ALASKA LNG

DOCKET NO. CP17-___-000
RESOURCE REPORT NO. 7
SOILS
PUBLIC

DOCUMENT NUMBER: USAI-PE-SRREG-00-000007-000

RESOURCE REPORT No. 7 SUMMARY OF FILING INFORMATION [1]	
Filing Requirement	**Found in Section**
1. Identify, describe, and group by milepost the soils affected by the proposed pipeline and aboveground facilities – Title 18 Code of Federal Regulations (CFR) part (§) 380.12(I)(1)	7.3
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 – 18 CFR § 380.12(I)(2	N/A for Project
3. Describe by milepost potential impacts on soils – 18 CFR § 380.12(I)(3,4)	7.5
4. Identify proposed mitigation to minimize impact on soils and compare with the staff's Upland Erosion Control, Revegetation, and Maintenance Plan – 18 CFR § 380.12(I)(5)	7.7 and Appendix D

[1] Guidance Manual for Environmental Report Preparation, Volume I (FERC, 2017). Available online at: https://www.ferc.gov/industries/gas/enviro/guidelines/guidance-manual-volume-1.pdf.

Resource Report No. 7
Agency Comments and Requests for Information Concerning Soils

Agency	Comment Date	Comment	Response/Resource Report Location
ADNR/AG/PMC	9/25/2016	General comment for this resource report. Plant Materials Center oversees a Weed Free Gravel Program. This voluntary program aims at providing a weed free gravel product to land managers working in sensitive areas while also offering producers a way to certify materials for a value-added product. More information on this program can be accessed here http://plants.alaska.gov/invasives/weed-free-gravel.htm	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
ADNR/AG/PMC	9/25/2016	V.D.3.a through V.D.3.h, points listed under 'Seeding Requirements' need to be discussed in greater detail. What are the methods of seedbed preparation, what are the seeding mixtures and seeding rates, what are the seeding dates, how is dormant seeding performed?......., etc.	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
ADNR/AG/PMC	9/25/2016	V.D.3.e, "The project will adhere to written recommendations from the local soil conservation authorities". The Plant Materials Center would like to be included as one of the 'authorities' for this section.	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
ADNR/DGGS/ Engineering Geology	9/25/2016	"These soils have a pergelic soil temperature regime (a mean soil temperature of less than 32 °F), are underlain by permafrost within 6.5 feet of the surface, and are formed from a variety of parent materials, including glacial deposits, mountain colluvium, residuum, loess, and organic materials." Describing "mountain colluvium" as a soil source in the Arctic Coastal Plain, a region with no mountains, seems in error?	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
ADNR/DGGS/ Engineering Geology	9/25/2016	"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 Brooks Range is not barren of vegetation, even in areas of very thin soils.	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
ADNR/DGGS/ Engineering Geology	9/25/2016	"Depths to permafrost typically increase in recently burned areas on north- and east-facing slopes." Depth to permafrost typically increases on recently burned slopes of all aspects; what is the reason for singling out only north-and east-facing slopes?	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
ADNR/DGGS/ Engineering Geology	9/25/2016	"Flooding is associated with spring snowmelt and runoff from adjacent mountains and ice jamming at river bends during break up." Flooding can also be associated with extreme rainfall events.	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
ADNR/DGGS/ Engineering Geology	9/25/2016	"Most urban and rural developments are located adjacent to rivers, where flooding is a severe hazard." Suggest rewording to "where flooding can be a severe hazard."	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
ADNR/DGGS/ Engineering Geology	9/25/2016	Colors in legend do not match map labels. For example, s9347 near the Yukon River crossing is green but the color in the legend is blue.	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
ADNR/DGGS/ Engineering Geology	9/25/2016	"As stated in Section 7.3.1, and in Table 7.3.1-1, Project components within the Arctic Coastal Plain MLRA (Mainline route MP 0.0 - 59.59, PTTL, PBTL, and GTP) cross primarily thick gravelly permafrost soils that are thaw-stable." This statement was not made in the cited sections/table. The statement made below	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.

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		(from page 27) in this section implies the soils are thaw-sensitive "The majority of the soils in the Arctic Coastal Plain MLRA fall under the Turbel soil subgroup, which consists of poorly and very poorly drained soils, impeded by the presence of permafrost, loamy stratified sediments with thaw-sensitive ground ice below 10 inches"	
ADNR/DGGS/ Engineering Geology	9/25/2016	Table 7.4.4-1 Depth to Water Table for Finer Particle loams, very poorly drained is shown as "6-12 months." This is not a depth measurement; statement may be in error.	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
BLM	9/26/2016	It is strongly recommended that construction/engineering techniques which minimize the impacts to permafrost are utilized. The proposed activity includes what sounds like a pretty shallow gravel pad over the extent of the project. Can engineering techniques that be used in conjunction with gravel pads (foam?) that would: i. Minimize impacts to permafrost and water table changes and therefore wildlife habitat; ii. Minimize the need for long-term gravel dependent resource extraction from the area for maintenance of the gravel as shifts in the underlying permafrost and water table lead to disintegration of the gravel pad (e.g. potholes).	The Applicant will address State of Alaska agency comments during the State permitting processes and timeframes.
EPA	9/30/2016	We recommend that the Reports include potential modifications, or descriptions of already incorporated modifications, to the design of the project to improve its resilience to the future climate scenarios. For example, the Reports indicate that permafrost soils would be impacted. Permafrost stability or anticipated changes to existing permafrost conditions can affect settlement and ground stability characteristics that would in turn significantly influence design and construction of the project components, such as facilities and infrastructure.	Climate change design considerations are addressed in Resource Report 1 Section 1.3.
EPA	9/30/2016	Soil Impacts During Project Construction - This Table is incomplete – Data Gaps. This table provides construction impacts to thaw sensitive permafrost soils from the mainline pipeline to be approximately 3,320 acres. We recommend that the construction impacts to permafrost be estimated resulting from the LNG Plant, Marine Terminal, PBTL, PTTL, GTP and associated infrastructure, and the non-jurisdictional facilities. The remaining impact values should be completed for the Table.	Based on available information, permafrost impacts to the LNG Plant, Marine Terminal, PBTL, PTTL, GTP, and the non-jurisdictional facilities are provided in Table 7.4.1-1 and also in Sections 7.5 and 7.6. The LNG plant is not on permafrost.
EPA	9/30/2016	Permafrost soils (Liquefaction Facility) – We recommend that the Reports include (1) baseline estimates of the quantity (acres or tons) of permafrost soils in the area of the Liquefaction Facility and (2) the impacts (acres or tons) to permafrost soils from the construction of the Liquefaction Facility. Permafrost soils serve as natural GHG sinks or reservoirs by trapping organic carbon in ice. As permafrost soils are impacted from construction activities, certain GHGs, such as carbon and methane are released into the atmosphere. We recommend that the permafrost soils be evaluated for potential GHG emissions (CO2-equivalent/acre or ton) during project construction of	As stated in Section 7.5.3.1, the Non-Jurisdictional features are not located on any known thaw sensitive permafrost soils.

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		the Liquefaction Facility.	
EPA	9/30/2016	Erodible Soils (Liquefaction Facility). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of erodible soils in the area of Liquefaction Facility and (2) the construction impacts (acres) to erodible soils from the construction of Liquefaction Facility. Similar to the Permafrost Map, we recommend that there be a map depicting the distribution of Erodible Soils in the Project Area.	A summary of soils impacted by construction at each facility is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Hydric Soils (Liquefaction Facility). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of hydric soils in the area of the Liquefaction Facility and (2) the construction impacts (acres) to hydric soils from the construction of the Liquefaction Facility. Similar to the Permafrost Map, we recommend that there be a map depicting the distribution of Hydric Soils in the Project Area.	A summary of soils impacted by construction at each facility is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Compaction-Prone Soils (Liquefaction Facility). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of compaction-prone soils in the area of the Liquefaction Facility and (2) the construction impacts (acres) to compaction-prone soils from the construction of the Liquefaction Facility. Similar to the Permafrost Map, we recommend that there be a map depicting the distribution of Compaction-prone Soils in the Project Area.	A summary of soils impacted by construction at each facility is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Topsoil (Liquefaction Facility). We recommend that a map be included where the top soil would be stored on existing uplands. If topsoil would be stored in wetland areas, then this impact should be evaluated and a discussion as to why upland alternatives are not available should be included. The Reports should describe the best management practices that would be implemented to prevent erosion, inadvertent mixing, and excessive compaction.	Topsoil storage will be decided during construction by the contractors. All current wetlands located on the Liquefaction Facility would be permanently impacted. The Applicant Plan provides the BMPs requested.
EPA	9/30/2016	Stony/Rocky Soils (Liquefaction Facility). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of stony/rocky soils in the area of the Liquefaction Facility and (2) the construction impacts (acres) to stony/rocky soils from the construction of the Liquefaction Facility. Similar to the Permafrost Map, we recommend that there be a map depicting the distribution of Stony/Rocky soils in the Project Area.	Due to the limited existing data, soils impacted by the Project were not able to be classified by Stony/Rocky features. Instead available data was used to determine depth to restrictive layer, which also serves as a strong indicator of re-vegetation potential. This information is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Prime Farmland Soils (Liquefaction Facility). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of prime farmland soils in the area of the Liquefaction Facility and (2) the construction impacts (acres) to prime farmland soils from the construction of the Liquefaction Facility. Similar to the Permafrost Map, we recommend that there be a map depicting the distribution of Prime Farmland Soils in the Project Area.	No Prime Farmland soils exist in Alaska.
EPA	9/30/2016	Interdependent Project Facilities. We recommend that the Reports include similar analysis of the soil types mentioned above for the interdependent project	A summary of soils impacted by construction at each facility, including Interdependent Project facilities, are

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		facilities.	provided in Section 7.5-1 and also in further detail in Appendix B in Resource Report No. 7.
EPA	9/30/2016	Permafrost Soils (Mainline Pipeline, PBTL, and PTTL). We recommend that the Reports include (1) baseline estimates of the quantity (acres or tons) of permafrost soils in the area of the mainline pipeline, PBTL, and PTTL and (2) the construction impacts (acres or tons) to permafrost soils from the construction of the mainline pipeline, PBTL, and PTTL. Permafrost soils are natural GHG sinks or reservoirs by trapping organic carbon in ice. As permafrost soils are impacted from construction activities, certain GHGs, such as carbon and methane are released into the atmosphere. We recommend that the permafrost soils be qualitatively and quantitatively evaluated for potential GHG emissions (CO2-equivalent/acre or ton) during project construction of the mainline pipeline, PBTL, and PTTL.	Based on available information, permafrost impacts to the Mainline Pipeline, PBTL, PTTL, GTP, and the non-jurisdictional facilities are provided in Table 7.4.1-1 and also in Sections 7.5 and 7.6.
EPA	9/30/2016	Granular Pads - The Reports indicate that at compressor stations underlain by thaw-sensitive permafrost, buildings, and associated infrastructure would be elevated and granular pads and would be installed to mitigate heat transfer to the underlying permafrost. We recommend that the Reports should evaluate alternatives to using granular fill material to protect underlying permafrost soils. For example, a reasonable alternative could be to elevate the compressor stations on pile supported engineered structures and install heat dissipaters, similar to the designed used to support the TAPS.	The Applicant will address this comment prior to the issuance of the DEIS
EPA	9/30/2016	Erodible Soils (Mainline Pipeline, PBTL, and PTTL). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of erodible soils in the area of the mainline pipeline, PBTL, and PTTL, and (2) the construction impacts (acres) to erodible soils from the construction of the mainline pipeline, PBTL, and PTTL.	A summary of soils impacted by construction at each facility is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Hydric Soils (Mainline Pipeline, PBTL, and PTTL). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of hydric soils in the area of the mainline pipeline, PBTL, and PTTL, and (2) the construction impacts (acres) to hydric soils from the construction of the mainline pipeline, PBTL, and PTTL.	A summary of soils impacted by construction at each facility is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Compaction-Prone Soils (Mainline Pipeline, PBTL, and PTTL). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of compact prone soils in the area of the mainline pipeline, PBTL, and PTTL, and (2) the construction impacts (acres) to compact prone soils from the construction of the mainline pipeline, PBTL, and PTTL.	A summary of soils impacted by construction at each facility is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Stony/Rocky Soils (Mainline Pipeline, PBTL, and PTTL). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of stony/rocky soils in the area of the mainline pipeline, PBTL, and PTTL, and (2) the construction impacts (acres) to stony/rocky soils from the construction of the mainline pipeline, PBTL, and PTTL.	A summary of soils impacted by construction at each facility is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.

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EPA	9/30/2016	Topsoil (Mainline Pipeline, PBTL, and PTTL). We recommend that the Reports include a map depicting where the top soil would be stored on existing uplands. If topsoil would be stored in wetland areas, then this impact should be evaluated and a discussion as to why upland alternatives are not available should be included. We recommend that the Reports describe the best management practices that would be implemented to prevent erosion, inadvertent mixing, and excessive compaction.	
EPA	9/30/2016	Prime Farmland Soils (Mainline Pipeline, PBTL, and PTTL). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of prime farmland soils in the area of the mainline pipeline, PBTL, and PTTL, and (2) the construction impacts (acres) to prime farmland soils from the construction of the mainline pipeline, PBTL, and PTTL.	No Prime Farmland soils exist in Alaska.
EPA	9/30/2016	Permafrost Soils (PTU expansion, PBU MGS, Kenai Spur Highway). We recommend that the Reports include (1) baseline estimates of the quantity (acres or tons) of permafrost soils in the area of the Non-Jurisdictional Facilities and (2) the construction impacts (acres or tons) to permafrost soils from the construction of the Non-jurisdictional facilities. Permafrost soils are natural GHG sinks or reservoirs by trapping organic carbon in ice. As permafrost soils are impacted from construction activities, certain GHGs, such as carbon and methane are released into the atmosphere. We recommend that the permafrost soils be qualitatively and quantitatively evaluated for potential GHG emissions (CO2-equivalent/acre or ton) during project construction of the non-jurisdictional facilities.	The Applicant will address this comment prior to the issuance of the DEIS
EPA	9/30/2016	Erodible Soils (PTU expansion, PBU MGS, Kenai Spur Highway). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of erodible soils in the area of the non-jurisdictional facilities and (2) the construction impacts (acres) to erodible soils from the construction of the non-jurisdictional facilities.	A summary of soils impacted by construction at each facility is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Hydric Soils (PTU expansion, PBU MGS, Kenai Spur Highway). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of hydric soils in the area of the non-jurisdictional facilities, and (2) the construction impacts (acres) to hydric soils from the construction of the non-jurisdictional facilities.	A summary of soils impacted by construction at each facility is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Compaction-Prone Soils (PTU expansion, PBU MGS, Kenai Spur Highway). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of compaction prone soils in the area of the non-jurisdictional facilities, and (2) the construction impacts (acres) to compaction prone soils from the construction of the non-jurisdictional facilities.	A summary of soils impacted by construction at each facility is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Stony/Rocky Soils (PTU expansion, PBU MGS, Kenai Spur Highway). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of stony/rocky soils in the area of the non-jurisdictional facilities, and (2) the construction impacts (acres) to stony/rocky soils from the construction of the non-	Due to the limited existing data, soils impacted by the Project were not able to be classified by Stony/Rocky features. Instead available data was used to determine depth to restrictive layer, which also serves as a strong

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		jurisdictional facilities.	indicator of re-vegetation potential. This information is provided in Section 7.5 of Resource Report No. 7 and also in Appendix B.
EPA	9/30/2016	Prime Farmland Soils (PTU expansion, PBU MGS, Kenai Spur Highway). We recommend that the Reports include (1) baseline estimates of the quantity (acres) of prime farmland soils in the area of the non-jurisdictional facilities, and (2) the construction impacts (acres) to prime farmland soils from the construction of the non-jurisdictional facilities.	No Prime Farmland soils exist in Alaska.
EPA	9/30/2016	Soil Impacts During Project Operations. This Table is incomplete – Data Gap. This table provides soil impacts during project operations to thaw sensitive permafrost soils from the mainline pipeline to be approximately 3,018 acres. We recommend that the soil impacts to permafrost be calculated for the project operations resulting from the LNG Plant, Marine Terminal, PBTL, PTTL, GTP and associated infrastructure, and the non-jurisdictional facilities. The remaining impact values should be completed for the Table.	Based on available information, permafrost impacts to the LNG Plant, Marine Terminal, PBTL, PTTL, GTP, and the non-jurisdictional facilities are provided in Table 7.4.1-1 of Resource Report No. 7. Additionally, impacts to permafrost are discussed in Sections 7.5 and 7.6.
EPA	9/30/2016	Potential Operational Impacts - Similar to the analysis conducted for construction impacts to each soil type from each facility, the Reports should include this analysis for operational impacts to soils.	A summary of soils impacted by operations at each facility is provided in Section 7.5 of Resource Report 7 and also in Appendix B.
FERC	11/16/2016	The following commitments were made by Alaska LNG in the resource report as information to be provided or pending in response to previous comments made by FERC or other agencies. If the information will not be included in the application as indicated by Alaska LNG, provide a schedule for when it will be filed with FERC or provided to the requesting agency as applicable.	See below
FERC	11/16/2016	a. Within the discussion of operational impacts and mitigation measures, discuss impacts and mitigation for buoyance forces in pipeline discussions.	The Applicant will address this comment prior to the initiation of the EIS process
FERC	11/16/2016	b. Perform thermal modeling to determine the pipelines' potential impact on soil temperatures. The modeling should include the area immediately surrounding the pipeline location, as well as the maximum distance from the pipeline the effects could occur and over what period of time. Include the results of these studies.	The Applicant will address this comment prior to the initiation of the EIS process
FERC	11/16/2016	c. Restoration Plan	See Resource Report No. 3, Appendix P.
FERC	11/16/2016	d. Tables 7.1.3-1 and 7.1.3-2.	Tables 7.1.3-1 and 7.1.3-2 are updated and included.
FERC	11/16/2016	e. Site-specific soil/geotechnical investigations.	Please see Appendices C and I of Resource Report No. 6 for geotechnical studies of the GTP and Liquefaction facilities. Alaska LNG has completed geotechnical investigations along the ML and PTTL.
FERC	11/16/2016	f. The results of the 2015 and 2016 geotechnical engineering analyses, terrain mapping, and DEM data	The Applicant will address this comment prior to the issuance of the

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		analysis that would be used to evaluate areas of the Project footprint for which all soil metadata is not available. Include a detailed discussion of the methodology used to complete each of these investigations and mileposted locations where each was conducted. Discuss how the results of these analyses have been incorporated into construction and restoration planning. Include a discussion, justification, and field verification of methods used to develop the Project-specific geological, geophysical, and geotechnical datasets including Project developed algorithms.	DEIS
FERC	11/16/2016	In response to the April 3, 2015 FWS comment regarding local soil survey information, Alaska LNG stated that the data sets were reviewed and compared to STATSGO2 data. Include clarification on whether any of these recommended data sets were incorporated into the Project soils data set.	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	In response to the May 15, 2015 FERC comment regarding the use of heater stations within the discussion of operational impacts and mitigation measures, it was stated that the text of section 7.6 was updated to provide information. There is no mention of heater stations within section 7.6. Include this discussion.	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	Include a figure and a description detailing the spatial extent that each soils data source (e.g., STATSGO2, geotechnical engineering analysis, etc.) was used in completing the analysis. Section 7.2.1.2 states that the STATSGO2 data set contained "georeferenced vector and tabular data for nearly half (39,590.35 acres) of the entire Project footprint." It is not clear where STATSGO2 data was available and used compared to where other data sources were used to populate tables. In addition, clarify whether or not impacts that are stated in section 7.5 are referencing only those areas that have STATSGO2 data coverage or if other data sources have been incorporated to supplement the data gaps.	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	Section 7.2.3 lists six projects where extensive soil and geotechnical data had been evaluated and states that that publicly available data was also used in the creation of the Project-specific dataset (section 7.2.3, page 7-22). Provide:	See below
FERC	11/16/2016	a. a summary of the specific datasets from the six projects;	The Applicant will address this comment prior to the initiation of the EIS process
FERC	11/16/2016	b. references to the publicly available datasets and any related reports and publications that were used in the analysis;	The Applicant will address this comment prior to the initiation of the EIS process
FERC	11/16/2016	c. a discussion, justification, and field verification of methods used to merge the information from these various data sources; and	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	d. a summary of the existing soil conditions at the facility sites and segments of the pipeline based upon the geotechnical investigations that were performed for	The Applicant will address this comment prior to the issuance of the DEIS

