APPENDIX P RESTORATION PLAN

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RESTORATION PLAN

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 PURPOSE AND SCOPE

1.1 PURPOSE AND SCOPE

The purpose of this draft Project *Restoration Plan* (Plan) is to summarize the goals and objectives of the Alaska LNG Project (Project) restoration effort for the Mainline pipeline (Mainline) trench and associated right-of-way (ROW) and the various site preparation and plant cultivation techniques that may be employed to achieve the goals and objectives. No other impacts requiring restoration are anticipated for the Project; however, if they occur, a site-specific restoration plan would be developed. This Plan is intended to provide Alaska-specific restoration practices to address impacts from pipeline construction. For some sections of the pipeline route (see Section 3.0), the ROW would be largely undisturbed and thus, would not require a restoration effort. The performance standards for achieving successful restoration would be developed in collaboration with the appropriate federal, state, and local regulatory agencies. The standards developed would reflect the restoration goals of the Project and would provide a framework for determining success and identifying any corrective measures that may be required to ensure restoration goals have been achieved.

This Plan is presented in four sections. Section 2.0 describes the general restoration approach. Section 3.0 summarizes the restoration strategies proposed for each construction method or mode and the associated spreads where the modes would be implemented. Section 4.0 describes site conditions along the proposed Project route that would require special consideration with respect to restoration regardless of construction mode (waterbody crossings and surface instability, e.g., thaw-sensitive areas or steep longitudinal slopes). Section 5.0 is a conclusion statement that summarizes efforts to achieve the goals of restoration through the development of specific construction methodologies and implementation of various restoration methodologies.

This Plan will be referenced and/or appended as part of both the Alaska LNG Project *Plan (Alaska LNG Project Upland Erosion Control, Revegetation, and Maintenance Plan)* and *Procedures* (Alaska LNG Project *Wetland and Waterbody Construction, and Mitigation Procedures*) documents, and the supporting *Winter and Permafrost Construction Plan*. The *Restoration Plan* will address Project-specific variations mostly regarding revegetation efforts associated with the *Plan and Procedures*. The *Restoration Plan* also will be referenced as part of the *Wetland Mitigation Plan* to address some of the requirements associated with permittee-responsible mitigation. This mitigation may include wetland and stream crossings of the pipeline and temporary workspaces such as access roads, yard sites, etc.

1.2 HISTORY OF RESTORATION PRACTICES IN RELEVANT ALASKAN ECOSYSTEMS

Initially, restoration efforts in Alaska were focused on maintaining water quality by controlling soil erosion resulting from the removal of natural vegetation (e.g., Bolstad 1971, McKendrick et al. 1984). In permafrost areas, revegetation was promoted to minimize thermal erosion (thermokarst) associated with disturbing ice-rich soils (MacKay 1970, Bureau of Land Management {BLM} 1973, Dabbs et al. 1974, Hernandez 1973a, Haag and Bliss 1973, Lawson 1986). More recently, however, the objectives of restoration have expanded to include the establishment of plant communities that are productive, self-regulating ecosystems integrated with the landscape in which they occur. Aesthetics, biological diversity, and wildlife habitat are all factors commonly considered in the development and implementation of restoration strategies (Densmore and Holmes 1987, Densmore et al. 1987, Walker et al. 1987, Helm 1994, Jorgenson and Joyce 1994). A variety of surface preparation techniques, soil amendments, and plant cultivation treatments have been used to promote the establishment of productive vegetation on disturbed sites in arctic, boreal, and northern coastal Alaska. These approaches are summarized below and in Table 1. Selected case histories of some of these restoration efforts are presented in Table 2.

The severe climate and short growing environment in many parts of Alaska pose many challenges to the restoration of disturbed lands. The growing season is very short, the number of warm days is limited, and frosts can occur at any time during the summer north of the Alaska Range. Low temperatures result in low rates of organic matter decomposition and nutrient cycling; limited and inconsistent seed production; and slow colonization of disturbed areas by plants (Haag 1974, Billings 1987). Along the more southern portions of the Project footprint, however, warmer summer temperatures and higher levels of precipitation help ameliorate these effects. In areas where the soils are mostly parent material, the soil frequently is poorly developed, containing little organic matter and few physical and chemical characteristics conducive to promoting plant establishment and growth. Where precipitation is low, raised disturbed surfaces such as gravel pads and roads are typically very dry, because they are disconnected from the natural water table. However, restoration can be successful if appropriate treatments to make the environment conducive in supporting plant growth are applied to the conditions at a particular site. Another important consideration in Alaska is the timeframe required for successful restoration to occur, particularly if the native soil and vegetation are removed or substantially altered (e.g., soil is replaced with granular fill or mineral overburden). Restoration may take decades to occur in northern Alaska, whereas a comparable site at a more southern latitude may only require 5–10 years to recover. Because the Mainline would cross many ecoregions with varying landscape and climatic conditions, it is anticipated that the rate of restoration would vary considerably across the length of the pipeline corridor.

The plant species (both cultivated and indigenous) that have been used in Alaska or that are under consideration for the Project are presented in Table 3. The selection of the various treatment methods and plant materials (where applicable) depends on the restoration goal(s), characteristics of the site disturbance, geographic region, and availability of plant materials. To the extent possible, developing a plant community that is integrated with adjacent, undisturbed plant communities is desirable as long as the vegetation growth results in a stable restored surface to avoid affecting downstream wetlands or waters as a result of sediment discharge from erosion.

1.2.1 Surface Preparation

Surface preparation techniques could include compaction, contouring, raking or dragging, scarifying, surface roughening, and mulching. Compaction was done on an abandoned spur road in the Kuparuk Oilfield with a large vehicle with low PSI (pounds per square inch) tires (Rolligon) to improve contact between the applied sod and the underlying thin layer of gravel (Cater and Jorgenson 1994). Scarifying (to improve soil-seed contact) (Jorgenson and Cater 1992b) has been done at many sites by using a grader equipped with chisel teeth, by pulling a pipe equipped with tines (Jorgenson et al. 1990; Jorgenson and Cater 1991, 1992b), hand raking, or by dragging a chain across the site. In windy, low-precipitation areas, the placement of rock structures or boulders can provide wind protection for young seedlings, prevent sheet flow of runoff, and improve soil moisture by capturing snow. Plants at scarified sites typically are most abundant in the bottom of furrows, suggesting that scarification increases seed germination by providing favorable microsites. Finally, mulch has been applied to thick (5–6 feet) granular fill to reduce the rate of evaporation of soil moisture with limited success. Although seed germination was improved in the mulched areas, soil temperatures and moisture were lower than in the unmulched plots because the mulch intercepted solar radiation and precipitation (Jorgenson and Cater 1992a).

1.2.2 Soil Amendments

Many disturbed areas targeted for restoration do not have sufficient levels of nutrients for promoting plant establishment and growth because the substrate is dominated by nutrient-poor, primarily mineral soil (Walker et al. 1987). In addition, some undisturbed plant communities have depressed levels of soil nutrients, particularly nitrogen, because decomposition is slow and much of the soil nitrogen is tied up in undecomposed plant material (Dadykin 1958, Haag 1974). To compensate for the lack of nutrients, fertilizer may be added initially to increase soil nutrient status and facilitate more rapid establishment of cover on disturbed soils. The rate of fertilizer to be applied is dependent on the composition of the soil substrate and on the types of plant species targeted for revegetation. Grasses and some herbs prefer fairly high rates of fertilizer (McKendrick et al. 1978, Chapin and Shaver 1985), whereas some shrubs respond more positively to lower levels of nutrients (Russell 1973, Henry et al. 1994).

The question of multiple versus single applications of fertilizer has not been completely resolved. In cases where grasses are used for establishing cover on thick granular fill, multiple fertilizations are usually necessary to maintain plant productivity (Kidd and Jorgenson 1992). If the soil has higher loam content and some organic material, a single application of fertilizer may be all that is necessary. A single fertilization also may be warranted if colonization of native shrubs is a priority.

To increase the water-storage capacity, nutrient status, and biological activity of disturbed soils, topsoil (a mixture of organic and mineral horizons from tundra soil) has been applied as a soil amendment in several studies (Jorgenson and Cater 1991, Jorgenson and Cater 1992a, Cater and Jorgenson 1994a). Topsoil significantly increased vegetation cover and plant productivity over reference plots in all of these studies. Unfortunately, the availability of topsoil is typically limited for most projects, particularly in Alaska, where the surface organic mat is relatively thin (<12 inches) in many areas.

Soil microorganisms have been applied in a soil-water slurry on small germination test plots to inoculate the roots of legumes with nitrogen-fixing *Rhizobium* bacteria (Cater and Jorgenson 1994a). The use of soil transfer for introducing mycorrhizal bacteria also has been tested at a coal mine site in southcentral Alaska (Helm and Carling 1992). That study found that *Populus balsamifera* (balsam poplar) cuttings grew taller in plots treated with soil transfer in combination with a phosphorus fertilizer than cuttings in plots treated with fertilizer alone. Mycorrhizae have been shown to be important to plant productivity because they increase soil nutrient availability and moisture by increasing the surface area of plant roots (Linderman 1994). Some evidence also indicates that mycorrhizae help guard against plant pathogens (Duchesne 1994).

Inadequate soil moisture is one of the primary factors limiting establishment of vegetation on disturbed surfaces. The soil is commonly made up of predominantly coarse sand and gravel, which have little capacity to hold water and promote high rates of evaporation. To increase the water storage capacity of coarse gravel soils, soil amendments such as starch-based polymer absorbents or sandy overburden (which would increase soil moisture by retaining additional water during snowmelt) have been tested on plots in the Kuparuk Oilfield on the North Slope of Alaska (Cater and Jorgenson 1994a). Initial results found that mean values for soil moisture in the absorbent treatment and overburden were similar to those in an unamended control, but over time these treatments may result in increased benefit.

Domestic treated sewage sludge from camp facilities has the potential to improve soil properties on granular fill. Like topsoil, it is composed primarily of organic matter and, thus, has many of the same beneficial properties. In experimental plots, treated sewage sludge was applied to a thick gravel pad on the North Slope of Alaska in the Kuparuk Oilfield (Cater and Jorgenson 1994a) and at an interior Alaska site (Cold Regions Research and Engineering

Research Alaska Projects Field Station) in Fairbanks, Alaska (Palazzo et al. 1980). For the North Slope site, differences in total organic carbon, and nitrogen and phosphorus were pronounced immediately after application when compared to the control, but soil properties did not appear to be improved substantially on a long-term basis. The lack of improvement appeared to be due to insufficient application rates. Factors that influence the application rates of sludge include the low cation-exchange capacity of gravel and concerns over applying excessive amounts of nitrate that can leach into adjacent wetlands. Although water samples collected below the plots had concentrations of fecal coliform bacteria and heavy metals that were similar to background levels, nitrate concentrations were three times higher under the sludge-amended plot. For the interior site, the plots treated with sludge had a comparable vegetation response as the fertilized plots, although the response was slower. Given the lack of topsoil available, sludge could provide an alternative source of organic matter. However, potential adverse impacts of pathogens, heavy metals, and nitrates associated with application of sludge on granular fill needs to be further evaluated.

1.2.3 Vegetation Establishment

1.2.3.1 Natural Colonization

Colonization of disturbed sites by species from adjacent undisturbed plant communities has been monitored at a number of sites (Hernandez 1973b, Kershaw and Kershaw 1987, Taylor and Gill 1974, Chapin and Chapin 1980, Jorgenson et al. 1990, Chapin and Shaver 1981, Abele et al. 1984, Everett et al. 1985, Gartner et al. 1983, 1986, Carghill and Chapin 1987, Ebersole 1987, McKendrick 1987, Felix and Reynolds 1989, Densmore 1994, Kidd et al. 2006), the success of which is dependent on factors such as the nature and type of disturbance, soil characteristics, and the species composition of potential source plant communities. When only the organic mat is disturbed, natural colonization typically occurs fairly rapidly (one to two years), and may include a variety of herbs, graminoids, and shrubs. On thin (<12 inches thick) granular fill, natural colonization may occur at a slower rate than at disturbed sites where only the surface is disturbed, depending on the climatic conditions of the area; recovery of sites in northern Alaska would likely be slower due to the shorter growing season and cooler and drier summer conditions. Colonizing vegetation even for the most northern portion of the Project, however, can still consist of a variety of species, primarily herbs (e.g., *Draba* and *Braya* sp.) and graminoids (e.g., *Carex aquatilis* and *Eriophorum* sp.) (Jorgenson et al. 1990). The rate of recovery increases considerably as the route enters the Arctic Foothills, as summer temperatures and precipitation increases. For granular-fill depths in permafrost environments greater than 3 feet, which are not uncommon for gravel pads and roads on the Arctic tundra, natural revegetation is typically negligible, or at least recovery is very slow. In non-permafrost granular-fill areas and areas south of the Arctic tundra, some recovery is possible in the near term, with the vegetation likely consisting of xeric forbs, grasses, and shrubs like alder and willow (Densmore 1994). Over time (>10 years), however, these areas can develop a productive cover of vegetation and in some cases revert back to wetlands if a wetland hydrologic regime can establish. In forested areas, saplings of drought-tolerant trees such as *Populus tremuloides* (quaking aspen) may establish over time, as evidenced on mine tailings in areas around Fairbanks (Interior Alaska). Where possible, natural colonization may be preferable over plant cultivation for revegetating disturbed sites because the colonizing species come from adjacent areas and thus, should be better adapted to the local conditions than cultivated species. Sites with soil characteristics (e.g., high organic content and a moderately fine texture) and moisture favorable to plant establishment and growth are good candidates for facilitating natural recovery.

1.2.3.2 Cultivated Seed

Research into developing reliable sources of seed for revegetating disturbed lands in Alaska has been ongoing since the early 1970s (Johnson and Van Cleve 1976; Johnson 1981; Hernandez 1973a; Mitchell and McKendrick 1974a, 1974b, Alaska Plant Materials Center {APMC} 1974–1977), and has undergone considerable evolution in subsequent years (Vaartnou 1988, Helm 1991, Jorgenson and Cater 1991, Jorgenson and Joyce 1994, Jorgenson et al. 1990, Wright 1990, Wright et al. 1993, Jacobs et al. 1994, Kidd and Jorgenson 1994, APMC 2008). Many of the first attempts to actively revegetate disturbed areas used commercially available cultivated grasses and legumes as the primary plant material source (Johnson and Van Cleve 1976; Johnson 1981; Hernandez 1973a; Mitchell and McKendrick 1974a, 1974b). A study in the Prudhoe Bay Oilfield evaluated over 100 commercial varieties based on positive laboratory tests (Mitchell and McKendrick 1974b) to determine what species may be applicable in arctic environments. Several grass species, were able to persist for up to three years or more and were used through the 1980s (Johnson 1981, Wishart 1988, Evans and Kershaw 1989). These species included *Poa pratensis* (Kentucky bluegrass), *Festuca ovina* (sheep fescue), *Agropyron trachycaulum* (revenue slender wheatgrass) and *Phleum pratense* (climax Timothy). The principal attraction of these species was their ability to establish a rapid cover, their tolerance to low moisture conditions, and their adaptability to short summers and cold winters. The APMC also has conducted numerous research trials for the commercial production of plant species for statewide restoration efforts, but their focus has been more on increasing the availability of native plant species as discussed as follows.

Several constraints are associated with using agronomic cultivars for revegetating disturbed lands in Alaska. First, because agronomic cultivars, are not part of the native flora (usually cultivated in more southern latitudes), they tend to be less adapted to conditions in Alaska. Second, they generally are dependent on a fairly high level of nutrients and tend to require repeated fertilizations, particularly if they are on granular soils with little organic matter (Johnson and Van Cleve 1976, Klebesadel 1966, Jorgenson and Joyce 1994). If repeated fertilization does not occur, the grasses tended to die back, leaving a large amount of above-ground biomass remaining that does not readily decompose. Finally, because they can establish a rapid cover and are very effective at sequestering nutrients, agronomic cultivars tend to competitively exclude natural colonizers (Native Plants 1980, Densmore et al. 1987, Younkin and Martens 1987, Densmore 1992, McKendrick et al. 1993). In cases where the disturbance involves thick granular fill, however, few native species are able to colonize these areas and competition with cultivars may not be a concern (Jorgenson and Joyce 1994).

