Alaska LNG

DOCKET NO. PF14-21-000

DRAFT RESOURCE REPORT NO. 7

SOILS

PUBLIC VERSION

Document Number: USAKE-PT-SRREG-00-0007

RESOURCE REPORT No. 7 SUMMARY OF FILING INFORMATION [1]	
Filing Requirement	**Found in Section**
Identify, describe, and group by milepost the soils affected by the proposed pipeline and aboveground facilities. (§ 380.12(i)(1)) • List the soil associations by milepost and describe their characteristics.	7.3
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 series that would be permanently affected. • Indicate which series are considered "prime or unique farmland".	7.2.3, 7.3.2
Describe by milepost potential impacts on soils. (§380.12(i) (3) and (4)).	Table to be provided in a subsequent version of this Resource Report
Identify proposed mitigation measures to minimize impact on soils and compare with the staff's Upland Erosion Control, Re-vegetation, and Maintenance 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.	7.5

[1] Guidance Manual for Environmental Report Preparation (FERC, August 2002). Available online at: http://www.ferc.gov/industries/gas/enviro/erpman.pdf.

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ACRONYMS AND ABBREVIATIONS

ABBREVIATION	DEFINITION
Abbreviations for Units of Measurement	
°C	degrees Celsius
°F	degrees Fahrenheit
BSCF/D	billion standard cubic feet per day
cfs	cubic feet per second
cm	centimeters
dB	decibels
dBA	A-weighted decibels
ft	feet
g	grams
gpm	gallons per minute
ha	hectare
hp	horsepower
Hz	hertz
in	inches
kg	kilogram
kHz	kilohertz
kW	kilowatts
L_{dn}	day-night sound level
L_{eq}	equivalent sound level
L_{max}	maximum sound level
m^3	cubic meters
Ma	mega-annum (millions of years)
mg	milligrams
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
MGD	million gallons per day
mm	millimeters
MMBtu/hr	million British thermal units per hour
MMSCF/D	million standard cubic feet per day
MPH	miles per hour
MMTA	million metric tons per annum
ng	nanograms
ppb	parts per billion
ppbv	parts per billion by volume
ppm	parts per million
ppmv	parts per million by volume
Psig	pounds per square inch gauge
rms	root mean square
SPL	sound pressure level
tpy	tons per year

ABBREVIATION	DEFINITION
µg	microgram
µg/kg	micrograms per kilogram
µPa	micropascals
Other Abbreviations	
§	section or paragraph
AAAQS	Alaska Ambient Air Quality Standards
AAC	Alaska Administrative Code
ACC	Alaska Conservation Corps
ACEC	Areas of Critical Environmental Concern
ACP	Arctic Coastal Plain
ACRC	Alaska Climate Research Center
ACS	U.S. Census, American Community Survey
AD	aggregate dock
ADCCED	Alaska Department of Commerce, Community, and Economic Development
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADGGS	Alaska Division of Geological and Geophysical Surveys
ADM	average daily membership
ADNR	Alaska Department of Natural Resources
ADOLWD	Alaska Department of Labor and Workforce Development
ADOT&PF	Alaska Department of Transportation and Public Facilities
AEIC	Alaska Earthquake Information Center
AES	Arctic Slope Regional Corporation Energy Service
AGDC	Alaska Gasline Development Corporation
AGPPT	Alaska Gas Producers Pipeline Team
AHPA	Alaska Historic Preservation Act
AHRS	Alaska Heritage Resources Survey
AIDEA	Alaska Industrial Development and Export Authority
AKNHP	Alaska Natural Heritage Program
AMP	approximate mile post
ANCSA	Alaska Native Claims Settlement Act
ANGPA	Alaska Natural Gas Pipeline Act
ANGTS	Alaska Natural Gas Transportation System
ANILCA	Alaska National Interest Lands Conservation Act
ANIMIDA	Arctic Nearshore Impact Monitoring in the Development Area
ANS Task Force	Aquatic Nuisance Species Task Force
ANVSA	Alaska Native Village Statistical Area
AOGCC	Alaska Oil and Gas Conservation Commission
AOI	Area of Interest
APCI	Air Products and Chemicals Inc.
APDES	Alaska Pollutant Discharge Elimination System
APE	Area of Potential Effect
API	American Petroleum Institute
APP	Alaska Pipeline Project

ABBREVIATION	DEFINITION
Applicants	ExxonMobil Alaska LNG LLC, ConocoPhillips Alaska LNG Company, BP Alaska LNG LLC, TransCanada Alaska Midstream LP, and Alaska Gasline Development Corporation
APSC	Alyeska Pipeline Service Company
AQRV	Air Quality Related Value
Arctic NWR	Arctic National Wildlife Refuge
ARD	acid rock drainage
ARDF	Alaska Resource Data File
ARPA	Archaeological Resources Protection Act of 1979
ARRC	Alaska Railroad Corporation
AS	Alaska Statute
ASAP	Alaska Stand Alone Pipeline
ASME	American Society of Mechanical Engineers
ASOS	Automated Surface Observation System
ASRC	Arctic Slope Regional Corporation
ATC	Allakaket Tribal Council
ATWS	additional temporary workspace
AWOS	Automated Weather Observing System
B.C.	British Columbia
BACT	Best Available Control Technology
BGEPA	Bald and Golden Eagle Protection Act
BIA	U.S. Department of the Interior, Bureau of Indian Affairs
BLM	U.S. Department of the Interior, Bureau of Land Management
BMP	best management practices
BOD_5	biochemical oxygen demand
BOEM	U.S. Department of the Interior, Bureau of Ocean Energy Management
BOG	boil-off gas
BP	Before Present
C.F.R.	Code of Federal Regulations
CAA	Clean Air Act
CAMA	Central Arctic Management Area
CCP	Comprehensive Conservation Plans
CDP	Census Designated Place
CEA	Chugach Electric Association
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CGF	Central Gas Facility
CGP	Construction General Permit
CH_4	methane
CHA	Critical Habitat Area
CIRCAC	Cook Inlet Regional Citizens Advisory Council
CIRI	Cook Inlet Region Inc.
CLG	Certified Local Government
CO	carbon monoxide

ABBREVIATION	DEFINITION
CO_2	carbon dioxide
CO_2e	total greenhouse gas emissions, in CO_2-equivalent global warming potential
COC	Certificate of Compliance
CONUS	Continental U.S.
COOP	National Weather Service, Cooperative Observer Program
CPCN	Certificate of Public Convenience and Necessity
CRA	Certificate of Reasonable Assurance
CSD	Contaminated Sites Database
CSP	Contaminated Sites Program
CSU	conservation system units
CV	coefficient of variation
CWA	Clean Water Act
DB	Denali Borough
DEM	Digital Elevation Model
DGGS	ADNR Division of Geological and Geophysical Surveys
DH	dock head
DHSS	Alaska Department of Health and Social Services
DMLW	Alaska Department of Natural Resources, Division of Mining, Land, and Water
DPS	Distinct Population Segment
DWPP	Drinking Water Protection Program
EDA	U.S. Department of Commerce, Economic Development Administration
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPRP	Emergency Preparedness and Response Plan
ERL	Environmental, Regulatory and Lands
ERMA	Extended Recreation Management Areas
ESA	Endangered Species Act
ESD	Emergency Shut Down
ESU	Evolutionary Significant Unit
FAA	U.S. Department of Transportation, Federal Aviation Administration
FCC	Federal Communications Commission
FE	U.S. Department of Energy, Office of Fossil Energy
FEED	front-end engineering design
FEIS	Final Environmental Impact Statement
FEMA	U.S. Department of Homeland Security, Federal Emergency Management Agency
FERC	U.S. Department of Energy, Federal Energy Regulatory Commission
FERC Plan	FERC Erosion Control, Revegetation, and Maintenance Plan
FERC Procedures	FERC Wetland and Waterbody Construction and Mitigation Procedures
FLPMA	Federal Land Policy and Management Act (of 1976) BLM
FMP	Fisheries Management Plan

ABBREVIATION	DEFINITION
FNSB	Fairbanks North Star Borough
FR	Federal Regulation
GDP	Gross Domestic Product
GHG	greenhouse gases
GIS	geographic information system
GMU	Game Management Units
GP	General Permit
GRI	Gas Research Institute
GTP	gas treatment plant
GWP	Global Warming Potential
H_2S	hydrogen sulfide
HABS	Historic American Building Survey
HAER	Historic American Engineering Record
HAP	Hazardous Air Pollutant
HAPC	Habitat Areas of Particular Concern
HCA	High Consequence Area
HDD	horizontal directional drill
HDMS	Hazard Detection and Mitigation System
HGM	hydrogeomorphic
HLV	heavy lift vessel
HMR	Hazardous Materials Regulations
HRS	Hazard Ranking System
IBA	Important Bird Areas
ICS	Incident Command System
IHA	Incidental Harassment Authorization
IHLC	Inupiat History, Language, and Culture
ILI	In-line Inspection
IMP	Integrity Management Plan
IP	Individual Permit
ISO	International Organization for Standardization
JPO	State and Federal Joint Pipeline Office
kbpd	thousand barrels per day
KCC	Kuparuk Construction Camp
KOP	key observation points
KPB	Kenai Peninsula Borough
KTC	Kuparuk Transportation Company
LiDAR	light detection and ranging
Liquefaction Facility	natural gas liquefaction
LLC	Limited Liability Company
LNG	liquefied natural gas
LNGC	liquefied natural gas carrier
LOA	Letter of Authorization
LOD	Limits of Distribution