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		this Project or for the six projects mentioned in section 7.2.3.	
FERC	11/16/2016	Update figure 7.3.1-1 to depict the Major Land Resource Areas by color and the Land Resource Regions by a bordered outline. As currently depicted it is difficult to see the boundaries of the Major Land Resource Areas.	The figure 7.3.1-1 has been updated for clarity.
FERC	11/16/2016	Update figure 7.3.2-1 so the colors in the legend match the colors used to symbolize the soils crossed by the Project. For example, s9412 on the map appears brown while the legend shows purple.	The figure 7.3.1-1 has been updated for clarity.
FERC	11/16/2016	Section 7.4.1 includes a brief discussion of thermokarst features. Include a discussion of the thermokarst features specific to the Project area including the aerial and vertical extent of the features. Include a crossing table of these features, or a cross reference to the appropriate section in Resource Report 2.	The Applicant will address this comment prior to the initiation of the EIS process
FERC	11/16/2016	Ice content connectivity was added to a list of factors that influence the degree of erosion in soils in section 7.4.2. Include a discussion of the specific erosion impacts associated with ice content connectivity and include information on how ice content connectivity was calculated to include in the erosion potential numbers presented in table 7.5-1 and table 1 within appendix B.	The Applicant will address this comment prior to the initiation of the EIS process
FERC	11/16/2016	Section 7.4.6 discusses stony/rocky soils but states that the “potential for introducing rock into the topsoil was evaluated based on bedrock depth.” Soils that have significant quantities of rock fragments in the profile also have the potential to introduce rocks to surface horizons. Include soils that have a cobbley, stony, bouldery, channery, flaggy, very gravelly, or extremely gravelly modifier to the textural class; and/or contain greater than 5 percent (by weight) of rocks larger than 3 inches. In addition to shallow bedrock, this soil query should be used in sections 7.5 and 7.6 when discussing impacts and mitigation and added to appendix 7B.	The Applicant will address this comment prior to the initiation of the EIS process
FERC	11/16/2016	Reduced revegetation potential is noted in section 7.5 as a potential construction impact; however, soils that may be affected, and mitigation measures to reduce impacts, are not discussed in the resource report. Include a discussion in section 7.4 of existing soils that may have reduced revegetation potential as a result of construction and include mitigation measures in section 7.5 that would be used to successfully revegetate soils. Insert a new column into tables 7.5-1 and 7.6-1 that shows acres of soils that may have reduced revegetation potential. These discussions should take into account the use of gravel fill along the right-of-way and areas where revegetation would not occur.	The Applicant will address this comment prior to the initiation of the EIS process
FERC	11/16/2016	Using the information gathered from the projects listed on page 7-22, and any other Alaska project experience, include a discussion of the impacts on permafrost that were observed through the construction and operation phases of the projects. Include a discussion of ongoing changes in permafrost observed from the continual operation of projects. Include additional discussion on	The Applicant will address this comment prior to the initiation of the EIS process

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		the proposed construction and operational mitigation measures that were proposed and/or conducted to minimize these potential impacts.	
FERC	11/16/2016	Provide clarification on what Project facilities were included in the acres presented in tables 7.4.1-1, 7.5-1, and 7.6-1. All of the Project facilities listed in section 1.3 of Resource Report 1 need to be included in the analysis including, but not limited to, the following: Update tables 7.4.1-1, 7.5-1, and 7.6-1 as needed. (section 7.4.1, page 7-34; section 7.5, page 7-46; section 7.6, page 7-57)	This information, based on availability, is provided in Appendices B and C, see below.
FERC	11/16/2016	a. access roads;	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	b. additional temporary workspaces;	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	c. construction camps;	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	d. telecommunication towers;	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	e. mainline aboveground facilities (compressor stations, mainline valves);	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	f. heater stations;	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	g. pipe storage yards; and	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	h. rail spurs.	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	Update tables 7.5-1 and 7.6-1 to include the following:	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	a. total acres for each of the facilities included (i.e., LNG Plant, Marine Terminal, etc.);	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	b. acres of permafrost broken down between thaw-stable and thaw-sensitive soils;	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	c. acres of stony/rocky soils;	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	d. acres of shallow depth to permafrost; and	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	e. acres of soils with revegetation concerns (see EIR number 12 above).	The Applicant will address this comment prior to the issuance of the

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			DEIS
FERC	11/16/2016	Include a summary table that shows areas subject to potential soil impacts during construction of the Project by topsoil depth and slope class categories. Topsoil categories should include 0 to 6 inches; 6 to 12 inches; 12 to 18 inches; and greater than 18 inches of topsoil. Slope categories should include 0 to 5 percent; 5 to 8 percent; 8 to 15 percent; 15 to 30 percent; and greater than 30 percent slope. Acreages presented in this table should match the acres presented in revised tables 7.4.1-1, 7.5-1, and 7.6-1.	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	Section 7.5.1.2 discusses erodible soils in relation to the Liquefaction Facility. Include a discussion regarding bluff erosion including what mitigation has been done in the past along the bluffs in Kenai, how it worked, changes observed (increases or decreases) in bluff erosion, and how the Project proposes to improve any shortcomings of past erosion control measures.	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	Section 7.5.2.1 provides a breakdown, by milepost, of the planned natural gas temperature strategy for maintaining soil temperature for operation of a “chilled pipeline.” Given that discontinuous permafrost spans small linear segments of permafrost areas and non-permafrost areas, include justification for the proposed temperature strategy for the Mainline. Additionally, within section 7.6.2, include a description of the current plan for monitoring the Mainline to ensure the gas is within the temperature parameters provided in this section.	The Applicant will address this comment prior to the initiation of the EIS process
FERC	11/16/2016	Given that the Project spans portions of discontinuous permafrost, provide plans for monitoring soils in these areas to ensure that the pre-existing permafrost boundaries are maintained during construction and operation of the Project. Additionally, provide plans for monitoring changes in permafrost in surrounding Project areas due to climate change and an adaptive management plan to assess any needed changes to the Project.	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	Given that the pipeline would be buried for the majority of the Mainline, include a discussion of the potential effects of a chilled pipeline causing a “freezing halo” on active layer processes, including a discussion of impacts on hydrology.	The Applicant will address this comment prior to the issuance of the DEIS
FERC	11/16/2016	Section 7.5.1.5 states that “topsoil would be stripped, segregated, and stored on site for use during final grading and restoration of areas not paved or occupied by plant facilities;” however, it is not clear where topsoil segregation would occur along the Mainline, PTTL, and GTP as discussed in section 7.5.2.6 or if it would occur in areas with soils of local importance as discussed in section 7.5.2.7. The Winter and Permafrost Construction Plan states that “No stripping and/or replacement of stripped topsoil is envisioned on the project…”, whereas table 7.7.1 states that “The Project will make practical efforts to segregate when site conditions allow.” Clarify this discrepancy and provide more detail regarding areas where topsoil segregation	The pipeline construction techniques are discussed in Appendix M of RR1. Figures are shown in Appendix E of RR1. BMP typicals are found in Attachment E of Appendix J of Resource Report No. 2.

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		would take place during construction of the Project and provide the specific topsoil and revegetation BMPs to be used in areas of soil with local importance.	
FERC	11/16/2016	Section 7.5.2.1 lists the potential freeze and thaw-related effects on permafrost that could occur during construction of the Project. The section goes on to list engineering designs and construction mitigation measures to minimize the potential for these effects to occur. Include a discussion of the remediation and mitigation measures that would be implemented if any of these thaw-related effects were to occur during construction of the Project. Include separate discussions for each of the following:	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	a. frost bulb and/or frost heave formation;	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	b. solifluction and soil creep;	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	c. thawed layer detachment; and	The Applicant will address this comment prior to the issuance of the DEIS.
FERC	11/16/2016	d. in situ effects including subsidence and thaw consolidation, thermokarsting, and thaw bulb formation.	The Applicant will address this comment prior to the issuance of the DEIS.
FERC	11/16/2016	Section 7.5.2.5 states "subsurface rocks can be expected in approximately half of the Mainline." Discuss how this determination was made due to the lack of soils data (stated that less than half of the Project area contains both spatial and tabular STATSGO2 data) and clarify if "subsurface rocks" are the result of the shallow bedrock query identified in section 7.4.6.	The Applicant will address this comment prior to the issuance of the DEIS.
FERC	11/16/2016	Section 7.5.2.6 states that "the establishment of stable surfaces would represent an additional man-made landform. This landform would be stabilized and reclaimed, but would be different from preconstruction conditions." Include details on the locations (if any) where gravel pads would be removed versus left in place along the Mainline, PTTL, and GTP. Include a discussion of the stabilization and reclamation efforts that would take place in areas where gravel construction pads would be left in place.	The Project does not intend to remove gravel unless required to do so by the landowner.
FERC	11/16/2016	Include a discussion of the "terrain data" used in section 7.5.2.5 and how it was determined that the PBTL, PTTL, and GTP facilities do not have, or have few, subsurface stones greater than 3 inches in size.	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	Section 7.6 lists a number of potential impacts on soil resources for each of the Project facilities and references "a number of Project plans, procedures, and BMPs that would be applied…" For each of the potential operational impacts on soils (e.g., permanent impervious cover, differential thaw settlement, thermokarsting, degradation of permafrost, frost bulb development, contamination), include separate discussions of the specific measures that could be	The Applicant will address this comment prior to the initiation of the EIS process.

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		used to mitigate for these impacts and how a decision would be made on which ones to use depending on the circumstances.	
FERC	11/16/2016	Include a discussion within section 7.6 of the potential operational life-time impacts on the Project associated with climate change. Include references to research on predicted changes in permafrost from climate change and information on any Project engineering design measures that would mitigate for these changes in permafrost. Also, include a discussion on cryoturbation and changes to hydrology, soil moisture, groundwater recharge, and flowpaths, which may impact or be affected by the Project.	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	27. Section 7.6.2 states that "In areas where removal of granular pads used for construction would be likely to create significant damage to underlying permafrost soils, pads would be left in place following construction to naturally settle, saturate, and eventually revegetate." Include the following	See below.
FERC	11/16/2016	a. more detail on the expected timing of settling, saturating, and revegetating of the granular pads;	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	b. impacts and mitigation discussion on potential for granular pads to settle below ground level and continue to sink; and	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	c. clarification if Alaska LNG is proposing to include these areas in their revegetation plan.	The Applicant will address this comment prior to the initiation of the EIS process.
FERC	11/16/2016	Figure 7.3.2-1 works well as an overview map; however, include a detailed map set (no smaller in scale than 1:24,000) showing the soils types at the Liquefaction Facility, GTP, along the Mainline, and along the PBTL and PTTL pipelines. The map set should include references and differentiate as to where the mapped soils data came from (i.e., STATSGO2 versus other data sets).	STATSGO2 soils data is currently the only available data source which provides the types of soils crossed by the entire Project. Due to the high level scale of the STASGO2 soils data map book based on 1:24,0000 scale would be a reproduction of the same images repeatedly.
FERC	11/16/2016	Table 7.7.1 item IV.F states that "erosion controls will be installed before spring thaw as rain or snow melt can induce erosion and sediment transport." Include additional detail within Resource Report 7 and Appendix D – Upland Erosion Control, Revegetation, and Maintenance Plan on how erosion control measures would be prepared prior to onset of erosion conditions, and maintained during periods/seasons of no construction activity.	The Applicant will address this comment prior to the issuance of the DEIS.
FERC	11/16/2016	Update appendix B tables to include:	See below.
FERC	11/16/2016	a. sequential milepost in/out and distance crossed, in miles, for each soil map unit along the Mainline, PBTL, and PTTL pipelines; and	Updated information is included in Appendix B of Resource Report No. 7.
FERC	11/16/2016	b. acres of impact for each soil map unit impacted by the LNG Plant, GTP, additional temporary workspaces, access roads, aboveground facilities, all additional Project facilities mentioned in question 13 above, and non-jurisdictional facilities.	Updated information is included in Appendix B of Resource Report No. 7.

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FERC	11/16/2016	Update appendix B tables to include additional columns for the following:	Updated information is included in Appendix B of Resource Report No. 7.
FERC	11/16/2016	a. farmland of local importance;	Updated information is included in Appendix B of Resource Report No. 7.
FERC	11/16/2016	b. soils with revegetation concerns;	Alaska LNG will address this comment prior to the issuance of the DEIS.
FERC	11/16/2016	c. stony/rocky soils; and	Alaska LNG will address this comment prior to the issuance of the DEIS.
FERC	11/16/2016	d. shallow depth to permafrost.	The Applicant will address this comment prior to the issuance of the DEIS.
FERC	11/16/2016	Remove sections of the Plan that are marked as “Not Applicable.”	Completed.
FERC	11/16/2016	We suggest adding a reference to the Alaska LNG Restoration Plan for details regarding revegetation and restoration.	The first sentence of Appendix D has been modified to read "The intent of this Plan is to assist the Alaska LNG Project (Project) by identifying baseline mitigation measures for minimizing erosion and enhancing revegetation (Resource Report No. 3 Appendix P Restoration Plan). "
FERC	11/16/2016	The Plan states” Ensure water entering wetlands from slope breakers will be first directed into energy dissipating devices.” This is an alternative measure that must be identified in the Application.	This is the standard BMP in FERC's Plan. Slope breakers empty into straw or hay bales or some other structure to prevent off ROW erosion. BMP's are detailed further in Attachment E of Appendix J of Resource Report No. 2.
FERC	11/16/2016	The Plan states “Ensure the post-construction right-of-way is graded to stable contours with the surface soils in a suitable condition for restoration.” The Project is currently still committing to topsoil provisions in section IV.B; therefore, we suggest adding a measure or editing this existing measure to address topsoil stripping and preservation restoration.	This issue is discussed in Appendix M of Resource Report No. 1.
FERC	11/16/2016	Given the more rural nature of the residential areas crossed by the Project, we suggest increasing the 50-foot distance to 100 feet.	Applicant will maintain 50-foot distance from residential areas, as per FERC requirements in this thinly settled territory.
FERC	11/16/2016	The Plan states “Where fill is imported to provide a stable work surface in any of the above areas, the fill will be left in place.” Current language suggests that FERC has approved the use of fill, which is not the case. Modify this language to be clear on the status of the use of fill for the Project.	This issue is discussed in Appendix M of Resource Report No. 1.
FERC	11/16/2016	The Plan states “The construction right-of-way width for the Project shall not exceed 145 feet or that described in the FERC application unless otherwise modified by the FERC Order.” The width included in the Plan should be the most common right-of-way width	The Applicant will address this comment prior to the initiation of the EIS process

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		proposed for the Project including the additional temporary workspace and travel lane as part of the right-of-way.	
FERC	11/16/2016	Include a cross reference to the Winter Construction and Permafrost Plan here for more information on temporary erosion control measures.	Appendix D. Section III.i. First paragraph, first sentence, has been modified to read "The Project shall develop and file a project-specific Winter and Permafrost Construction Plan with the FERC application. ".
FERC	11/16/2016	The Plan states “Temporary erosion controls must be properly maintained throughout construction (on a regular basis) and reinstalled as necessary…” Include justification for change from “daily” in FERC’s Erosion Control, Revegetation, and Maintenance Plan (Plan) and provide clarification on what “regular basis” will mean (i.e., every other day, weekly).	The Applicant will address this comment prior to the initiation of the EIS process
FERC	11/16/2016	The Plan states “Where temporary erosion slope breakers are installed in wetlands, an energy dissipating discharge structure at the end of the breaker will be installed.” Clarify whether this would only be done within wetlands or if it also relates to other sensitive environmental resources.	Slope breakers will be installed in accordance with the Project Stormwater Pollution Prevention Plan which is in Appendix J of Resource Report No 2.
FERC	11/16/2016	The Plan states “when access is no longer required, the travel lane will be deactivated and the right-of-way will be restored.” Include detail on the locations and site-specific justifications where the travel lane is expected to be left in place for the life of the Project rather than restored. It should be noted that in areas of wetland the permanent fill must be permitted by the COE.	See Appendix M of Resource Report No. 1.
FERC	11/16/2016	The Plan states “Except for agricultural and residential areas, excess trench rock may be spoiled on the right-of-way in such a way as to not impede right-of-way restoration.” This language will need to be identified as an alternative measure with explanations of equal or better environmental protection. If approved by FERC, in addition to not impeding right-of-way restoration, spoiling excess trench rock must not impact surface water hydrology.	These locations will be approved by the landowner (BLM or State) to avoid building roads, disposal sites, and to stabilize the ROW. Locations will be determined during lease/ROW Grant review and approval
FERC	11/16/2016	The Plan states “Grade the construction right-of-way to stable contours with the surface soils in a suitable condition for restoration.” The Plan should indicate that some areas will be returned post thaw and describe who would determine the restoration protocol during the transitional state.	This is addressed in the Restoration Plan which is Appendix L of Resource Report No. 3.
FERC	11/16/2016	The Plan states “Remove temporary synthetic sediment barriers when replaced by permanent erosion control measures or when initial revegetation and/or stabilization is complete.” Clarify if any temporary sediment barriers are proposed to be left in place and include a definition for “initial.”	Slope breakers will be installed in accordance with the Project SWPPP, which is Appendix J of Resource Report No. 2.
FERC	11/16/2016	The Plan excludes text from the FERC Plan which states “Do not install trench breakers within a wetland.” Explain why this language does not apply to the Project, if and where the Applicant plans to install trench breakers in wetlands, justification for this use,	There are wetlands that cover slopes over many areas of the Project (see Resource Report No. 2, Section 2.6). This requires trench breakers within wetlands to prevent erosion along the

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		and how hydrology would be maintained.	trench from runoff on the slope.
FERC	11/16/2016	Add cross reference to the Project Revegetation Plan for more information	Appendix D of Resource Report 7, Section V.D.1.a. has been modified to read "The Project is responsible for ensuring successful revegetation of soils disturbed by project-related activities, except as noted in section V.D.1.b. or in other areas where application of stabilization measures precludes revegetation (such as where a permanent mulch or other ground cover has been installed). (Resource Report No. 3 Appendix P Restoration Plan) ".
FERC	11/16/2016	The Plan states "…or in other areas where application of stabilization measures precludes revegetation (such as where a permanent mulch or other ground cover has been installed)." Clarify this statement to indicate if these stabilization measures would prevent active revegetation or if addition measures would be taken to restore vegetation in these locations.	Yes, the stabilization measure would prevent active revegetation.
FERC	11/16/2016	The Plan states "Seed bed preparation, soil amendments, and seed mixtures will be customized to Arctic and sub-Arctic climatic zones, ecological regions, and soil characteristics." We suggest adding a reference that specifics on seeding locations and seed mixes are found in the Project Restoration Plan.	Appendix D of Resource Report No. 7, Section V.D.3.a. has been modified to read "Seed bed preparation, soil amendments, and seed mixtures will be customized to Arctic and sub-Arctic climactic zones, ecological regions and soil characteristics (Resource Report No. 3 Appendix P Restoration Plan Section 3.1.3)".
FERC	11/16/2016	Add reference to the Project Restoration Plan for additional information.	Appendix D of Resource Report 7, Section V.D.3.e. has been modified to read "The Project will adhere to written recommendations from the local soil conservation authorities, subject to the specifications in section V.D.3.a through V.D.3.d. For additional information see Resource Report No. 3 Appendix P Restoration Plan".
USFWS	9/26/2016	Thermokarsting and subsidence would lead to high maintenance requirements, local changes in drainage patterns, and impacts to wetland resources. These would be avoided by using an above ground pipeline. In our letter dated April 3, 2015, we recommend the first 60 miles of the main gas line from the Prudhoe Bay Unit toward the Brooks Range be elevated on Vertical Support Members (VSMs). The Service continues to recommend the elevated design.	Aboveground versus belowground design and potential impacts are addressed in Resource Report No. 10, Section 10.4.5.1.
USFWS	9/26/2016	Hydrocarbon Spills- The RRs do not contain an in-depth spill analysis for LNG and other petroleum products. A thorough discussion of impacts associated with accidental releases of liquefied natural gas and/or fuel spills into watercourses and the coastal and marine environments of Cook Inlet and the Beaufort Sea is warranted. Section 4.12 of the NPR-A IAP/EIS (2012) (http: www.blm.gov/ak) could be used as a template for	Release of LNG is discussed in Resource Report No. 13. Other fuels are discussed in Resource Report No. 1.

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		this discussion. The Service would appreciate reviewing the spill analysis before the RRs are finalized.	
USFWS	9/26/2016	2nd paragraph: There seems to be conflicting information between what is presented in this paragraph and what is listed in App. C of RR7. Additionally, most of the information presented in all RR s clearly states soils on the ACP are thaw-sensitive (thaw unstable), yet here it says project components within the ACP cross thaw-stable soils. Please define where “thaw stable” soils are likely to be located on the Arctic Coastal Plain (e.g.: historic river corridors)	The statement in the 2nd paragraph of Section 7.4.1.2 has been modified as requested. As the Project Mainline route continues south, the terrain and soils crossed become less continuous and more susceptible to saturation or thawing.
USFWS	9/26/2016	3rd paragraph: There is no “Table 7.4.1-1 in App. C”; however, there is a table 7.4.1-1 in RR7 titled “Immediate Soil Compaction Potential”, which likely is not the intended reference.	This statement has been modified to reference the proper table and appendix.
USFWS	9/26/2016	Please be consistent with the definition for topsoil; see what is provided in App. A of RR7. Topsoil depth is relevant in revegetation work. Most soils in Northern and Interior of Alaska have no A Horizon (commonly referred to as topsoil). However, the organic layer or O horizon is valuable material for reclamation work.	The definition of topsoil in Appendix A has been modified to be consistent with language relevant to revegetation work.
USFWS	9/26/2016	RR1 App. M mentions there is no agricultural land, perhaps this is just in reference to where there are permafrost soils? Also, there seems to be a lot of text addressing agricultural land in RR7. If there is little to no agricultural lands impacted by the Project, the additional, unnecessary text should be removed.	There is some land designated as agricultural in the footprint.
USFWS	9/26/2016	1st bullet of 2nd set of bullets: The Project is proposing to keep the buried pipeline chilled to below freezing from MP 0 – MP 180 to maintain stability of thaw-sensitive soils. What does the Project plan to do to maintain soil stability from the time the pipe is laid in the ground to when it finally has chilled gas running through it? That 2 to 3-year time span could lead to thawing of the permafrost causing subsidence issues and possible drainage of adjacent wetlands. Also, Burying/trenching the mainline through the tundra from the Central Gas Facility south through the Arctic Coastal Plain also will result in subsidence over the pipeline. Once the tundra and underlying soil is disturbed via trenching the soil will become aeriated. Once the soil is placed back in the trench subsidence will occur, allowing water to pond and further infiltrate into the soil during spring/summer thaw. This will cause further subsidence. Once this process of subsidence and ponding begins it is nearly impossible to rectify. It is the disturbance of the soils above the pipeline during trenching that causes the soils to subside. Cooling the pipeline will not abate the problem as the pipeline itself is not the cause of the subsidence. Once subsidence occurs, water will pond along the trench and may cause adjacent wetlands to drain into the trench. In addition, sheet flow during spring break-up on the ns tends to flow northward. As the pipeline in oriented in a North/South direction, the trench could become a conduit for water during breakup, potentially exacerbating erosion and drainage of adjacent	The Applicant will follow engineering and mitigation procedures and techniques detailed in the Alaska Stand Alone Pipeline (ASAP) Project Belowground Pipeline Mode: Selection, Construction, Operation, and Maintenance on Alaska’s North Slope.