The concern over introducing exotic species into Alaska ecosystems, and the variable success associated with using agronomic cultivars prompted researchers to investigate the use of native-grass cultivars and other native species for vegetation rehabilitation (Gill 1974, Vaartnou 1988, Mitchell and McKendrick 1974b, Jorgenson and Joyce 1994, APMC 1973–present). The APMC collected and evaluated 226 herbaceous and 34 shrub species in 1973 (formerly the Palmer Plant Materials Center 1974). Mixtures of native grasses have been used for several experimental (Klebesadel 1966, Mitchell 1972) and full-scale applications in Alaska oilfields and mine sites (Jorgenson et al. 1990, Wright 1990, Helm 1991, Jorgenson and Cater 1991, Wright et al. 1993, Kidd and Jorgenson 1994, Jacobs et al. 1994), and at mine sites in the northern Yukon and Northwest Territories (Wilson 1987, Hutchinson and Kuja 1988, Maslen and Kershaw 1989). Results have shown a productive cover can develop fairly rapidly, although results on thick granular fill were best where organic topsoil has been applied (Jorgenson and Cater 1991), and on overburden stockpiles where the soil had a high percentage of fines and where permafrost under the thin active layer prevents leaching of nutrients (Jorgenson et al. 1990, Jacobs et al. 1994). Growth of grasses on thick granular fill without any manipulation of the site or topsoil application has been slower in the Arctic, even after fertilizer was applied the first and third years (Jorgenson and Cater 1992a). A similar result was found at the Usibelli Coal Mine in southcentral Alaska (Elliott et al. 1987, Helm 2006), although at that site, the decline in grass cover helped facilitate the establishment of shrubs by trapping seeds and contributing to soil organic matter through decomposition. Sites where organic-rich topsoil was available as an amendment can help sustain grass cover, but the availability of topsoil would be limited for the Project.

Although native-grass cultivars are more adapted to Alaska conditions than their agronomic cousins, the problem of declining productivity over time and the inhibitory effect on natural colonizers are still problems yet to be resolved. However, native-grass cultivars still are a useful tool for establishing rapid cover on disturbed soils (e.g., Alaska Department of Transportation & Public Facilities [{ADOT&PF} 2006], and they may help improve soil properties by increasing soil biological activity, soil moisture, and capturing wind-dispersed plant propagules. To minimize competition with native colonizers, seeding rates at some sites have been reduced to establish a more open cover, thereby encouraging species from adjacent undisturbed areas to colonize.

1.2.3.3 Indigenous Seed

In an effort to more closely restore land disturbances with plant communities dominated by native species, research into the effectiveness of using indigenous species for use in revegetation began as early as the 1970s (e.g., Wein and MacLean 1973), although more concerted efforts began in the late 1980s and continue into the present (Maslen and Kershaw 1989, Jorgenson and Joyce 1994, Athey and Brekken 2001, APMC 2012, Kidd et al. 2006). With the exception of some grasses, only a few native plants are available at a commercial scale, thus, most collections tend to be small, localized, and site-specific. Observations and testing of seed germination of these plant groups indicate that the technique is feasible, although germination rates are low (Gartner 1983) and often occur over multiple years (e.g., Kidd 2015). Successful germination and growth for some species, e.g., willows, are influenced by the quality of the growing medium and soil moisture (Cooper and Van Haveren 1994). For many species, however, even under suitable growing conditions, the growth rates of seedlings can be slow and the availability of seed dependent on how successful seed production is in a given year. In addition, grazing pressure can interfere with the effectiveness of sowing native seed.

To address the growing need for the availability of native species on a commercial scale, the APMC initiated a project in 1999 referred to as the Native Plant Commercialization Evaluation Project (APMC 2005). The project was designed to evaluate the feasibility of producing a variety of native species at a scale available for landscaping and revegetation needs associated with transportation and resource extraction projects. Species being evaluated include grasses, sedges, forbs, and shrubs that occur throughout the state, in a variety of habitats. As a result of this effort, several native grasses and forbs are now available through the APMC as breeder and foundation seed (for testing) and/or through the Alaska Seed Growers, Inc. (for use in revegetation efforts). The APMC is also a processing and curation partner of the BLM's Seeds of Success program. The goals of this national effort are to develop a native seed bank for research, species preservation, land rehabilitation, and ecosystem restoration.

1.2.3.4 Containerized Seedlings

Germinating seeds and growing seedlings in a greenhouse before planting has not generally been used as a revegetation technique because of the expense in maintaining a greenhouse and the logistical constraints associated with most sites requiring rehabilitation in Alaska. A study conducted in Denali National Park and Preserve evaluated 10 species (grasses, forbs, and shrubs) for use in revegetating areas in the Park disturbed by construction activities

(Densmore and Holmes 1987). Survival after one year was high for all species planted, but their long-term survival is yet to be determined. The APMC has conducted growth trials for a variety of wetland species (Wright et al. 2005), mainly to identify germination requirements but also for restoration projects (APMC 2011). They propagated and produced seedlings of seaside arrowgrass (*Plantago maritima*) and seaside plantain (*Triglochin maritima*) for an aquatic ecosystem restoration project in Westchester Lagoon, southcentral Alaska. For small-scale disturbances or important habitat areas, containerized seedlings may be warranted, but because research is limited on their potential compared to other methods, they probably would not be practical for large areas.

1.2.3.5 Cutting and Sprigs

Revegetation with cuttings only has been done for woody shrubs and a few tree species, but the technique has been used for projects from Southcentral to the Arctic tundra in Alaska (Epps 1973, Densmore et al. 1987, Jorgenson and Cater 1991, Kidd and Jorgenson 1994, Helm 1994, Nolan 2007). Their potential for use in revegetation studies has not been fully evaluated but initial results are encouraging. Some of the factors affecting establishment and long-term survival of cuttings are season of collection, plant competitors, planting media, and climatic conditions. Survival appears to be greater when cuttings are obtained as early in the spring as possible, which allows them enough time to develop overwintering buds (Densmore et al. 1987). A moderate-to-high cover of cultivated grasses affects survival, because the grasses are more effective at capturing soil nutrients than the cuttings (Densmore et al. 1987, Helm 1994). A gravel substrate in a low precipitation area also may affect cutting survival, especially during initial establishment. Finally, if cuttings are planted in windy areas that lack snow cover in winter, mortality may occur from wind desiccation (Kidd and Jorgenson 1994).

For sprigs, *Arctophila fulva* (arctic pendant grass) has been used for experiments in establishing wetland vegetation on the Arctic tundra (Moore 1991, Moore 1993, Jorgenson et al. 1992, Kidd et al. 2004), and has proven to be highly amenable to transplanting, even into fairly nutrient-poor, gravelly substrates (Jorgenson et al. 1993). The species is an appealing source for restoration efforts as productive stands are important habitats for waterbirds such as eiders and loons (e.g., Derksen et al. 1981). At most study sites where *Arctophila* has been planted, additional tillers are present usually within the same growing season. The main limiting factor is the intense grazing some of the young plants experience, which includes both removal of biomass and uprooting (Jorgenson et al. 1992). Although no studies are available for the use of this species elsewhere in Alaska, it seems feasible to successfully transplant it wherever it occurs, which includes lowlands and tidal areas throughout Alaska (Alaska Geospatial Data Committee 2013). Other species that have been successfully planted as sprigs in southcentral and western Alaska include *Typha latifolia* (cattails) (APMC 1998) and *Leymus mollis* (dunegrass) (APMC 2013). *Typha* is used by muskrats (Natural Resource Conservation Service 2001) as forage and as brood-rearing habitat for waterbirds such as scaup, scoters, and grebes (Lewis et al. 2015). *Leymus* is more important for supporting microtines such as the shrew (Byrd and Norvell 1993). Although more expensive than seeding, planting sprigs has proven to be reasonably cost-effective because of the colonizing ability of these species when the species is in the vicinity of the planting area. Further research with other wetland species may identify additional candidates for sprig transplants.

1.2.3.6 Vegetation Plugs, Vegetation Sod, and Vegetation Mats

Revegetation using plugs, sod, and mats of native vegetation has been tested at several sites and has appeal because the plants are already well established, thus having the potential to speed the rate of recovery if transplant survival is high. In addition, in the case of plugs and sod, more than one species is typically present, which increases the potential for colonization of a disturbed area by a variety of indigenous species. Several studies using vegetation plugs have been conducted in the Prudhoe and Kuparuk oilfields of Alaska (Jorgenson and Joyce 1994, Kidd et al. 2004, 2006), and along Willow Creek in Anchorage (Walter et al. 2005). The species present in plugs come primarily from moist and wet habitats and include *Carex aquatilis* (water sedge), *C. bigelowii* (Bigelow sedge), *Eriophorum* sp. (cottongrass), *Calamagrostis canadensis*, and *Salix* sp. (willows). The plugs usually were planted in an organic substrate, although shallow depths of gravel were present at the surface. At one location, plugs were planted in a thick gravel substrate (Jorgenson and Joyce 1994). Survival of the plugs has been quite high, but lateral expansion is more prevalent in wetland soils.

The harvest and planting of vegetated sod has been tested in the Kuparuk and Prudhoe Bay oilfields and Denali National Park and Preserve (Vander Meer 1995, Densmore et al. 2000). The first attempt in the Kuparuk Oilfield was unsuccessful, because the sod was in a frozen state and very difficult to excavate (Jorgenson 1992). The attempt was aborted after the excavating equipment was severely damaged. More recently, the technique has been tested at four sites in the Prudhoe Bay Oilfield (Cater et al. 2015) and at two sites in association with the Point Thomson Project (ExxonMobil Development Company 2015). The sod was used in the Prudhoe Bay Oilfield to restore tundra affected by oil and diesel spills and at Point Thomson, to create a vegetated buffer between a stream and gravel pad and to stabilize the sideslope of an airstrip. The ability to overwinter sod for future use also is being evaluated at Point Thomson. Results of the sodding effort at Prudhoe Bay were mostly very successful; three of the four areas treated with sod were comparable in percent cover and species composition to undisturbed tundra. The fourth site was sodded in winter (versus summer for the other areas), which made placing the sod in the treatment area challenging. Vegetated sod only covers a portion of this site, leaving some areas relatively barren or only covered with moss. Mean indigenous total live vascular cover (ILVC) as of 2015 was 29.7 percent. A factor affecting the recovery of the site has been heavy grazing of the vegetation by geese, an effect observed at other rehabilitation sites in the Prudhoe Bay Oilfield (Kidd 2014, ABR and BP Environmental Studies Group 2015). Grazing pressure, however, mainly slows (does not prevent) the pace of vegetation recovery. At the Point Thomson sites, preliminary observations from photo points suggest the transplant efforts were largely successful in the first couple years thus far. The overwintered sod also appeared to have remained viable after overwintering and was planted on the sideslope of the airstrip next to the other sod for future monitoring. The transplant of tundra sod (referred to as vegetation mats) in Denali National Park and Preserve has largely been successful, although the species composition often changed after transplant, with mosses and lichens commonly replaced by grasses and fireweed (*Epilobium* spp.). Tundra sod transplanting may be an effective method for revegetation; however, it requires sod to be available, is labor intensive, and is not cost-effective because of high storage and transportation expenses. Thus, it is unlikely to be used to support Project revegetation efforts except in isolated target areas, likely as a corrective measure for promoting surface stability of the trench.

Transplant of vegetation mats is described in APMC's *Alaska Coastal Revegetation and Erosion Control Guide* (Wright and Czapla 2013) and has been tested in the Prudhoe Bay Oilfield (HDR and BP Environmental Studies Group 2014). The Prudhoe Bay study was conducted to test the effectiveness of installing a wetland vegetation mat to restore portions of a backfilled cable trench that had subsided. Seeds from indigenous populations of water sedge (*Carex aquatilis*) in Prudhoe Bay were collected and sent to the University of Minnesota for germinating testing and growing in a greenhouse. The seeds were planted in three different growth media: coconut fiber and peat, burlap and peat, and peat only. The mats were transported to Prudhoe Bay by air and planted in the trenches in July 2013. Preliminary results after one full growing season were encouraging (new growth was observed in all the mats). Due to the expensive logistical costs, it is unlikely this method will become more commonplace.

Like containerized seedlings, however, it may be recommended when specific habitats are targeted for accelerated restoration and/or the benefits outweigh the costs.

1.3 DEFINITIONS

For purposes of this Plan, restoration is defined as the return of the pipeline trench (and associated ROW where applicable) to a condition that is physically stable and similar, but not necessarily the same as the previous condition or adjacent undisturbed areas. As the Project crosses properties owned by multiple landowners and multiple ecological regions, on a case-by-case basis the goal of restoration would be dependent upon the applicable state, federal, and local laws, regulations, and policies and agreements with the landowner or land managing agency. To promote restoration of the trench to a state similar to pre-disturbance conditions to the extent possible, the physical, chemical, biological, and environmental characteristics of the area (including permafrost conditions) prior to disturbance would be taken into account. Revegetation is typically a key component of restoration activities and involves establishing plant cover, including short-term and long-term, to control erosion and stabilize the ROW and maintain ecosystem functions where practicable. Restoration involves near-term activities such as removal of construction debris from the ROW and surface grading and stabilization practices. Restoration also involves activities that occur in years following construction such as seeding and/or fertilizer treatment of the ROW. These definitions are generally consistent with guidance and definitions provided by state and federal agencies.

1.4 GOALS OF RESTORATION

The goal of restoration for the Project is to establish a ROW that is stable, both physically and thermally, and that maintains some of the ecosystem functions that were present prior to construction, where feasible. These may include wildlife habitat, plant species diversity, and wetlands. The tactics for achieving these goals may include installing temporary erosion-control structures; applying fertilizer to enhance natural recovery; sowing seed of selected commercial species; sowing indigenous seed; and selectively applying plant materials such as cuttings or sprigs.

Establishment of goals would be done in consultation with the appropriate federal, state, and local regulatory agencies and landowners and would vary according to the different site conditions along the pipeline corridor and within the off-ROW infrastructure footprints. The goals of restoration are intended to be different than performance standards, which are described in Section 3.0 of this document.

2.0 GENERAL APPROACHES

2.1 RESTORATION STRATEGIES

Strategies for restoration would be developed to meet the goals defined in collaboration with agencies and landowners. First and foremost would be site stabilization in accordance with the Alaska LNG Project *Plan and Procedures* and the supporting *Winter and Permafrost Construction Plan*. For maintaining the pipeline ROW in uplands, the methodology is summarized in the Alaska LNG Project *Plan* and for wetlands and waters, the Alaska LNG Project *Procedures*.

The risk of erosion varies along the pipeline route; thus, erosion control measures would focus on areas with high surface- or thermal-erosion (thawing permafrost) potential. Where required, surface erosion-control treatments may include a combination of weed-free erosion control blankets or other geomembranes to hold soil in place and seeding with annual or short-lived perennials that can establish in the first growing season following construction. Areas with substantial thaw subsidence may be backfilled with additional overburden or, depending on the length and characteristics of the subsided segment (e.g., depth of flooding), may be planted with wetland vegetation. A productive vegetation cover can help reduce the absorption of heat by the trench substrate, thereby minimizing additional subsidence. Erosion management would comply with both state and federal standards. Recommendations provided in *A Revegetation Manual For Alaska* (Wright 2008), *Alaska Coastal Revegetation and Erosion Control Guide*, 3rd Printing (Wright and Czapla 2013), and *Interior Alaska Revegetation and Erosion Control Guide* (Czapla and Wright 2012) would be used to assist the restoration effort, as well as results from the numerous studies referenced in Section 1.2 of this document.

Revegetation methods may range from fertilization only to applying various plant cultivation treatments, as appropriate with consideration for restoration goals and site conditions. Treatments may include seeding with native grasses, sedges, and forbs; transplanting dormant shrub cuttings; or transplanting wetland graminoid sprigs. Transplanting cuttings and sprigs would likely be confined to specific sections of the route, such as stream crossings and areas targeted for wildlife habitat enhancement. Note that some areas of the ROW would be left in compacted rock/gravel with few fines and may simply be stabilized in place and monitored.

2.2 POST-CONSTRUCTION MAINTENANCE

The pipeline trench would be backfilled with mostly native material and additional sands and gravels, as needed, to accommodate for consolidation of fill. Except for areas where the pipeline crosses matted wetlands (see Section 3.3), the trench would be left with a small roach, or berm, centered on the trench to allow for settling. This raised roach would not be permanently maintained, but rather allowed to subside over time. The roach would be breached where cross drainage is required.

Upon completion of restoration, the guidelines outlined in Alaska LNG Project *Plan and Procedures* would be followed. The permanent (operations) ROW consists of an area 53.5 to 80–feet wide for Mainline and PTTL, respectively. The temporary ROW is estimated to be 110–145 feet wide not including temporary work spaces such as travel lanes, cut/fill slopes, widenings at crossings and bends, short-term storage areas, and access roads. In uplands, a 10-foot-wide corridor, centered on the trench within the permanent ROW, would be maintained in an herbaceous or low shrub cover state at a frequency necessary to facilitate aerial monitoring and surveillance of the pipeline corridor/ROW. Maintenance activities would include mowing or clearing the vegetation every three years (or more) to prevent the establishment of trees or tall shrubs. Areas where the height of woody vegetation does not exceed 2 feet would be evaluated to determine the degree to which shrub maintenance is required. The temporary

ROW would not be maintained but would instead be allowed to recover naturally or would be revegetated as needed, depending on construction mode (see Section 3.0 for descriptions of the modes).

