ATTACHMENT M: R&M GEOTECHNICAL INVESTIGATIONS REPORT

FINAL SUBMITTAL

GEOTECHNICAL INVESTIGATION AND SITE CONDITIONS REPORT

KENAI RIVER BLUFF EROSION

KENAI, ALASKA

CONTRACT NO. W911KB-05-D-0004
DELIVERY ORDER NO. 0010
MODIFICATION NO. 01

Prepared for:

U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. Box 6898
Elmendorf AFB, Alaska 99506

February, 2007

R&M CONSULTANTS, INC.

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February 14, 2007 R&M No. 1209.10

U.S. Army Engineer District, Alaska
ATTN: Mr. Chuck Wilson (CEPOA-EN-ES-SG)
P.O. Box 6898
Elmendorf AFB, Alaska 99506

RE: Geotechnical Investigation and Site Conditions Report
Kenai River Bluff Erosion
Kenai, Alaska
Contract No. W911KB-05-D-0004, Delivery Order No. 0010, Modification No. 01

Gentlemen:

Attached find our final report for the above-referenced geotechnical investigation. This report was prepared under the terms of Contract No. W911KB-05-D-0004, Delivery Order No. 0010, Modification No. 01. This final submittal includes the incorporation of your verbal review comments of February 6, and February 13, 2007.

We trust that this report is found to be responsive to your requirements. Should you have any questions or require further information, please contact us.

Very truly yours,

R&M CONSULTANTS, INC.

Charles H. Riddle, C.P.G.
Vice President

CHR*slv

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Attention:
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Prepared by:

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GEOTECHNICAL INVESTIGATION AND SITE CONDITIONS REPORT

KENAI RIVER BLUFF EROSION

KENAI, ALASKA

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GEOTECHNICAL INVESTIGATION AND SITE CONDITIONS REPORT

KENAI RIVER BLUFF EROSION

KENAI, ALASKA

1.0 INTRODUCTION

1.1 Background

For many years, the City of Kenai has been concerned with the ongoing erosion of a one mile portion of the steep bluff along the right bank of the Kenai River within the city. This erosion has required the relocation of privately owned buildings as well as city infrastructure and utilities. Unless measures to control the erosion and protect the bluff are implemented, bluff erosion is expected to continue, further threatening existing buildings, infrastructure, and utilities within proximity to the bluff.

The U.S. Army Corps of Engineers - Alaska District (USACE-AD) has conducted a geotechnical investigation to provide design-level information for the Kenai River Bluff Erosion Project. The geotechnical investigation provides site-specific geotechnical design information necessary to establish an erosion control method that is technically feasible and satisfies resource agency needs. The work consisted of drilling and logging test borings, installing groundwater monitoring wells, laboratory testing, and the preparation of various reports. Ultimately, the geotechnical data obtained will be used, in conjunction with other considerations, in developing the specifications and design criteria for the project. An area map is provided as Figure 1.

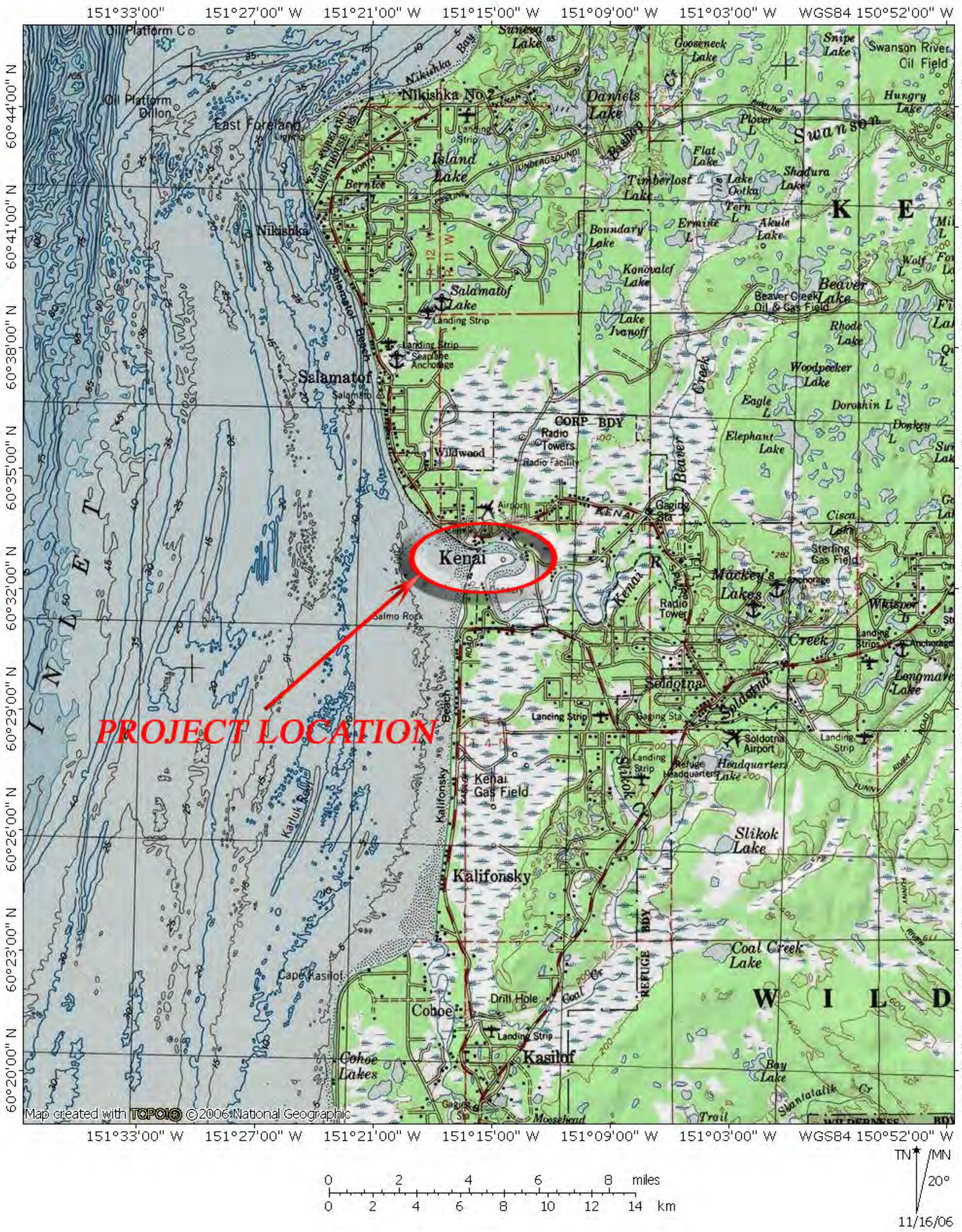
R&M Consultants, Inc. (R&M) has been tasked by the USACE-AD to provide professional geotechnical services for the project. Drilling, sampling, and groundwater monitoring well installation services were performed by Discovery Drilling, Inc. of Anchorage, Alaska under direct contract to R&M.

To gain a better understanding of the area and to formulate the scope-of-work needed for this exploration, a reconnaissance visit to the area was undertaken by personnel from the USACE-AD and R&M. As a result of the reconnaissance and previous meetings, two areas were selected for exploration. These are designated as the bluff crest and the bluff toe. General bluff conditions are discussed in R&M's prior geotechnical scope-of-work report (R&M, 2006). All test boring explorations along the bluff toe were performed in the Kenai River Habitat Protection Area and within 50 feet of the ordinary high water (OHW) zone, thus requiring special permits and minimal disturbance to the drill sites.

During the geotechnical field investigations, a total of 20 test borings were drilled and sampled at the project site. Fourteen (14) of these test borings were completed as groundwater monitoring wells. Soil samples have been subjected to a number of laboratory tests for the determination of

FIGURE 1

AREA MAP



soil classification and engineering properties useful in geotechnical/geohydrologic analysis and future civil design.

The site conditions presented herein are based on our current understanding of the project as outlined within this report and illustrated on the drawings in Appendix A. Any deviation from the proposed locations may necessitate further evaluation of subsurface conditions.

1.2 Contract Authorization

This work was completed under the terms of Contract No. W911KB-05-D-0004 between the U.S. Army Corps of Engineers – Alaska District and R&M Consultants, Inc. The geotechnical investigation and this report were completed in specific fulfillment of Delivery Order No. 0010, Modification No. 01.

Measurements and weights presented in this report are generally shown as U.S. customary units. Where previous investigations and reports have utilized SI units, we have retained the units expressed in the original document. A conversion chart is included as Table 1 for use in conversion from U.S. customary units to the International System (SI) units. Actual conversion should be made with the appropriate numbers carried to three or more significant figures.

1.3 Purpose and Scope-of-Work

The intent of this investigation has been to provide geotechnical information to evaluate the subsurface conditions for the analysis and design of a bluff stabilization project. Geotechnical investigations were performed in accordance with procedures outlined in "Geotechnical Investigations" (USACE, 2001), "Soils and Geology" (USACE, 1983), and "Soil Sampling" (USACE, 1996). This report presents a summary of the results of R&M's field exploration programs and our interpretation of subsurface conditions.

This work was performed under a Statement-of-Work prepared by the USACE-AD, revised 13 September 2006. The Statement-of-Work is presented as Appendix E to this report.

The Scope-of-Work for R&M's geotechnical investigation was comprised of seven tasks (with various subtasks) as follows:

- Task 1: Planning
  - Subtask 1a – Work Plan
  - Subtask 1b – Rights of Entry, Utility Locates and Permits
- Task 2: Geologic Logging of Bluff
- Task 3: Location Surveys of Test Borings
- Task 4: Drilling and Groundwater Monitoring Well Installation
- Task 5: Laboratory Testing
- Task 6: Report Preparation
- Task 7: Groundwater Monitoring

No geotechnical analysis or recommendations were required under the Statement-of-Work. Additionally, groundwater monitoring will continue on a periodic basis. A groundwater monitoring report will be submitted under separate cover.

1.4 Existing Information

R&M reviewed the following documents, provided by the USACE-AD, which included some geologic and/or geotechnical information specific to the subject project.

Peratrovich, Nottingham, and Drage, Inc. (PN&D). 2000. Kenai Coastal Trail & Erosion Control Project, Design Concept Report. *Prepared for* City of Kenai, Alaska.

Smith, O., W. Lee and H. Merkel. 2001. Erosion at the Mouth of the Kenai River, Alaska; Analysis of Sediment Budget with regard to the proposed Kenai Coastal Trail & Erosion Control Project. University of Alaska Anchorage. *Prepared for* Peratrovich, Nottingham, and Drage, Inc.

Tibbetts-Abbett-McCarthy-Stratton (TAMS). 1982. City of Kenai, Bluff Erosion Study, Draft Report. *Prepared for* City of Kenai, Alaska.

U.S. Army Corps of Engineers (USACE-AD). 2004. Geotechnical Findings Report, Kenai River Bluff Erosion, Kenai, Alaska. Alaska District, Soils and Geology Section.

Note that only the 2004 USACE-AD report included any factual data pertaining to the geologic and geotechnical conditions in the project area (e.g. test hole logs, laboratory soil tests, groundwater levels, etc.). Exploration logs from the 2004 USACE-AD report are reproduced in Appendix B of this report. Well logs by American Environmental are also included in Appendix B. In addition, a number of U.S. Geological Survey documents and other technical reports were reviewed in regards to regional conditions. These various reports are cited herein and listed in the references section of this report.

2.0 REGIONAL SETTING AND GENERAL SITE CONDITIONS

2.1 Regional Setting

2.1.1 Location

The City of Kenai is located about 65 air miles southwest of Anchorage, Alaska. The bluff area that is the subject of this investigation lies along the right bank of the Kenai River near where the river empties into Cook Inlet. The project site is located on U.S. Geological Survey (USGS) Kenai (C-4) Quadrangle, Township 5 North, Range 11 West, Sections 5 and 6, Seward Meridian, Alaska. A site map is included as Figure 2.

A fortified post called Fort St. Nicholas was built in the area by Russians in 1791. The village was also called Paul's Fort. In 1869 a U.S. Military Post, named Fort Kenai for the Indians living in the area, was established (Orth, 1967).

2.1.2 Regional Geology

Kenai is situated on the Kenai Peninsula, which lies within the Cook Inlet-Susitna Lowland physiographic province (Wahrhaftig, 1965). The area is characterized as a glaciated lowland containing areas of ground moraine and stagnant ice topography, drumlin fields, eskers and outwash plains with rugged mountains located to the east.

The Kenai Peninsula is bounded by Turnagain Arm to the north, Cook Inlet to the west, the North Pacific Ocean to the south, and includes the Kenai Mountains to the east (see Appendix A, Drawing A-01). The Kenai Lowland is the portion of the peninsula located west of the Kenai Mountains; it is part of the larger Cook Inlet-Susitna geologic structural basin which is surrounded by the Chugach, Talkeetna, and Alaska Mountain Ranges. The Cook Inlet-Susitna basin and adjacent Kenai Mountains are in a relatively active seismic zone and are bisected by several inactive and active faults. Within the basin, bedrock is generally overlain by relatively thick unconsolidated glacial, fluvial, and marine sediments, whereas in the adjacent mountains bedrock is commonly exposed at the surface or covered with a relatively thin veneer of soil.

Bedrock beneath the lowland consists mainly of poorly consolidated coal-bearing rocks of Tertiary-age, generally mildly deformed or flat-lying. This poorly consolidated bedrock is mantled by glacial moraine and outwash, and marine and lake deposits.

This portion of southcentral Alaska was covered with glacial ice during glacial advances of early to middle Pleistocene-age (Coulter et al., 1965), as evidenced by local topography and soil stratigraphy. This region of Alaska is considered to be generally free of permafrost except where isolated masses of permafrost occur in lowland areas where ground insulation is high, such as peat bogs and swamps (Ferrains, 1965).

FIGURE 2

SITE MAP

Not to Scale

Regional geologic mapping for the area has been published at a scale of 1:250,000 (1 inch = 4 miles) by the U.S. Geological Survey (Magoon et al, 1976). Quaternary geology of the Kenai Lowland has also been published at a scale of 1:250,000 (Karlstrom, 1964). Additionally, Karlstrom (1958) has mapped ground conditions and surficial geology of the Kenai-Kasilof area at a scale of 1:63,360 (1 inch = 1 mile). Although quite dated, Martin et al. (1915) present data on the geology and mineral resources of the Kenai Peninsula.

2.1.3 General Seismicity

Southcentral Alaska, including the Kenai Peninsula, is located in a very active seismic region associated with the collision of two tectonic plates (Plafker et al., 1993). The Pacific Plate is being thrust under the North American Plate along a northwestward-dipping Aleutian subduction zone. This under-thrusting produces compression in the crust of the overlying North American Plate expressed as folds and high-angle reverse and thrust fault systems. Evaluations of seismic hazards in southcentral Alaska typically recognize four faults or faulting zones, including: the Megathrust and Benioff segments of the Aleutian subduction zone, the Lake Clark-Castle Mountain Fault System, and the Border Ranges Fault Zone.

The Aleutian subduction zone is represented as two distinct planes, Megathrust and Benioff, each with different characteristic earthquakes. From the Aleutian Trench, about 200 miles east-southeast of Kenai, the subduction plane maintains a shallow dip to the northwest extending to a depth of about 12 to 15 miles (Megathrust zone). The seismicity of the Megathrust zone is characterized by shallow, very large magnitude, but infrequent earthquakes. The 1964 Great Alaska Earthquake (Moment Magnitude, 9.2 Mw) occurred within this zone, with the epicenter about 125 miles northeast of Kenai in Prince William Sound. At a depth of about 25 to 30 miles, the subducting Pacific plate dips steeply to the northwest (Benioff or Intra-Plate zone). The seismicity of the Benioff zone is characterized by deep (>30 miles), moderate magnitude and frequent earthquakes. Based on theoretical models, maximum credible earthquakes (MCE) of magnitude 9.5 Mw and 7.5 Mw have been predicted for the Megathrust and Benioff zones, respectively (WCC, 1982).

The Castle Mountain Fault is a prominent, right-lateral strike-slip, reverse fault which traces from the Talkeetna Mountains northeast of the Matanuska Glacier, southwesterly through the lowlands along the Susitna River and southern flank of Mount Susitna (Determan et al., 1974). Kenai is about 60 miles south of the fault trace. A magnitude 5.2 Ms earthquake in 1984 about 125 miles northeast of Kenai was attributed to a rupture along this fault (Lahr et al., 1986). A MCE of magnitude 7.5 Mw has been predicted for the Castle Mountain Fault (WCC, 1982).

The Border Ranges Fault zone is a major reverse fault, locally positioned along the western flank of the Kenai Mountains, and interpreted to be an ancient subduction zone from the Mesozoic or early Tertiary time (MacKevett and Plafker, 1974). A surface trace of this fault in the area is unknown, but has been mapped within about 35 miles west of the site (Magoon et al., 1976). The seismic activity along this fault subsequent to early Tertiary time is unknown. In terms of considering seismic risk for building design, the MOA Geotechnical Advisory Commission (GAC, 1997) characterized the Border Ranges Fault zone as exhibiting a relatively low rate of seismic activity and not capable of producing large magnitude earthquakes.

According to the U.S. Geological Survey (Stanley, 1968 and Plafker et al., 1969), the two communities most seriously affected by coastal erosion following the 1964 Great Alaska Earthquake were Homer and Kenai. Stanley (1968) states that, "During the earthquake the area (Kenai) subsided 12 to 18 inches… After regional subsidence, the pre-earthquake accumulation of sloughed debris along the toe of the bluffs was quickly removed. Undercutting by waves and by the river began a few days after the earthquake, and within three months the bluff had receded as much as 20 feet."

2.1.4 Climate

Lying between Cook Inlet and the Kenai Mountains, Kenai has a transitional climate which may be characterized as variable with the influence of both maritime and continental climate regimes. Kenai receives an average of about 19.1 inches of precipitation per year. The temperature ranges from daily extremes of about minus 47°F to 93°F with an annual mean of 34°F. The mean monthly temperature ranges from about 12.5°F in January to 54.7°F in July. The annual heating degree days (base temperature equals 65°F) for the Kenai area is 11,288°F days (Hartman and Johnson, 1984).

A summary of climatological data obtained from the Kenai FAA Airport recording station is presented in Table 2.

2.2 General Site Conditions

2.2.1 Topography

Topography of the project site is marked by the Kenai River bluff, a feature which drops 60 to 70 feet at slope angles ranging from about 18 degrees to 90 degrees from the City of Kenai to the Kenai River (Figure 2). The project site may thus be divided into two distinct topographic areas, the bluff crest and the bluff toe. The bluff crest area is relatively flat. The bluff toe area slopes gently from the base of the bluff to the river's edge and is inundated by high tides.

2.2.2 Surface Drainage

Surface drainage at the site is interpreted to occur through two mechanisms, infiltration and surface flow to natural drainage courses. The two primary natural drainage courses within the project site are Ryan's Creek and Cemetery Creek, both of which are shown on Figure 2.

2.2.3 Vegetative Cover

The project site is located within a Bottomland Spruce-Poplar Forest system (AEIDC, 1974), as characterized by the local white spruce forests with large cottonwood and balsam poplar trees. Alaska paper birch, quaking aspen, and black spruce trees are also in evidence, along with willow and alder shrubs. Much of the bluff crest portion of the project site has been developed, though segregated stands of primarily spruce trees are present along intermittent portions of the bluff crest. Toppling of these trees is in evidence where the bluff has been receding in recent years. The toe of the bluff area is primarily devoid of vegetation, with the exception of localized grasses and the occasional shrub in the summer months. The area of the bluff toe that abuts Cemetery Creek, however, is vegetated with grasses and shrubs, as well as cottonwood, birch, willow and the occasional spruce tree.

2.2.4 Soils

Soils exposed along the bluff at Kenai consisted of marine, glacial, and alluvial deposits that have been altered by glacial action and erosion (Figure 3). The surficial soils and features in the area around Kenai have been created by several major Pleistocene glacial events. These included the deposition of marine sandy clays of the Bootlegger Cove Formation (Reger, 1997) in glacioestuarine waters approximately 16,500 years ago. A Killey-age tidewater glacier then passed over the site from the northwest. It apparently floated over the site as the effects of the glacial override did not penetrate deeply into the marine clay. Submarine-fan deposits were spread over the clay. Folding and displacement of the marine sediments occurred when the glacier grounded.

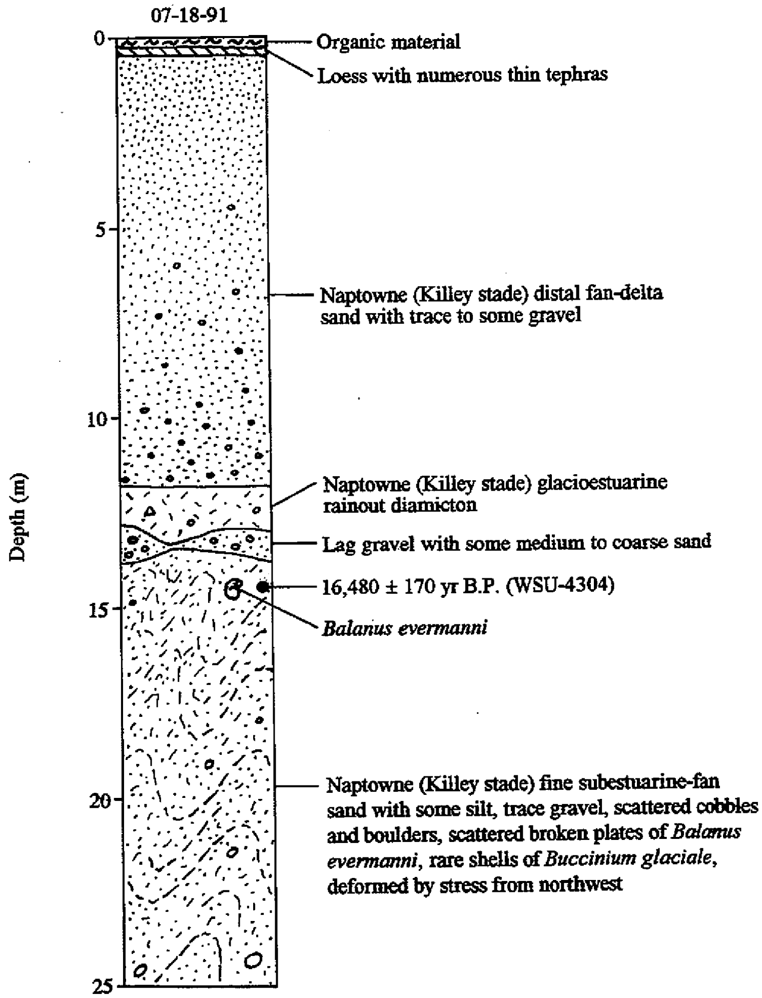
The first recorded description of the geology at the bluff at Kenai was provided by Moffit in 1906. He described partially cemented (ferruginous) sands overlying bluish-black silt (till). He also noted springs flowing from the bluff on top of the glacial till. Site-specific soils data obtained from the current bluff logging and test borings are provided in Section 5.0.

2.2.5 Bedrock

The Kenai area is reportedly underlain by rocks of the Sterling Formation which is the upper unit of the Tertiary Kenai Group (Hartman et al., 1972). The Sterling Formation consists of sandstone deposited during late Tertiary – early Quaternary-age. The sandstone is similar to sand deposits in the overlying Quaternary material and thus it is difficult to define the top of the formation. However, on the Kenai Peninsula depths to the formation of approximately 500 to 3,000 feet were indicated. Kirschner and Lyon (1973) present additional information on the stratigraphic and tectonic development of the area. Bedrock was not encountered in any of the 20 test borings drilled for this program.

FIGURE 3

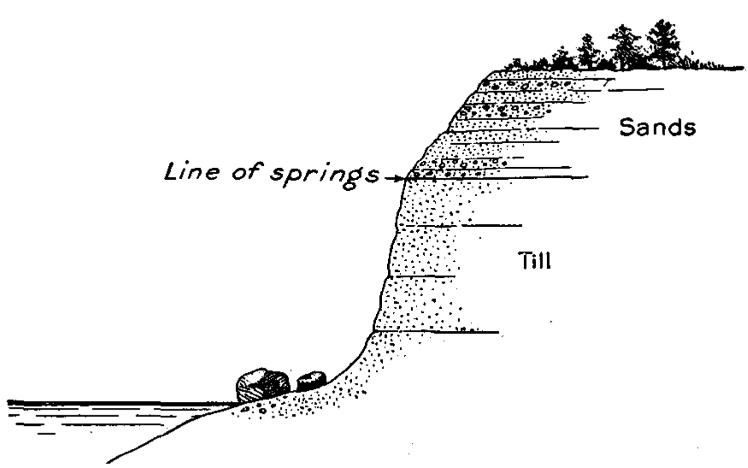
RIVER BLUFF STRATIGRAPHY



a. Stratigraphy exposed near project site (60º33'07"N, 151º14'17"W), Kenai C-4 SE Quadrangle.

After Reger et al., 1996.

b. Diagrammatic sketch showing relations of stratified sands and till at Kenai.



After Moffit, 1906.

On the basis of available information, it appears that bedrock is located at a considerable depth beneath the project site. Therefore, bedrock is not expected to be involved with any design or construction consideration.

2.2.6 Groundwater

Various water resources and groundwater studies have been performed in the area. Freethey and Scully (1980), explain regional groundwater potential in terms of geologic materials, depositional environment, and sediment thickness. The document also describes aquifers in five different areas and estimates groundwater yield. Anderson (1971) presents data on groundwater exploration and testing at Beaver Creek Valley near Kenai. The report further documents that an artesian aquifer is the principal source of groundwater. Anderson and Jones (1972), provide additional data on the water resources of the Kenai-Soldotna area. Bailey and Hogan (1995), in cooperation with the Federal Aviation Administration, give an overview of environmental and hydrogeologic conditions near Kenai while Glass (1996) documents groundwater conditions and quality in the area.

Each of the above cited studies focuses on area-wide groundwater conditions. Discussion of site-specific groundwater conditions is presented in Section 5.0.

3.0 FIELD INVESTIGATION

Methods of field investigation for the Kenai River Bluff Erosion geotechnical study can be divided into the following six categories.

- Planning and Site Reconnaissance
- Geologic Logging of Bluff
- Test Borings
- Groundwater Monitoring Well Installation
- Groundwater Monitoring
- Location Surveys

Following is a brief description of each of these categories along with methods and procedures used in acquiring the various geologic and geotechnical information.

3.1 Planning and Site Reconnaissance

On 29 June 2006, Robert (Buzz) Scher, P.E., R&M's senior geotechnical engineer, and John Rajek, P.E., USACE-AD geotechnical engineer, visited the project site to observe the stratigraphy, groundwater and erosion conditions exposed along the bluff at that time. During this visit, Scher and Rajek walked the entire length of the project area, along both the toe and crest of the bluff. Detailed observations of site conditions are presented in the Final Geotechnical Scope-of-Work (R&M, 2006) that was compiled to guide this geotechnical investigation. Based on the observations set forth in that document, as well as further research of existing information, the following geotechnical explorations were planned.

- Detailed Bluff Log
- Geotechnical Borings
- Geohydrology Borings
- Laboratory Soil Testing

Once the scope of geotechnical explorations was decided upon, R&M began laying the necessary groundwork to facilitate field work. This effort included obtaining rights of entry from property owners adjacent to the bluff, utility locates for subsurface utility lines, and permits to allow stream crossings and drilling adjacent to the Kenai River.

3.2 Geologic Logging of Bluff

During the period of December 10 through 13, 2006, a team of two R&M geologists/engineers obtained soil profiles at 10 locations along the bluff face (Soil Profiles SP-A through SP-J). At each profile location, an engineer, secured by harness and climbing rope, traversed the bluff from top to bottom (Figure 4). Data collection included measuring the slope profile using a rope tape and a four-foot digital level. Shallow test pits were excavated to expose soils and collect samples. A detailed description of soil and groundwater conditions was also made. Soil profiles are presented in Appendix D. Soil profile locations are shown in plan on Drawings A-02 and A-

FIGURE 4

BLUFF MAPPING PHOTOGRAPHS

a. Rappelling down the bluff face at Soil Profile SP-D. The four-foot yellow electronic level was used to measure slope angle. Slope distances were measured using the white tape. October, 2006.

b. Measuring water flow from the bluff at Soil Profile SP-E.
The procedure involved catching the flow and then measuring in a bucket. October, 2006.

03 of Appendix A. Soil profile locations are also shown on the annotated photo mosaic presented as Drawings A-08 through A-10.

