed/pest control, and easement restrictions).

Topsoil conservation practices shown in APP's Plan will be employed therefore impacts on agricultural land are likely to be temporary to short-term. Similarly, impacts are expected to be negligible to short-term in areas constructed during winter. For undisturbed land that is crossed by construction during summer, most direct impacts are expected to be temporary (lasting a few months after construction) to short-term (effects persisting for up to three years) in areas where topsoil and loose surface material are placed on the surface of the reclaimed area.

Persistent direct and indirect impacts may result in areas where segregation of topsoil and surface soils is not practicable, or where constructed pads have been permanently placed. After reclamation these areas may not replicate pre-construction conditions. The establishment of stable surfaces will represent an additional natural landform. This landform will be stabilized and reclaimed but will be different from pre-construction conditions.

7.5.1.7 Slope

Longitudinal and cross slope information expressed as slope classes is summarized in Tables 7.5.1-8 and 7.5.1-9. Detailed longitudinal slope data are provided in Appendix 7A, Tables 7A-2 and 7A-4. The data are based on over 18,000 longitudinal and cross slope intervals along the Alaska Mainline. Also shown in these tables are data for the PT Pipeline derived from available topographic DEMs.

TABLE 7.5.1-8

Alaska Pipeline Project
Longitudinal Slope Class Distribution for the Alaska Pipeline Project

Borough/ Census Area	Major Land Resource Area	Acres of Right-of-Way and Additional Temporary Workspace in each Slope Gradient (Percent) Class								
		0-<2	2-<5	5-<10	10-<14	14-<20	20-<25	25-<36	36-<50	≥ 50
PT Pipeline										
North Slope Borough	Arctic Coastal Plain	1313.2	73.7	9.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	1313.2	73.7	9.0	0.0	0.0	0.0	0.0	0.0	0.0
PT Pipeline Total		1313.2	73.7	9.0	0.0	0.0	0.0	0.0	0.0	0.0
Alaska Mainline										
North Slope Borough	Arctic Coastal Plain	1154.0	21.1	2.3	0.4	0.0	0.0	0.2	0.0	0.0
	Arctic Foothills	876.1	564.0	277.3	29.0	5.5	0.7	1.4	0.0	0.0
	Northern Brooks Range Mountains	238.1	222.2	107.2	23.8	16.9	3.4	4.8	2.6	1.6
	Interior Brooks Range Mountains	100.7	91.7	58.9	20.2	15.2	6.7	8.6	2.9	1.0
	Total	2368.9	899.0	445.7	73.4	37.6	10.8	15.0	5.5	2.6
Yukon-Koyukuk Census Area	Interior Brooks Range Mountains	888.1	451.9	166.2	38.0	22.8	9.2	4.8	2.1	1.1
	Upper Kobuk and Koyukuk Hills and Valleys	62.4	29.6	12.0	4.9	1.8	0.4	0.3	0.0	0.0
	Interior Alaska Highlands	1021.0	996.1	845.2	345.4	267.9	110.3	86.1	20.0	7.9
	Total	1971.5	1477.6	1023.4	388.3	292.5	119.9	91.2	22.1	9.0

TABLE 7.5.1-8

Alaska Pipeline Project
Longitudinal Slope Class Distribution for the Alaska Pipeline Project

Borough/ Census Area	Major Land Resource Area	Acres of Right-of-Way and Additional Temporary Workspace in each Slope Gradient (Percent) Class								
		0-<2	2-<5	5-<10	10-<14	14-<20	20-<25	25-<36	36-<50	≥ 50
Fairbanks North Star Borough	Interior Alaska Highlands	507.5	359.4	294.4	152.2	133.5	65.5	42.4	5.2	1.1
	Interior Alaska Lowlands	248.8	63.7	15.0	4.2	2.5	0.9	0.6	0.2	1.0
	Total	756.3	423.1	309.4	156.4	136.0	66.4	43.0	5.4	2.1
Southeast Fairbanks Census Area	Interior Alaska Highlands	446.3	297.2	234.7	95.8	81.9	37.2	30.0	11.0	1.9
	Interior Alaska Lowlands	2321.6	756.0	398.8	138.6	109.9	47.0	34.4	11.2	7.5
	Total	2767.9	1053.2	633.5	234.4	191.8	84.2	64.4	22.2	9.4
Alaska Mainline Total		7864.6	3852.9	2412.0	852.5	657.9	281.3	213.6	55.2	23.1
PT Pipeline and APP Total		9177.8	3926.6	2421.0	852.5	657.9	281.3	213.6	55.2	23.1

Longitudinal slopes are relevant to erosion because they reflect where runoff of surface water is parallel to the pipeline, and may occur over short to moderate distances. Cross slopes are also relevant to erosion, requiring mitigation on cut-and-fill slopes adjacent to and across the construction right-of-way. Erosion control BMPs on longitudinal and cross slopes will be placed within the construction right-of-way. The selection of right-of-way preparation method, erosion control, and reclamation measures is dependent on the route-specific slopes, material substrate, permafrost, and moisture conditions, among other factors.

TABLE 7.5.1-9

Alaska Pipeline Project
Cross Slope Class Distribution for the Alaska Pipeline Project

Borough/ Census Area	MLRA	Acres of Right-of-Way and Additional Temporary Workspace in Each Slope Gradient (Percent) Class								
		0-<2	2-<5	5-<10	10-<14	14-<20	20-<25	25-<36	36-<50	≥ 50
PT Pipeline										
North Slope Borough	Arctic Coastal Plain	1368.5	26.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
	Total	1368.5	26.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
PT Pipeline Total		1368.5	26.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Alaska Mainline										
North Slope Borough	Arctic Coastal Plain	1164.5	12.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	Arctic Foothills	749.2	589.0	365.0	46.4	4.2	0.3	0.0	0.0	0.0
	Northern Brooks Range Mountains	61.6	118.5	266.3	86.1	58.2	13.2	15.4	1.1	0.0
	Interior Brooks Range Mountains	59.3	48.9	56.0	36.6	33.4	20.5	34.9	16.3	0.0
	Total	2034.6	768.8	688.3	169.1	95.8	34.0	50.3	17.4	0.0

TABLE 7.5.1-9

Alaska Pipeline Project
Cross Slope Class Distribution for the Alaska Pipeline Project

