PEBBLE PROJECT
ENVIRONMENTAL BASELINE DOCUMENT
2004 through 2008

CHAPTER 29.
SOILS
Cook Inlet Drainages

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ACRONYMS AND ABBREVIATIONS

ESS	Exploratory Soil Survey of Alaska
mm	millimeter(s)
NRCS	Natural Resources Conservation Service
USDA	United States Department of Agriculture

29. SOILS

29.1. Soils—Cook Inlet

29.1.1. Introduction

The overall Pebble Project study area is divided into the Cook Inlet region which comprises 16 percent of the project study area, and the Bristol Bay region. A literature review and previous studies for the Cook Inlet region are discussed in this document. Review of existing data for the Bristol Bay region drainages is discussed in Chapter 5.

The Cook Inlet region is comprised of a transportation corridor study area (Figure 29-1). Minimal comprehensive soils work has been completed in the vicinity of the transportation corridor study area. The *Exploratory Soil Survey of Alaska* (ESS) was completed by the U.S. Department of Agriculture (USDA) Soil Conservation Service (now the USDA Natural Resources Conservation Service [NRCS]) about 40 years ago (Rieger et al., 1979). The ESS covers the entire Pebble Project area and is the only direct coverage available. A soil investigation had also been completed for Chisik Island (Clark and Ping, 1995). Chisik Island is in proximity to the Cook Inlet region and near the Pebble Project study area.

29.1.2. Study Objectives

The goal of the soil studies for the Cook Inlet region transportation corridor study area was to gain an understanding of the general types of soils that occur in the region. The objective of the soils program was to review historical soils data from the region to determine the typical and common soil types occurring in the study area.

29.1.3. Study Area

The soil study area within the Cook Inlet region is approximately 145,000 acres in size. The study area is on the eastern flanks of the Chigmit Mountains extending down to the shore of Cook Inlet (Figure 29-1).

The study area was glaciated during the Pleistocene and is in proximity to several active volcanoes in the Alaska Range. The fine textured soil layers that cover some of the landscapes is thought to be an admixture of glacial loess and volcanic ash. The nearest source of ash, Augustine Volcano, is an active stratovolcano on Augustine Island about 15 miles southeast of the study area.

29.1.4. Previous Studies

The entire Pebble Project study area is included in the ESS. The ESS is a product of the National Cooperative Soil Survey, an interagency program responsible for classifying and mapping the soils of the entire United States. The ESS is useful as a general soils map, but is not intended to be used for site-specific interpretations. The mapping scale used was necessarily very small (1:1,000,000, i.e., 1 inch is the equivalent of 15.8 miles). The small scale precludes the definition of soil details at the square-mile

scale or smaller, but the mapping provides an introduction to the types of soils and their variability across the project study area. Figure 29-1 and Table 29-1 show the two ESS map unit delineations that occur within the Cook Inlet region study area.

Soil map units can comprise areas of soils, soils and intermingled miscellaneous areas (non-soil, e.g., rock outcrop or ice), or miscellaneous areas alone. Small scale mapping commonly defines map units as associations that combine multiple associated soil types together. These associations may consist entirely of soil types or may be a grouping of soil types and associated miscellaneous areas. Miscellaneous areas may also stand alone as a map unit if the mapped area is almost entirely non-soil. One of the map units identified for the study area is a soil association and the other map unit is a miscellaneous area (Table 29-1).

The soil types within the soil association map unit are classified to the subgroup level, which is an intermediate level of detail in *Soil Taxonomy*, the United States soil taxonomic system (USDA NRCS, 1999).

The field work for the ESS was completed between 1967 and 1973. At that time, *Soil Taxonomy* included 10 soil orders, which is the highest categorical level. Two additional soil orders, Andisols and Gelisols, were added later. This addition to *Soil Taxonomy* affects the classification of some soil types described in the ESS that occur in the Pebble Project study areas.