ABBREVIATION	DEFINITION
LP	Limited Partnership
LPG	liquefied petroleum gas
LUP	Land Use Permit
LUST	Leaking Underground Storage Tanks
MACT	maximum achievable control technology
Mainline	An approximately 800-mile-long, large-diameter gas pipeline
MAOP	maximum allowable operating pressure
MARPOL	Marine Pollution Protocol
MBTA	Migratory Bird Treaty Act
MCD	marine construction dock
MHHW	mean higher high water
MHW	mean high water
ML&P	Anchorage Municipal Light and Power
MLA	Mineral Leasing Act
MLBV	Mainline block valve
MLLW	mean lower low water
MLW	mean low water
MMPA	Marine Mammal Protection Act
MMS	Mainline Meter Station
MOE	margin of error
MOF	material offloading facility
MP	Mainline milepost
MPRSA	Marine Protection Research and Sanctuaries Act of 1972
MSB	Matanuska-Susitna Borough
MSCFD	Thousand standard cubic feet per day
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAS	nonindigenous aquatic species
NCC	national certification corporation
NCDC	National Climatic Data Center
NDE	non-destructive examination
NEP	non-essential experimental population
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFIP	National Flood Insurance Program
NGA	Natural Gas Act
NHPA	National Historic Preservation Act of 1996, as amended
NID	Negligible Impact Determination
NLURA	Northern Land Use Research Alaska, LLC
NMFS	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
NO_2	nitrogen dioxide
NO_X	nitrogen oxides
NOAA	National Oceanographic and Atmospheric Administration

ABBREVIATION	DEFINITION
NOI	Notice of Intent
North Slope	Alaska North Slope
NPDES	National Pollutant Discharge Elimination Systems
NPL	National Priority List
NPP	National Park and Preserve
NPR-A	National Petroleum Reserve – Alaska
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NSA	Noise-Sensitive Areas
NSB	North Slope Borough
NSPS	New Source Performance Standards
NTC	national training center
NTP	Notice to Proceed
NVIC	Navigation and Vessel Inspection Circular
NWA	Northwest Alaska Pipeline
NWI	National Wetland Inventory
NWR	National Wildlife Refuge
O_3	Ozone
OC	open-cut
OCS	Outer Continental Shelf
OD	outside diameter
OEP	FERC, Office of Energy Projects
OHA	ADNR Division of Parks and Outdoor Recreation, Office of History and Archaeology
ONA	Outstanding Natural Area
OPMP	ADNR, Office of Project Management and Permitting
OU	Operating unit
PAC	potentially affected community
Pb	the element lead
PBTL	Prudhoe Bay Gas Transmission Line
PBU	Prudhoe Bay Unit
PCB	polychlorinated biphenyl
PHMSA	Pipeline and Hazardous Materials Safety Administration
$PM_{2.5}$	particulate matter having an aerodynamic diameter of 2.5 microns or less
PM_{10}	particulate matter having an aerodynamic diameter of 10 microns or less
PMP	Point Thomson Gas Transmission Line milepost
POC	Plan of Cooperation
POD	Plan of Development
Project	Alaska LNG Project
PRPA	Paleontological Resources Preservation Act
PSD	Prevention of Significant Deterioration
PTTL	Point Thomson Gas Transmission Line
PTU	Point Thomson Unit

ABBREVIATION	DEFINITION
PWS	public water supply
Q&A	question and answer
RCA	Regulatory Commission of Alaska
RCRA	Resource Conservation and Recovery Act
RNA	Research Natural Area
ROD	Record of Decision
ROE	right-of-entry
ROW	right-of-way
RR	Resource Report
SCC	Deadhorse Airport
SDWA	Safe Drinking Water Act
SEIS	Supplemental Environmental Impact Statement
SGR	State Game Refuge
SHPO	State Historic Preservation Office(r)
SIP	State Implementation Plan
SMA	Special Management Areas
SRMA	Special Recreation Management Areas
SO_2	sulfur dioxide
SPCC	Spill Prevention, Control, and Countermeasure Plan
SPCO	State Pipeline Coordinator's Office
SPLASH	Structure of Populations, Levels of Abundance, and Status of Humpbacks
SPMT	self-propelled module transporters
SRA	State Recreation Area
SRR	State Recreation River
STATSGO	State Soil Geographic
STATSGO2	State Soil Geographic2 – General Soils Map of Alaska & Soils Data (2011)
SWAPA	Southwest Alaska Pilots Association
SWPPP	Stormwater Pollution Prevention Plan
TAHC	total aliphatic hydrocarbons
TAPS	Trans-Alaska Pipeline System
TBD	To be determined
TCC	Tanana Chiefs Conference
The Applicants' Plan	Applicants' Upland Erosion Control, Revegetation, and Maintenance Plan
The Applicants' Procedures	Applicants' Wetland and Waterbody Construction, and Mitigation Procedures
TPAH	total polycyclic aromatic hydrocarbons
TSA	Transportation Security Administration
TSCA	Toxic Substances Control Act
TSD	tug support dock
TSS	total suspended solids
UCIDA	United Cook Inlet Drift Association
UIC	Underground Injection Control
U.S.	United States
U.S.C.	U.S. Code

ABBREVIATION	DEFINITION
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USDHHS	U.S. Department of Health and Human Services
USDOE	U.S. Department of Energy
USDOI	U.S. Department of the Interior
USDOT	U.S. Department of Transportation
USDW	underground sources of drinking water
USFS	U.S. Department of Agriculture, Forest Service
USFWS	U.S. Department of the Interior, Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
VPSO	Village Public Safety Officer
VRM	Visual Resource Management Methodology
VSM	Vertical Support Members
WELTS	Well Log Tracking System
WRCC	Western Regional Climate Center
WSA	Waterway Suitability Assessment
WSR	Wild and Scenic Rivers

Information in this draft Resource Report, including maps, is preliminary and may change during Project pre-filing. Updated information will be provided in the subsequent draft and final versions of the Resource Reports.

7.0 RESOURCE REPORT NO. 7 – SOILS

7.1 PROJECT DESCRIPTION

The Alaska Gasline Development Corporation, BP Alaska LNG LLC, ConocoPhillips Alaska LNG Company, ExxonMobil Alaska LNG LLC, and TransCanada Alaska Midstream LP (Applicants) plan to construct one integrated LNG Project (Project) with interdependent facilities for the purpose of liquefying supplies of natural gas from Alaska, in particular the Point Thomson Unit (PTU) and Prudhoe Bay Unit (PBU) production fields on the Alaska North Slope (North Slope), for export in foreign commerce and opportunity for in-state deliveries of natural gas.

The Natural Gas Act (NGA), 15 U.S.C. § 717a(11) (2006), and FERC regulations, 18 C.F.R. § 153.2(d) (2014), define “LNG terminal” to include “all natural gas facilities located onshore or in State waters that are used to receive, unload, load, store, transport, gasify, liquefy, or process natural gas that is ... exported to a foreign country from the United States.” With respect to this Project, the “LNG terminal” includes the following: a liquefaction facility (Liquefaction Facility) in Southcentral Alaska; an approximately 800-mile, large diameter gas pipeline (Mainline); a gas treatment plant (GTP) on the North Slope; a gas transmission line connecting the GTP to the PTU gas production facility (PTU Gas Transmission Line or PTTL); and a gas transmission line connecting the GTP to the PBU gas production facility (PBU Gas Transmission Line or PBTL). All of these facilities are essential to export natural gas in foreign commerce.

These components are shown in Resource Report No. 1, Figure 1.1-1, and their current basis for design is described below.

The new Liquefaction Facility will be constructed on the eastern shore of Cook Inlet in the Nikiski area of the Kenai Peninsula. The Liquefaction Facility will include the structures, equipment, underlying access rights and all other associated systems for pre-processing (other than that performed by the GTP) and liquefaction of natural gas, as well as storage and loading of LNG, including terminal facilities (dock) and auxiliary marine vessels used to support marine terminal operations (excluding LNG carriers). The Liquefaction Facility will include three liquefaction trains combining to process up to approximately 20 million metric tons per annum (MMTPA) of LNG. Three 160,000 cubic meter (m^3) tanks will be constructed to store the LNG. The Liquefaction Facility will be capable of accommodating two LNG carriers. The size range of LNG carriers that the Liquefaction Facility will accommodate will be determined through further engineering study and consultation with the United States Coast Guard (USCG) as part of the Waterway Suitability Assessment (WSA) process.

In addition to the Liquefaction Facility, the LNG Terminal will include the following interdependent facilities:

- Mainline: A new large-diameter natural gas pipeline approximately 800 miles in length will extend from the Liquefaction Facility to the GTP on the North Slope, including the structures, equipment, and all other associated systems. The diameter of the pipeline has not been finalized but for the purpose of these resource reports a 42-inch diameter pipeline is assumed. The Mainline will include compressor stations, heater stations, meter stations, and various mainline block valves; pig launcher and receiver facilities; and associated ancillary and auxiliary facilities. Ancillary and auxiliary facilities will include additional temporary work spaces, access roads, helipads, construction camps, pipe storage areas, contractor yards, material extraction sites, and material disposal sites. Along the Mainline route, there will be at least five off-take interconnection points to allow for the opportunity for future in-state deliveries of natural gas. The size and location of such interconnection points are unknown at this time. None of the potential third-party facilities used to condition, if required, or move natural gas away from these off-take points will be part of the Project.

- GTP: A new GTP and associated facilities in the Prudhoe Bay area will receive natural gas from the PBU Gas Transmission Line and the PTU Gas Transmission Line. The GTP will treat/process the natural gas for delivery into the Mainline. The Project also includes a new pipeline that will deliver natural gas processing byproducts from the GTP to the PBU.

- PBU Gas Transmission Line: A new natural gas transmission line will extend approximately one mile from the inlet flange of the GTP to the outlet flange of the PBU gas production facility.

- PTU Gas Transmission Line: A new natural gas transmission line will extend approximately 60 miles from the inlet flange of the GTP to the outlet flange of the PTU gas production facility.

- Ancillary Facilities: Existing State of Alaska transportation infrastructure will be used during the construction of these new facilities including ports, airports, roads, and airstrips (potentially including previously abandoned airstrips). The potential need for new infrastructure and modifications or additions to these existing in-state facilities is under evaluation. The Liquefaction Facility, Mainline, and GTP will require the construction of material offloading facilities.

Draft Resource Report No. 1, Appendices A and B contain general maps of the Project footprint. Detailed plot plans will be developed during the pre-front-end engineering and design (Pre-FEED) process and will be provided to the Commission in a subsequent draft of Resource Report No. 1. An update to the current list of affected landowners is being filed under separate cover as privileged and confidential information.