Borough/ Census Area	MLRA	Acres of Right-of-Way and Additional Temporary Workspace in Each Slope Gradient (Percent) Class								
		0-<2	2-<5	5-<10	10-<14	14-<20	20-<25	25-<36	36-<50	≥ 50
PT Pipeline										
North Slope Borough	Arctic Coastal Plain	1368.5	26.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
	Total	1368.5	26.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
PT Pipeline Total		1368.5	26.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Alaska Mainline										
Yukon-Koyukuk Census Area	Interior Brooks Range Mountains	543.2	417.0	267.4	180.1	116.3	35.1	25.1	0.1	0.0
	Upper Kobuk and Koyukuk Hills and Valleys	70.6	28.1	8.5	2.9	1.3	0.0	0.0	0.0	0.0
	Interior Alaska Highlands	1101.3	1072.7	998.5	326.3	146.1	33.7	20.6	0.7	0.0
	Total	1715.1	1517.8	1274.4	509.3	263.7	68.8	45.7	0.8	0.0
Fairbanks North Star Borough	Interior Alaska Highlands	539.0	343.3	329.9	149.0	135.3	45.0	19.3	0.4	0.0
	Interior Alaska Lowlands	290.2	37.0	4.8	2.2	2.8	0.0	0.0	0.0	0.0
	Total	829.2	380.3	334.7	151.2	138.1	45.0	19.3	0.4	0.0
Southeast Fairbanks Census Area	Interior Alaska Highlands	424.4	333.7	250.9	93.4	75.1	24.8	30.1	3.6	0.0
	Interior Alaska Lowlands	2256.2	641.6	586.1	181.5	93.3	40.2	22.8	3.4	0.0
	Total	2680.6	975.3	837.0	274.9	168.4	65.0	52.9	7.0	0.0
Alaska Mainline Total		7259.5	3642.2	3134.4	1104.5	666.0	212.8	168.2	25.6	0.0
Total		8628.0	3668.2	3135.9	1104.5	666.0	212.8	168.2	25.6	0.0

Tables 7.5.1-8 and 7.5.1-9 note the following relative to slopes in the Project area:

- The PT Pipeline route traverses low-relief soils;
- Though steep slopes characterize much of Alaska, the Project takes advantage of lower relief terrain wherever practicable;
- Approximately 93 percent of the route has longitudinal slopes less than 10 percent; and
- Approximately 93 percent of the route has cross slopes that are less than 10 percent.

Special construction procedures used to construct the PT Pipeline and the Alaska Mainline in areas where both longitudinal and cross slopes are described in Section 1.6.3.6 of Resource Report 1.

7.5.1.8 Droughty Soils and Poor Revegetation Potential

Some soils affected by the Project were identified as having a poor revegetation potential based on the surface texture and drainage class. Droughty soils that have coarse-textured surface layers and are moderately well to excessively drained may prove difficult to revegetate. The drier, coarser-textured soils have a lower water-holding capacity, which could hinder germination and produce moisture deficiencies in the root zone, creating unfavorable conditions for many plants.

The distribution of droughty soils, as determined by GIS query of the NRCS STATSGO2 dataset, is provided in Table 7.5.1-10. A detailed presentation of droughty soils by MP along the Project area is provided in Appendix 7B, Table 7B-2.

Based on the Table 7.5.1-10, drought-affected soils are expected to have a minor effect on revegetation potential along the PT Pipeline or the Alaska Mainline routes. Approximately 12 percent of total drought-affected soils can be expected along the PT Pipeline, primarily associated with river wash areas and coarse-textured elevated terraces adjacent to rivers. Similarly, approximately 4 percent of total drought-affected soils can be expected along the Alaska Mainline route.

During construction and reclamation, APP will comply with APP's Plan regarding areas affected by pipeline construction, including potentially sensitive, drought-affected areas.

TABLE 7.5.1-10

Alaska Pipeline Project
Distribution of Droughty Soils along the Pipeline Facilities

Pipeline/Season	Borough/Census Area	Major Land Resource Area	Droughty Soils (Acres) [a] Not Droughty	Droughty [b]	Total
PT Pipeline Winter	North Slope Borough	Arctic Coastal Plain	1232.4	163.6	1396.0
		Total	1232.4	163.6	1396.0
	Total		1232.4	163.6	1396.0
Alaska Mainline Summer	North Slope Borough	N. Brooks Range Mtns	203.2	0.0	203.2
		Interior Brooks Range Mtns	298.1	7.0	305.9
		Total	501.3	7.0	509.1
	Yukon-Koyukuk Census Area	Interior Brooks Range Mtns	1027.1	51.1	1078.2
		Interior Alaska Highlands	1834.3	0.0	1834.3
		Total	2861.4	51.1	2912.5
	Fairbanks North Star Borough	Interior Alaska Highlands	162.5	0.0	162.5
		Total	162.5	0.0	162.5
	Southeast Fairbanks Census Area	Interior Alaska Highlands	379.1	60.8	439.9
		Interior Alaska Lowlands	2412.4	85.5	2497.8
		Total	2791.5	146.3	2937.7
	Total		6316.7	204.4	6521.8

TABLE 7.5.1-10

Alaska Pipeline Project
Distribution of Droughty Soils along the Pipeline Facilities

Pipeline/Season	Borough/Census Area	Major Land Resource Area	Droughty Soils (Acres) [a] Not Droughty	Droughty [b]	Total
Alaska Mainline Winter	North Slope Borough	Arctic Coastal Plain	1045.3	132.6	1177.9
		Arctic Foothills	1668.3	85.8	1754.1
		N. Brooks Range Mtns	417.3	0.0	417.3
		Total	3130.9	218.4	3349.3
	Yukon-Koyukuk Census Area	Interior Brooks Range Mtns	487.2	18.9	506.1
		Upper Kobuk and Koyukuk Hills and Valleys	111.4	0.0	111.4
		Interior Alaska Highlands	1835.3	30.2	1865.4
		Total	2433.9	49.1	2482.9
	Fairbanks North Star Borough	Interior Alaska Highlands	1380.5	18.2	1398.7
		Interior Alaska Lowlands	336.2	0.7	336.9
		Total	1716.7	18.9	1735.6
	Southeast Fairbanks Census Area	Interior Alaska Highlands	735.3	61.0	796.3
		Interior Alaska Lowlands	1177.2	150.0	1327.2
		Total	1912.5	211.0	2123.5
	Total		9194.0	497.4	9691.3
Alaska Mainline Total			15510.7	701.8	16213.4
Total			16743.1	865.4	17609.1

[a] Acreage subtotals and totals may not exactly equal the sum of the constituent values due to rounding errors.
[b] Area of droughty soils within the construction footprint (right-of-way and ATWS) of the PT Pipeline and the Alaska Mainline was determined by a query of soil physical and hydrologic characteristics in the NRCS STATSGO2 database. Droughty soils includes coarse-textured soils (sandy loams and coarser) that are moderately well- to excessively drained.