In wetlands, only a small portion of the ROW, centered on the pipeline trench (up to 10 feet wide), would be regularly maintained to facilitate surveillance and monitoring. Otherwise, remaining sections of the permanent and temporary ROW would not be actively managed, except in forested areas. Trees within 15 feet of the pipeline ROW in forested wetlands may be selectively cut and removed out of concern that the tree roots could compromise the integrity of the pipeline coating.

On slopes where permafrost degradation is a concern (e.g., Mode 5B, Section 3.6), the slope may be covered with wood chips to help insulate the soil. Preliminary results from a study conducted on the Dalton Highway testing a variety of techniques for insulating ice-rich slopes found that a blanket of wood chips was effective in insulating the slope and limiting thermal degradation (Li et al. 2013).

Except in agricultural and residential areas, rocks (or gravel) excavated from the trench but not used to backfill the trench may be permanently placed on the ROW, but in such a way as to not impede ROW restoration, where applicable. In some modes, granular fill material used for a flat, stable work space during construction may be left in place. Depending on site conditions, these areas may then be actively revegetated or allowed to naturally revegetate over time.

A plan for mitigating the introduction of noxious and invasive species (the Project *Noxious and Invasive Plant and Animal Control Plan* {Appendix K in Resource Report No. 3}) and a material mine site reclamation plan (Project *Gravel Sourcing Plan and Reclamation Measures* {Appendix F in Resource Report No. 6}) will be further developed as the Project progresses. In addition, site-specific mine rehabilitation plans would be prepared, in consultation with regulatory agencies, for each material mine site as appropriate. For this reason, the restoration of individual mine sites is not addressed in this Plan.

2.3 PERFORMANCE STANDARDS AND PERFORMANCE PERIOD

Development of performance standards and a performance period (i.e., monitoring) are key elements of a restoration plan and would be developed in consultation with federal, state, and local regulatory agencies, relying on lessons learned from previous practices in Alaska. The standards and monitoring efforts would vary by ecoregion and ROW mode to address site-specific climatic and soil conditions and degrees of disturbance. The pipeline would cross three (Level 2) ecoregions (Nowacki et al. 2001): the (Polar) Arctic Tundra, which includes the Beaufort Coastal Plain south to the Brooks Range; the Boreal Intermontane, which includes Interior Alaska between the Brooks and Alaska mountain ranges; and the Alaska Range Transitional, which includes Southcentral and the Cook Inlet Basin. The growing season varies by several weeks with the shortest being approximately three months on the Beaufort Coastal Plain to greater than five months in Nikiski on the southern side of Cook Inlet. As with previous efforts in Alaska, the monitoring effort would require Adaptive Management (see Section 2.4) because the response to restoration efforts would be an iterative process.

For wetland restoration of the Arctic tundra portion of the Project, previous studies have found that if the total live indigenous (native) vascular cover can reach a minimum of 10–15 percent, depending on site characteristics (e.g., quality of the substrate), the site will develop a plant community that is productive and sustainable over the long term (Figures 1–2). Adding the requirement that the site includes a variety of species (and growth forms) (diversity standard) helps ensure the plant community can adapt to potential changes in site conditions that may occur during the first few years following treatment. Site response varies, but most sites can meet the performance standards in 10 years.

Total live vascular cover is expected to be higher for the portion of the Project south of the Arctic tundra, because climatic conditions are more favorable (warmer summer temperatures and higher precipitation) for plant establishment and growth. At the Washington Creek trenching test site 28 miles north of Fairbanks, a performance standard of 30% was established, which was achieved at the end of the 10-year performance period (Figure 3). Revegetation of a gravel pit at milepost (MP) 105 of the Dalton Highway (APMC 2012) also appears to have good vegetation cover after seven years (Figure 4), although no vegetation cover data were available.

Vegetation performance criteria for Southcentral Alaska are not available, but for the Hecla Green Creek Mine in Southeast Alaska near Juneau, a performance standard of 30 percent vegetation cover that included native trees and/or shrubs, and/or naturally colonizing native trees, shrubs, herbaceous species, or organic material (duff) in five years was established. This standard is probably also achievable in Southcentral Alaska.

Requirements for surface stability depend on whether the trench is on a slope (>2 percent) or relatively flat. For slopes, the trench would be backfilled to allow for settlement with a final surface elevation comparable to the adjacent, undisturbed terrain. Trench segments below grade can potentially capture and channelize surface water during spring flooding, which can result in down cutting of the trench, thermal instability in permafrost areas, and offsite discharge of sediments. Final backfill of the trench would allow for cross drainage where needed so water does not impound on the uphill side. For portions of the trench that are relatively flat (<2 percent slope), the trench also would be backfilled to a final surface elevation at grade, but some trench segments (<30 feet long) may be allowed to settle slightly below grade (<4 inches). Based on results at the MS3 trenching test site (ABR and BP Environmental Studies Group 2012), which was constructed in flat terrain, long-term stability of the trench and vegetation recovery were not negatively affected when segments were slightly below tundra grade and flooded.

Where surface stability is a concern on steep slopes (cut and fill areas ≥ 20%), a higher vegetation cover performance standard, closer to 40 percent, is warranted to guarantee sufficient cover has established to bind with the soil. For these sites, the plant community composition would need to be sustainable, but may not be dominated by indigenous species, at least during the performance period (some natural recovery likely would occur over time). This cover standard should be met in three to five years. The time needed for a dense vegetation cover to establish, particularly in the northern portion of the route, would be influenced by other erosion-control measures that would be implemented in these areas (e.g., geotextiles). As stated previously, however, it may be necessary to modify the performance period or revise the restoration strategy based on the response to post-construction conditions. This is further discussed in the following section.

2.4 ADAPTIVE MANAGEMENT

According to the United States Army Corps of Engineers (USACE) Engineering Research and Development Center (Fischenich et al. 2012), Adaptive Management (AM) prescribes a process wherein management actions can be changed in response to monitored system response, so as to maximize restoration efficacy or achieve a desired ecological state. The basic steps include:

1. Plan: Defining the desired goals and objectives, evaluating alternative actions, and selecting a preferred strategy with recognition of sources of uncertainty.
2. Design: Identifying or designing a flexible management action to address the challenge.
3. Implement: Implementing the selected action according to its design.
4. Monitor: Monitoring the results or outcomes of the management action.

5. Evaluate: Evaluating the system response in relation to specified goals and objectives.
6. Adjust: Adjusting (adapting) the action if necessary to achieve the stated goals and objectives.

Implementation of AM would be incorporated, as appropriate, for all aspects of restoration at all facilities. This may require adjusting performance periods, modifying performance criteria, and/or applying new treatments/methods in response to monitoring and evaluating progress. For example, if conditions in the field during construction require a change in construction mode, or if the proposed restoration treatment fails or is not feasible, then various restoration approaches would be prioritized or listed sequentially. In other words, if the planned approach is deemed to be infeasible or not appropriate due to unexpected site conditions, then the next approach on the list would be applied unless it too is inappropriate. Meeting with agencies to develop an alternate strategy would be an important component of AM for this Project.

Monitoring of vegetation and overall site characteristics are described for each mode in Section 3.0 of this document, but additional monitoring may be conducted in response to observations made during the annual surveys of the pipeline ROW. These areas may include sites where additional post-construction remedial work was performed or where vegetation recovery does not appear to be progressing as expected.

2.5 REPORTING

The frequency of reporting may vary according to ecoregion and recent activity and would be done in concert with the monitoring schedule set out for each area. At a minimum, an annual report summarizing monitoring efforts and site conditions would be provided for five years following Project construction. The area of coverage for each report and subsequent reporting schedule requirements would be defined in consultation with regulatory agencies. A standard reporting format would be developed and followed for all restoration areas, including photographs to document site conditions, and would address applicable performance criteria/standards for each area.

3.0 RESTORATION APPROACHES FOR CONSTRUCTION ROW MODES

To complement construction activities, the Plan would be organized according to typical construction ROW modes. Four construction spreads are planned from MP 0 to MP 807 of the Mainline and two for the Point Thomson Gas Transmission Line (PTTL) (MP 0 to MP 63). ROW construction modes have been identified based on terrain, soils, and season of construction. Actual site conditions are expected to vary from "assumed" site conditions during construction, and as a result it is anticipated that "actual" ROW mode would vary from the "planned" mode at certain locations. Because restoration strategies described in this Plan are tied to typical construction modes, changes to ROW modes due to seasonal and ground conditions encountered during construction would be reflected in changes to restoration strategies accordingly.

This section would provide a brief description of construction techniques along the pipeline corridor and accompanying restoration procedures, including revegetation efforts, for each construction mode. Detailed construction technique descriptions are provided in Resource Report No. 1 (General Project Description) and its Appendix M: *Pipeline Winter and Permafrost Construction Plan,* and in the Alaska LNG Project *Plan and Procedures,* Resource Report Nos. 7 and 2, respectively.

Special consideration is given to river crossings, regardless of mode, due to the importance of riparian vegetation in providing habitat support, erosion control, and the maintenance of water quality. Restoration of these areas is described in Section 4.0 (Special Cases).

3.1 MODE 1 – ICE WORK PAD OVER PERMAFROST IN FLAT TERRAIN

3.1.1 Construction Techniques

Mode 1 would be conducted solely during the winter season and involves allowing a depth of frost and snow to develop on the tundra to allow the construction of ice work pads and roads. A typical construction layout for this mode (Mode 1) is provided in Appendix A. The ice pad/road construction would be conducted in accordance with Alaska Department of Natural Resources (ADNR 2015) requirements (soil temperature of -5 degrees Celsius (°C) at 30 centimeters (12 inches) deep and 6 inches of snow on the surface). The general opening for tundra travel is determined by ADNR and historically has occurred between October through January and most recently within the last couple of decades in January or December. Once frozen soil temperatures and snow depth requirements are achieved, ADNR opens the Arctic tundra area from the foothills to the coastal area to off-road travel or "tundra travel" to allow ice road and pad construction. Construction of an ice work pad is accomplished by combining snow with water and sometimes ice chips to a specified depth and width for construction.

The construction of ice/snow pads results in a footprint of disturbance confined to the vicinity of the trenchline because of the protection provided by the ice work pad and the return of the snow/ice as meltwater to the adjacent watershed in the summer (Michael Baker Jr. 2008, Holland et al. 2008). Topsoil salvage is technically infeasible due to frozen ground conditions, so the material excavated from the trench would be used to backfill the trench following pipeline placement with no segregation. The trench would be "roached" to allow for thaw settlement, with the goal of establishing a final surface elevation that is close to tundra grade to promote the re-establishment of local hydrologic conditions. Erosion and sediment control measures would be deployed and maintained as needed, and any cross drainages would be re-established following pipeline installation. Monitoring results for the MS3 trenching test site (which satisfied the vegetation and surface stability performance criteria developed for the site) would be used to guide restoration efforts for Mode 1.

Some of the construction challenges associated with working in a permafrost environment in winter include:

- Managing snow to limit the extent to which it gets incorporated into backfill material; the void spaces left after the snow melts further complicate efforts to create a final trench elevation integrated with the adjacent, undisturbed tundra.
- Determining the height of the roach when backfilling with frozen fill:
  - Overfilling, leading to a roach that is too high, thus potentially affecting natural surface drainage patterns and creating low soil moisture content in the overburden for promoting vegetation recovery.
  - Underfilling, promoting the impoundment of water that disrupts the underlying thermal regime by transferring heat into the soil from the ponded water, which can lead to thaw subsidence.

These challenges would be mitigated by implementing a snow handling and removal plan as described in the Project *Winter and Permafrost Construction Plan*. Snow removal would be an ongoing activity throughout the winter season and would involve the use of snow blowers and bulldozers as needed to remove drifting snow. Determining the proper height of the roach would be aided by detailed terrain mapping and analysis that has been performed for the Project. Additional fill may be placed in particularly ice-rich areas where greater than anticipated thaw-subsidence (and impounding water) has occurred. In some areas, water diversion structures may be needed (mainly on slopes) to deflect water away from the trench to prevent surface erosion of the trench and the discharge of sediment into downstream waters and wetlands. Breaching the trench in selected areas as needed also would help minimize disruption of natural drainage patterns surrounding the trench line.

3.1.2 Restoration Goals and Objectives

Because much of the pipeline trench in Mode 1 consists of wetlands and permafrost, the restoration goal would be to first stabilize the trench and then facilitate the restoration of wetland habitats that are integrated with the adjacent, undisturbed tundra. This goal would be achieved using a combination of fertilizing and either natural recovery or plant cultivation, as needed. Restoring wetland communities to the extent possible would help reduce the overall wetland and permafrost impacts associated with the Project.

3.1.3 Restoration/Revegetation Techniques

Revegetation techniques would focus on controlling surface erosion in the short term and promoting natural recovery of wetland vegetation dominated by sedges over the long term. Initial revegetation efforts would include applying a balanced (20-20-10) fertilizer of nitrogen (N) phosphorus (P), and potassium (K), and a light seeding (5–10 pounds/acre) of short-lived perennial grass or upland grass species (Table 3) that would decline as a wetland hydrology re-establishes. The fertilizer application rate would depend on the characteristics of the backfill material, but would range between 200 and 400 pounds/acre. Indigenous species that might be planted in some areas could include wetland sedges (e.g., cottongrass {*Eriophorum* spp.} and water sedge {*Carex aquatilis*}) and the emergent grass *Arctophila fulva*. The extent of indigenous seeding would depend on the amount of seed available, but a rate of 1 pound/acre is recommended, based on the *North Slope Plant Establishment Guidelines, 2nd Edition* (BPXA et al 2014). Planting *Arctophila* sprigs only would be conducted in areas where natural collection stands are nearby and for enhancing wildlife habitat in selected areas. Potential sites would be identified as part of initial pipeline inspections post construction. In areas where the backfilled trench might consist of moderately well-drained, floodplain soils (e.g., MP 33–35), establishing a forb and low and dwarf shrub community might be more appropriate than seeding with wetland sedges. These communities may include willows (*Salix* spp.), legumes (e.g., *Oxytropis* spp.) and forbs (e.g., *Artemisia* spp.). Similar to the sedges, a rate of 1 pound/acre is recommended, but would again, depend on the availability of seed.

3.1.4 Treatment Schedule

The backfilled trench would be fertilized and seeded with a native-grass cultivar when most appropriate, using mechanized equipment to the extent possible. Treatments may be applied immediately following completion of pipeline installation to take advantage of access to the ROW provided by the ice pad. Depending on accessibility or timing of work completion, however, treatments may be applied in the following summer. For seed, the APMC recommends fertilizing and planting before July 1 or after the first hard fall frost to prevent winter kill (die-off in winter due to out-of-sync senescence with climatic conditions). Based on monitoring results for the MS3 trenching test site study, additional site preparation of the trench likely would be required in the two to three years following pipeline installation in some areas. After the trench surface has stabilized and site preparation work is complete, additional indigenous plant cultivation treatments may be applied to enhance natural recovery. Depending on how much remedial work is required, any additional fertilizing and seeding applied would likely be done manually, because access to the ROW would be limited post construction.

3.1.5 Monitoring

The pipeline trench would be monitored annually for the first three years following construction to identify any trouble spots and to identify remedial actions that may be appropriate, such as seeding, erosion control measures, or additional fill. Trouble spots may include areas with insufficient trench breaching to allow for cross drainage; greater than expected settlement of the trench roach; and insufficient sediment barriers for protecting waterbodies and streams intersected by the trench. These spots would be visited in the field to determine the extent of remedial action needed and the rehabilitation treatments required. After three years, the trench would be monitored every three years until the end of the performance period. The schedule would be adjusted as needed if additional work such as applying site preparation or plant cultivation treatments is necessary. As part of the AM strategy for the Project (described in Section 2.4), any additional remedial action taken and monitoring required would be done in consultation with resource agencies.

Surface stability would initially be assessed qualitatively by reviewing aerial photography taken of the route following completion of pipeline construction. The goal would be to ensure the backfilled trench does not impede surface water movement or create conditions that affect vegetation recovery. Monitoring and repair work would be performed in areas identified as having surface stability concerns.

Quantitative monitoring would include sampling vegetation cover along permanent 100-meter transects established across the long axis of the trench in association with compressor stations and other set locations, to the extent possible. The vegetation would be sampled at 1-meter intervals along the transect using a laser pointer mounted on a metal rod, recording the plant species (or other cover type) that intersected the laser beam. If multiple layers of vascular plant cover are present at a sampling point, all would be included in the vascular cover calculations. This method gives a repetitive cover estimate that may exceed 100 percent but generally is well correlated with biomass (Jonasson 1988). Only single "hits" of mosses and other nonvascular plants would be recorded. Other cover types (e.g., litter, soil) would be recorded only if no live plant cover is present (though water would be recorded wherever it occurs). In riparian areas targeted for revegetation, percent survival of planted species would be used as the primary parameter for measuring success (see Section 4.1).

