PEBBLE PROJECT
ENVIRONMENTAL BASELINE DOCUMENT
2004 through 2008

CHAPTER 27.
GEOLOGY AND MINERALIZATION
Cook Inlet Drainages

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27. GEOLOGY AND MINERALIZATION

27.1 Introduction

This chapter discusses the baseline geology characteristics for the Cook Inlet drainages study area. The discussion has been based largely on reviews of the following existing information and materials.

- *Bathymetric and Geophysical Survey—Iniskin Bay, Alaska* (Golder Associates Inc., 2005).
- *Possible Mine Access Road—Desk Study Review* (Knight Piésold Ltd., 2006).
- *Dredge Slopes in Iliamna Bay near Williamsport, Alaska* (Golder Associates Inc., 1995).
- *Navigation Channel Feasibility Report and Environmental Assessment, Williamsport, Alaska* (U.S. Army Corps of Engineers (USACE), 1995).
- *Surficial Geology of the Iliamna Quadrangle, Alaska* (Detterman and Reed, 1973).

The geology discussion in this chapter includes bedrock and surficial geology, geologic structure, and deposit types.

27.2 Study Objectives

The objective of the geology study in the Cook Inlet drainages was to provide baseline information to characterize the geology in the Cook Inlet drainages study area.

27.3 Study Area

The Cook Inlet drainages study area is in the southern part of the Alaska Range physiographic division. The study area is bounded on the west by the boundary between the Bristol Bay and Cook Inlet drainages and on the east by the mountains of the Iniskin Peninsula, upstream of Oil Bay (Figure 27-1). The study area is bounded on the north by Lake Clark National Park and extends south far enough to include the drainages into Iliamna Bay. The study area includes the eastern slopes of the Chigmit Mountains and all drainages into Iniskin Bay.

27.4 Scope of Work

Generally, this environmental baseline document presents baseline information collected during 2004 through 2008; however, no geologic baseline data were collected for the Cook Inlet drainages study area during that period. The information discussed is this chapter was obtained through desktop studies and reviews of published information.

27.5 Methods

As described below, the information presented in this chapter is based on reviews of published information and a previous offshore site investigation program conducted near Williamsport by the U.S. Army Corps of Engineers and on an assessment of the surficial geology along the possible transportation corridor in the Cook Inlet drainages based on geological mapping and infrared imagery.

27.5.1 Knoll Head and Iniskin Bay

A preliminary evaluation of the baseline geological conditions around Knoll Head on Iniskin Bay was based on a review of a geophysical investigation report on the channel through Iniskin Bay (Golder Associates Inc., 2005). Side-scan sonar and seismic reflection surveys were used to determine the surficial geology of the bay floor, to identify bedrock outcrops, and to help characterize the surficial marine sediments. Seismic reflection systems were used to estimate the thickness of unconsolidated, fine-grained sediments and medium to coarse-grained sediments and the depth to bedrock. The thickness of unconsolidated fine-grained sediments was estimated from data acquired with a wide-bandwidth (2 to 10 kilohertz) sub-bottom profiler. This system can measure subsurface depths up to approximately 15 feet in fine-grained sediments. The thickness of unconsolidated medium to coarse-grained sediment was estimated from a low-frequency seismic reflection system that can measure subsurface depths up to 35 feet in unconsolidated sediments.

27.5.2 Williamsport and Iliamna Bay

A preliminary evaluation of the geological conditions for Williamsport and for Iliamna Bay was based on a review of a 1995 offshore site-investigation report by the U.S. Army Corps of Engineers. This USACE site-investigation program involved the collection of geological data primarily from drillholes and geophysical surveys in Iniskin and Iliamna bays. The investigation included five drillholes drilled in the Williams Creek Arm of Iliamna Bay to depths of 11 to 23 feet using a hollow-stem auger. The drillhole locations are shown as AP-1 through AP-5 on Figure 27-2. There is an existing marine dock located at drillhole AP-1 (USACE, 1995).

27.5.3 Williamsport - Pile Bay Road

A preliminary assessment of the geological materials likely to be encountered along the Williamsport – Pile Bay road was completed by examining a 1:250,000-scale geological map for the study area (Detterman and Reed, 1973), using aerial photo interpretation (API) of orthophotos produced by Aeromap U.S. in 2005, and through interpretation of infrared imagery, where available.