Groundwater flow measurements were made at three locations (Soil Profiles SP-E, SP-F and SP-I) using a section of six-inch PVC pipe cut in half lengthwise. The end of the PVC pipe was pushed into the slope on top of the glacial till where water was issuing out of the bluff so as to seal off water flow under the pipe. The water was collected in a calibrated bucket for a period of five minutes and an approximate flow rate determined. The calculated flow rates are as follows:

- SP-E 0.75 gallons per minute per foot
- SP-F 1.5 gallons per minute per foot
- SP-I 0.25 gallons per minute per foot

3.3 Test Borings

Test borings were located and drilled to meet two primary objectives. The first objective involves delineating the subsurface soil conditions, and the second entails a study of the groundwater regime in the area.

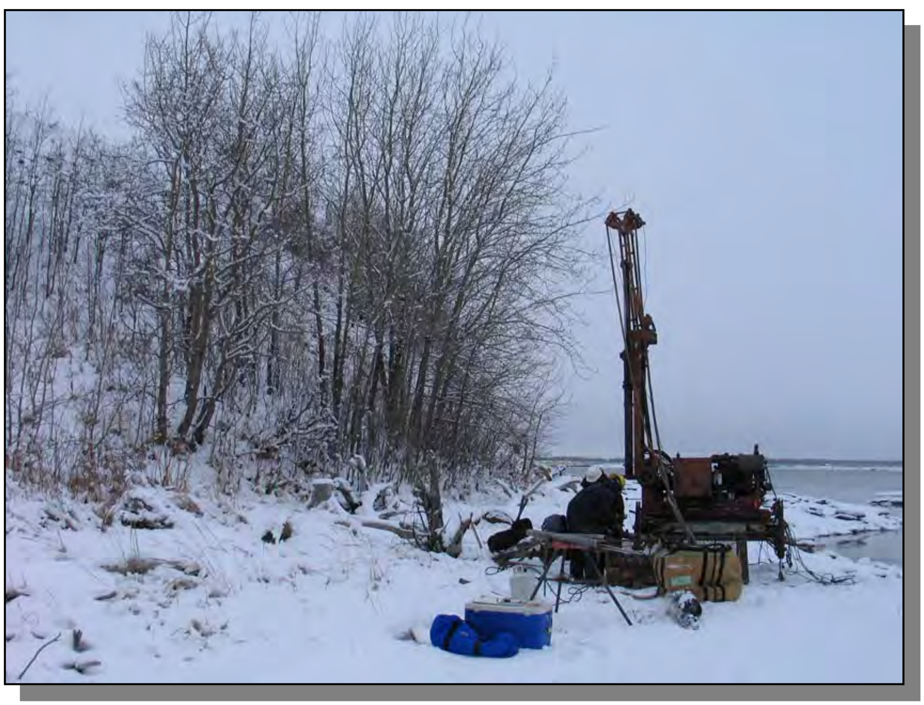
A total of twenty (20) test borings were drilled by R&M at the project site during the period of November 9, 2006 through December 16, 2006, fourteen (14) of which were completed as groundwater monitoring wells. Each of the borings was logged in accordance with standard engineering practices, and data obtained in this manner were utilized to determine geotechnical site conditions. The depth of the test borings ranged from 30 to 101.5 feet. The total number of feet drilled during the field program was approximately 1,135. Drilling and sampling operations were performed by Discovery Drilling, Inc. of Anchorage, Alaska under direct contract to R&M. Approximate test boring locations are shown on Drawings A-02 through A-06 of Appendix A. Logs of the test borings are illustrated in Appendix B, Drawings B-03 through B-17. A key to the test hole log general notes and an example of a typical log are illustrated on Drawings B-01 and B-02, respectively. Table 3 provides a summary of all R&M test borings performed for the project.

Soil boring, sampling, and groundwater well installation on the bluff crest were performed utilizing a truck-mounted CME-75 drill rig (Figure 5a). Soil boring and sampling operations on the bluff toe were performed either with a Nodwell-mounted CME-75 drill rig (Test Boring AP-627 as shown in Figure 6b) or with a helicopter portable CME-45 drill rig (Test Borings AP-622 through AP-626 as shown in Figure 5b). Maritime Helicopters of Homer, Alaska provided a Bell Model 207 helicopter under contract with Discovery Drilling. Test borings were advanced using continuous flight, hollow-stem augers. Representative soil samples were generally obtained at the surface, at 2.5 feet and five feet, and then at approximately five-foot intervals or at obvious changes in soil strata. However at each grouping of three groundwater monitoring well installations (e.g. AP-608-MW through AP-610-MW), only one of the three borings was sampled and logged in detail. The other two borings were only sampled at the bottom of the boring.

FIGURE 5

PHOTOGRAPHS SHOWING DRILLING OPERATIONS

a. Drilling at Group 4 borings. November, 2006.



b. Drilling at Test Boring AP-622 with helicopter portable drill rig. December, 2006.

FIGURE 6

PHOTOGRAPHS SHOWING DRILLING OPERATIONS

a. Tide flats at high tide along the eastern part of the project.
High tides made it difficult to access drills along the beach. October, 2006.

b. Drill struck in mud near Senior Center.
The soft mud made it difficult to use tracked equipment on tide flats. November, 2006.

The drilling program was conducted under the supervision of an experienced engineering geologist who maintained a detailed log of the materials encountered and the samples attempted and recovered. Representative soil samples generally were collected either by means of grab samples taken directly off of the augers, in the case of the surface sample, or via split-spoon samplers. In all but one boring, disturbed samples were obtained using a 2.5-inch I.D. (3.0-inch O.D.) split-spoon sampler driven by means of a 340-lb hammer with a 30-inch free-fall stroke.

Both manual (rope and cathead) and automatic (hydraulic) hammers were used on this project, as denoted for each sample on the logs of test borings in Appendix B. The penetration resistance, defined as the number of blows required to drive the sampler the last 12 inches of an 18-inch interval, gives an indication of the in-place relative density for unfrozen cohesionless soils. Blow counts reported per six-inch interval are shown on boring logs in Appendix B. Penetration resistances thus obtained can be corrected to approximate the Standard Penetration Test (SPT) "N" values by an energy to area ratio adjustment. A correction factor should be used to convert actual blow counts to the corresponding approximate SPT blow counts. Note, however, that the blow counts appearing on the logs of test borings are actual values, not converted SPT values. The Standard Penetration Test (SPT) was performed in the upper 40 feet of Test Boring AP-617-MW utilizing the 1.4-inch I.D. (2.0-inch O.D.) drive sampler and a 140-pound automatic drop hammer. When judged appropriate by the field geologist, brass liners were used inside the split-spoon sampler to retain soil for later laboratory testing. Most of the soils encountered proved unsuitable for "undisturbed" Shelby tube sampling (ASTM Designation D 1587), but one such sample was able to be collected in Test Boring AP-622.

It should be noted that heaving or flowing sands interfered with sampling in every test boring along the bluff toe, as well as in the deeper test borings located on the bluff crest. The logs of test borings in Appendix B include notes on whether a sampler was overfilled with heaving sand, or whether samples were not attempted below a certain depth due to heaving sand flowing up into the augers.

All soils recovered were visually classified and logged in the field following ASTM Designation D 2488. After visual and tactile classification in the field, all soil samples were returned to the R&M laboratory. Representative samples were then selected for further examination and testing.

3.4 Groundwater Monitoring Well Installation

After completion of drilling, fourteen (14) of the test borings on the crest of the bluff were completed as groundwater monitoring wells. Groundwater monitoring wells were installed in general accordance with ASTM Designation D 5092, "Design and Installation of Groundwater Monitoring Wells in Aquifers". Each monitoring well was constructed to allow for the accurate measurement of groundwater depths relative to the top of the well riser. The well riser pipe was constructed of 2-inch I.D. polyvinyl chloride (PVC) pipe. A locking steel protective over casing was installed around the well riser pipe extending approximately three feet below and three feet above the top of ground surface. Bollards were placed around some of the installations to protect the wells from traffic and snow removal equipment.

Groundwater levels were measured upon completion of the installation and will be measured monthly for one year, with a total of 13 readings for each monitoring well. Groundwater elevations and a groundwater monitoring report will be furnished to the USACE-AD after completion of the groundwater monitoring program.

A typical groundwater monitoring well schematic is presented as Figure 7. Monitoring well photographs are shown in Figure 8.

3.5 Groundwater Monitoring

Groundwater monitoring will occur on a monthly basis in the 14 R&M test borings that were converted to monitoring wells and the three pre-existing American Environmental monitoring wells. This monitoring is anticipated to continue to occur on this basis for a period of one year from the installation date. Access to the protective over casings is gained and a Solinst Model 101 water level meter is lowered down the well to measure the groundwater level. The water level meter tape is measured against a constant point on each well casing to ensure a consistent measuring point.

3.6 Borehole Location Surveys

Survey information was based on a field survey performed by R&M Consultants, Inc. during January, 2007. The project coordinates are ACS83 Zone 4, U.S. Survey Feet. The project datum is NAD83 (CORS). The project coordinates and datum were established by ties to CP 1 and USC&GS BM NO. 3 1966 from the DOWL Engineers drawing “Kenai River Bluff Erosion Survey Topography” dated July 16, 2003. The vertical datum was established by holding USC&GS BM NO. 3 1966 with an elevation of 31.44 feet. The drawing indicates that the vertical datum is referenced to Mean Lower Low Water (2003) in U.S. Survey Feet.

Monitor wells and test borings were located horizontally using RTK GPS techniques and vertically by a combination of RTK GPS and differential leveling techniques. The RTK GPS accuracy was quality controlled by taking three-dimensional check shots on established control positions. All of the check positions fell within the tolerances defined in the scope of the project.

The elevations for the top of the pipe of the monitor wells were determined by differential levels run from TBMs with elevations established by RTK GPS. The wells were broken up into four groups based on proximity. One TBM was established for each group of wells with RTK GPS. Differential levels were then run from the TBM to the group of wells in the surrounding area. All level loops closed well within the tolerances defined in the scope of the project.

FIGURE 7

TYPICAL GROUNDWATER MONITORING WELL GROUP

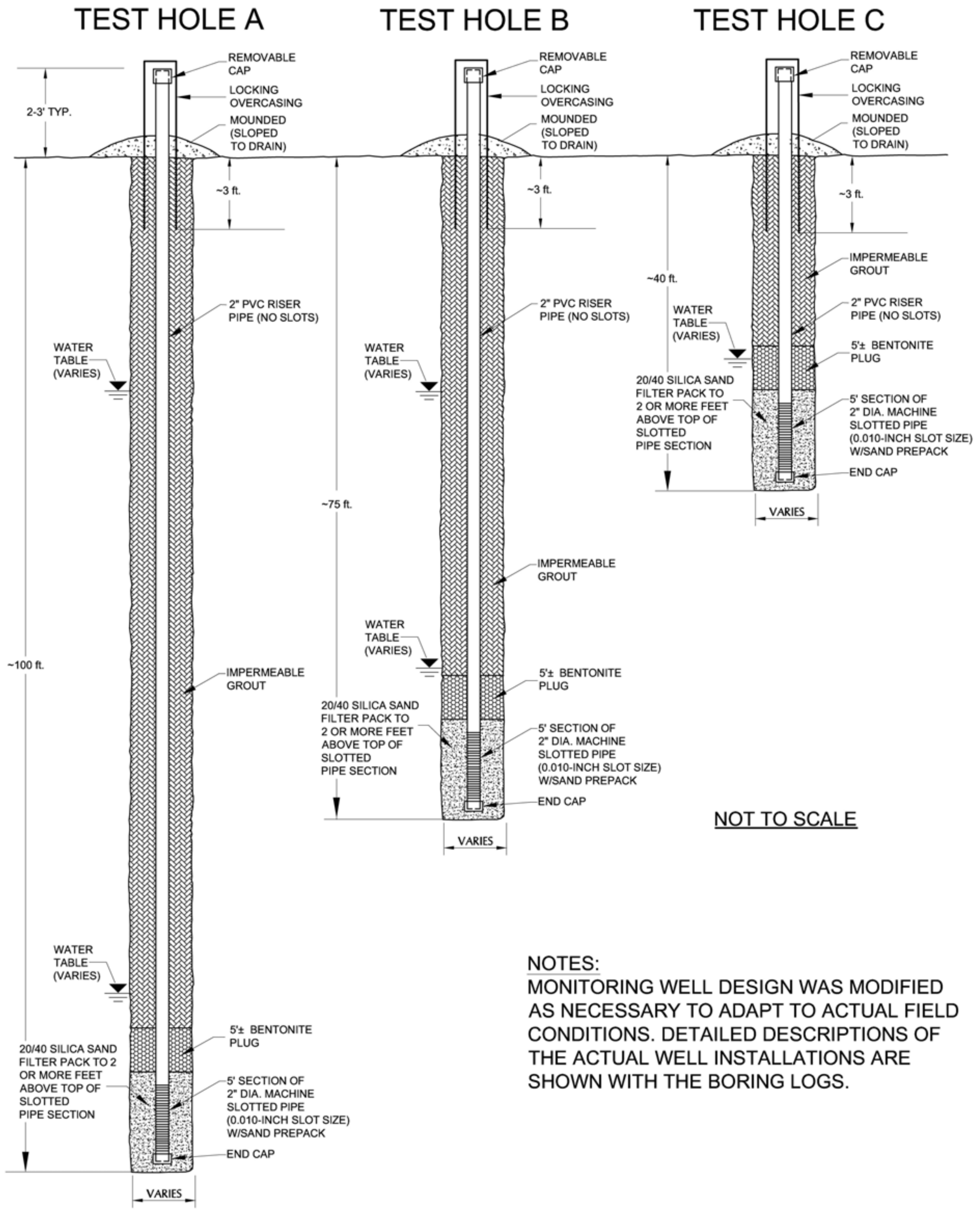


FIGURE 8

PHOTOGRAPHS SHOWING MONITORING WELLS

a. Monitoring well installation at Group 3 borings with protective bollards. December, 2006.

b. Grouting at Group 2 borings. November, 2006.

4.0 LABORATORY TESTING PROGRAM

The laboratory testing program was developed to provide data on the important subsoil characteristics necessary for subsurface characterization of the site. A select number of the soil samples collected during the bluff logging field work and recovered from the test borings were tested both to measure key index properties and to determine the engineering or mechanical properties of the soils. These tests verified and allowed modification of the field descriptions, thereby improving the data base for engineering application and geotechnical interpretation of site conditions.

4.1 Index Testing of Soils

Selected soil samples were tested to measure index properties, which are important for classification and grouping of the soils into general units. Laboratory index testing and soil classification were performed in accordance with the following ASTM designations (ASTM, 2006).

TEST	ASTM DESIGNATION
Description and Identification of Soils (Visual-Manual Procedure)	D 2488
Classification of Soils for Engineering Purposes	D 2487
Laboratory Determination of Water (Moisture) Content	D 2216
Particle Size Analysis (Sieve)	D 422
Particle Size Analysis (Hydrometer)	D 422
Liquid Limit, Plastic Limit, and Plasticity Index of Soils	D 4318
Specific Gravity of Soil Solids by Water Pycnometer	D 854

In addition to the ASTM version of the Unified Soil Classification (USC) System, the samples received a frost classification based on the Army Corps of Engineers Method (USACE, 1992). Each classification method (USC and USACE) is presented on the log of test borings for those representative samples tested. When a classification was estimated, the estimated classification symbol is followed by an asterisk (*) on the test boring log and the laboratory data summary sheets.

A summary of soil index property data is provided in Appendix C, Drawings C-03 through C-06. Particle size distribution (gradation) curves are presented for Soil Profile samples only in Appendix D, Drawings D-11 through D-16. Gradation curves for glacial till samples with a 24-hour hydrometer are shown on Drawings C-19 and C-20 of Appendix C. For clarification of soil call outs, Drawing C-01 defines the classification of soils for engineering purposes. Drawing C-02 provides an explanation of the USACE Frost Design Soil Classification.

It should be noted that the size of the gravel particles obtained with either the 1.4-inch or 2.5-inch I.D. drive samplers is limited by the size of the opening of the sampler, and the sample may thus not necessarily be representative of the coarse gravel fraction.

4.2 Engineering Properties Testing of Soils

Selected soil samples were tested to measure certain engineering properties, such as shear strength and permeability. This testing was performed in accordance with the following ASTM designations (ASTM, 2006).

TEST	ASTM DESIGNATION
One-Dimensional Consolidation Properties of Soils Using Incremental Loading	D 2435
Consolidated Undrained Triaxial Compression Test for Cohesive Soils	D 4767
Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils	D 2850
Permeability of Granular Soils (Constant Head)	D 2434

4.2.1 One-Dimensional Consolidation Tests

One-dimensional, incremental loading consolidation tests were conducted on selected specimens to assess stress history and compressibility characteristics. Tests were performed following ASTM D 2435-04. All samples were trimmed into brass rings prior to testing to produce initial specimen dimensions of approximately 2.4 inches in diameter and one inch in height. Tested samples were set with an initial seating load, and then loaded in the following increments of 1/8-ton per square foot (tsf), ¼ tsf, ½ tsf, 1 tsf, 2 tsf, 4 tsf, 8 tsf, 12 tsf, and 20 tsf. Samples were kept saturated throughout the test.

Results of the consolidation tests are presented graphically in Drawings C-07 through C-09 of Appendix C. Plots are provided as void ratio versus load.

4.2.2 Triaxial Compression Tests

Triaxial shear strength tests were performed for the purpose of determining the stress-strain behavior of the glacial till unit. Triaxial tests were conducted on drive-sampled plastic liner specimens. Consolidated-undrained (CU) tests were performed following ASTM D 4767-02. Unconsolidated-undrained (UU) tests were conducted following ASTM D 2850-03.

The CU tests could not be run at a rate slow enough to allow equalization of pore pressure. The tests were performed on specimens with diameters of approximately 2.4 inches. Specimen height/width ratios were between 2.0 and 2.5. Because of the presence of small gravel particles in the material it was not possible to trim the specimens to smaller diameters. Filter strips were applied to the perimeter of the specimens to allow radial drainage. However, even with radial drainage, the measured consolidation rate required strain rates of about 0.02 to 0.03% per minute for the equalization of pore pressure. The CU tests were run at about 0.1% per minute, which is the slowest strain rate the test equipment can accommodate. Photographs showing triaxial test procedures are presented in Figure 9.

FIGURE 9

TRIAXIAL COMPRESSION TEST PHOTOGRAPHS

a. Triaxial test apparatus.

b. Sample TB-2C No. 16 (AP-611-MW) after testing. Note failure plane.

Triaxial test data are presented in Drawings C-10 through C-16. Pore pressures were measured in CU tests, utilizing a pressure transducer connected to the base of the specimen. Total deviator stress, and pore pressure are plotted against axial strain in the drawings. Mohr diagrams for both CU and UU tests are shown on Drawing C-17.

4.2.3 Permeability Tests

Constant head permeability tests (ASTM Designation D 2434) were performed to assess the permeability of the granular alluvial material. The tests were performed on specimens in brass liner sampling tubes. Results from all permeability tests are tabulated on Drawing C-18.

5.0 GEOTECHNICAL CONDITIONS

Our field investigation has revealed variable subsurface conditions at the Kenai River Bluff Erosion site. To facilitate a discussion of the soil and groundwater conditions, the following sections have been set out to characterize each parameter on an individual basis. The reader is referred to the drawings included within the appendices of this report for graphic representation of the various conditions encountered.

A field log was prepared for each boring by the field geologist. The log contains information concerning the boring methods, samples attempted and recovered, and descriptions of the various soils and groundwater conditions encountered. It also contains the field geologist's interpretation of the conditions in intervals between recovered samples. Therefore, these logs contain both factual and interpretive information. The final drafted logs also represent additional interpretation of the contents of the field logs and the results of the laboratory tests of samples. The final logs are included within Appendix B of this report. It is emphasized that because of the inclusion of laboratory data, our interpretations are based on the contents of the final logs and the information contained therein, and not solely on the field logs.

The final drafted logs included in Appendix B have a two-fold function: they serve as a format for the presentation of some of the significant raw field and laboratory data gained from the test boring as well as illustrating the interpretation of this data – the delineating of the different soil strata encountered. From the standpoint of preparing the test boring logs, the first function involved the mechanical extraction and transferal of data, whereas the second function requires knowledge of soil mechanics, and a good understanding of field soil sampling techniques and geomorphic processes, especially those of the northern environment.

Soil profiles are provided as Drawings D-01 through D-10 of Appendix D. An annotated photo mosaic is presented on Drawings A-08 through A-10. Additionally, a generalized subsurface profile showing interpreted soils and groundwater conditions is presented in Appendix A, Drawing A-11. Soil units reflect those found on the soil logs in Appendix B, but have been generalized and abbreviated for clarity of presentation.

5.1 General Soil Stratigraphy

Between the mouth of Cemetery Creek and the Pacific Star Seafoods Plant (Drawings A-02 and A-03), the river bluffs were underlain by alluvial deposits overlying glacially modified marine deposits (glacial till). The two units were separated by a thin layer of lag gravel from which a year-round flow of groundwater emerges from the bluff.

The upper alluvial deposits consisted of sands that were interpreted by Reger in Karl et al., (1997) to be a distal fan and/or delta deposits (see Figure 3). The deposits had previously been interpreted by Karlstrom (1964) to be reworked alluvial/lake deposits, laid down along the shoreline of a proglacial lake during the retreat of the Naptowne Glaciers. Paleosols buried in the sands indicate an intermittent depositional environment.

Generally, the glacial till unit was interpreted to have originally consisted of Quaternary-age marine clays similar to the Bootlegger Cove deposits near Anchorage. However, the material contained more gravel ("dropstones") than was typically found in the Bootlegger deposits. These marine deposits at Kenai were reportedly older than the Bootlegger Cove deposits (Karl et al., 1997). The marine clays were overridden by one or more glaciers, consolidating and deforming the clay deposits and incorporating significant amounts of coarser gravel, cobbles, boulders, and larger glacial erratics into the clay. Layers of fine sands deposited either before or interbedded with the clays also formed irregularly shaped pockets.

The interlayered lag gravel was interpreted to be a residual accumulation of coarse, hard rock remaining on the glacial till surface after the fines were washed or blown away. Thus, it assumes an unconformity exists between the alluvial deposits and glacial till after the retreat of the glacial ice. An unconformity can be defined as a period in the geologic record when deposition ceased and erosional processes dominated (Bates and Jackson, 1980).

5.2 Soil Conditions

Generally, the soils encountered in the 20 test borings drilled during the current program can be divided into two major units. These units were an upper alluvial unit overlain by surficial silts and a lower glacial till unit; separated from the alluvial unit by a thin bed of lag gravel formed at the unconformity between the two units. The glacial till unit contains distinct pockets of nonplastic sand that for the purposes of this discussion are described as a subunit. Minor stream/coastal deposits were encountered near the mouth of Cemetery Creek and a large man-made disposal site was identified near the Group 1 test borings. General interpretations and compilations of laboratory test data are presented below.

COMPILATION OF LABORATORY TEST RESULTS*
Average / [Range]
(Number of Tests) "Standard Deviation"

	Avg. % Gravel [(1)]	Avg. % Sand	Avg. % Fines	Avg. Liquid Limit	Avg. Plastic Index	Avg. % Moisture Content
Alluvial Unit	**6** / [0-32] (28) "12"	**88** / [45-99] (28) "10"	**5.6** / [1-52] (28) "2"	**NV** / [--] (1) "4"	**NP** / [--] (1) "1"	**7** / [1-27] (28) "6"
Lag Gravel	**45** / [39-54] (5) "6"	**53** / [46-59] (5) "6"	**1.4** / [0.5-2.7] (5) "1"	**No Tests**	**No Tests**	**8** / [3-13] (5) "4"
Glacial Till Unit	**6** / [0-22] (43) "6"	**25** / [8-56] (43) "10"	**68** / [42-91] (43) "12"	**27** / [18-38] (30) "4"	**11** / [6-20] (30) "3"	**17** / [11-78] (46) "10"
Sand Pockets	**2** / [0-12] (17) "3"	**95** / [83-99] (17) "5"	**3.6** / [1-11] (17) "3"	**No Tests**	**No Tests**	**13** / [2-24] (18) "7"

* Test results for five samples – two of the surficial soils (AP-611-MW #2 and AP-624 #1), one of interlayered sand and clay (AP-614-MW #19) and two of soils interpreted to be stream or coastal deposits (AP-622 #2 and #5) – were omitted from this table.

(1) As previously mentioned, the size of the gravel particles in samples obtained with the 1.4-inch and 2.5-inch I.D. drive samplers used in test borings at this site was limited by the size of the opening of the sampler, and the

sample was thus not necessarily representative of the coarse gravel fraction. Results from surface grab samples contained larger particles of gravel, but the sample sizes still were not large enough to be entirely representative.

5.2.1 Surficial Soils

Surficial deposits at the top of the bluff consisted of an organic mat overlying silt grading to sandy silt (ML), with localized deposits of clayey gravel with sand (GC). These surficial deposits ranged up to four feet thick. In some places, the upper one to two feet of the surficial soils were bound together by roots and overhung the lower slopes as the sand raveled down the bluff. Large trees have tended to break off “chunks” of this organic mat and pulled them downhill as the slope retreats.

5.2.2 Fills

Small fills containing construction debris were observed dispersed throughout the surficial soils along the crest of the bluff, which included abandoned parking lots, abandoned utility trenches, and building foundations. At the west end of the project there was a large fill consisting of debris, organic material and silty soils located near the Group 1 test borings (see Figure 10a). This area was reportedly used as a disposal site for many years until a portion of the fill failed and some of the material slid down onto the tidal flats. Based on observations of the slope and data from the test borings, it appeared that fill material was dumped over the bluff between Hansen Park and Mission Avenue near Broad Street. Most of the remaining fill was encountered on the property on which the Group 1 test borings were drilled and the property to the west between the Group 1 borings and Hansen Park. It appeared that the fill slope was being undercut near these two properties as the slope was actively raveling (see Figure 10b).

5.2.3 Alluvial Unit

Alluvial deposits were found underlying the entire upper bluff area to a depth of about 40 feet (37.5 to 42.5 feet). The material consisted of a thick layer of medium dense, fine to medium sand interspersed with layers of sand with gravel (SP, SP-SM). The gravel was rounded to subrounded, and ranged up to two inches in diameter. The sand with gravel layers typically ranged up to one foot thick. At Test Boring Groups 1 and 3, five-foot thick sand with gravel layers were noted. This unit exhibited horizontal layering and cross bedding. Measured slope angles in the sand ranged from 30 to 40 degrees (see Figure 11a). Slope angles were steepest at Soil Profiles SP-B, SP-C, and SP-D, near the west end of the project. Near Soil Profile SP-C, what appeared to be dark brown to black ferruginous cementation was observed in the sands. The cementation apparently allowed the slopes to stand steeper here than elsewhere (Figure 11b). A temporary increase in drilling resistance noted in the sand layer at other locations may also indicate the presence of cemented sands.

FIGURE 10

PHOTOGRAPHS OF EXISTING FILL MATERIAL

a. Area adjacent to Mission Road where fill was pushed over the edge of the bluff.
The black material on the flats was broken asphalt.
The fill slopes have reportedly failed during the past. September, 2006.

b. Photograph taken at bottom of slope on left side of photo above.
Note undermining of the slope and "Marston Mat" in foreground. October, 2006.

FIGURE 11

PHOTOGRAPHS OF ALLUVIAL DEPOSITS

a. Slope in alluvial unit at Soil Profile SP-F.
Overhanging surficial soil layer can be seen at upper left. October, 2006.

b. Cemented layers of sand at Soil Profile SP-C.
Cementation appears to allow the sand to stand almost vertical. October, 2006.

5.2.4 Lag Gravel

Lag gravel consisted of a relatively thin layer of more highly permeable material on top of the glacial till. For the most part, this layer was observed to be less than one foot thick; however near Soil Profile SP-C it was approximately six feet thick (see Figure 12).

Typically, on a geotechnical exploration project for foundation evaluation, a layer this thin would not be differentiated from the glacial till below, except that in this case it was the principal avenue for water flowing out of the bluff face.

This unit consisted of sand and gravel with cobbles (SP, SW and GP). The layer contained significantly more gravel and cobbles than the alluvial unit above. The coarse material was subrounded to rounded and hard. Laboratory tests indicate the material contained 0.5 to 2.7 percent fines and the sand was predominately medium to coarse-grained. For the most part, the material was saturated with moisture contents ranging up to 13 percent. Near Soil Profile SP-C, the gravel appeared to be cemented and no water was observed flowing from the bluff at that location.