7.5.2 ABOVEGROUND FACILITIES

The Project will also include the installation and operation of the GTP, compressor stations, meter stations, MLBVs, launchers and receivers, and provisions for intermediate gas delivery points summarized in Section 1.3.2 of Resource Report 1. Section 8.2 of Resource Report 8 provides a description of construction and operational impacts by land use type associated with APP. The characteristics and limitations of the underlying soils associated with these facilities are provided below.

7.5.2.1 Gas Treatment Plant

The GTP site is located on state land within the North Slope Borough. The site is located entirely within the Arctic Coastal Plain MLRA.

The GTP is located in a low-relief area consisting of continuous, thaw-sensitive permafrost (refer to Table 7.5.2-1). The facility will incorporate proven arctic design techniques of gravel pads, piles, vertical support members and thermosyphons to protect the active layer and underlying permafrost. The material, sand, and gravel required for construction of the GTP will be obtained from the Putuligayuk-23 (Put-23), the dedicated water reservoir, and other existing borrow sites, such as MS-102. Approximately 163 acres of thaw-sensitive permafrost soils are anticipated to be converted to constructed pads that will be engineered to avoid thaw and subsidence of the underlying, ice-rich permafrost.

TABLE 7.5.2-1

Alaska Pipeline Project
Soil Properties and Limitations for Aboveground Facilities Associated with the Gas Treatment Plant

Borough/ Census Area	Facility	Total Acres	Highly Erodible Water [a]	Highly Erodible Wind [b]	Compaction -Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
		Acres [g]						
North Slope Borough	GTP Operations and Process Area	170.0	0.0	54.5	149.6	20.4	144.5	149.6
	Flare Area Constructed Pad	15.0	0.0	4.8	13.2	1.8	12.8	13.2
	Exclusion Area (Undisturbed)	50.0	0.0	16	44.0	6.0	42.5	44.0
	Total	235.0	0.0	75.3	206.8	28.2	199.8	206.8

[a] Includes soils that are in SCL classes 4e through 8e and soils with slopes greater than 9%.
[b] Includes soils in WEGs 1 and 2.
[c] Includes soils that have peat or sandy loam or finer textures in somewhat poor, poor, and very poor drainage classes.
[d] Includes coarse-textured soils (sandy loams or coarser) that are moderately well- to excessively drained.
[e] As designated by the NRCS.
[f] Includes soils that are in the Gelisol soil order and are somewhat poor, poor, and very poor drainage classes.

During the construction of the GTP, APP will comply with APP's Plan and Procedures to reduce the effects of erosion on affected soils within the Project area.

7.5.2.2 Compressor Stations

At stations underlain by thaw-sensitive permafrost, buildings and Associated Infrastructure will be elevated and gravel pads will be installed to mitigate heat transfer to the underlying permafrost. Selected soil properties and limitations are provided in Table 7.5.2-2. Construction of the compressor stations represents a permanent impact on up to 200 acres of soil (25 acres per compressor station). During construction of compressor stations, APP will comply with APP's Plan and Procedures to reduce the effects of erosion on affected soils planned compressor station construction.

TABLE 7.5.2-2

Alaska Pipeline Project
Soil Properties and Limitations for Compressor Stations along the Alaska Mainline

Borough/ Census Area	Compressor Station Name	Milepost	Total Acres	Highly Erodible Water [a]	Highly Erodible Wind [b]	Compaction-Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
			Acres						
North Slope Borough	Happy Valley	79.6	25.0	0.0	2.7	19.2	2.7	3.5	21.7
	Galbraith Lake	149.9	25.0	25	4.9	11.8	0.0	6.9	11.8
	Total		50.0	25	7.6	31.0	2.7	10.4	33.5
Yukon-Koyukuk Census Area	Chapman Creek	256.0	25.0	0.0	3.9	19.5	0.0	18.0	18.0
	Fort Hamlin Hills	338.0	25.0	20.2	0.0	10.8	0.0	9.1	9.6
	Tatalina River	419.1	25.0	0.0	0.0	23.4	0.0	23.4	23.4
	Total		75.0	20.2	3.9	53.7	0.0	50.5	51.0
Fairbanks North Star Borough	Johnson Road	494.0	25.0	0.0	6.2	10.1	0.5	6.4	6.4
	Total		25.0	0.0	6.2	10.1	0.5	6.4	6.4

TABLE 7.5.2-2

Alaska Pipeline Project
Soil Properties and Limitations for Compressor Stations along the Alaska Mainline

Southeast Fairbanks Census Area	George Lake	579.1	25.0	0.0	16.0	14.1	0.0	7.9	7.9
	Tetlin Junction	670.2	25.0	23.1	9.7	8.9	6.5	8.9	8.9
	Total		50.0	23.1	25.7	23.0	6.5	16.8	16.8
Total			200.0	68.3	43.4	117.8	9.7	84.1	107.7

[a] Includes soils that are in SCL classes 4e through 8e and soils with slopes greater than 9%.
[b] Includes soils in WEGs 1 and 2.
[c] Includes soils that have peat or sandy loam or finer textures in somewhat poor, poor, and very poor drainage classes.
[d] Includes coarse-textured soils (sandy loams or coarser) that are moderately well- to excessively drained.
[e] As designated by the NRCS.
[f] Includes soils that are in the Gelisol soil order and are somewhat poor, poor, and very poor drainage classes.

7.5.2.3 Miscellaneous Aboveground Facilities

Miscellaneous Aboveground Facilities are discussed in Section 1.3.3.2 of Resource Report 1. The land necessary for siting meter stations, MLBVs, launcher and receivers, provisions for intermediate gas delivery points, and cathodic protection facilities are anticipated to be within the pipeline right-of-way or the footprint of a compressor station and disturb less than 5 acres. Therefore, no additional land disturbance or impacts to the right-of-way outside of the permanent right-of-way are expected for these facilities.