Andisols are defined by the presence of andic soil properties within the upper 24 inches of soil. Andic soil properties result from volcanic ash or the products of weathered volcanic ash. The criteria for andic soil properties are presented in Appendix 29A. It is likely that the Andisols of this region may classify as more than one of 18 subgroups defined in *Keys to Soil Taxonomy, 10th Edition* (Soil Survey Staff, 2006). However, accurate classification to and within the Andisol order requires laboratory analyses.

Gelisols are soils that have permafrost within 40 inches of the soil surface and/or have gelic materials within 80 inches of the soil surface. The ESS did not map or describe soils with permafrost within the Cook Inlet region portion of the proposed transportation corridor.

A detailed soils investigation is available for Chisik Island, an area about 20 miles northeast of the Cook Inlet region study area (Clark and Ping, 1995).

29.1.5. Scope of Work

The scope of work for the Cook Inlet region soil study included the following:

- A literature review, including scientific journals, soil survey reports, and online sources, for data related to the study area and region.
- A review and summary of the ESS map unit descriptions in the project area.

Three Parameters Plus, Inc. conducted this work.

29.1.6. Methods

A review of library reference and/or search systems was conducted using key words, including volcanic ash, tephra, Andisols, Alaska, and other terms. The literature search generated lists of documents with data pertinent to the study area, and references were added to an in-house library.

29.2. Soil Map Units

The ESS recognized two soil map units in the Cook Inlet region study area. The map units are delineated on Figure 29-1 and are described below in decreasing order by the percentage of the study area they comprise (Figure 29-2):

- **IA11: Typic Cryandepts, very gravelly, hilly to steep and rough mountainous land association** (approximately 74,000 acres, 51 percent). This map unit consists of 55 percent Typic Cryandepts, 35 percent rough mountainous land, and 10 percent riverwash. The map unit occurs primarily east of Iniskin Bay. The Typic Cryandepts soils form in materials containing volcanic ash, are well drained, are strongly acidic, and have a thin surface mat of partly decomposed plant litter mixed with volcanic ash.
- **RM1: Rough mountainous land** (approximately 71,000 acres, 49 percent). This map unit consists of sparsely vegetated, steep rocky slopes on the western side of Iniskin Bay. The sparsely vegetated soils are thin, overlying bedrock or stones/boulders. Thicker vegetation and deeper soils may be present on lower slopes and in valleys.

29.3. Results and Discussion

The 1979 ESS summarized one major soil type that occurred in one or both of the two soil map units delineated over the Cook Inlet region study area. These summaries are based on descriptions of representative pedons. The source pedons for the summaries were not necessarily located within the Pebble Project study area.

- **Typic Cryandepts** are soils in which less than half of the soil between depths of 10 and 40 inches (25 and 100 centimeters) exhibits thixotropic properties. They generally are dark reddish brown or dark brown. Some are made up mostly of ash grains of sand or cinder size. Others consist of fine thixotropic ashy material that is fairly thin over other material.

Soil Taxonomy is periodically updated and expanded; therefore, terminology used in 1979 may not still be in use in the current classification system. The soil descriptions and laboratory data presented in the ESS survey were used to determine how the 1979 soil classifications for the study areas would translate to the 2006 classification system (Soil Survey Staff, 2006). Table 29-2 matches the 1979 ESS taxonomic classification with a current equivalent.

29.4. Summary

A thorough literature review revealed two existing soil studies that covered or were near the Pebble Project transportation corridor study area in the Cook Inlet Region. These studies, the ESS and the soil

investigation of Chisik Island, represent the only previously published soils information for the study area in this region.

The two existing publications indicate that many of the soils in the study area are influenced to some degree by volcanic ash within the parent materials. The ESS classifies the dominant soils of the area as Typic Cryandepts and describes their ash-influenced, or andic, properties. The Chisik Island soil investigation describes similar soils, although the soil classifications reflect the version of *Soil Taxonomy* current at the time of that publication.

29.5. References

American Geological Institute. 2008. Glossary of Geology. http://www.agiweb.org/pubs/glossary/ (November 23, 2010).