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		wetlands. For these reasons, the Service strongly recommends the mainline be elevated on VSMs on the ACP.	
USFWS	9/26/2016	Last full paragraph: Is there a difference between thaw-sensitive soils and thaw-unstable soils? These terms are being used interchangeable throughout the reports. Perhaps explaining this or choosing one term over the other if they are one in the same.	Thaw sensitive has been removed from Resource Report No. 7.
USFWS	9/26/2016	Brooks Range and South: We recommend removing granular workpads that will not be used for project maintenance or operations into the future. To facilitate pad removal, we recommend the use of filter fabric material below the pad to prevent the material from settling or being "punched into" the soil profile. If pad removal is not an option, then in areas where these granular workpads will be left in place, they should be constructed to prevent them from settling into thaw unstable soils or thaw stable soils with thick organic mats. Also, placing foam board to laying material may help prevent thaw and maintain workpad integrity into the future. Arctic Coastal Plain: On the ACP, ice pads and roads should be used as much as possible for temporary use during winter. Gravel pads and roads should be constructed only when needed for year-round use. These gravel roads and pads should be constructed in winter using standard North Slope construction methods (5 ft. thick; 3:1 side slopes, etc.) Once these pads and roads are no longer needed they should be removed and the gravel stored for reuse elsewhere in the oil fields.	The pipeline construction techniques are discussed in Appendix M of Resource Report No 1. Figures are shown in Appendix E of Resource Report No. 1.
USFWS	9/26/2016	V Restoration: is this "travel lane" the same as the linear "granular workpad" that will be left in place? If so, then "granular work pad" needs to be identified as such and constructed to be an access road/travel lane. The Service does not understand the need for a thin granular workpad (see App. M of RR1), especially on the ACP when ice roads could easily be utilized.	A travel lane is not the same as the gravel work pad. Travel lanes are required where access from existing public roads are infrequent to allow mainline equipment to pass around a construction area during the construction season. Without such access, a separate, parallel pad is required to allow equipment to pass through the area while construction work is ongoing. Thin gravel, even with an ice pad, is required on slopes > 2%, which occurs towards the foothills of the Brooks Range. See an updated Appendix M in Resource Report No. 1.
USFWS	9/26/2016	Be consistent with the description of topsoil provided in RR7 section 7.4.5 pg. 7-42 where it says that topsoil is a common term used to describe a combination of the O and A soil horizons.	The definition of topsoil in Appendix A has been modified to be consistent throughout Resource Report No. 7.
USFWS	9/26/2016	Plastic degradable netting is not recommended for use in erosion control for any aspect of the proposed project. Prior to degradation, the netting can entangle wildlife, including amphibians, birds, and small mammals. In addition, because the plastic netting is degradable (not biodegradable), once the plastic does degrade (which takes many years, especially in cold	Refer to Attachment E of Appendix J of Resource Report No. 2 for BMP typical drawings.

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		climates) it does not decompose into biologic components of the soil. Instead, the plastic degrades into small fragments which are blown or washed into waterways creating a toxic ingestion hazard for aquatic wildlife for many years. To minimize wildlife entanglement and plastic debris pollution, we recommend the use of plastic-free erosion and sediment control products such as netting manufactured from 100% biodegradable, non-plastic materials such as jute, sisal, or coir fiber. Plastic products, regardless of their degradability, are not recommended for use anywhere in the project. http://www.coastal.ca.gov/water-quality/permits/	

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ACRONYMS AND ABBREVIATIONS

ABBREVIATION	DEFINITION
Abbreviations for Units of Measurement	
°C	degrees Celsius
°F	degrees Fahrenheit
Other Abbreviations	
§	section or paragraph
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ADOT&PF	Alaska Department of Transportation and Public Facilities
AGDC	Alaska Gasline Development Corporation
AGPPT	Alaska Gas Producers Pipeline Team
Applicant's Plan	Applicant's Upland Erosion Control, Revegetation, and Maintenance Plan
Applicant's Procedures	Applicant's Wetland and Waterbody Construction, and Mitigation Procedures
ANGTS	Alaska Natural Gas Transportation System
APDES	Alaska Pollutant Discharge Elimination System
APP	Alaska Pipeline Project
Applicant	The Alaska Gasline Development Corporation
ASAP	Alaska Stand Alone Pipeline
BLM	United States Department of the Interior, Bureau of Land Management
BMP	best management practices
C.F.R.	Code of Federal Regulations
DEM	Digital Elevation Model
Denali	Denali Project
DGGS	Alaska Department of Natural Resources Division of Geological and Geophysical Surveys
DOD	Department of Defense
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
FERC	United States 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
GIS	geographic information system
GTP	gas treatment plant
KPB	Kenai Peninsula Borough
KSH	Kenai Spur Highway
LANDSAT	Land Remote Sensing Satellite
LiDAR	light detection and ranging
Liquefaction Facility	natural gas liquefaction facility
LLC	Limited Liability Company
LNG	liquefied natural gas
LRR	Land Resource Region

ABBREVIATION	DEFINITION
LP	Limited Partnership
Mainline	an approximately 807-mile-long, large-diameter gas pipeline
MGS	Major Gas Sales
MLRAs	Major Land Resource Areas
MP	Mainline milepost
MSB	Matanuska-Susitna Borough
NEPA	National Environmental Policy Act
NGA	Natural Gas Act
NMFS	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
North Slope	Alaska North Slope
NPS	U.S. Department of the Interior, National Park Service
NRCS	Natural Resources Conservation Service
NRG	Natural Resource Group
NSB	North Slope Borough
OFE	United States Department of Energy, Office of Fossil Energy
PBTL	Prudhoe Bay Gas Transmission Line
PBU	Prudhoe Bay Unit
Project	Alaska LNG Project
PTTL	Point Thomson Gas Transmission Line
PTU	Point Thomson Unit
PHMSA	U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration
ROW	right-of-way
SHPO	State Historic Preservation Office(r)
SPCS	State Pipeline Coordinator's Section
SSURGO	Natural Resources Conservation Service Soil Survey Geographic database
STATSGO	State Soil Geographic
STATSGO2	State Soil Geographic2 – General Soils Map of Alaska & Soils Data (2011)
SWPPP	Stormwater Pollution Prevention Plan
TAPS	Trans-Alaska Pipeline System
TBD	to be determined
U.S.	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USDOI	United States Department of the Interior
USFWS	United States Department of the Interior, Fish and Wildlife Service
USGS	United States Geological Survey
VSM	Vertical Support Member
WEG	Wind Erodibility Group

7.0 RESOURCE REPORT NO. 7 – SOILS

Potential impacts to soil resources have been assessed in this Resource Report for both construction and operation of the proposed Project. Impacts from the proposed Project would be limited to the construction and operation of the Liquefaction Facility, Mainline, Prudhoe Bay Gas Transmission Line (PBTL), Point Thomson Gas Transmission Line (PTTL), Pipeline Aboveground Facilities, Pipeline Associated Infrastructure, Gas Treatment Plant (GTP), GTP Associated Infrastructure, and Non-Jurisdictional Facilities, including the Prudhoe Bay Unit Major Gas Sales Project (PBU), Point Thomson Gas Expansion Project (PTU), and Kenai Spur Highway Project. Unless specified, impacts have been assessed specific to the Project's footprint.

7.1 PROJECT DESCRIPTION

The Alaska Gasline Development Corporation (Applicant) plans to construct one integrated liquefied natural gas (LNG) Project (Project) with interdependent facilities for the purpose of liquefying supplies of natural gas from Alaska, in particular from 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 for in-state deliveries of natural gas.

The Natural Gas Act (NGA), 15 U.S.C. § 717a (11) (2006), and Federal Energy Regulatory Commission (FERC) regulations, 18 Code of Federal Regulations (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 807-mile gas pipeline (Mainline); a gas treatment plant (GTP) within the PBU on the North Slope; an approximately 63-mile gas transmission line connecting the GTP to the PTU gas production facility (PTU Gas Transmission Line or PTTL); and an approximately 1-mile 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 and will have a nominal design life of 30 years.

These components are shown in Resource Report No. 1, Figure 1.1-1, as well as the maps found in Appendices A and B of Resource Report No. 1. Their proposed basis for design is described as follows.

The new Liquefaction Facility would be constructed on the eastern shore of Cook Inlet just south of the existing Agrium fertilizer plant on the Kenai Peninsula, approximately 3 miles southwest of Nikiski and 8.5 miles north of Kenai. The Liquefaction Facility would include the structures, equipment, underlying access rights, and all other associated systems for final processing and liquefaction of natural gas, as well as storage and loading of LNG, including terminal facilities and auxiliary marine vessels used to support Marine Terminal operations (excluding LNG carriers [LNGCs]). The Liquefaction Facility would include three liquefaction trains combining to process up to approximately 20 million metric tons per annum (MMTPA) of LNG. Two 240,000-cubic-meter tanks would be constructed to store the LNG. The Liquefaction Facility would be capable of accommodating two LNGCs. The size of LNGCs that the Liquefaction Facility would accommodate would range between 125,000–216,000-cubic-meter vessels.

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

- Mainline: A new 42-inch-diameter natural gas pipeline approximately 807 miles in length would extend from the Liquefaction Facility to the GTP in the PBU, including the structures, equipment, and all other associated systems. The proposed design anticipates up to eight compressor stations; one standalone heater station, one heater station collocated with a compressor station, and six cooling stations associated with six of the compressor stations; four meter stations; 30 Mainline block valves (MLBVs); one pig launcher facility at the GTP meter station, one pig receiver facility at the Nikiski meter station, and combined pig launcher and receiver facilities at each of the compressor stations; and associated infrastructure facilities.

  Associated infrastructure facilities would include additional temporary workspace (ATWS), access roads, helipads, construction camps, pipe storage areas, material extraction sites, and material disposal sites.

  Along the Mainline route, there would be at least five gas interconnection points to allow for future in-state deliveries of natural gas. The approximate locations of three of the gas interconnection points have been tentatively identified as follows: milepost (MP) 441 to serve Fairbanks, MP 763 to serve the Matanuska-Susitna Valley and Anchorage, and MP 807 to serve the Kenai Peninsula. The size and location of the other 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 gas interconnection points are part of the Project. Potential third-party facilities are addressed in the Cumulative Impacts analysis found in Appendix L of Resource Report No. 1;

- GTP: A new GTP and associated facilities in the PBU would receive natural gas from the PBU Gas Transmission Line and the PTU Gas Transmission Line. The GTP would treat/process the natural gas for delivery into the Mainline. There would be custody transfer, verification, and process metering between the GTP and PBU for fuel gas, propane makeup, and byproducts. All of these would be on the GTP or PBU pads;

- PBU Gas Transmission Line: A new 60-inch natural gas transmission line would extend approximately 1 mile from the outlet flange of the PBU gas production facility to the inlet flange of the GTP. The PBU Gas Transmission Line would include one meter station on the GTP pad; and

- PTU Gas Transmission Line: A new 32-inch natural gas transmission line would extend approximately 63 miles from the outlet flange of the PTU gas production facility to the inlet flange of the GTP. The PTU Gas Transmission Line would include one meter station on the GTP pad, four MLBVs, and pig launcher and receiver facilities—one each at the PTU and GTP pads.

Existing State of Alaska transportation infrastructure would be used during the construction of these new facilities including ports, airports, roads, railroads, and airstrips (potentially including previously abandoned airstrips). A preliminary assessment of potential new infrastructure and modifications or additions to these existing in-state facilities is provided in Resource Report No. 1, Appendix L. The Liquefaction Facility, Mainline, and GTP would require the construction of modules that may or may not take place at existing or new manufacturing facilities in the United States.

Resource Report No. 1, Appendix A, contains maps of the Project footprint. Appendices B and E of Resource Report No. 1 depict the footprint, plot plans of the aboveground facilities, and typical layout of aboveground facilities.

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

- Modifications/new facilities at the PTU (PTU Expansion project);
- Modifications/new facilities at the PBU (PBU Major Gas Sales [MGS] project); and
- Relocation of the Kenai Spur Highway.

7.1.1 Purpose of Resource Report

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

- 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.

Appendices included in this Resource Report include the following:

- Appendix A – Common Soil Term Definitions;
- Appendix B –STATSGO2 Soil Metadata Table;
- Appendix C – Extended Tables for Resource Report No. 7; and
- Appendix D –Applicant's *Upland Erosion Control, Revegetation, and Maintenance Plan* .

Data for this Resource Report were compiled based on a review of the following:

- Preliminary engineering design analysis results and proposed construction plans;
- Geospatial data from federal and state agencies;
- Recent aerial photography, surficial geology mapping, and Light Detection and Ranging (LiDAR);
- Field assessments and geotechnical data;
- Agency provided comments and data;
- Review of data from adjacent and prior projects;
- Feedback from FERC; and
- Scientific literature.

Soil characterization information used in this Resource Report was primarily obtained from the U.S. Department of Agriculture (USDA) NRCS STATSGO2 database. It should be noted that STATSGO2 soil metadata is only available for approximately half (39,590.35 acres) of the Project footprint, thereby limiting the analysis of soil properties for the entire area potentially impacted by the Project.

7.1.2 Effect Determination Terminology

The following definitions were used when assessing the duration, significance, and outcome of potential effects related to the Project:

- Duration**:** ***Temporary*** effects are those that may occur only during a specific phase of the Project, such as during construction or installation activities. ***Short-term effects*** could continue up to five years. ***Long-term*** effects are those that would take more than five years to recover. ***Permanent*** effects could occur as a result of any activity that modified a resource to the extent that it would not return to preconstruction conditions during the 30-year life of the Project.

- Significance: ***Minor*** effects are those that may be perceptible, but are of very low intensity and may be too small to measure. ***Significant*** effects are those that, in their context and due to their intensity, have the potential to result in a substantial adverse change in the physical environment.

- Outcome: A ***positive*** effect may cause positive outcomes to the natural or human environment. In turn, an ***adverse*** effect may cause unfavorable or undesirable outcomes to the natural or human environment. ***Direct effects*** are "caused by the action and occur at the same time and place" (40 CFR 1508.8). ***Indirect effects*** that are "caused by an action and are later in time or farther removed in distance but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8). Indirect effects are caused by the Project, but do not occur at the same time or place as the direct effects.

7.1.3 Agency and Organization Consultations

This section describes consultations that have been conducted with agencies and other parties interested in the Project.

7.1.3.1 Federal Agencies

Discussions with multiple federal agencies were held regarding various Project details. Table 7.1.3-1 includes meetings and correspondence (through December 2016) where discussions regarding soil resources were raised.

A list of the required federal permits for the Project is provided in Resource Report No. 1, Appendix C. A preliminary summary of public, agency, and stakeholder engagement is provided in Resource Report No. 1, Appendix D.

TABLE 7.1.3-1

Summary of the Project's Consultations with Federal Agencies (through December 2016)

Contact	Date	Summary
FERC; National Marine Fisheries Services (NMFS); U.S. Army Corps of Engineers (USACE); U.S. Coast Guard (USCG); Office of Fossil Energy (OFE); U.S. Department of Interior (USDOI); United States Environmental Protection Agency (EPA); United States Fish and Wildlife Service (USFWS); National Park Service (NPS)	2/10/2015	Project Web Mapper and SharePoint Overview for State and Federal Agency Representatives
Bureau of Land Management (BLM); FERC; NMFS; Pipeline and Hazardous Materials Safety Administration (PHMSA); State Historic Preservation Office (SHPO); State Pipeline Coordinator's Section (SPCS); USACE; USCG; USDOI; USEPA; USFWS; USNPS	3/17/2015 3/18/2015	Meeting with FERC and other agencies to review Resource Reports
Bureau of Land Management (BLM); FERC; USFWS;	3/19/2015	Meeting with FERC and other agencies to review Resource Reports
EPA, FERC, USACE, NPS, USFWS	5/12/2015	Multi-Agency Pipeline Routing Workshop —Revision B Route
FERC; OFE; USDOI	5/28/2015	Roundtable Discussion – Federal Processes for Permitting the Project
USACE; USDOI; USEPA; USFWS	6/24/2015	Agency workshop do discuss the large-diameter natural gas pipeline construction planning and execution as it pertains to the Project including an overview of pipeline construction by season.
FERC; NMFS; USACE; USCG; USEPA; USFWS	8/12/2015	Meeting with agencies to review the GTP Footprint
FERC, NMFS, USACE, USFWS	8/19/2015	Meeting with agencies to review Cook Inlet Routing and Construction
FERC; NMFS; USACE; USCG; USFWS, USEPA	9/2/2015	Meeting with agencies to review the LNG Footprint
FERC	9/10/2015	Meeting with agencies to review the Upland Erosion and Sedimentation Control Plan (Plan)
FERC	3/24/2016	Geotechnical and Geophysical
FERC	3/31/2016	Project Review
FERC; USACE	4/14/2016	Wetlands, Plans and Procedures, Traditional Knowledge, Permits
FERC; PHMSA	4/14/2016	PHMSA Pipeline Special Permit and Environmental Overview
NMFS; USACE	5/27/2016	Vibracoring Operations and Incidental Harassment Authorization (IHA)
NPS	5/27/2016	Denali National Park geohazards
USACE	6/3/2016	Restoration Planning Group
FERC	7/14/2016	Uplands Plan and Wetland/Waterbody Procedures
FERC	8/23/2016	Geotechnical Data Technical Review
USACE	9/23/2016	Kenai Spur Highway Wetlands

7.1.3.2 State and Local Agencies/Entities

Discussions with multiple State of Alaska and local agencies, as well as private corporation representatives, were held. Table 7.1.3-2 includes meetings and correspondence (through December 2016) where discussions of geological and soil resources were raised.

A list of required state permits for the Project is provided in Appendix C of Resource Report No. 1. A summary of public, agency, and stakeholder engagements is provided in Resource Report No. 1, Appendix D.

TABLE 7.1.3-2

Summary of the Project's Consultations with Alaska State and Local Agencies/Entities (through December 2016)

Contact	Date	Summary
ADEC; ADFG; ADNR; ADOT&PF; SHPO; SPCS	3/17/2015 3/18/2015	Meeting with FERC and other agencies to review Resource Reports
ADOT, ADFG, ADNR, DGGS	3/19/2015	Meeting with FERC and other agencies to review Resource Reports
Alaska Gasline Development Corporation (AGDC)	4/1/2015	Meeting with agencies to discuss the Alaska Stand Alone Pipeline (ASAP) Project scope for 2015 and the data sharing between Projects.
North Slope Borough (NSB)	5/1/2015	Meeting with agencies to review General overview of the Project, focusing on portions within the NSB (Pipelines and GTP)
ADEC	5/21/2015	Meeting with agencies to review comments to Alaska Pollutant Discharge Elimination System (APDES) Individual Discharge Permit for Cook Inlet Geotechnical Borings
ADEC; ADFG; ADNR; ADOT&PF; NSB; ADHS, ADEC, SPCS,	6/24/2015	Agency workshop do discuss the large-diameter natural gas pipeline construction planning and execution as it pertains to the Project including an overview of pipeline construction by season.
ADEC, ADFG, ADHSS, ADNR, DGGS, SPCS;	6/25/2015	Agency workshop do discuss, review, and seek alignment on pipeline construction and construction across waterbodies.
SPCS	7/2/2015	Meeting SPCS to discuss review the June 24 and 25 large-diameter natural gas pipeline construction planning and execution workshops
ADFG; ADNR; NSB; SPCS	8/12/2015	Meeting with agencies to review the GTP Footprint
ADES, ADHS, ADFG; ADNR; ADOT&PF; KPB; SPCS	9/2/2015	Meeting with agencies to review the LNG Footprint

7.2 SOIL DESCRIPTION AND DATA ANALYSIS METHODOLOGY

Although Local NRCS Soil Survey information is typically used to identify soil properties of potentially impacted areas, due to the general lack of intensive land use, the rugged nature of the landscape, and relative inaccessibility of the area, limited comprehensive NRCS Soil Survey Geographic (SSURGO) database information exists for areas crossed by the Project. To effectively identify physical and interpretive characteristics of soils that would be impacted by the construction and operation of the Project, supplemental data sources were analyzed and evaluated to develop Project-specific soil and geotechnical datasets for use in engineering analyses and execution planning. These data sources are described in the following sections.