7.5.3 ASSOCIATED INFRASTRUCTURE

The Associated Infrastructure, locations, and their land requirements are discussed in detail in Section 1.3.3 of Resource Report 1. Section 8.2 of Resource Report 8 provides a description of construction and operational impacts by land use type associated with APP.

7.5.3.1 Gas Treatment Plant

The infrastructure associated with the GTP site is located on state land within the North Slope Borough entirely within the Arctic Coastal Plain MLRA. Approximately 252 acres of land will be disturbed during construction; of which, 193 acres will be permanently impacted (refer to Table 1.4-1 of Resource Report 1). The Associated Infrastructure for the GTP is described in Section 1.3.3.1 of Resource Report 1.

The infrastructure associated with the GTP is located in a low-relief area consisting of continuous, thaw-sensitive permafrost (refer to Table 7.5.3-1). Approximately 193 acres of permafrost soils will be converted to constructed roads and pads that will be engineered to avoid thaw and subsidence of the underlying, ice-rich permafrost.

TABLE 7.5.3-1

Alaska Pipeline Project
Soil Properties and Limitations for Infrastructure Associated with the Gas Treatment Plant

Borough/ Census Area	Facility	Total Acres	Highly Erodible Water [a]	Highly Erodible Wind [b]	Compaction -Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
		Acres [g]						
North Slope Borough	Ice Roads	59.0	0.0	18.9	51.9	7.1	50.2	51.9
	Existing Roads Upgrades	17.0	0.0	5.4	15.0	2.0	14.4	15.0
	New Permanent Roads	39.0	0.0	12.5	34.3	4.7	33.2	34.3
	Module Staging Area	25.0	0.0	8.0	22.0	3.0	21.2	22.0
	Water Reservoir and Pump Houses	112.0	0.0	35.8	98.6	13.4	95.2	98.6
	Total	252.0	0.0	80.6	221.8	30.2	214.2	221.8

[a] Includes soils that are in SCL classes 4e through 8e and soils with slopes greater than 9%.
[b] Includes soils in WEGs 1 and 2.
[c] Includes soils that have peat or sandy loam or finer textures in somewhat poor, poor, and very poor drainage classes.
[d] Includes coarse-textured soils (sandy loams or coarser) that are moderately well to excessively drained.
[e] As designated by the NRCS.
[f] Includes soils that are in the Gelisol soil order and are somewhat poor, poor, and very poor drainage classes.

7.5.3.2 Pipeline Facilities

Access Roads

[Note: Information on access roads is still being developed; therefore, this section will be updated and will be provided in the final report.]

Based on a STATSGO2 assessment of soil characteristics and limitations, access roads along the Alaska Mainline will cross hydric soils, thaw-sensitive permafrost, compaction-prone soils, and wind-erodible soils, with lesser amounts of crossing wind-erodible soils and droughty soils.

Winter access road construction will occur on about 50 percent of the Alaska Mainline. Winter construction will avoid and/or reduce adverse impacts due to compaction, water and wind erosion, adverse effects in thaw-sensitive permafrost soils, and construction on hydric soils. APP will comply with APP's Plan (Resource Report 1, Appendix 1J) to reduce the effects of erosion and construction on potentially affected soils within the construction zone and adjacent to access roads.

Prior to the start of construction, APP will work with the appropriate land management agency (e.g., BLM, DOD, and ADNR) to select, and, if necessary, further develop appropriate mitigation measures.

Helipads and Airstrips

Each helipad will be constructed of borrow material with approximate dimensions of 100 feet long by 100 feet wide. The impacted land will be within the permanent operations right-of-way of the pipeline, or a compressor station or campsite. No additional land use impacts will occur beyond those already associated with these facilities.

APP will use existing airports and airfields, collectively termed airstrips, to transport personnel and freight to and from the Project area. APP does not anticipate the need to upgrade any existing commercial airports for the Project, but may need to make minor upgrades to some existing non-commercial airstrips. [Note: APP is evaluating airstrip requirements and will provide an update of this information in the final report.]

Construction Camps, Pipe Storage Areas, and Contractor Yards

Due to limited infrastructure in the Project vicinity, APP will use temporary camps, pipe storage areas, and contractor yards at various locations during construction. These areas have been, to the extent practicable, located at previously disturbed sites. None of the sites will be maintained during operation of the pipeline.

Soil characteristics and limitations associated with construction camps, pipe storage areas, and contractor yards are summarized by borough/census area and facility in Table 7.5.3-2.

Based on a STATSGO2 assessment of soil characteristics and limitations, the PT Pipeline and Alaska Mainline construction camps, pipe storage areas, and contractor yards will encompass hydric soils, thaw-sensitive permafrost, compaction-prone soils, with lesser amounts of water-erodible soils, wind-erodible soils, and droughty soils. [Note: Soil impacts greater than 5 acres are being evaluated and will be updated in the final report.]

During construction of camps, contractor and pipe storage areas, APP will follow APP's Plan to reduce the effects of erosion on affected soils within these areas.

In areas where the proposed facilities are located on federal and state lands, APP will work with the appropriate land management agency (e.g., BLM, DOD, and ADNR) to select and, if required, further develop appropriate mitigation and reclamation measures.