Clark, M. H., and C. L. Ping. 1995. Soil Survey Investigation. Chisik Island Tuxedni Wilderness Area Alaska.

Rieger, S., D.B. Schoephorster, and C. E. Furbush. 1979. Exploratory Soil Survey of Alaska. USDA-SCS. Washington, D.C.: U.S. Government Printing Office.

Soil Survey Staff. 2006. Keys to Soil Taxonomy, 10th Edition. USDA NRCS. Washington, D.C.: U.S. Government Printing Office.

_____. 1993. Soil survey manual. USDA-NRCS. U.S. Department of Agriculture Handbook 18(rev.), Washington, D.C.: U.S. Government Printing Office.

USDA-Natural Resources Conservation Service. 1999. Soil Taxonomy. A Basic System of Soil Classification for Making and Interpreting Soil Surveys. 2nd ed. AH 436, Washington, DC.

29.6. Glossary

Andic soil properties—soil material of volcanic origin. These properties include organic carbon content, bulk density, phosphate retention, and iron and aluminum extractable with ammonium oxalate; containing a significant content of volcanic glass in the fine-earth fraction (<2 millimeters [mm]).

Andisols—one of the 12 orders of soil taxonomy (the broadest level of soil classification). These include soils that are strongly influenced by volcanic ash. Andic soils have distinct properties including low organic carbon content, low bulk density, phosphate retention, ammonium oxalate extractable iron and aluminum, and significant content of volcanic glass in the fine-earth fraction (<2 mm).

Ash [volcanic]—fine material (under 2.0 mm diameter; under 0.063 mm diameter for fine ash) blown from a volcanic vent, usually referring to the unconsolidated material but sometimes also used to refer to its consolidated counterpart, tuff.

Gelic materials—mineral or organic soil materials that have evidence of cryoturbation (frost churning) and/or ice segregation in the active layer (seasonal thaw layer) and/or the upper part of the permafrost.

Gelisols—one of the twelve orders of soil taxonomy (the broadest level of soil classification). The unique property of Gelisols is the presence of permafrost and soil features and properties associated with freezing and thawing. These features include irregular or broken horizons and incorporation of organic materials in the lower horizons, especially along the top of the permafrost table. Freezing and thawing produce granular, platy, and vesicular structures in surface and subsurface horizons.

Horizons—a specific layer or stratum of soil or subsoil in a vertical cross section of land. Horizons are designated and subdivided on the basis of color, texture, structure, and the observation of soil-forming properties. Primary horizon designations are O, A, E, B, and C horizons:

- O horizon: layers dominated by organic material.
- A horizon: mineral soil layer at soil surface or below O horizon having an accumulation of organic matter.
- E horizon: mineral soil layer characterized by loss of clay, iron, and\or aluminum in some combination, leaving a combination of sand and silt particles.
- B horizon: mineral soil layer characterized by any of the following: pedogenic structure; accumulation of iron, aluminum, or humus; reddish colors due to pedogenic processes.
- C horizon: subsurface layers showing little affect by pedogenic processes.

Inceptisols—one of the 12 orders of soil taxonomy (the broadest level of soil classification). These include soils that are moderately well developed and are transitioning toward other soil orders.

Loess—a widespread, homogeneous, commonly nonstratified, porous, friable, slightly coherent, fine-grained blanket deposit), consisting predominantly of silt with secondary grain sizes ranging from clay to fine sand.

Pedogenic—related to the formation and development of soil.

Pedon—a three-dimensional body of soil with lateral dimensions large enough to permit the study of horizon shapes and relations. Its area ranges from 1 to 10 square meters.

Pyroclastic—fragmented rock material formed by a volcanic explosion or ejection from a volcanic vent.

Stratovolcano—a volcano that is constructed of alternating layers of lava and pyroclastic deposits, along with abundant dikes and sills. Viscous, acidic lava may flow from fissures radiating from a central vent, from which pyroclastics are ejected.

Tephra—materials of all types and sizes that are erupted from a crater or volcanic vent and deposited from the air.