Outside the scope of the Project, but in support of, or related to, the Project, additional facilities or expansion/modification of existing facilities will be needed or may be constructed. These other projects may include:

- Modifications/new facilities at the PTU;

- Modifications/new facilities at the PBU;

- Relocation of the Kenai Spur Highway; and
- Third-party pipelines and associated infrastructure to transport natural gas from the off-take interconnection points to markets in Alaska.

7.1.1 Purpose

As required by 18 C.F.R. § 380.12, Alaska LNG Applicants have prepared this draft Resource Report in support of a future application under Section 3 of the NGA to construct and operate the Project facilities. The purpose of this draft Resource Report is as follows:

- Identify, describe, and list the soils traversed by the Project;
- Summarize potential effects to these resources from construction and operation of the Project; and
- Identify potential mitigation measures to avoid or minimize potential adverse effects to soil resources in the vicinity of the Project area.

Soil characterization information to be provided in a subsequent draft of this Resource Report will be obtained from desktop analysis, review of available literature, analysis of data from other projects, and field investigations. Information provided in this draft Resource Report will be addressed generally by Physiographic Region and by Major Land Resource Areas (MLRA).

7.1.2 Agency and Organization Consultations

This section describes consultations that will be conducted with agencies and other interested parties to the Alaska LNG Project. As Project details are refined in the Pre-FEED process currently underway, additional consultations will be conducted. A subsequent draft of this Resource Report will describe these additional consultations in Sections 7.1.2-1 through 7.1.2-3.

7.1.2.1 Federal Agencies

A summary of public, agency, and stakeholder engagement conducted by Alaska LNG Project representatives is provided in Resource Report No. 1, Appendix C. Subsequent versions of this resource report will describe any soil specific federal agency consultation that has taken place.

7.1.2.2 State Agencies

A summary of public, agency, and stakeholder engagement is provided in Resource Report No. 1, Appendix C. Subsequent versions of this resource report will describe any soil specific state agency consultation that has taken place.

7.2 SOIL DESCRIPTION METHODOLOGY

Only a few detailed and comprehensive U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) soil survey databases exist for Alaska due to the general lack of intensive land use, the rugged nature of the landscape, and relative inaccessibility of the area. In addition, the presence of permafrost, and other unique Arctic and high-latitude conditions, make NRCS soil surveys alone insufficient to thoroughly characterize soils in the Project area. Thus, multiple methods and databases were used in combination to evaluate soil properties and limitations, as discussed below. Additional geotechnical engineering analyses will be conducted to further evaluate soil resources in the Project area as the footprint of the Project facilities, including interdependent facilities, is identified and refined during Pre-FEED and subsequent phases of the Project.

7.2.1 STATSGO2 Soil Distribution

The terrain of Alaska has been divided into general STATSGO2 Soil Distribution based on variation in topography and large-scale geomorphic processes. The terrain of Alaska is further divided in this Resource Report using defined Major Land Resource Areas (MLRAs) which are more specific to the soil type present (USDA NRCS, 2004).

7.2.2 Major Land Resource Areas (MLRAs)

The broad-scale soil interpretations utilized in this Resource Report are based on MLRAs. The MLRAs crossed by the project, and their correlation with STATSGO2 Soil Distribution, are addressed below, along with their dominant soil types and landforms. Within a given MLRA, certain features 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 Ecoregions discussed in detail in Section 7.3. The MLRAs crossed by the Project, and their correlation with STATSGO2 Soil Distribution , are addressed below, along with their dominant soil types and landforms.

7.2.3 USDA NRCS Soils Series

The existing NRCS datasets for Alaska include the following:

- Exploratory Soil Survey of Alaska (USDA Soil Conservation Service, 1979);
- 1993 State Soil Survey Geographic Database (STATSGO; USDA NRCS, 1993);
- 1998 Interim STATSGO product (USDA NRCS, 1998);
- 2002 STATSGO Update (STATSGO2; USDA NRCS, 2002); and
- 2011 STATSGO2 General Soils Map of Alaska (USDA NRCS, 2011a).

Based on differences in soil classifications, these databases are not interchangeable. In the later databases, the soil classifications have been updated to include development of a new soil order Gelisols[2] to characterize and map permafrost[3] soils. Thus, the soil map units have been modified and are therefore difficult to correlate between databases.

The scale of mapping for these NRCS databases is 1:1,000,000. At this scale, the range in characteristics for most soil properties of interest is provided from a generalized perspective. Detailed soil information is only available for a small portion of Alaska. Each map unit in the most recent Alaska STATSGO2 database represents an association of soils identified to the suborder level that are arranged in a consistent pattern associated with broad landforms. Individual soil boundaries are not shown, and soil series are not identified as map unit components.

NRCS based soil interpretations in the continental U.S. are generally developed to assess potential impacts to the following:

- Agricultural/silvicultural soils;
- Prime farmland;
- Highly erodible soils;
- Compaction-prone soils; and
- Topsoil to maintain agricultural soil quality.

These soil interpretations are applicable to only a minor portion of the Project area in Alaska. They describe conditions in the top 3 to 6.5 feet of the geological sediment, thereby limiting the assessment of potential construction and operation related effects where permafrost conditions extend deeper.

7.2.4 Geotechnical Engineering Analysis

Geotechnical engineering analyses have been, and are continuing to be conducted using various combined geological/geotechnical datasets to evaluate soil resources and associated known hazards in the Project area. These new analyses are needed to supplement the reconnisance nature of the existing published data and to produce site specific information at a scale to meet Project specifications. The use of these combined datasets is more appropriate for evaluating key soil properties than solely relying upon the existing NRCS soils data for Alaska (Clark, 2011). The geological/geotechnical datasets are being derived from the following data sources:

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[2] Gelisols are an order in USDA soil taxonomy. They are soils of very cold climates which are defined as containing permafrost within two meters of the soil. Ping, C.L. Article: Gelisols: Part II. Classification and Related Issues Soil Horizons, 2013. 54., doi:10.2136/sh2013-54-4-gc

[3] Permafrost is defined by DGGS (2011) as any soil, subsoil, or other surficial deposit, or even bedrock, occurring in the arctic, subarctic, and alpine regions at variable depth beneath the Earth's surface in which a temperature below freezing has existed continuously from two years to tens of thousands of years.

- Digital terrain maps (Rawlinson, 1990);
- Digital elevation models (DEMs) of the Project area obtained using light detection and ranging (LiDAR) methods, supplemented with other available digital elevation datasets to fill data gaps;
- Terrain, landform, geothermal, bedrock, borehole, and soil properties data from other projects, including the Trans-Alaska Pipeline System (TAPS), the Alaska Natural Gas Transportation System (ANGTS), the Alaska Pipeline Project (APP), the Alaska Stand Alone Pipeline (ASAP), Alaska Gas Producers Pipeline Team (AGPPT) and the Denali Project (Denali);
- Publicly available digital maps of Ecoregions (Nowacki et al., 2001), bedrock geology and faults (various U.S. Geological Survey [USGS] and other map series), surficial geology and engineering geology (produced by the Alaska Department of Natural Resources [ADNR], Division of Geological & Geophysical Surveys [DGGS]), and permafrost (Jorgenson et al., 2008); and
- Related reports and publications.

7.2.4.1 Terrain Mapping

Terrain mapping is a classification system that describes the characteristics and spatial distribution of surficial materials, soils, landforms and geomorphological processes.

It provides a continuous interpretation of surface and implied subsurface conditions along a mapped corridor. The qualitative characterization of conditions along the Project area from terrain mapping 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.

The landform is the most significant recognizable terrain mapping unit that can be seen or inferred from stereoscopic analysis of aerial photographs. Each landform group described has a common geological origin, geomorphic expression (surface topography), texture (grain size), and other engineering characteristics. Soils are distributed on the landscape in close association with specific landforms, therefore terrain mapping is a useful surrogate for soil mapping because it is completed at a suitable mapping scale, and captures relevant attribute data for each mapping unit.

The terrain map unit represents a three-dimensional landform feature, or suite of related landform features, expected to occur from the ground surface to a depth of up to 50 feet. Terrain units may comprise one or more landforms:

- 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; and

- Complex terrain units are a combination of layered and/or mosaic terrain units.

Terrain units represent the smallest length division along the Project area for which many soil attributes are mapped, however, when combined with landform, slope, geothermal, or other datasets, further segmentation is possible to identify specific soil-related limitations and potential hazards.

The footprint of the Project facilities, including interdependent facilities, will be identified and refined during Pre-FEED and subsequent phases of the Project. Terrain mapping for the Project is still in development. To date, 1D terrain mapping[4] of the Project route has been completed. In addition, 2-D terrain maps and a landform profile have been developed for the Project area north of Livengood using legacy terrain mapping from ANGTS and APP. For the Project area south of Livengood, a 2-D terrain map and landform profile will be developed from ASAP data and new terrain mapping to supplement the 1-D terrain mapping. Similar terrain mapping information (Rawlinson, 1990) has also been used to develop a terrain map and landform profile for the PTTL. The attributes relevant to soil resources that can be derived from terrain mapping include the following:

- Genetic class related to the geomorphic process associated with material deposition;

- Type and relative abundance of various materials associated with a terrain unit, including physical modifiers related to texture and grain size;

- Stratigraphy and thickness of various landforms comprising a terrain unit;

- Generalized topographic and drainage characteristics of a terrain unit; and

- Permafrost conditions associated with a terrain unit or a portion of a terrain unit.

Other attributes may also be available from existing terrain maps acquired for the Project depending on the terrain mapping system used.

7.2.4.2 Topographic Data Analysis

Detailed topographic information is important for Project siting and for assessing potential effects of clearing, construction, and long-term operation of the Project facilities 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 Project area is available as true slope (e.g., gradient), and is also resolved into longitudinal and cross slope components (e.g., components parallel and perpendicular to the pipeline centerline, respectively).