TABLE 7.5.3-2

Alaska Pipeline Project
Soil Properties and Limitations for Construction Camps, Pipe Storage Areas, and Contractor Areas

Borough/ Census Area	Milepost	Facility Name	Total Acres	Highly Erodible Soils: Water [a]	Highly Erodible Soils: Wind [b]	Compaction -Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
			Acres						
PT Pipeline									
North Slope Borough	1.3	Point Thomson East Storage Area	70.0	0.0	22.4	61.6	8.4	59.5	61.6
	45.0	Point Thompson Central 1 Storage Area	52.0	0.0	5.7	40.6	5.7	7.3	45.8
	45.5	Point Thompson Central 2 Storage Area	72.0	0.0	7.9	56.2	7.9	10.1	63.4
	50.4	Prudhoe Bay Storage Area	131.0	0.0	15.5	102.7	14.5	21.9	115.3
	Total		325.0	0.0	51.5	261.1	36.5	98.8	286.1
Alaska Mainline									
North Slope Borough	12.8	Deadhorse Camp 1	49.0	0.0	5.4	38.2	5.4	6.9	43.1
	44.3	Franklin Bluff Camp 2 [g]	49.0	0.0	5.4	38.2	5.4	6.9	43.1
	87.0	Happy Valley Camp 3	49.0	1.0	4.9	46.1	2.0	45.1	46.1
	88.0	Happy Valley Storage Area	29.0	0.6	2.9	27.3	1.2	26.7	27.3
	144.3	Galbraith Lake Storage Area	49.0	42.6	9.8	23.5	0.0	13.7	23.5
	145.7	Galbraith Lake Camp 4 [g]	49.0	42.6	9.8	23.5	0.0	13.7	23.5
	168.7	Atigun River Camp 5 [g]	22.0	22.0	0.0	0.0	0.0	0.0	0.0
	169.0	Atigun River Storage Area [g]	12.0	12.0	0.0	0.0	0.0	0.0	0.0
	177.8	Chandalar Camp 6 [g]	35.0	35.0	5.6	26.3	0.0	19.3	19.3

TABLE 7.5.3-2

Alaska Pipeline Project
Soil Properties and Limitations for Construction Camps, Pipe Storage Areas, and Contractor Areas

Borough/ Census Area	Milepost	Facility Name	Total Acres	Highly Erodible Soils Water [a]	Highly Erodible Soils Wind [b]	Compaction -Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
			Acres						
	179.9	Chandalar Shelf Storage Area	19.0	19.0	3.0	14.3	0.0	10.5	10.5
	Total		362.0	174.8	46.8	237.4	14.0	142.8	236.4
Yukon-Koyukuk Census Area	210.1	Dietrich Camp 7	49.0	1.0	4.9	46.1	2.0	45.1	46.1
	210.2	Dietrich Storage Area	19.0	0.4	1.9	17.9	0.8	17.5	17.9
	244.3	Coldfoot Camp 8 [g]	49.0	1.0	4.9	46.1	2.0	45.1	46.1
	281.7	Prospect Creek Storage Area [g]	36.0	0.0	1.8	30.6	0.0	28.8	28.8
	308.7	Kanuti River (Old Man) Camp 9 [g]	49.0	33.8	6.4	21.6	0.0	18.1	19.1
	329.8	Dall River Storage Area	19.0	13.1	2.5	8.4	0.0	7.0	7.4
	355.6	Five Mile Camp 10 [g]	39.0	23.4	17.6	17.6	0.0	13.7	13.7
	356.4	Five Mile Storage Area	19.0	11.4	8.6	8.6	0.0	6.7	6.7
	387.5	Hess Creek Storage Area [g]	38.0	22.8	17.1	17.1	0.0	13.3	13.3
	404.4	Livengood Camp 11 [g]	49.0	0.0	0.0	46.6	0.0	46.6	46.6
	419.4	Tatalina River Storage Area [g]	19.0	0.0	0.0	18.1	0.0	18.1	18.1
	Total		385.0	106.9	65.7	278.7	4.8	260.0	263.8
Fairbanks North Star Borough	448.7	Treasure Creek Storage Area	19.0	13.1	2.5	8.4	0.0	7.0	7.4
	469.0	Little Chena Camp 12	49.0	0.0	2.5	29.4	0.0	29.4	29.4
	470.4	Fort Wainwright Storage Area	89.0	0.0	4.5	53.4	0.0	53.4	53.4
	495.3	Johnson Road Camp 13	49.0	31.4	12.3	20.1	1.0	12.7	12.7
	503.7	Salcha river Storage Area	19.0	6.1	3.0	15.0	0.0	13.9	13.9
	Total		225.0	50.6	24.8	126.3	1.0	116.4	116.8

TABLE 7.5.3-2

Alaska Pipeline Project
Soil Properties and Limitations for Construction Camps, Pipe Storage Areas, and Contractor Areas

Borough/ Census Area	Milepost	Facility Name	Total Acres	Highly Erodible Soils: Water [a]	Highly Erodible Soils: Wind [b]	Compaction -Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
			Acres						
Southeast Fairbanks Census Area	521.5	Rosa Creek Camp 14	49.0	31.4	12.3	20.1	1.0	12.7	12.7
	532.8	Quartz Lake Storage Area	19.0	0.0	1.0	11.4	0.0	11.4	11.4
	549.1	Delta Junction Camp 15	49.0	0.0	46.6	2.5	0.0	2.5	2.5
	563.8	Arrow Creek Storage Area [g]	19.0	0.0	12.4	10.8	0.0	6.1	6.1
	582.0	George Lake Camp 16 [g]	49.0	47.5	7.8	17.6	4.9	16.2	17.6
	593.3	Sears Creek Storage Area [g]	15.0	0.0	0.8	9.0	0.0	9.0	9.0
	625.7	Cathedral Bluffs Alternate Storage Area [g]	20.0	0.0	19.0	1.0	0.0	1.0	1.0
	632.0	Cathedral Bluffs Storage Area [g]	19.0	0.0	18.1	1.0	0.0	1.0	1.0
	646.3	Tok River Alternate Storage Area [g]	20.0	0.0	19.0	1.0	0.0	1.0	1.0
	647.1	Tok Alternate Camp 17	49.0	0.0	46.6	2.5	0.0	2.5	2.5
	659.3	Tok Camp 17	49.0	0.0	2.5	41.7	0.0	39.2	39.2
	662.2	Tok River Storage Area [g]	19.0	0.0	1.0	16.2	0.0	15.2	15.2
	700.3	Beaver Creek Camp 18	49.0	12.3	19.6	17.2	13.2	17.2	17.2
	701.5	Beaver Creek Camp & Storage Alternate Camp 18	37.0	9.3	14.8	13.0	10.0	13.0	13.0
	702.8	Northway Junction Storage Area [g]	19.0	4.8	7.6	6.7	5.1	6.7	6.7
	731.9	Seaton Storage Area [g]	19.0	4.8	7.6	6.7	5.1	6.7	6.7
	Total		500.0	109.9	236.7	178.4	39.3	161.4	162.8
Alaska Mainline Total			1472.0	442.4	374.0	820.8	59.1	680.6	779.8
Total			1797.0	442.4	425.5	1081.9	95.6	779.4	1065.9

[a] Includes soils that are in SCL classes 4e through 8e and soils with slopes greater than 9%.
[b] Includes soils in WEGs 1 and 2.
[c] Includes soils that have peat or sandy loam or finer textures in somewhat poor, poor, and very poor drainage classes.
[d] Includes coarse-textured soils (sandy loams or coarser) that are moderately well to excessively drained.
[e] As designated by the NRCS.
[f] Includes soils that are in the Gelisol soil order and are somewhat poor, poor, and very poor drainage classes.
[g] This yard/area is previously disturbed. Additional evaluations are underway to determine the acreage of new soil impacts at these sites.