Thixotropic—subject to loss of structural support upon movement due to positive pore pressures.

Typic Cryandepts—(obsolete) subgroup level of soil taxonomy, and belonging to the Inceptisols soil order. Typic Cryandepts are cold, moderately well developed soils strongly influenced by volcanic ash.

Sources for glossary: American Geological Institute, 2008; Soil Survey Staff, 1993; and USDA NRCS, 1999.

TABLES

TABLE 29-1
Map Units for the Cook Inlet Region Study Area as Defined in the ESS

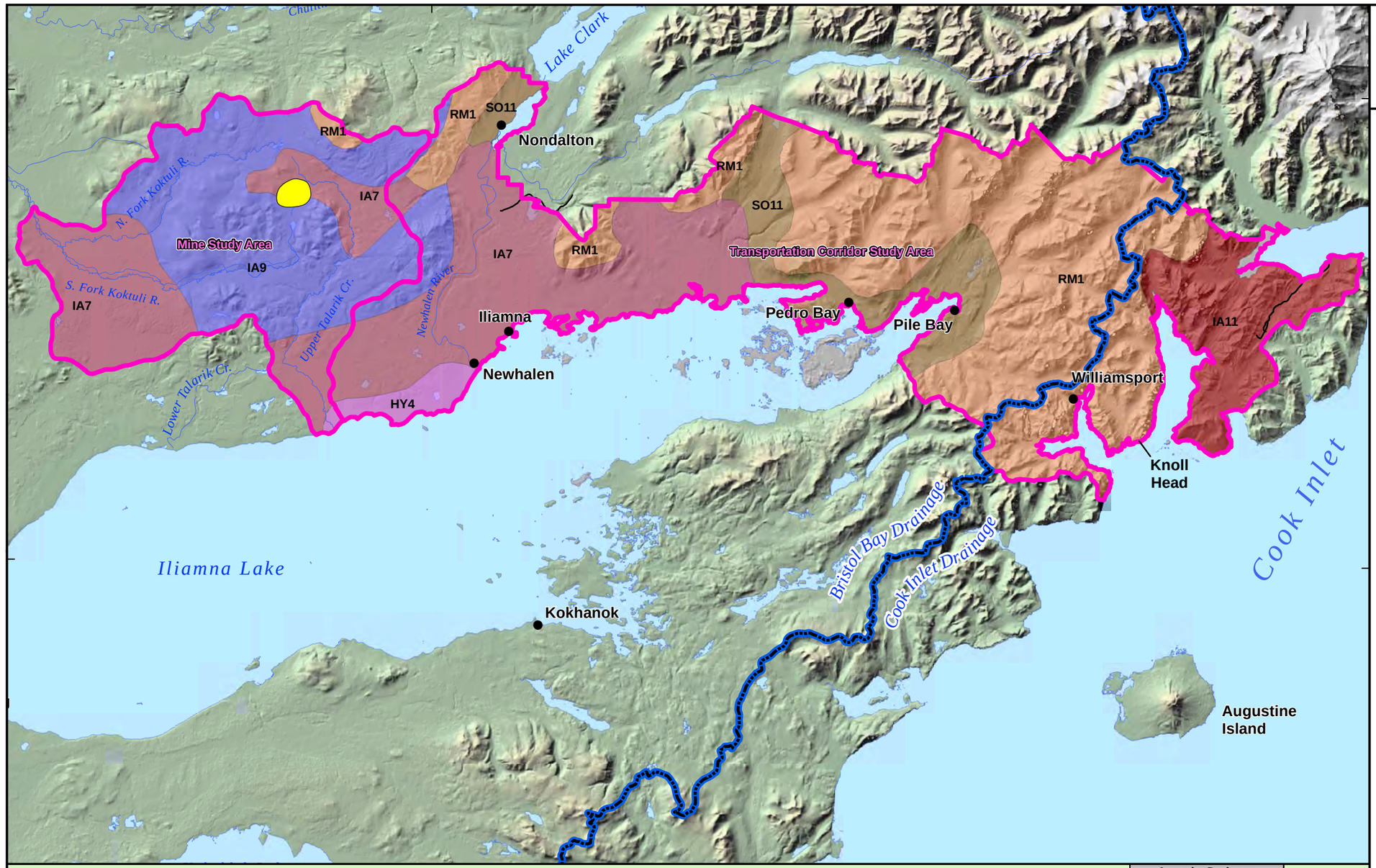
Map Unit Code	Map Unit Name	Total Acreage in Project Vicinity (% of total)
IA11	Typic Cryandepts, very gravelly, hilly to steep – Rough mountainous land association	74,000 (51%)
RM1	Rough mountainous land	71,000 (49%)