27.6 Results and Discussion

27.6.1 Surficial Geology

Examination of U.S. Geological Survey mapping indicates that the geology of the study area consists of predominantly exposed bedrock from the shoreline to the ridge tops, with scattered talus deposits on the slopes. There are scattered moraine deposits on the upper slopes from Pleistocene glaciation and Holocene glaciers. Mass movement deposits of talus and rubble are scattered on the exposed bedrock of

the upper slopes. Holocene alluvial deposits are located in the valley that runs through the peninsula between Iliamna Bay and Iniskin Bay. The northernmost shoreline of Iliamna Bay and the western shoreline of Iniskin Bay have Holocene estuarine silt deposits in the tidal flat area, where bedrock does not make up the shoreline (Detterman and Reed, 1973). The surficial deposits of the study area are shown on Figure 27.3.

27.6.1.1 Knoll Head and Iniskin Bay

Geophysical measurements of the surface and subsurface materials in Iniskin Bay in 2005 indicated that the unconsolidated layer of sediments increased in thickness from the shoreline to the main channel. Coarse-grained sediment with cobbles and boulders mantled the shoreline. Glacial till deposits are located in the Y Valley on the peninsula. Sediment in the main channel was interpreted to be medium- to fine-grained. The measured thickness of unconsolidated sediment ranged from 30 to 35 feet in the main channel and from 10 to 15 feet along the shoreline; however, the depth to bedrock may be deeper because the maximum range of measurement of the side-scan sonar survey was 15 feet in unconsolidated, fine-grained sediments and 35 feet in unconsolidated, coarser sediments. There was no evidence of rock outcrops on the bay floor (Golder Associates Inc., 2005).

27.6.1.2 Williamsport and Iliamna Bay

Geophysical measurements and samples of the surficial and subsurface materials taken by the U.S. Army Corps of Engineers at Williamsport and in Iliamna Bay in 1995 indicate that the depth to bedrock ranged from approximately 130 to 200 feet in the tidal flat area and was mainly overlain by fine-grained sediments. The depth to bedrock in the vicinity of the existing dock at Williamsport was shallower, ranging from approximately 65 to 130 feet (USACE, 1995).

Soil sampling in Iliamna Bay in 1995 indicated that the tidal deposits consisted primarily of fine-grained sediments (clays, silts, and fine sands) and were black in color, indicating the presence of organic matter. These tidal deposits also contained coarse-grained angular gravel, as well as occasional cobbles and boulders. The existing tidelands had scattered large boulders protruding from the tidal flats and also had higher gravel content closer to the existing dock structure on the northwestern shoreline of Iliamna Bay. A gravelly subgrade was exposed along the natural tidal-drainage channels (USACE, 1995). The coastline of Iliamna Bay consists of weathered bedrock and talus deposits.

27.6.1.3 Williamsport – Pile Bay Road

A brief inspection of the available aerial photographs was conducted of the existing road between Pile Bay and Williamsport; it was noted that the surficial geology along this road is composed of predominantly lake-terrace deposits and alluvium, with some weathered bedrock and talus deposits at the base of the valley slopes. Weathered bedrock and talus become the predominant deposits encountered at the coastline.

27.6.2 Bedrock Geology

The exposed bedrock that makes up the rugged mountains along the Cook Inlet shoreline is predominantly gently dipping Middle and Late Jurassic sedimentary rocks, including greywacke, sandstone, conglomerate, siltstone, arkose, and shale. The sedimentary rocks are marine in origin and

contain numerous fossils. These rocks are part of the Tuxedni Group and the Chinitna and Naknek Formations (Detterman and Reed, 1973).

27.7 Summary

The area surrounding Iliamna and Iniskin bays is situated in steep terrain with exposed bedrock from the shorelines to the ridge tops. The bedrock is predominantly Middle and Late Jurassic sedimentary rock of marine origin. The valley bottoms are infilled with alluvial deposits, and talus deposits are encountered at the base of the valley slopes. The Iliamna Bay inlet and parts of the western shoreline of Iniskin Bay have thick deposits of estuarine silts below steep cliffs of weathered bedrock and talus deposits.

The marine channels through Iliamna Bay and Iniskin Bay have a mantle of unconsolidated, fine-grained sediment. The particle size typically decreases as water depth and distance from the shoreline increase. Coarse-grained sediments with cobbles and boulders were observed along the shorelines of both Iliamna Bay and Iniskin Bay.

27.8 References

Detterman, R.L., and B.L. Reed. 1973. Surficial Geology of the Iliamna Quadrangle, Alaska. U.S. Department of the Interior, Geological Survey Bulletin # 1368-A. (Map reproduced with permission.)

Golder Associates Inc. 2005. Bathymetric and Geophysical Survey—Iniskin Bay, Alaska. Ref. No. 053-5727. August.