Borrow Sites

APP will require the use of borrow sites to provide base material for numerous Project activities. The borrow material required for these facilities will be obtained from numerous borrow sites that are either available or will be developed by APP. Resource Report 1, Appendix 1G lists the locations of the proposed borrow sites associated with APP.

Soil characteristics and limitations associated with borrow sites are summarized by borough/census area and facility in Table 7.5.3-3.

TABLE 7.5.3-3

Alaska Pipeline Project
Soil Properties and Limitations for Potential Borrow Sites

Borough/ Census Area	Milepost	Facility Name	Total Acres	Highly Erodible Soils		Compaction -Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
				Water [a]	Wind [b]				
			Acres						
PT Pipeline									
North Slope Borough	0.0	Alternate borrow material site - access along trail from P1. P0	147.0		16.2	114.7	16.2	20.6	129.4
	0.2	Prime borrow material site - potential borrow material site - access from existing road. P1	259.0		82.9	227.9	31.1	220.2	227.9
	4.4	Alternate borrow material site - access along right-of-way or along trail. P2	5.0		1.6	4.4	0.6	4.3	4.4
	9.4	Alternate borrow material site - access along right-of-way or trail from P1, 2 miles East. P3	57.0		18.2	50.2	6.8	48.5	50.2
	11.5	Prime borrow material site - access along right-of-way. P4	107.0		34.2	94.2	12.8	91.0	94.2
	14.0	Alternate borrow material site - access along right-of-way. P5	93.0		29.8	81.8	11.2	79.1	81.8
	17.8	Prime borrow material site - existing pit for the Badami field - active borrow material site - access along right-of-way. P6	66.0		21.1	58.1	7.9	56.1	58.1
	19.5	Alternate borrow material site - access along right-of-way. P7a	63.0		20.2	55.4	7.6	53.6	55.4
	22.6	Alternate borrow material site - access along right-of-way or access along trail near landing strip. P8	40.0		12.8	35.2	4.8	34.0	35.2
	23.5	Prime borrow material site - access along right-of-way. P9	47.0		15.0	41.4	5.6	40.0	41.4
	24.0	Alternate borrow material site - access along right-of-way. P10	64.0		20.5	56.3	7.7	54.4	56.3
	24.4	Alternate borrow material site - access along right-of-way. P11a	115.0		36.8	101.2	13.8	97.8	101.2
	24.6	Alternate borrow material site - access along right-of-way. P11b	58.0		18.6	51.0	7.0	49.3	51.0
	28.2	Alternate sand borrow material site - access along right-of-way. P12	35.0		11.2	30.8	4.2	29.8	30.8
	32.7	Alternate borrow material site - access along right-of-way. P13	59.0		18.9	51.9	7.1	50.2	51.9
	33.1	Prime borrow material site - access along right-of-way. P14	49.0		15.7	43.1	5.9	41.7	43.1
	41.7	Alternate borrow material site - Archeology Site - access along right-of-way. P15	31.0		3.4	24.2	3.4	4.3	27.3
	42.8	Prime borrow material site - access along right-of-way. P16	180.0		19.8	140.4	19.8	25.2	158.4

TABLE 7.5.3-3

Alaska Pipeline Project
Soil Properties and Limitations for Potential Borrow Sites

Borough/ Census Area	Milepost	Facility Name	Total Acres	Highly Erodible Soils		Compaction -Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
				Water [a]	Wind [b]				
			Acres						
	46.6	Alternate borrow material site - access along right-of-way. P17	68.0		7.5	53.0	7.5	9.5	59.8
	46.6	Alternate borrow material site - access along right-of-way. P17b	99.0		10.9	77.2	10.9	13.9	87.1
	47.4	Prime borrow material site - End Pit Extension	112.0		12.3	87.4	12.3	15.7	98.6
	48.4	Alternate borrow material site - access along right-of-way. P18	156.0		17.2	121.7	17.2	21.8	137.3
	49.3	Alternate borrow material site - access along right-of-way. Extension of SAG C	180.0		19.8	140.4	19.8	25.2	158.4
	55.7	Prime borrow material site - access along road. Put Pit 2 Extension	53.0		17.0	46.6	6.4	45.1	46.6
	56.1	Alternate borrow material site - access along road. Put Pit 1 Extension	101.0		32.3	88.9	12.1	85.9	88.9
	Total		2244.0		513.9	1877.4	259.7	1217.2	1974.7
PT Pipeline Total			2244.0		513.9	1877.4	259.7	1217.2	1974.7

TABLE 7.5.3-3

Alaska Pipeline Project
Soil Properties and Limitations for Potential Borrow Sites