5.2.5 Glacial Till Unit

The glacial till consisted of a very hard, heterogeneous mixture of clay, sand, and gravel, with cobbles and boulders ranging widely in shape and size. The glacial till stood near vertical close to the top of the unit (Figure 13a). In some locations the glacial till had the appearance of soft, poorly indurated bedrock similar to the Tertiary-age Kenai Group found on the lower Kenai Peninsula (Figures 13b and 14a). The clay was very hard when dry, becoming softer when exposed to water. It could be carved with a knife, excavated with difficultly using a hand pick, and scratched readily with the fingernail. The clay was plastic with an average liquid limit of 27 and a plasticity index of 11. The plasticity index generally appeared to decrease with increasing sand content.

Thin layers of sand were observed throughout the clay. These layers ranged from as thin as 1/16-inch up to ¼-inch thick and were oriented at 25 to 60 degrees from the horizontal. The layers were observed to be both dry and wet. They also appeared as sand fillings of fractures or fissures in the clay. The clay apparently contained fine to coarse sand dispersed throughout and was classified in most places as a sandy lean clay.

The marine clay appeared to contain gravel scattered throughout. These gravel particles have been interpreted to be dropstones (Karl et al., 1997). Dropstones are defined as stones that drop out of glacial ice when the ice melts over water (Figure 14b). Layers of gravel with cobbles and boulders up to six feet thick were observed scattered throughout the upper portion of the glacial till unit. Typically, the large cobbles and boulders were hard, and subangular to angular. The gravel and some small cobbles were hard and rounded to angular. More and larger gravel and cobbles were observed exposed in the upper portion of the glacial till than lower in the glacial till along the tide flats.

FIGURE 12

PHOTOGRAPHS OF LAG GRAVEL DEPOSIT

a. Cemented lag gravel (darker center bed in photo) at Soil Profile SP-C.
The light gray bed below it was the dense glacial till with cobbles and boulders.
There was no water observed seeping from the bluff at this location. October, 2006.

b. Thin layer of lag gravel near Soil Profile SP-H. Layer ranged from two to six inches thick
and can be seen between the rust stained glacial till below and brown sand above.
Water was observed flowing out of the gravel at this location. October, 2006.

FIGURE 13

PHOTOGRAPHS OF GLACIAL TILL DEPOSIT

a. Top of glacial till unit at Soil Profile SP-H. Note gravel layers in till. October, 2006.

b. Glacial till exposed at the bottom of the bluff.
Note the bedrock-like jointed appearance of the clay. October, 2006.

FIGURE 14

PHOTOGRAPHS OF GLACIAL TILL DEPOSIT

a. Large chunks (boulders) of clay found at bottom of bluff.
From a distance, these chunks can be mistaken for cobbles and boulders. October, 2006.

b. Scattered gravel in clayey glacial till.
Much of this gravel may be "dropstones" derived from floating glacial ice. October, 2006.

Large glacial erratics were observed protruding from the bluff in several places and there were many large boulders located on the tide flats (Figure 15). Bates and Jackson (1980) define erratics as rock fragments carried by glacial ice and deposited at some distance from the outcrop from which they were derived. Erratics are often randomly scattered throughout glacially derived material.

The tide flats located at the base of the bluff lie on a marine platform cut into the glacial till. The platform slopes gently toward the river for a horizontal distance of about 100 to 200 feet. The platform was covered with what appeared to be a thin veneer of boulders, cobbles, gravel and sand apparently washed down from the bluff above. Under this veneer of soil, the clays had become soft in many places making travel on the tide flats treacherous for vehicles or personnel (Figure 6b).

5.2.6 Sand Pockets in the Glacial Till

Sand pockets within the glacial till consisted predominately of fine sand with some fine to medium dark gray nonplastic sand (SP and SP-SM). Larger pockets of sand were also noted along the bluff (Figure 16a). The largest of these pockets ranged up to about 12 feet high and 100 feet long (Figure 17b). The size and incidence of the sand pockets appeared to increase toward the west end of the project and a significant portion of the glacial till unit was composed of this sand at the Group 1 test boring location.

These sand pockets often occurred along the toe of the bluff, where they were rapidly eroded leaving small caves in the bluff (Figure 16b). The presence of these caves along the toe of the bluff appeared to accelerate undermining of the glacial till (Figure 17a). There were significant quantities of sand encountered in the eight test borings drilled along the tide flats. It appeared that the sand unit was becoming continuous and that the clay lenses were decreasing with depth.

The material consisted of a dark gray, poorly graded sand (SP) and sand with silt (SP-SM). The sands heaved when encountered during drilling, particularly in the test holes drilled on the tide flats. Layers of clay in the sand bed were noted in several of the borings, ranging from two inches to three feet thick. Samples of the material indicated the sand has an average fines content of 3.6 percent and a sand content of 95 percent. The sand ranged from fine to coarse but had little of the very fine sands (P140). There were minor amounts of gravel to 1.5 inches in diameter in some samples. Blow counts indicate the sand was medium dense to dense.

5.3 Groundwater Conditions

Observations along the bluff face coupled with test borings and measurements of monitoring wells indicate that there were two groundwater aquifers in the project area, within the 100-foot depth explored. Fourteen groundwater monitoring wells were installed in test borings drilled during this program (AP-608-MW through AP-621-MW) to provide ongoing groundwater measurements. Three monitoring wells (MW-1 through MW-3) previously installed by

FIGURE 15

PHOTOGRAPHS OF GLACIAL ERRATICS

a. Large boulder protruding from glacial till unit in bluff near Soil Profile SP-E.
The boulder was approximately five feet in length. October, 2006.

b. Large boulders on beach near Soil Profile SP-C. October, 2006.

FIGURE 16

PHOTOGRAPHS OF SAND POCKETS IN BLUFF

a. Sand pocket in glacial till showing signs of erosion. October, 2006.

b. Caves interpreted to have been created by the erosion of sand pockets along bottom of the bluff near Soil Profile SP-C. October, 2006.

FIGURE 17

PHOTOGRAPHS OF SAND POCKETS IN BLUFF

a. Caves formed in bluff by erosion of sand pockets.
Note caving of clay caused by undermining due to removal of sand. October, 2006.

b. Light gray material in center of photo was part of a large
sand pocket observed west of Soil Profile SP-C. October, 2006.

American Environmental in June, 2000 were also included in the groundwater monitoring program. Groundwater measurements in all wells will continue monthly for one year and will be published in a separate project report.

Initial groundwater measurements are presented in the following table.

GROUNDWATER MEASUREMENTS AT COMPLETION OF DRILLING PROGRAM 20-21 NOVEMBER 2006

MW ID	TOTAL DEPTH	Depth to GWT	Elev. of GWT	AQUIFER
Wells Installed by R&M in November, 2006				
AP-608-MW	100	67.3	21.1	Lower
AP-609-MW	75	67.2(1)	21.4	Lower
AP-610-MW	40	34.5	54.4	Upper
AP-611-MW	100	75.5	15.6	Lower
AP-612-MW	75	38.0(2)	53.3	Upper (?)
AP-613-MW	40	33.2	57.8	Upper
AP-614-MW	100	82.9	11.0	Lower
AP-615-MW	75	53.2(3)	40.3	Upper (?)
AP-616-MW	40	36.9	56.8	Upper
AP-617-MW	100	78.7	14.2	Lower
AP-618-MW	70	38.2(4)	54.9	Upper
AP-619-MW	40	29.8	63.3	Upper
AP-620-MW	40	28.3	63.9	Upper
AP-621-MW	40	21.7	71.0	Upper
Wells Installed by American Environmental in 2000				
MW-1	25	21.8	69.0	Upper
MW-2	25	20.3	72.0	Upper
MW-3	30	25.9	67.0	Upper

(1) A concerted effort to lower the water level with a manual baler resulted in only a 0.2-foot drop in the water level.

(2) The water level was lowered to 56.1 feet below ground surface after this reading by using a manual baler. The water level had recovered to 52.9 feet two hours later. The measured water level on December 27, 2006 was 52.1 feet. Thus, it appeared the upper aquifer had been sealed off and the water level measured in the monitoring well may have been either an aquifer in the clay or water remaining in the drill hole and/or surrounding formation after installation.

(3) The water level was lowered to 69.8 feet below ground surface after this reading by using a manual baler. The water level had recovered to 52.8 feet two hours later. The measured water level on December 27, 2006 was 59.5 feet. Further monitoring will be required to determine if this well was reading an aquifer in the clay or whether it was reading water remaining in the drill hole and/or surrounding formation after installation.

(4) After this reading the water level was lowered to 47.3 feet below ground surface by manual baling. Two hours later the water level had returned to 38.2 feet. This indicates that the well is recording water levels in the upper aquifer due to leakage in the seal or due to water entering the well from around the seal.

One of the prominent features of the Kenai River bluff within the project area was the groundwater flow from the upper aquifer at the contact between the upper alluvial deposit and the lower glacial till. Water flowing over the glacial till creates bright orange rust staining of the glacial till (Figure 18). The upper aquifer appeared to be perched on the glacial till and flowed south and west toward the bluff face. Measured depths to groundwater in this aquifer during November, 2006 varied from 20.3 feet to 38.2 feet. The groundwater table appeared be higher, the further from the bluff the monitoring well was installed. East of about Ryan's Creek, American Environmental reported a southwesterly water table gradient of about six feet in 400 feet, or approximately a 1.5 percent grade. Measurements taken from the monitoring wells in Group 4 indicated a steeper gradient closer to the bluff face (see Drawing A-11 of Appendix A). While there was less data available west of Ryan's Creek, it appeared that the groundwater gradient in that area may be lower.

Groundwater from the upper aquifer flowed out of the bluff face through a lag gravel layer that varied in thickness from about two inches to six feet. This flow occurred along the entire bluff face with the exceptions of areas near Soil Profile SP-C. Aufeis formed along the vegetated slopes between the project area and South Spruce Street in November, 2006 and it appeared that groundwater flow from the bluff face was also occurring there (Drawing A-08).

Water was noted flowing out of a sand layer near the top of the glacial till unit near the Senior Center facility. This was interpreted to be groundwater from the upper aquifer entering the glacial till through thin sand layers. Small isolated pockets of groundwater in the sand may also occur. Otherwise, there appeared to be no notable aquifer in the glacial till.

Near Soil Profile SP-C, groundwater seepage was observed as being minor or nonexistent. A significant amount of cementation was noted in the alluvial deposits and lag gravels at Soil Profile SP-C and this may have been the cause of the decreased flow in this immediate area (see Figure 12a). However, the cementation itself may be a result of lower groundwater flow. Water levels in Test Boring AP-620-MW and in Group 2 borings indicate there may be a lower groundwater gradient toward the bluff face in this area, but with limited data this was not conclusive. Flow rates out of the bluff varied, with higher flow rates at locations where the top of the bluff was slightly lower. This appeared to concentrate water flow across the flats producing small drainages that become more apparent in the winter (Figure 19).

The lower aquifer lies at about sea level and may in part be connected to the river. As shown in the table below, water levels in the Test Boring AP-617-MW monitoring well were noted to vary over time, possibly in relation to tide levels. However, if this was true there appeared to be about a four to six hour lag between the tide and measured groundwater levels.

FIGURE 18

PHOTOGRAPHS OF GROUNDWATER SEEPAGE

a. Groundwater seeping out of bluff at Soil Profile SP-D west of Ryan's Creek. October, 2006.

b. Small stream flowing out of bluff face near Soil Profile SP-I, east of Ryan's Creek. October, 2006.

FIGURE 19

PHOTOGRAPH OF TIDE FLATS, NOVEMBER, 2006

Looking east along tide flats from Group 2 test borings at low tide on one of the first cold days of the winter. Later in the winter the flats were completely covered by ice. Note the high water line above (white area on left side of flats) and the frozen streams of fresh water as they flow into the river.

WATER LEVEL MEASUREMENTS OVER TIME
IN TEST BORING AP-617-MW (21 NOVEMBER 2006)

Time (AST)	Depth bgs (feet)	Tides [(1)]
8:00 AM	78.7	
10:00 AM	82.3	Low Tide 10:30 AM 4.7 feet
12:30 PM	83.8	
4:00 PM	75.3	High Tide 3:58 PM 22.4 feet

(1) From NOAA http://tidesandcurrents.noaa.gov; Kenai River Entrance

5.4 Bluff Erosion

The cause of continued bluff erosion within the project area was interpreted to be removal of material from the toe of the bluff by river and tidal action. This can be seen when one compares the bluff within the project area to its continuation to the west where the toe was set back from the water (Drawing A-08). Without the removal of debris at the toe by river and tidal action, the slope in that area stabilized at an angle of about 38 degrees and became vegetated. No active erosion was observed in that area. There is no reason to believe that soil conditions to the west of the project area were significantly different than those within the project area. The bluff face tends to retreat due to continuous removal of both in-place material and material sloughed off the slope face.

Numerous secondary processes were interpreted to be involved in the raveling and sloughing of the bluff face, including the following:

- Softening of the clay by water, particularly the water flowing off the top of the glacial till and river water along the toe of the bluff.
- Undercutting of the alluvial sand by retreat of the glacial till.
- Undermining of glacial till by erosion of sand pockets as described in Section 5.2.6.
- Groundwater sapping undercutting the base of the alluvial sand along the bluff face.
- Falling trees dragging the organic mat down the slope.
- Frost action.

It appeared that the very hard clay would soften when exposed to water (slaking). In areas where the clay was exposed to standing or slow moving water it was soft. This did not occur in areas where water was observed to be actively flowing over the clay, which may have been due to flowing water carrying the clay away as it softened it. As the clay retreats, it undermines the alluvial sands above causing them to also retreat.

Small local areas of what appeared to be groundwater sapping were noted along the bluff. Groundwater sapping occurs where groundwater flows out of a bank or hillslope laterally as seeps or springs and erodes soil away. This may cause the slope above to be undermined and fail. In areas along the bluff where sapping appeared to have occurred, a relatively higher rate of flow was observed. These areas were typically between 10 and 20 feet wide. The steep walled gully through which Ryan's Creek flowed may have been created by groundwater sapping. Groundwater sapping appeared to have only a locally significant effect on erosion along the bluff.

Trees that had fallen at the crest of the bluff were observed to drag large sections of topsoil in their root wads down the bluff, accelerating the erosion along the top of the bluff. Where trees had been cut, the organic mat would lie over the slope, apparently slowing the erosion.
During the November, 2006 drilling program the lower slopes of the bluff were covered by a thick layer of ice. One afternoon temperatures warmed into the upper 30s with the sun shining directly on the bluff face. We noted cobbles and boulders falling out of the bluff face as it thawed. Large pieces of ice also slid down the slope carrying soil with it. It appeared that a significant amount of material moved downslope during the four to five hours these conditions existed.

Debris piles were also observed along the toe of the slope. These debris piles consisted of a heterogeneous mixture of wet, very soft clay, sand, gravel, organic material. This material appeared to have raveled or flowed downslope from the bluff above. It also included trees that have broken off from the crest of the slope. Flow failures were noted in the debris slopes where they had been undercut.

Presumably, if the erosion of the toe by current and wave action stopped, the debris piles would build up. As the slope retreated back to an angle of about 35 to 40 degrees, vegetation would become established which would further stabilize the slope. The stable slope condition which occurs in the absence of toe erosion can be seen in Soil Profile SP-A.

6.0 CONCLUSIONS

The following conclusions are based on data collected from library searches, report reviews and R&M's field work and testing. Geotechnical investigations for the Kenai River Bluff Erosion Study reveal that:

1. The site is located within the Kenai Lowland portion of the Cook Inlet-Susitna Lowland physiographic province.

2. Segregated stands of primarily spruce trees are present along intermittent portions of the bluff crest. The toe of the bluff area is primarily devoid of vegetation.

3. Soils at the project site generally consist of alluvial deposits overlying glacially modified marine deposits (glacial till). The two units were separated by a thin layer of lag gravel from which a year-round flow of groundwater emerges from the bluff.

4. On the basis of currently available information, it appears that bedrock is located at a considerable depth beneath the project site. Therefore, bedrock is not expected to be involved with any construction considerations.

5. Observations and monitoring well readings indicate that there were two separate groundwater aquifers within the upper 100 feet at the project area. The upper aquifer flows from the bluff at the contact between the upper alluvial deposit and the lower glacial till. Technical studies and reports have noted seeps and springs emerging from the bluff at this contact for at least the past 100 years.

6. The elevation of the lower aquifer along the face of the bluff appeared to be influenced by tides.

7. Permafrost has not been encountered, nor should it be expected, within the project area.

8. Cemented layers of sand and gravel appeared to allow the soil to stand near vertical where the cementation occurred. There was no water observed seeping from the bluff at some of these cemented locations.

9. Marine clay within the glacial till unit was plastic with an average liquid limit of 27, and a plasticity index of 11.

10. Permeability tests conducted on the alluvial material indicated a permeability in the vertical direction of about 10^{-4} ft/sec. It is likely that this value does not represent the overall permeability of the unit. The presence of gravel layers would likely result in a much higher permeability in the horizontal direction.

11. Consolidation and triaxial strength tests conducted on the glacial till material indicated that the material was hard, overconsolidated, and strong. The average dry density of the specimens was 118 pcf. The compression index (C_c) ranged from 0.06 to 0.07.

12. Geologic logging of the bluff and the test borings indicated that the soils contain a large number of boulders. Therefore, any excavation contractor should be prepared to deal with said over-size material.

13. Contractors should also be prepared to deal with the soft, quick conditions of the soils along the tide flats (see Figure 20).

14. Within three months of the 1964 Great Alaska Earthquake, the bluff had receded as much as 20 feet within the project area. This was attributed to regional subsidence, rapid removal of sloughed debris along the toe, and undercutting by waves and the river.

15. The retreat of the bluff appears to be caused by several processes including erosion at the toe of the bluff by river and tidal action, slaking of the glacial till by groundwater and surface water, groundwater sapping of the alluvial sand, and frost action.

16. It is expected that in the absence of river and tidal action, the slope will naturally flatten to an angle between 35 and 40 degrees and become vegetated.

FIGURE 20

DRILL RIG STUCK ON TIDE FLATS

a. Nodwell stuck in mud near Test Boring AP-627 at low tide. November 10, 2006.

b. The Nodwell has sunk into unfrozen mud below the high tide line (edge of snow covered area). The surface of the mud was frozen under the snow covered area. November 10, 2006.

7.0 CLOSURE

The interpretations of geotechnical conditions presented in this report are based on our understanding of the project requirements, our limited bluff logging and test boring explorations, and other pertinent information listed herein. Significant alteration of any of these concepts or site locations could substantially alter the foregoing interpretations. We would, therefore, appreciate having the opportunity to review and evaluate the final design, and where necessary, present any required changes to our present conclusions. Additionally, because subsurface characteristics can change significantly within a given area, and with the passing of time, the possibility exists that important subsurface conditions not disclosed during our current investigation may be discovered during any future investigation or construction. Should this situation occur, the influence of the new information on the present interpretations should be evaluated without delay.

R&M Consultants, Inc. performed this work in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, express or implied, beyond exercise of reasonable care and professional diligence, is made. This report is intended for use only in accordance with the purposes of study described within.

We appreciate the opportunity to perform this geotechnical investigation. Should you require further information concerning the investigation or this report, please contact us at your convenience.

Very truly yours,

R&M CONSULTANTS, INC.

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Senior Engineering Geologist

Charles H. Riddle, C.P.G.
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CHR*slv

8.0 REFERENCES

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TABLE 1

CONVERSION FACTORS FOR SI UNITS

CONVERSION TO THE SI INTERNATIONAL SYSTEM OF UNITS		
To Convert From	**To**	**Multiply By**
Mile	Kilometer (km)	1.609344
Mile	Meter (m)	1,609.344
Foot	Meter (m)	0.3048
Foot	Centimeter (cm)	30.48
Inch	Centimeter (cm)	2.54
Square Foot	Square Meter (m^2)	0.09290304
Square Yard	Square Meter (m^2)	0.8361274
Acre	Square Meter (m^2)	4,046.825
Cubic Foot (cf)	Cubic Meter (m^3)	0.02831685
Cubic Yard (cy)	Cubic Meter (m^3)	0.7645549
Gallon (U.S. Liquid)	Cubic Meter (m^3)	0.003785412
Pound-Mass (lbf)	Kilogram (kg)	0.4535924
Ton (short)	Kilogram (kg)	907.1847
Pound-Force (lbf)	Newton (N)	4.448222
Degree Fahrenheit (°F)	Degree Celsius (°C)	T°C=(T°F-32)/1.8
Pound per Square Foot (psf)	Kilonewtons per Square Meter (kN/m^2)	0.47880
Pound per Cubic Foot (pcf)	Kilonewtons per Cubic Meter (kN/m^3)	0.157087

TABLE 2

CLIMATOLOGICAL DATA

LOCATION	KENAI FAA AIRPORT
Period of Record	1949 – 2006
Elevation (ft)	90
Mean Annual Temperature (°F)	34.0
Record High Temperature (°F)	93 (June 14, 1969)
Record Low Temperature (°F)	-47 (Jan. 4, 1975)
Mean Annual Precipitation (in.)	19.1
Highest Monthly Precipitation (in.)	7.36 (Oct., 1986)
Maximum Daily Precipitation (in.)	4.28 (Oct. 10, 1986)
Mean Annual Total Snowfall (in.)	61.2
Highest Monthly Snowfall (in.)	51.6 (Nov., 1994)
Maximum Annual Snowfall (in.)	133.8 (1994)

After Western Regional Climate Center (WRCC)
http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?akkena

TABLE 3

SUMMARY OF TEST BORINGS
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

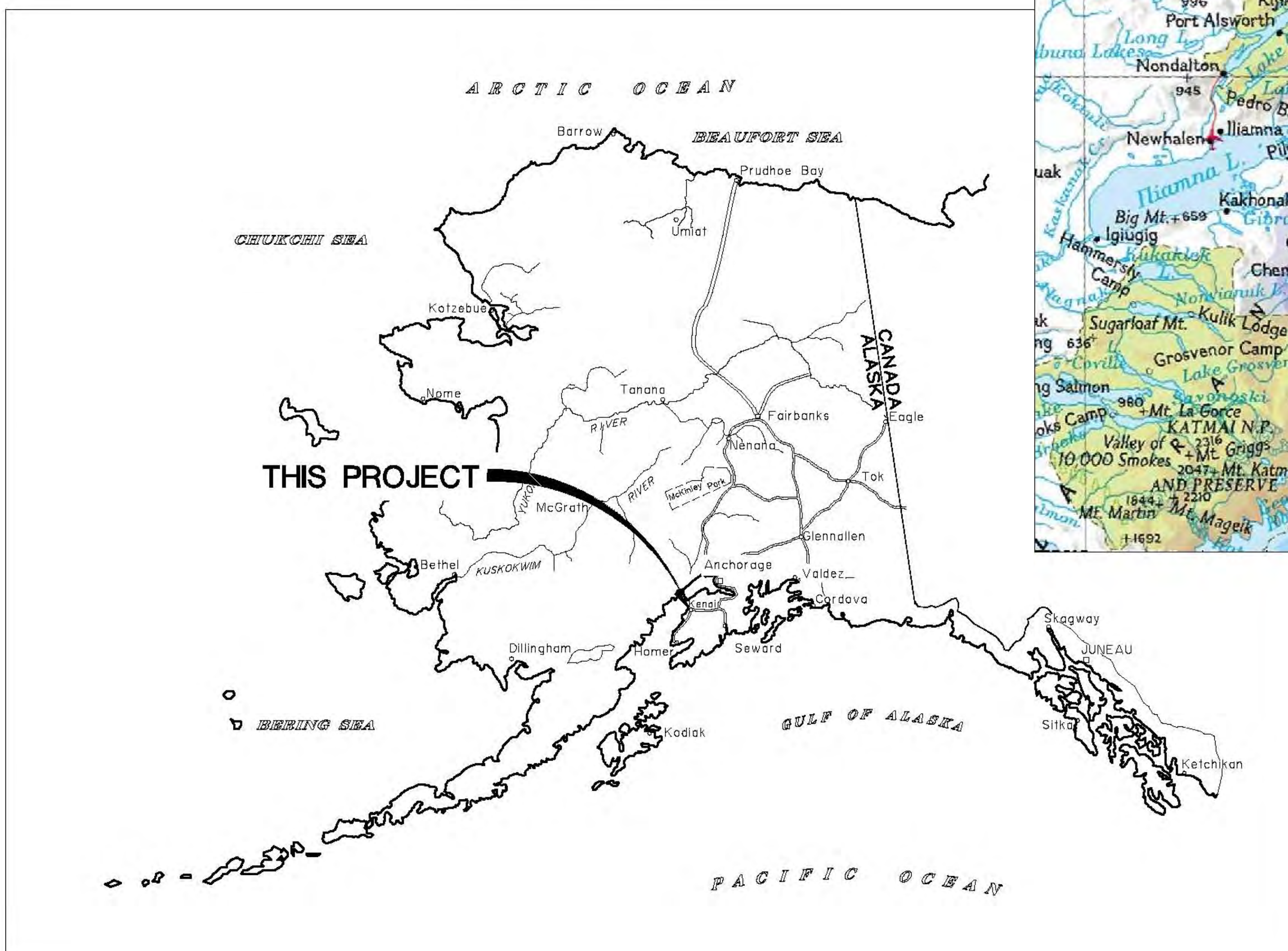
TEST BORING NUMBER (FINAL)	TEST BORING NUMBER (FIELD)	COORDINATES (FEET)		COLLAR ELEVATION (FEET)	TOTAL DEPTH (FEET)	GROUNDWATER DEPTH (FEET)
		NORTHING	EASTING			
AP-608-MW	TB-1A	2,395,412.81	1,413,139.72	88.4	101.2	34 W.D. – 67.5 A.B.
AP-609-MW	TB-1B	2,395,415.41	1,413,150.90	88.6	76.5	33 W.D. – 70 A.B.
AP-610-MW	TB-1C	2,395,430.86	1,413,141.62	88.9	41.3	34 W.D.
AP-611-MW	TB-2C	2,395,775.73	1,414,431.97	91.1	101.5	35 W.D. – 83 A.B.
AP-612-MW	TB-2B	2,395,786.22	1,414,437.68	91.3	76.5	35 W.D.
AP-613-MW	TB-2A	2,395,795.10	1,414,440.67	91.0	41.5	35 W.D. – 32.9 A.B.
AP-614-MW	TB-3A	2,396,258.31	1,415,755.43	93.9	101.5	37.5 W.D. – 82.5 A.B.
AP-615-MW	TB-3B	2,396,268.68	1,415,756.19	93.5	76.5	37.5 W.D. – 46.3 A.B.
AP-616-MW	TB-3C	2,396,280.50	1,415,756.60	93.7	41.5	35 W.D. – 38.8 A.B.
AP-617-MW	TB-4A	2,396,189.80	1,416,979.96	92.9	101.5	33 W.D. – 82.5 A.B.
AP-618-MW	TB-4B	2,396,207.48	1,416,981.72	93.1	70.0	35 W.D.
AP-619-MW	TB-4C	2,396,224.77	1,416,982.32	93.1	40.0	35 W.D. – 29.6 A.B.
AP-620-MW	TB-02	2,396,321.05	1,414,354.82	92.2	41.4	28 W.D. – 28.5 A.B.
AP-621-MW	TB-03	2,396,759.77	1,417,031.71	92.7	41.0	25 W.D. – 21.5 A.B.
AP-622	TB-08	2,395,300.06	1,412,903.84	24*	31.5	6.5 W.D.
AP-623	TB-07	2,395,437.96	1,414,078.32	20*	30.0	14 W.D.
AP-624	TB-06	2,395,725.08	1,414,587.74	20*	30.0	13.5 W.D.
AP-625	TB-05	2,396,055.30	1,415,467.21	20*	30.0	10 W.D.
AP-626	TB-04	2,396,137.75	1,416,086.29	19*	30.0	10.5 W.D.
AP-627	TB-01	2,395,983.03	1,417,218.15	21*	31.5	22.5 W.D.

NOTE: The test boring elevations shown with an asterisk were surveyed at the top of ice cover of varying thickness. The elevations shown were therefore determined by subtracting the estimated ice thickness at the time of survey from the elevation surveyed at the top of the ice. These elevations are estimated, and due to the thick snow and ice cover are considered only accurate to +/- 5 feet.