———. 1995. Dredge Slopes in Iliamna Bay near Williamsport, Alaska. August.

Knight Piésold Ltd. 2006. Possible Mine Access Road—Desk Study Review. Pebble Project Draft Document. September 21.

U.S. Army Corps of Engineers (USACE). 1995. Navigation Channel Feasibility Report and Environmental Assessment, Williamsport, Alaska. Anchorage, Alaska. December. (Map reproduced with permission.)

27.9 Glossary

Alluvial deposits—sediment and detritus transported by a stream or river and deposited as the river floodplain.

Arkose—a rock containing quartz and 25 percent or more of feldspar.

Clast—fragment of sediment or rock that was formed by the deterioration of larger rocks.

Conglomerate—coarse-grained rock with rounded clasts that are greater than 2 millimeters in size.

Estuarine—relating to a semi-enclosed coastal body of water which has a free connection with the open sea and where freshwater, derived from land drainage, is mixed with seawater as a result of tidal action.

Glacial till—collective term for the group of sediments laid down by the direct action of glacial ice without the intervention of water.

Glaciofluvial deposits—material transported and deposited by meltwater streams flowing from glaciers.

Greywacke—texturally and mineralogically immature sandstones that contain more than 15 percent clay minerals.

Hollow-stem auger—an auger used for drilling in sediments, the center of which is hollow and allows for sediment sampling and well installation without borehole collapse.

Holocene—epoch that covers the last 10,000 years, often referred to as Recent or post-glacial.

Jurassic—from 208 to 145.6 million years ago, the Mesozoic period following the Triassic and preceding the Cretaceous.

Lacustrine deposits—material deposited by or settled out of lake waters and exposed by the lowering of water levels or the elevation of land.

Mass movement deposits—bulk movements of soil and rock debris down slopes in response to the pull of gravity.

Moraine—an accumulation of material that has been transported on the surface of ice, within ice, or beneath ice.

Orthophoto—(also orthophotograph) an aerial photograph geometrically corrected such that the scale is uniform and the photo has the same lack of distortion as a map.

Pleistocene—from 1.64 million years ago to about 10,000 years ago, the first of two epochs of the Quaternary sub-era.

Seismic reflection—a type of seismic survey that measures the rebounding of seismic waves from an interface between two media with different densities to estimate the location of subsurface features.

Shale—fine-grained, fissile, sedimentary rock composed of clay and silt-sized particles of unspecified mineral composition.

Side-scan sonar—a sideways-looking acoustic system that uses the reflection of high-frequency sound waves by a surface to map the texture of that surface. It is most commonly used to map features of the sea floor, but it also can be used to investigate vertical surfaces.

Talus—a sloping mass of coarse rock fragments and debris accumulated at the base of a cliff or slope.

Tidal flat—a sand flat, mud flat, or marshy area that is alternately covered and uncovered by the tide.

FIGURES

1,600,000 1,700,000 1,800,000

2,200,000

2,100,000

Lake Clark National Park and Preserve

Lake Clark National Park and Preserve

Mt. Iliamna

Pedro Bay

Pile Bay

Williamsport

Iliamna Lake

Iliamna Bay

Iniskin Bay

Knoll Head

Oil Bay

Iniskin Peninsula

Cook Inlet

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Figure 27-1
Geology Study Area
Cook Inlet Drainages

Legend

- Study Area Boundary
- National Park and Preserve Boundary
- BB / CI Drainages Boundary
- Existing Roads
- Population Centers

Notes

1. BB/CI refers to Bristol Bay/Cook Inlet drainages.

0 5 10 15 Miles

0 5 10 15 20 Kilometers

Scale 1:300,000

N

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

File: B27_r0.mxd	Date: August 16, 2010
Version: 2008-1	Author: Knight Piesold Ltd.