Borough/ Census Area	Milepost	Facility Name	Total Acres	Highly Erodible Soils		Compaction -Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
				Water [a]	Wind [b]				
			Acres						
Alaska Mainline									
North Slope	12.1	65-9-102-2 (MS 3)	235.0		25.9	183.3	25.9	32.9	206.8
	24.2	65-9-026-2	408.0		44.9	318.2	44.9	57.1	359.0
	33.7	Alternate 133-1	254.0		27.9	198.1	27.9	35.6	223.5
	34.6	65-9-041-2	122.0		13.4	95.2	13.4	17.1	107.4
	40.9	65-9-024-2	341.0		37.5	266.0	37.5	47.7	300.1
	47.5	65-9-040-2	56.0		6.2	43.7	6.2	7.8	49.3
	57.0	65-9-096-2	256.0		28.2	199.7	28.2	35.8	225.3
	68.2	Alternate 65-9-073-2	171.0	3.4	17.1	160.7	6.8	157.3	160.7
	77.3	65-9-072-2	381.0		41.9	297.2	41.9	53.3	335.3
	88.0	Alternate Site 34 Extra	187.0	3.7	18.7	175.8	7.5	172.0	175.8
	96.9	Proposed Site 1 Extra	62.0	1.2	6.2	58.3	2.5	57.0	58.3
	99.1	65-9-067-2	265.0	5.3	26.5	249.1	10.6	243.8	249.1
	111.0	65-9-062-2	94.0		10.3	73.3	10.3	13.2	82.7
	119.2	Alternate Site 35 Extra	201.0	174.9	40.2	96.5		56.3	96.5
	119.9	Slope Mountain Site	190.0	165.3	38.0	91.2		53.2	91.2
	122.6	Alternate Site 37 Extra	43.0	37.4	8.6	20.6		12.0	20.6
	130.1	Alternate 65-9-059-2	62.0	1.2	6.2	58.3	2.5	57.0	58.3
	139.4	Alternate Site 38 Extra	68.0	59.2	13.6	32.6		19.0	32.6
	145.5	Galbraith Airstrip	83.0	72.2	16.6	39.8		23.2	39.8
	151.4	65-9-056-2	122.0	106.1	24.4	58.6		34.2	58.6
	154.2	Alternate Site 40 Extra	92.0	84.2	12.0	28.8		16.8	28.8
	158.0	65-9-021-2	20.0	20.0					0.0
	158.8	65-9-022-2	43.0	43.0					0.0
	163.5	Alternate Site 41 Extra	67.0	67.0					0.0
	165.4	65-9-008-2	158.0	158.0					0.0
	178.0	Chandalar Airstrip	150.0	150.0	24.0	112.5		82.5	82.5
	183.2	Upper Dietrich	117.0	114.7	39.8	17.6	7.0	14.0	14.0
	Total		4248.0	1266.8	528.1	2875.1	273.1	1298.8	3056.2
Yukon-Koyukuk	193.7	65-9-079-2	150.0	147.0	51.0	22.5	9.0	18.0	18.0
	197.1	Unnamed Creek	128.0	125.4	43.5	19.2	7.7	15.4	15.4
	221.9	65-9-052-2	143.0	2.9	14.3	134.4	5.7	131.6	134.4
	239.1	65-9-098-2	237.0	4.7	23.7	222.8	9.5	218.0	222.8
	246.6	Proposed Site 3 Extra	90.0	1.8	9.0	84.6	3.6	82.8	84.6
	264.0	Alternate Site 43 Extra	89.0	86.3	14.2	32.0	8.9	29.4	32.0
	275.4	65-9-045-2	71.0		3.6	60.4		56.8	56.8
	285.1	Proposed Site 4 Extra	55.0		2.8	46.8		44.0	44.0
	286.9	Alternate Site 44 Extra	45.0	31.1	5.9	19.8		16.7	17.6
	293.5	Bonanza West	105.0		5.3	89.3		84.0	84.0
	302.1	Alternate Fish Creek	82.0	56.6	10.7	36.1		30.3	32.0
	304.9	Dhmp 112.3	145.0	100.1	18.9	63.8		53.7	56.6
	308.6	65-9-075-2	24.0	16.6	3.1	10.6		8.9	9.4
	315.5	Kanuti Approach	56.0	55.4	24.1	37.0		8.4	30.8

TABLE 7.5.3-3

Alaska Pipeline Project
Soil Properties and Limitations for Potential Borrow Sites

Borough/ Census Area	Milepost	Facility Name	Total Acres	Highly Erodible Soils		Compaction -Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
				Water [a]	Wind [b]				
			Acres						
	327.8	65-9-043-2	168.0	166.3	72.2	110.9		25.2	92.4
	339.5	65-9-078-2	130.0	89.7	16.9	57.2		48.1	50.7
	351.5	65-9-029-2	28.0	17.3	11.0	12.6		9.9	10.0
	368.7	65-3-019-2	96.0	57.6	43.2	43.2		33.6	33.6
	375.5	65-3-016-2	146.0	87.6	65.7	65.7		51.1	51.1
	381.6	Alternate 65-3-015-2	168.0	100.8	75.6	75.6		58.8	58.8
	385.4	65-3-014-2	50.0	30.0	22.5	22.5		17.5	17.5
	398.0	Alternate 65-3-012-2	142.0	85.2	63.9	63.9		49.7	49.7
	405.3	Tolovana D	191.0			181.5		181.5	181.5
	413.0	Alternate Site 12 Extra	32.0	22.1	4.2	14.1		11.8	12.5
	420.1	Proposed Site 14 Extra	63.0			59.9		59.9	59.9
	Total		2634.0	1284.5	605.3	1586.4	44.4	1345.1	1456.1
Fairbanks North Star	431.8	Alternate 680-015-2	16.0	11.0	2.1	7.0		5.9	6.2
	445.3	Proposed Site 18 Extra	64.0	44.2	8.3	28.2		23.7	25.0
	449.9	Alternate Site 19 Extra	63.0	43.5	8.2	27.7		23.3	24.6
	452.9	Proposed Site 20 Extra	92.0	58.9	23.0	37.7	1.8	23.9	23.9
	457.7	Alternate Site 47 Extra	87.0	55.7	21.8	35.7	1.7	22.6	22.6
	465.6	Proposed Site 21 Extra	87.0	55.7	21.8	35.7	1.7	22.6	22.6
	482.9	Proposed Site 22 Extra	243.0		12.2	145.8		145.8	145.8
	483.1	Alternate Site 48 Extra	36.0		1.8	21.6		21.6	21.6
	495.4	Alternate Site 49 Extra	38.0	24.3	9.5	15.6	0.8	9.9	9.9
	502.5	Proposed Site 23 Extra	124.0	79.4	31.0	50.8	2.5	32.2	32.2
	512.8	Alternate Site 50 Extra	48.0	30.7	12.0	19.7	1.0	12.5	12.5
	Total		898.0	403.4	151.7	425.5	9.5	344.0	346.9
Southeast Fairbanks	521.2	Proposed Site 25 Extra	115.0	73.6	28.8	47.2	2.3	29.9	29.9
	535.5	62-3-157-2A	22.0		1.1	13.2		13.2	13.2
	541.0	Alternate 711-008-2	57.0		2.9	34.2		34.2	34.2
	544.7	711-011-2	42.0		27.3	23.9		13.4	13.4
	553.6	711-002-2	87.0	78.3	13.1	10.4	4.4	10.4	10.4
	557.9	Alternate 62-3-179-2	283.0		184.0	161.3		90.6	90.6
	562.7	62-3-078-2	130.0		84.5	74.1		41.6	41.6
	573.7	62-3-077-2	90.0		58.5	51.3		28.8	28.8
	579.8	62-3-073-2	165.0		107.3	94.1		52.8	52.8
	590.2	62-2-069-2 (Dry Creek Pit)	83.0	37.8	16.0	38.6	1.2	29.7	29.7
	601.9	62-2-066-2	62.0	60.1	9.9	22.3	6.2	20.5	22.3
	616.5	Alternate 62-2-022-5	22.0		20.9	1.1		1.1	1.1
	622.0	62-2-174-2	94.0		89.3	4.7		4.7	4.7
	627.7	Alternate 62-2-177-2	189.0		179.6	9.5		9.5	9.5
	634.4	62-2-176-2	137.0		130.2	6.9		6.9	6.9
	642.3	Alternate Site 29 Extra	82.0		77.9	4.1		4.1	4.1
	648.6	62-2-171-2	52.0		49.4	2.6		2.6	2.6
	653.8	Alternate Site 30 Extra	184.0		174.8	9.2		9.2	9.2
	661.1	62-2-005-5(2)	159.0		8.0	135.2		127.2	127.2