---

[4] 1-Dimensional (1-D) and 2-Dimensional (2-D) terrain modeling are used in conjunction with digital elevation data for soils, hydrological and geomorphological applications. 1-D modeling and terrain mapping of previously proposed pipeline corridors was developed by ANGTS, ASAP and APP. The ability to combine the existing 1-D models with updated 2-D modeling will allow project scientists to enhance terrain mapping where appropriate.

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 (e.g., vegetation). Geographically referenced elevation values can be determined from digitized topographic maps or directly using LiDAR technology. The following three digital elevation datasets have been used for the Project area to date:

- LiDAR data of the Project area, including data from public sources and other projects, and newly acquired data;
- Topographic information obtained from digitized aerial photography; and
- Coarser resolution DEMs from the USGS National Elevation Database for Alaska for certain areas where no Project-specific LiDAR or topographic information exists.

A composite DEM, derived from the sources described above, is used to generate gradient maps and the cross slope and longitudinal slope profiles. Longitudinal and cross slope angles are calculated at fixed intervals along the Project area; cross slope angle at each fixed point represents the average slope angle over a transect of prescribed length centered on the Project area. Calculated slope angle data are then filtered to segment the area into a continuous set of slope-class intervals. Slope classes and associated slope angle ranges are listed in Table 7.2.4-1. The footprint of the Project facilities, including ancillary facilities, will be identified and refined during Pre-FEED and subsequent phases of the Project. The composite DEM is still in development. Additional LiDAR has been obtained for the Project areas not previously covered.

TABLE 7.2.4-1

Slope Classes and Slope Angle Ranges Used for Topographic Datasets to Date

	Slope Angle Range (percent)	
Slope 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 natural gas flow; a positive cross slope rises to right or falls to left looking in direction of natural gas flow.

7.2.4.3 Other Route Data

The Project's Mainline corridor closely follows portions of other existing, or proposed, pipeline project routes. Extensive geotechnical data obtained from other projects (TAPS, ANGTS, APP, ASAP, AGPPT, and Denali), as well as publicly available maps and digital files (e.g., bedrock geology, faulting, permafrost distribution), are used to create geotechnical datasets for Project area characterization and engineering analyses.

The actual footprint of the Project facilities, including ancillary facilities, will be identified and refined during Pre-FEED and subsequent phases of the Project. As details become available, the additional geological and geotechnical datasets used to evaluate soil resources and associated known hazards within the Project footprint will be further described in a subsequent draft of this Resource Report.

7.2.4.4 Data Analysis Approach

Based on the different data sources described above, various methods are being used to develop Project-specific geological, geophysical and geotechnical datasets for use in engineering analyses and execution planning. Aerial extent of different soil related conditions (e.g., erosion, slope instability, permafrost thawing, and ground freezing) within the Project footprint are identified by merging various datasets according to Project-developed algorithms.

7.3 EXISTING SOILS DESCRIPTION

7.3.1 STATSGO2 Soil Distribution and Major Land Resource Areas (MLRAs)

The relationship between the STATSGO2 soil distribution crossed by the Project and other geographic classification systems, including MLRAs, is presented in Table 7.3.1-1. The Project area lies within seven generalized STATSGO2 soil distributions and ten MLRAs that are recognized by the NRCS. The MLRAs are depicted in Figure 7.3.1-1 and discussed below. The STATSGO2 soil distribution is depicted in Figure 7.3.1-2.

7.3.1.1 Liquefaction Facility

The Liquefaction Facility is located in the Cook Inlet Basin (MLRA 224).

Cook Inlet Basin (MLRA 224)

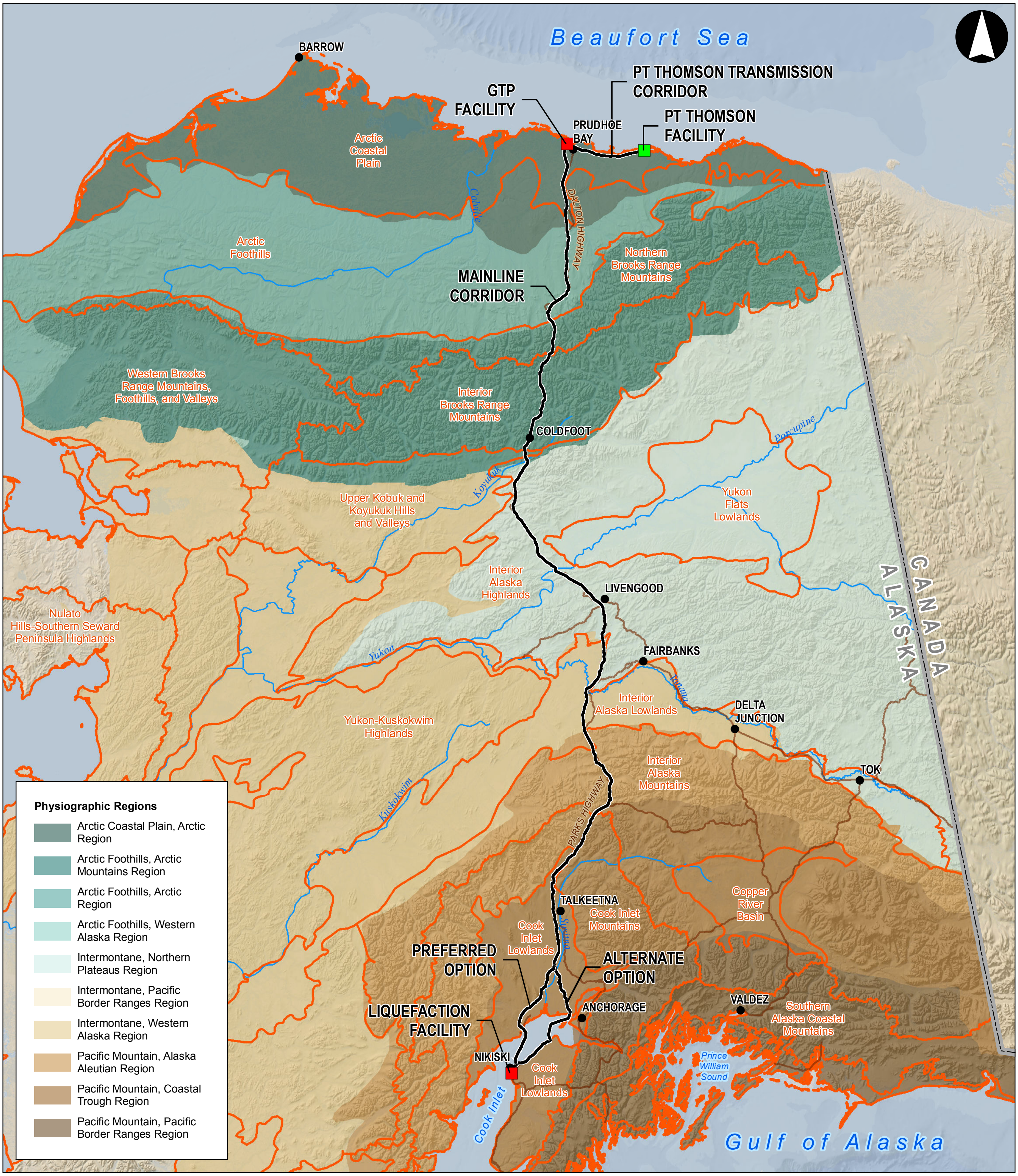
Soils in the Cook Inlet Basin MLRA consist of silty loess and volcanic ash over loamy, sandy, and gravelly glacial till and outwash spread over the plains and hills that are typically found in this region. These soils are typically well drained and generally deep. In the many broad shallow drainage basins, thick organic deposits are generally poorly drained. On the stream terraces, stratified alluvium dominated by silt and sand over gravel are typical, with a wide range in permeability. Soils of the Cook Inlet Basin MLRA typically consist of peats and bogs in low areas that are flanked by morainal deposits, till, and outwash landforms. In some areas, where freshwater mixes with seawater, deposits of glacial till are known as glacioestuarine. Extensive glacioestuarine and lake-bottom sediments also exist in the lowland. Permafrost within the Cook Inlet Basin MLRA ranges from sporadic in the north to absent in the south. Near its southern extent, permafrost exists only in isolated lenses beneath thick peat bogs. Permafrost is unlikely near Cook Inlet (Gallant et al., 1995).

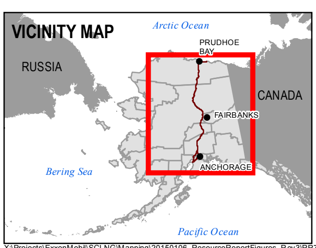
TABLE 7.3.1-1

Physiographic Regions and Major Land Resource Areas Crossed by the Alaska LNG Project

Alaska LNG Facility	**Ecosystem[a]**	**Ecoregion Equivalent[a]**	**NRCS Major Land Resource Area[b]**	**STATSGO-2 Soil Distrubtion**	**Drainage Basins**	**Borough/Census Area**
GTP PTTL PBTL Mainline	Polar-Arctic Tundra	Beaufort Coastal Plain	Arctic Coastal Plain	TBD	Kuparuk R. Sagavanirktok R. Mikkelson Bay	North Slope Borough
Mainline		Brooks Range Foothills	Arctic Foothills	TBD		
		Brooks Range	Northern Brooks Range Mountains	TBD		
			Interior Brooks Range Mountains	TBD	Upper Koyukuk R. Middle Fork/N. Fork Chandalar R. Upper Koyukuk R.	Yukon-Koyukuk Census Area
	Boreal-Intermontane Boreal	Kobuk Ridges and Valleys	Upper Kobuk and Koyukuk Hills & Valleys	TBD	Upper Koyukuk R. South Fork Koyukuk R. Kanuti R.	
		Ray Mountains Yukon Tanana Uplands	Interior Alaska Highlands	TBD	Yukon Flats Rampart Tolovana R.	Fairbanks North Star Borough
		Ray Mountains				
		Tanana Kuskokwim Lowlands	Interior Alaska Lowlands	TBD	Tanana Flats	Yukon-Koyukuk Census Area
	Boreal-Alaska Range Transition	Alaska Range	Interior Alaska Mountains	TBD	Chulitna River Nenana River L. Tanana River Tolovana River	Denali Borough
			Cook Inlet Mountains	TBD		Matanuska-Susitna Borough
Mainline Liquefaction Facility		Cook Inlet Basin	Cook Inlet Lowlands	TBD	Cook Inlet Basin	Kenai Peninsula Borough

[a] Unified Ecoregions of Alaska (Nowacki et al. 2001).
[b] Major Land Resource Regions as provided in NRCS Staff (2004).
TBD = Data to be completed in a subsequent draft of this Resource Report.





LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Project Corridor
- Major Highways
- Major Rivers
- Major Land Resource Area

0 35 70 140 Miles

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ALASKA PHYSIOGRAPHIC REGIONS & MLRA

FIGURE 7.3.1-1

Alaska LNG

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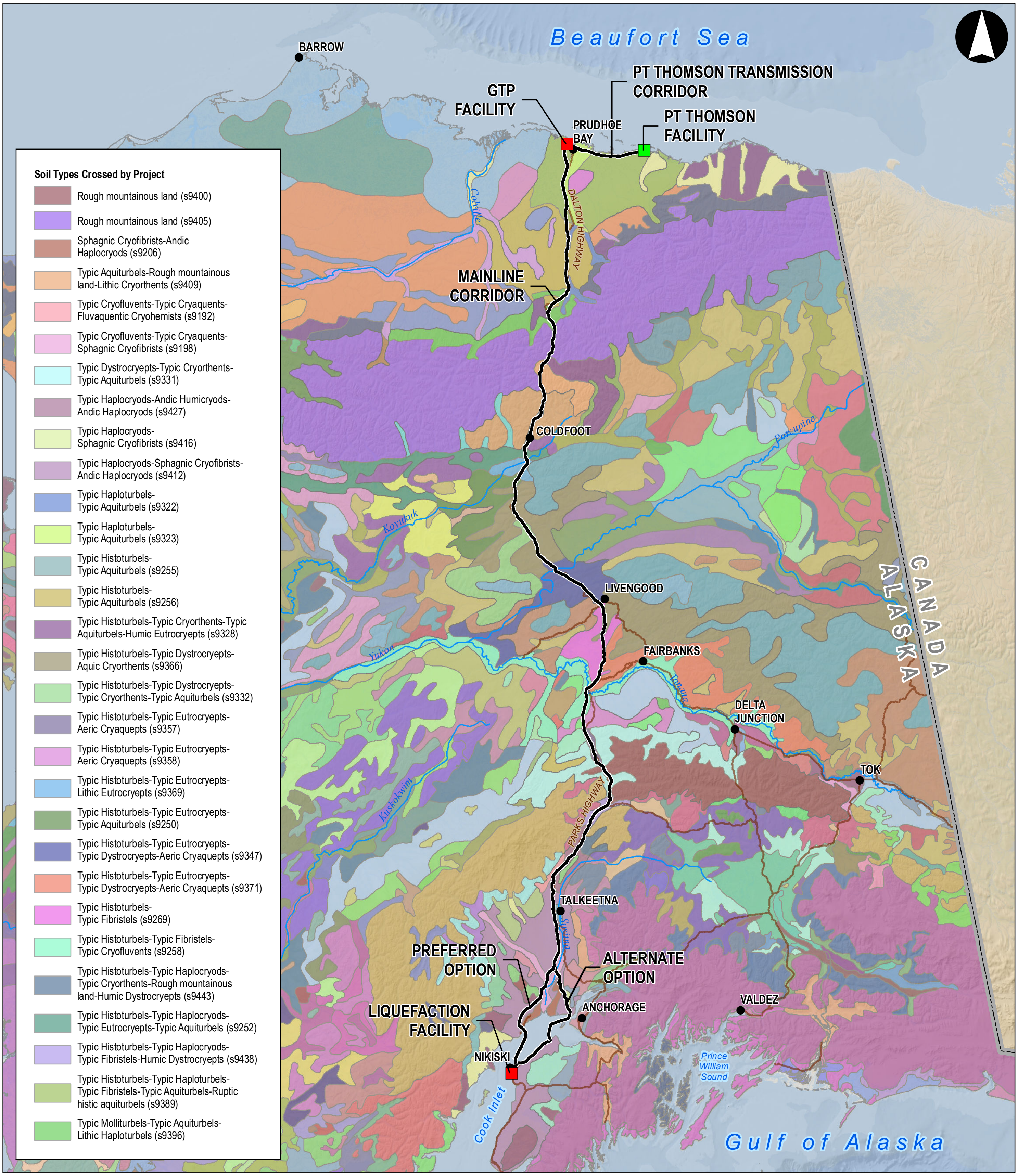

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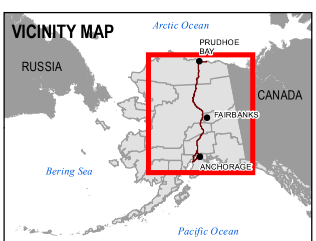

LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Project Corridor
- Major Highways
- Major Rivers

0 35 70 140 Miles

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STATSGO SOIL DISTRIBUTION

FIGURE 7.3.1-2

Alaska LNG

X:\Projects\ExxonMobil\SCLNG\Mapping\20150106_ResourceReportFigures_Rev3\RR7\Figure 7_3_1-2 STATSGO Soil Distribution.mxd

7.3.1.2 Interdependent Facilities

An overview of each of the MLRAs crossed by the Project's Interdependent Facilities from north to south is provided below.

Arctic Coastal Plain (MLRA 246)

Soils in the Arctic Coastal Plain MLRA have a pergelic soil-temperature regime, indicating they have a mean soil temperature of less than 32°F. All soils in the area are underlain by permafrost, and most soils are usually 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 in the Arctic Coastal Plain MLRA consist of poorly and very poorly drained, loamy stratified sediments with thaw-sensitive ground ice below 10 inches. 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). Therefore, upon thaw, these soils may be subject to subsidence in level areas, and to fluid and plastic deformation on upland slopes near the transition to the Arctic Foothills MLRA.

In the Arctic Coastal Plain MLRA, sandy, well-drained soils form 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. Thaw-stable permafrost soils are soils that, upon thawing, do not experience either substantial thaw-settlement or loss of strength (van Everdingen, 2005).

Soils that occupy low terraces and braided floodplains bordering the Sagavanirktok River in the Arctic Coastal Plain MLRA 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 escarpments on low terraces, slightly above the floodplains. Permafrost soils with gravelly and very gravelly substrates are not likely to experience thaw-induced subsidence or mass movement and are typically thaw-stable.

Arctic Foothills (MLRA 245)

Soils in the Arctic Foothills MLRA are underlain by permafrost. Near-surface soils with thin peat layers are typically wet during summers. Poorly and very poorly drained soils are thaw-sensitive and may be subject to subsidence and erosion on gentler slopes, and thaw-induced mass wasting on steeper slopes in addition to these other effects, depending on ground conditions.

In the Arctic Foothills MLRA, shallow bedrock, rubbly slopes, and rough mountainous terrain become more common south toward the Brooks Range. 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 in the Arctic Foothills MLRA along small streams and in shallow depressions. Discontinuous gravelly soils with a thicker active layer are present on floodplains, and permafrost may be absent under larger perennial rivers. Gravel terraces border the floodplains of major streams and 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)

Soils in the Northern and Interior Brooks Range MLRAs are 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 and soils are extremely thin or absent in more than 70 percent of the area. The Mainline corridor preferentially follows river valleys, where thin soils over bedrock and soils with thin surface peat covering colluvium and alluvium are dominant on steep lower slopes. For example, thin peats and wet mineral soils with shallow permafrost are present where the Mainline corridor traverses valley bottoms along the Dietrich and Koyukuk rivers.

In the Northern and Interior Brooks Range MLRAs, 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. Some of these other soils could experience thaw-induced mass wasting on steeper slopes or subsidence on level and nearly level surfaces.

Kobuk and Koyukuk Hills and Valleys (MLRA 233)

A short segment of the Project area along the Mainline corridor traverses the extreme northeastern Kobuk and Koyukuk Hills and Valleys MLRA along the boundary between the Interior Brooks Range Mountains and the Interior Alaska Highlands. The soils in this area are similar to the Interior Alaska Highlands MLRA, discussed above.

Interior Alaska Highlands (MLRA 231)

Soils in the Interior Alaska Highlands MLRA are usually deficient of moisture in midsummer. Most valley bottoms, north- and east-facing slopes, and hills with summit elevations above 2,600 feet are underlain by permafrost, which is locally ice rich (Shur et al, 2010). 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 occur in alpine areas with tundra vegetation characterized by sparse, shrubby plants.

In the Interior Alaska Highlands MLRA, 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. Several soils associated with stream terraces and south and west-facing slopes are permafrost-free.

Fine-grained, thawing permafrost terrain in the Interior Alaska Highlands MLRA 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)

Soils in the Interior Alaska Lowlands MLRA consist of silty loess of varying thickness that overlies loamy, sandy, and gravelly alluvium and colluvium. Poorly or very poorly drained Gelisols[5] are shallow to moderately deep over permafrost. Peats have typically developed in poorly drained depressions on stream terraces, outwash plains, and moraines. Peats also form in floating fibrous organic mats around the margins of lakes and in shallow basins.

In the Interior Alaska Lowlands MLRA, 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, permafrost temperature, and particle size, these thawed soils may or may not revert back to Gelisols.

In the Interior Alaska Lowlands MLRA, poorly developed non-permafrost soils occur in stratified silty, sandy, and gravelly alluvium on the same landforms as the Gelisols, and are formed in the same materials, 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.

Interior Alaska Mountains (MLRA 228)

Soils in the Interior Alaska Mountains MLRA are dominated by fractured bedrock and gravelly colluvium that result from bedrock weathering. Soils on outwash plains, hills, and terraces are composed of eolian deposits over sandy and gravelly alluvium. These soils tend to be excessively drained.