Permanent photo points also would be established along the ROW for documenting ecosystem recovery of the trench over time.

3.2 MODE 2 – WINTER FROST PACKED IN NON-PERMAFROST OR THAW-STABLE PERMAFROST IN FLAT TERRAIN

3.2.1 Construction Techniques

Mode 2 construction techniques would be followed in winter in terrain underlain by either non-permafrost soils or with thaw-stable permafrost soils (i.e., soils with low ice content) and where constructing an ice pad is not feasible. A typical construction layout for this mode (referred to as ROW 2) is provided in Appendix A. Mode 2 terrain could either be uplands or wetlands. The benefits of this ROW mode are that it minimizes disturbance to the vegetation and soils adjacent to the trenchline. Once finished, the frost-packed ROW can support heavy loads and pipeline construction equipment with minimal impact to the underlying vegetation or mixing of the surface organics and sub-soils. Pipeline construction would then follow normal winter practices.

Topsoil salvaging within the trenchline for segregation is impracticable because the backhoe trenchers excavators typically used for this ROW mode would not be able to properly separate frozen organics from the mineral soil underneath due to frozen ground conditions. Instead, the material excavated from the trench (which would consist of predominantly mineral overburden) would be backfilled following pipeline installation. A roach would be left behind to account for settling of the backfilled overburden.

3.2.2 Restoration Goals and Objectives

Because Mode 2 construction would occur in both wetlands and uplands during the winter, restoration goals and objectives would vary, depending on local conditions. In areas where the ROW crosses wetlands, similar to Mode 1, emphasis would be placed on re-establishing wetland habitats that are integrated with the adjacent, undisturbed tundra. This goal would be achieved using a combination of fertilizing and either natural recovery or plant cultivation, as needed. Although the topdressing on the trench would be low in organic matter, Mode 2 would be used south of the Brooks Range, where warmer summer temperatures and higher precipitation would help promote vegetation recovery.

For upland areas, vegetation recovery may result in plant communities comparable to those of adjacent undisturbed areas over time by promoting natural recovery, but only to the extent the ROW does not develop into a forested community. To maintain pipeline integrity and conform to Federal Energy Regulatory Commission (FERC) requirements, approximately 15 feet either side of the pipeline ROW (30 feet total) would be actively managed in forested areas to prevent trees from establishing.

3.2.3 Restoration/Revegetation Techniques

For both wetland and upland areas, restoration techniques would focus on controlling surface erosion in the short term. Similar to Mode 1, for areas where wetland restoration is the goal, initial revegetation efforts would include applying a balanced (20-20-10 [N-P-K]) fertilizer and a light seeding (5–10 pounds/acre) of short-lived perennial grass or upland grass species (Tables 1 and 3) that would decline as wetland hydrology re-establishes. The fertilizer application rate would depend on the characteristics of the backfill material, but would range between 200 and

400 lbs./acre. Because climatic conditions would be more favorable for natural colonization, actively seeding wetland species is not anticipated to be needed for Mode 2.

Upland areas would be similarly fertilized and seeded with a temporary cover of grasses to control surface erosion, but would otherwise be left to recover naturally. In forested segments, plant cultivation treatments may be focused on establishing a permanent dense cover of grasses (e.g., bluejoint {*Calamagrostis canadensis*} or *Festuca rubra* {red fescue}) or alder (*Alnus* spp.) to help prevent trees from establishing. The seeding rate for these species would be 20 pounds/acre.

3.2.4 Treatment Schedule

The backfilled trench would be fertilized and seeded with a native-grass cultivar when appropriate. Treatments may be applied immediately following completion of pipeline to take advantage of access to the ROW provided by the frost packing. Depending on accessibility or timing of work completion, however, treatments may be applied in the following summer. In selected areas, additional site preparation of the trench likely would be required in the two to three years following installation. Depending on how much remedial work is required, any additional fertilizing and seeding needed may be done manually, because access to the ROW would be limited.

3.2.5 Monitoring

The pipeline trench and ROW would be monitored annually for the first three years following construction to identify any trouble spots and any remedial actions that may be necessary. Trouble spots may include areas with insufficient trench breaching to allow for cross drainage; greater than expected settlement of the trench roach; and insufficient sediment barriers for protecting waterbodies and streams intersected by the trench. These spots would be visited in the field to determine the extent of remedial action needed and the rehabilitation treatments required. After three years, the trench would be monitored every three years until the end of the performance period. The schedule would be adjusted if additional site preparation or plant cultivation treatments are needed in some areas. As part of the AM strategy for the Project (described in Section 2.4), any additional remedial action taken and monitoring required would be done in consultation with resource agencies.

Quantitative monitoring would include sampling vegetation cover along permanent 100-meter transects established across the long axis of the trench. The number and locations of transects would depend on the length of each construction mode segment, the ecoregion, and the extent to which remedial action is required to stabilize the trench surface and to promote vegetation recovery. To facilitate access, transects would typically be established in association with compressor stations and other set locations, to the extent possible. The vegetation would be sampled at 1-meter intervals along the transect using a laser pointer mounted on a metal rod, recording the plant species (or other cover type) that intersected the laser beam. If multiple layers of vascular plant cover are present at a sampling point, all would be included in the vascular cover calculations. This method gives a repetitive cover estimate that may exceed 100 percent but generally is well correlated with biomass (Jonasson 1988). Only single "hits" of mosses and other nonvascular plants would be recorded. Other cover types (e.g., litter, soil) would be recorded only if no live plant cover is present, except that water would be recorded wherever it occurs. In riparian areas targeted for revegetation, percent survival of planted species would be used as the primary parameter for measuring success.

A qualitative assessment would be conducted of the ROW to ensure that any damage to vegetation and soils that is evident is limited and can recover in three to five years. Potential disturbance includes removing the vegetation and underlying organic mat as a result equipment turning around and repeated passes of heavy equipment affecting portions of the vegetation mat. The inspection also would note any areas of substantial thaw settlement. If damage is extensive in selected areas, a rehabilitation plan would be developed that outlines treatments and monitoring requirements for the area as well as performance criteria to ensure recovery occurs that is in line with restoration goals and objectives.

Permanent photo points also would be established along the ROW for documenting ecosystem recovery of the trench over time.

3.3 MODE 3 – MATTED SUMMER WETLANDS

3.3.1 Construction Techniques

Mode 3 was developed for summer construction across wetlands that cannot support equipment without rutting, which causes surface organics and subsurface soil mixing. These wetlands are characterized by being seasonally flooded and saturated (e.g., fens and bogs), semi-permanently flooded, or permanently flooded. To cross inundated wetlands, mats would be placed on the wetland surface to support equipment and materials. Mats help distribute loads across a wide surface and minimize compaction of the underlying vegetation and soils. Mats can be made from a variety of materials but are typically hardwood timber. If available, locally sourced logs from the ROW may be used to build a "corduroy" pad. A typical construction layout for this mode (referred to as ROW 3) is provided in Appendix A.

This method involves welding the pipe string next to the inundated wetland and then floating it into place by pulling or pushing at the boundaries of the wetland. Activities within the wetland are limited to excavation and whatever subsequent backfilling is necessary. No roach would be established on the backfilled trench.

Surface organics would not be stripped from the trench due to the impracticability of stripping the organic layer in inundated ground. This is consistent with FERC's *Wetland and Waterbodies Construction and Mitigation Procedures*. Erosion and sediment controls would be deployed where required at the boundaries between inundated areas and adjacent wetlands or uplands. Matting materials would be removed after the pipeline is installed, with fabricated mats reused at other locations. Logs would be salvaged or disposed of as per permit stipulations.

3.3.2 Restoration Goals and Objectives

Mode 3 construction would occur in inundated wetlands, some of which may be mosaics of open water and emergent graminoids or moss and string bogs. Thus, the restoration goal would be to re-establish the wetland hydrologic regime and not the development of a specific wetland plant community. Restoring hydrologic functionality is considered the most effective means of facilitating natural colonization by local indigenous plant species. This goal would be achieved by ensuring the surface elevation of the trench is integrated with the elevation of the surrounding undisturbed terrain such that natural water flow patterns are maintained to the greatest extent possible.

3.3.3 Restoration/Revegetation Techniques

No restoration or revegetation treatments are proposed for this mode, other than restoring the hydrologic regime to stimulate natural wetland vegetation recovery, where applicable. Post-construction site conditions are expected to be good for natural recovery.

3.3.4 Treatment Schedule

No revegetation treatments are proposed for this mode, but the mode segments would be assessed during the spring/summer following construction and any remedial action required would be conducted at that time. Some additional remedial work may be required in spring, summer, fall, or winter post-construction (whenever most appropriate for the work scope and access). Remedial activities are likely to include modifying surface contours to promote return to natural hydrologic flow patterns.

3.3.5 Monitoring

Monitoring would be qualitative and consist of 1) an assessment of Mode 3 segments to determine how well they are integrated with adjacent, undisturbed communities; 2) using a categorical ranking system (e.g., trace to 2 percent, 3–10 percent, 11–25 percent, 26–50 percent, 51–100 percent), compile a plant species list and visually estimate the cover of the top five species in the trench and compare to the adjacent undisturbed (reference) area, where applicable; and 3) review established photo points in each segment to identify any problem areas that may require rehabilitation. As part of the AM strategy for the Project (described in Section 2.4), any additional remedial action taken and monitoring required would be done in consultation with resource agencies.

3.4 MODE 4 – GRANULAR WORK PAD OVER THAW-SENSITIVE PERMAFROST OR THICK ORGANIC MAT

3.4.1 Construction Techniques

Mode 4 was developed for flat or sloping terrain that is underlain by fine-grained thaw-sensitive permafrost or by thaw-stable permafrost with a thick organic mat. Granular fill would be placed on top of the working side of the ROW and trench area. The fill would not be removed after pipeline construction because it would be difficult to avoid disrupting the thermal regime of adjacent, undisturbed areas. Geotextile materials might be placed under the working side of the fill if geotechnical analysis indicates it is warranted. The fabric may be needed in some areas to entrain the gravel and keep it in place.

Where cross slopes exist (areas where the pipeline route runs perpendicular to the slope), the granular work pad would extend as a thin traction layer across the trench line from the edge of the working side. After the pipeline is lowered-in and the trench backfilled, the thicker section of granular work pad material may be spread from the working side across the trench to provide a uniform cover over the existing surface.

Erosion and sediment controls would be deployed along the edge of the granular work pad between adjacent wetlands or uplands.

3.4.2 Restoration Goals and Objectives

The goal of restoration in Mode 4 is to create primarily upland habitats that are stable, do not require regular maintenance, and that possibly provide value to some wildlife species. These habitats would be established either with fertilizer to enhance natural recovery, or through planting of upland species such as forbs and selected grasses. In some areas, restoring wetland habitats may be feasible, if a wetland hydrologic regime develops.

3.4.3 Restoration/Revegetation Techniques

For areas targeted for upland revegetation, mesic to xeric native forbs and grasses may be used to promote vegetation recovery, depending on availability, site characteristics, and ecoregion of the construction spread. For areas where erosion is not a concern, promoting natural recovery by amending soil properties with fertilizer may be the preferred option. Plant communities established through natural colonization tend to be more sustainable and better integrated with the surrounding undisturbed terrain over the long term. Soil properties are expected to be poor for this Mode, because it would consist of granular fill, so fertilizer (20-20-10 N-P-K) would be applied at a rate of 400 pounds/acre).

The extent to which wetlands can be restored would depend on the hydrology of the wetlands covered by granular fill, the thickness of the fill, and the landscape setting. If the granular layer is relatively thin (12 inches), wetlands may eventually re-establish, but soil thermal changes associated with the granular fill also are likely in ice-rich soils, because the gravel would transfer heat in the summer to the underlying soil. Thaw settlement (thermokarst) can often create a surface topography favorable to wetland colonizers, but deep troughs with steep margins and deeply flooded troughs are less conducive to vegetation establishment. Areas identified as having wetland revegetation potential would be fertilized with 20-20-10 N-P-K at a rate of 400 pounds/acre.

3.4.4 Treatment Schedule

Erosion control measures would be implemented as part of both pre- and post-construction activities in accordance with the Alaska LNG Project *Plan and Procedures* (see Section 2.2). Fertilization and seeding would occur after construction is complete, either in late fall or early spring. Depending on site conditions, additional plant cultivation treatments may be applied in years 2 and 3 following construction.

3.4.5 Monitoring

The pipeline trench and ROW would be monitored annually for the first three years following construction to identify any trouble spots and identify any remedial actions that may be necessary. Trouble spots may include areas with insufficient trench breaching to allow cross drainage; greater than expected settlement of the trench roach; and insufficient sediment barriers for protecting waterbodies and streams intersected by the trench. These spots would be visited in the field to determine the extent of remedial action needed and the rehabilitation treatments required. After three years, the trench would be monitored every three years until the end of the performance period. The schedule would be adjusted if additional site preparation or plant cultivation treatments are needed in some areas. As part of the AM strategy for the Project (described in Section 2.4), any additional remedial action taken and monitoring required would be done in consultation with resource agencies.

Quantitative monitoring would include sampling vegetation cover along permanent 100-meter transects established across the long axis of the trench. The number and locations of transects would depend on the length of each construction mode segment, the ecoregion, and the extent to which remedial action is required to stabilize the trench surface and to promote vegetation recovery. To facilitate access, transects would typically be established in association with compressor stations and other set locations, to the extent possible. The vegetation would be sampled at 1-meter intervals along the transect using a laser pointer mounted on a metal rod, recording the plant species (or other cover type) that intersected the laser beam. If multiple layers of vascular plant cover are present at a sampling point, all would be included in the vascular cover calculations. This method gives a repetitive cover estimate that may exceed 100 percent but generally is well correlated with biomass (Jonasson 1988). Only single "hits" of mosses and other nonvascular plants would be recorded. Other cover types (e.g., litter, soil) would be recorded only if no live plant cover is present, except that water would be recorded wherever it occurs. In riparian areas targeted for revegetation, percent survival of planted species would be used as the primary parameter for measuring success.

Permanent photo points also would be established along the ROW for documenting ecosystem recovery of the trench over time.

3.5 MODE 5A – GRADED

3.5.1 Construction Techniques

This mode may be used in both winter and summer in flat or sloping terrain with thaw-stable permafrost or non-permafrost soils. The grading would be required where the pipeline is on a side-slope, and not where it is perpendicular to the slope. The technique involves using standard earth-moving equipment to create a level work surface by cutting the upslope side of the hill and moving that material to the downslope side of the ROW as fill. When this mode is used in flat terrain during the summer, thin surface organics would be stripped to an approximate depth of 1 foot across the full ROW, stockpiled to the sides of the ROW, and then spread across the ROW after the trench is backfilled. When used in sloping wetlands during the summer, thin surface organics would be stripped to an approximate depth of 1 foot from the trench and spoil area only and stockpiled upslope. Surface organics would not be stripped in uplands. Erosion and sediment control measures would be implemented to maintain surface stability of the ROW and protect downstream wetlands and waters.

3.5.2 Restoration Goals and Objectives

The primary goal of ROW restoration would be to return the ROW to a stable physical condition across the side slope to the extent practicable. The goal of vegetation restoration for Mode 5A is where possible, promote natural vegetation or establish plant community that would stabilize the ROW and may provide some value for wildlife over time. Restoring wetlands would be done by re-establishing wetland hydrology, thereby promoting wetland vegetation recovery over time. Upland habitats would be established either with fertilizer to enhance natural recovery or through planting of upland species such as forbs and selected grasses. Otherwise, upland habitats would be created that are stable, sustainable, and possibly provide value to some wildlife species.

3.5.3 Restoration/Revegetation Techniques

For level terrain in wetlands, conditions for promoting natural recovery should be favorable, given that the top 1 foot of surface organics would be pulled back across the ROW after the trench has been backfilled. Restoration would be promoted by applying fertilizer (20-20-10 N-P-K) at a rate of 100 pounds/acre within the graded area. Applying seed of indigenous wetland species (as described for Mode 1) may be considered in the northern portion of the route (approximately MP 56.8–210), where natural recovery is expected to be slower than the remainder of the route.

If re-establishing wetlands is not feasible and/or desirable, mesic to xeric native forbs and grasses would be planted that are adapted to the landscape characteristics of the selected spread segment(s) (Table 3). A seeding rate of 1 pound/acre is recommended, but would again, depend on the availability of seed.

3.5.4 Treatment Schedule

Similar to the other modes, erosion control measures would be implemented as part of both pre- and post-construction activities in accordance with the Alaska LNG *Plan* and *Procedures* (see Section 2.2). Fertilization and seeding would occur after construction is complete, either in late fall or early spring. Depending on site conditions, additional plant cultivation treatments may be applied in years 2 and 3 following construction.