Additional geotechnical engineering analyses have been and will continue to be conducted to further evaluate soil resources in the Project area as the footprint of the Project facilities are refined based on pre-FEED data and subsequent phases of the Project. Existing Project geotechnical information, including physiography, topography, and surface bedrock data, is discussed in detail in Resource Report No. 6.

Site-specific soil/geotechnical investigations will continue to be performed where insufficient data exists to document and classify the soil for use in the ongoing soil evaluation and engineering analyses. Information from these analyses, including field investigations, computer modeling, and desktop studies that evaluate soil resources within the Project area will be added to the Project knowledge base as they become available.

7.2.1 USDA NRCS Soils Databases

The existing NRCS soil 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).

The most recent soil datasets include Gelisols, a new soil order which characterizes and maps permafrost soils (See Appendix A, Common Soil Term Definitions). The inclusion of this soil order resulted in the change of previously defined soil map units, which restricted correlation between datasets. Due to this limitation, mapped soil data was only used from the most recent datasets (2002 STATSGO Update and 2011 STATSGO2 General Soils Map of Alaska).

7.2.1.1 NATSGO Database

The National Soil Geographic database (NATSGO) is used primarily for national, regional, and multistate resource assessment, planning, and monitoring. The major land resource areas (MLRAs) and land resource regions (LRRS) were used to form the NATSGO database. MLRAs are sub-regions of the land resource regions and comprise smaller homogeneous areas.

MLRAs are intended to represent subregional areas containing similar physiographic and geomorphic patterns and processes, along with general vegetation. Within an MLRA, there are relatively consistent types of landforms, soils, surficial geologic features, soil parent materials, geomorphic and soil forming processes, and predominant vegetation types and structures. MLRA names include the geographic location and predominant physiography. The scale of this coverage is 1:2,000,000.

7.2.1.2 STATSGO2 Database Soil Distribution

The Digital General Soil Map of the United States (STATSGO2) is a broad-based inventory of soils and non-soil areas that occur in a repeatable pattern on the landscape that is mapped at a scale of 1:1,000,000 for the state of Alaska. STATSGO2 data is typically used for extensive land planning and management uses covering state, regional, and multistate areas. This dataset was created by assembling and relating geology, topography, vegetation, and climate data to Land Remote Sensing Satellite (LANDSAT) images. Soils of similar areas were studied, and the probable classifications and extents of the soils were determined. Map unit composition was determined by transecting or sampling areas on the more-detailed maps and then statistically expanding the data to characterize the whole map unit. The dataset consists of georeferenced vector and tabular data for nearly half (14,567.72 acres) of the entire onshore Project footprint.

7.2.2 Geotechnical Engineering Analysis

Geotechnical engineering analyses were conducted using various combined soil/geotechnical datasets to characterize in-situ conditions and evaluate soil resources, associated construction quantities, and limitations in the Project area. The evaluation and analysis can be found in Appendix H of Resource Report 6. The results of these analyses were route-specific and supplemented existing published data with information defined at a scale suitable to meet Project needs. The soil/geotechnical datasets were derived from the following baseline data sources:

- Digital terrain maps of the PTTL portion of the Project area (Rawlinson, 1990);
- Digital elevation models (DEMs) of the Project area obtained using LiDAR methods, supplemented with other available digital elevation datasets to fill data gaps; and
- Project-specific field investigations, terrain mapping, prior project borehole information, and desktop analysis.

7.2.2.1 Terrain Mapping

Terrain mapping is a classification system that describes the characteristics and spatial distribution of surficial materials, soils, landforms, and geomorphological processes. The qualitative characterization of conditions in the Project area from terrain mapping may be sufficient for a high-level evaluation of soil resources.

The terrain map unit represents a three-dimensional landform feature, or suite of related landform features, that can be expected to occur from the ground surface to a depth of up to 20 feet based on terrain mapping alone, but can be extended to 50 feet or deeper with boreholes or other supplemental data. Terrain units may consist of 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 in 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 impacts. Terrain unit mapping provides a continuous interpretation of surface and implied subsurface conditions in the mapped area, including permafrost conditions, topography, and related effects from ground freezing, and effects from permafrost thawing. Soil resource attributes that can be derived from terrain mapping include the following:

- 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.

7.2.2.2 DEM Data Analysis

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 data acquired by this Project;

- 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 previously described, was used to generate gradient maps, as well as 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 route. Calculated slope angle data are then filtered to segment the area into a continuous set of slope-class intervals. The preliminary footprint of the Project facilities, including associated facilities, would be refined based pre-FEED data and subsequent phases of the Project. The composite DEM is expected to be improved with the acquisition of additional LiDAR data for the Project areas not previously covered.

7.2.3 Additional Data Sources

The Project's Mainline corridor closely follows portions of other existing, proposed, or previously considered pipeline project routes. Extensive soil/geotechnical data, including terrain, landform, geothermal, bedrock, borehole, and soil properties, were evaluated from other projects including:

- Trans-Alaska Pipeline System (TAPS);
- Alaska Natural Gas Transportation System (ANGTS);
- Alaska Pipeline Project (APP);
- Alaska Stand Alone Pipeline (ASAP);
- Alaska Gas Pipeline Producers Team (AGPPT); and
- Denali Pipeline Project (Denali).

Additionally, publicly available digital maps of soils and bedrock geology, along with related reports and publications, were also used to create soil/geotechnical datasets to evaluate soil resources and associated limitations within the Project corridor. Information includes:

- Pipeline route centerline (Revision B) and grade profile data;
- Physiographic regions and related data;

- Terrain and landform data;
- Permafrost and geothermal data;
- Soils data derived from boreholes and other data sources;
- Bedrock data;
- Slope data;
- Environmental data; and
- Construction planning and execution data.

7.3 EXISTING SOILS DESCRIPTION

Soils are classified through established hierarchies that represent the relationship between soils and the factors responsible for their development and function. This taxonomy includes the grouping of soils according to limitations that affect specific purposes, including habitat formation, land uses, and potential constraints and impacts (See Appendix A, Common Soil Term Definitions for descriptions of soil taxonomy and classifications). The six categories of the USDA NRCS soil classification (from highest to lowest) are: order, suborder, great group, subgroup, family, and series. The highest categories (order and suborder) have the fewest classes and criteria separating classes, while the lowest categories (family and series) have the most classes and criteria.

Soil orders place soils in 1 of 12 categories (USDA NRCS, 1999). The soil orders the Project would traverse would be primarily Gelisols, some Entisols, Inceptisols, and Spodosols (USDA NRCS, 2011a). Gelisols are soils with permafrost within 6-7 feet of the surface (USDA NRCS, 2004). These soils generally have limited profile development. Most of the soil forming processes in these soils occur near the surface, sometimes resulting in significant accumulation of organic matter. These soils tend to become boggy wetlands in the summer and support large numbers of birds and mammals. The permafrost of Gelisols tends to become unstable if disturbed, leading to waterlogged soils.

Entisol soils were developed by unconsolidated parent material. These soils typically do not have visibly, chemically, and/or physically distinct layers, referred to as horizons. There are typically six soil horizons: O, A, E, B, C, and R (see Table 7.3.1-1 and Appendix A, Common Soil Term Definitions, for a description and classification of typical soil horizons). Entisols commonly only have the A horizon (USDA NRCS, 1999), which is an indication of the primary stage these soils are in with regards to the soil formation process. This soil order is a diverse soil order that can be found in a variety of landscapes including steep, rocky settings and large river valleys. Entisol soil problems include erosion by water, wind, and mass wasting, which is important in steep and hilly to mountainous areas where runoff is rapid. Rocky, shaley, and sandy lands pose these hazards in different ways. Flooding and deposition is a concern within lowlands, particularly on river floodplains and tidal flats.

TABLE 7.3.1-1

Typical Soil Horizons

O	**O Horizon** -An organic layer developed mainly from mosses, rushes, and woody materials. This is the least decomposed layer, containing large amounts of well-preserved fiber.
A	**A Horizon-**A mineral horizon formed at or near the surface in the zone of removal of materials in solution and suspension, or maximum in situ accumulation of organic carbon, or both.
E	**E Horizon** -The E horizon appears lighter in color than an associated A horizon (above) or B horizon (below). An E horizon has a lower clay content than an underlying B horizon, and often has a lower clay content than an overlying A

TABLE 7.3.1-1

Typical Soil Horizons

	horizon, if an A is present.
B	**B Horizon**- A mineral horizon characterized by one or more of the following: • An enrichment in silicate clay, iron, aluminum, or humus. • A prismatic or columnar structure that exhibits pronounced coatings or stainings associated with significant amounts of exchangeable sodium. • An alteration by hydrolysis, reduction, or oxidation to give a change in color or structure from the horizons above or below, or both.
C	**C Horizon**- A mineral horizon comparatively unaffected by the pedogenic processes operative in A and B, except gleying, and the accumulation of carbonates and more soluble salts
R	**R Horizon**-Underlying consolidated bedrock that is too hard to break with the hands or to dig when moist.
Source: (USDA NRCS, 1999)	

Inceptisols are youthful soils in the early stages of soil profile development. The differences and distinctions between horizons are just beginning to appear. The natural productivity of these soils varies widely, and is dependent upon clay and organic matter content, and other edaphic (plant-related) factors (USDA NRCS, 1999).

Spodosols are sandy soils with a subsoil accumulation of organic acids called a spodic horizon. This horizon is found less than six feet below the land surface and is overlain by a strongly bleached sandy layer that gives the soil profile a strong visual contrast. The defining characteristic of the spodic layer is the significant accumulation of iron- and aluminum-bearing minerals intermixed with humus. The presence of organic compounds derived from acid-tolerant vegetation, usually needle-leaved evergreen forest, contributes to the acidic humus content of the soil and to the mobilization of the iron and aluminum.

7.3.1 Major Land Resource Areas (MLRAs)

The Project area lies within 3 LRRs and 10 MLRAs that are recognized by the NRCS. A listing of each Project component by MLRA, LRR, and milepost (MP) is provided in Table 7.3.1-2 and depicted in Figure 7.3.1-1.

TABLE 7.3.1-2

Major Land Resource Areas Crossed by the Project

Feature Type [a]	MP (from)	MP (to)	NRCS Major Land Resource Area [b]	Borough/Census Area	Land Resource Region [b]
LIQUEFACTION FACILITY					
LNG Plant	N/A	N/A	Cook Inlet Lowlands (224)	Kenai Peninsula Borough	Southern Alaska Region
Marine Terminal	N/A	N/A	Cook Inlet Lowlands (224)	Kenai Peninsula Borough	Southern Alaska Region
INTERDEPENDENT PROJECT FACILITIES					
PIPELINES					
Mainline	0.00	61.70	Arctic Coastal Plain (246)	North Slope Borough	Northern Alaska
Mainline	61.70	143.04	Arctic Foothills (245)		
Mainline	143.04	169.87	Northern Brooks Range Mountains (244)		
Mainline	169.87	182.40	Interior Brooks Range Mountains (234)		Interior Alaska
Mainline	182.40	251.48		Yukon-Koyukuk Census Area	
Mainline	251.48	256.68	Upper Kobuk and Koyukuk Hills and Valleys (233)		
Mainline	256.68	421.87	Interior Alaska Highlands (231)		
Mainline	421.87	424.31		Fairbanks North Star Borough	
Mainline	424.31	430.23		Yukon-Koyukuk Census Area	
Mainline	430.23	442.18	Interior Alaska Lowlands (229)		

TABLE 7.3.1-2

Major Land Resource Areas Crossed by the Project

Feature Type [a]	MP (from)	MP (to)	NRCS Major Land Resource Area [b]	Borough/Census Area	Land Resource Region [b]
Mainline	442.18	454.78	Interior Alaska Highlands (231)		
Mainline	454.78	488.58			
Mainline	488.58	516.09		Denali Borough	
Mainline	516.09	575.40	Interior Alaska Mountains (228)		
Mainline	575.40	579.57	Interior Alaska Mountains (228)	Matanuska-Susitna Borough	
Mainline	579.57	616.36	Cook Inlet Mountains (223)		Southern Alaska
Mainline	616.36	755.33			Southern Alaska
Mainline	755.33	766.04		Kenai Peninsula Borough	Southern Alaska
Mainline	766.04	766.29			
Mainline	792.85	793.29			
Mainline	793.29	806.57			
PBTL	0.00	1.20	Arctic Coastal Plain (246)	North Slope Borough	Northern Alaska
PTTL	0.00	62.55			
Gas Treatment Plant (GTP)					
GTP	N/A	N/A	Arctic Coastal Plain (246)	North Slope Borough	Northern Alaska Region
GTP Associated Infrastructure	N/A	N/A			
NON-JURISDICTIONAL FACILITIES					
PTU Expansion Project	N/A	N/A	Arctic Coastal Plain (246)	North Slope Borough	Northern Alaska Region
PBU MGS	N/A	N/A			
Kenai Spur Highway Relocation	N/A	N/A	Cook Inlet Lowlands (224)	Kenai Peninsula Borough	Southern Alaska Region

TABLE 7.3.1-2

Major Land Resource Areas Crossed by the Project

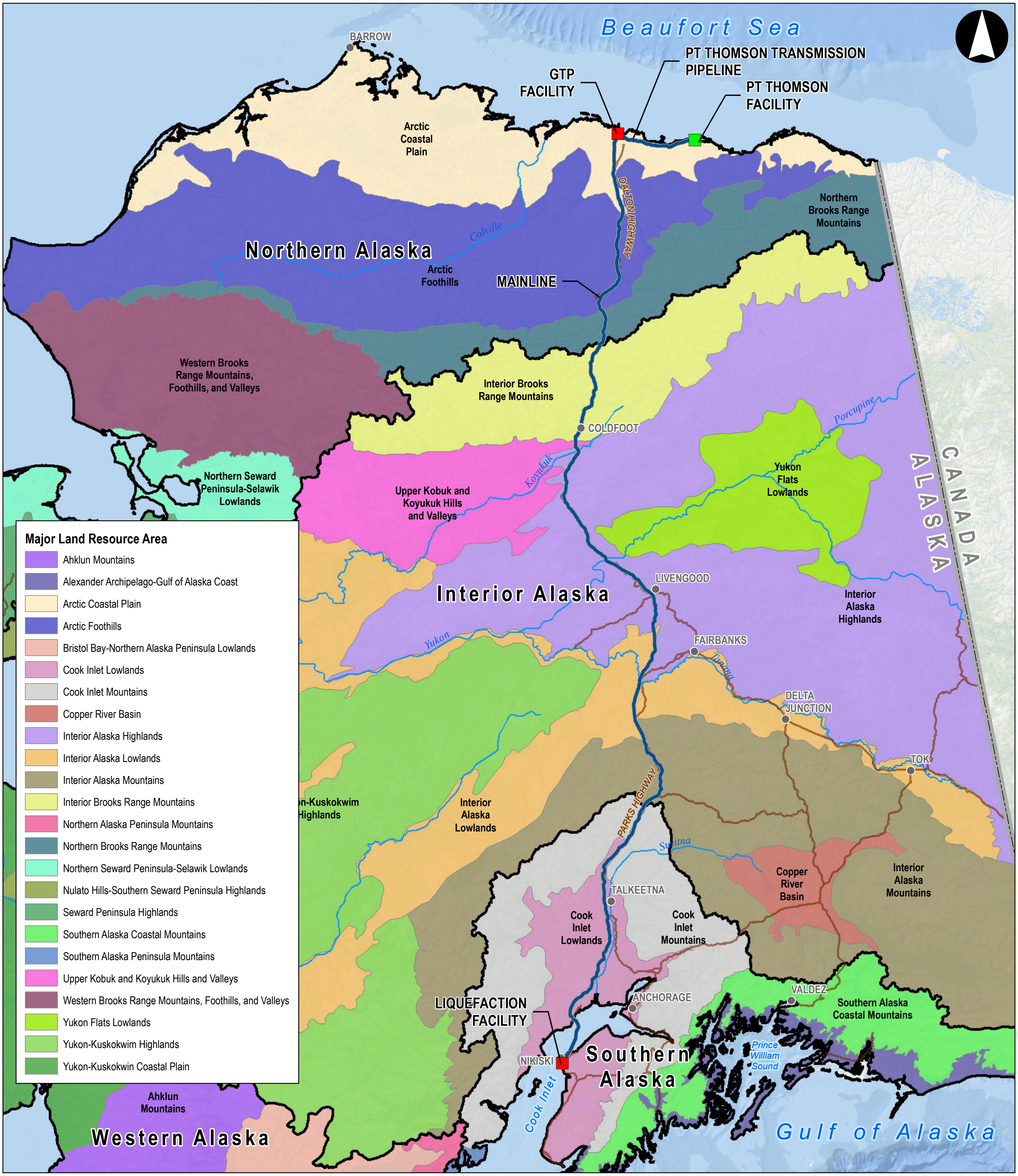
Feature Type [a]	MP (from)	MP (to)	NRCS Major Land Resource Area [b]	Borough/Census Area	Land Resource Region [b]

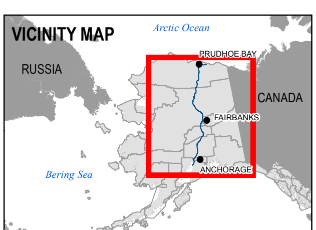
Source-

[a] GIS Feature ID as determined by **exp**,

b Resource determined by: USDA NRCS, 2004. Land Resource Regions and Major Land Resource Areas of Alaska. Web Source Link: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_035792.pdf

Numbers adjacent to the MLRA represent unique identifiers as defined by: USDA NRCS, 2014. National Ecological Site Handbook. Web Source Link: http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=35306





LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Major Highways
- Major Rivers
- Land Resource Region

0 35 70 140 Miles

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MAJOR LAND RESOURCE AREAS AND LAND RESOURCE REGIONS

FIGURE 7.3.1-1

ALASKA LNG

X:\AKLNG\Resource Reports\RR07\Figure 7_3_1-1 Major Land Resource Areas and Land Resource Regions.mxd

7.3.1.1 Liquefaction Facility

The Liquefaction Facility would be located in the Cook Inlet Lowlands MLRA (224). A brief description of the climate, soils, biological resources, and land use within this MLRA is provided in the following sections. More detailed information regarding specific soil properties is located in Section 7.4.

7.3.1.1.1 Cook Inlet Lowlands MLRA (224)

The Liquefaction Facility would be located on the northwestern shore of the Kenai Peninsula in the Cook Inlet Lowlands MLRA. Soils in this MLRA are generally deep and range in permeability from well drained to poorly drained. Many of these soils were formed in volcanic ash, glacial drift, or in residuum or colluvium on mountain slopes. Soils in this MLRA commonly have an O horizon (See Appendix A, Common Soil Term Definitions, for a description and classification of common soil horizons) over a very thin or intermittent albic (light-colored and leached) horizon, which overlies an accumulation of translocated organic matter intermixed with minerals such as aluminum and iron (USDA NRCS, 2004).

The major soil resource management considerations within this MLRA are erosion and water quality. Conservation practices that minimize ground disturbance and maintain adequate vegetation cover can lessen negative impacts.

7.3.1.2 Interdependent Project Facilities

An overview of each of the MLRAs crossed by the Interdependent Project Facilities (Mainline, PBTL, PTTL, and GTP) from north to south is provided in the following sections. More detailed information regarding specific soil properties is located in Section 7.4.

7.3.1.2.1 Arctic Coastal Plain MLRA (246)

The northernmost portion of the Project occurs in the Arctic Coastal Plain MLRA. The soils in this area are primarily of the Gelisols soil order. These soils have a pergelic soil temperature regime (a mean soil temperature of less than 32 °F), are underlain by permafrost within 6.5 feet of the surface, and are formed from a variety of parent materials, including glacial deposits, residuum, loess, and organic materials. The low soil temperature slows and restricts morphological development, such as chemical weathering and the decomposition of organic materials, resulting in large quantities of organic carbon existing in these soils.

The majority of the soils in the Arctic Coastal Plain MLRA fall under the Turbel soil subgroup, which consists of poorly and very poorly drained soils (impeded by the presence of permafrost), loamy stratified sediments with thaw-sensitive soil below 10 inches.. These soils typically have one or more horizons with evidence of soil frost churning, known as cryoturbation, caused by vertical and lateral soil movements from soils displaced by thawing and freezing actions. Cryoturbation generates a circular motion in the surface material, heaving the soil to the surface and dragging it down at the margins to form gutters. This process creates a network of circular patches which, on slopes, are stretched into long stripes by an additional creeping movement (USDA NRCS, 1999). Flowing water then deepens the gutters in the form of irregular, broken, or distorted horizon boundaries.

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. 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. The major soil resource management concern within this MLRA is impacts to the permafrost soils. An important environmental consequence of the combined very cold temperatures and frost churning has been the accumulation of organic matter within and above the permafrost zone.