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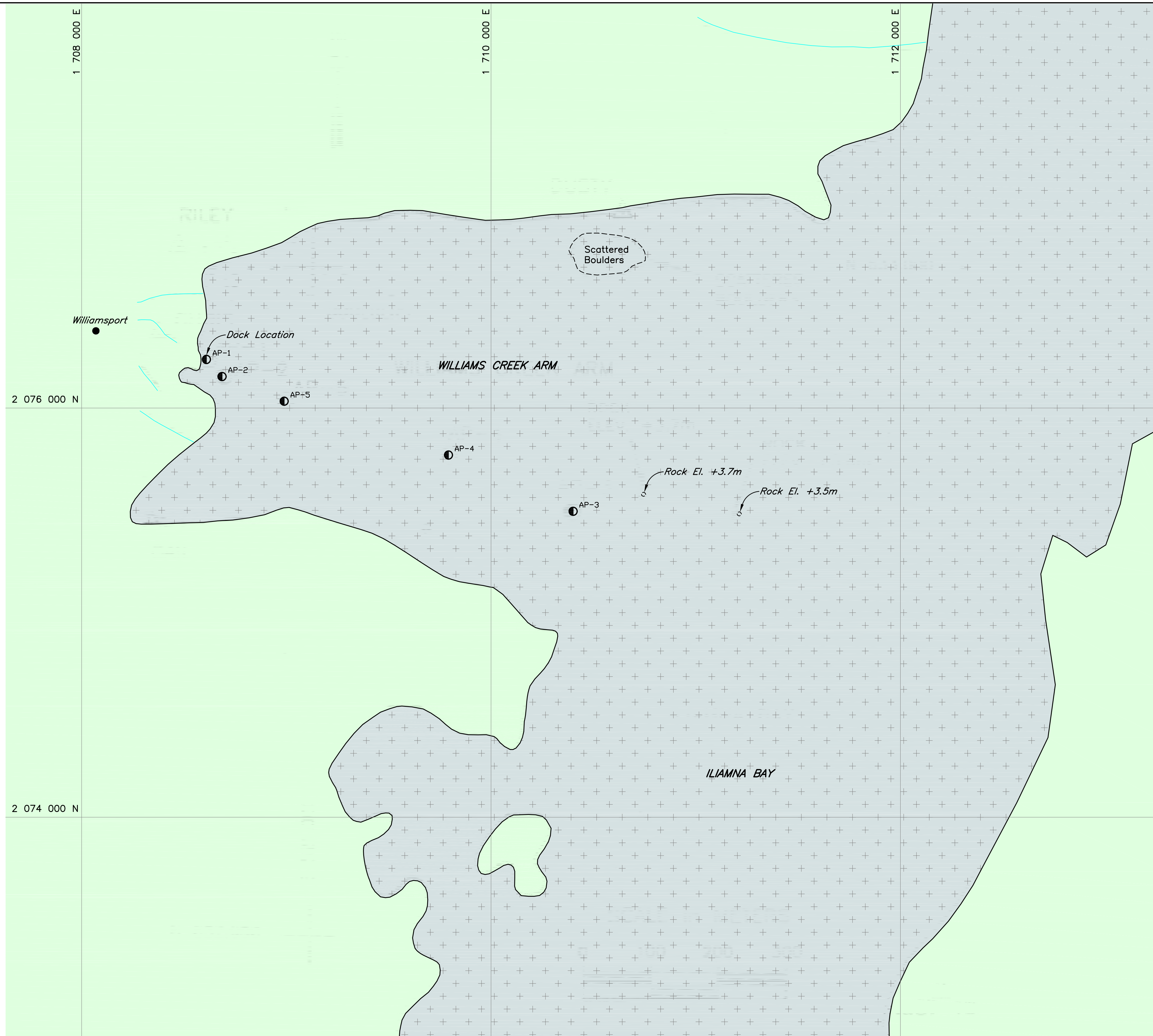

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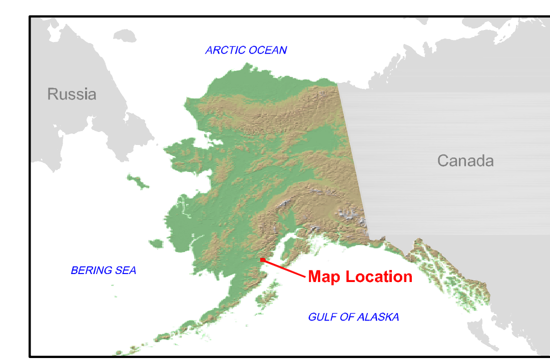
Figure 27-2
Geology Study
1995 Drillhole Locations
U.S. Army Corps Of Engineers
Williamsport and Iliamna Bay

Legend

◐ AP-1 Offshore Drillholes

● Community

Source: USACE, 1995.