Permafrost is discontinuous in the Interior Alaska Mountains MLRA, with an average temperature of 30°F to 32°F (Brown et al., 1997; Jorgenson et al., 2008). Ice-rich permafrost and thermokarst lakes occur in the lowlands, where loess is deposited. Permafrost is generally absent on south-facing slopes.

Cook Inlet Mountains (MLRA 223)

Soils in the Cook Inlet Mountains MLRA (commonly referred to as "Talkeetna Mountains) are generally deep and range in permeability from well drained to poorly drained. Narrow to broad valleys contain a majority of gravelly and sandy colluvium over fractured bedrock that is typical of this area. Some mid-mountain slopes have formed a surface of silty loess and volcanic ash over gravelly colluvium. Snow-covered peaks and rock outcrops occupy approximately 70 percent of the Cook Inlet Mountains MLRA. Permafrost is discontinuous to sporadic in the Cook Inlet Mountains MLRA, with an average temperature of 30°F to 32°F (Brown et al., 1997; Jorgenson et al., 2008). Ice-rich permafrost and thermokarst lakes locally occur in the lowlands. Permafrost is generally absent on south-facing slopes.

---

[5] Gelisols are an order in USDA soil taxonomy. They are soils of very cold climates which are defined as containing permafrost within two meters of the soil. Ping, C.L. Article: Gelisols: Part II. Classification and Related Issues Soil Horizons, 2013. 54., doi:10.2136/sh2013-54-4-gc.

Cook Inlet Basin (MLRA 224)

In addition to the Liquefaction Facility, the Project's Interdependent Facilities also cross the Cook Inlet Basin. Soils in the Cook Inlet Basin MLRA are discussed above in Section 7.3.2.1.

7.3.2 USDA NRCS Soils Series and Selected Physical/Interpretive Characteristics

The footprint of the Project facilities, including ancillary facilities, will be identified and refined during Pre-FEED and subsequent phases of the Project. Information concerning the physical and interpretative characteristics of the specific NRCS soil series crossed in the Project area will be presented in a subsequent draft of this Resource Report once further details are known. Table 7.3.2-1 demonstrates how information concerning these soil series will be presented in a subsequent draft of this Resource Report.

TABLE 7.3.2-1

Selected Physical and Interpretative Characteristics of the Soils Crossed by the Alaska LNG Project

Location (Borough/ Census Area)	Alaska LNG Facility	Soil Series (Map Unit) – If available	Range in Slope (Percent)			Drainage Class	Surface Texture	Subsurface Texture	Typical Vegetation	Soil Survey Area Name
			Low	High	Avg.					

7.3.3 Terrain and Selected Physical/Interpretive Characteristics

The footprint of the Project facilities, including ancillary facilities, will be identified and refined during Pre-FEED and subsequent phases of the Project. Information concerning the terrain units crossed within the Project area will be presented in a subsequent draft of this Resource Report once further details are known. Table 7.3.3-1 demonstrates how information concerning terrain will be presented in a subsequent draft of this Resource Report.

TABLE 7.3.3-1

Selected Physical and Interpretative Characteristics of the Terrain Crossed by the Alaska LNG Project

Location (Borough/ Census Area)	Alaska LNG Facility	Terrain Unit Symbol	Terrain Description	Soils Description	Permafrost			Surface Drainage
					Frozen Ground %	Thaw Sensitive %	Thaw Stable %	

This effort involves using interpretation of stereo imagery, terrain analysis, LiDAR and geologic information to map landforms expected to occur from the ground surface to a depth of about 50 feet.

7.3.4 Topography

The topography of the Project area varies from the high mountain peaks in the Brooks and Alaska ranges to below sea level in Cook Inlet. The footprint of the Project facilities, including ancillary facilities, will be identified and refined during Pre-FEED and subsequent phases of the Project. Information concerning the topography of the Project area will be presented in a subsequent draft of this Resource Report once further details are known. Table 7.3.4-1 demonstrates how information concerning topography will be presented in a subsequent draft of this Resource Report. Topography for the Project area is also provided in Appendix A of Resource Report No. 1. and in Resource Report No. 6.

TABLE 7.3.4-1

Topography in the Alaska LNG Project Area

Alaska LNG Facility	Approximate MP	Major Land Resource Area	Average Elevation Range (ft)	Topography	Special Features

7.4 SOIL PROPERTIES AND PERMAFROST

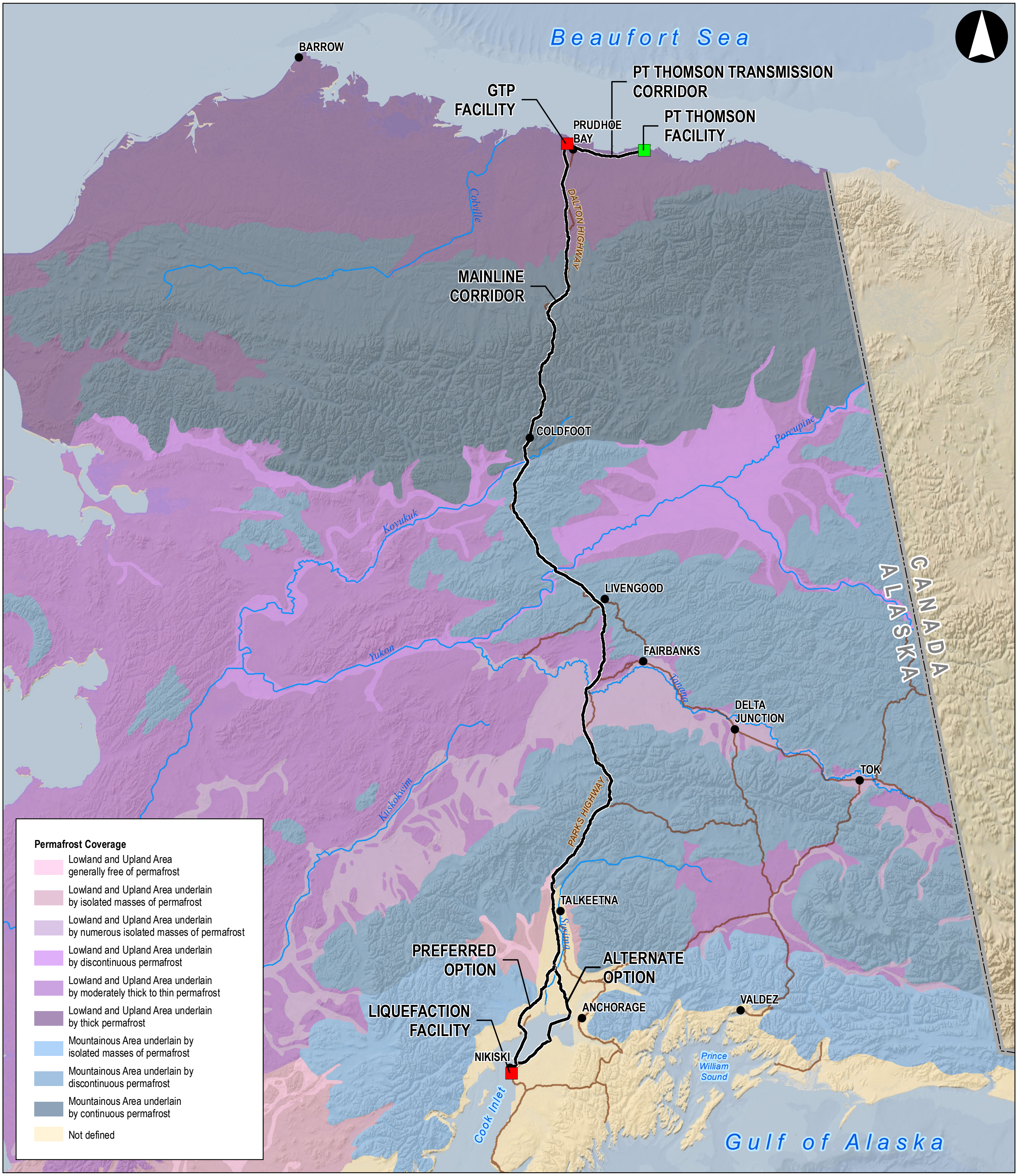
Knowledge of the soil properties and permafrost in the Project area is necessary for predicting potential Project impacts and determining measures to reduce the potential for impact.

Upon completion of a review of the Project footprint and available soils information, including studies by private oil and natural gas companies, as well as peer-reviewed journals, the adequacy of soil information in the Project area will be determined. This will be used to inform geotechnical investigations (subsurface exploration and laboratory testing program) for support of engineering design and execution planning to reduce effects of geotechnical hazards, such as thaw settlement. Information concerning geological hazards (e.g., mass wasting, seismicity, liquefaction) is provided in Resource Report No. 6.

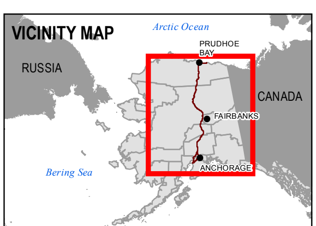
The information below discusses how individual soil properties and the presence of permafrost will be evaluated across the Project area. The footprint of the Project facilities, including ancillary facilities, will be identified and refined during Pre-FEED and subsequent phases of the Project. Information concerning the location of individual soil limitations in the Project area will be presented in a subsequent draft of this Resource Report once further details are known.

7.4.1 Permafrost

Permafrost is defined by DGGS (2011) as any soil, subsoil, or other surficial deposit, or even bedrock, occurring in the arctic, subarctic, and alpine regions at variable depth beneath the Earth's surface in which a temperature below freezing has existed continuously from two years to tens of thousands of years. On the basis of its extent, permafrost is classified as continuous (covering from 90 to 100 percent of an area), discontinuous (50 to 90 percent coverage), sporadic (10 to 50 percent coverage), isolated patches (up to 10 percent coverage), or absent (Brown et al., 1997) (see Figure 7.4.1-1). Permafrost creates an impermeable layer that inhibits drainage and causes surface saturation on much of the landscape (Everett, 1975). Polygonal patterning may develop when winter contraction forms fractures in the surface soils, which then fill with water in summer, and freeze in the winter. Subsurface ice wedges may grow as a result of seasonal surface distortion of soil (Lachenbruch, 1962; Washburn, 1980).