7.3.1.2.2 Arctic Foothills MLRA (245)

The Mainline stretches more than 83 miles across soils in the Arctic Foothills MLRA. These soils are greatly similar to soils in the Arctic Coastal Plains MLRA in that they are primarily Gelisols underlain by permafrost with a pergelic soil temperature regime and mixed mineralogy.

These soils are very poorly drained, causing thin peat layers to form in upper horizons, typically during wet summers. These soils are thaw-sensitive and may be subject to subsidence and thermal erosion on shallow slopes (USDA NRCS, 2004). 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.

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 along small streams and in shallow depressions. Discontinuous gravelly soils with a thicker active layer (the uppermost layer in which soil formation takes place) 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.

The major soil resource management concern is impacts to the permafrost soils.

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

The Mainline extends more than 100 miles across soils in the Northern and Interior Brooks Range MLRA. These soils are typically underlain by permafrost, with the exception of soils on steep, forested, south-facing slopes, and soils under perennial streams. These soils are shallow to moderately deep over permafrost and are poorly drained or very poorly drained. 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 range from 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 (USDA NRCS, 2004). Some of these other soils could experience thaw-induced mass wasting on steeper slopes or subsidence on level and nearly level surfaces

7.3.1.2.4 Kobuk and Koyukuk Hills and Valleys MLRA (233)

A short segment of the Mainline 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. These soils have a pergelic temperature regime, an aquic or udic soil moisture regime, and mixed mineralogy. Soils occurring on stream terraces, hills, and upland slopes are formed in silty loess or alluvium over very gravelly loamy alluvium and glacial drift. The majority of the soils in this MLRA are generally shallow to moderately deep over permafrost and poorly drained or very poorly drained.

Soils in this MLRA that are formed in silty loess over very gravelly loamy colluvium, glacial till, and alluvium lack permafrost within the soil profile and are deep and moderately well drained to excessively drained. These soils range from very poorly drained to excessively drained.

The major soil resource management concern is disturbance of the permafrost soils. All activities must consider the protection of the organic surface and the thermal balance of the soils.

7.3.1.2.5 Interior Alaska Highlands MLRA (231)

The Mainline extends more than 180 miles across soils in the Interior Alaska Highlands MLRA. The majority of the soils consist of shallow permafrost areas 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.

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 (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.

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.

The major soil resource management considerations are wind erosion and water erosion in areas cleared of native vegetation. Most urban and rural developments are located adjacent to rivers, where flooding is a severe hazard. Flooding is associated with spring snowmelt and runoff from adjacent mountains and ice jamming at river bends during break up.

7.3.1.2.6 Interior Alaska Lowlands MLRA (229)

The Mainline extends more than 70 miles across soils in the Interior Alaska Lowlands MLRA. These soils consist of silty loess of varying thickness that overlies loamy, sandy, and gravelly alluvium and colluvium. Poorly or very poorly drained Gelisols 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.

Farming, including the harvesting of principal crops and some dairy cattle, beef cattle, and hog husbandry are active along the flood plains and low stream terraces near the Tanana and Yukon rivers. These areas are some of the most productive forestlands in Interior Alaska.

The major soil resource management concerns are wind erosion and water erosion in areas cleared of native vegetation. Most urban and rural developments are located adjacent to rivers, where flooding is a severe hazard. Flooding is associated with spring snowmelt and runoff from adjacent mountains and ice jamming at river bends during break-up.

7.3.1.2.7 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 30–32 °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.

7.3.1.2.8 Cook Inlet Mountains MLRA (223)

The Cook Inlet Mountains MLRA (commonly referred to as the “Talkeetna Mountains”) is primarily a non-soil mountainous area. Soils that do exist are typically of the Spodosols soil order (acidic soils characterized by a subsurface accumulation of humus, aluminum, and iron oxides) and have a pergelic soil temperature regime, an udic or aquic soil moisture regime, and mixed mineralogy. They range from shallow to very 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 30–32 °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.

7.3.1.2.9 Cook Inlet Lowlands MLRA (224)

The Mainline extends more than 200 miles across soils in the Cook Inlet Lowlands MLRA. See Section 7.3.1.1.1 for a description of Cook Inlet Lowlands MLRA.

The major soil resource management considerations are erosion and water quality. Conservation practices that reduce ground disturbance and maintain adequate vegetation cover can lessen negative impacts.

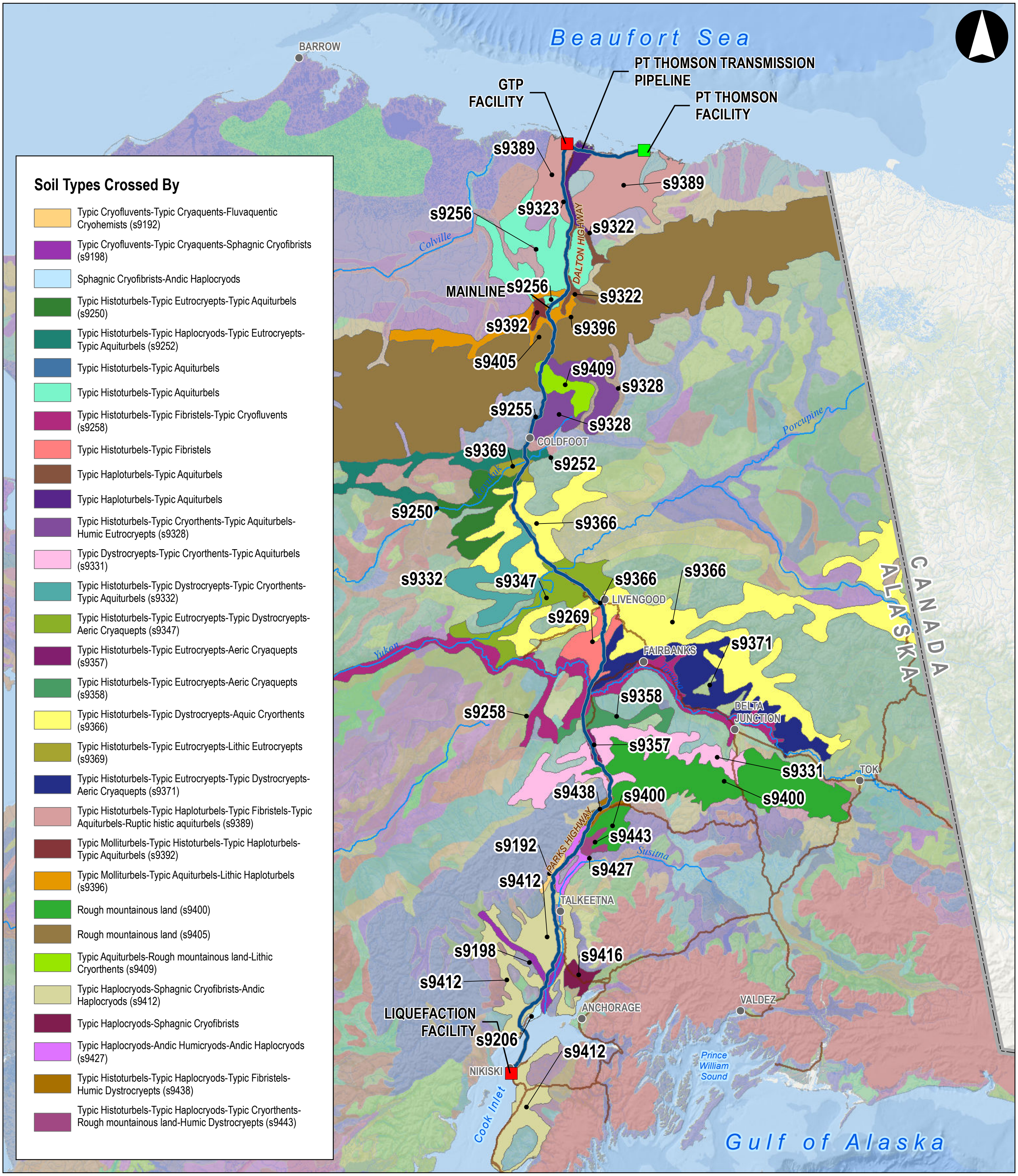
7.3.1.3 Non-Jurisdictional Facilities

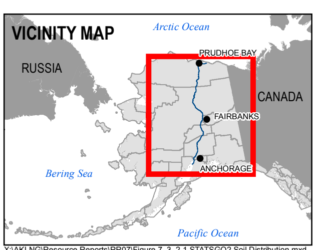
The Kenai Spur Highway relocation project is within the Cook Inlet Lowlands MLRA, which is described in Section 7.3.1.1.

The PTU Expansion and PBU MGS facilities are within the Arctic Coastal Plain MLRA, which is described in Section 7.3.1.2

7.3.2 USDA NRCS Soils Series and Selected Physical/Interpretive Characteristics

Information concerning the physical and interpretative characteristics of the specific NRCS soil series impacted in the Project area is summarized in Appendix B Table 1 and depicted in Figure 7.3.2-1. STATSGO2 soil metadata was only available for approximately 14,567.72 acres of the Project footprint.





X:\AKLNG\Resource Reports\RR07\Figure 7_3_2-1 STATSGO2 Soil Distribution.mxd

LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Major Highways
- Major Rivers

0 35 70 140 Miles

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STATSGO2 SOIL DISTRIBUTION

FIGURE 7.3.2-1

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7.4 SOIL PROPERTIES

Understanding soil properties and limitations in the Project area is necessary for predicting potential impacts and determining measures to reduce or mitigate the potential impacts. The information used to characterize soil conditions in the Project area to date is considered adequate to support this phase of the Project. Further evaluation of soil and permafrost conditions in the Project area is planned through field investigations, laboratory testing, modeling, and ongoing review of available information from similar projects and relevant publications.

Soil hazards associated with soil and permafrost conditions, including processes and effects related to erosion, compaction, permafrost thawing and frost bulb development in previously unfrozen ground, are discussed in this section. Information concerning geological potential impacts (e.g., mass wasting, seismicity, liquefaction) is provided in Resource Report No. 6. The following sections identify and discuss soil properties that may increase the potential for adverse construction-related impacts. The soil properties evaluated include: permafrost condition, erosion potential (wind and water), hydric soils, compaction potential, topsoil, stony rocky soils, and Prime Farmland/Soils of Local Importance. Detailed soil property information of affected soils can be found in Appendix B, STATSGO2 Soil Metadata Table.

It should be noted that data from 2015 and 2016 geotechnical engineering analyses, terrain mapping, and DEM data analysis would be used to evaluate areas of the Project footprint for which soil metadata is not available. These methods are discussed in further detail in Section 7.2.

The construction and operational impacts associated with the permafrost and other soil conditions in the Project area are discussed in Sections 7.5 and 7.6, respectively.

7.4.1 Permafrost

Permafrost is defined as ground (soil or rock including ice and organic material) that remains at or below 32 °F for at least two consecutive years (van Everdingen, 2005). Permafrost soils as mapped by the NRCS in Alaska are characterized by the presence of permanently frozen soil within 3 feet to just over 6 feet of the surface depending on the nature of the frozen substrate. Soil taxonomy does not recognize permafrost soils where the top of the permafrost layer is deeper than 6.6 feet.

On the basis of its extent, permafrost is classified as continuous (covering from 90–100 percent of an area), discontinuous (50–90 percent coverage), sporadic (10–50 percent coverage) or isolated patches (up to 10 percent coverage) (Brown et al., 1997). As shown in Figure 7.4.1-1 and Table 7.4.1-1, the North Slope is underlain by continuous permafrost. The permafrost in this area is thick, widespread, and generally ice rich near the surface.

TABLE 7.4.1-1

Permafrost Areas Crossed by the Project

Feature Type [a]	MP (from)	MP (to)	MLRA [b]	Permafrost Conditions [d]	Permafrost Extent [d]	Permafrost Crossed (Miles) [a]	Permafrost Crossed (Acres) [a]
LIQUEFACTION FACILITY							
LNG Plant	N/A	N/A	Cook Inlet Lowlands (224)	None	N/A	N/A	0.00
Marine Terminal	N/A	N/A	Cook Inlet Lowlands (224)	None	N/A	N/A	0.00
INTERDEPENDENT PROJECT FACILITIES							
PIPELINES							
Mainline	0.00	61.70	Arctic Coastal Plain (246)	Lowland and Upland Area underlain by thick permafrost	Continuous	60.18	802.41
Mainline	61.70	85.80	Arctic Foothills (245)			24.10	321.36
Mainline	85.80	143.04		Mountainous Area underlain by continuous permafrost		57.24	763.20
Mainline	143.04	169.87	Northern Brooks Range Mountains (244)			26.83	357.71
Mainline	169.87	251.48	Interior Brooks Range Mountains (234)			81.61	1,088.15
Mainline	251.48	256.68	Upper Kobuk and Koyukuk Hills and Valleys (233)			5.20	69.34
Mainline	256.68	259.12	Interior Alaska Highlands (231)			2.44	32.56
Mainline	259.12	260.84		Lowland and Upland Area underlain by discontinuous permafrost		1.72	22.97
Mainline	260.84	354.85		Mountainous Area underlain by discontinuous permafrost		92.68	1,235.73
Mainline	354.85	355.88		Lowland and Upland Area underlain by discontinuous permafrost		1.03	13.74
Mainline	355.88	356.44			Large Waterbody	0.56	7.45
Mainline	356.44	358.69			Discontinuous	2.25	30.06
Mainline	358.69	358.93		Mountainous Area underlain by discontinuous permafrost		0.24	3.17
Mainline	358.93	388.06			Continuous	29.13	388.36
Mainline	388.06	426.55			Discontinuous	38.49	513.20
Mainline	426.55	430.23		Lowland and Upland Area underlain by moderately thick to thin permafrost		3.68	49.05
Mainline	430.23	442.18	Interior Alaska Lowlands (229)			11.96	159.42
Mainline	442.18	454.78	Interior Alaska Highlands (231)			12.60	167.99
Mainline	454.78	468.58	Interior Alaska Lowlands (229)			13.79	183.92
Mainline	468.58	469.54			Isolated	0.97	12.90

TABLE 7.4.1-1

Permafrost Areas Crossed by the Project

Feature Type [a]	MP (from)	MP (to)	MLRA [b]	Permafrost Conditions [d]	Permafrost Extent [d]	Permafrost Crossed (Miles) [a]	Permafrost Crossed (Acres) [a]
Mainline	469.54	470.22		Lowland and Upland Area underlain by numerous isolated masses of permafrost		0.67	8.97
Mainline	470.22	470.24		Lowland and Upland Area underlain by moderately thick to thin permafrost		0.02	0.26
Mainline	470.24	471.95		Lowland and Upland Area underlain by numerous isolated masses of permafrost		1.72	22.92
Mainline	471.95	473.10		Lowland and Upland Area underlain by numerous isolated masses of permafrost	Large Waterbody	1.15	15.31
Mainline	473.10	482.79		Lowland and Upland Area underlain by numerous isolated masses of permafrost	Isolated	9.69	129.16
Mainline	482.79	484.31		Lowland and Upland Area underlain by numerous isolated masses of permafrost	Discontinuous	1.52	20.33
Mainline	484.31	491.59		Lowland and Upland Area underlain by numerous isolated masses of permafrost	Isolated	7.28	97.05
Mainline	491.59	496.60		Lowland and Upland Area underlain by numerous isolated masses of permafrost	Discontinuous	5.01	66.79
Mainline	496.60	499.74		Lowland and Upland Area underlain by numerous isolated masses of permafrost	Isolated	3.14	41.87
Mainline	499.74	511.17		Lowland and Upland Area underlain by numerous isolated masses of permafrost	Discontinuous	11.43	152.38
Mainline	511.17	516.09		Mountainous Area underlain by discontinuous permafrost	Discontinuous	4.92	65.55
Mainline	516.09	534.21	Interior Alaska Mountains (228)	Mountainous Area underlain by discontinuous permafrost	Discontinuous	18.12	241.59
Mainline	534.21	534.49	Interior Alaska Mountains (228)	Mountainous Area underlain by discontinuous permafrost	Continuous	0.28	3.77
Mainline	534.49	535.00	Interior Alaska Mountains (228)	Mountainous Area underlain by discontinuous permafrost	Discontinuous	0.51	6.86
Mainline	535.00	540.60	Interior Alaska Mountains (228)	Mountainous Area underlain by discontinuous permafrost	Continuous	5.60	74.64
Mainline	540.60	550.21	Interior Alaska Mountains (228)	Mountainous Area underlain by discontinuous permafrost	Discontinuous	9.61	128.13
Mainline	550.21	565.00	Interior Alaska Mountains (228)	Mountainous Area underlain by discontinuous permafrost	Continuous	14.79	197.18
Mainline	565.00	579.57	Interior Alaska Mountains (228)	Mountainous Area underlain by discontinuous permafrost	Discontinuous	14.57	194.28
Mainline	579.57	588.33	Cook Inlet Mountains (223)	Mountainous Area underlain by discontinuous permafrost	Discontinuous	8.52	113.66
Mainline	588.33	599.92	Cook Inlet Mountains (223)	Mountainous Area underlain by discontinuous permafrost	Continuous	11.59	154.54
Mainline	599.92	604.58	Cook Inlet Mountains (223)	Mountainous Area underlain by discontinuous permafrost	Discontinuous	4.66	62.20
Mainline	604.58	616.36	Cook Inlet Mountains (223)	Mountainous Area underlain by discontinuous permafrost	Sporadic	11.78	157.00
Mainline	616.36	623.49	Cook Inlet Lowlands (224)	Mountainous Area underlain by discontinuous permafrost	Sporadic	7.13	95.07
Mainline	623.49	634.10	Cook Inlet Lowlands (224)	Mountainous Area underlain by discontinuous permafrost	Isolated	10.61	141.48
Mainline	634.10	635.04	Cook Inlet Lowlands (224)	Lowland and Upland Area generally free of permafrost	Isolated	0.94	12.53
Mainline	635.04	635.97	Cook Inlet Lowlands (224)	Lowland and Upland Area generally free of permafrost	Sporadic	0.93	12.41
Mainline	635.97	637.42	Cook Inlet Lowlands (224)	Lowland and Upland Area generally free of permafrost	Isolated	1.45	19.38
Mainline	637.42	641.30	Cook Inlet Lowlands (224)	Mountainous Area underlain by discontinuous permafrost	Isolated	3.88	51.72
Mainline	641.30	641.41	Cook Inlet Lowlands (224)	Lowland and Upland Area generally free of permafrost	Isolated	0.11	1.43
Mainline	641.41	644.32	Cook Inlet Lowlands (224)	Lowland and Upland Area generally free of permafrost	Undefined	2.91	38.81
Mainline	644.32	648.77	Cook Inlet Lowlands (224)	Lowland and Upland Area generally free of permafrost	Isolated	4.45	59.29
Mainline	648.77	651.01	Cook Inlet Lowlands (224)	Not defined	Isolated	2.25	29.95
Mainline	651.01	651.25	Cook Inlet Lowlands (224)	Lowland and Upland Area	Isolated	0.24	3.17

TABLE 7.4.1-1

Permafrost Areas Crossed by the Project

Feature Type [a]	**MP (from)**	**MP (to)**	**MLRA** [b]	**Permafrost Conditions** [d]	**Permafrost Extent** [d]	**Permafrost Crossed (Miles)** [a]	**Permafrost Crossed (Acres)** [a]
				generally free of permafrost			
Mainline	651.25	715.42		Not defined		64.17	855.55
Mainline	715.42	718.00			Undefined	2.58	34.44
Mainline	718.00	728.41			Isolated	10.41	138.79
Mainline	728.41	733.59			Undefined	5.18	69.12
Mainline	733.59	744.68			Isolated	11.08	147.77
Mainline	744.68	746.01			Undefined	1.34	17.81
Mainline	746.01	755.36			Isolated	9.34	124.60
Mainline	755.36	757.01			Undefined	1.66	22.07
Mainline	757.01	764.38			Isolated	7.37	98.29
Mainline	764.38	806.57			Undefined	14.18	189.05
PTTL	0.00	62.55	Arctic Coastal Plain (246)	Lowland and Upland Area underlain by thick permafrost	Continuous	62.55	833.00
Gas Treatment Plant (GTP)							
GTP	N/A	N/A	Arctic Coastal Plain (246)	Lowland and Upland Area underlain by thick permafrost	Continuous	N/A	283.88
GTP Associated Infrastructure	N/A	N/A			Continuous	N/A	642.07
NON-JURISDICTIONAL FACILITIES							
PTU Expansion Project	N/A	N/A	Arctic Coastal Plain (246)	Lowland and Upland Area underlain by thick permafrost	Continuous	N/A	135.94
PBU MGS	N/A	N/A			Continuous	N/A	513.59
Kenai Spur Highway Relocation	N/A	N/A	Cook Inlet Lowlands (224)	Not defined	Undefined	N/A	949.47

Source –

[a] GIS Feature ID as determined by exp.

[b] Resource determined by: USDA NRCS, 2004. Land Resource Regions and Major Land Resource Areas of Alaska.

[c] U.S. Geological Survey Global Change Program, Land Data Systems - Arctic Land Processes Studies, 2008

[d] National Snow and Ice Data Center, 2002

[e] Acreage was calculated based on an assumed 110-foot ROW for construction.

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).

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 (discussed in further detail in Section 7.4.1.2).

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.

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 upon thawing. This weakening may increase susceptibility of soils composed of loose sand or non-plastic silt to liquefaction from seismic wave propagation, and to erosion. Soil liquefaction and seismic hazards are discussed in Resource Report No. 6.