A.B. = After Boring
AP = Auger Point
TB = Test Boring
W.D. = While Drilling

APPENDIX A
SITE MAPS

N

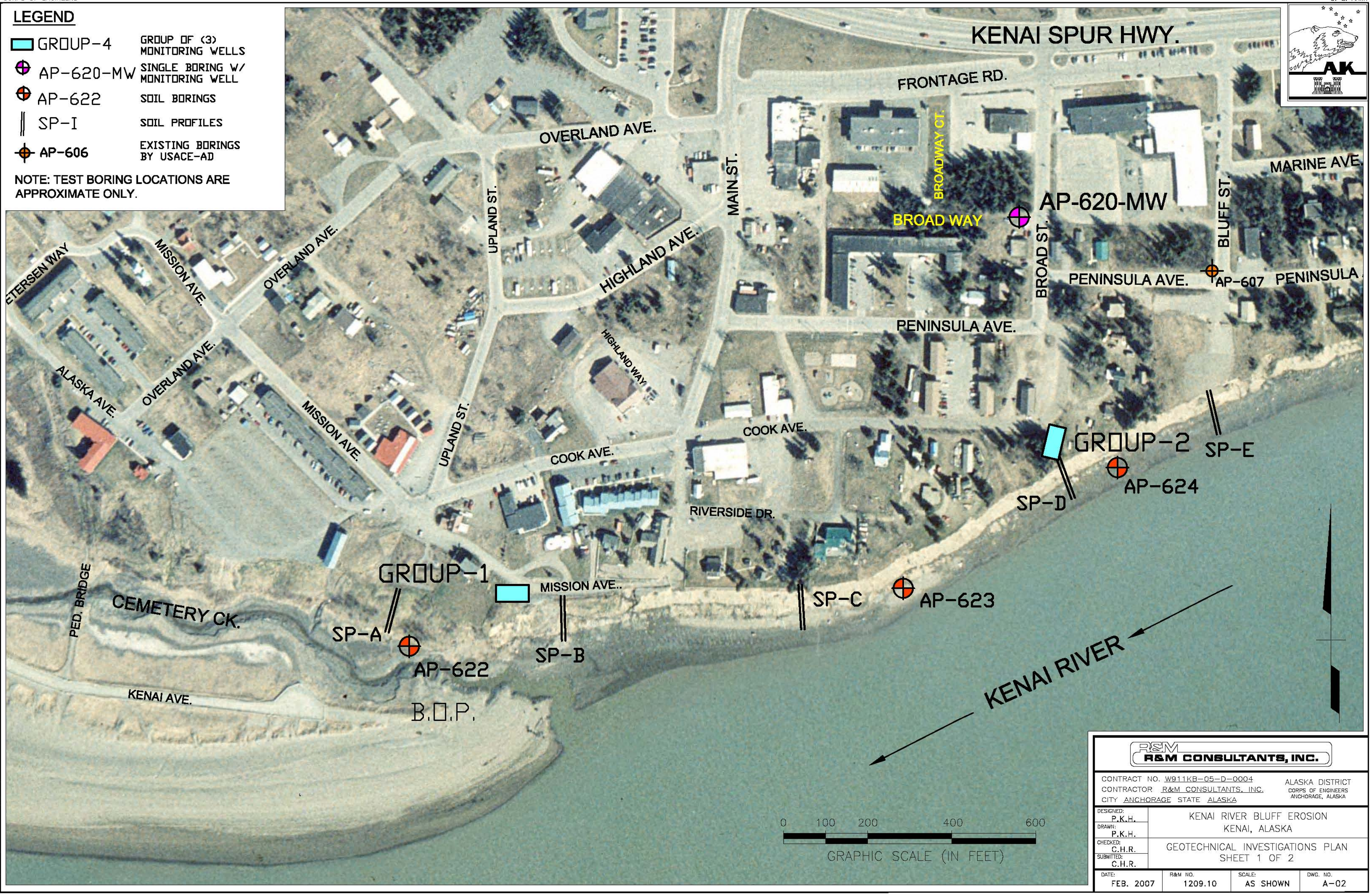


R&M
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	VICINITY MAP

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	A-01

project\1209.10\geo\Kenai Bluff-A-01, 1=1, 10/03/06 at 08:42 by pkh



R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

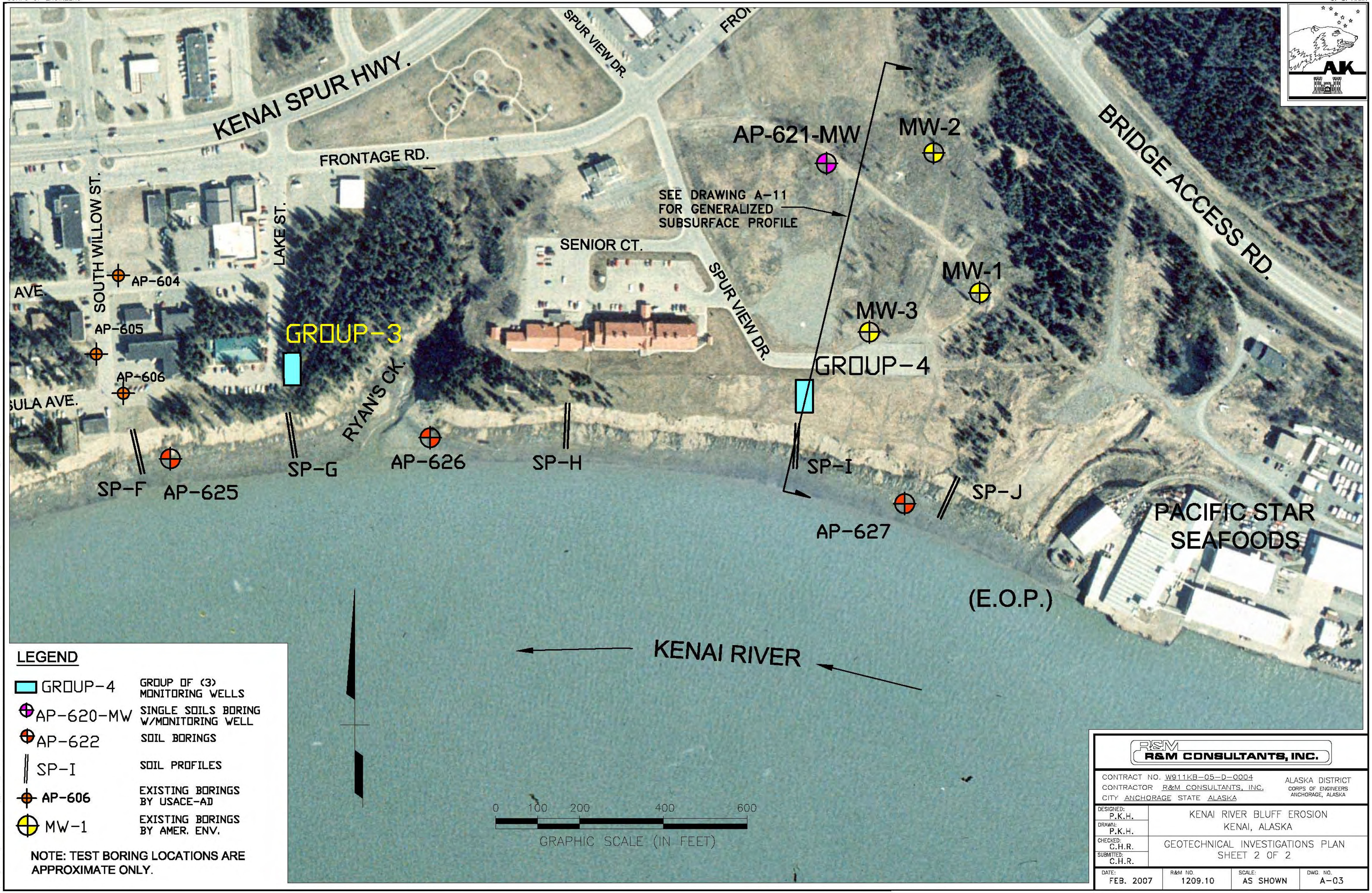
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	
DRAWN: P.K.H.		
CHECKED: C.H.R.	GEOTECHNICAL INVESTIGATIONS PLAN SHEET 1 OF 2	
SUBMITTED: C.H.R.		

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-02

project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh

CORPS OF ENGINEERS U. S. ARMY



R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.
DRAWN: P.K.H.
CHECKED: C.H.R.
SUBMITTED: C.H.R.

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

GEOTECHNICAL INVESTIGATIONS PLAN
SHEET 2 OF 2

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-03

project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh

NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300
GRAPHIC SCALE (IN FEET)

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	BOREHOLE LOCATION MAP
SUBMITTED: C.H.R.	GROUP 1 AND VICINITY

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-04

project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh

NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300
GRAPHIC SCALE (IN FEET)

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	BOREHOLE LOCATION MAP
SUBMITTED: C.H.R.	GROUP 2 AND VICINITY

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-05

project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh

NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300
GRAPHIC SCALE (IN FEET)

R&M CONSULTANTS, INC.

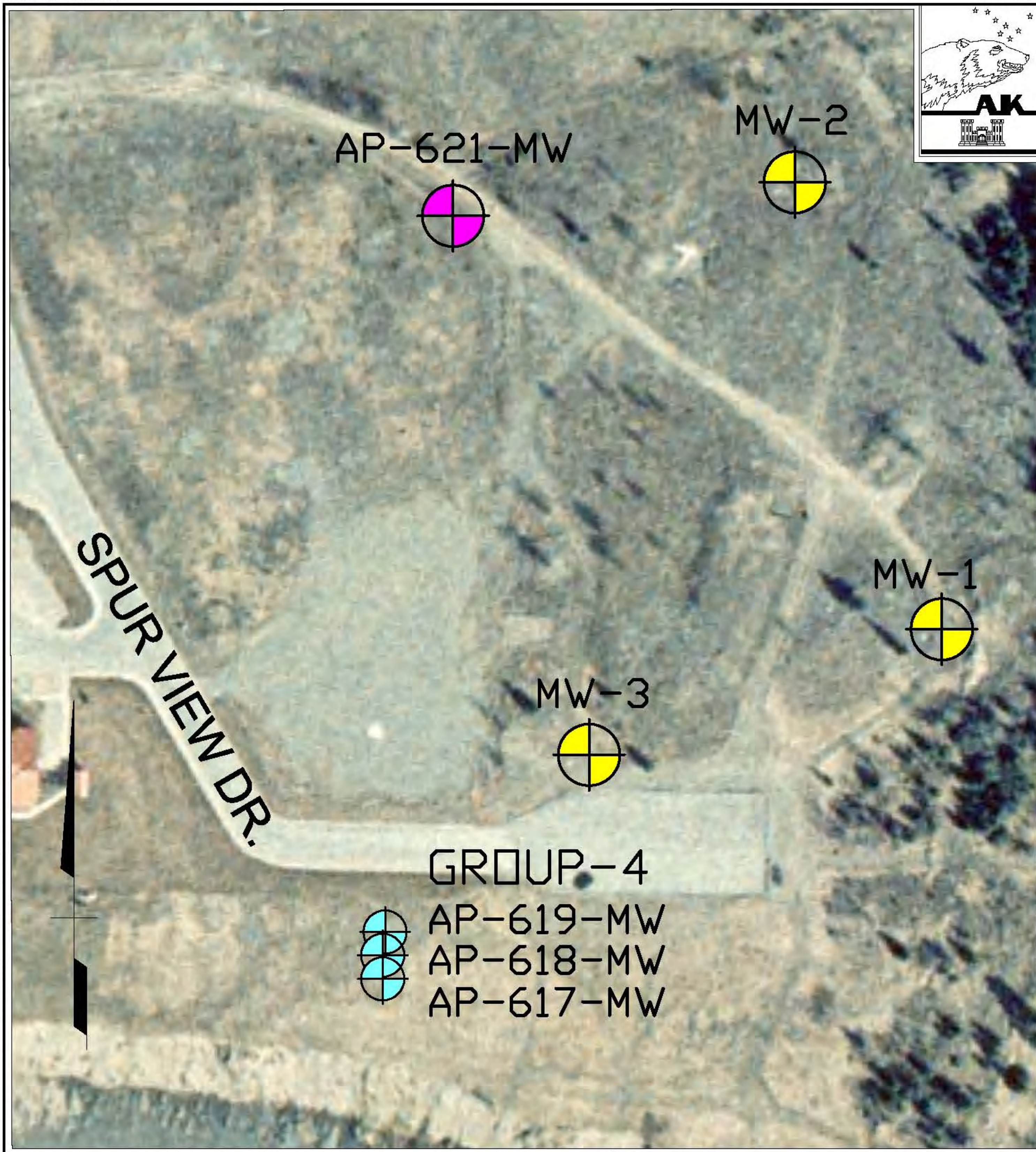
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	BOREHOLE LOCATION MAP
SUBMITTED: C.H.R.	GROUP 3 AND VICINITY

DATE:	R&M NO.	SCALE:	DWG. NO.
FRB. 2007	1209.10	AS SHOWN	A-06

project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh



NOTE: TEST BORING LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 200 300
GRAPHIC SCALE (IN FEET)

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

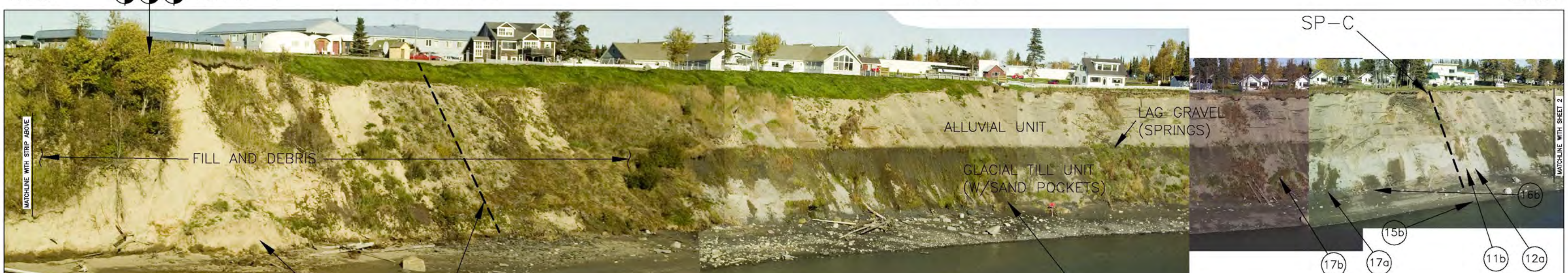
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	BOREHOLE LOCATION MAP
SUBMITTED: C.H.R.	GROUP 4 AND VICINITY

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-07

project\1209.10\geo\Kenai Site Plan A-02-07 new, 1=1, 02/12/07 at 13:43 by pkh

CORPS OF ENGINEERS

U. S. ARMY



LEGEND:

- SOIL PROFILES
- AP–622 TEST BORINGS
- 16a FIGURES (PHOTOS) IN REPORT

Photography dated September 19, 2001 by Eagle Eye Helicopter.

project\1209.10\geo\Kenai Photo Mosaic 1, 1=1, 02/14/07 at 11:03 by pkh

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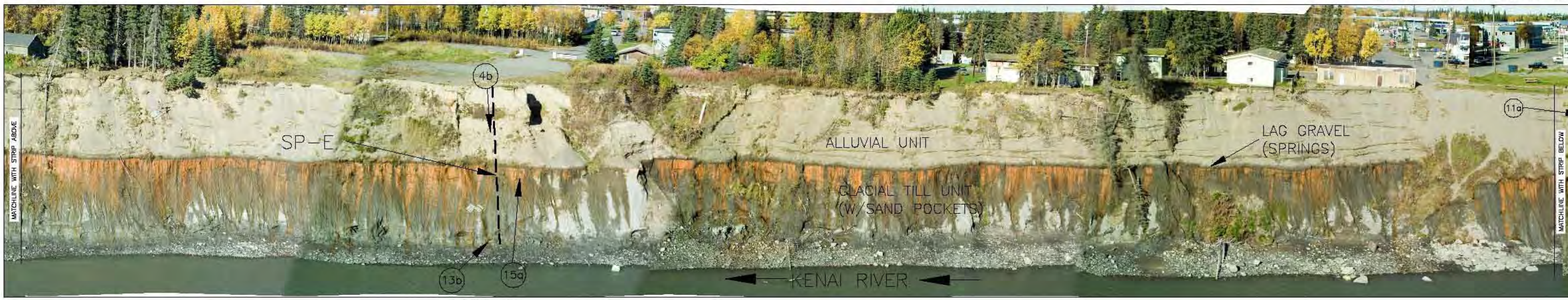
CONTRACT NO. W911KB–05–D–0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.H.K.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	ANNOTATED PHOTO MOSAIC SHEET 1 OF 3

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	NOT TO SCALE	A–08

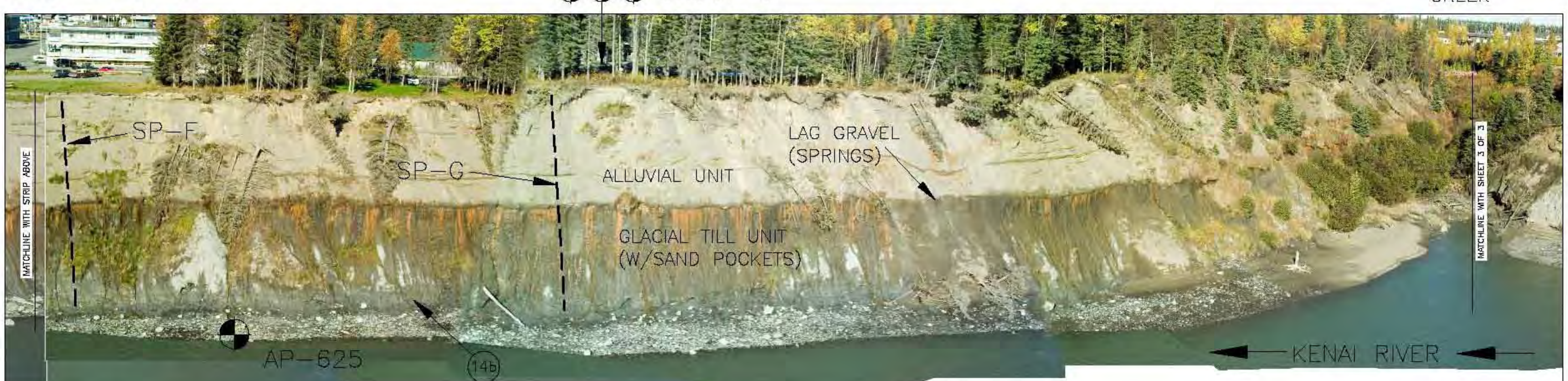
CORPS OF ENGINEERS U. S. ARMY

WEST — GROUP 2 — BROAD ST. — EAST

WEST — BLUFF ST. — SOUTH WILLOW ST. EAST



WEST SOUTH WILLOW ST. — LAKE ST. — GROUP 3 — RYAN'S CREEK — EAST



Photography dated September 19, 2001 by Eagle Eye Helicopter.

LEGEND:

- - - - - - SOIL PROFILES

AP-622 TEST BORINGS

16a FIGURES (PHOTOS) IN REPORT

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	ANNOTATED PHOTO MOSAIC SHEET 2 OF 3
SUBMITTED: C.H.R.	

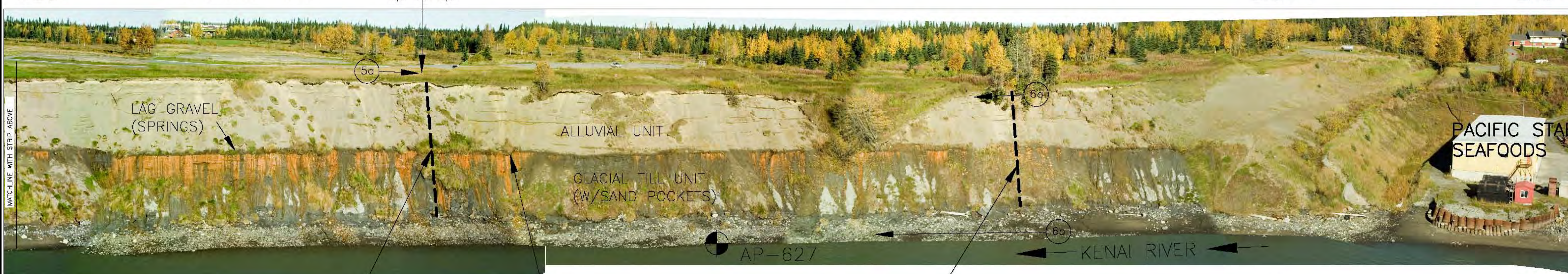
DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	NOT TO SCALE	A-09

project\1209.10\geo\Keni Photo Mosaic 2, 1=1, 02/14/07 at 11:02 by pkh

CORPS OF ENGINEERS U. S. ARMY

WEST RYAN'S CREEK SENIOR CENTER EAST

WEST SPURVIEW DR. GROUP 4 E.O.P. EAST



LEGEND:

- SOIL PROFILES
- AP-622 TEST BORINGS
- (16a) FIGURES (PHOTOS) IN REPORT

Photography dated September 19, 2001 by Eagle Eye Helicopter.

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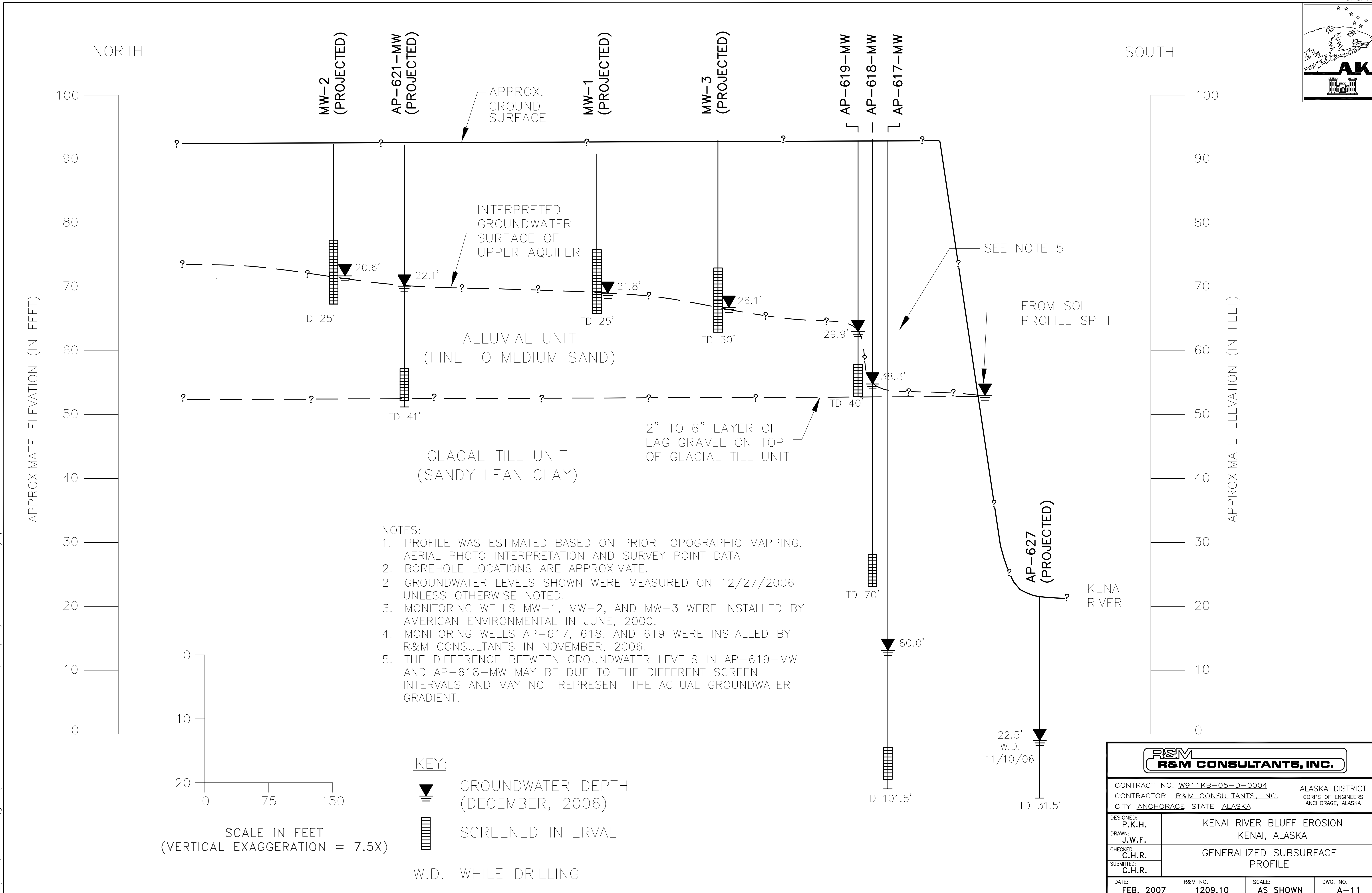
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	ANNOTATED PHOTO MOSAIC
SUBMITTED: C.H.R.	SHEET 3 OF 3

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	NOT TO SCALE	A-10

project\1209.10\geo\Kenai Photo Mosaic 3, 1=1, 02/14/07 at 11:02 by pkh



NOTES:

1. PROFILE WAS ESTIMATED BASED ON PRIOR TOPOGRAPHIC MAPPING, AERIAL PHOTO INTERPRETATION AND SURVEY POINT DATA.
2. BOREHOLE LOCATIONS ARE APPROXIMATE.
2. GROUNDWATER LEVELS SHOWN WERE MEASURED ON 12/27/2006 UNLESS OTHERWISE NOTED.
3. MONITORING WELLS MW-1, MW-2, AND MW-3 WERE INSTALLED BY AMERICAN ENVIRONMENTAL IN JUNE, 2000.
4. MONITORING WELLS AP-617, 618, AND 619 WERE INSTALLED BY R&M CONSULTANTS IN NOVEMBER, 2006.
5. THE DIFFERENCE BETWEEN GROUNDWATER LEVELS IN AP-619-MW AND AP-618-MW MAY BE DUE TO THE DIFFERENT SCREEN INTERVALS AND MAY NOT REPRESENT THE ACTUAL GROUNDWATER GRADIENT.

KEY:

- ▼ GROUNDWATER DEPTH (DECEMBER, 2006)
- SCREENED INTERVAL
- W.D. WHILE DRILLING

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CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: J.W.F.	
CHECKED: C.H.R.	GENERALIZED SUBSURFACE PROFILE
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	A-11

project\1209.10\geo\1209.10-GGP NEW, 1=1, 02/12/07 at 13:41 by pkh

APPENDIX B
LOGS OF TEST BORINGS

SOILS
CONSISTENCY AND SYMBOLS

CLASSIFICATION: Identification and classification of the soil is accomplished in accordance with the ASTM version of the Unified Soil Classification System. When laboratory testing data on material passing the 75-mm sieve is available Standard D 2487 (Classification of Soils for Engineering Purposes) is used and when laboratory data is not available D 2488 Visual-Manual Procedure) is used. This classification system identifies three major soil divisions: coarse-grained soils, fine-grained soils, and highly organic soils. These three divisions are further subdivided into a total of 15 basic soils groups. Based on the results of visual observations and prescribed laboratory tests, a soil is catalogued according to the basic soil groups, assigned a group symbol(s) and name, and thereby classified. Flow charts contained in the two standards can be used to assign the appropriate group symbol(s) and name.

SOIL DENSITY/CONSISTENCY - CRITERIA: Soil density/consistency as defined below and determined by normal field and laboratory methods applies only to non-frozen material. For these materials, the influence of such factors as soil structure, i.e. fissure systems shrinkage cracks, slickensides, etc., must be taken into consideration in making any correlation with the consistency values listed below. In permafrost zones, the consistency and strength of frozen soil may vary significantly and inexplicably with ice content, thermal regime and soil type.

COHESIONLESS

Description	N * (blows/FT.)	Relative Density
Loose	0 - 10	0 to 40%
Medium Dense	10 - 30	40 to 70%
Dense	30 - 60	70 to 90%
Very Dense	>60	90 to 100%

* Standard Penetration "N": Blows per 12 inches of a 140-pound manual hammer (lifted with rope & cathead) falling 30 inches on a 2-inch O.D. split-spoon sampler except where noted.