3.5.5 Monitoring

Monitoring would be conducted annually for the first three years following construction to identify any trouble spots as described above and identify any remedial actions that may be necessary. Trouble spots would then be visited in the field to determine the extent of remedial action needed and the rehabilitation treatments required. After three years, the trench would be monitored every three years until the end of the performance period. The schedule would be adjusted if additional site preparation or plant cultivation treatments are needed in some areas. As part of the AM strategy for the Project (described in Section 2.4), any additional remedial action taken and monitoring required would be done in consultation with resource agencies.

Quantitative monitoring would include sampling vegetation cover along permanent 100-m transects established across the long axis of the trench as described for modes 1, 2, and 4. The number and locations of transects would depend on the length of each construction mode segment, the ecoregion, and the extent to which remedial action is required to stabilize the trench surface and to promote vegetation recovery. To facilitate access, transects would typically be established in association with compressor stations and other set locations, to the extent possible.

Permanent photo points also would be established along the ROW for documenting ecosystem recovery of the trench over time.

3.6 MODE 5B – MOUNTAIN GRADED CUT

3.6.1 Construction Techniques

The Mountain Graded Cut Mode (Mode 5B) is proposed for steep mountain sidehill work. This Mode also may be used in areas that require excessively high fills to reduce risk of post-construction instability of the fill. After the initial cut is complete, ditching operations would commence and the spoil would be placed and spread across the working side of the ROW. This material would be used to backfill the trench. Due to the steep slopes involved, stripping of surface organics is not possible, nor is the restoration of the cuts.

3.6.2 Restoration Goals and Objectives

The restoration goal for Mode 5B would be focused on providing a stable land surface and minimizing the risk of slope failure. For some spread sections, this may require an armoured surface with no revegetation. For other sections, some degree of revegetation may be possible, but with the primary goal of preventing soil erosion. In these areas, the primary objective would be to rapidly establish a vegetation cover with the secondary objective of establishing vegetation that is sustainable over the long term. The vegetation may not necessarily be well integrated with adjacent undisturbed plant communities.

3.6.3 Restoration/Revegetation Techniques

Depending on the level of instability risk and site conditions, a combination of native-grass cultivars and geotextile fabric would be applied to those areas that are not reinforced with rock or other coarse materials. The plant species selection would follow recommendations outlined in the *Interior Alaska Revegetation and Erosion Control Guide* (Czapla and Wright 2012). Although Mode 5B would be used starting in the Arctic Foothills south, many of the species recommended in the interior guide can be effectively used in these other geographic areas. Fertilizer (20-20-10 N-P-K) would be applied at a rate of 400 pounds/acre and seed would be applied at 40 pounds/acre.

3.6.4 Treatment Schedule

Erosion control measures, both physical and through plant cultivation, would occur immediately following completion of pipeline installation. For areas targeted for revegetation, installing a geotextile membrane may be required to ensure the soil remains in place during seed germination and initial plant growth. Any erosion-control mats/blankets used would comply with requirements in the *Noxious/Invasive Plant and Animal Control Plan* for using only certified weed-free materials.

3.6.5 Monitoring

Monitoring would initially consist of qualitative assessments through repeat ground photography, the extent to which the mountain cut areas are stable. Evidence of instability, including slumping, gullying, and slides would be documented and identified for potential additional survey work and site stabilization. Areas targeted for revegetation would be similarly assessed qualitatively and any areas with evidence of erosion would be documented and additional plant cultivation and/or erosion-control treatments reapplied.

3.7 MODE 6 – POINT THOMSON GAS TRANSMISSION LINE (PTTL) ABOVEGROUND PIPELINE ON VERTICAL SUPPORT MEMBERS (VSMS) – POINT THOMSON TO THE GAS TREATMENT PLANT (GTP)

ROW Mode 6 was developed for construction of the above-ground portion of the PTTL that parallels the coast line east to west from the Point Thomson facility to the Gas Treatment Plant (GTP). The entire PTTL is within the Beaufort Coastal Plain, where use of ice work pads, similar to ROW Mode 1, is feasible. ROW Mode 6 differs from ROW Mode 1 in that it is narrower and incorporates vertical support members (VSMs) to elevate the pipeline. The ROW is narrower because no trench or spoil pile areas are required.

The entire ROW would be covered with an ice work pad and surface disturbance would be confined to the backfilled VSM post holes. Consequently, soil would not need to be salvaged to promote revegetation of this portion of the pipeline route. No restoration or revegetation efforts are planned or are anticipated to be needed for this Mode, thus, no monitoring is required.

4.0 SPECIAL CASES

Two situations (cases) have been identified along the proposed Project route that require special consideration with respect to restoration regardless of Mode. These special cases require a different restoration approach, for the purposes of re-establishing habitat lost as part of pipeline construction, to ensure that the transition from terrestrial to aquatic conditions along the route are stable, and to ensure thermal stability of the backfilled trench and ROW is maintained in ice-rich permafrost.

4.1 WATERBODY CROSSINGS

Waterbody crossings include sections of the Mainline route that intersect rivers, ponds, and lakes. For riverine waters, except for small drainages with little to no riparian zone (e.g., beaded streams on the North Slope), restoration efforts at river crossings would focus on restoring the riparian vegetation that was present prior to construction to promote slope stabilization and restore habitat value. At a minimum, all river banks would be restored to pre-construction contours or to a stable angle of repose (vertical banks cannot be restored). The extent of site preparation required (erosion-control measures) would influence the types of plant materials used but where possible (and appropriate), dormant cuttings of willow may be planted on the stream banks to promote vegetation recovery and enhance bank stabilization efforts. Seeding with grasses would be limited (unless grass is the natural streambank vegetation), as grass cover tends to impede the establishment of willows.

The dormant willow cuttings (Figure 5) would be harvested and planted in the fall (e.g., Figure 6), following completion of pipeline construction. Any geotextiles used for bank stabilization would be evaluated to ensure they are amenable for planting with the cuttings. Spring planting of willow cuttings is more difficult because the ground is frozen when the willows are harvested; thus, they would have to be harvested and stored frozen for at least a month until the soil is workable.

Performance criteria would be developed in consultation with resource agencies but may include a minimum percent survival of willows planted and/or percent cover of bank vegetation. Bank erosion or degradation would be assessed qualitatively by reviewing established photo points. Substantial degradation would include slumps that result in the sloughing of material from the top to the bottom of the bank; conspicuous sediment load in the stream channel; and channel bank undercutting that is likely to result in bank failure. Corrective measures would be implemented in consultation with resource agencies.

Restoration of the pipeline ROW where it intersects lakes and ponds would be managed to ensure that sediment is not transported into the waterbody or conversely, that water is not diverted into the backfilled trench. Subsurface and surface measures to control water flow as well as erosion control measures are described in the Alaska LNG Project *Plan*. Similar to river banks and streams, shoreline lake and pond contours would be restored to pre-disturbance conditions, to the extent possible. To control inflows and outflows, site preparation techniques may include sediment barriers and/or trench plugs. Re-establishing wetland vegetation along the waterbody margin also would help to preserve the integrity of the shoreline. In some instances, sod plugs may be necessary to create an effective barrier to water movement between the waterbody and the trench. The plugs have the advantage of being dominated by an organic mat, which helps keep the plug in place and serves as a substrate for colonizing wetland plants.

4.2 SURFACE INSTABILITY CONCERNS

As part of the AM strategy described in Section 2.4, the Project entity is prepared to respond to surface stability concerns associated with the backfilled trench and overall ROW after pipeline installation is complete. The Project entity has made a concerted effort to predict where surface stability may be an issue—e.g., ice-rich permafrost in the form of massive ice and ice wedges and steep mountain slopes with highly erodible soils, through terrain analysis and a geotechnical boring program. If a “hot spot” of thaw settlement or soil wasting occurs, a post-construction rehabilitation plan would be prepared that outlines the additional surface preparation and revegetation efforts (if applicable) that would be applied. Monitoring would be conducted to ensure the stability problem has been rectified and restoration proceeds as planned. To ensure that surface stability is maintained and no indirect impacts result from instability of the ROW, the original restoration goals and performance standards for the site may need to be revised.

After a problem area has been identified, remedial work would commence as soon as possible, depending on the site location and accessibility. Transport and placement of any backfill material required would be done in the summer, if possible, to avoid having to place frozen blocks of material along the ROW. If winter access is required, an effort would be made to break up frozen material to allow for better placement and attempts would be made to keep snow out of the placement area to the extent practicable. Repairing slope slumps also would likely be needed to be conducted in summer, to the extent possible.

5.0 CONCLUSION

This draft *Restoration Plan* outlines the Project approach to restoration for the range of proposed typical construction methodologies (modes), ecoregions, and seasons of construction anticipated. Surface disturbance would be minimized to the maximum extent practicable; and where it cannot be avoided, appropriate restoration methodologies, including treatments and monitoring, would be implemented as described. Examples of mitigation measures implemented during construction include modes 1 and 2, where the use of ice roads/pads and frost-packing is expected to minimize the need for extensive restoration in the construction ROW outside of the actual pipeline trench. In all of the modes the primary goal would be to stabilize the disturbed areas to prevent erosion including thermal instability (i.e., thermokarst in areas underlain by permafrost). Consideration is also given to “special cases” where restoration strategies would be tailored to specific sites/locations, such as waterbody crossings. Restoration goals and strategies would be subject to consultation and agreement with relevant agencies and land owners/managers over the course of developing and finalizing this Plan.

As discussed in the Performance Standards, the performance periods change with latitude and altitude, which determine the effective growing season for the re-establishment of vegetation along the ROW. This requires longer periods of time in order to meet minimum standards of successful revegetation in areas with shorter growing seasons. ASAP’s Revegetation Plan is being incorporated by reference into the Project’s Restoration Plan (See Appendix B). For recommended seed mixes and application rates refer to Section 3.2.1.4 “Seed Mixtures” of Appendix B. Appendix B also provides a table showing the “Latest Date to Seed” for the 3 major Land Regions crossed by the Project (Table 1 Section 3.2.1.2).

Finally, the use of AM would be incorporated as a critical component to the overall and long term success of restoration goals. Monitoring and reporting would focus on the progress in relation to performance standards and provide recommendations using AM strategies as appropriate and necessary. This would also provide valuable information toward future planning and execution of restoration in the watersheds/ecoregions crossed by the Mainline.

6.0 ACRONYMS AND TERMS

Term	Definition
Alaska LNG Project *Plan*	Alaska LNG Project Upland Erosion Control, Revegetation, and Maintenance Plan
Alaska LNG Project *Procedures*	Alaska LNG Project Wetland and Waterbody Construction, and Mitigation Procedures
AM	Adaptive Management
ADNR	Alaska Department of Natural Resources
APMC	Alaska Plant Material Center
BLM	United States Department of the Interior, Bureau of Land Management
ERDC	Engineering and Research Development Center
FERC	Federal Energy Regulatory Commission
GTP	Gas Treatment Plant
ILVC	indigenous live vascular cover
LNG	liquefied natural gas
Mode	construction mode
MP	milepost
PSI	pounds per square inch
PTTL	Point Thomson Gas Transmission Line
ROW	right-of-way
sp	Species (singular)
spp	Species (plural)
TLVC	total live vascular cover
USACE	United States Army Corps of Engineers
VSM	verticle support member

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Table 1: Summary of Restoration Options in the Arctic and Subarctic and Their Potential for use in the Project

Restoration Goal	Substrate	Hydrology	Site Preparation	Revegetation Treatment	Plant Species[1]	Positives	Negatives	Potential Use	Reference Sites
Erosion control	Loess/Gravel?	Mesic to dry	Backfilling with mineral overburden; applying geotextile mat, if needed	1) Initially seeding with annual grass; 2) Seed with native-grass cultivar mix with emphasis on mat-forming species	1) *Lolium multiflorum*; 2) *Festuca rubra, Calamagrostic canadensis, Festuca viviparoidea, Leymus innovatus*	Cover establishes within one to two growing seasons and seed is inexpensive	Mat forming habit makes it difficult for native species to establish	Confined primarily to Mode 5B, although would also be considered for other modes that include moderate to steep slopes.	
Establish indigenous plant community integrated with adjacent, undisturbed communities		Dry to Wet	Backfilling with mineral overburden	Natural Colonization (Fertilizer only)	Natural colonizers	Promotes establishment of natural colonizers, relatively inexpensive.	Effect may be temporary, "weedy" species that colonize may inhibit colonization by other desired species. Productive vegetation cover may take more than 10 years (northern sites). Sometimes a thick moss mat forms first, which can make it difficult for seeds to penetrate and germinate.	Primarily modes 1, 2, 4, and 5A and only in areas with flat terrain.	Gravel removal areas at various exploratory well sites, including West Sak River State 3, West Sak 17, KRU Ugnu SWPT
Temporary cover (to facilitate longer-term natural recovery)	Organic-rich to mineral overburden	Mesic to dry	Backfilling with organic-rich or mineral overburden	Seeding with short-lived perennial grass	*Puccinellia borealis*, *Elymus trachycaulus*	Provides good cover for trapping snow and potentially seeds of natural colonizers	Future commercial availability of *Puccinellia borealis* uncertain.	Primarily modes 1, 2, and 5A	MS3 Trenching Trials Site; NW Eileen Exploratory Well Site (gravel removal area)
Productive vegetation cover	Organic-rich to mineral overburden	Mesic to dry	Backfilling with organic-rich overburden	Seeding with native-grass cultivars	Mesic: *Deschampsia caespitosa* and *Arctagrostis latifolia*[2] Dry: *Poa alpina, Poa glauca, Trisetum spicatum, Poa arctica*	Commercially available; relatively rapid cover development (one to two years south of the Brooks Range; two to three years Arctic Coastal Plain)	Heavy feeders; sustainable if soil has sufficient organic matter, otherwise die back in three to five years	Primarily modes 1, 2, and 5A	Capped reserve pits (e.g., West Sak 9, West Sak B10, West Sak 11); gravel side slopes (Alpine)
Productive vegetation cover	Granular Fill	Dry	None	Seeding with native-grass cultivars	*Deschampsia caespitosa, Poa alpina, Poa glauca, Trisetum spicatum, Arctagrostis latifolia*[2]*, Poa arctica*	Commercially available; relatively rapid cover development (one to two years south of the Brooks Range; two to three years Arctic Coastal Plain)	Heavy feeders; sustainable if soil has sufficient organic matter, otherwise die back in three to five years	Primarily Mode 4	West Sak B10 (former gravel pad), West Sak 1 (former gravel pad), West Sak 11 (former gravel pad)
Establish indigenous plant community integrated with adjacent, undisturbed communities	Organic-rich to silty sand, coarse gravel OK if soil is saturated	Saturated	Backfilling with salvaged organic soil (may include silt and sand)	Indigenous Sedge Seeding		1) Contributes to goal of natural recovery; 2) Provides wildlife habitat (nesting, foraging)	1) Not commercially available; 2) Highly variable year-to-year seed availability and viability; 3) Manual collections are expensive	Limited to selected sections of primarily modes 1, 2, and 5A; wetland areas of Mode 4 also may be feasible.	Former gravel access roads next to old ARCO airstrip (Kidd et al. 2006), West Kuparuk State Pad, Mobil Kuparuk State Airstrip (also several Kuparuk sites)
Establish indigenous plant community that will facilitate the establishment of a plant community integrated with adjacent, undisturbed communities	Silty to sand to gravelly substrate. Some organic content desirable.	Mesic to dry	Backfilling with mineral overburden	Indigenous Forb Seeding		Typically creates open canopy that would allow for native colonizers to establish, depending on the substrate type and soil moisture. Can potentially improve soil fertility (legumes).	Labor intensive to collect.	Dry portions of all modes except Mode 3. Would only be able to be used for selected areas unless a concerted effort is made to establish "seed farms." Might be able to be supplemented with APMC collections (some have been available for purchase in recent years).	West Sak 11 (capped reserve pit), Mine Site F (Cell 1 berms)