VICINITY MAP



LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Project Corridor
- Major Highways
- Major Rivers

0 35 70 140 Miles

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ALASKA PERMAFROST EXTENT & RANGES

FIGURE 7.4.1-1

Alaska LNG

X:\Projects\ExxonMobil\SCLNG\Mapping\20150106_ResourceReportFigures_Rev3\RR7\Figure 7_4_1-1 Permafrost Extent and Ranges.mxd

Near-surface soils subject to seasonal thaw are referred to as the active layer. Active-layer depths in the Project area range from 0.9 to 4.2 feet, with an average of about 1.5 feet. The areas with the deepest active layer are adjacent to bodies of water (Jorgenson and Brown, 2005). The thickness of the active layer is governed by multiple variables, including mean annual air temperature, soil texture, water-holding capacity, and vegetation cover. Areas with thick organic cover tend to have a shallower active layer than other areas due to the insulation provided by the organic material (Kade et al., 2006).

Permafrost can occur in both soils and bedrock. Generally, the ice content in the soil or bedrock is related to the porosity and the moisture content of the material before it freezes. However, moisture migration during freezing can create massive ice formations. In general, fine-grained soils tend to have higher ice content than coarse-grained soils, which in turn generally have higher ice content than fractured bedrock. Permafrost and ice content are not synonymous. Thaw-induced effects such as thaw settlement are related, directly or indirectly, to the water, and/or ice content of permafrost.

7.4.1.1 Effects of Permafrost Alteration

Permafrost can be disrupted naturally by climate change, forest fires, or drainage of lakes or artificially by human-induced impacts. Permafrost degradation occurs as a result of thawing of near-surface permafrost and lowering of the permafrost table. Permafrost aggradation is the result of cooling soil temperatures and the propagation of permafrost. Both degradation and aggradation can be triggered by natural or artificial influences.

Warming of the upper permafrost soil results in deepening of the active layer. When the affected permafrost contains substantial ground ice, thaw-induced subsidence, solifluction, soil creep, erosion, or mass wasting may occur, depending on site-specific conditions such as topography and soil stratigraphy. The presence of visible ground ice indicates that moisture contents in the frozen soil 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 produced by melting of ground ice in the soil matrix. Slope instability related to thawing of permafrost may include viscous flow in the downslope direction, or sudden thawed layer detachment. These slope-related effects may occur in areas characterized by thick unconsolidated sediments as well as areas with thin permafrost soils over bedrock.

Thermokarst features are formed by the melting of ice in an ice-rich soil, leaving local voids and potentially causing the ground surface to subside. The degree and extent of thermokarst development is largely dependent on the volume and distribution of ground ice and mineral grain size (Walker et al., 1987). Ground ice is found as either pore ice, occupying the pore spaces in organic or coarse mineral soils, or as massive ice, such as ice wedges or pooled ice (Tedrow, 1977). If water is prevented from draining due to the presence of underlying permafrost or other confining layers, the soil may become saturated and lose strength. This weakening may increase susceptibility of soils composed of loose sand or non-plastic silt to liquefaction from seismic wave propagation, and to erosion.

Long-term freezing of previously unfrozen ground may lead to frost heaving in some fine-grained soils. Frost heaving is caused by the expansion of soil volume due to the formation of ice within pore spaces, and development of ice lenses. This change in volume results in upward displacement of the ground surface. When frost heaving happens on a large scale, such as at the site of a former lake, pingos may develop. Pingos are common on Alaska’s North Slope, and are generally the local topographic highs.

7.4.1.2 Thaw-Stable and Thaw-Sensitive Soils

Thaw-stable permafrost soils are soils that, upon thawing, do 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).

Thaw-sensitive soils are soils, which, 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).

To differentiate thaw-stable and thaw-sensitive permafrost in the Project area, data from Project terrain evaluations, as well as data (e.g., mapping, borehole drilling, and geophysical surveys) from other projects (e.g., ANGTS) are being analyzed. For portions of the Project area not covered by other datasets, the STATSGO2 dataset is being 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 developed by transecting representative map units and determining the representative percentage of each component soil in the map unit;
- 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 a high ice content and could potentially be subject to thaw-induced subsidence and slope instability. All STATSGO2 map unit soil components that are classified into the Gelisols soil order and have somewhat poor, poor, and very poor drainage classes are considered thaw-sensitive permafrost soils. All soils not meeting these criteria are considered thaw-stable permafrost soils or non-permafrost soils.

Additional terrain mapping and geotechnical investigation will supplement the merged data to better refine soil conditions.

The footprint of the Project facilities, including ancillary facilities, will be identified and refined during Pre-FEED and subsequent phases of the Project. Information concerning thaw-stable and thaw-sensitive soils in the Project area will be presented in a subsequent draft of this Resource Report once further details are known.

7.4.2 Erosion

Erosion is a natural process that can be accelerated by ground disturbance. Factors that influence the degree of erosion include soil texture, structure, length and steepness 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, could result in the discharge of sediment to waterbodies and wetlands. Soil loss due to erosion could also reduce soil fertility in agricultural land and impair natural revegetation.

For the Project area, soil erodibility will be determined based on textural characteristics of soils associated with Project terrain mapping in conjunction with the terrain profile. Landforms will be assigned soil properties, including grain size, based on available laboratory test data and qualitative descriptions of soil characteristics. The grain size and soil type are then used to classify soil erodibility in the respective terrain polygon. When considered in combination with Project-specific slope datasets and geothermal conditions, erosion potential along the route, as well as appropriate mitigation measures, can be assessed[6]. Although coarse sediments of floodplains are not 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. Erosion potential is considered only for overland segments of the route.

In addition to the terrain-based analysis of erosion potential, the Project area will be 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 will be 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)7 (Table 7.4.2-1); and
- Land Capability Subclass (SCL) (Table 7.4.2-2).

Soils in WEG 1 and 2 include coarse-textured soils with poor aggregation that are particularly susceptible to wind erosion (Table 7.4.2-1). A component soil is considered to be highly erodible by wind if it is in WEG 1 or 2. Most soils 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.

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[6] Data for soil erodibility, right-of-way slope, and frozen moisture content can be used to conduct an engineering assessment of erosion potential along the Project route.

[7] 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

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, years)
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 2011b).

[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.

TABLE 7.4.2-2

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

Group or Class	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.

TABLE 7.4.2-2

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

Group or Class	Description
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 water table, 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 2011b).

[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.

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 lack of SCL designations for many non-agricultural soils. Soils in SCL 4e or higher have severe to extreme erosion limitations for agricultural use and are usually classified as HEL. A component soil will be considered to be generally highly erodible by water if the soil is in SCL 4e through 8e. The STATSGO2[8] data indicate that 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. Given that 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).

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 an area-specific assessment.

[8] STATSGO2 data include broad intermediate slope classes (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.

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 Resource Report No. 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 a groundwater regime that resembles a "perched" water table, with saturated soils above and unsaturated soils below the impermeable layer. Permafrost presence, combined with low evapotranspiration, results in extensive hydric soils being present in level areas and on sloping ground. Hydric soil designations will be based on component soil attributes in the STATSGO2 database.

7.4.4 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. Equipment traveling over wet, unfrozen soils can 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 are the most susceptible to compaction and/or rutting. Coarse-textured, well-drained, and non-permafrost soils or permafrost soils that remain frozen are not typically considered compaction-prone.

Compaction-prone soils in the Project area will be identified by querying the STATSGO2 database for component soils that have a histic epipedon[9]; a surface texture of sandy clay loam or finer; and/or a drainage class of somewhat poorly drained through very poorly drained.

7.4.5 Stony/Rocky Soils

Soils with cobbles, rocks, and boulders present can affect constructability and revegetation. 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; deposits in active and lower terraces of high-gradient streams; and glacial till. Terrain-mapped soil groups will be developed for the Project area based on the texture, layering, and stratigraphic unit description associated with the surface strata characteristics. The soil units will then be classified to qualitatively represent stone, cobble, and boulder content.

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[9] 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.

Blasting may be required in areas where shallow bedrock, boulders, coarse soils, and/or permafrost are encountered and cannot be removed by conventional mechanical excavation equipment. Route geotechnical, geologic, and geophysical datasets will be analyzed to identify areas where blasting may be required. Areas potentially requiring blasting are also discussed in Resource Report No. 6.

7.4.6 Topsoil

There is limited agricultural land in the Project area; however, topsoil depth may be relevant in construction and revegetation planning. Topsoil depth will be determined using the NRCS STATSGO2 dataset by grouping the lower limit of the component soil A horizons into one of five thickness ranges:

- 1–6 inches;
- 6–12 inches;
- 12–18 inches;
- 18–24 inches; and
- Greater than 24 inches.

Histic epipedons are separated from soils with mineral topsoils. Acreage and percentages of soils within each topsoil group will be summarized by map unit. When the component soil can be inferred by aerial photographic interpretations in the context of the terrain unit, the topsoil depths characteristic of the component soil series will be used.

7.4.7 Slope

The identification of slopes is relevant to erosion and mass wasting, as described in Resource Report No. 6. Publicly available and Project-specific DEM data will be used to identify slope-related characteristics along the Project area. Results will be summarized in terms of the areal extent of slope classes listed in Table 7.4.2-2 in the Project footprint to be defined during Pre-FEED.

7.4.8 Droughty Soils and Poor Revegetative Potential

Droughty soils that have coarse-textured surface layers and are moderately well to excessively drained may prove difficult to revegetate. Drier, coarser-textured soils have a lower water-holding capacity, which can hinder germination and produce moisture deficiencies in the root zone, creating unfavorable conditions for many plants. Droughty soils in the Project area will be identified by querying the STATSGO2 database for component soil series that (1) have a surface texture of sandy loam or coarser and (2) are moderately well to excessively drained.