COHESIVE

Consistency	Shear Strength (TSF)	Unconfined Compressive Strength (TSF)
Very Soft	0.0 - 0.25	0.0 - 0.5
Soft	0.25 - 0.5	0.5 - 1.0
Firm	0.5 - 1.0	1.0 - 2.0
Stiff	1.0 - 2.0	2.0 - 4.0
Very Stiff	2.0 - 4.0	4.0 - 8.0
Hard	OVER 4.0	OVER 8.0

KEY TO TEST RESULTS

- DD - Dry Density
- LL - Liquid Limit
- MC - Moisture Content
- Org - Organic Content
- PI - Plastic Index
- PL - Plastic Limit
- PP - Pocket Penetrometer
- P200 - % Passing No. 200 Screen
- P.02 - % Passing 0.02 mm
- SG - Specific Gravity
- TV - Torvane

DWN:	K.J.P.
CKD:	R.M.P.
DATE:	FEB 06
SCALE:	NONE

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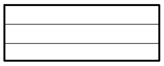
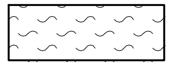
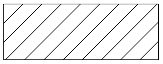
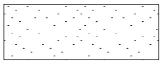
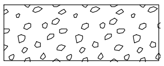
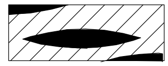
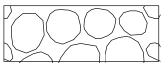
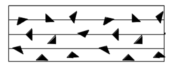
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

GENERAL NOTES

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	B-01

STANDARD SYMBOLS

SYMBOL	NAME	PARTICLE SIZE	SYMBOL	NAME
	CLAY	< 0.002mm, Plastic		ORGANICS
	SILT	0.002mm, - #200		ICE
	SAND	#200, - #4		ICE W/SOIL INCLUSIONS
	GRAVEL	#4, - 3"		ICE LENSE IN SILT
	COBBLES & BOULDERS	3" - 12" & > 12"		ICE CRYSTALS IN CLAY

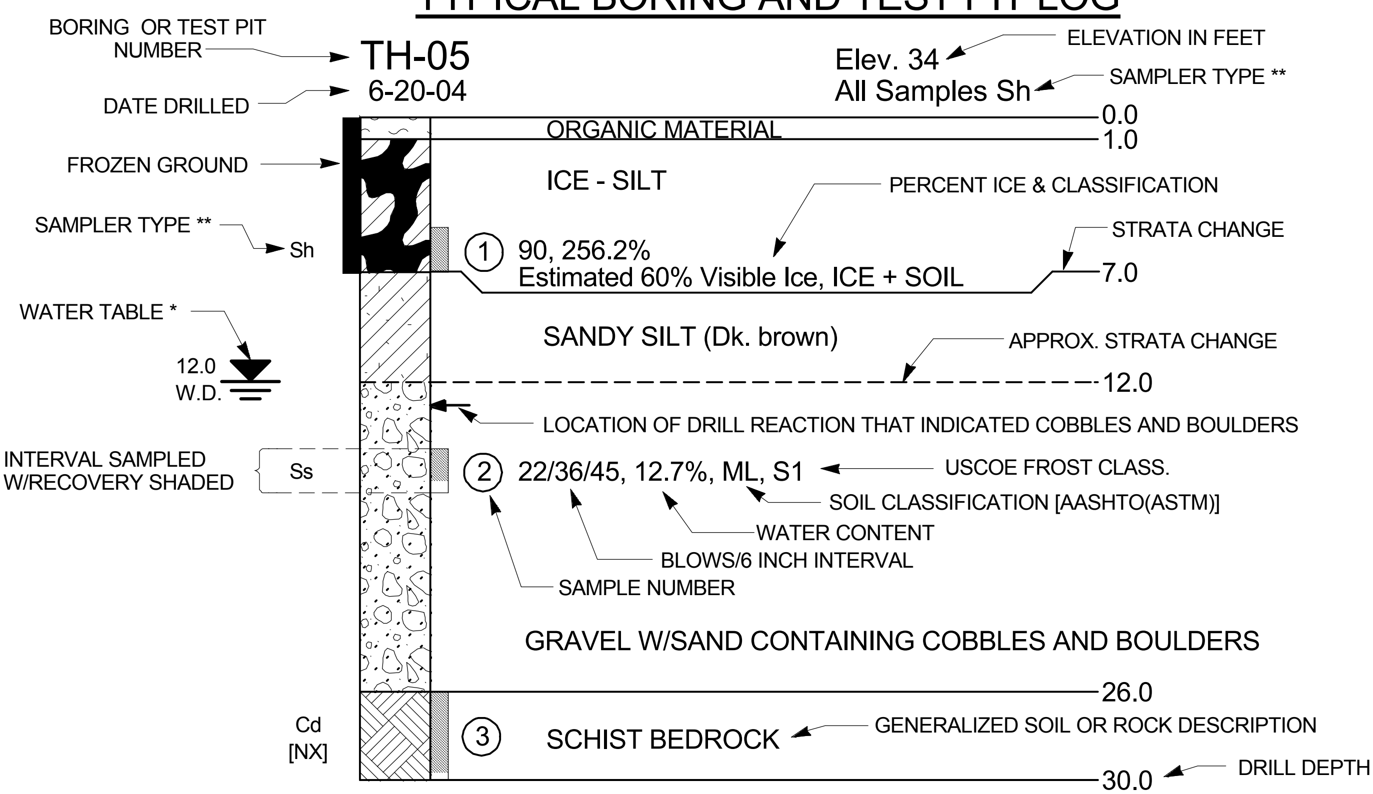
(The symbols shown above are frequently used in combinations, e. g. GRAVEL W/SILT AND SAND)

SAMPLER TYPE SYMBOLS

A	Auger Sample	Sh	2.5 In. Split Spoon w/340 lb. Manual Hammer	Sp	2.5 In. Split Spoon Pushed
C	Cuttings Sample	Sha	2.5 In. Split Spoon w/340 lb. Auto Hammer	Sz	1.4 In. Split Spoon w/340 lb. Hammer
Cd	Double Tube Core Barrel	Sl	2.5 In. Split Spoon w/140 lb. Hammer	Ts	Shelby Tube
Ct	Triple Tube Core Barrel	Ss	1.4 In. Split Spoon w/140 lb. Manual Hammer	Tm	Modified Shelby Tube
Cs	Auger Core Barrel	Ssa	1.4 In. Split Spoon w/140 lb. Auto Hammer	[x]	Sampler I. D. (Added to Symbol)
G	Grab Sample				

NOTE: Sampler types are either noted above the boring log or adjacent to it at the respective depth. An individual log may not utilize all of the items listed.

TYPICAL BORING AND TEST PIT LOG



* W.D. - WHILE DRILLING, A.B. - AFTER BORING, Ref. - SAMPLER REFUSAL
** - REFER TO SAMPLER SYMBOL (Ss, Sh, ETC.) FOR SAMPLER I.D. & HAMMER WEIGHT/TYPE
NOTE: Water levels shown on the boring logs are the levels measured in the boring at the times indicated.

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JUNE 04
SCALE:	NONE

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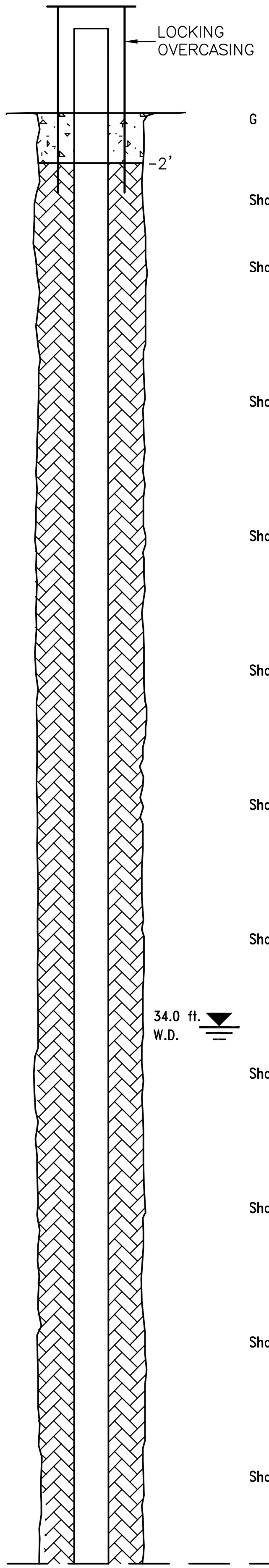
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

EXPLANATION OF SELECTED SYMBOLS

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	B-02

Z:\PROJECT\1209.10\LOGS\B01&B02.GDW (DRAWING T - B-02 COE (ENG.) (CURRENT)) 2/14/07 03:39 PM

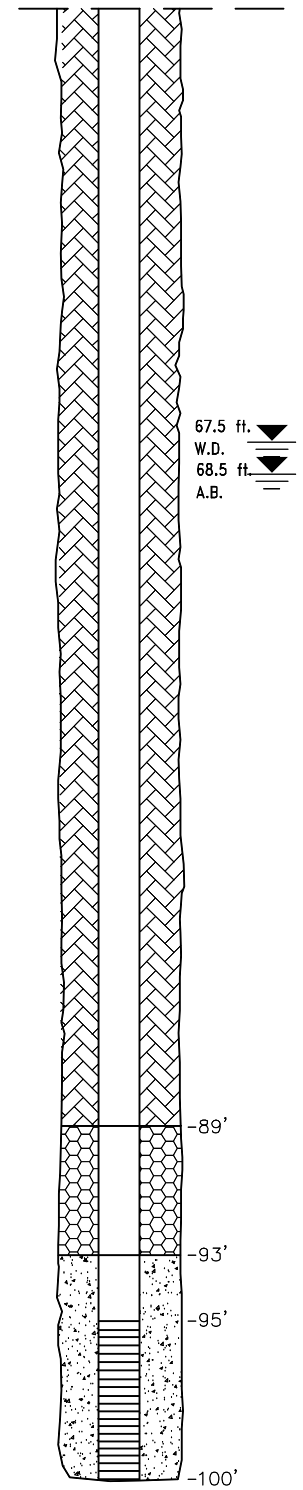


AP-608-MW (TB-1a)

N 2,395,412.81
E 1,413,139.72 Elev. 88.4
11/17/06

Depth	Sample	Description
0.0	G (1)	ML*, F4*
0.5		SILT CONTAINING ORGANICS
	Sha (2)	5/12/10, ML*, F4*
	Sha (3)	3/3/4, 27%, ML*, F4 Gr=3, Sa=45, Fines=52
		SANDY SILT (FILL) (Dk. brown, Trace gravel to 1/2" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Loose, Moist)
	Sha (4)	1/2/2, ML*, F4*
	Sha (5)	2/2/2, ML*, F4* Fragments of glass in bottom of sample
17.5		Drilled fast and smooth to 27.5 feet
	Sha (6)	3/8/10, SP*, NFS*
		POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry)
	Sha (7)	8/12/15, 4.3%, SP, NFS* Gr=1, Sa=95, Fines=3.7
		Ferruginous cementation 27.5 to 30 feet, tougher drilling.
	Sha (8)	7/8/6, SP*, NFS*
		Drilled fast and slightly rough 30 to 37.5 feet.
32.5		POORLY GRADED SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Wet)
	Sha (9)	18/29/29, SP*, S2*
		Driller noted a gravel layer from 37.5 to 38.0 feet.
37.5		POORLY GRADED GRAVEL W/SAND
38.0		Driller indicated clay at 38.0 feet.
	Sha (10)	7/11/13, CL*, F3*, PP=4.5+ tsf
		SANDY LEAN CLAY (Dk. gray, Gravel to 3/4" dia., rounded to subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)
		Drilled slower, tighter, w/gravel hits 38 to 43 feet, Very slow and hard 43 to 45 feet.
45.0	Sha (11)	13/20/22, 2.3%, SP, NFS, Gr=12, Sa=86, Fines=1.8
		POORLY GRADED SAND (Dk. gray, Gravel to 1.5" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Dry)
47.0		SANDY LEAN CLAY (Dk. gray)
49.5		Drilled faster 45 to 50 feet.
	Sha (12)	9/12/16, SP*, NFS*
		POORLY GRADED SAND (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Dry)
54.0		

(Continued Above)



AP-608-MW (Continued)

11/17/06

Depth	Sample	Description
54.0		
	Sha (13)	6/12/18, 2.8%, SP, NFS Sa=99, Fines=1.3
		Drilled slow, very tight, bit smoking 50 to 60 feet.
	Sha (14)	6/16/19, SP*, NFS*
		Drilled faster and smooth 60 to 85 feet.
	Sha (15)	3/8/15, 9.7%, SP, NFS Gr=1, Sa=96, Fines=3.0
		Gravel increases with depth.
	Sha (16)	6/18/26, SP*, NFS Sampler overfilled
72.5		SANDY LEAN CLAY (Dk. gray, Trace gravel to 3/4" dia., subrounded, hard, Fine to coarse sand, Plastic, Very stiff, Dry)
	Sha (17)	6/11/12, CL*, F3, PP=3.0 tsf
77.5		POORLY GRADED SAND W/SILT (Dk. gray, Gravel to 1" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Wet)
	Sha (18)	18/35 blows for 6", 17%, SP-SM*, F2* Gr=6, Sa=83, Fines=11, Sampler overfilled
84.0		
	Sha (19)	6/18/23, 13%, CL, F4, PP=4.5+ tsf Gr=15, Sa=22, Fines=63, LL=24, PL=15, PI=9
		SANDY LEAN CLAY (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Layers of sand to 1/16" thick, irregular dip, Plastic, Very hard, Wet to dry)
	Sha (20)	7/13/18, CL*, F3*, PP=4.5+ tsf
		Drilled hard, slow, and smooth 85 to 100 feet.
	Sha (21)	6/12/18, 16%, CL, F4, PP=4.5+ tsf Gr=2, Sa=18, Fines=80, LL=27, PL=16, PI=11
97.5		POORLY GRADED SAND (Dk. gray, Fine sand, Nonplastic, Dense, Wet)
	Sha (22)	8/18/22 blows for 3", SP*, PFS* Sampler bouncing
101.2		

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 95 and 100 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

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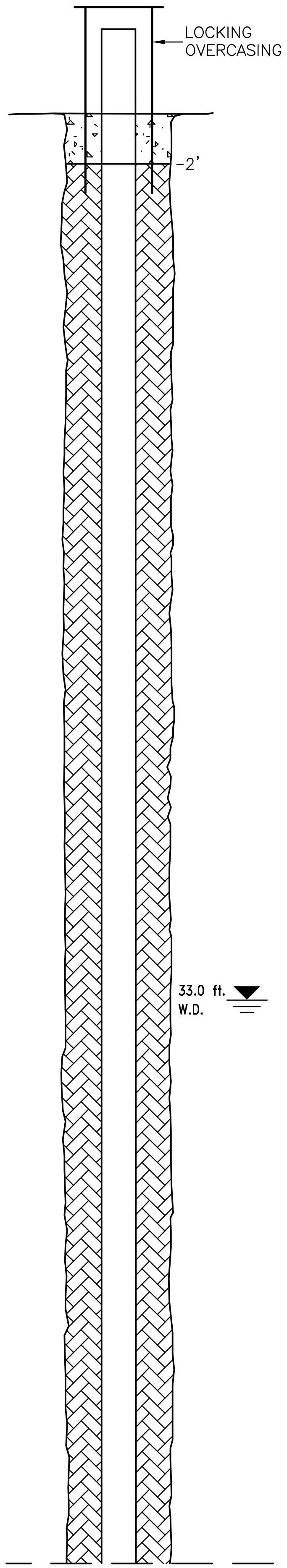
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-608-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-03

project\1209.10\geo\KENAI AP-608-MW (1a), 1=1, 01/17/07 at 11:29 by pkh

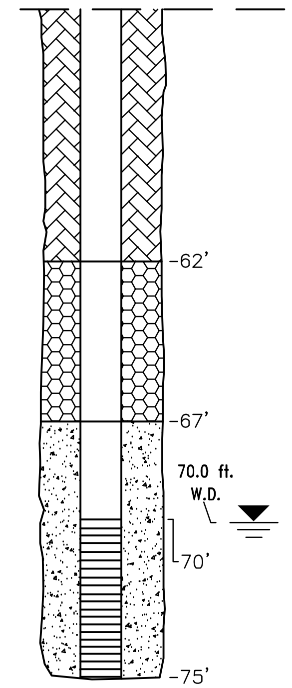


AP-609-MW (TB-1b)

N 2,395,415.41
E 1,413,150.90
Elev. 88.6
11/18/06

Depth	Description
0.0 – 0.5	SILT CONTAINING ORGANICS
0.5 – 17.5	Drilled fast and smooth to 25 feet. SANDY SILT (FILL) (Dk. brown, Gravel to 1/2" dia., Fine to medium sand, Nonplastic). Driller indicated looser material at about 17.5 feet.
17.5 – 37.5	POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry). Ferruginous cementation 25 to 30 feet, tougher drilling. Drilled fast and smooth to 30 to 37.5 feet. Drilled slightly rough 37.5 to 38 feet.
37.5 – 38.0	
38.0 – 44.0	Drilled tight and smooth 38 to 44 feet. SANDY LEAN CLAY (Dk. gray). Drilled tight and smooth 38 to 44 feet.
44.0 – 45.0	POORLY GRADED SAND W/GRAVEL. Drilled fast, slightly rough 44 to 45 feet.
45.0 – 46.0	POORLY GRADED SAND
46.0 – 47.0	POORLY GRADED SAND W/GRAVEL
47.0 – 54.0	Drilled fast and smooth 45 to 46 feet, Slightly rough 46 to 47 feet. POORLY GRADED SAND (Dk. gray, Gravel to 1.5" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Dense, Dry)

(Continued Above)



AP-609-MW (Continued)

11/17/06

Depth	Description
54.0 – 76.2	Drilled fast and smooth 47 to 75 feet.
76.2	Sha (1) 6/12/18**, 9" heave, sampler floated, SP-SM*, F2*

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 70 and 75 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

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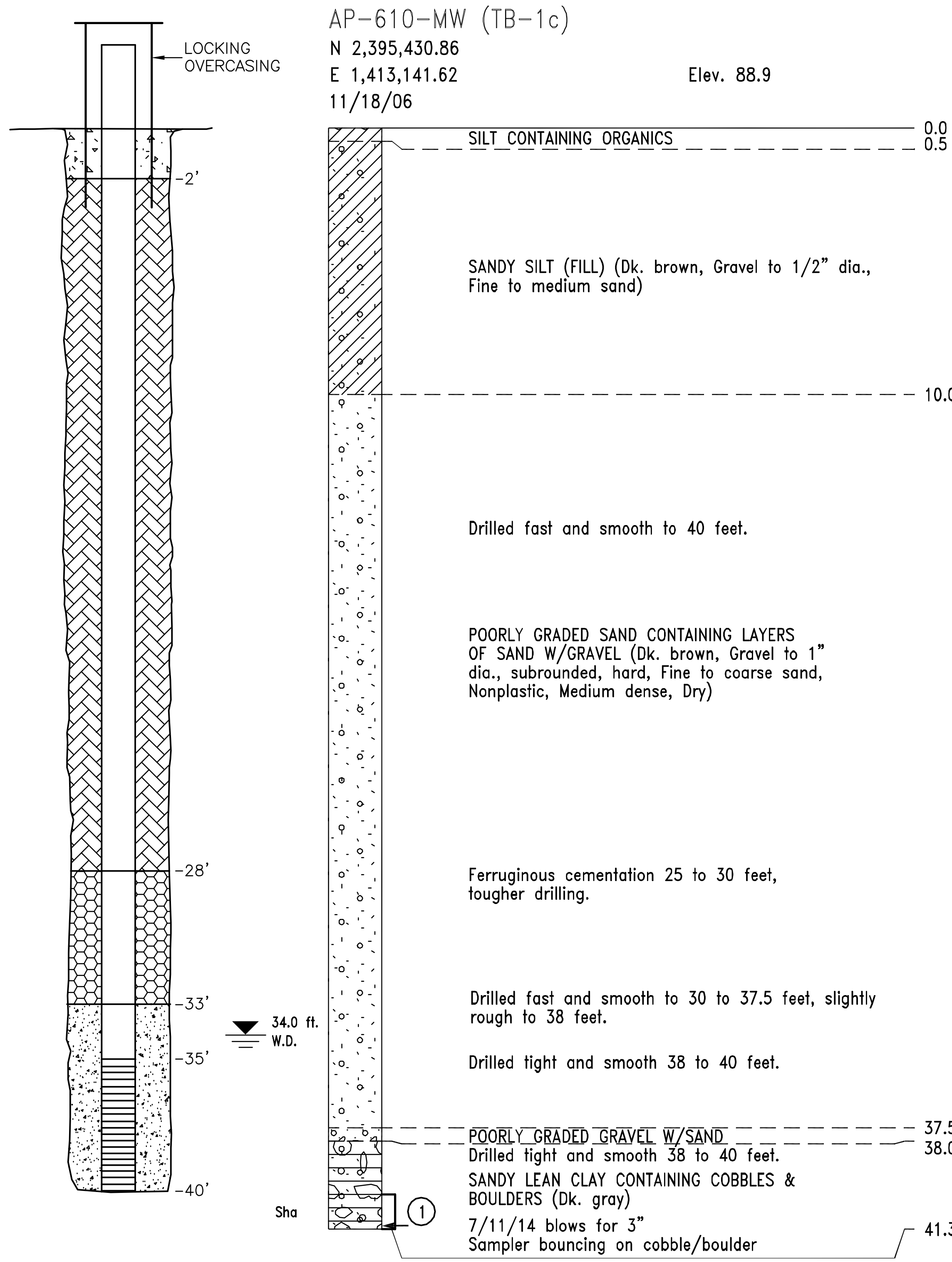
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-609-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-04

project\1209.10\geo\KENAI AP-609-MW (1b), 1=1, 01/17/07 at 11:38 by pkh



Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 35 and 40 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

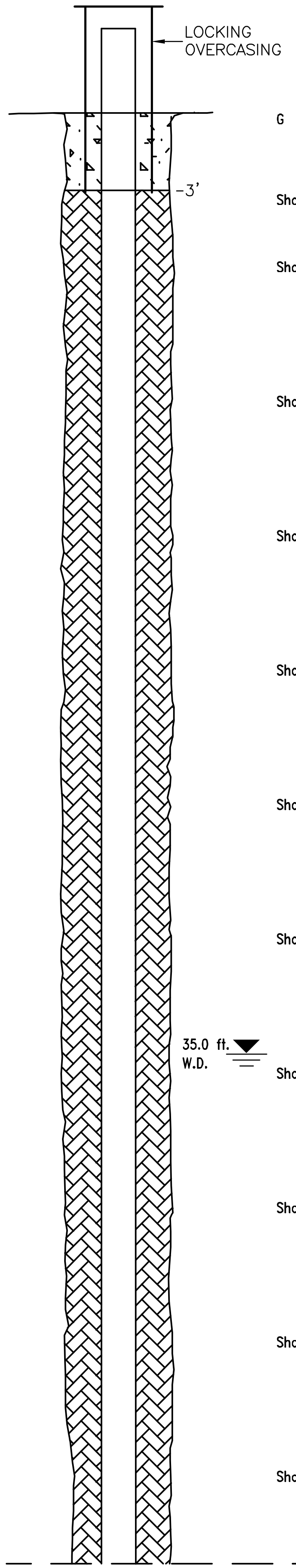
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-610-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-05



AP-611-MW (TB-2c)

N 2,395,775.73
E 1,414,431.97 Elev. 91.1
11/14/06 - 11/15/06

0.0

G (1) ML*, F4*
SILT (Dk. brown)

2.5

Sha (2) 1/2/3, 10%, SM*, F3*, Gr=2, Sa=71, Fines=27
SILTY SAND (Dk. brown, Fine to medium sand, Nonplastic, Loose, Dry)

4.0

Sha (3) 2/4/3, SP*, NFS*
POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Loose to medium dense, Dry to wet)

Sha (4) 2/5/6, SP*, NFS*
Drilled fast and smooth w/fine gravel to 38 feet.

Sha (5) 2/4/4, 3.5%, SP, NFS, Gr=7, Sa=92, Fines=1.2

Sha (6) 4/6/8, SP*, NFS*

Sha (7) 3/5/8, SP*, NFS*

Sha (8) 3/7/6, 5.1%, SP, NFS, Gr=6, Sa=91, Fines=3

Sha (9) 2/4/6, SP*, NFS*
Driller indicated clay encountered at 38 feet.

38.0

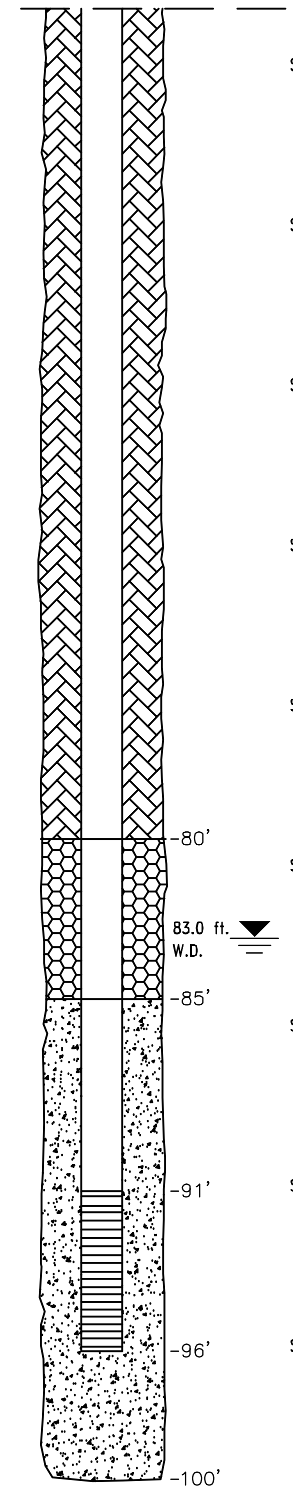
Sha (10) 6/9/14, CL*, F3*
SANDY LEAN CLAY (Dk. gray, Gravel to 1.5" dia., rounded to angular, hard, Fine to medium sand, Plastic, Very hard, Dry)

Sha (11) 8/12/16, CL*, F3*
Drilled moderately fast, smooth and tight 38 to 83 feet.

Sha (12) 6/11/14***, 11%, CL, F4
Gr=22, Sa=18, Fines=60, LL=27, PL=16, PI=11

54.0

(Continued Above)



AP-611-MW (Continued)

11/14/06 - 11/15/06

54.0

Sha (13) 3/7/11***, CL*, F4*

Sha (14) 7/12/16***, 15%, CL, F4
Gr=2, Sa=26, Fines=72, LL=26, PL=16, PI=10

Sha (15) 8/17/21***, CL*, F4*
Sampler overfilled

Sha (16) 10/12/13***, 18%, CL, F4
Sa=25, Fines=75, LL=22, PL=14, PI=8

Sha (17) 8/16/18***, 15%, CL, F4
Gr=1, Sa=21, Fines=78.0, LL=24, PL=16, PI=8

Sha (18) 8/12/19, CL*, F3*
Fine sand layers <1/4" thick

83.0

Sha (19) 10/21 blows for 6" **, SP*, S2*
6" heave, Sampler floated
POORLY GRADED SAND (Black, Fine angular sand, Nonplastic, Medium dense, Wet)

Sha (20) 2/6/10**, SP*, S2*
15 feet of heave after sample 19, pulled auger back 15 feet, and redrilled to 90 feet. 12" heave at 90 feet, sampler floated.

95.0

Sha (21) 3/5/7, CL*, F3*, PP=4.5+ tsf
SANDY LEAN CLAY (Dk. gray, Trace gravel to 1/2" dia., subrounded to subangular, hard, Fine to coarse sand, Plastic, Very hard, Dry)

Sha (22) 3/6/8, 20%, CL*, F3*, PP=4.5+ tsf
Sa=18, Fines=82

101.5

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with plastic liners.
Unconsolidated-undrained triaxial compression test performed on samples #12, #14, and #16.

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 91 and 96 ft.
2. Installation was uneventful.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

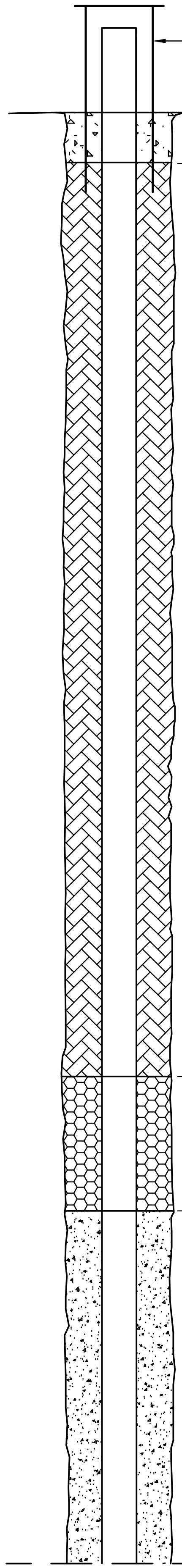
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-611-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-06



AP-612-MW (TB-2b)

N 2,395,786.22
E 1,414,437.68 Elev. TBD
11/15/06 – 11/16/06

0.0

SILT (Dk. brown)

2.5

POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Dry to wet)

Drilled fast and smooth w/fine gravel to 38 feet.

Color change to red-brown at 30 feet, may indicate ferruginous cementation.

Driller indicated clay encountered at 38 feet.

38.0

Drill reaction indicates pieces of gravel in top 1-inch of clay.

Gravelly layer at 43 feet.

Soft sand layer between 44 and 44.5 feet.