Restoration Goal	Substrate	Hydrology	Site Preparation	Revegetation Treatment	Plant Species[1]	Positives	Negatives	Potential Use	Reference Sites
Establish indigenous plant community integrated with adjacent, undisturbed communities		Mesic to saturated	Backfilling with organic-rich overburden or salvaged organic soil (some silt, sand, gravel OK)	Tundra Plug Transplants	Typically consist of a variety of species (depending on source community type), including *Salix* sp., *Carex* spp. (commonly *C. aquatilis*), *Eriophorum*, *Equisetum*, and *Saxifraga* spp.	Achieves goal of restoring plant communities disturbed by pipeline construction	Labor intensive to harvest. Also concerns about impact on harvest areas. Holes should be backfilled with overburden to promote tillers from adjacent tundra to colonize plug "holes."	Limited to selected, small areas where establishing wetland vegetation quickly is warranted.	West Sak B10 (former gravel pad), West Sak 1 (former gravel pad), West Sak 24 (former flare pit berm)
Establish indigenous plant community integrated with adjacent, undisturbed communities		Saturated	Backfilling with organic-rich overburden or salvaged organic soil (some silt, sand, gravel OK)	Sedge Mats	*Carex aquatilis, Eriophorum* spp., potentially other species	Achieves goal of restoring plant communities disturbed by pipeline construction	Has some of the same constraints as sodding, with the added requirement to grow the mats in a greenhouse or other facility prior to planting	Limited to selected, small areas where establishing wetland vegetation quickly is warranted.	Powerline trench in the Prudhoe Bay Unit
Establish indigenous plant community integrated with adjacent, undisturbed communities		Dry to saturated	Backfilling with mineral overburden	Grass Mats	*Calamagrostis canadensis,* other species listed above under seeding with native-grass cultivars treatments	Might be useful for areas where erosion is a particular concern and therefore a need to establish an immediate vegetative cover.		Limited to selected, small sloping areas in modes 5A and 5B	Alaska Plant Materials study in southcentral Alaska
Establish indigenous plant community integrated with adjacent, undisturbed communities		Saturated	Backfilling with organic-rich overburden or salvaged organic soil (some silt, sand, gravel OK)	Tundra Sod	Similar to tundra plug transplants but probably includes a higher species richness, due to the larger size of the individual sod pieces.	Provides immediate vegetative cover on a site, and species are able to establish on a large area more quickly than with other forms of transplanting (i.e., using sprigs or individual plants).	Extremely labor intensive; requires availability of a donor site. For safety reasons, area to be planted must be accessible by heavy equipment or at least a means of transporting the sod to the target areas (e.g., conveyor belt).	Limited to areas where breaking up flooded trench segments is warranted or as a sediment barrier at waterbody (lakes and ponds) crossings	GC2 spill site, DS5 diesel spill, ASRC Rolligon trail, L3 spill site
Establish indigenous plant community integrated with adjacent, undisturbed communities		Saturated to flooded < 4 inches water depth)	Backfilling with organic-rich overburden or salvaged organic soil	Wetland sprigs	*Arctophila fulva, Hippurus* sp., *Typha latifolia, Menyanthes, Scirpus?*	Provides wildlife habitat, might be considered as part of a mitigation plan for selected areas along the pipeline	Labor intensive	Limited to flooded segments too deep to promote natural recovery by indigenous wetland species.	West Sak Pilot Pad (former flare pit berm), Mine Site D (perched pond), Mine Site F (Cell 1 shoreline, island shorelines)
Erosion control	Loess/Gravel?	Mesic to dry	Backfilling with mineral overburden	Willow cuttings, bundles, mats	*Salix alaxensis, S. richardsonii, S. pulchra*	Establishes rooting system to control erosion.	Labor intensive to collect and plant.	Limited to stream crossings to support bank stabilization efforts and enhance wildlife habitat	Land rehabilitation studies in the Alpine Oilfield, 2001; Mobil W/Z airstrip; Mine Site F Cell 1 (berms, islands)
Establish indigenous plant community integrated with adjacent, undisturbed communities				Containerized seedlings	Various sedge and forb species	Large numbers could be cultivated in greenhouse prior to transplanting	Labor intensive to grow and plant.	Unlikely to be used for this project due to lack of growth facilities	Mine F Cell 1 (islands)
Establish plant cover on sites/components where soil is too saline for most plants		Mesic		Salt-tolerant species	*Puccinellia angustata, Cochlearia officinalis* On moderately saline sites with wetland hydrology, some wetland sedges (e.g., *Eriophorum angustifolium*) may be able to establish.		Labor-intensive to collect; resulting community doesn't resemble adjacent tundra	Unlikely to be needed for the Project as fill material not anticipated to be saline	Test plots have been established at East Ugnu 1, West Sak 17

[1] Species availability ranges from common to scarce (i.e., may not be available every year and quantity may be limited).
[2] Species has rank growth that can inhibit natural recovery unless sown at low rate.

Table 2: Summary of Land Restoration Activities and Lessons Learned at Selected Sites in the Arctic and Subarctic

Study Area/Description	Revegetation Goals	Revegetation Methods	Site Response	Lessons Learned
Kanuti Pit Rehabilitation (Boreal Ecoregion) (Figure 3) • Material site (65-9-031-2) • Located near MP 105, Dalton Hwy • 19.5 acres • 2001 asbestos • 2002 site preparation for rehab	• Soil stability • Plant growth • Water retention • Wetland habitat creation • Match surrounding landscape • Quantitatively and qualitatively site monitoring	• Asbestos capped with imported (Bonanza Creek material site) organic overburden • Contoured for littoral wetland • Rip ground with dozer to encourage invasion of alder/willow • Native seeds, fertilizer (20N-20P-10K) using handheld or ATV broadcaster	• Areas completely voided of plant growth • 2010 satisfactory performance of seeded grasses • Natural re-invasion of native species • Wetlands are holding water • Development of niche wetland habitat	• Better planning needed • Better oversight • Wrong equipment, no ripper on dozer • Planned areas for soil/seeding completely missed • Fertilizer boundary area reduced

Fairbanks Partial Landfill Closure (Cell C/D & Cell #1) (Boreal Ecoregion)
• 28 acres of disturbed ground
	• Reconstruction of site topography/slope specification
	• Leachate recirculation system
	• Provide soil coverage with surface
	• Provide gas collection and piping systems
	• Quantitatively and qualitatively site monitoring
		• Contoured topography topped with 6 inches of soil
		• 90% of project area drilled seeded
		• Sprayed with Eco-Fibre/Plus
		  ○ Mulch with tackifier
		• Ditch and berm areas hydroseeded
		• Cell C/D 2 feet of treated sludge
		  ○ Ni-Viro topped with 6 inches of topsoil
		• Native seed mixture and
		• 20N-20P-10K fertilizer
			• Drill seeded areas germinated in 8 days with thick uniformed stand within 30 days
			• Hydroseeded required 40% re-seeding of area
			• 80% vegetation coverage of ditch and berm areas in 2010
				• Drill seeding is preferred method of seeding
				• Hydroseeding required more maintenance/water
				• Remote sites with no water access, exclude hydroseeding

Faro Mine Complex (FMC)
• Central Yukon
• Mining activities
• Grum Overburden slope revegetation trials
  ○ 2 hectares (ha) of surficial soil characteristics for reclamation coverage
  ○ Trials began in 2009
	• Develop effective surface treatments
	• Develop revegetation options
	• Establish vegetation
	• Mitigate erosion
	• Reclaim disturbed area
	• Allow natural succession trajectories
	• Identify most effective combination of surface treatments and revegetation methods
		• Three seed mixes (agronomic, native, and nursery & native)
		• Three woody plant treatments (horizontal and vertical stakes and alder seedlings)
		• Two fertilizer treatments
		• (8N-38P-15K and control unfertilized)
		• Three soil surface treatments (micro-rill, planar, and rough and loose)
		• Quantitatively and qualitatively assess vegetation response
			• Fertilizer application necessary to establish herbaceous vegetation
			• Unfertilized plots had minimal growth
			• All seed mixes and surface treatments reached successful vegetation coverage in fertilized plots
			• Alder seedlings showed negative response to fertilizer
			• Ambiguous results for staked willow and poplar cuttings
			• Rough and loose surface treatment effective for controlling erosion from run-off
				• Soils and climate make revegetation challenging
				• Selection of proper site preparation
				  ○ Reduces erosion
				  ○ Provides additional time for vegetation to establish
				• Additional work is required
				  ○ Seed mixes
				  ○ Fertilization ratio/rates
				  ○ May improve revegetation coverage
				• Fertilized rough and loose treatment with seeding, horizontal staking are key aspects of successful revegetation and erosion control prescriptions

Faro Mine Complex (FMC)
• Central Yukon
• Mining activities
• Grum Sulphide Cell (GSC) revegetation trials
  ○ 26 ha
  ○ Trials began in 2012
	• Develop effective surface treatments
	• Develop revegetation options
	• Establish vegetation
	• Mitigate erosion
	• Reclaim disturbed area
	• Allow natural succession trajectories
	• Identify most effective combination of surface treatments and revegetation methods
		• Surface treatment (rough and loose, ripping across slope)
		• Hydroseed (nursery and native)
		• Woody plant treatments (plugs and horizontally staked willow and poplar cuttings)
		• Fertilizer teabags (hydration pack 16N-8P-5K and Chilcotin-pack 17N-5P-7K)
		• Quantitatively and qualitatively assess vegetation response
			• 2013 grass cover height survey below projection
			• 2014 13% increase of herbaceous species cover
			• Cover highest at deeper cross-slope furrows, high moisture content Teabag application promotes increase grass height and vigor
			• Vegetation cover below level to control erosion and slope stabilization
				• Woody stem moderately successful planting appears
				• Moss growth assisted with soil/slope stabilization
				  ○ Woody species more prevalent in mossy areas
				  ○ Provided natural regeneration

True North Mine Reclamation (Boreal Ecoregion)
• Placer mining/exploration activities
• 68 acres of disturbed ground
• Within the Chatanika watershed
• 2007 reclamation activities began
	• Retaining and compiling growth medium
	• Compacted soils recontoured for suitable revegetation
	• Preparation of seedbeds for adequate germination
	• Proper seed mix to achieve quick vegetation to minimize erosion
	• Reclaim area to match natural surrounding vegetation
		• D8N CAT dozer, equipped with two- or three-shank ripper
		• Ripped contours along slope
		  ○ Create suitable seedbed
		  ○ Provide erosion controls
		• Application of growth medium
		  ○ 12 inches of native soil material
			• Successful revegetation results
			  ○ 70% of disturbed area seeded and establish adequate growth
			• Vegetative maintenance
			  ○ Seeding and fertilizing as needed
				• Aerial broadcast application provided adequate coverage
				• Need for mulch application would be evaluated if germination is limited for re-establishment of vegetation

Study Area/Description	Revegetation Goals	Revegetation Methods	Site Response	Lessons Learned
	• Quantitatively and qualitatively site monitoring	○ Physical and chemical properties added to provide germination • Seed mix and fertilizer ○ Five native-grass cultivar varieties ○ 20N-20P-10K for spring seeding ○ 10N-20P-10K for fall seeding ○ Aerial broadcaster	• Natural reinvasion of native species throughout mine area • Areas of no revegetation contained volunteer species (birch) 8 feet high	
2002 Trenching Trials Site: Material Site 3 (MS3) (Arctic Tundra Ecoregion) (Figure 1) • South of Deadhorse, AK • 2002 field trials • 13 test trenches • 37-acre footprint (trenches 3.22 acres)	• Surface stabilization to minimize thaw settlement and soil erosion • Promote native vegetation recovery on backfilled trenches • 80% of trenches above tundra grade with no linear depression ≥ 33 feet holding surface water • More than 15% coverage of live vascular plants (excluding seeded species) with fewer than five indigenous species with more than 0.2% of each • Quantitatively and qualitatively site monitoring for 10 years • Remedial action if performance standards not met	• Imported 6,000 cubic yards (yd^3) of thaw-stable gravel • Ditch settlement index (DSI) • Values 50% and 60% • Backfill trench 4.5 feet above grade to impede subsidence • Applied the seed Arctic alkali grass (*Puccinellia borealis*) and fertilizer (10N-20P-20K) with hand held broadcasters • 2008 backfill subsided trenches and plant ditch plugs to promote surface stability • 2011 install tundra sod along Trench 1	• 2004 mean total indigenous live vascular coverage (ILVC) for all trenches was 13.6% • 80% above-grade trench criteria dropped • 2012 mean ILVC for all trenches was 31.4% • Mean thaw depth on trenches in 2006 ranged from 1.97–2.58 feet • Mean thaw depth on trenches in 2012 ranged from 2.45–3.55 feet • Mean thaw depth in tundra in 2012 was 1.97 feet	• Gradual increase of active layer depth in trenches compared to undisturbed tundra • 2011 data exclusion due to miscommunication with field crew • Tundra sod application on Trench 1 seems to be stable/holding providing substrate for plant growth • No negative impact on vegetation recovery due to subsidence (excludes Trench 1) • Mean cover and vascular plant diversity exceeded performance standards • Areas above tundra grade, less vegetation cover
2002 Trencher Trial Site: Washington Creek (K8A) (Boreal Ecoregion) (Figure 2) • Near Fairbanks, AK • 2002 field trials • 10 test trenches • 37-acre footprint (trench area was 1.5 acres)	• Surface stabilization to minimize soil erosion • Promote native vegetation recovery on backfilled trenches and cleared area between trenches • 80% of trenches above grade with no linear depression ≥ 33 feet holding surface water • More than 30% coverage of live vascular plants (excluding seeded species) with fewer than five indigenous species with more than 0.2% of each within trenches • Quantitatively and qualitatively site monitoring for 10 years • Remedial action if performance standards not met	• Backfilled trenches with 7,000 cubic yards of thaw-stable gravel • Ditch settlement index (DSI) Values 55% range • Backfill trench above grade ○ 5.5 feet to impede subsidence • Seed mix of fireweed (*Epilobium angustifolium*) and annual rye grass (*Lolium multiflorum*) and fertilizer (10N-20P-20K) • Remedial action required to stabilize the surface of two trenches in 2002, including installing fiber mats, hay bale berms, and ditch plugs	• 2005 mean ILVC for all trenches was 80.0% and 47.6% between the trenches • 2012 mean ILVC for all trenches was 62.8% and • 68.8% between the trenches • > 34% of elevation stations below grade	• Mean cover and vascular plant diversity exceeded performance standards • Plant community dominated by indigenous species that is sustainable • Trench surface stability performance standards were not achieved but recommended they be revised in accordance with MS3 guidelines (surface stability was not impeding vegetation recovery) • Preventative measures to control erosion were effective but impacts may have been avoided with better pre-planning
Badami Pipeline East Shaviovik Crossing, Prudhoe Bay Oilfield (Arctic Tundra Ecoregion)	• No specific goals or performance standards were established, but a general goal was for a stable backfilled trench surface with no significant signs of subsidence or erosion.	• Backfilled trench with gravel and topdressed with overburden to promote natural vegetation recovery	• Some initial subsidence of the trench occurred, but vegetation cover was productive and included a variety of indigenous tundra graminoids and forbs	• Not overfilling the trench and topdressing the gravel fill with a good growing medium helped create favorable conditions for vegetation establishment
Northstar Pipeline Landfall Shore Crossing, Prudhoe Bay Oilfield (Arctic Tundra Ecoregion)	• No specific goals or performance standards were established, but a general goal was for a stable backfilled trench surface with no significant signs of subsidence or erosion.	• Backfilled trench with a mixture of sand and gravel • Applied the seed Arctic alkali grass (*Puccinellia borealis*) in 2001 and again in 2002 and fertilizer (10N-20P-20K) in 2001 and 2004 with handheld broadcasters, following installation and subsequent replacement of erosion-control mat on ocean face of trench	• Monitoring in 2013 found a moderate cover of vegetation dominated by the seeded species Arctic alkali grass had established, although indigenous grasses, forbs, and shrubs also were present.	• Erosion-control mat (on ocean face of trench) likely would need periodic maintenance and it is uncertain whether the trench surface would remain stable in the event of a significant storm.
Badami Weir Site, Prudhoe Bay Oilfield (Arctic Tundra Ecoregion)	• Establish diverse and productive wetland and upland plant communities similar to those of the surrounding area • By year 10, 10% cover by live vascular plants, including seeded grasses, • Species composition consisting of at least five naturally colonizing species with 0.2% canopy cover each.	• After the failure of several treatments to prevent erosion of the site from an adjacent abandoned river channel (oxbow), a weir was constructed, including wing walls to reduce flow velocities during breakup. Sandbags also were temporarily placed atop the scoured areas to prevent erosion until revegetation could be initiated • Overburden was spread over the scoured areas • Applied fertilizer (132 pounds/acre phosphorous) and seed (12 pounds/acre “Arctared” Fescue {*Festuca rubra*} and 13 pounds/acre Arctic alkali grass ({*Puccinellia borealis*}).	• As of 2012, TLVC of the site was 30.1%, which exceeded the performance standard of 10%. • The diversity standard was not met (only two indigenous species had cover values more than 0.2%). Diversity is expected to increase over time; however, trace cover was recorded for an additional 13 species.	• A better understanding of the landscape setting of the backfilled pipeline, including hydrologic factors, may have prevented or at least reduced the extent to which remedial action was required to stabilize the area.