Source: USDA SCS, 1979.

TABLE 29-2
Corresponding 1979 and 2006 Classifications for Pedons as Described in the ESS

ESS Map Units	1979 Classification *(ESS pedons)*	2006 Classification *(ESS pedons)*
IA11	Typic Cryandepts	Typic Haplocryands, Typic Vitricryands

FIGURES



STUDY AREA	CODE	DESCRIPTION	LAND FORM	Acres by Drainage		Total Acres
				Bristol Bay	Cook Inlet	
Mine Study Area	HY4	Pergelic Cryofibrists, nearly level association.	Broad, nearly level, wet lowland neat large lakes and coastal areas.	1,251		1,251
	IA7	Typic Cryandepts, very gravelly, nearly level to rolling-Pergelic Cryofibrists, nearly level association.	Rolling plains bordering Iliamna Lake. Inactive and active stream channels, uplifted beaches, hilly terminal moraines, and glacial outwash plains.	105,227		105,227
	IA9	Typic Cryandepts, very gravelly, hilly to steep association	Low rounded mountains, moraine-covered mountain foot slopes and foothills.	154,723		154,723
	RM1	Rough mountainous land	Steep rocky slopes, ice fields, and glaciers.	3,463		3,463
Transportation Corridor Study Area	HY4	Pergelic Cryofibrists, nearly level association.	Broad, nearly level, wet lowland neat large lakes and coastal areas.	14,384		14,384
	IA11	Typic Cryandepts, very gravelly, hilly to steep-Rough mountainous land association.	Steep mountainous areas, dissected by streams and braided rivers, glacier fed.		73,944	73,944
	IA7	Typic Cryandepts, very gravelly, nearly level to rolling-Pergelic Cryofibrists, nearly level association.	Rolling plains bordering Iliamna Lake. Inactive and active stream channels, uplifted beaches, hilly terminal moraines, and glacial outwash plains.	155,145		155,145
	IA9	Typic Cryandepts, very gravelly, hilly to steep association	Low rounded mountains, moraine-covered mountain foot slopes and foothills.	17,981		17,981
	RM1	Rough mountainous land	Steep rocky slopes, ice fields, and glaciers.	248,146	71,380	319,526
	SO11	Humic Cryorthods, very gravelly, hilly to steep-Pergelic Cryofibrists, nearly level association.	Mountain foot slopes and moraine hills, small streams, sloping valleys, and nearly level muskegs.	72,458		72,458
Grand Total				772,777	145,324	**918,101**

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Figure 29.1-1
Bristol Bay and Cook Inlet Drainages Exploratory Soil Survey

Legend

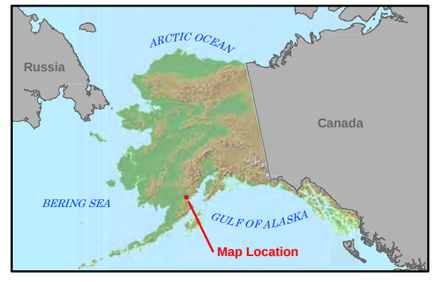
- General Deposit Location
- Bristol Bay/Cook Inlet Drainage Divide
- Study Areas

Soil Types

- HY4 - Pergelic Cryofibrists, nearly level
- IA11 - Typic Cryandepts, very gravelly, hilly to steep-rough mountainous land association.
- IA7 - Cryandepts, very gravelly, nearly level to rolling-Pergelic Cryofibrists, nearly level.
- IA9 - Typic Cryandepts, very gravelly, hilly to steep association
- RM1 - Rough mountainous land
- SO11 - Humic Cryorthods, very gravelly, hilly to steep-Pergelic Cryofibrists, nearly level association.