TABLE 7.5.3-3

Alaska Pipeline Project
Soil Properties and Limitations for Potential Borrow Sites

Borough/ Census Area	Milepost	Facility Name	Total Acres	Highly Erodible Soils		Compaction -Prone [c]	Droughty [d]	Hydric [e]	Thaw-Sensitive [f]
				Water [a]	Wind [b]				
			Acres						
	669.7	62-1-018-5	18.0		0.9	15.3		14.4	14.4
	681.5	Alternate 62-1-016-5	46.0	11.5	18.4	16.1	12.4	16.1	16.1
	683.4	Alternate Site 52 Extra	71.0	17.8	28.4	24.9	19.2	24.9	24.9
	688.2	62-1-019-5	12.0	3.0	4.8	4.2	3.2	4.2	4.2
	691.4	Alternate 62-1-020-5	173.0	43.3	69.2	60.6	46.7	60.6	60.6
	699.4	Proposed Site 32 Extra Option B	119.0	29.8	47.6	41.7	32.1	41.7	41.7
	705.4	Alternate Site 53 Extra	68.0	17.0	27.2	23.8	18.4	23.8	23.8
	714.6	Alternate 62-1-008-5	39.0	9.8	15.6	13.7	10.5	13.7	13.7
	716.8	62-1-168-2	73.0	18.3	29.2	25.6	19.7	25.6	25.6
	725.8	Alternate 62-1-141-2	31.0	21.4	4.0	13.6		11.5	12.1
	728.2	62-1-007-5	61.0	19.7	21.7	22.3	13.8	21.6	21.8
	731.5	Alternate 62-1-022-5	105.0	26.3	42.0	36.8	28.4	36.8	36.8
	737.5	62-1-002-5	34.0	10.7	6.2	25.5	0.8	23.7	23.7
	743.0	62-1-001-5	14.0	4.5	2.2	11.1		10.2	10.2
	Total		2919.0	482.9	1580.9	1079.1	219.3	859.2	861.8
Alaska Mainline Total			10699	3437.6	2866.0	5966.1	546.3	3847.1	5721.0
Total			12943	3437.6	3379.9	7843.5	806.0	5064.3	7695.7

An unknown acreage of borrow sites are existing or abandoned sites that have been previously disturbed.
[a] Includes soils that are in SCL classes 4e through 8e and soils with slopes greater than 9%.
[b] Includes soils in WEGs 1 and 2.
[c] Includes soils that have peat or sandy loam or finer textures in somewhat poor, poor, and very poor drainage classes.
[d] Includes coarse-textured soils (sandy loams or coarser) that are moderately well to excessively drained.
[e] As designated by the NRCS.
[f] Includes soils that are in the Gelisol soil order and are somewhat poor, poor, and very poor drainage classes.

Obtaining construction materials from these borrow sites constitutes a direct impact on the environment. Excavation and use of the geologic material in the Project is a permanent impact to soils. The impact of opening and operating the borrow site will vary based on whether the borrow site is temporary or if the site is depleted and/or will be abandoned. Reclamation and stabilization of these depleted/abandoned sites will reduce the site's impact on the soil resource. Reclaiming these sites will vary from a temporary to short-term impact dependent on the size of the borrow site. Privately owned sites will remain open for an indeterminate period of time, dependent on the owner's plans. Therefore, the impact for these temporary sites cannot be determined at this time.

In areas where proposed borrow areas are located on state or federal land, APP will work with the appropriate federal and/or state land management agency to select and, where necessary, further develop appropriate post construction reclamation and operational mitigation measures to be employed in these areas.

APP is currently evaluating the suitability and accessibility of these and other potential borrow sites for the Project. Site selection will be finalized prior to construction. Additional existing commercial sites may also be utilized during construction, as necessary.

7.6 RECLAMATION

The Project area traverses a wide variety of soils that must be considered during site reclamation. Reclamation is discussed in further detail in the Project-specific Plan and Procedures in Resource Report 1, Appendices 1J and 1K, respectively. APP will complete monitoring, maintenance, and reporting of reclamation efforts as indicated in APP's Plan and Procedures.

Where the pipeline is located on federal or state land, APP will work with the appropriate federal and/or state land management agency to further define/develop appropriate post-construction reclamation and operational mitigation measures to be employed in these areas.

7.7 PLAN COMPARISON

The FERC requires that differences between APP's Plan and the FERC Plan be discussed. A comparison between standard FERC and APP Plans and a justification of differences is provided in Resource Report 1, Appendix 1J. Similarly, the FERC requires that the differences between APP's Procedures and the FERC Procedures be discussed. A comparison between the FERC Procedures and the APP Procedures and a justification of differences is provided in Resource Report 1, Appendix 1K.

7.8 CUMULATIVE IMPACTS

Field surveys and agency consultation are ongoing. Cumulative impacts will be updated in the final report.

7.9 REFERENCES

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