SANDY LEAN CLAY (Dk. gray, Gravel to 1.5" dia., rounded to angular, hard, Fine to medium sand, Plastic, Very hard, Dry)

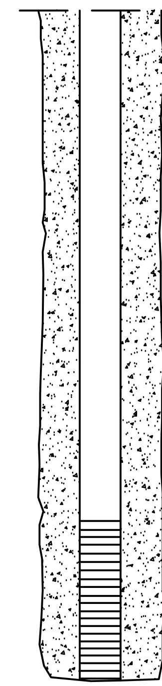
Drilled slower, tight, and smooth 38 to 75 feet.

54.0

(Continued Above)

AP-612-MW (Continued)

11/17/06



54.0

Pieces of fine gravel between 45 and 75 feet.

Sha ① 1/5/6, CL*, F3*, PP=4.5+ tsf

76.5

* Estimated Classification

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 70 and 75 ft.
2. Silica sand bridged in augers and bridge could not be removed until augers were pulled to 40 feet.
3. Sand from upper sand unit caved into hole to a depth of 41 feet.
4. Well appeared to be measuring water level of upper aquifer.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

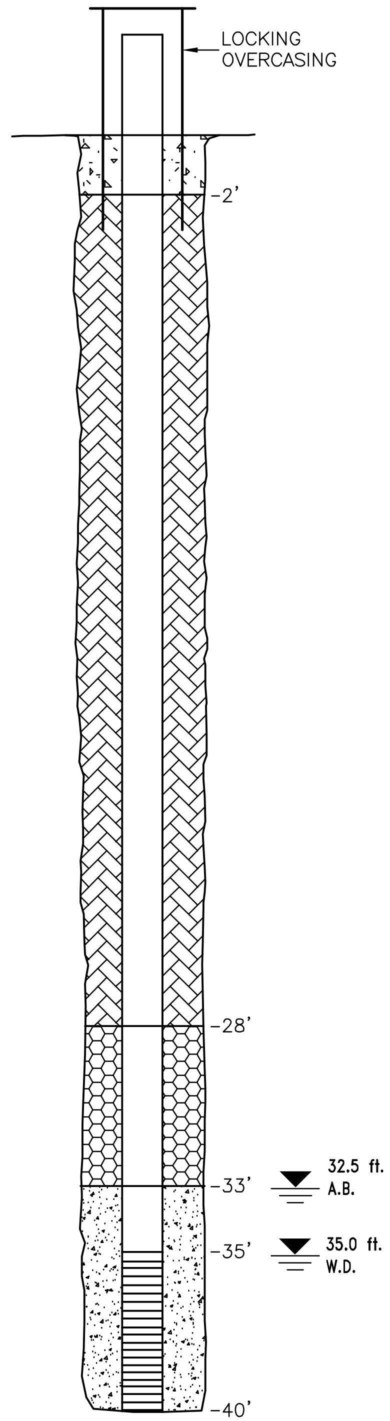
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-612-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-07



AP-613-MW (TB-2a)

N 2,395,795.10
E 1,414,440.67
11/15/06

Elev. 91.0

0.0 — SILT (Dk. brown)

2.5 — POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Fine to coarse sand, Nonplastic, Dry to wet)

Drilled fast and smooth w/fine gravel to 38 feet.

Color change to red-brown at 30 feet, may be ferruginous cementation.

Driller indicated gravel encountered on top of clay at 38 feet.

38.0 — SANDY LEAN CLAY (Dk. gray)

Sha (1) 4/8/12, CL*, F3*, PP=4.5+ tsf

41.5

* Estimated Classification

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

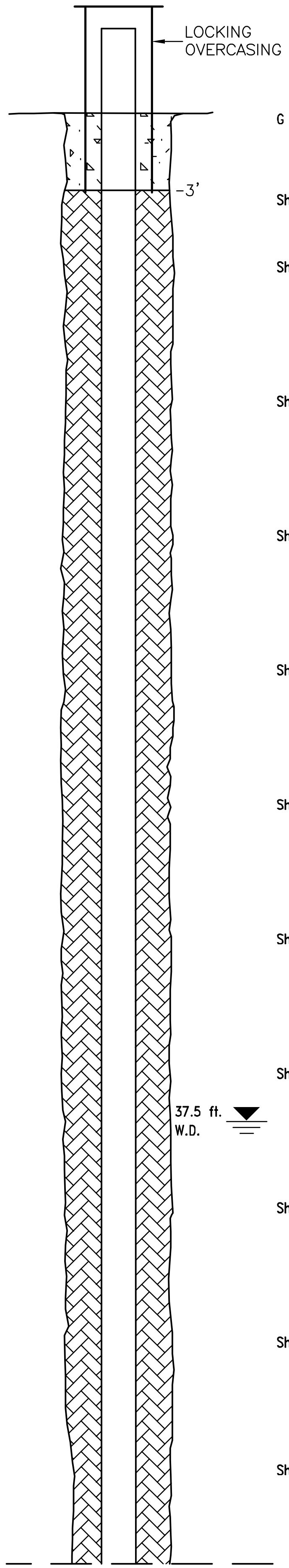
1. Screen w/prepacked sand was installed between 35 and 40 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	TEST BORING LOG AP-613-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-08



AP-614-MW (TB-3a)

N 2,396,258.31
E 1,415,755.43
Elev. 93.9
11/11/06

G
0.0
(1) ML* to SM*, F4*
SILT GRADING TO SILTY SAND (Dk. brown, Fine to coarse sand, Nonplastic)
1.0
Sha
(2) 1/4/6, SM*, F3*
SILTY SAND GRADING TO POORLY GRADED SAND (Dk. brown, Fine sand, Nonplastic, Medium dense, Dry)
4.0
Sha
(3) 3/4/4, 5.8%, SP, PFS*
Gr=11, Sa=85, Fines=4.2

Sha
(4) 3/6/8, SP*, NFS*

POORLY GRADED SAND TO SAND W/SILT CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 1" dia., subrounded to rounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry)

Sha
(5) 2/5/6, 4.8%, SP, NFS*
Sa=97, Fines=3.1

Drilled fast and smooth to 32.5 feet.

Sha
(6) 2/4/6, SP*, NFS*

Ferruginous cementation 22.5 to 32.5 feet.
24.0

Sha
(7) 7/10/15, 4.9%, SP-SM*, S2*
Sa=95, Fines=5.3

Sha
(8) 6/10/11, SP*, NFS*
Driller indicated change at 32.5 feet.
32.5
Drilled fast and slightly rough 32.5 to 42.5 feet.

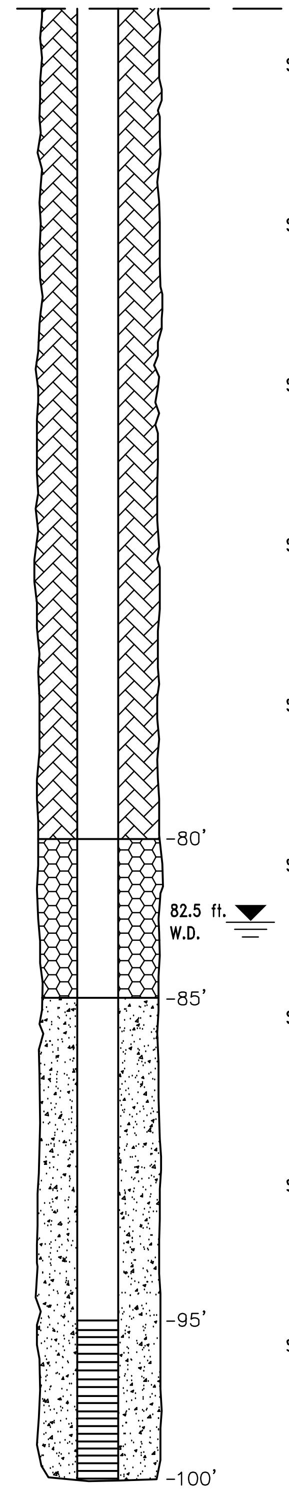
Sha
(9) 8/18/22, 2.4%, SP-SM*, S2
Gr=32, Sa=63, Fines=5.5, P.02=3.3
POORLY GRADED SAND W/SILT AND GRAVEL (Dk. brown, Gravel to 1.5" dia., subrounded to rounded, hard, Fine to coarse sand, Nonplastic, Medium dense to dense, Dry to wet)

Sha
(10) 10/12/10, SP-SM*, S2*
42.5
Driller indicated gravel layer at 42.5 feet.
Drilled slightly rough and tight 42.5 to 52.5 feet.

Sha
(11) 10/15/16, 16%, SC*, F3*, Gr=2, Sa=56, Fines=42
Gravel layer to 6" thick at 47.5 feet.
CLAYEY SAND W/GRAVEL LAYERS CONTAINING COBBLES & BOULDERS (Dk. gray, Gravel subrounded to angular, hard, Fine to coarse sand, Sand layers to 1/4" thick, Plastic, Very hard, Dry)

Sha
(12) 12/32 blows for 6", CL*, F3*, Sampler bouncing on cobble/boulder
52.5

(Continued Above)



AP-614-MW (Continued)

11/17/06

Sha
(13) 10/20/18***, 14%, CL, F4, Gr=1, Sa=20, Fines=79, LL=24, PL=15, PI=9, SG=2.682

SANDY LEAN CLAY TO LEAN CLAY W/SAND (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)

Sha
(14) 5/12/16***, 13%, CL, F4
Gr=3, Sa=22, Fines=75, LL=27, PL=15, PI=12

Drilled moderately fast, smooth and tight 52.5 to 82.5 feet.

Sha
(15) 7/12/19***, 16%, CL*, F4*

Sha
(16) 7/9/14***, 17%, CL, F3
Gr=2, Sa=19, Fines=79, LL=31, PL=18, PI=13

Sha
(17) 8/14/15, 15%, CL*, F3*
Gr=4, Sa=43, Fines=53, Thin layers of sand

Sha
(18) 6/10/10, 17%, CL*, F3*
Gr=2, Sa=22, Fines=76, P.02=52.8
82.5
Drilled fast, easy and smooth 82.5 to 100 feet.

Sha
(19) 7/17 blows for 6"**, 18%, SC*, F3*, Gr=6, Sa=64, Fines=30, 6" heave, sampler floated, sampler overfilled
POORLY GRADED SAND CONTAINING LAYERS OF LEAN CLAY (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine to medium sand, Nonplastic, Medium dense, Wet)
87.5

Sha
(20) 6/12/11**, SP-SM*, S2*
18" heave, sampler floated
POORLY GRADED SAND TO SAND W/SILT (Dk. gray, Fine to medium sand, Nonplastic, Medium dense to dense, Wet)

Sha
(21) 7/15/17**, 24" heave sampler floated

Sha
(22) 6/10/17**, 24%, SP-SM*, S2*
Sa=94, Fines=6.1, 24" heave, sampler floated
101.5

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with plastic liners.
Consolidated undrained triaxial compression test performed on samples #13, #14, and #15.

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 95 and 100 ft.
2. Due to heaving conditions the screen could not be placed down the hole and the augers were reinstalled with a wooden plug. Otherwise installation was uneventful.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

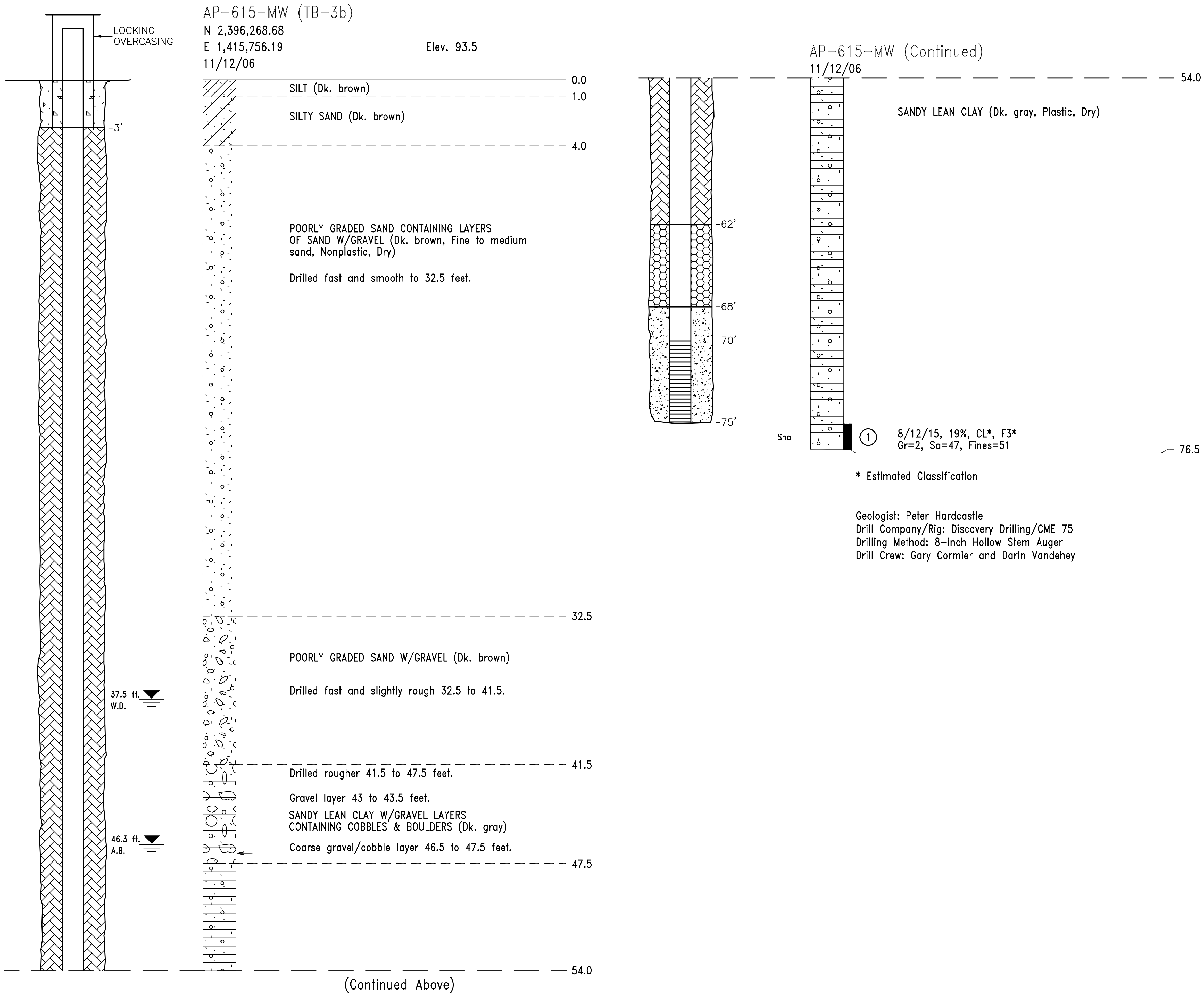
R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-614-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	B-09

project\1209.10\geo\KENAI AP-614-MW (3a), 1=1, 02/13/07 at 09:40 by kjp



* Estimated Classification

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 70 and 75 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

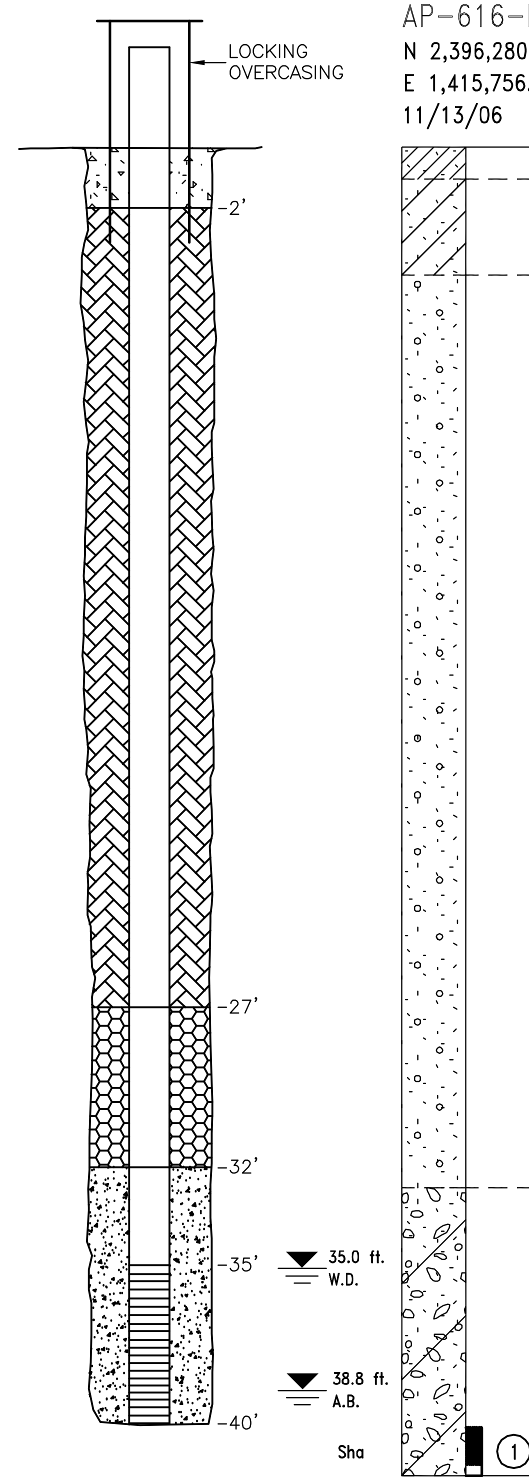
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-615-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-10

project\1209.10\geo\KENAI AP-615-MW (3b), 1=1, 01/17/07 at 08:57 by pkh

AP-616-MW (TB-3c)

N 2,396,280.50
E 1,415,756.60
11/13/06
Elev. 93.7



0.0 — SILT (Dk. brown)

1.0 — SILTY SAND GRADING TO POORLY GRADED SAND (Dk. brown, Nonplastic)

4.0 — POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Fine to medium sand, Nonplastic, Dry)

Drilled fast and smooth to 32.5 feet.

32.5 — POORLY GRADED SAND W/GRAVEL (Dk. brown)

Drilled fast and slightly rough 32.5 to 40 feet.

(1) 10/9/11***, SP*, S2*

41.5

* Estimated Classification
*** Sampler driven with plastic liners.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger Drill
Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screen w/prepacked sand was installed between 35 and 40 ft.
2. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

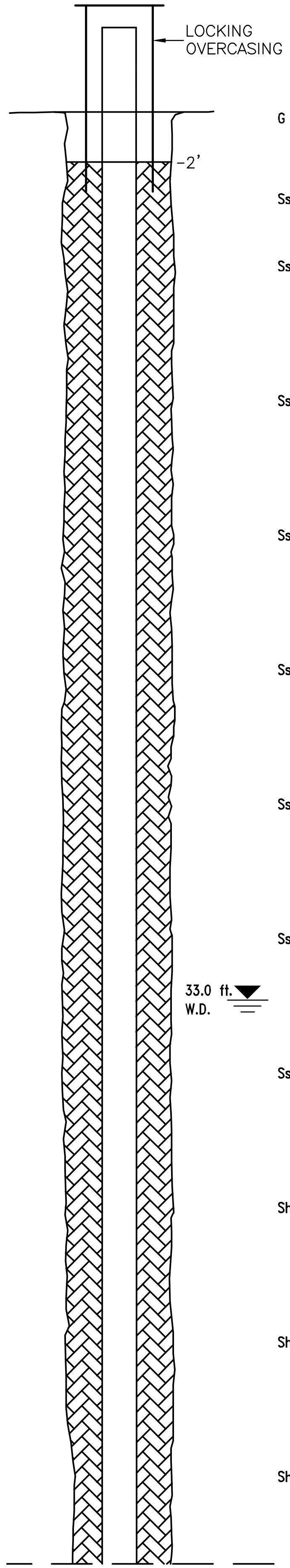
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-616-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-11

project\1209.10\geo\KENAI AP-616-MW (3c), 1=1, 01/17/07 at 09:51 by pkh

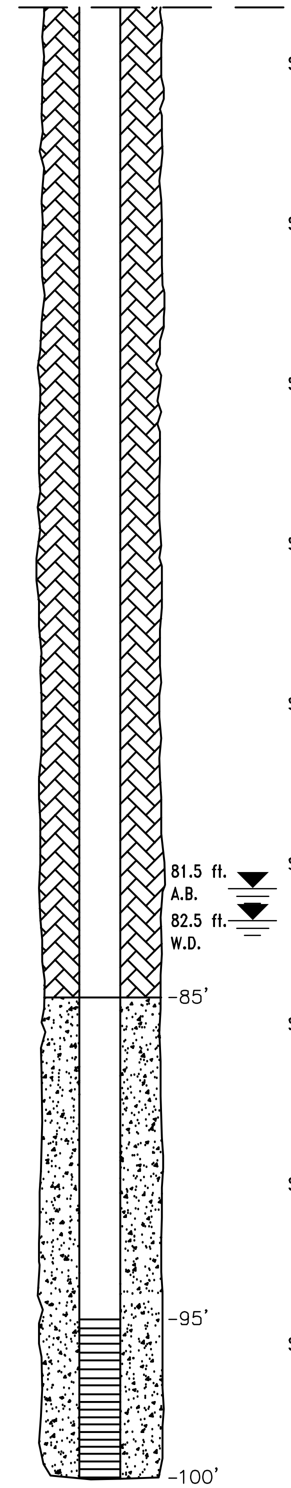


AP-617-MW (TB-4a)

N 2,396,189.80
E 1,416,979.96 Elev. 92.9
11/19/06

Sample type	Depth (ft)	Sample	Description
G	0.0		ORGANIC MAT
	0.2	①	SM*, F3*
			SILTY SAND GRADING TO SAND (Dk. brown, Gravel to 1/4" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dry)
Ssa		②	5/8/9, SM*, F3*
	4.0		
Ssa		③	3/5/5, SP*, NFS*
			POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 3/8" dia., subrounded, hard, Fine to medium sand, Nonplastic, Medium dense, Dry)
Ssa		④	3/7/10, 6.5%, SP, PFS* Gr=1, Sa=95, Fines=3.9
Ssa		⑤	3/12/15, SP*, NFS*
Ssa		⑥	4/12/11, SP*, NFS* Drilled fast and smooth to 39.5 feet.
Ssa		⑦	3/5/10, 8.4%, SP, NFS*, Sa=96, Fines=4.3. Ferruginous cementation in portions of sample, Fragments of carbonized wood in sample
Ssa		⑧	3/11/16, SP*, NFS* Ferruginous cementation in portions of sample
Ssa		⑨	7/18/27, SP*, NFS*
			Driller indicated clay at 39.5 feet.
	39.5		
Sha		⑩	5/7/12, CL*, F3*, PP=4.5+ tsf, Pocket penetrometer leaves little impression
			Drilled moderately fast, tight, and smooth 39.5 to 55 feet.
Sha		⑪	5/11/12, 15%, CL*, F3* Gr=7, Sa=39, Fines=54, PP=4.5+ tsf, Pocket penetrometer doesn't leave impression, Fine sand layer to 1/8" thick, dipping at ~50°
Sha		⑫	15/35 blows for 6"**, CL*, F3* 12" heave in augers, sampler floated
			Drilled faster and smooth 55 to 60 feet.
	54.0		

(Continued Above)



AP-617-MW (Continued)

11/19/06

Sample type	Depth (ft)	Sample	Description
	54.0		
Sha		⑬	9/11/12***, 13%, CL, F3 Gr=16, Sa=21, Fines=63, LL=31, PL=18, PI=13
			SANDY LEAN CLAY W/GRAVEL TO LEAN CLAY W/SAND (Dk. gray, Gravel to 1.5" dia., subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)
Sha		⑭	4/10/19, 15%, CL, F3, PP=4.5+ tsf Gr=6, Sa=23, Fines=71, LL=33, PL=17, PI=16
			Drilled slow and tight 60 to 75 feet.
Sha		⑮	8/16/22, CL*, F3*, PP=4.5+ tsf Sand layer to 6" thick
			Drilled slow and tight 70 to 75 feet.
Sha		⑯	5/10/13, 13%, CL*, F3*, PP=4.5+ tsf Gr=7, Sa=19, Fines=74, LL=27, PL=16, PI=11, SG=2.724
Sha		⑰	3/7/10, 15%, CL*, F3*, PP=4.5+ tsf Gr=21, Sa=28, Fines=51, P.02=36.2 Drilled fast and smooth 75 to 85 feet.
Sha		⑱	6/9/14, 14%, CL, F4 Gr=3, Sa=28, Fines=69, LL=24, PL=16, PI=8
			Drilled easy and smooth 85 to 90 feet.
	85.0		
Sha		⑲	4/7/11, SP & CL*, PFS & F3*
			POORLY GRADED SAND CONTAINING LAYERS OF LEAN CLAY (Dk. gray, Fine sand, Nonplastic sand and plastic clay, Medium dense, Wet) Drilled slower and smooth 90 to 92.5 feet
	90.0		
Sha		⑳	3/7/12, 17%, CL*, F3*, PP=3.5 tsf, Gr=4, Sa=20, Fines=76
			LEAN CLAY W/SAND (Dk. gray, Gravel to 1/4" dia., subrounded, hard, Plastic, Very stiff, Moist)
	92.5		
			POORLY GRADED SAND (Dk. gray, Fine to medium sand, Nonplastic, Medium dense, Wet)
Sha		㉑	3/5/7**, 6 ft. of heave after sampling
			Drilled fast and smooth 92.5 to 100 feet.
Sha		㉒	18/28/11**, SP*, PFS* 5 ft. of heave, Sampler floated down and sanded in
	101.5		

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
One-dimensional consolidation test performed on sample #16.
Unconsolidated-undrained triaxial compression test performed on sample #13.

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES:

1. Due to heaving conditions the screen could not be placed down the hole and the augers were reinstalled with a wooden plug.
2. Screen w/prepacked sand was installed between 95 and 100 ft.
3. Unable to get bentonite down hole due to slurry in hole.
4. Pulled augers to 40 feet and backfilled with grout to surface. Grout sank to 35 by the next morning.
5. Additional grout was placed in hole until it came to within 2 feet of surface.
6. Water measurement indicated that the grout had sealed off the upper aquifer.
7. Water levels were observed to changed over time, apparently relative to the tides.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

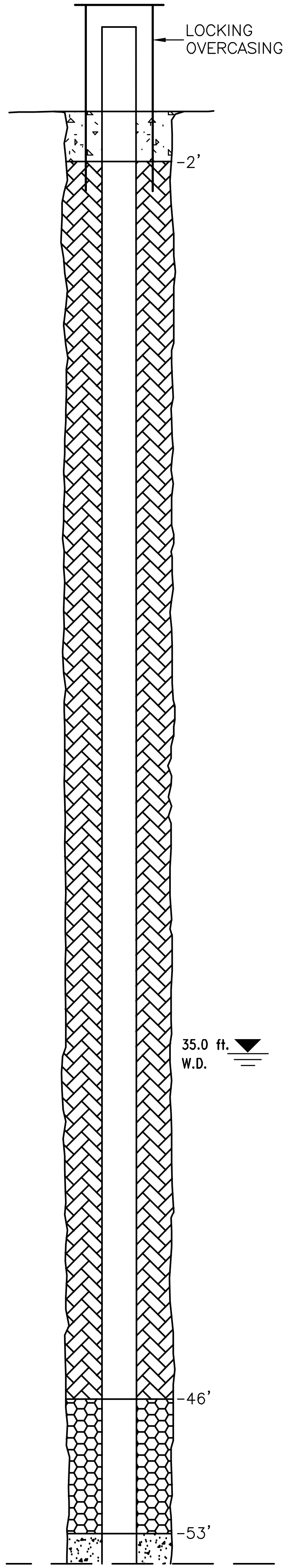
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	TEST BORING LOG
SUBMITTED: C.H.R.	AP-617-MW

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	B-12

project\1209.10\geo\KENAI AP-617-MW (4a), 1=1, 02/13/07 at 09:41 by kjp



AP-618-MW (TB-4b)

N 2,396,207.48
E 1,416,981.72 Elev. 93.1
11/20/06

0.0
SILT CONTAINING ORGANICS (Dk. brown)
0.5
SILTY SAND (Dk. brown, Gravel to 1/4" dia., rounded to subrounded, hard, Fine to coarse sand, Nonplastic, Dry)
4.0
POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown)

Drilled fast and smooth to 35.0 feet. Faster to 40 feet.

Driller indicated clay at 39.5 feet.
39.5
Smooth drilling alternated between slow and fast 40 to 45 feet. Tight hard drilling from 45 to 48 feet, faster 48 to 50 feet.