NOTES:
Based on *Exploratory Soil Survey of Alaska*, Sheet Number 19 (USDA SCS, 1979). The map is a broad-based inventory of soils and nonsoil areas that occur in a repeatable pattern on the landscape and that can be cartographically shown at the 1:1,000,000 scale.

These data compiled in 1971 by the U.S Department of Agriculture, Soil Conservation Service, and coorperating agencies.



Miles 0 5 10 15 20

Kilometers 0 7 14 21 28 35

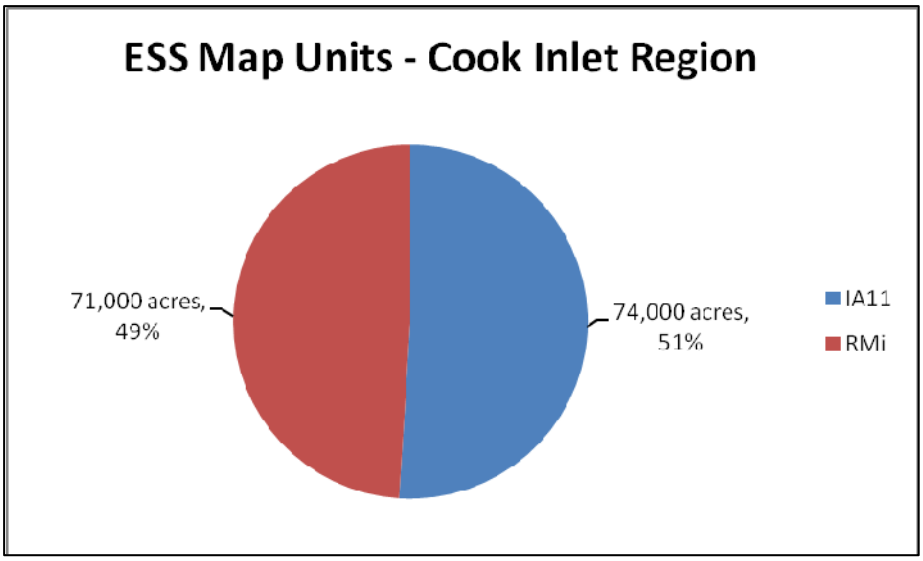
Scale 1:510,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

N

File: RDI_ND_NRCS_BB-Fig29-1_11X17L_1of1_D03.mxd	Date: December 27, 2010
Version: 3	Author: RDI-DWR, LS

FIGURE 29-2
ESS Map Units, Cook Inlet Region



Map Unit Code	Map Unit Name
IA11	Typic Cryandepts, very gravelly, hilly to steep - Rough mountainous land association
RM1	Rough mountainous land

Source: Rieger et al.,1979.

APPENDICES

APPENDIX 29A
Required Characteristics for Andic Soil Properties

Soil materials with andic soil properties must have a fine earth fraction that meets the following requirements:

- Less than 25 percent organic carbon (by weight) and one or both of the following:
- All of the following:
  - Bulk density, measured at 33 kilopascals water retention, of 0.90 grams per cubic centimeter or less; and
  - Phosphate retention of 85 percent or more; and
  - Al + ½ Fe content (by ammonium oxalate) equal to 2.0 percent or more; or
- All of the following:
  - Thirty percent or more of the fine-earth fraction is 0.02 to 2.0 mm in size; and
  - Phosphate retention of 25 percent or more; and
  - Al + ½ Fe content (by ammonium oxalate) equal to 0.4 percent or more; and
  - Volcanic glass content of 5 percent or more; and
  - [(Al + ½ Fe content, percent) times (15.625)] + [volcanic glass content, percent] = 36.25 or more.