7.5 POTENTIAL CONSTRUCTION IMPACTS AND MITIGATION MEASURES

Impacts to soil resources from Project construction and the potential soil-related hazards encountered will vary with the properties of the soil types crossed. This will include consideration of the presence of permafrost and thaw-sensitive areas. A general summary of potential impacts to soils resources from construction of projects similar to this Project is provided in Appendix A. This appendix also includes a summary of the types of plans, as examples, that can be developed to address potential impacts. As additional Project details become available, a subsequent draft of this Resource Report will identify site-specific impacts to soil resources crossed by the (1) Liquefaction Facility and (2) the Interdependent Facilities. Included will be a discussion of general impacts and mitigation measures from similar projects in Alaska plans and mitigation measures, including any site-specific measures.

Some of the examples provided in Appendix A of the types of plans or measures and best management practices (BMPs) will include FERC's 2013 or the Project's *Upland Erosion Control, Revegetation, and Maintenance Plan* with requested project-specific variances or modifications. Alaska LNG will also work with the appropriate land management agencies (e.g., the U.S. Department of the Interior, Bureau of Land Management [BLM], the U.S. Army Corps of Engineers [USACE], the U.S. Department of Defense [DOD], and ADNR) to further define/develop appropriate mitigation measures to be employed on public lands.

7.6 POTENTIAL OPERATIONAL IMPACTS AND MITIGATION MEASURES

Impacts to soil resources from Project operation and the potential soil-related hazards encountered will vary with the properties of the soils crossed. Considerations for impacts to soil resources as a result of Project operation generally include:

- Permanent conversion of soils with the installation of impervious surface (e.g., foundations);
- Maintenance activities (e.g., seasonal considerations);
- Differential thaw settlement along and across the right-of-way; and
- Contamination (e.g., spills).

A general summary of potential impacts to soils resources from operation of projects similar to this Project is provided in Appendix A. This appendix also includes a summary of the types of plans, as examples, that can be developed to address potential impacts. As additional Project details become available, a subsequent draft of this Resource Report will identify site-specific impacts to soil resources crossed, or in the vicinity of, the (1) Liquefaction Facility and (2) the Interdependent Facilities. Included will be a discussion of proposed mitigation measures, including site-specific measures.

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APPENDIX A GENERAL IMPACTS FROM SIMILAR PROJECTS IN ALASKA

Potential Impact	Project Activity											Resource Report No.	*Potential Plans to Address Impacts
	Grading, Clearing, Excavating (incl. Blasting), Trench, Pipelay, Backfill, Reclamation	**Water Crossings (Pipelines & Bridges)**	**Ice Roads & Pads**	**Erosion Control & Drainage Control**	**Water Withdrawal & Usage**	**Water Discharge**	**Solid Waste Storage & Disposal**	**General Infrastructure Activities**	**Facility Construction**	**Facility Operations**	**Offshore Construction**		
Air Emissions (including dust) from Construction	X	X	X	X	X	X	X	X	X		X	1, 9	C, J, O, T, W
Air Emissions from Operations										X		9	J, W, LL
Surface Water Quality Impacts (Increased Turbidity [TSS] / Sedimentation in Surface Water)	X	X	X	X	X	X	X	X	X	X	X	2, 3, 7	G, H, J, T, V, Y, II, KK
Contamination Migration	X	X				X	X	X		X		1, 2, 3, 7	G, I, GG
Disruption / Loss of Wildlife, Fish or Marine Mammal Habitat	X	X	X	X	X	X		X	X	X	X	2, 3	A, B, C, G, H, K, N, R, V, DD, EE, JJ
Disturbance & Vessel Strikes from Vessel Traffic								X		X	X	3	B, N
Disturbance of Known Historic Archaeological or Architectural) and Paleontological Resources	X	X	X					X	X		X	1, 4, 6, 7	C, D, E, Z, AA
Erosion	X	X		X		X			X		X	1, 2, 6, 7, 8	G, H, II, KK
Groundwater Impacts (Withdrawal, Drawdown, Vertical & Horizontal Hydraulic connectivity, Wells)	X	X	X		X				X	X		1, 2	Y, MM
Hazards to Aviation								X	X	X		1, 11	M
Hazards to Marine Navigation		X						X			X	1, 11	B, M
Inadvertent HDD Mud Release		X										1, 2, 3, 7	I
Incidental Take of Wildlife, Birds, & Marine Mammals	X	X	X		X	X	X	X	X		X	3	A, B, C. F, G, H, N, R
Increased Surface Water Runoff	X			X		X			X	X		2, 3, 7	Y, II
Introduction of Non-native Species	X	X	X			X		X	X	X	X	2, 3	G, K, KK
Impact to Public Use or Public Land	X	X						X	X	X	X	1, 2, 3, 8	B, F, H, L, BB, CC, FF
Impacts to existing infrastructure	X							X	X	X	X	1, 2, 3, 7, 8	M, S, U
Construction Noise Impacts	X	X						X	X			3, 9	C, F, P, N, FF, JJ
Operational Noise Impacts										X		9	F, P, FF
Potential Impacts to Vegetation, Wildlife, Fish, Birds, & Threatened Species	X	X	X	X	X	X	X	X	X	X	X	1, 2, 3, 6, 7, 8, 9	A, C. G, H, K, Q, R, T, DD,EE, JJ
Fish passage impacts		X										3	H, DD, JJ
Reduced Surface Water Recharge Rates	X		X		X	X						2, 3, 6	V, Y, MM
Watercourse Realignment and Scouring		X		X		X		X	X			2	G, H, V
Seismic Hazards / Mass Wasting, Soil Liquefaction	X	X						X	X	X	X	1, 6, 11	X
Tundra Degradation, Thermokarst	X	X	X	X	X				X	X		2, 3, 6, 7	G, X, KK
Unanticipated Discovery of Cultural Resources	X	X	X					X	X		X	1, 4	D, E
Unanticipated Discovery of Paleontological Resources	X	X						X	X		`	1, 4, 6	C, Z, AA
Unplanned spills/releases		X							X	X	X	2	G, I, HH, II
Vegetation & Topsoil Degradation or Loss	X		X	X				X				3, 7	G, II, KK

Potential Impact	Project Activity												*Potential Plans to Address Impacts
	Grading, Clearing, Excavating (incl. Blasting), Trench, Pipelay, Backfill, Reclamation	Water Crossings (Pipelines & Bridges)	Ice Roads & Pads	Erosion Control & Drainage Control	Water Withdrawal & Usage	Water Discharge	Solid Waste Storage & Disposal	General Infrastructure Activities	Facility Construction	Facility Operations	Offshore Construction	Resource Report No.	
Vertical and Horizontal Hydraulic Connectivity of Ground Water and Surface Water (Groundwater Discharge to Surface Water)	X	X	X		X	X			X		X	2, 3	C, G, X, Y, MM
Visual Impacts	X	X					X	X	X	X	X	1, 8	L, V, CC
Waste from Construction and Operations - Liquid and Solid, Hazardous and Non-Hazardous									X	X		2, 8	T
Impacts to Wetlands – footprint and functionality									X			2	DD, EE
***Potential Plans to Address Activity**	A, C, D, E, G, K, L, O, P, R, Z, GG, II, KK	D, E, G, H, I, K, L, O, V, Y, DD, EE, II, JJ	G, L, O, R	G, L, O, V, II, KK	G, L, O, MM	G, K, L, O Y, MM	G, O, T, Y, GG, HH	D, G, M, O, R, S, HH, II	D, E, F, G, K, M, P, R, S, T, W, X, Z, FF, GG, HH, JJ, II, MM	F, HH, J, K, O, P, R, T, W, FF, MM	D, E, G, M, N, O, P, Q, R, W	All	

List of Potential Plans*

A. Avian Protection Plan

B. Marine Logistics Shipping Plan

C. Blasting Plan

D. Unanticipated Cultural Resource Discovery Plan

E. Cultural Resources Data Recovery Plans and/or Treatment Plans

F. Ambient Noise Level Studies

G. FERC 2013 Wetland and Waterbody Construction and Mitigation Procedures with Requested Project-Specific Variances (the Applicants' Procedures) AKLNG Procedures

H. Site-specific Waterbody Crossing Plans

I. HDD Inadvertent Release Plan (Project Specific HDD Contingency Plan)

J. Health Impact Assessment

K. Invasive Species Mitigation Plan

L. Public Land Construction Plan

M. Project Logistics Plans

N. Marine Mammal Mitigation and Monitoring Plan

O. Mobile Emissions Control Plan

P. Noise Control and Mitigation Plan

Q. Plan of Cooperation (POC)

R. Polar Bear and Wildlife Interaction Plan

S. Project Transportation Plan

T. Project Waste Management Plan

U. Project-specific Railroad crossing Plans

V. Riparian Buffer Planting Plan

W. Modeling Site-specific Impacts to Air Quality Emissions

X. Site-specific Geohazards Plan

Y. Water Monitoring Plan

Z. Unanticipated Paleontological Discovery Plan

AA. Paleontological Resources Management Plans

BB. Site-specific Public Land Use and Recreational Use Coordination Plans

CC. Visual Aesthetics Study

DD. Site-specific Wetland Resources Crossing Plans (as required)

EE. Wetland Mitigation Plans

FF. Site-specific Noise Mitigation Plans (as required)

GG. Unanticipated Contamination Discovery Plan

HH. Spill Prevention, Control, and Countermeasure Plan (SPCC)

II. Storm Water Pollution Prevention Plan (SWPPP) – general and spread specific

JJ. Species-specific Wildlife Protection Plan

KK. FERC 2013 Upland Erosion Control, Revegetation, and Maintenance Plan with Requested Project-Specific Variances (the Applicants' Procedures) AKLNG Plan

LL Design/Operations Emissions Management Plan

MM Groundwater Management Plan

* In addition to the potential plans listed above, FERC requires implementation plans that outline how the Project will meet all required environmental permits and stipulations. The applicants will also prepare overarching Construction Environmental Management Plans and Operations Environmental Management Plans for the Project.