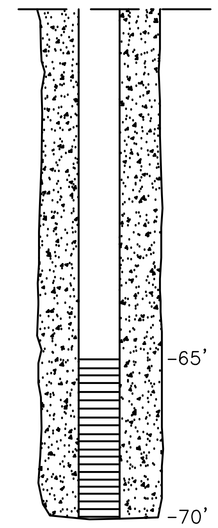
SANDY LEAN CLAY CONTAINING LAYERS OF POORLY GRADED SAND (Dk. gray, Gravel to 1.5" dia., subrounded, hard, Fine to coarse sand, Plastic, Very hard, Dry)

Drilled fast and smooth 50 to 50.5 feet, slower 50.5 to 51 feet. Rough from 51 to 53 feet, and faster and smooth 53 to 55 feet.
51.0
SANDY LEAN CLAY CONTAINING COBBLES & BOULDERS (Dk. gray, Plastic, Very hard, Dry)
53.0
54.0

(Continued Above)

AP-618-MW (Continued)

11/20/06



54.0
Drilled slow and tight 55 to 56.5 feet. Faster and smooth w/ occasional small cobbles 56.5 to 60 feet.

POORLY GRADED SAND CONTAINING LAYERS OF LEAN CLAY (Dk. gray)

Drilled fast 60 to 63 feet, slower and tighter 63 to 65 feet.
Drilled fast and smooth 65 to 68 feet, tighter 68 to 70 feet.
68.0
SANDY LEAN CLAY (Dk. gray, Plastic)
70.0

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Hole was drilled with wooden plug in end of augers.
2. Screen w/prepacked sand was installed between 65 and 70 ft.
3. Installation was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

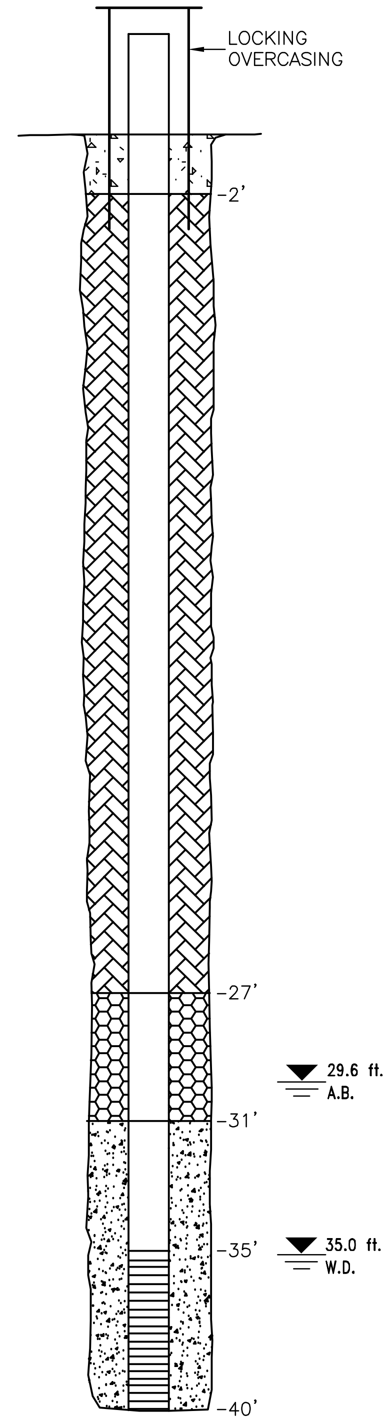
CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	TEST BORING LOG AP-618-MW

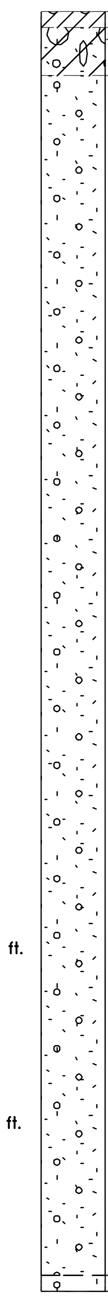
DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-13

project\1209.10\geo\KENAI AP-618-MW (4b), 1=1, 01/17/07 at 09:50 by pkh

AP-619-MW (TB-4c)

N 2,396,224.77
E 1,416,982.32
Elev. 93.1
11/21/06





Depth (ft)	Description
0.0 – 0.5	SILT CONTAINING ORGANICS (Dk. brown)
0.5 – 2.0	SILTY SAND CONTAINING COBBLES & BOULDERS (FILL) (Dk. brown, Nonplastic, Dry)
2.0 – 39.5	POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown)
39.5 – 40.0	SANDY LEAN CLAY

Drilled rough to 2.0 feet.

Drilled fast and smooth 2.0 to 39.5 feet.

Driller indicated clay at 39.5 feet.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Hole was drilled with wooden plug in end of augers.
2. Screen w/prepacked sand was installed between 35 and 40 ft.
3. Hole walls caved to 31 feet when augers were withdrawn. Sand backfill is mixture of silica sand and natural sand.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

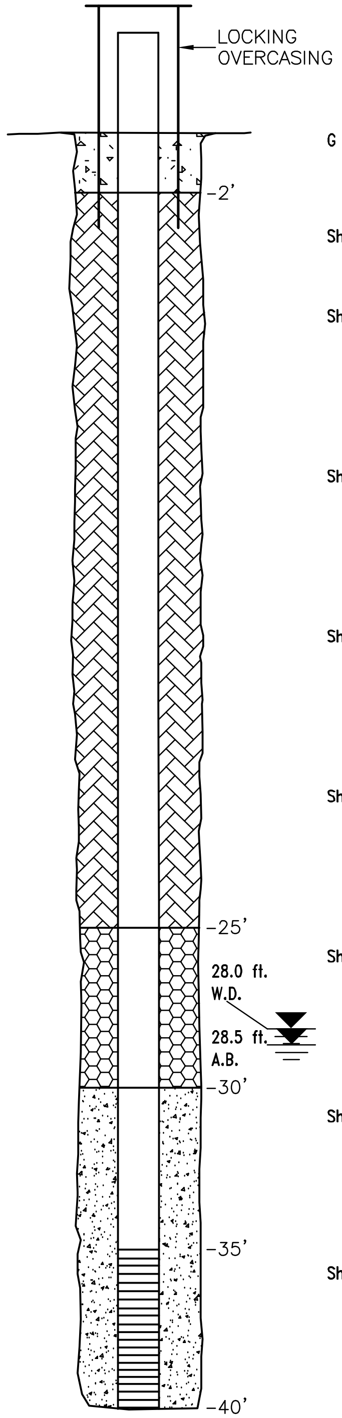
CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-619-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-14

project\1209.10\geo\KENAI AP-619-MW (4c), 1=1, 01/17/07 at 08:38 by pkh



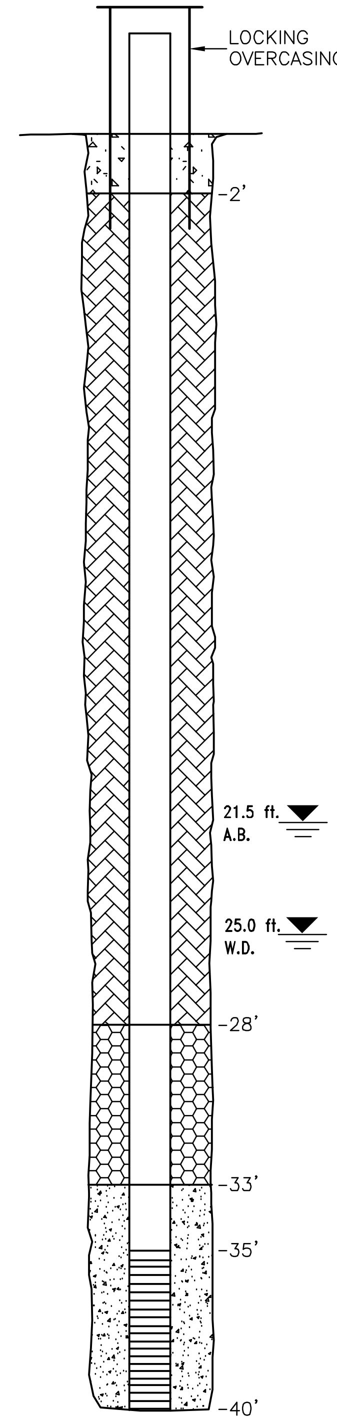
AP-620-MW (TB-02)

N 2,396,321.05
E 1,414,354.82 Elev. 92.2
11/13/06

Sampler	Depth	No.	Description
G	0.0	1	ML*, F4* SILT CONTAINING ORGANICS (Dk. brown)
Sha	2.5	2	3/3/5, 10%, SM*, F3*, Gr=2, Sa=76, Fines=22 SILTY SAND (Dk. brown, Fine to medium sand)
Sha	4.0	3	3/4/4, SP*, NFS* Drilled fast and smooth to 39 feet.
Sha		4	1/3/4, 5.1%, SP, NFS, Gr=7, Sa=92, Fines=1.7 POORLY GRADED SAND CONTAINING LAYERS OF SAND W/GRAVEL, Gravel to 2" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry becoming wet below 28 ft.
Sha		5	3/5/8***, 4.6%, SP, S2*, Sa=96, Fines=4.4, LL=NV, PL=NP, PI=NP, SG=2.716
Sha		6	5/8/8, 6.0%, SP, NFS*, Gr=1, Sa=95, Fines=3.9
Sha		7	3/6/12***, 7.6%, SP, NFS*, Gr=10, Sa=87, Fines=3.3
Sha		8	5/8/6, 21%, SP, NFS*, Gr=12, Sa=85, Fines=3.2
Sha		9	7/13/15 blows for 4"***, SP*, NFS* Sampler had a piece of wood blocking shoe. Driller indicated clay at 39 feet.
Sha	39.0	10	LEAN CLAY W/SAND CONTAINING COBBLES & BOULDERS (Dk. gray, Plastic, Very hard, Dry) 4/10/16 blows for 5"**, 16%, CL, F3, Gr=3, Sa=16, Fines=81, LL=35, PL=21, PI=14, SG=2.747, 1 foot of heave in augers, sampler floated. Sampler bouncing on cobble/boulder
	41.4		

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
One-dimensional consolidation performed on sample #10.
Constant head permeability test performed on sample #5.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey



AP-621-MW (TB-03)

N 2,396,759.77
E 1,417,031.71 Elev. 92.7
11/14/06

Sampler	Depth	No.	Description
G	0.0	1	SM*, F3* SILT W/ORGANICS (Dk. brown)
Sha	2.0	2	4/10/11, SP*, NFS*
Sha		3	3/9/8, 6.2%, SP, NFS, Gr=11, Sa=86, Fines=2.7 Drilled fast and smooth to 40 feet.
Sha		4	2/4/3***, SP*, NFS* POORLY GRADED SAND TO SAND W/SILT CONTAINING LAYERS OF SAND W/GRAVEL (Dk. brown, Gravel to 3/4" dia., subrounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Dry becoming wet below 28 ft.)
Sha		5	3/3/7, 7.7%, SP, S2*, Gr=1, Sa=95, Fines=4.3
Sha		6	4/6/7***, 12%, SP, NFS*, Gr=8, Sa=88, Fines=3.6
Sha		7	5/8/12, SP*, NFS*
Sha		8	3/6/12**, 19%, SP-SM*, S2*, Gr=2, Sa=92, Fines=6.5, 6" heave, sampler floated
Sha		9	3/7/10**, SP*, NFS*, 6" heave, sampler floated
Sha	40.0	10	6/11 blows for 1", Sampler bouncing on cobble/boulder GRAVEL W/SAND CONTAINING COBBLES & BOULDERS
	41.0		

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
Constant head permeability test performed on samples #4 and #6.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

MONITORING WELL LEGEND

- SCREEN - 0.010" SLOT
- 20/40 SILICA SAND
- BENTONITE (CHIPS)
- VOLCLAY GROUT
- CONCRETE

MONITORING WELL NOTES :

1. Screens w/prepacked sand were installed between 35 and 40 ft.
2. Caving sand prevented placement of silica sand through the augers until they had been pulled back 10 feet in AP-620-MW. Sand backfill was a mixture of silica sand and sand cave in.
2. Installation of AP-621-MW was uneventful.

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-620-MW & AP-621-MW
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
JAN. 2007	1209.10	AS SHOWN	B-15

AP-622 (TB-08)

N 2,395,300.06
E 1,412,903.84
Elev. 24.1
12/16/06

0.0
G ① ML*, F4*
SILT W/ SAND (Brown, Very fine to fine sand, Nonplastic)
1.5
SILT (Mottled gray and brown, Nonplastic, Firm, Moist)
Sh ② 2/2/33***, 37%, ML, F4
Sa=6, Fines=94, LL=49, PL=28, PI=21
6.5 ft. W.D.
Ts ③ ML*, F4*
6.5
POORLY GRADED SAND (Gray, Fine to coarse sand, Moist to saturated)
8.5
SILT (Nonplastic, Moist to wet)
Sh ④ 5//
10.5
⑤ //13/12, 10%, GP-GM*, F1*, Gr=48, Sa=43, Fines=9.1
POORLY GRADED GRAVEL W/SILT AND SAND (Brown, Gravel to 1" dia., rounded, hard, Fine to coarse sand, Nonplastic, Medium dense, Wet)
14.0
SILTY, CLAYEY SAND (Dk. gray, Gravel angular, hard, Plastic, Hard, Moist)
Sh ⑥ 6/18/26***, 14%, SC-SM, F4*
Gr=12, Sa=39, Fines=49, LL=18, PL=12, PI=6
16.5
SILTY GRAVEL W/SAND (Brown, Gravel subrounded, hard, Fine to coarse sand, Nonplastic)
18.0
POORLY GRADED SAND (Gray, Fine to coarse sand)
20.0
Sh ⑦ 6/18/18, 14%, CL*, F3*, PP=>4.5 tsf
LEAN CLAY W/SAND TO SANDY LEAN CLAY (Dk. gray, Plastic, Hard, Moist)
Sh ⑧ 11/16/21***, 14%, CL, F4
Gr=9, Sa=21, Fines=70, LL=25, PL=14, PI=11
Sh ⑨ 13/23/33, 17%, CL, F3
Sa=12, Fines=88, LL=29, PL=16, PI=13
31.5

* Estimated Classification
*** Sampler driven with brass liners.

Geologist: Kevin Pendergast
Drill Company/Rig: Discovery Drilling/CME 45
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

AP-623 (TB-07)

N 2,395,437.96
E 1,414,078.32
Elev. 20 (See note below)
12/16/06

0.0
ICE
0.5
G ① No recovery, grinding on cobble
POORLY GRADED SAND W/ GRAVEL (Gray, Gravel subrounded, hard, Fine to coarse sand)
2.0
Sh ② 6/7/6***, 8.2%, SP*, NFS*
Sh ③ 3/5/5, 3.8%, SP, NFS, Sa=98, Fines=1.6
Sh ④ 7/9/12, 13%, SP-SC*, F2*, Sa=90, Fines=10, Sample is contaminated with clay layer
POORLY GRADED SAND CONTAINING LAYERS OF SAND W/CLAY (Gray, Fine to medium sand, Nonplastic, Loose to medium dense, Dry to saturated)
14 ft. W.D.
Sh ⑤ 8/14/18**, 22%, SP, NFS, Sa=98, Fines=1.9, Sampler overfilled
Sampling was not successful between 20 ft. bgs and 30 ft. bgs due to excessive heave within the augers
Borehole was advanced to 30 ft. and soil description is based upon cuttings observation and rig reaction
30.0

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.

Geologist: Kevin Pendergast
Drill Company/Rig: Discovery Drilling/CME 45
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

AP-624 (TB-06)

N 2,395,725.08
E 1,414,587.74
Elev. 20 (See note below)
12/15/06

0.0
ICE
0.5
G ① 22%, GC*, F2, Gr=45, Sa=30, Fines=25, P.02=16.9
CLAYEY GRAVEL W/SAND (Dk. gray, Gravel to 2" dia., angular, hard, Fine sand, Plastic, Moist)
Sh ② 6//
3.0
③ //6/12, 21%, SP*, NFS*, Sa=96, Fines=4.5
POORLY GRADED SAND (Dk. gray, Fine to medium sand, Medium dense, Moist)
Sh ④ 10//, 18%, SP*, NFS*
5.5
⑤ //11/19, 18%, CL*, F4
LEAN CLAY W/SAND (Dk. gray, Gravel to 1.5" dia., rounded, hard, Plastic, Hard, Moist)
Sh ⑥ 5/12/16, 15%, CL, F3, PP=>4.5 tsf,
Gr=10, Sa=18, Fines=72, LL=29, PL=16, PI=13
13.5 ft. W.D.
13.5
POORLY GRADED SAND (Dk. gray, Fine to medium sand, Medium dense, Saturated)
Sh ⑦ 7/7//, 22%, SP, NFS, Sa=99, Fines=1.3
16.0
⑧ //6, 17%, CL, F4, Gr=1, Sa=26, Fines=73, LL=26, PL=15, PI=11
LEAN CLAY W/SAND (Dk. gray, Plastic, Hard, Moist)
17.0
Sampling was not successful between 20 ft. bgs and 30 ft. bgs due to excessive heave within the augers
POORLY GRADED SAND (Gray, Fine to coarse sand, Moist to saturated)
Borehole was advanced to 30 ft. and soil description is based upon cuttings observation and rig reaction
30.0

* Estimated Classification

Geologist: Kevin Pendergast
Drill Company/Rig: Discovery Drilling/CME 45
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

Note: The above test boring elevations for TB-06 and TB-07 were surveyed at the top of ice cover of varying thickness. The elevations shown were therefore determined by subtracting the estimated ice thickness at the time of survey from the elevation surveyed at the top of the ice. These elevations are estimated, and due to the thick snow and ice cover are considered only accurate to +/- 5 feet.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

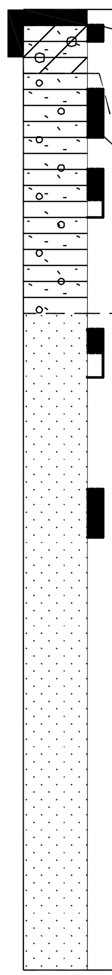
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	TEST BORING LOG AP-622 THRU AP-624
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
FEB. 2007	1209.10	AS SHOWN	B-16

project\1209.10\geo\KENAI AP-622-24, 1=1, 02/13/07 at 09:41 by kjp

AP-625 (TB-05)

N 2,396,055.30
E 1,415,467.21 Elev. 20 (See note below)
12/15/06



Sample type	No.	Description	Depth (ft)
		ICE	0.0
G	1	78%, CL-ML*, F4* Gr=10, Sa=35, Fines=55, P.02=39.1	0.5
		SANDY SILTY CLAY (Dk. gray, Gravel to 2" dia., rounded to subangular, hard, Fine to coarse sand, Plastic)	2.0
Sh	2	4/6/9, 17%, CL, F4, Gr=4, Sa=19, Fines=77, LL=27, PL=16, PI=11	
Sh	3	4/6/8***, 17%, CL, F4, Gr=2, Sa=17, Fines=81, LL=26, PL=16, PI=10	
		LEAN CLAY W/SAND (Dk. gray, Plastic, Hard, Moist)	9.5
Sh	4	2/10/18, 14%, SP, NFS, Gr=2, Sa=96, Fines=2.3	
		POORLY GRADED SAND (Gray, Fine to coarse sand, Moist to saturated)	
Sh	5	17/19/23**, 20%, SP, NFS, Sa=99, Fines=1.2	
		Sampling was not successful between 20 ft. bgs and 30 ft. bgs due to excessive heave within the augers	
		Borehole was advanced to 30 ft. and soil description is based upon cuttings observation and rig reaction	30.0

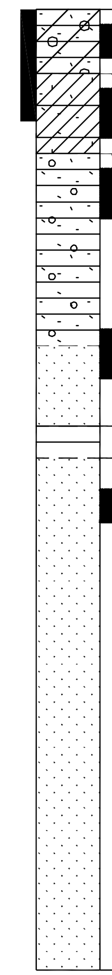
10 ft. W.D.

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.
*** Sampler driven with brass liners.
One-dimensional consolidation test performed on sample #3.

Geologist: Kevin Pendergast
Drill Company/Rig: Discovery Drilling/CME 45
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

AP-626 (TB-04)

N 2,396,137.75
E 1,416,086.29 Elev. 19 (See note below)
12/14/06



Sample type	No.	Description	Depth (ft)
		Cobbles observed on surface	0.0
G	1	SANDY SILTY CLAY (Dk. gray, Gravel to 1.5" dia., subangular, hard, Very fine sand, Plastic) 25%, CL-ML*, F4*, Gr=9, Sa=35, Fines=56, P.02=35.5	2.0
Sh	2	5/5/2, 28%, CL-ML, F4 PP=>4.5 tsf, Gr=12, Sa=37, Fines=51, LL=19, PL=13, PI=6	
		SANDY SILTY CLAY (Gray, Fine to medium sand, Plastic)	4.5
Sh	3	6/13/18, 15%, CL, F4, PP=>4.5 tsf, Gr=6, Sa=22, Fines=72, LL=27, PL=16, PI=11	
		LEAN CLAY W/SAND, Plastic, Hard, Moist	
Sh	4	5//, CL*, F4*	10.5
	5	//10/12, 16%, SP, S2*, Gr=6, Sa=90, Fines=3.9	
		POORLY GRADED SAND (Gray, Fine to coarse sand, Medium dense, Saturated)	13.0
		LEAN CLAY, Soil description based on rig reaction	14.0
Sh	6	9/7/8**, 20%, SP, S2*, Gr=1, Sa=94, Fines=4.9	
		POORLY GRADED SAND (Gray, Fine to coarse sand, Medium dense, Saturated)	
		Sampling was not successful between 20 ft. bgs and 30 ft. bgs due to excessive heave within the augers	
		Borehole was advanced to 30 ft. and soil description is based upon cuttings observation and rig reaction	30.0

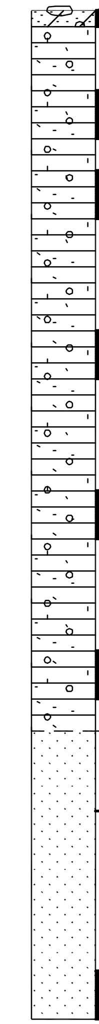
10.5 ft. W.D.

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.

Geologist: Kevin Pendergast
Drill Company/Rig: Discovery Drilling/CME 45
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

AP-627 (TB-01)

N 2,395,983.03
E 1,417,218.15 Elev. 21 (See note below)
11/10/06



Sample type	No.	Description	Depth (ft)
G	1	SILTY SAND W/GRAVEL CONTAINING COBBLES & BOULDERS (Dk. gray, Gravel subrounded to angular, hard, Fine sand, Cobbles and boulders on surface, Nonplastic, Wet) SM*, F3*	0.0 / 0.5
Sha	2	4/5/8, 17%, CL*, F3*, PP=4.5+ tsf, Gr=5, Sa=36, Fines=59, Sand Layers to 1/8" thick, dipping at ~25° to 45°	
Sha	3	3/7/8, 15%, CL*, F3*, PP=4.5+ tsf, No sand lenses apparent Gr=8, Sa=24, Fines=68, P.02=47.3	
		Drilled fast and smooth to 22.5 ft.	
Sha	4	4/6/7, 17%, CL, F4, PP=4.5+ tsf, Gr=2, Sa=30, Fines=68, LL=29, PL=17, PI=12, No sand lenses apparent	
		SANDY LEAN CLAY CONTAINING LAYERS OF POORLY GRADED SAND (Dk. gray, Gravel to 1" dia., subrounded, hard, Fine sand, Plastic, Very hard, Dry)	
Sha	5	2/6/9, CL*, F3*, PP=4.5+ tsf, Sand layers to 1/8" thick, dipping at ~60°	
Sha	6	2/5/8, 17%, CL*, F3*, PP=4.5+ tsf, Gr=3, Sa=43, Fines=54, No sand lenses apparent	22.5
Sha	7	6 ft. of heave, unable to sample	
		SAND (Dk. gray, Fine sand, Nonplastic, Wet)	
Sha	8	4/8/9**, SP*, NFS*, 6" heave, sampler floated	31.5

22.5 ft. W.D.

* Estimated Classification
** Designates that blow counts may not be representative due to sand heaving into the augers.

Geologist: Peter Hardcastle
Drill Company/Rig: Discovery Drilling/CME 75
Drilling Method: 8-inch Hollow Stem Auger
Drill Crew: Gary Cormier and Darin Vandehey

See Drawings B-01 and B-02 for Explanation of Boring Log Symbols.

Note: The above test boring elevations were surveyed at the top of ice cover of varying thickness. The elevations shown were therefore determined by subtracting the estimated ice thickness at the time of survey from the elevation surveyed at the top of the ice. These elevations are estimated, and due to the thick snow and ice cover are considered only accurate to +/- 5 feet.

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA	ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
CHECKED: C.H.R. SUBMITTED: C.H.R.	TEST BORING LOG AP-625 THRU AP-627
DATE: FEB. 2007 / R&M NO. 1209.10	SCALE: AS SHOWN / DWG. NO. B-17

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study
Kenai, Alaska

Date: 15 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,502 ft. Easting: 1,415,363 ft.

Top of Hole Elevation: 90.0 ft.

Hole Number, Field: TB-1 Permanent: AP-604-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.0 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks (Surface: Second growth willows)
0		1		NFS	Grab	SP	Poorly graded SAND					-/ 0.0		Brown, moist, fine to medium sand
3		2		NFS	1 1 2 1	SP	Poorly graded SAND	8	87	5		-/ 0.0	3	Brown, moist, fine to medium sand
5.5		3		NFS	1 1 1 1	SP	Poorly graded SAND					-/ 0.0		Brown, moist, fine to medium sand
10.5		4		NFS	2 3 3 5	SP	Poorly graded SAND	4	93	3		-/ 0.0	5	Gray, moist, fine to medium sand
15.5		5		NFS	2 5 7 9	SP	Poorly graded SAND					-/ 0.0		Gray, moist, fine to medium sand
20.5		6			3 4 3 5	SP	Poorly graded SAND					-/ 0.0		Gray, moist, fine to medium sand
25.5		7a			3 5 5 9	SP	Poorly graded SAND							
26		7b				SM	Silty SAND	1	75	24			22	Dark gray, moist, fine sand, nonplastic (NP) fines
		7c				SP	Poorly graded SAND							
30.5		8			7 11 15	SP	Poorly graded SAND							Gray, wet, medium sand
35.5		9			5 8	SP	Poorly graded SAND							Gray, wet, fine to medium sand

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 15 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,502 ft. Easting: 1,415,363 ft.

Top of Hole Elevation: 90.0 ft.

Hole Number, Field: TB-1 Permanent: AP-604-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.0 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Second growth willows
38					13									
40–41.5		10			6 11 14	CL	Lean CLAY with Sand	0	22	78				Dark gray, moist, fine sand, plastic fines. LL=30.8, PI=15.5
45–46.5		11			7 7 10	CL	Lean CLAY with Sand							Dark gray, moist, rounded gravel, fine sand, plastic fines, very stiff
50–51.5		12			6 8 13	CL	Lean CLAY with Sand							Dark gray, moist, plastic fines, very stiff
55–56.5		13			8 20 12	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff
60–61.5		14			5 9 8	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff
65–66.5		15			4 9 12	CL	Lean CLAY with Sand	7	18	75	0.25		15	Dark gray, moist, fine sand, plastic fines, very stiff
70–71.5		16			4 6 9	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project:	Kenai River Bluff Erosion Study, Kenai, Alaska
Date:	15 Sep 2003
Drilling Agency:	☐ Alaska District ☒ Other Hughes Drilling
Elevation Datum:	MLLW ☐ MSL ☒ other
Location:	Northing: 2,396,502 ft. Easting: 1,415,363 ft.
Top of Hole Elevation:	90.0 ft.
Hole Number, Field:	TB-1
Permanent:	AP-604-P
Operator:	Pat Kelley
Inspector:	Steven Henslee
Type of Hole:	☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer
Depth to Groundwater:	27.0 ft. WD
Depth Drilled:	100.0 ft.
Total Depth:	101.5 ft.
Hammer Weight:	340 lbs
Split Spoon I.D:	2.5 in.
Size and Type of Bit:	8 in. HSA
Type of Equipment:	CME-75 with Autohammer
Type of Samples:	Grab and Drive

Depth (ft.)	Sample	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Description and Remarks
								Surface: Second growth willows
74–75.5			CL	Lean CLAY with Sand				Dark gray, moist, fine sand, plastic fines, very stiff
75.5–90.5	17	6 14 21	SP-SM	Poorly graded SAND with Silt				Gray, wet, fine to medium sand
	18	10 14 18	SP-SM	Poorly graded SAND with Silt	1	92	7	Gray, wet, medium sand
	19a	4 12 11	SP-SM	Poorly graded SAND with Silt				Gray, wet, medium sand
91–94	19b		CL	Lean CLAY with Sand				Dark gray, moist, fine sand, plastic fines
94–101.5		7 15 18	SP	Poorly graded SAND				Gray, wet, fine to medium sand

Bottom of Hole 101.5 ft.
Groundwater Encountered While Drilling: at an elevation of 63.0 ft.
PID = (Cold/Hot) Photo Ionization Detector

Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.