Table 3: Plant Species and the Various Cultivation Methods Used for Restoring Disturbed Lands in the Ecoregions Associated with the Project

Species (common name)	Natural Colonization	Seed	Stem Cuttings/ Bulbils	Sprigging	Plugs/Sod Transplanting
Cultivars[a]					
Grasses					
Arctagrostis latifolia (polargrass)	*	*			
Bechmannia syzigachne (sloughgrass)		–			
Calamagrostis canadensis (bluejoint)	*	–			
Deschampsia cespitosa (tufted hairgrass)	*	*			
D. beringensis (Bering hairgrass)		–			
Elymus macrourus (thickspike wheatgrass)		?			
Festuca rubra (red fescue)	*	*			
Poa alpina (alpine bluegrass)		*			
P. glauca (tundra bluegrass)	–	*			
Puccinellia borealis (boreal alkaligrass)		–			–
Trisetum spicatum (spike trisetum)	*	*			
Indigenous					
Grasses					
Alopecurus magellanicus (alpine foxtail)	*	–			
Arctagrostis latifolia (polargrass)	*				
Arctophila fulva (Arctic pendant grass)	*			*	
Calamagrostis canadensis (bluejoint)	*				
Deschampsia cespitosa (tufted hairgrass)	*				
Dupontia fisheri (Fisher's tundra grass)	–	*			–
Leymus mollis (dunegrass)	–	?		*	
Festuca altaica (fescue grass)		?			
F. baffinensis (Baffin fescue)	*				
Poa pratensis colpodea (Kentucky bluegrass)	*				
Poa arctica (arctic bluegrass)	–				
Puccinellia angustata (tall alkaligrass)	*	–			–
Puccinellia tenella (tundra alkaligrass)	*	–			–
P. phryganodes (goose grass)	–				
Sedges and Rushes					
Carex aquatilis (water sedge)	*	*			*
Eriophorum angustifolium (tall cottongrass)	*	*			*
E. scheuchzeri (white cottongrass)	*	*			*
Luzula arcuata (curved woodrush)		?			

Species (common name)	Natural Colonization	Seed	Stem Cuttings/ Bulbils	Sprigging	Plugs/Sod Transplanting
Luzula sp. (woodrush)	–				
Forbs					
Artemisia arctica (Arctic wormwood)	*	*			
A. tilessi (tilsey sage)		?			
Astragalus alpinus (alpine milk vetch	–	*			
Braya purpurascens (rockcress)	*				
Cerastium beeringianum (Bering chickweed)	–				
Cochlearia officinalis (scurvy grass)	*				
Descurainia sophioides (northern tansymustard)	*				
Draba sp. (mustard)	*				
Epilobium latifolium (river beauty)	*	–			
E. angustifolium (tall fireweed)	*	–			
Hedysarum alpinum (alpine sweet-vetch)	*	*			
H. mackenzii (northern sweet-vetch)	*	*			
Oxyria digyna (mountain sorrel)		?			
Oxytropis borealis (boreal oxytrope)	*	*			
O. campestris (field locoweed)	-	–			
O. deflexa (deflexed oxytrope)	*	*			
O. nigrescens (blackish oxytrope)	–	–			
O. viscida (viscid oxytrope)	*	*			
Polemonium boreale (northern Jacob's ladder	*				
Polemonium acutiflorum (tall Jacob's ladder)	*	?			
Polygonum viviparum (alpine bistort)			?		
Sagina intermedia (snow pearlwort)	–				
Saxifraga oppositifolia (purple mountain saxifrage)			?		
Solidago multiradiata (goldenrod)		?			
S. decumbens (dwarf goldenrod)		?			
Tripleurospermum phaeocephalum (false mayweed)	–	?			
Shrubs					
Arctostaphylos uva-ursi (kinnikinnik bearberry)			?		
Cassiope tetragona (four-angled cassiope)			?		
Dryas integrifolia (entire-leaf mountain-avens)	-	?			–
D. octopetala (white mountain-avens)		?	?		
Empetrum nigrum (crowberry)			?		

Species (common name)	Natural Colonization	Seed	Stem Cuttings/ Bulbils	Sprigging	Plugs/Sod Transplanting
Salix alaxensis (feltleaf willow)	–		*		
S. arctica (Arctic willow)	–		–		–
S. ovalifolia (ovalleaf willow)					
S. planifolia (diamondleaf willow)	-		–		–
S. polaris (polar willow)			?		
S. richardsonii (Richardson's willow)			*		
Vaccinium vitis-idaea (mountain-cranberry)			?		
Trees					
Picea glauca (white spruce)					-

[a] Species are native to Alaska but are cultivated in southcentral and interior Alaska (and southern Canada) to maximize seed production.

* Commonly found or used, - uncommon, ? under evaluation.

Figure 1: Views of vegetation recovery of selected backfilled trenches between 2003 and 2014 at the Material Site 3 (MS3) trenching test site, North Slope, Alaska. Mean indigenous total live vascular cover at the end of a 10-year performance period was 31.4 percent.

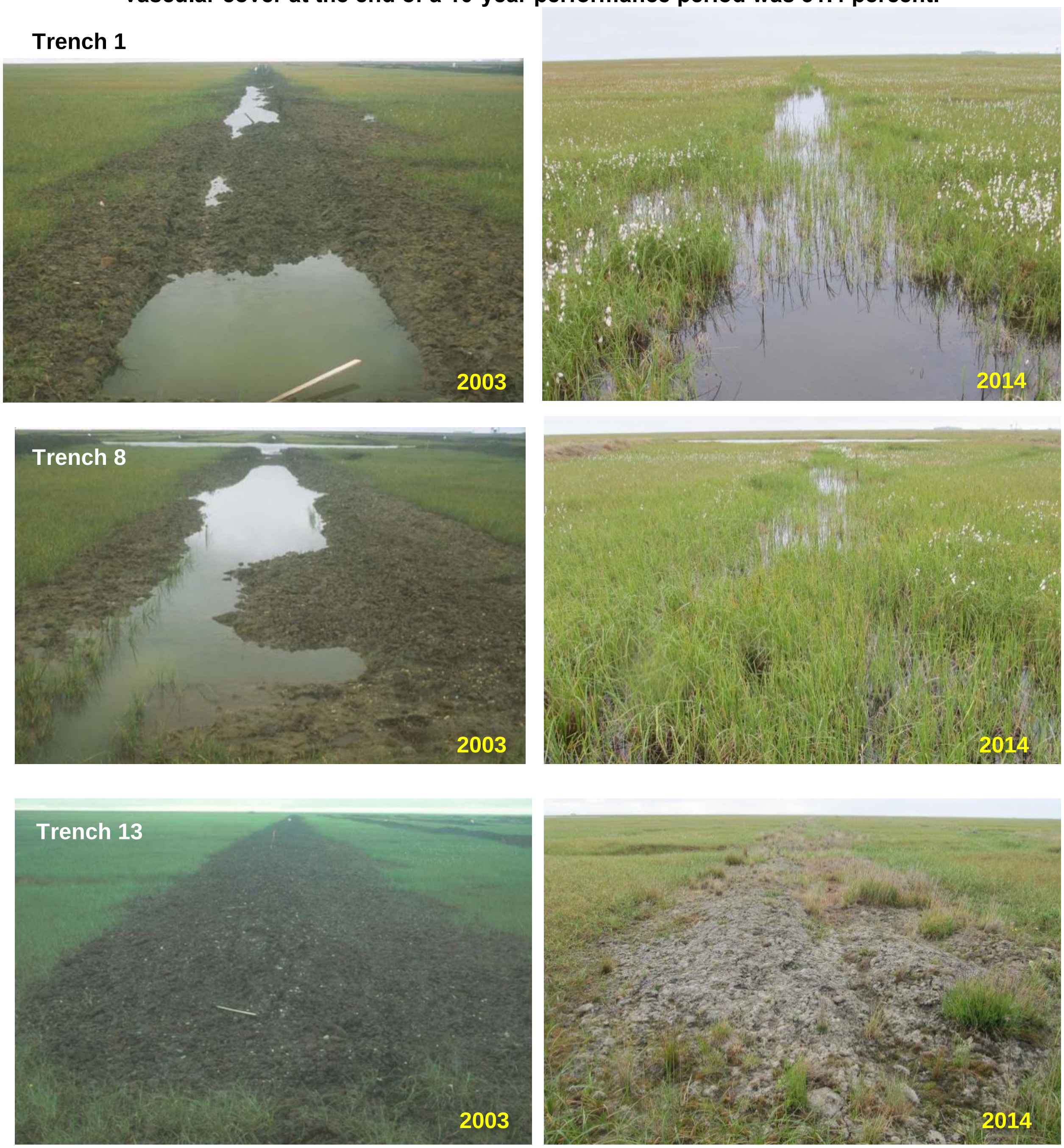


Figure 2: Views of vegetation recovery of capped flare pit between 2002 and 2014 at the West Sak 14 exploratory well site, North Slope, Alaska. Mean indigenous total live vascular cover at the end of a 10-year performance period was 23.8 percent.

Figure 3: Views of vegetation recovery of selected backfilled trenches between 2002 and 2014 at the Washington Creek trenching test site, Interior Alaska. Mean indigenous total live vascular cover at the end of a 10-year performance period was 62.8 percent.

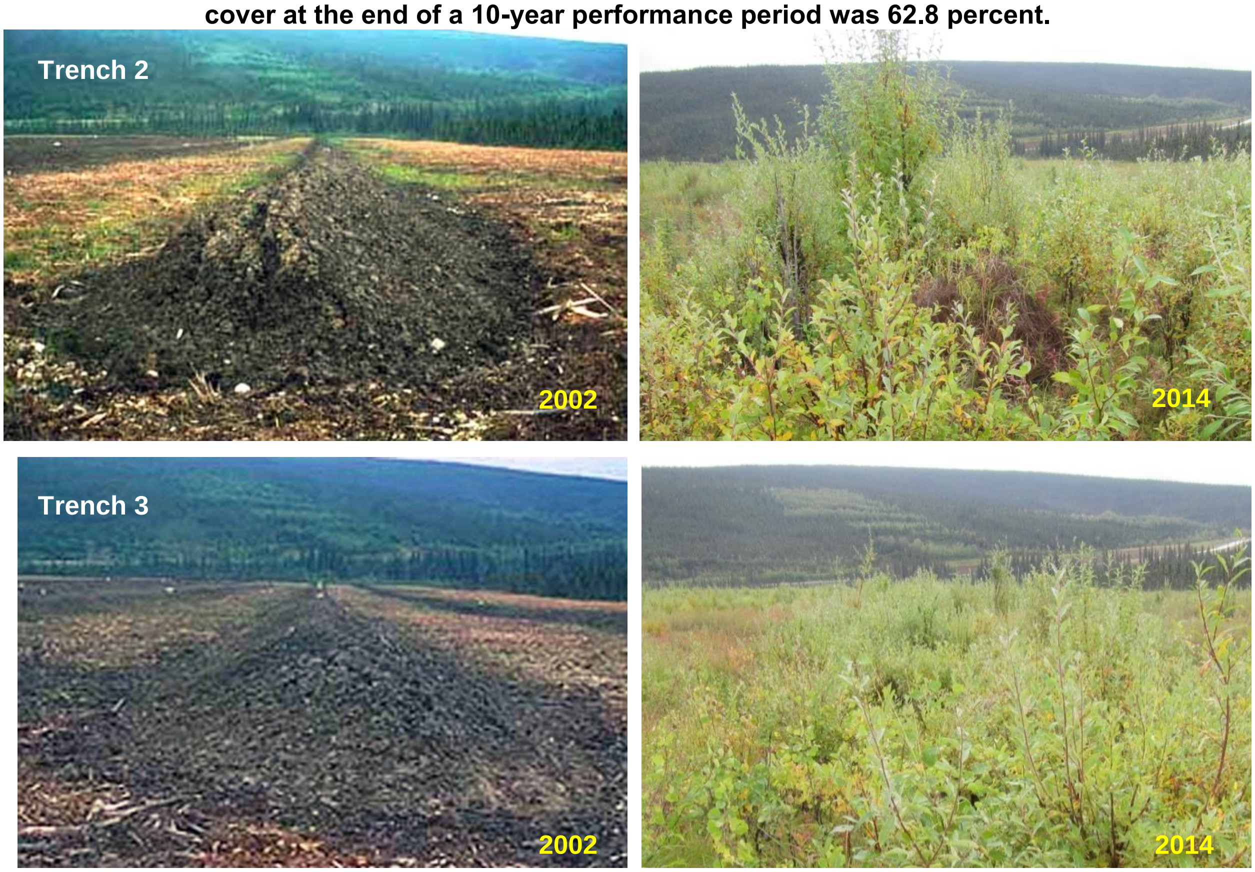


Figure 4: Views of vegetation establishment between 2003 and 2010 following site preparation and plant cultivation of Kanuti Pit, Interior Alaska. No quantitative vegetation cover was available, but a high density of cover of planted cultivar species and natural colonization of native species was noted during the 2010 monitoring.

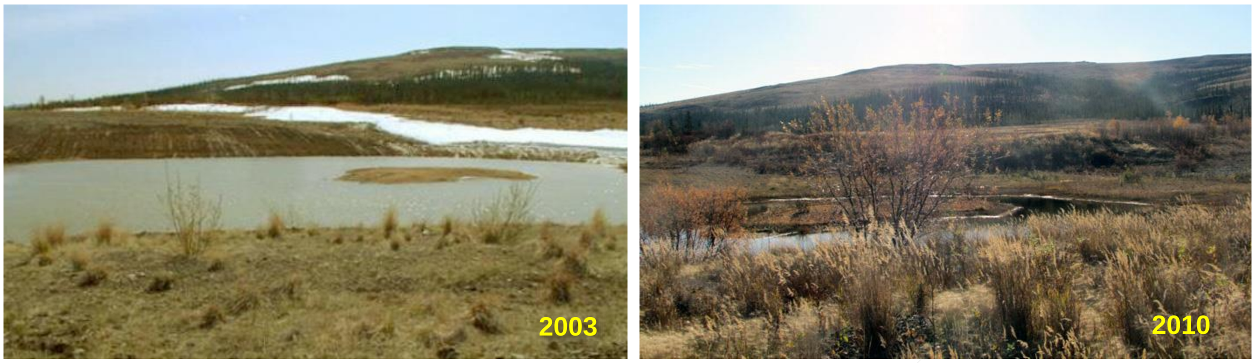
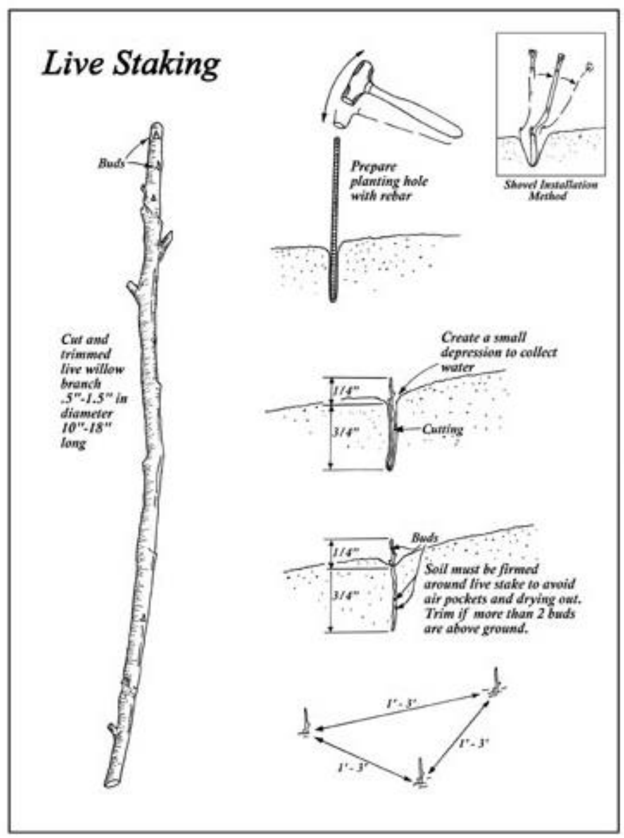
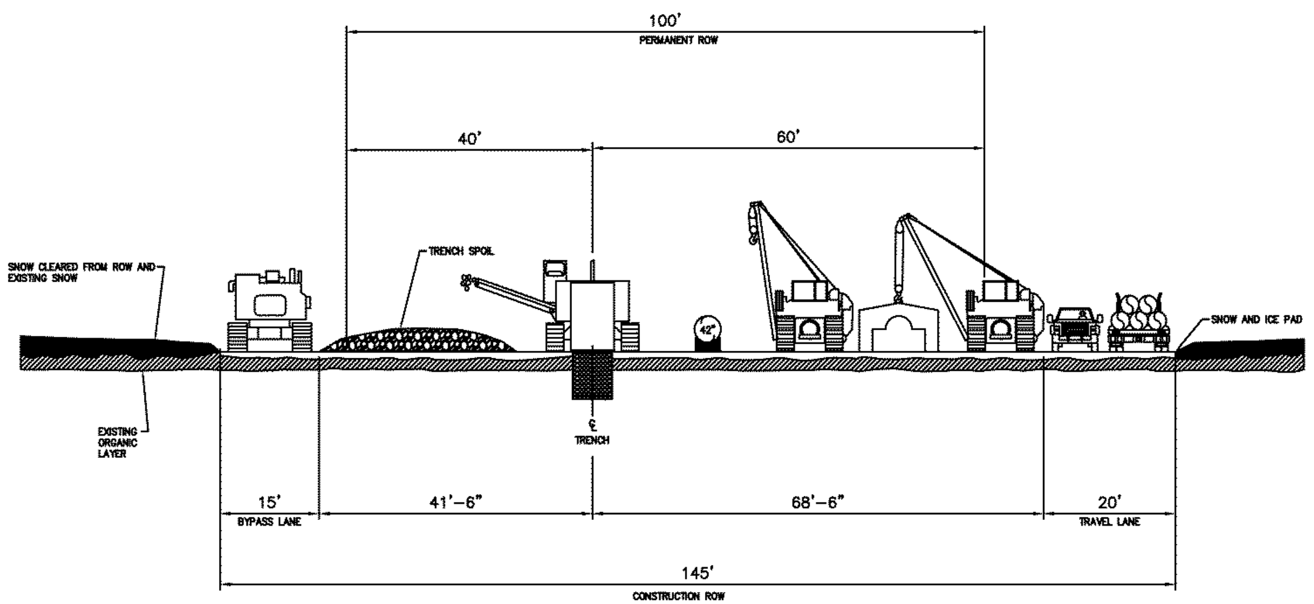


Figure 5: Dormant willow collection.