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 (i.e., hills containing an ice core) may develop. Pingos are common on Alaska's North Slope, and generally constitute the local topographic highs. Pingos are formed by annual freeze-thaw cycles at the site of drained lakes or river channels. Two types of pingos exist, originating from closed systems (hydrostatic pingos) and open systems (hydraulic pingos). Hydrostatic pingos form when the permafrost level rises beneath the drained water body during which free water is expelled upward. The pressure from the expelled water forces the ground upward as ice is formed in its place. Hydraulic pingos form as a result of groundwater entering the system from an outside source, such as a natural aquifer in subpermafrost or intrapermafrost conditions. Water is supplied to the pingo via the aquifer, which is often artesian, which freezes and forces the ground upward. As more water is supplied, the pingo continues to grow as the ice core expands. Pingos are slow growing, approximately <1 inch per annum, and are closely related to frost heaving. The Project would not affect any pingos, because these have been avoided during pipeline routing and facility siting.

7.4.1.1 Permafrost Freeze-Thaw Sensitivity

Near-surface permafrost soils that are subject to seasonal thaw are referred to as the active layer. Active-layer depths in the Project area range from approximately 0.9 to 4.2 feet, with an average depth 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).

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 downslope viscous flow, 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. These and other slope instability processes are discussed in Resource Report No. 6.

Permafrost can be disrupted naturally by changing annual ambient temperatures, 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.

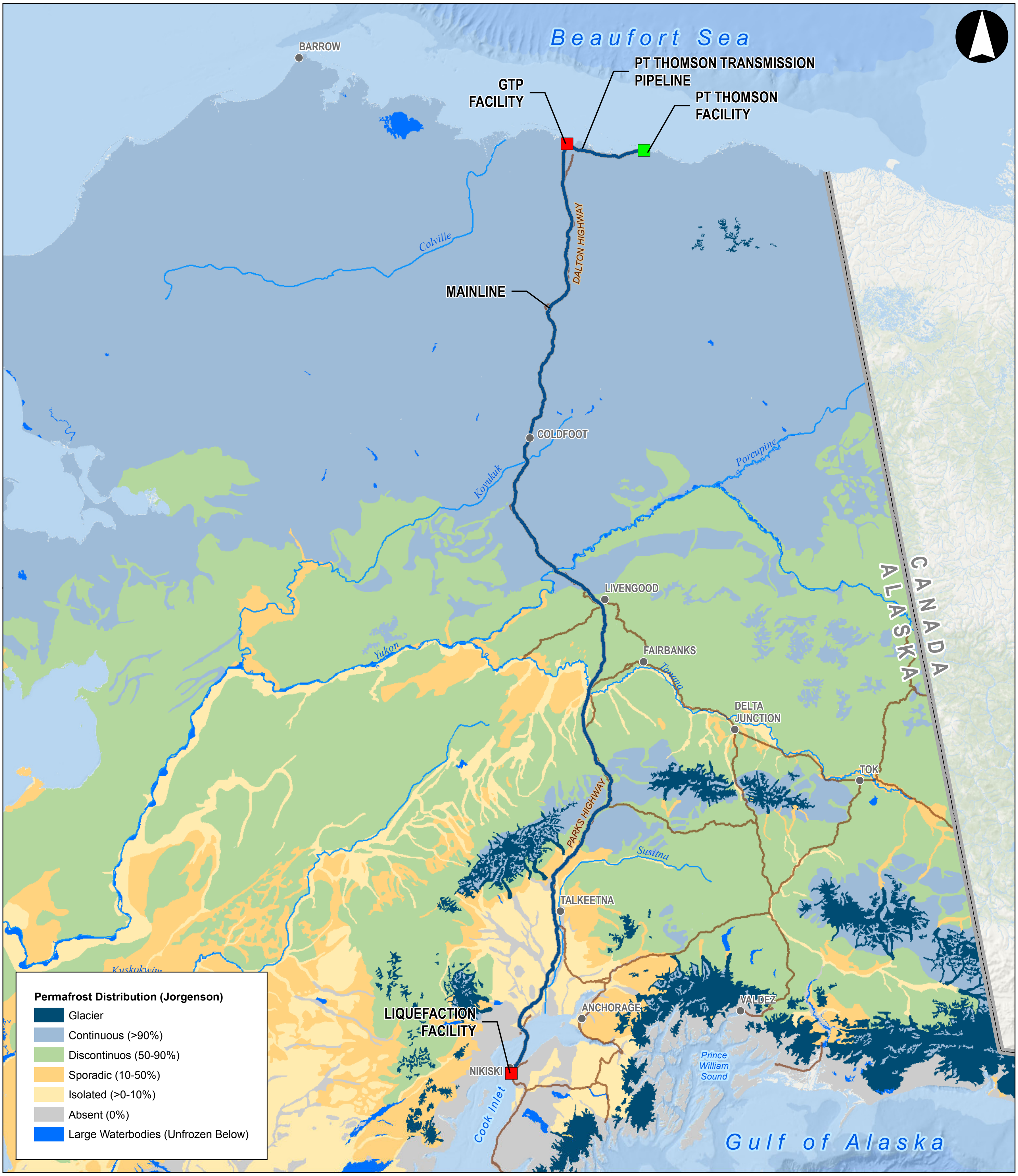
7.4.1.2 Thaw-Sensitive Permafrost Soils

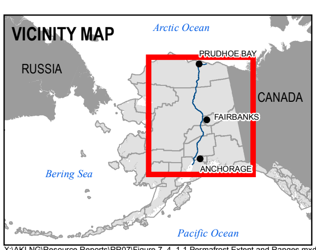
Permafrost soils are typically divided into two distinct categories, thaw-stable and thaw-sensitive. Thaw-stable soils are defined as soils that do not subside or have a change in volume upon saturation or thawing. Thaw-sensitive soils are soils that upon thawing may experience substantial thaw-settlement 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 (direction a slope faces) (Brown et al., 1981; Hunter et al., 1981; Jorgenson et al., 2008; USDA NRCS, 2001; Williams and Smith, 1989).

As stated in Section 7.3.1, and in Table 7.3.1-1, Project components within the Arctic Coastal Plain MLRA (Mainline route MP 0.0 - 59.59, PTTL, PBTL, and GTP) cross the Turbel soil subgroup, which consists of poorly and very poorly drained soils (impeded by the presence of permafrost), loamy stratified sediments with thaw-sensitive soil below 10 inches. As the Project Mainline route continues south, the terrain and soils crossed become less continuous and more susceptible to saturation or thawing.

As outlined in Section 7.2, Project terrain mapping, borehole data, and results from field surveys and route-specific engineering analysis have been used to delineate thaw-stable and thaw-sensitive permafrost along the Project Mainline pipeline routes and facilities. The footprint of the Project facilities was defined based on pre-FEED geotechnical and construction assessments, and will be refined based on pre-FEED and other data during later phases of the Project.

Information concerning thaw-sensitive soils in throughout the Mainline are summarized in Table 7.4.1-1 and also in Appendix C, Extended Tables for Resource Report No. 7.





X:\AKLNG\Resource Reports\RR07\Figure 7_4_1-1 Permafrost Extent and Ranges.mxd

LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Major Highways
- Major Rivers

0 35 70 140 Miles

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SCALE:	1:6,000,000		
DATE:	2017-03-10	SHEET:	1 of 1

ALASKA PERMAFROST EXTENT & RANGES

FIGURE 7.4.1-1

ALASKA LNG

7.4.2 Erodible Soils

Overland erosion is a natural process involving the transport of soil particles by water or wind. This process can be accelerated by ground disturbance such as clearing, grading, and equipment movement. Factors that influence the degree of erosion include soil texture, structure, length and steepness of slope, vegetative cover, soil depth, thermal regime, ice content, 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 thaw-sensitive permafrost. Erosion can result in result in the discharge of sediment to waterbodies and wetlands. Soil loss due to erosion may also reduce soil fertility in agricultural land and impair natural revegetation.

7.4.2.1 Wind Erosion

Wind erosion may be anticipated when dry, fine-grained, non-cohesive soils (e.g., silt loam and silty clay loam soils) are exposed to high-velocity wind. The wind erodibility group (WEG) in the physical soil properties of the NRCS SSURGO database was queried to evaluate this potential impact from the Project. The data are presented as a range between 1 and 8, with 1 being most susceptible to wind erosion and 8 being least susceptible to wind erosion (USDA NRCS, 2008). The following categories were used for wind erosion evaluation on the Project:

- Severe wind erosion potential – WEG values 1 to 2;
- Moderate wind erosion potential – WEG values 3 to 6; and
- Slight wind erosion potential – WEG values 7 to 8.

Soils susceptible to severe wind erosion during construction activities are identified in Table 7.5-1 and discussed in Section 7.5.1 for the Liquefaction Facility, Section 7.5.2 for Interdependent Project Facilities, and Section 7.5.3 for Non-Jurisdictional Facilities.

7.4.2.2 Water Erosion

Soils highly susceptible to water erosion were identified by reviewing the soil erosion factor (Kw) values provided in the physical soil properties of the STATSGO2 database. Kw is the measure of soil erodibility modified by the presence of rock fragments. Soils with small or fine particles (high-clay soils) tend to have low Kw values (0.02 to 0.15) because they are resistant to detachment. Coarse-textured soils with large particles (sandy soils) tend to have low Kw values (0.05 to 0.2) because of the low runoff amounts, despite the soils being easily detached. Medium textured soils (loam soils) have a moderate Kw value (0.25 to 0.40) because they are moderately susceptible to detachment and produce moderate runoff. Soils having high silt content have the highest Kw value (greater than 4) of all soils because they are easily detached and tend to crust and produce high rates of runoff. Kw value estimates are based primarily on the soils' percentage of silt, sand, and organic matter and on the soils' structure and permeability. The higher the Kw value, the more susceptible the soil is to sheet or rill erosion by water (USDA NRCS, 2008). The following categories were used for water erosion evaluation on the Project:

- Severe water erosion potential – Kw values greater than 0.4;
- Moderate water erosion potential – Kw values 0.25 to 0.4; and
- Slight water erosion potential – Kw values 0.02 to 0.15.

Soils susceptible to severe water erosion during construction activities are identified in Table 7.5-1 and discussed in Section 7.5.1 for the Liquefaction Facility, Section 7.5.2 for Interdependent Project Facilities, and Section 7.5.3 for Non-Jurisdictional Facilities.

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 NRCS, 2007). 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, resulting in extensive hydric soils being present in level areas and on sloping ground. Soil saturation, flooding, or ponding potential, restrictive or stratified layers, and poor drainage are potential impacts associated with these soils." Hydric soil designations have been based on the hydrologic soil group component within in the STATSGO2 database. Soils are classified into four hydrologic groups described subsequently (USDA NRCS, 2007):

- Group A – Sand, loamy sand or sandy loam types of soils. These soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well, to excessively drained sands or gravels and have a high rate of water transmission;

- Group B – Silt loam or loam type of soils. These soils have a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures;

- Group C – Sandy clay loam soils that have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water, and soils with moderately fine to fine structure; and

- Group D – Clay loam, silty clay loam, sandy clay, silty clay or clay soils with the highest runoff potential. These soils have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material.

Soils categorized under hydrologic group D were designated as hydric due to the soil texture, drainage, water table depth, and infiltration rates. Hydric soils that may be impacted during construction activities are identified in Table 7.5-1 and discussed in Section 7.5.1 for the Liquefaction Facility, Section 7.5.2 for Interdependent Project Facilities, and Section 7.5.3 for Non-Jurisdictional Facilities.

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.

High compaction potential is commonly encountered in finer grained soils (e.g., soils containing high amounts of silts or clays) having a high water holding capacity (USDA NRCS, 2008). Hydric soils, organic soils, and poorly drained non-hydric soils may also be susceptible to rutting. Compaction typically alters surface hydrology by diverting/holding stormwater runoff, minimizing surface water infiltration, and restricting root growth.

Immediate compaction susceptibility is influenced predominantly by its texture, mainly by the increase in finer particles, but drainage class and the surficial water table are also factors in immediate compaction. In general, immediate soil compaction potential is classified as detailed in Table 7.4.4-1.

TABLE 7.4.4-1

Immediate Soil Compaction Potential[a]

Soil Surface Texture	Drainage Class	Depth to Water Table	Soil Compaction Potential
Sandy	Somewhat excessively drained Well-drained	< 3 inches	Slight
Clayey	Somewhat poorly drained Moderately well-drained Excessively drained	3 to 6 inches	Moderate
Finer Particle Loams	Poorly drained Very poorly drained	10 inches 6 to 12 months	Severe

Source:
[a] USDA NRCS, 2014. National soil survey handbook, title 430-VI. Revised August 2014. Available online at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054241. Accessed August 2014.

Compaction-prone soils in the Project area have been identified by querying the STATSGO2 database for component soils that have a surface texture of sandy clay loam or finer; and/or a drainage class of somewhat poorly drained through very poorly drained. Soils susceptible to severe compaction potential during construction activities are identified in Table 7.5-1 and discussed in Section 7.5.1 for the Liquefaction Facility, Section 7.5.2 for Interdependent Project Facilities, and Section 7.5.3 for Non-Jurisdictional Facilities.

7.4.5 Topsoil

There is limited agricultural land in the Project area; however, topsoil depth may be relevant in construction and revegetation planning. The upper horizons, typically O and A, contain the most organic matter in soils and are commonly referred to as topsoil. The soils in the Project area are predominantly Gelisols, which typically consist of an A horizon resting on permafrost. The cryoturbation process in many Gelisols, particularly soils classified under the Turbel sub-order, often results in irregular or broken horizons and limited fertility. Other sub orders of Gelisols typically have histic epipedons (a surface soil horizon, not less than 2 feet in depth, high in organic carbon, and saturated with water for some part of the year) which normally have a high content of organic matter resulting from intermixing of organic soil material and mineral material.

Topsoil depth has been determined using the STATSGO2 dataset by identifying the depth of upper soil horizons based on sub-order and great group soil taxonomy descriptions (USDA NRCS, 1999). The depths of the horizons were grouped into three different ranges: 0–6 inches; 6–20 inches; and >20 inches. Acreage and percentages of soils within each topsoil group summarized by facility and map unit can be seen in Appendix B-STATSGO2 Soil Metadata Table.

7.4.6 Stony/Rocky Soils

Soils with cobbles, rocks, and boulders present can affect revegetation post construction. Introducing stones, cobbles, or rocks to surface soil layers can reduce soil moisture-holding capacity and thus reduce soil productivity. 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.

The potential for introducing rock into the topsoil was evaluated based on bedrock depth. STATSGO2 data was used to identify soil map units where depth to bedrock is generally anticipated to be less than 5 feet (60 inches) from the soil surface (USDA, 2008). Soils with bedrock less than 5 feet of the surface are identified in Table 7.5.-1 and discussed in Section 7.5.1 for the Liquefaction Facility, Section 7.5.2 for Interdependent Project Facilities and Section 7.5.3 for Non-Jurisdictional Facilities.

Blasting may be required in areas where bedrock, boulders, coarse soils shallow, and/or permafrost cannot be excavated by conventional mechanical equipment. Geotechnical, geologic, and geophysical datasets have been analyzed to identify areas where blasting may be required for right-of-way (ROW) preparation and pipeline ditch excavation. Areas potentially requiring blasting are discussed in Resource Report No. 6.

7.4.7 Prime Farmland Soils/Soils of Local Importance

Prime Farmland Soils have a specific combination of physical and chemical properties that allow for high yield of food, feed, forage, fiber, and oilseed crops. These soils are identifiable as having the highest quality and can sustain substantial yields of economically important crops when managed accordingly. No Prime Farmland Soils exist in Alaska as soil temperatures do not meet the threshold established by Congress.

Soils of Local Importance are soils identified by a local agency or agencies to have specific properties favorable to regional agriculture and crops. The distinguishing characteristics of the soil vary by region. The state of Alaska has designated Soils of Local Importance within the Kenai Peninsula and Matanuska-Susitna areas. These soils would be impacted by the Mainline only. Appendix C, Table 2 summarizes the Soils of Local Importance along the Mainline that would be affected.

7.5 CONSTRUCTION IMPACTS AND MITIGATION MEASURES

Potential impacts to soil resources from Project construction and the potential soil-related impacts encountered would vary with the properties of the soil types impacted, including the presence of permafrost and thaw-sensitive areas. Table 7.5-1 provides a summary of the areas subject to potential soil impacts during Project construction based on limited available data. Findings and outcomes from geotechnical work, both intrusive and non-intrusive, were finalized in the first quarter of 2016 and included in Appendix H of Resource Report 6.

Potential construction activities of the Project that may impact soil properties could include:

- Clearing to remove trees and vegetation;
- Grading and excavation to prepare the pipeline ROW and facility sites, including cut and fills along longitudinal and cross slopes;
- Placement of work pads (granular or snow/ice) to support construction equipment;
- Installation of pipe support structural members in areas of aboveground pipe construction;
- Pipe stringing, welding, and coating activities to prepare the pipe for burial or placement on vertical support members (VSMs);
- Pipeline trench excavation, pipelaying, and backfill activities in areas of pipe burial;
- Erosion and drainage control activities during construction;
- Watercourse crossings for pipelines, including open-cut, isolated, buried trenchless (HDD), and aerial crossings, as well as temporary bridges (ice, snow-fill or structural) for construction traffic;
- Borrow source development;
- Reclamation activities following pipe installation;
- Aboveground facility construction;
- Installation of foundations, underground structures, and utilities;
- Offshore construction, including shore crossings;
- Hydrostatic testing water discharge; and
- General infrastructure activities, including construction of camps, laydown areas, stockpile areas, and airstrips.

TABLE 7.5-1

Areas Subject to Potential Soil Impacts During Project Construction

Facility Name	Total Acreage	Severe Wind Erosion (acres)	Severe Water Erosion (acres)	Hydric Soil (acres)	Severe Compaction (acres)	Soils of Local Importance (acres)	Top Soil Range (inches)			Depth to Bedrock (feet)		
							0 - 6	6 - 20	> 20	0 - 0.6	0.7 - 5	> 5
LIQUEFACTION FACILITY												
LNG Plant	995.78	995.78	0.00	0.00	0.00	0.00	0.00	0.00	995.78	0.00	0.00	995.78
INTERDEPENDENT PROJECT FACILITIES												
PIPELINES												
Mainline [b]	12,379.47	4,506.27	1,007.20	7,514.72	4,641.70	895.49	2857.90	21.86	9500.14	743.91	574.65	11,060.91
PBTL [b]	7.31	0.00	0.00	7.31	7.31	0.00	0.00	0.00	7.31	0.00	0.00	7.31
PTTL [b]	349.82	0.00	0.00	349.82	349.82	0.00	0.00	0.00	349.82	349.82	0.00	0.00
GTP												
GTP Associated Infrastructure	835.34	0.00	0.00	835.34	835.34	0.00	0.00	0.00	835.34	0.00	0.00	835.34
NON-JURISDICTIONAL FACILITIES												
PTU Expansion project	135.94	0.00	0.00	135.94	135.94	0.00	0.00	0.00	135.94	0.00	0.00	135.94
PBU MGS	496.83	0.00	0.00	496.83	496.83	0.00	496.83	0.00	0.00	0.00	0.00	496.83
Kenai Spur Highway relocation	949.47	949.47	0.00	0.00	0.00	0.00	0.00	0.00	949.47	0.00	0.00	949.47
Total[a]	16,149.96	6,451.52	1,007.20	9,339.96	6,466.94	895.49	3,354.73	21.86	12,773.80	1,093.73	574.65	14,481.58

[a] The results are based on available USDA NRCS, 2017 STATSGO2 data, which thereby limited the analysis of soil properties for the entire area potentially impacted by the Project.
[b] GIS Feature ID as determined by exp,

These activities could result in impacts to soils throughout the Project including:

- Soil erosion due to wind or water;
- Reduced re-vegetation potential;
- Differential thaw settlement along and across the ROW within thaw-sensitive permafrost;
- Contamination (e.g., spills);
- Groundwater depletion or recharge; and
- Fugitive dust generated by operation activities on granular pads.

Inadvertent spills of fluids used during construction, such as fuel, lubricants, antifreeze, detergents, paints, solvents, and herbicides, could contaminate soils. A *Spill Prevention, Control and Countermeasure Plan* (*SPCC Plan*) has been developed that describes measures that would be implemented to prevent and, if necessary, control any inadvertent spill of hazardous substances (See Resource Report No. 2, Appendix M). During construction, all hazardous materials would be handled in accordance with the *SPCC Plan*.

Herbicides may be applied to noxious weeds, stumps, and low-growing brush for conducting vegetation control where necessary before and after construction as described in the *Noxious/Invasive Plant and Animal Control Plan*. Herbicides may be toxic to soil organisms and affect the revegetation potential of the area depending on the type used and the concentration. During construction, any herbicides would be handled in accordance with the label instructions; in compliance with any local, state, and federal regulations; and in accordance with landowner agreements as required by land use (organic farms, wetland reserves, etc.).