Meters: 50 0 50 100 150 200 250

Feet: 250 0 250 500 750

N

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

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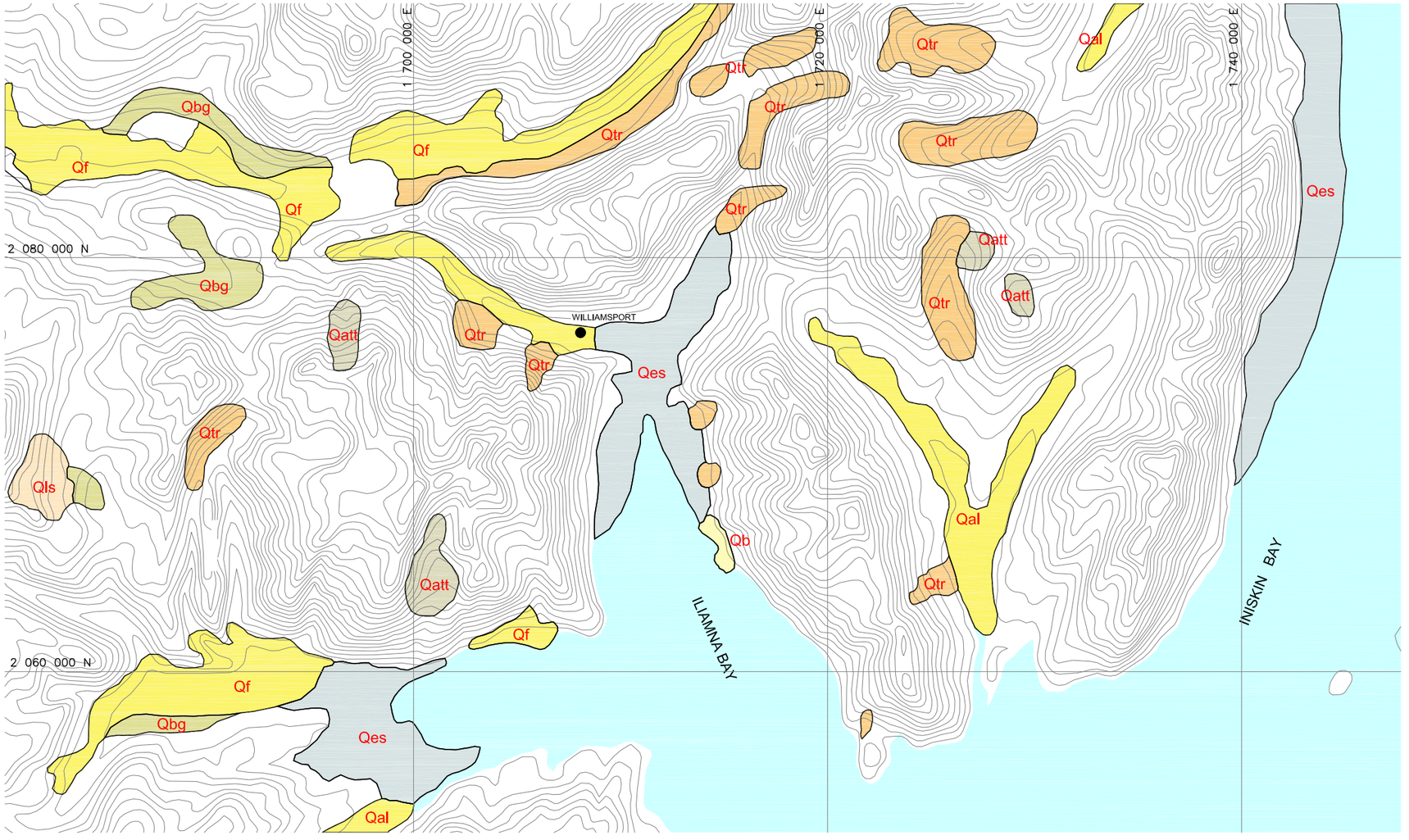

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Figure 27-3
Surficial Geology
Cook Inlet Drainages

Legend

GLACIAL DEPOSITS

Qatt Moraine of the Tustumena Stade

Qbg Ground Moraine

GLACIOFLUVIAL AND ALLUVIAL DEPOSITS:

Qal Flood-plain Alluvium

Qf Alluvial Fans and Cones

ESTUARINE AND LACUSTRINE DEPOSITS:

Qes Estuarine Silt

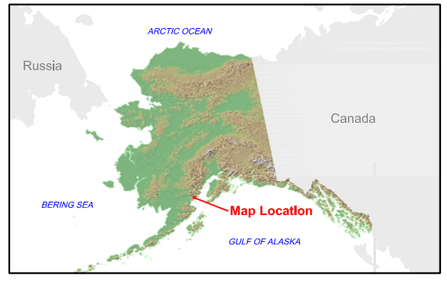
Qb Beach Deposits

MASS MOVEMENT DEPOSITS:

Qtr Talus and Rubble Deposits

Qls Landslide Deposits

Source: Detterman and Reed, 1973.



Kilometers 1 0 1 2 3

Miles 0.5 0 1 2

N

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

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Version: 2008-1	Author: Knight Piesold Ltd.