Figure 6: View of live staking technique for dormant willow cuttings (from: Streambank Revegetation and Protection: A Guide for Alaska, Alaska Department of Fish and Game).



Appendix A. Typical Drawings for the Proposed Project Construction Modes.



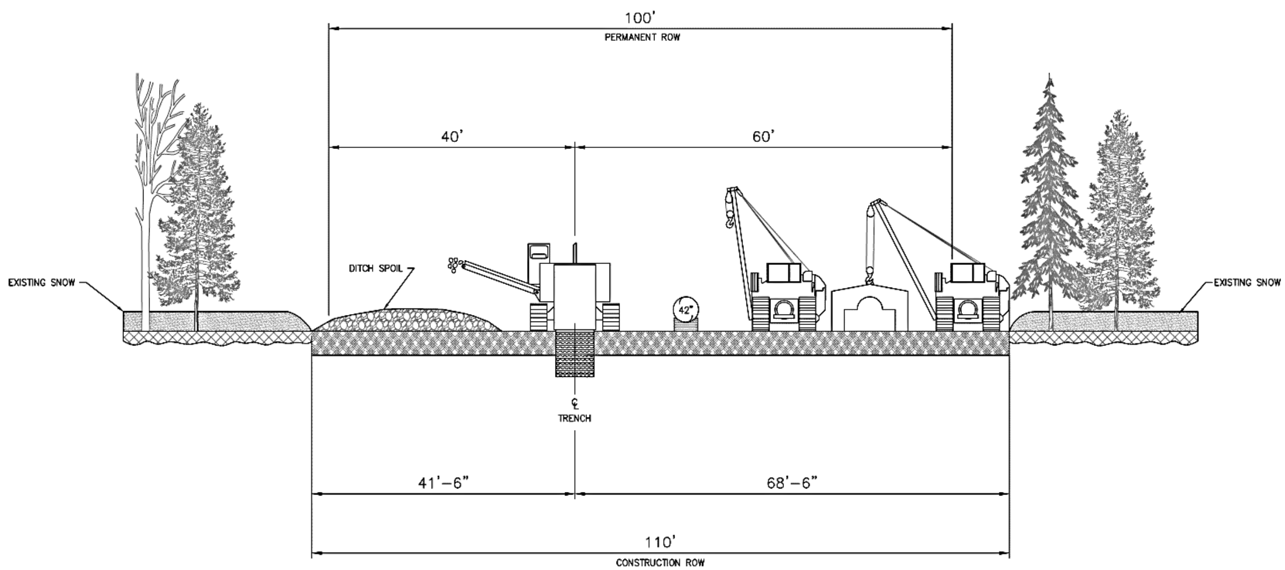
NOT FOR CONSTRUCTION

ROW–01

ALASKA LNG PIPELINE PROJECT

Right–of–Way Modes – Ice Work Pad ROW North Slope (Winter)

Rev.
0



NOTES:

1. WHERE REQUIRED, 20 FEET MORE FOR TRAVEL LANE ON WORKING SIDE.
2. WHERE REQUIRED, 15 FEET MORE FOR BYPASS LANE ON SPOIL SIDE.

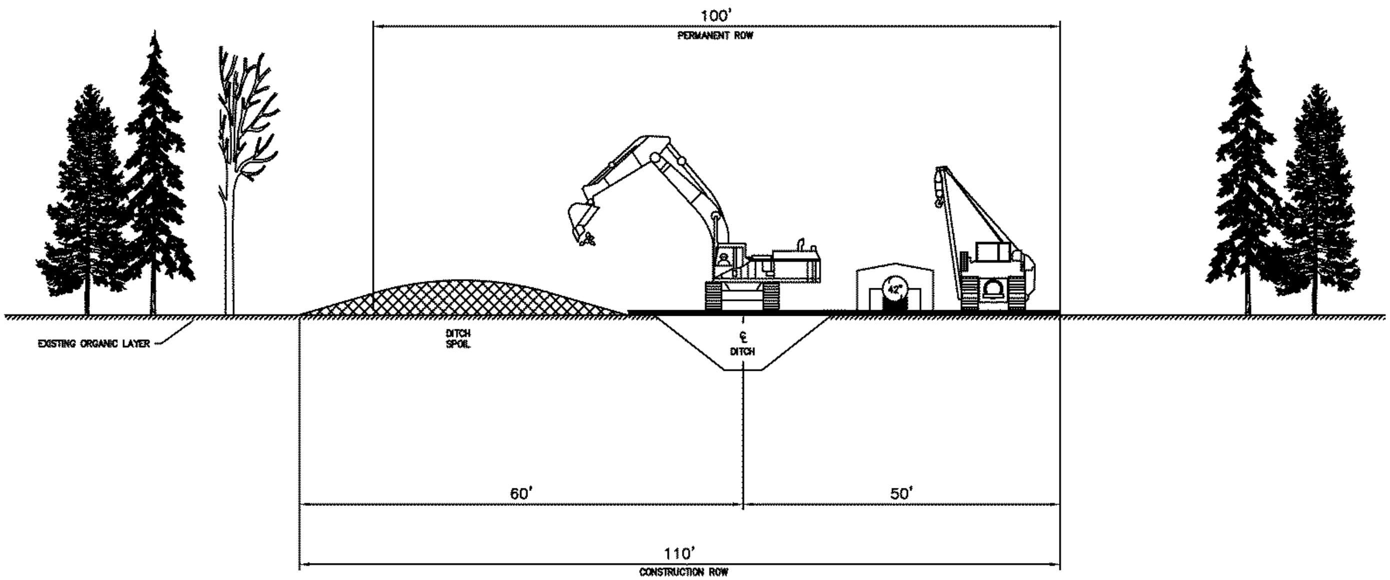
NOT FOR CONSTRUCTION

ROW-02

ALASKA LNG PIPELINE PROJECT

Right-of-Way Modes – Winter Frost Packed

Rev. 0



NOTES:

1. WHERE REQUIRED, 20 FEET MORE FOR TRAVEL LANE ON WORKING SIDE.
2. WHERE REQUIRED, 15 FEET MORE FOR BYPASS LANE ON SPOIL SIDE.
3. MATS WILL BE TRADITIONAL PIPELINE WETLAND MATS (HARDWOOD OR COMPOSITE).
4. MATS WILL BE USED ONLY AT SITE SPECIFIC LOCATIONS WHERE SATURATED WETLANDS PREVENT CONSTRUCTION EQUIPMENT FROM WORKING ON THE ROW.

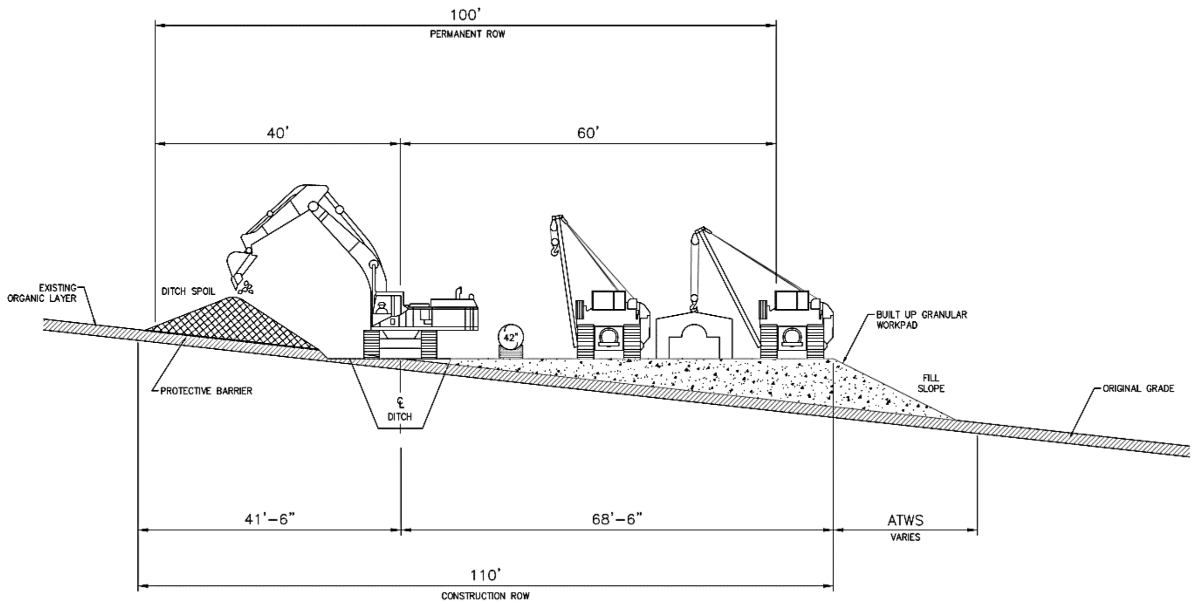
NOT FOR CONSTRUCTION

ROW–03

ALASKA LNG PIPELINE PROJECT

Right–of–Way Modes – Matted Summer Wetlands

Rev. 0



NOTES:

1. GEOTEXTILE AND GEOGRID REINFORCEMENT MAY BE PLACED AT BASE OF BUILT-UP WORK PAD.
2. NOMINAL CONFIGURATION FOR MAXIMUM OF 10% CROSS SLOPE.
3. WHERE REQUIRED, 20 FEET MORE FOR TRAVEL LANE ON WORKING SIDE.
4. WHERE REQUIRED, 15 FEET MORE FOR BYPASS LANE ON SPOIL SIDE.
5. ATWS FOR FILL SLOPES WHERE REQUIRED.

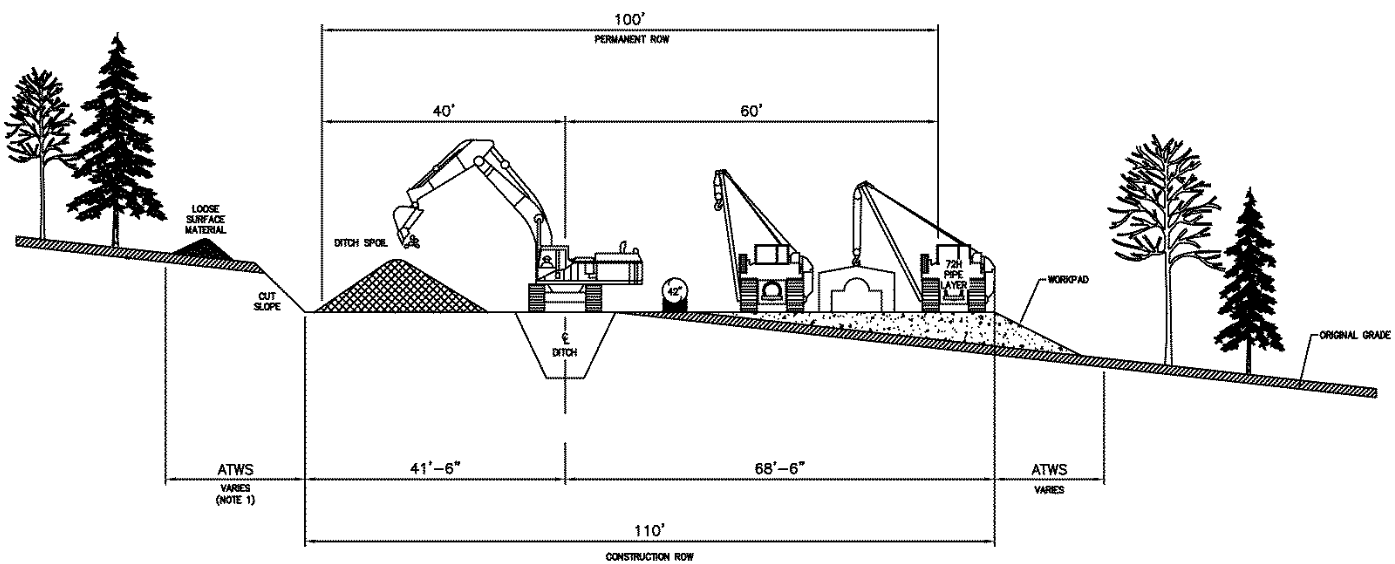
NOT FOR CONSTRUCTION

ROW-04

ALASKA LNG PIPELINE PROJECT

Right-of-Way Modes – Granular Work Pad Over Thaw Sensitive Permafrost (Winter & Summer)

Rev. 0



NOTES:

1. WHERE REQUIRED, 20 FEET MORE FOR TRAVEL LANE ON WORKING SIDE.
2. WHERE REQUIRED, 15 FEET MORE FOR BYPASS LANE ON SPOIL SIDE.
3. ATWS FOR LOOSE SURFACE MATERIAL FROM GRADED CUT WILL BE STORED ON TOP OF CUT SLOPE WHERE REQUIRED.

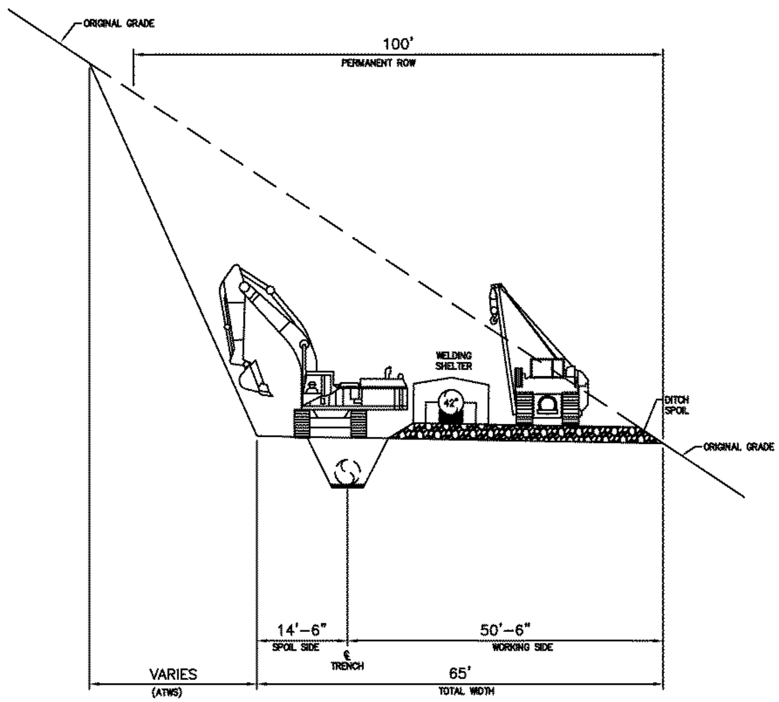
NOT FOR CONSTRUCTION

ROW–05A

ALASKA LNG PIPELINE PROJECT

Right–of–Way Modes – Graded Cross Slopes (Winter or Summer)

Rev. 0



NOT FOR CONSTRUCTION

NOTES:

1. ROW CUT MATERIAL TO BE HAULED TO DISPOSAL AREA.
2. CUT SLOPE VARIES WITH TERRAIN AND COMPETENCY OF ROCK.

ROW-05B

ALASKA LNG PIPELINE PROJECT

Right-of-Way Modes – Mountain Graded Cut (Summer)

Rev. 0

Appendix B. Alaska Stand Alone Pipeline (ASAP) Project Revegetation Plan.