Adverse effects resulting from soil-related potential impacts due to construction would be avoided or greatly reduced through route selection, engineering design, monitoring, and agency consultation. In addition to these reports, industry best-management practices (BMPs) and engineering design would be used to prevent or mitigate adverse effects wherever possible. Induced impacts will be addressed in overarching construction environmental management plans and operations environmental management plans prepared by the Project and prior to construction or during permitting. These documents include, but may not be limited to:

- Specific Designs for Major Highway and Railroad Crossings (Resource Report No. 1, Appendix H);

- *Pipeline Winter Permafrost Construction Plan* (Resource Report No. 1, Appendix M);

- Groundwater Monitoring Plan (Resource Report No. 2, Appendix B);

- Site-Specific Construction Drawings: Site-Specific Waterbody Crossing Plans (Resource Report No. 2, Appendix I);

- *Stormwater Pollution Prevention Plan* (*SWPPP*) – general and spread-specific (Resource Report No. 2, Appendix J);

- *HDD Inadvertent Release Contingency Plan* (*Project-Specific HDD Contingency Plan*) (Resource Report No. 2, Appendix L);

- *Spill Prevention, Control and Countermeasure Plan* (*SPCC Plan*) (Resource Report No. 2, Appendix M);
- Applicant's *Wetland and Waterbody Construction and Mitigation Procedures* (Resource Report No. 2, Appendix N);
- *Wetland Mitigation Plan* (Resource Report No. 2, Appendix O);
- *Noxious/Invasive Plant and Animal Control Plan* (Resource Report No. 3, Appendix K);
- *Blasting Plan* (Resource Report No. 6, Appendix B);
- *Gravel Sourcing Plan and Reclamation Measures* (Resource Report No. 6, Appendix F);
- *Geological Hazard Assessments* (Resource Report No. 6, Appendix H); and
- Applicant's *Upland Erosion Control, Revegetation, and Maintenance Plan* (Resource Report No. 7, Appendix D, Applicant's *Plan*).

Many of the Project-specific plans and procedures were developed from public reports, guidelines, and best practices published by state or federal agencies and departments, including: ADOT&PF, ADNR, USACE, and BLM.

The following sections briefly summarize construction impacts to soil resources from Project construction and mitigations for potential soil-related impacts anticipated at the Liquefaction Facility and Interdependent Project Facilities.

7.5.1 Liquefaction Facility

The construction of the Liquefaction Facility may have several impacts on the native soils within the facility footprint. Anticipated impacts associated with construction of the Liquefaction Facility include: clearing and grubbing, excavation of overburden soils, borrow source development, foundation construction, aboveground facility construction, and general infrastructure activities.

7.5.1.1 Permafrost

No known permafrost exists at the Liquefaction Facility.

7.5.1.2 Erodible Soils

The native soil at the Liquefaction Facility consists primarily of silts and loams that can have the potential to be erodible. During construction, clearing and grubbing operations would expose topsoil. To reduce potential impacts due to soil erosion and associated sedimentation, erosion and sedimentation control methods described in the Applicant's *Plan* would be followed. Exposed soils have an increased potential to be eroded via wind and water, as discussed in the previous sections; to combat this, measures would be taken to reduce the time that soils are left exposed during construction. The Applicant's *Plan* has adapted and modified the FERC *Plan* to accommodate Alaska-specific conditions. The Applicant's *Plan* employs a toolbox approach of BMPs for selection and implementation based on site-specific conditions at the time of construction.

It would take approximately seven years to complete construction, which would likely result in work being completed in stages to limit the amount of soil that has been cleared and exposed to erosive forces. As work progresses on the property, surfacing materials (granular materials, asphalt, concrete) would be placed as soon as practical to reduce exposure and risk of erosion; where unfinished surfaces must remain exposed for extended durations, dust suppressants/soil binders would be used to provide protection, and stable contour grading would be used to minimize soil runoff from the site.

7.5.1.3 Hydric Soils

No impacts to mapped hydric soils are anticipated to take place during Project construction of the Liquefaction Facility.

7.5.1.4 Compaction-Prone Soils

Construction activities, including clearing to remove trees and vegetation, aboveground facility construction, and general infrastructure activities grading and excavation, may cause soil compaction. Compaction impacts could result in loss of soil productivity due to damage to soil structure from heavy equipment. To minimize potential impact to soil resources, soil would be prepared after final grading to facilitate revegetation in undeveloped areas of the Liquefaction Facility site as outlined in the Applicant's *Plan*. This could include tilling compacted soil or other measures depending on the extent and severity of compaction.

7.5.1.5 Topsoil

In the initial stages of construction, topsoil would be stripped, segregated, and stored on site for use during final grading and restoration of areas not paved or occupied by plant facilities. Maintenance of the stripped topsoil would include best management practices to prevent erosion, inadvertent mixing, and excessive compaction. If excess topsoil would remain, procedures for the disposal of materials for beneficial reuse would be followed, as detailed in a final grading plan.

7.5.1.6 Stony/Rocky Soils

There are no stony or rocky soils within the upper 72 inches of any soil that could be impacted by the Liquefaction Facility.

7.5.1.7 Prime Farmland Soils

No Prime Farmland Soils exist in Alaska and no Soils of Local Importance would be impacted by the construction of the Liquefaction Facility.

7.5.2 Interdependent Project Facilities

The construction of the Interdependent Project Facilities may have several impacts on the native soils within the facilities' footprints. These anticipated impacts would be associated with the clearing and grading along the ROW, placement of work pads, borrow source development, aboveground facility construction, pipeline excavation (trenching, backfilling, and reclamation), hydrostatic testing water withdrawal, trenchless methods of burial, and general infrastructure activities.

7.5.2.1 Permafrost

During construction the pipeline excavation could cause freezing and thaw-related effects that could include:

- Freezing of unfrozen ground leading to frost-bulb formation and potential frost heave;
- Solifluction and soil creep;
- Thawed layer detachment; and
- In-situ effects including subsidence and thaw consolidation, thermokarsting, and thaw bulb formation.

Approximately 348.7 miles of the Mainline portion of the route cross 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 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 Mainline would be crossed by construction during winter. During operations, the Mainline would be chilled as described below.

Operation of a chilled gas pipeline could produce a frost bulb around the pipe which could extend several feet from the pipe, up, down, and laterally. Frost bulbs have the potential to increase the height of permafrost above the pipe or impact subsurface water flows which could accelerate thawing of adjacent permafrost. The frost bulb formation in fine-grained saturated silty soil could also induce formation of ground ice. The impact of the formation of ground ice could be a serious threat to pipeline safety as frost heaving of the pipe might take place. Natural gas temperature would be managed by geography, with separate strategies and technologies planned for implementation North and South of the Brooks Range, as described below.

Short term changes to the thermal regime in thaw sensitive permafrost areas where gravel pads are constructed to permit access will occur. These changes would occur, albeit more slowly, if insulation is incorporated. Long term changes will include subsidence of the gravel pads and natural revegetation. Anticipated changes in surface drainage will be considered in design and drainage breaks will be incorporated to maintain natural flow patterns. Requirements for gravel during the operation phase to maintain the work pads and construction access roads are not anticipated. There will be a need for some gravel over time to maintain the permanent access roads and facility pads. A few material sites near these facilities will be maintained in an operational state to satisfy this need.

- From MP 0–MP 180, the pipeline temperature would remain below freezing throughout the year in continuous permafrost. The natural gas in the pipeline would be cooled and maintained to below freezing temperatures to maintain the stability of thaw-sensitive soils, reducing thaw-related movement of the pipeline and impact to permafrost. For compressor stations with cooling, two types of natural gas cooling equipment are proposed: gas-to-gas exchangers and aerial coolers.
- From MP 180–MP 567, seasonal variation in natural gas temperatures would range from below freezing in the winter to above freezing in the summer. The in-line temperature in discontinuous permafrost areas was designed for a 32°F year-round average. This design maintains ground conditions under the pipe close to original conditions.
- From MP 567–MP 804, in areas of predominantly warm, non-permafrost conditions, the natural gas temperature would be allowed above freezing temperatures and maintained by using indirect

fired natural gas heaters to prevent frost heaving and to meet design inlet natural gas temperature at the LNG Plant.

Winter construction in frozen soil conditions would 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). Construction protocols and ROW configurations to reduce, to the extent practicable, adverse impacts on thaw-sensitive permafrost soil areas during winter construction have been developed. A detailed presentation of thaw-sensitive and thaw-stable soils by MP in the Project area is provided in Appendix C, Extended Tables for Resource Report No. 7.

The majority of the soils and terrain units within the construction footprint of the North Slope facilities (PTTL, PBTL, GTP, and associated facilities) are permafrost soils that are thaw-sensitive in terms of thaw-settlement and loss of strength on thawing. However, given the flat topography of the North Slope and the fact that pipelines would be constructed in winter from ice roads onto VSMs, and that work on the GTP would be from a granular pad, it is unlikely that solifluction, soil creep, or thawed layer detachment would be issues either during construction, reclamation, or for operations and maintenance. There could be potential for thaw-induced subsidence depending on site-specific conditions such as natural drainage patterns. The PTTL and PBTL would be placed aboveground on VSMs to reduce heat transfer to underlying soils, minimize impacts to areas of thaw-sensitive permafrost, and keep the ground frozen. The GTP facility would incorporate proven Arctic design techniques of granular pads, piles, VSMs and thermosiphons to protect the active layer and underlying permafrost. The granular material required for construction of the GTP would be obtained from the planned mine to the southwest and the dedicated water reservoir.

At compressor stations underlain by thaw-sensitive permafrost, buildings and associated infrastructure would be elevated and granular pads would be installed to mitigate heat transfer to the underlying permafrost. During construction of compressor stations, adherence with the Project *Plan* and *Procedures* would reduce the effects of erosion on affected soils.

Special pipeline construction methods have been developed for winter and permafrost soil conditions that address both thaw-sensitive and thaw-stable permafrost. Those methods are described in detail in the *Pipeline Winter and Permafrost Construction Plan* found in Resource Report No. 1, Appendix M. This plan describes construction techniques and mitigation measures to be used during the construction of the pipelines for PTTL, PBTL, and Mainline to minimize the extent and duration of Project-related disturbance on permafrost terrain whether constructed in winter or summer. These construction techniques and mitigation measures are based on experience gained in constructing TAPS, more than 30 years of Arctic construction experience on Alaska's North Slope, as well as cold-region pipeline construction in other parts of North America. Construction methods and procedures include development of multiple ROW modes that consider the thaw sensitivity of permafrost, terrain slope conditions, MLRA, and season of construction. The *Pipeline Winter and Permafrost Construction Plan* is also intended to fulfill the requirement of the Applicant's *Plan*.

7.5.2.2 Erodible Soils

During construction of Interdependent Project Facilities, clearing and grading along the ROW, pipeline excavation (trenching, backfilling, and reclamation), and general infrastructure activities 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.

Approximately one-third of the soils impacted by the Mainline are considered highly water-erodible and one-quarter are considered highly wind-erodible. No soils were identified as highly water or wind erodible soils along the entire length of the PBTL and PTTL, or the GTP.

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 effects would result in areas that are restored to stable conditions that may not reflect preconstruction contours; however, the establishment of stable surfaces would represent the presence of an additional natural landform after the area has been stabilized, though different from preconstruction conditions.

To reduce potential impacts due to soil erosion and associated sedimentation, erosion and sedimentation control methods would be used as described in the Applicant's *Plan*. The Applicant's *Plan* includes proposed modifications to the FERC *Plan* to accommodate Alaska-specific conditions, including permafrost (via the *Pipeline Winter and Permafrost Construction Plan)* and widespread silty soil deposits. The Applicant's *Plan* employs 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 would be monitored by the Project. Except in actively cultivated agricultural areas, temporary erosion control devices would be maintained until the ROW would be stabilized successfully, as defined in the Applicant's *Plan*. Following successful stabilization of construction areas, temporary erosion control devices would be removed by the Project, where appropriate.

7.5.2.3 Hydric Soils

Over half of the soils crossed by the Mainline are expected to be hydric. Of these, approximately one-quarter would be crossed during winter construction. Construction during winter would be an effective mitigation measure when crossing hydric soils by allowing permafrost soils to remain stable.

The soils impacted by the PBTL and the majority of the PTTL are also expected to be hydric. Areas that may not be hydric along the PTTL include dune areas, sand blankets, and the coarse-textured terraces adjacent to rivers. Hydric soils along the PBTL and PTTL would be crossed during the winter, minimizing disturbance. In addition, the PBTL and PTTL would be placed aboveground on VSMs from ice roads, further reducing the amount of ground disturbance.

The soils impacted by the GTP are also hydric. The GTP would be constructed on a granular pad and the associated infrastructure would be built using ice pads and roads. Soils outside of the GTP pad would be subject to minimal disturbance. Similarly, the Pipeline Aboveground Facilities would be constructed on granular pads with minimal offsite disturbance anticipated for any hydric soils present.

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 the Applicant's *Procedures*.

7.5.2.4 Compaction-Prone Soils

The majority of the soils crossed by the Mainline are compaction-prone, however, an estimated one-third are crossed during winter using construction methods outlined in the *Pipeline Winter and Permafrost Construction Plan*. Construction during winter is anticipated to limit compaction impacts on these soils. Additionally, the majority of the soils impacted by the PBTL and PTTL are also 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 would occur in the winter using ice roads.

Approximately one-fifth of the compaction-prone soils would 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 would avoid or reduce compaction typically associated with heavy machinery working over thin layers of topsoil. Seasonal freezing and thawing of Gelisols, 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.

Prior to construction, actively cultivated agricultural land would be identified (if any) and adverse impacts would be reduced with adherence to the measures outlined in the Applicant's *Plan*.

Because of compaction alleviation practices in the Applicant'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.

The majority of the soils impacted by the GTP are compaction-prone. However, the GTP would be constructed on a granular pad and the associated infrastructure would be built using ice pads and roads during the winter or from granular roads. Compaction-prone soils outside of the GTP pad would be subject to minimal disturbance. Similarly, the GTP associated infrastructure would be constructed on granular pads or ice roads with minimal offsite disturbance anticipated for any compaction-prone soils present. Although the soils present exhibit compaction characteristics, there would be no compaction impacts since the soils would be covered with gravel or temporarily covered with ice.

7.5.2.5 Stony/Rocky Soils

Introducing stones, cobbles, or rocks to surface soil layers can reduce soil moisture-holding capacity and thus reduce soil productivity. For the buried Mainline, subsurface rocks can be expected in some areas throughout the Mainline.

During construction, adverse impacts due to the presence of stones and rocks in cultivated agricultural soils would be reduced by following mitigation protocols provided in the Applicant's *Plan* (Appendix D). Similarly, impacts are expected to be negligible to short term in areas constructed during winter. In undisturbed land that is impacted 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 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 ROW; 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 preconstruction conditions. The establishment of stable surfaces would represent an additional natural landform after the area has been stabilized.

For the PBTL and PTTL, the terrain data suggest that most of the ROW has few or no subsurface stones greater than 3 inches in size. In addition, these pipelines would be constructed aboveground on VSMs.

The terrain data suggest the Project footprint of the GTP does not have any subsurface stones greater than 3 inches in size. The presence of bedrock and large stones would not affect GTP construction because the facility would be placed on a granular pad. Similarly, the Pipeline Aboveground Facilities would be constructed on granular pads and would not be anticipated to be affected by the presence of subsurface stones.

7.5.2.6 Topsoil

The majority of the soils (75 percent of total) impacted by the Mainline, PTTL, and GTP have topsoils that are greater than 20 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. However, all of the PBTL traverses soils with very thin topsoil and both the PBTL and the majority of the PTTL would not require trench construction.

The treatment and conservation of agricultural land, topsoil, and loose surface material is illustrated for ROW construction configurations in Resource Report No. 1. During construction protocols would be followed for treatment of topsoil and loose surface material as indicated in the Applicant's *Plan*.

Persistent direct and indirect effects may result in areas where segregation of topsoil and surface soils is not practicable, or where constructed pads have been permanently placed. The establishment of stable surfaces would represent an additional man-made landform. This landform would be stabilized and reclaimed, but would be different from preconstruction conditions.

The GTP facility would be placed on a granular pad and the associated infrastructure would be built using ice pads and roads during the winter. Topsoil outside of the GTP pad would be subject to minimal disturbance. Similarly, the Pipeline Aboveground Facilities would be constructed on granular pads with minimal offsite disturbance anticipated.

7.5.2.7 Prime Farmland Soils

No Prime Farmlands Soils exist in Alaska; however, the Mainline would cross Soils of Local Importance. Topsoil and revegetation BMPs would be followed to reduce impacts to these soils.

7.5.3 Non-Jurisdictional Facilities

7.5.3.1 Permafrost

The PTU Expansion project and PBU MGS project footprints cross primarily thick gravelly permafrost soils that are thaw-stable. To reduce impacts, the following mitigation efforts would be implemented:

- Placing a minimum of 5 feet of granular fill;

- Elevating permanent heated buildings or structures on piles;
- Elevating off-pad pipelines containing warm (above freezing) fluids on vertical support members (VSMs);
- Minimizing or avoiding impoundments by maintaining natural drainage patterns to the extent practicable;
- Installing thermosyphons around wells to control heat transfer from wellbore fluids and protect wellbore integrity; and
- Insulating conductor piles and filling well annuli with insulating gel to minimize heat transfer to the permafrost.

No known permafrost exists along the KSH relocation project footprint.

7.5.3.2 Erodible Soils

The PTU Expansion and PBU MGS Project footprints are underlain by peat soils that are not susceptible to wind or water erosion. The native soil on the Kenai Spur Highway relocation project area consists primarily of silts and loams, which can have a high potential to be susceptible to wind erosion. Plans to reduce wind erosion impacts during construction, along with mitigation efforts, are discussed in Section 7.5.1.2.

7.5.3.3 Hydric Soils

All of the soils within the PBU MGS and PTU Expansion Projects are hydric. Plans to reduce impacts during construction and mitigation efforts are discussed in Section 7.5.2.3. The current routing of the Kenai Spur Highway relocation project alternatives avoid hydric soils.

7.5.3.4 Compaction-Prone Soils

All of the soils within the PBU MGS and PTU Expansion are peat, which have a high potential for compaction. The native soil on the Kenai Spur Highway relocation project area consists primarily of well drained silts and loams, which have a low potential for compaction. Because the PTU Expansion project and the PBU MGS would be built in winter off of ice roads, or involve the use of gravel pads or gravel roads, impacts to compaction prone soils are not anticipated.

7.5.3.5 Topsoil

Topsoil maintenance and disposal for Non-Jurisdictional Facilities would follow the procedures discussed in Section 7.5.2.6, as applicable.

7.5.3.6 Stony Rocky Soils

There are no stony or rocky soils within the upper 72 inches of any soil that could be impacted by the Non-Jurisdictional Facilities.

7.5.3.7 Prime Farmland Soils

No Prime Farmland Soils exist in Alaska and no Soils of Local Importance would be impacted by the Non-Jurisdictional Facilities.

7.6 POTENTIAL OPERATIONAL IMPACTS AND MITIGATION MEASURES

Impacts to soil resources from Project operation and the potential soil-related impacts encountered would vary with the properties of the soils impacted and the nature of the operational activity. Operation activities that could impact soil properties are maintenance activities, geohazard monitoring and intervention, vegetation maintenance, maintenance of drainage control structures (e.g., interception ditches, culverts, and subdrains), and main equipment traffic.

Impacts to soil resources as a result of Project operations may include:

- Permanent conversion of soils due to installation of impervious surface (e.g., foundation paving);
- Differential thaw settlement along and across the ROW within thaw-sensitive permafrost;
- Long-term degradation of permafrost and deepening of the active layer;
- Frost bulb development and frost heave in susceptible unfrozen soils; and
- Contamination (e.g., spills);

Table 7.6-1 provides a summary of areas subject to potential soil impacts during operation of the Project.

TABLE 7.6-1

Areas Subject to Potential Soil Impacts During Project Operations

Facility Name	Total Acreage	Severe Wind Erosion Potential (acres)	Severe Water Erosion Potential (acres)	Hydric Soil (acres)	Severe Compaction Potential (acres)	Soils of Local Importance (acres)	Top Soil Range (inches)			Depth to Bedrock (feet)		
							0 - 6	6 - 20	> 20	0 - 0.6	0.7 - 5	> 5
LIQUEFACTION FACILITY												
LNG Plant	901.61	901.61	0.00	0.00	0.00	0.00	0.00	0.00	901.61	0.00	0.00	901.61
INTERDEPENDENT PROJECT FACILITIES												
PIPELINES												
Mainline [b]	907.08	439.35	10.21	543.65	68.29		365.76	0.00	540.33	1.37	41.79	863.93
PBTL [b]	7.31	0.00	0.00	7.31	7.31	0.00	7.31	0.00	0.00	0.00	0.00	7.31
PTTL [b]	76.82	0.00	0.00	76.82	76.82	0.00	0.00	0.00	76.82	76.82	0.00	0.00
GTP												
GTP Associated Infrastructure	835.34	0.00	0.00	835.34	835.34	0.00	835.34	0.00	0.00	0.00	0.00	835.34
Total[a]	2,728.16	1,340.96	10.21	1,463.12	987.76	0.00	1,208.41	0.00	1,518.76	78.19	41.79	2,608.19

[a] The results are based on available USDA NRCS, 2017 STATSGO2 data, which thereby limited the analysis of soil properties for the entire area potentially impacted by the Project.
[b] GIS Feature ID as determined by exp,

7.6.1 Liquefaction Facility

Operations that may result in permanently altered soils or loss of soil resources include the developed site of the Liquefaction Facility, permanent roads, granular pads left in place following construction, and granular pads for aboveground facilities.

7.6.2 Interdependent Project Facilities

Reclamation planned for the pipeline ROW would involve mitigation measures, such as re-contouring to stable contours, but not restoring original contours in all cases. In areas where removal of granular pads used for construction would be likely to create significant damage to underlying permafrost soils, pads would be left in place following construction to naturally settle, saturate, and eventually revegetate.

In the continuous permafrost region, the pipeline temperature would be a relatively constant 30° F year round to prevent thaw settlement of the pipeline. In discontinuous permafrost regions, in order to minimize differential settlement of the pipe relative to that of the ROW, pipeline sections would operate above freezing in the summer months and below freezing throughout the winter months. The average annual discharge temperature would be maintained at or below freezing for the majority of the line. This would ensure overall preservation of permafrost in the vicinity of the pipe.

Maintenance of granular pads and access roads following construction is not planned unless required for ongoing operations/maintenance access to specific locations in the Project area, or required by the landowner. In this case, only limited maintenance would be planned to be carried out, possibly affecting recovery of soil resources along roads and pads used for maintenance activities.

Associated with each activity and impact are a number of Project plans, procedures, and BMPs that would be applied to address the induced impacts. These are detailed in Section 7.5.

7.7 REQUESTED MODIFICATIONS TO FERC'S PLAN

Requested modifications to FERC's 2013 Plan for construction and operation of the Liquefaction Facility and Interdependent Project Facilities are listed in Table 7.7-1. The work related to the requested modifications would be performed in a conscientious manner and in accordance with applicable federal and state environmental laws.

TABLE 7.7-1

Requested Modifications to the 2013 FERC Plan for Construction and Operation of the Interdependent Facilities

Section No.	FERC Plan (May 2013)	Alaska LNG's Proposed Measure	Justification
II	SUPERVISION AND INSPECTION		
II.B.6	Ensuring that the design of slope breakers will not cause erosion or direct water into sensitive environmental resource areas, including cultural resource sites, wetlands, waterbodies, and sensitive species habitats.	Ensuring that the design of slope breakers will not cause erosion or direct water into sensitive environmental resource areas, including cultural resource sites, waterbodies, and sensitive species habitats. Ensure water entering wetlands from slope breakers would be first directed into energy dissipating devices.	Discharging into wetlands is unavoidable due to the extensive occurrence of wetlands within the proposed Project footprint (see Appendix E of Resource Report No. 2). This modification clarifies that water discharge to wetlands will first pass through an energy dissipating device to minimize the potential for erosion and discharging water with sediments into a wetland.

TABLE 7.7-1

Requested Modifications to the 2013 FERC Plan for Construction and Operation of the Interdependent Facilities

Section No.	FERC Plan (May 2013)	Alaska LNG's Proposed Measure	Justification
I.B.10	Ensuring restoration of contours and topsoil;	Ensure the post-construction right-of-way is graded to stable contours with the surface soils in a suitable condition for restoration.	As discussed in Resource Report No. 1 Appendix M Winter Construction Plan and Resource Report No. 3 Appendix P, Restoration Plan, ensuring a stable ROW is critical to the long-term success of any revegetation efforts and will be the primary measure implemented after construction is complete. See Section 7.7.2 for additional justification.
III	PRECONSTRUCTION PLANNING		
III.I.1	winter construction procedures (e.g., snow handling and removal, access road construction and maintenance, soil handling under saturated or frozen conditions, topsoil stripping);	winter construction procedures (e.g., snow handling and removal, access road construction and maintenance, soil handling under saturated or frozen conditions, topsoil stripping) and for permafrost terrain during winter and summer periods;	Addition required to address permafrost terrain and management of permafrost to ensure long-term ROW stability.
IV	INSTALLATION		
IV.A.1	Project-related ground disturbance shall be limited to the construction right-of-way, extra workspace areas, pipe storage yards, borrow and disposal areas, access roads, and other areas approved in the FERC's Orders. Any project-related ground disturbing activities outside these areas will require prior Director approval. This requirement does not apply to activities needed to comply with the Plan and Procedures (i.e., slope breakers, energy-dissipating devices, dewatering structures, drain tile system repairs) or minor field realignments and workspace shifts per landowner needs and requirements that do not affect other landowners or sensitive environmental resource areas. All construction or restoration activities outside of authorized areas are subject to all applicable survey and permit requirements, and landowner easement agreements.	Project-related ground disturbance shall be limited to the construction right-of-way, additional temporary workspace (ATWS) areas, pipe storage yards, borrow and disposal areas, access roads, shooflies, and other areas approved in the FERC's Orders. Where fill is imported to provide a stable work surface in any of the above areas, the fill would be left in place. Any project-related ground disturbing activities outside these areas will require prior Director approval. This requirement does not apply to activities needed to comply with the Plan and Procedures (i.e., slope breakers, energy-dissipating devices, dewatering structures, drain tile system repairs) or minor field realignments and workspace shifts per landowner needs and requirements that do not affect other landowners or sensitive environmental resource areas. All construction or restoration activities outside of authorized areas are subject to all applicable survey and permit requirements, and landowner easement agreements.	Additional text to clarify potential disturbance areas. Included shooflies as an additional feature. Not all fill placed to facilitate safe construction will be removed following construction. See Resource Report No. 2, Section 2.6 for additional information on ROW stabilization.
IV.A.2	The construction right-of-way width for a project shall not exceed 75 feet or that described in the FERC application unless otherwise modified by a FERC Order. However, in limited, non-wetland areas, this construction right-of-way width may be expanded by up to 25 feet without Director approval	The construction right-of-way width for the Project shall not exceed 145 feet or that described in the FERC application unless otherwise modified by a FERC Order. However, in limited, non-wetland areas, this construction right-of- way width may be expanded by up to 25 feet without Director approval to accommodate full construction right-of-way topsoil	See ROW justification in Appendix G of Resource Report No. 1. Further justification is provided in Section 7.7.3

TABLE 7.7-1

Requested Modifications to the 2013 FERC Plan for Construction and Operation of the Interdependent Facilities

Section No.	FERC Plan (May 2013)	Alaska LNG's Proposed Measure	Justification
	to accommodate full construction right-of-way topsoil segregation and to ensure safe construction where topographic conditions (e.g., side-slopes) or soil limitations require it. Twenty-five feet of extra construction right-of-way width may also be used in limited, non-wetland or non-forested areas for truck turn-arounds where no reasonable alternative access exists.	segregation and to ensure safe construction where topographic conditions (e.g., side-slopes) or soil limitations require it. Twenty-five feet of extra construction right-of-way width may also be used in limited, non-wetland or non-forested areas for truck turn-arounds where no reasonable alternative access exists.	
IV.B.3	Where topsoil segregation is required, the project sponsor must: a. segregate at least 12 inches of topsoil in deep soils (more than 12 inches of topsoil); and b. make every effort to segregate the entire topsoil layer in soils with less than 12 inches of topsoil.	Where organic material segregation is required, the Project will: a. segregate at least 12 inches of organic material in deep soils (more than 12 inches of organic material), except in areas where standing water is present, soils are saturated or frozen, or where the ditch is opened by "Drill & Shoot; and b. make every practical efforts to segregate the entire organic material layer in soils with less than 12 inches of organic material present, except in areas where standing water is present, soils are saturated or frozen, or where the ditch is opened by "Drill & Shoot"	Project-specific conditions such as terrain, environment (e.g., permafrost), construction season, and other constraints applicable to pipeline construction in Alaska render the segregation of topsoil infeasible. The Project will make practical efforts to segregate when site conditions allow. See further justification in Section 7.7.3
IV.F	Install temporary erosion controls immediately after initial disturbance of the soil. Temporary erosion controls must be properly maintained throughout construction (on a daily basis) and reinstalled as necessary (such as after backfilling of the trench) until replaced by permanent erosion controls or restoration is complete.	Temporary erosion controls would be installed prior to the onset of conditions that could cause erosion (e.g., spring thaw), or when those conditions exist immediately after initial disturbance of the soil. Temporary erosion controls must be properly maintained throughout construction (on a daily basis) and reinstalled as necessary (such as after backfilling of the trench) until replaced by permanent erosion controls or restoration is complete.	The use of temporary erosion control is applicable when terrain, topography, climatic and environment conditions are present that allows erosion to initiate and sediment transport to occur. Erosion is not active when the ground surface is frozen or snow covered. Therefore, it is not necessary to install temporary erosion control measures under these circumstances. However, erosion controls will be installed before spring thaw as rain or snow melt can induce erosion and sediment transport.
V.F.1.d	Position the outfall of each temporary slope breaker to prevent sediment discharge into waterbodies, or other sensitive environmental resource areas. Where temporary slope breakers are installed in wetlands, an energy dissipating discharge structure at the end of the breaker	Position the outfall of each temporary slope breaker to prevent sediment discharge into waterbodies, or other sensitive environmental resource areas. Where slope breakers are installed in wetlands, an energy dissipating device will be placed at the end of the breaker.	Modified language to account for slope wetlands and the requirement to direct slope breaker run-off into discharge structures in the wetland.

TABLE 7.7-1

Requested Modifications to the 2013 FERC Plan for Construction and Operation of the Interdependent Facilities

Section No.	FERC Plan (May 2013)	Alaska LNG's Proposed Measure	Justification
	will be installed.		
/.F.3. a	Sediment barriers may be constructed of materials such as silt fence, staked hay or straw bales, compacted earth (e.g., driveable berms across travelways), sand bags, or other appropriate materials.	Sediment barriers may be constructed of materials such as silt fence, staked hay or straw bales, compacted earth/snow (e.g., drivable berms across travelways), sand bags, or other appropriate materials.	It is likely that snow will be present that would be compacted with earth in creating ROW berms. Snow would also be used in winter construction to manage wind drift snow.
V	RESTORATION		
V.A.2	A travel lane may be left open temporarily to allow access by construction traffic if the temporary erosion control structures are installed as specified in section IV.F and inspected and maintained as specified in sections II.B.12 through 14. When access is no longer required the travel lane must be removed and the right-of-way restored.	A travel lane may be left open temporarily to allow access by construction traffic if the temporary erosion control structures are installed as specified in section IV.F and inspected and maintained as specified in sections II.B.12 through 14. When access is no longer required the travel lane would be deactivated and the right-of-way restored.	For the purposes of this document "deactivate" shall mean the site will be modified so it will no longer be usable for access, by the placement of traffic barriers and removal of culverts and reestablishment of natural drainage. Deletion of "must be removed" to clarify that fill placed for safe construction may not be removed.
V.A.3	Rock excavated from the trench may be used to backfill the trench only to the top of the existing bedrock profile. Rock that is not returned to the trench shall be considered construction debris, unless approved for use as mulch or for some other use on the construction work areas by the landowner or land managing agency.	Rock excavated from the trench may be used to backfill the trench only to the top of the existing bedrock profile. Except for agricultural and residential areas, excess trench rock may be spoiled on the right-of-way in such a way as to not impede right-of-way restoration.	Additional text to clarify that the Project may dispose of excess trench rock on the right-of-way rather than hauling it to dedicated disposal site.
V.A.5	Grade the construction right-of-way to restore pre-construction contours and leave the soil in the proper condition for planting.	Grade the construction right-of-way to stable contours with the surface soils in a suitable condition for restoration.	Stability of the ROW is paramount to the success of restoration. Stable contours to ensure restoration may not be the pre-construction contours. See further justification in Section 7.7.2
V.A.7	Remove temporary sediment barriers when replaced by permanent erosion control measures or when revegetation is successful	Remove temporary synthetic sediment barriers when replaced by permanent erosion control measures or when initial revegetation and/or stabilization is complete.	Changed to reflect the notion that only sediment barriers made of synthetic material need to be removed from site, those made from natural materials will bio-degrade over time. Introduced concept that site stabilization is another measure that may be used to determine if temporary sediment barriers are no longer needed, in addition to initial revegetation. 'Initial' added to revegetation to recognize that full revegetation generally takes an extended period of time in Alaska.
V.B.3	N/A	Mulch a. Permanent mulch may consist of wood fiber hydromulch, wood chips, granular soils or rock, or	Stabilization of the ROW is paramount to ensuring successful operation and pipeline integrity over the long term. Different mulches will be used depending on the presence thaw

TABLE 7.7-1

Requested Modifications to the 2013 FERC Plan for Construction and Operation of the Interdependent Facilities

Section No.	FERC Plan (May 2013)	Alaska LNG's Proposed Measure	Justification
		some functional equivalent. b. The site-specific application of mulch as a permanent erosion control mitigation will be designed by an engineer or similarly qualified professional. c. Ensure that mulch is adequately anchored to minimize loss due to wind and water. Do not use synthetic monofilament mesh/netted erosion control materials in areas designated as sensitive wildlife habitat, unless the product is specifically designed to minimize harm to wildlife. Anchor erosion control fabric with staples or other appropriate devices.	sensitive permafrost, slope (and degree of slope), presence of rock at or just below the ground surface, or the need insulate or cover the ROW to maintain a stable surface to allow over the long term to ensure pipeline integrity.
V.D.1.a	The project sponsor is responsible for ensuring successful revegetation of soils disturbed by project-related activities, except as noted in section V.D.1.b.	The Project is responsible for ensuring successful revegetation of soils disturbed by project-related activities, except as noted in section V.D.1.b. or in other areas where application of stabilization measures precludes revegetation (such as where a permanent mulch or other ground cover has been installed).	See V.B.3 above.
V.D.3.a	Prepare a seedbed in disturbed areas to a depth of 3 to 4 inches using appropriate equipment to provide a firm seedbed. When hydroseeding, scarify the seedbed to facilitate lodging and germination of seed.	Seed bed preparation, soil amendments, and seed mixtures will be customized to Arctic and sub-Arctic climactic zones, ecological regions and soil characteristics.	See the Resource Report No. 3, Appendix P, Restoration Plan for post construction restoration.
V.D.3.e	In the absence of written recommendations from the local soil conservation authorities, seed all disturbed soils within 6 working days of final grading, weather and soil conditions permitting, subject to the specifications in section V.D.3.a through V.D.3.c.	The Project will adhere to written recommendations from the local soil conservation authorities, subject to the specifications in section V.D.3.a through V.D.3.d.	See V.D.3.a above.
VII	POST-CONSTRUCTION ACTIVITIES AND REPORTING		
VII.A.2	Revegetation in non-agricultural areas shall be considered successful if upon visual survey the density and cover of non-nuisance vegetation are similar in density and cover to adjacent undisturbed lands. In agricultural areas, revegetation shall be considered successful when upon visual survey, crop growth and vigor are similar to adjacent undisturbed portions of the same field, unless the easement	Where revegetation is performed, revegetation in non-agricultural areas shall be evaluated against performance standards in the Alaska LNG Restoration Plan. Continue revegetation efforts until revegetation is successful.	See justification of restoration methods in the Resource Report No. 3, Appendix P, Restoration Plan.

TABLE 7.7-1

Requested Modifications to the 2013 FERC Plan for Construction and Operation of the Interdependent Facilities

Section No.	FERC Plan (May 2013)	Alaska LNG's Proposed Measure	Justification
	agreement specifies otherwise. Continue revegetation efforts until revegetation is successful.		
VII.A.4	Restoration shall be considered successful if the right-of-way surface condition is similar to adjacent undisturbed lands, construction debris is removed (unless otherwise approved by the landowner or land managing agency per section V.A.6), revegetation is successful, and proper drainage has been restored.	Restoration of the right-of-way surface shall be evaluated against performance standards in the Alaska LNG Restoration Plan, construction debris is removed (unless otherwise approved by the landowner or land managing agency per section V.A.6), and proper drainage has been restored.	See justification of restoration methods in the Resource Report No. 3, Appendix P, Restoration Plan.
VII.A.5	Routine vegetation mowing or clearing over the full width of the permanent right-of-way in uplands shall not be done more frequently than every 3 years. However, to facilitate periodic corrosion/leak surveys, a corridor not exceeding 10 feet in width centered on the pipeline may be cleared at a frequency necessary to maintain the 10-foot corridor in an herbaceous state. In no case shall routine vegetation mowing or clearing occur during the migratory bird nesting season between April 15 and August 1 of any year unless specifically approved in writing by the responsible land management agency or the U.S. Fish and Wildlife Service.	Routine vegetation mowing or clearing over the full width of the permanent right-of-way in uplands shall not be done more frequently than every 3 years. However, to facilitate periodic corrosion/leak surveys, a corridor not exceeding 10 feet in width centered on the pipeline may be cleared at a frequency necessary to maintain the 10-foot corridor in an herbaceous state. In no case shall routine vegetation mowing or clearing occur during the migratory bird nesting season of any year unless specifically approved in writing by the responsible land management agency or the U.S. Fish and Wildlife Service.	Some vegetation maintenance may occur in the winter because of restrictive access to the ROW, therefore the window will vary across by region and terrain.

7.7.1 ROW Stabilization

The *Pipeline Winter and Permafrost Construction Plan* (Resource Report No.1, Appendix M) was prepared to fulfill the requirements of FERC's Procedures and Plan (May 2013 version). Because of the Project's unique crossing of hundreds of miles of permafrost terrain in both summer and winter, the construction plan is combined with a description of methods used to cross Permafrost terrain in both summer and winter. The construction methods also addressed Alaska unique conditions associated with assuring the stability of the ROW as a key element to both erosion control and the success of restoration measures. Modifications to FERC's Plan related to restoring ROW post-construction grading and contours are needed to assure a stable ROW is maintained to allow for the implementation of the Project *Restoration Plan* (see Appendix P of Resource Report No. 3).

The short growing seasons on the northern portion of the pipeline will impact restoration and revegetation and may require extended efforts to stabilize the ground where permafrost exists. This includes time for the disturbed ground to reach a new thermal equilibrium. Disturbance to permafrost will result from ROW clearing (within the boreal forest area), trenching, and grade-cuts on the ROW. While the installation of granular pads does not breach the tundra or cut into permafrost, the granular pads will conduct solar radiation to the underlying permafrost resulting in some long-term ground thaw. The extent of these construction impacts may result in long-term changes to the surface and subsurface thermal and drainage regimes that, when combined with annual variations, may extend or shorten the period in which equilibrium is re-established.

Initial restoration of wetlands in winter sections should be completed to the maximum extent practicable during frozen conditions as access to complete additional remediation following spring melt may be limited. Completing this remediation work during non-frozen conditions may require specialty equipment, access roads, or gravel pads to provide a stable surface to work from.

Permafrost terrain stabilization and rehabilitation activities may extend several years after construction and initial rehabilitation is complete. Complete details of the ROW restoration are provided in the Resource Report No. 3, Appendix P, *Project Restoration Plan*.

When the ground surface is frozen in the winter, no surface erosion should occur. This applies to both permafrost and non-permafrost terrain. Within permafrost terrain, when the active layer is thawed following spring breakup, typically reaching its maximum depth in about late September, erosion potential at the ground surface is essentially the same as it would be in non-permafrost terrain. During seasonal thaw periods, permafrost soil terrain behaves like non-permafrost soil relative to erosion susceptibility and control. Based on the preceding discussion, all mineral soil regardless of whether it is within permafrost or not can be treated the same from an erosion protection perspective.

There are several aspects of erosion control that are influenced by the permafrost conditions including the following:

- Frozen soils are generally less erodible than unfrozen soils due to the cohesive nature of the frozen soil mass.
- Presence of the seasonal active layer. This relatively thin layer at the ground surface experiences seasonal freezing and thawing. Where ROW grading or pipeline trenching exposes ice-rich soils, the erosion potential, susceptibility, and volume may be elevated above that of non-permafrost soils.

As noted above, thermal erosion will exacerbate erosion of susceptible mineral soils through the melting of interstitial or massive ice present in the exposed soils. This aspect of erosion in permafrost terrain is the most significant and important difference compared to erosion in non-permafrost terrain. Using the ROW construction methods outlined in the *Pipeline Winter and Permafrost Construction Plan* will allow a stable ROW for implementation for erosion control strategies typically used for pipeline construction projects.

7.7.2 Construction ROW Width Greater than 75 feet

The rationale and details for selection of the construction ROW widths is presented in the Resource Report No. 1 in the following sections and related appendices:

- 1.5.2.3.1.1.1 Construction Spreads and Seasons;
- 1.5.2.3.1.1.2 ROW Construction Modes;
- 1.5.2.3.1.1.3 Selection of the ROW Construction Mode;
- 1.5.2.3.1.1.4 Selection of the ROW Width;
- *Rationale for the Selection of Pipeline ROW Width* (Appendix G); and
- *Pipeline Winter and Permafrost Construction Plan* (Appendix M).

Construction ROW width greater than 75 feet is based ROW modes determined by construction season, permafrost soil conditions, slope terrain and ROW access. See Resource No 2, Section 2.6 for additional details regarding ROW mode width justifications.

7.7.3 Topsoil Segregation

Project-specific conditions such as terrain, environment (e.g., permafrost), construction season, and other constraints applicable to pipeline construction in Alaska render the segregation of topsoil infeasible. The Project will make practical efforts to segregate when site conditions allow. See Resource Report No. 2 Section 2.6.3 for specific justification details.

7.8 REFERENCES

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