Other columns (Frozen ASTM D 4083, Frost Class. TM 5-822-5, Max Size (in.), PID (ppm), % Water): no entries.

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 16 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,309 ft. Easting: 1,415,302 ft.

Top of Hole Elevation: 89.8 ft.

Hole Number, Field: TB-2 Permanent: AP-605-MW

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☒ Monitoring Well ☐ Piezometer

Depth to Groundwater: 29.9 ft. WD

Depth Drilled: 37.5 ft.

Total Depth: 38.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Surface: Lawn

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM-5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
		1a			Grab	ML	SILT					-/		Brown, moist, nonplastic (NP) fines, organics (sixty percent by volume)
2		1b				SP	Poorly graded SAND				1	1.0		Brown, moist, rounded gravel, fine to medium sand
4		2			2 2 4 6	SP	Poorly graded SAND				0.5	-/ 1.0		Brown, moist, fine to medium sand
6		3			2 3 4 5	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine to medium sand
10		4			5 4 6	SP	Poorly graded SAND				0.75	-/ 0.0		Gray, moist, fine to medium sand
16		5			2 6 7	SP	Poorly graded SAND	4	92	4	0.75	-/ 1.0	5	Gray, moist, fine to medium sand
20		6			3 3 5	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine to medium sand
26		7			3 4 8	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine to medium sand, localized evidence of mottling, one small area (one inch thick) of 30% silt
30		8			2 6 10	SP	Poorly graded SAND with Gravel	24	74	2	1			Brown, wet, rounded gravel, fine to coarse sand
36		9			2 3	SP	Poorly graded SAND							Twelve inches of heaving sand; Gray, wet, fine to medium sand

EXPLORATION LOG KENAI_BLUFFS.GPJ ACE_ANC.GDT 9/3/04

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 16 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,309 ft. Easting: 1,415,302 ft.

Top of Hole Elevation: 89.8 ft.

Hole Number, Field: TB-2 Permanent: AP-605-MW

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☒ Monitoring Well ☐ Piezometer

Depth to Groundwater: 29.9 ft. WD

Depth Drilled: 37.5 ft.

Total Depth: 38.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Lawn
					4									
38		10			3 7	CL	Lean CLAY with Sand	4	14	82			17	Dark gray, moist, fine sand, plastic fines, very stiff
40														Bottom of Hole 38.5 ft. Groundwater Encountered While Drilling: at an elevation of 59.9 ft. PID = (Cold/Hot) Photo Ionization Detector
42														
44														Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.
46														
48														
50														
52														
54														
56														
58														
60														
62														
64														
66														
68														
70														
72														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 17 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,225 ft. Easting: 1,415,366 ft.

Top of Hole Elevation: 88.7 ft.

Hole Number, Field: TB-3 Permanent: AP-606-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.9 ft. WD

Depth Drilled: 99.5 ft.

Total Depth: 101.0 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks (Surface: Dirt parking lot)
0		1			Grab	SP	Poorly graded SAND with Gravel				0.75			Brown, moist, rounded gravel, fine to medium sand, FILL
3		2			2 3 4 4	SP	Poorly graded SAND							Brown, moist, fine sand
5.5		3			2 3 1 4	SP	Poorly graded SAND				0.25	-/ 0.0		Brown, moist, fine sand
10		4			2 1 3	SP	Poorly graded SAND				0.25	-/ 0.0		Brown, moist, fine sand
15		5			2 2 3 4	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine sand
20		6			2 4 6	SP	Poorly graded SAND					-/ 1.0		Brown, moist, fine sand
25		7			4 7 9	SM	Silty SAND	0	79	21		-/ 0.0	15	Brown, moist, fine sand
30		8			7 9 15	SP	Poorly graded SAND with Gravel	17	81	2				Brown, moist, medium to coarse sand
35		9			1 6 9	SP	Poorly graded SAND with Gravel	32	66	2				Brown, wet, rounded gravel, fine to coarse sand

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska		Page 2 of 3	Date: 17 Sep 2003
Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling		Elevation Datum: MLLW ☐ MSL ☒ other	
Location: Northing: 2,396,225 ft. Easting: 1,415,366 ft.		Top of Hole Elevation: 88.7 ft.	
Hole Number, Field: TB-3	Permanent: AP-606-P	Operator: Pat Kelley	Inspector: Steven Henslee
Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer	Depth to Groundwater: 27.9 ft. WD	Depth Drilled: 99.5 ft.	Total Depth: 101.0 ft.
Hammer Weight: 340 lbs	Split Spoon I.D: 2.5 in.	Size and Type of Bit: 8 in. HSA	Type of Equipment: CME-75 with Autohammer
Type of Samples: Grab and Drive			

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Dirt parking lot
38														
40		10a			4 8 15	CL	Lean CLAY with Sand					-/ 1.0		Gray, moist, plastic fines, very stiff
		10b				GP	Poorly graded GRAVEL							Gray, moist, rounded gravel, coarse sand, 1.5 inches thick
42		10c				CL	Lean CLAY with Sand							
44		11a			7 17 24	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff
		11b				SP	Poorly graded SAND							Dark gray, moist, medium sand
46		11c				CL	Lean CLAY with Sand							Dark, gray, moist, fine sand, plastic fines, very stiff
48														
50		12			7 13 16	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, fine sand, plastic fines, very stiff
52						SP	Poorly graded SAND							Estimated by drill action
54		13			6 13 16	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, fine sand, plastic fines, very stiff, marbled with clean gray medium sand to one and one sixteen inches thick
56														
58														
60		14			9 13 38	CL	Lean CLAY with Sand	0	23	77		-/ 0.0	17	Dark gray, moist, fine sand, plastic fines. LL=29, PI=15
62														
64		15			7 11 15	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, fine sand, plastic fines
66														
68														
70		16			4 8 12	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, fine sand, plastic fines
72														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 17 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,225 ft. Easting: 1,415,366 ft.

Top of Hole Elevation: 88.7 ft.

Hole Number, Field: TB-3 Permanent: AP-606-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.9 ft. WD

Depth Drilled: 99.5 ft.

Total Depth: 101.0 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 8 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Dirt parking lot
74–76		17			4 9 11	CL	Lean CLAY with Sand	1	26	73		-/ 0.0	17	Dark gray, moist, fine sand, plastic fines, very stiff
80		18			5 9 12	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, fine sand, plastic fines, 1.25-inch thick seam of fine gray sand in sample
85		19			5 13 21	SP-SM	Poorly graded SAND with Silt					-/ 0.0		Dark gray, moist, fine to medium sand, NP fines
90		20			3 7 17	SP-SM	Poorly graded SAND with Silt	0	89	11		-/ 0.0	20	Dark gray, moist, fine to medium sand, NP fines
95		21			7 12 12	SP-SM	Poorly graded SAND with Silt					-/ 1.0		Dark gray, moist, medium sand, NP fines
100		22			6 17	SP-SM	Poorly graded SAND with Silt					-/ 0.0		Dark gray, moist, fine to medium sand, NP fines

Bottom of Hole 101.0 ft.
Groundwater Encountered While Drilling: at an elevation of 60.8 ft.
PID = (Cold/Hot) Photo Ionization Detector

Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.

ALASKA DISTRICT CORPS OF ENGINEERS ENGINEERING SERVICES		
Soils and Geology Section	Project: Kenai River Bluff Erosion Study, Kenai, Alaska	Page 1 of 3
EXPLORATION LOG		Date: 18 Sep 2003
	Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling	Elevation Datum: MLLW ☐ MSL ☒ other
	Location: Northing: 2,396,206 ft. Easting: 1,414,825 ft.	Top of Hole Elevation: 89.6 ft.

Hole Number, Field: TB-4	Permanent: AP-607-P	Operator: Pat Kelley	Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer	Depth to Groundwater: 27.9 ft. WD	Depth Drilled: 100.0 ft.	Total Depth: 101.5 ft.

Hammer Weight: 340 lbs	Split Spoon I.D: 2.5 in.	Size and Type of Bit: 8 in. HSA	Type of Equipment: CME-75 with Autohammer	Type of Samples: Grab and Drive

Depth (ft.) scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36

Sample	Frozen ASTM D 4083	Frost Class, TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
												Surface: Second growth willows and spruce
1		F2	Grab	SM	Silty SAND with Gravel				2	-/ 0.0		Brown, moist, rounded gravel, fine to medium sand, nonplastic (NP) fines
2		NFS	4 3 3 5	SP	Poorly graded SAND				0.25	-/ 1.0		Brown, moist, fine sand
3		NFS	3 3 4 5	SP	Poorly graded SAND				1.25	-/ 0.0		Brown, moist, rounded gravel, fine sand
4a			5 4 4 4	SP	Poorly graded SAND							Brown, moist, fine sand
4b				SM	Silty SAND	0	65	35		-/ 0.0	23	Brown, moist, fine sand, NP fines
4c				SP	Poorly graded SAND							Brown, moist, fine sand
5			4 7 6	SP	Poorly graded SAND	7	92	1				Brown, wet, medium to coarse sand
6			2 9	GP	Poorly graded GRAVEL with Sand	50	48	2				Twelve inches of heaving sand. Dark gray, wet, rounded gravel, fine to coarse sand

EXPLORATION LOG KENAI BLUFFS.GPJ ACE_ANC.GDT 9/3/04

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska

Date: 18 Sep 2003

Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling

Elevation Datum: MLLW ☐ MSL ☒ other

Location: Northing: 2,396,206 ft. Easting: 1,414,825 ft.

Top of Hole Elevation: 89.6 ft.

Hole Number, Field: TB-4 | Permanent: AP-607-P

Operator: Pat Kelley

Inspector: Steven Henslee

Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer

Depth to Groundwater: 27.9 ft. WD

Depth Drilled: 100.0 ft.

Total Depth: 101.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D: 2.5 in.

Size and Type of Bit: 6 in. HSA

Type of Equipment: CME-75 with Autohammer

Type of Samples: Grab and Drive

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks (Surface: Second growth willows and spruce)
38					13									
46		7			5 15 18	CL	Lean CLAY with Sand					-/ 0.0		Dark gray, moist, find sand, plastic fines, very stiff
56		8			3 6 10	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, rounded gravel, fine sand, plastic fines, very stiff
66		9a			2 6 8	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, fine sand, plastic fines, very stiff
66		9b				SP	Poorly graded SAND							Dark gray, moist, fine to medium sand
70		10			6 11 14	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines, very stiff, 1.25-inch layer of gray fine sand

EXPLORATION LOG KENAI BLUFFS.GPJ ACE ANC.GDT 9/3/04

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: Kenai River Bluff Erosion Study, Kenai, Alaska	Page 3 of 3
	Date: 18 Sep 2003
Drilling Agency: ☐ Alaska District ☒ Other Hughes Drilling	Elevation Datum: MLLW ☐ MSL ☒ other
Location: Northing: 2,396,206 ft. Easting: 1,414,825 ft.	Top of Hole Elevation: 89.6 ft.
Hole Number, Field: TB-4 Permanent: AP-607-P	Operator: Pat Kelley
Inspector: Steven Henslee	
Type of Hole: ☐ other ☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☒ Piezometer	Depth to Groundwater: 27.9 ft. WD
Depth Drilled: 100.0 ft.	Total Depth: 101.5 ft.
Hammer Weight: 340 lbs	Split Spoon I.D: 2.5 in.
Size and Type of Bit: 8 in. HSA	Type of Equipment: CME-75 with Autohammer
Type of Samples: Grab and Drive	

Depth (ft.)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	%Gravel	%Sand	%Fines	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
														Surface: Second growth willows and spruce
80		11			5 6 9	CL	Lean CLAY with Sand					-/ 1.0		Dark gray, moist, fine sand, plastic fines
85		12a			5 12 25	CL	Lean CLAY with Sand							Dark gray, moist, fine sand, plastic fines
86		12b				SP	Poorly graded SAND							Dark gray, moist, fine to medium sand
89						CL	Lean CLAY with Sand							
90		13			3 9 12	SP	Poorly graded SAND					-/ 1.0		Dark gray, moist, fine to medium sand
95		14			3 4 16	SP	Poorly graded SAND	0	98	2		-/ 1.0	20	Dark gray, moist, fine to medium sand
100		15			.33	CL	Lean CLAY	0	8	92		-/ 0.0	27	Dark gray, moist, fine sand, plastic fines, very soft

Bottom of Hole 101.5 ft.
Groundwater Encountered While Drilling: at an elevation of 61.6 ft.
PID = (Cold/Hot) Photo Ionization Detector

Survey datum is Alaska State Plane, Zone 4, NAD83. Elevation datum MLLW.

EXPLORATION LOG KENAI BLUFFS.GPJ ACE_ANC.GDT 9/3/04

WELL LOG DATA

American Environmental

PROJECT: Daubenspeck Property	WELL NO. MW-1
LOCATION: Grid 337.7, 315.1	DATE DRILLED: 6/14/2000
DRILLING METHOD: Hollow Stem Auger \ Split Spoon Sample	CASING TYPE/DIA. PVC 2"
DEPTH DRILLED: 28 feet	TOTAL CASING: 20 feet
GROUND ELEVATION:	T.O.C. ELEVATION:
GROUT TYPE/QUANTITY: Bentonite Chips ½ bag \ Bentonite slurry 20 gallons	SCREEN TYPE/ LENGTH: 0.20 slot PVC \ 10 feet
GROUT INTERVAL: Chips 12 to 14.11' Slurry 1 to 12'	SCREENED INTERVAL:
SAND PACK TYPE/INTERVAL: 14.11 to 28 feet	STATIC WATER LEVEL/DATE:
DEPTH TO WATER WHILE DRILLING: 21.5' bgl	LOGGED BY: PETE CAMPBELL
WATER LEVEL ELEVATION:	DRILLER: Hughes Drilling

DEPTH	H20\SOIL SAMPLE	FORMATION DESCRIPTION
0-5'		Sand, brown, clean
5-7	SSS #1 BC:3-5-5-5	5-6' Sand, medium, brown with minor gravel, moist 6-7' Sand, fine brown, moist PID 8.1
7-9'	SSS#2 BC: 3-3-4-5	7-8' Sand, fine brown, moist 8-9' Sand, fine, gray PID 0.0
9-11	SSS#3 BC: 3-4-6-8	Sand, fine, gray PID 0.0
11-13	SSS#4 BC: 4-8-8-4	Sand, fine, gray PID 0.0
13-15	SSS#5 BC: 6-7-8-9	Sand, fine, gray to 13.8 13.8-15 Sand, very fine, gray, moist PID 0.0
15-17	SSS#6 BC: 4-7-9-8	Sand, medium, brown salt & pepper. PID 0.0 Drill to 20
20-28	SSS#7 BC: 5-10-13-15	20-21' Sand fine, brown, wet 21-22' Sand with minor silt, wet, approximately 6" of water in augers PID 5.1 Sample Collected: MW-1-20-22 @09:34 Drill to 24', water at 21.5 Drill to 28' EOB

WELL LOG DATA

American Environmental

PROJECT: Daubenspeck Property	WELL NO. MW-2
LOCATION: Grid 669.3, 198.9	DATE DRILLED: 6/14/2000
DRILLING METHOD: Hollow Stem Auger \ Split Spoon Sample	CASING TYPE/DIA: PVC 2"
DEPTH DRILLED: 25 feet	TOTAL CASING: 13'
GROUND ELEVATION:	T.O.C. ELEVATION:
GROUT TYPE/QUANTITY: Bentonite Chips ½ bag \ Bentonite slurry 20 gallons	SCREEN TYPE/ LENGTH: 0.20 slot PVC \ 10 feet
GROUT INTERVAL: Chips 8 to 10' Slurry 1 to 8'	SCREENED INTERVAL: 15 to 25'
SAND PACK TYPE/INTERVAL: 10 to 25 feet	STATIC WATER LEVEL/DATE:
DEPTH TO WATER WHILE DRILLING: 18.8' bgl	LOGGED BY: PETE CAMPBELL
WATER LEVEL ELEVATION:	DRILLER: Hughes Drilling

DEPTH	H20\SOIL SAMPLE	FORMATION DESCRIPTION
0-4'		Drill, no cuttings
4-6	SSS #1 BC: 1-1	Sand, brown with some surface litter, (wood) 50% recovery PID 4.5
6-8'	SSS#2 BC: 1-1-1-0	Sand, brown, dry 30% recovery PID 6.6
8-10	SSS#3 BC: 3-3-2-2	0% recovery, Spoon bounced as if on a log. Bailing wire on tip of bit
10-12	SSS#4 BC: 2-1-1-1	Sand, brown with some organics PID 7.5 20% recovery
12-14	SSS#5 BC: 3-5-5-6	Sand, brown dry to moist PID 4.5
14-16	SSS#6 BC: 4-7-7-8	Sand, brown dry to moist PID 1.3 Drill to 20
20-22	SSS#7 BC: 4-4-4-7	Sand, brown wet PID 2.5 Water at 18.8 Sample Collected: MW-2-20-22 @ 12:14 Drill to 25', water at 18.8 EOB As the augers were removed from the hole a large chunk of metal came up the augers with several pieces of copper wire.

WELL LOG DATA

American Environmental

PROJECT: Daubenspeck Property	WELL NO. MW-3
LOCATION: Grid 238.7, 54.1	DATE DRILLED: 6/14/2000
DRILLING METHOD: Hollow Stem Auger \ Split Spoon Sample	CASING TYPE/DIA: PVC 2"
DEPTH DRILLED: 30 feet	TOTAL CASING: 22.9'
GROUND ELEVATION: 100.3	T.O.C. ELEVATION: 103.41
GROUT TYPE/QUANTITY: Bentonite Chips 1 bag \ Bentonite slurry 20 gallons	SCREEN TYPE/ LENGTH: 0.20 slot PVC \ 10 feet
GROUT INTERVAL: Chips 12.5 to 17' Slurry 4.5 to 12.5'	SCREENED INTERVAL: 20 to 30'
SAND PACK TYPE/INTERVAL: 17 to 30 feet	STATIC WATER LEVEL/DATE:
DEPTH TO WATER WHILE DRILLING: 24' bgl	LOGGED BY: PETE CAMPBELL
WATER LEVEL ELEVATION:	DRILLER: Hughes Drilling

DEPTH	H20\SOIL SAMPLE	FORMATION DESCRIPTION
0-5'		Sand, brown
5-7	SSS #1 BC: 1-1-1-1	Sand, brown, moist, fine PID 0.0
7-9'	SSS#2 BC: 1-1-1-1	7-8 Sand, medium, brown, moist 8-8.3 Sand, fine, brown 8.3-9 Sand, medium, brown, some organics PID 0.0
9-11	SSS#3 BC: 1-1-1-1	Sand, medium, brown, with minor gravel. PID 0.0
11-13	SSS#4 BC: 1-1-1-1	Sand, medium, brown. PID 0.0
13-15	SSS#5 BC: 1-1-1-1	Sand, medium, brown. PID 0.0
15-17	SSS#6 BC: 1-1-1-1	Sand, medium, brown. PID 0.0
17-19	SSS#7 BC: 1-1-1-1	Sand, medium, brown, with minor gravel. PID 5.0
19-21	SSS#8 BC: 1-1-1-1	Sand, medium, brown, with minor gravel. PID 8.5
21-23	SSS#9 BC: 2-7-23	21-22 Sand, fine, brown. 22-23 Pea Gravel with concrete in tip, refusal. PID 8.6
		The augers apparently hit the suspected lip of the cistern that was rumored to be in the area. The rig was moved east 10 feet and re-drilled to 23'
23-25	SSS#10 BC: 3-7-7-10	Sand, brown with minor gravel, wet. PID 8.2 Sample Collected MW-3-23-25 @17:57

APPENDIX C
LABORATORY TEST DATA

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse-grained Soils More than 50% retained on the No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]	GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]	GP	Poorly-graded gravel [F]
		Gravels with Fines More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel [F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5 % fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]	SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]	SP	Poorly-graded sand [I]
		Sands with Fines More than 12 % fines [D]	Fines classify as ML or MH	SM	Silty sand [G,H,I]
			Fines classify as CL or CH	SC	Clayey sand [G,H,I]
Fine-grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	inorganic	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 and plots below "A" line [J]	ML	Silt [K, L, M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic Clay [K, L, M,N] / Organic Silt [K, L, M,O]
	Silts and Clays Liquid Limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic Clay [K, L, M,P] / Organic Silt [K, L, M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravel with 5 to 12 % fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly-graded gravel with silt
- GP-GC poorly-graded gravel with clay

[D] Sands with 5 to 12 % fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly-graded sand with silt
- SP-SC poorly-graded sand with clay

[E] $Cu = D_{60} / D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥15% sand, add "with sand " to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.

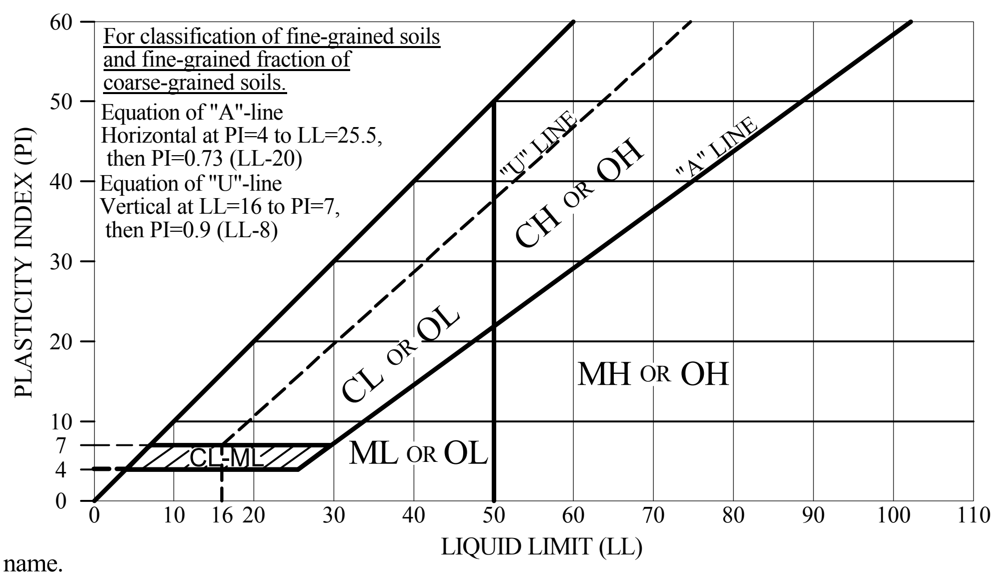
[M] If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 and plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Z:\PROJECT\1209.10\LOGS\ASTM.GDW (DRAWING ASTM CLASS) 2/14/07 03:44 PM

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JUNE 04
SCALE:	NONE

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CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES ASTM D 2487

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	C-01

U.S. ARMY CORPS OF ENGINEERS
FROST DESIGN SOIL CLASSIFICATION

FROST GROUP	KIND OF SOIL	PERCENTAGE FINER THAN 0.02 mm BY WEIGHT	TYPICAL SOIL TYPES UNDER UNIFIED SOIL CLASSIFICATION SYSTEM
NFS*	(a) Gravels Crushed Stone Crushed Rock (b) Sands	0 - 1.5 0 - 3	GW, GP SW, SP
PFS+	(a) Gravels Crushed Stone Crushed Rock (b) Sands	1.5 - 3 3 - 10	GW, GP SW, SP
S1	Gravelly Soils	3 - 6	GW, GP, GW-GM, GP-GM
S2	Sandy Soils	3 - 6	SW, SP, SW-SM, SP-SM
F1	Gravelly Soils	6 - 10	GM, GW-GM, GP-GM
F2	(a) Gravelly Soils (b) Sands	10 - 20 6 - 15	GM, GW-GM, GP-GM SM, SW-SM, SP-SM
F3	(a) Gravelly Soils (b) Sands, Except Very Fine Silty Sands (c) Clays, PI>12	Over 20 Over 15 --------	GM, GC SM, SC CL, CH
F4	(a) All Silts (b) Very Fine Silty Sand (c) Clays PI<12 (d) Varved Clays and Other Fine-grained Banded Sediments	-------- Over 15 -------- --------	ML, MH SM CL, CL-ML CL, CL-ML CL and ML CL, ML, and SM; CL, CH and ML; CL, CH, ML and SM

* Non-frost-susceptible
\+ Possibly frost-susceptible, but requires laboratory test to determine frost design soils classification.

From: "Seasonal Frost Conditions", June, 1992, U.S. Army Corps of Engineers TM-5-822-5.

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JUNE 04
SCALE:	NONE

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9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

FROST DESIGN
SOIL CLASSIFICATION

FB:	N/A
GRID:	N/A
PROJ.NO:	GENERAL
DWG.NO:	C-02

SUMMARY OF SOIL INDEX PROPERTY DATA

KENAI RIVER BLUFF EROSION

SURFACE SAMPLES COLLECTED FROM SOIL PROFILES

SAMPLE IDENTIFICATION			PARTICLE SIZE ANALYSIS (% FINER)																	ATTERBERG LIMITS			MOIST. CONT.	SPECIFIC GRAVITY	ASTM CLASS.	FROST CLASS.
			STANDARD SIEVE SIZE														(mm)									
SOIL PROFILE	NO.	DEPTH (FT.)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	.02	.005	.002	LL	PL	PI	%			
SP-B	1	SURFACE		100	98	97	94	85	77	58	37	18	6	3	1	0.6							5.1		SP	NFS
SP-C	1	SURFACE		100	88	81	79	75	73	61	49	38	19	7	3	2.0							3.3		SP	NFS
SP-C	2	SURFACE								100	99	99	95	22	3	2.3							4.2		SP	NFS
SP-C	3	SURFACE							100	99	99	99	98	97	92	91				38	18	20	16		CL	F3
SP-C	4	SURFACE				100	99	99	98	95	88	64	20	7	3	2.9							9.8		SP	NFS
SP-D	1	SURFACE							100	99	98	94	65	26	2	1.6							0.9		SP	NFS
SP-D	2	SURFACE	100	86	86	86	86	86	86	85	84	83	82	79	73	69				25	14	11	16		CL	F4
SP-D	3	SURFACE										100	96	18	1	0.7							3.5		SP	NFS
SP-E	1	SURFACE	100	93	90	85	80	73	68	57	47	41	24	6	1	1.3							13		SP	NFS
SP-E	2	SURFACE					100	99	98	97	96	94	93	90	82	78				28	15	13	14		CL	F3
SP-F	1	SURFACE			100	97	89	81	72	52	32	21	13	9	4	2.7							11		SW	NFS
SP-G	1	SURFACE					100	98	97	93	89	84	53	13	1	0.7							3.0		SP	NFS
SP-G	2	SURFACE		100	81	81	81	81	80	80	78	78	76	73	67	64				28	15	13	11		CL	F3
SP-H	1	SURFACE								100	99	99	88	25	2	0.8							1.6		SP	NFS
SP-H	2	SURFACE		100	95	86	80	69	62	46	32	24	13	5	1	0.5							6.8		GP	NFS
SP-H	3	SURFACE	100	87	87	87	86	86	85	84	82	81	79	76	69	66				26	15	11	15		CL	F4
SP-H	4	SURFACE									100	99	98	40	4	3.1							17		SP	NFS
SP-I	1	SURFACE				100	98	90	86	71	56	42	15	5	1	0.6							2.4		SP	NFS
SP-I	2	SURFACE				100	99	98	97	95	93	87	45	10	1	1.0							5.2		SP	NFS
SP-I	3	SURFACE			100	99	99	99	99	98	96	95	93	90	81	76				24	14	10	14		CL	F4
SP-J	1	SURFACE								100	99	98	86	47	11	5.7							9.9		SP-SM*	S2*
SP-J	2	SURFACE			100	99	98	93	90	83	73	59	22	5	1	0.6							4.2		SP	NFS

* Estimated Classification

SUMMARY OF SOIL INDEX PROPERTY DATA

KENAI RIVER BLUFF EROSION

SAMPLE IDENTIFICATION				PARTICLE SIZE ANALYSIS (% FINER) **																	ATTERBERG LIMITS			MOIST. CONT.	SPECIFIC GRAVITY	ASTM CLASS.	FROST CLASS.
				STANDARD SIEVE SIZE														(mm)									
HOLE	HOLE	NO.	DEPTH (FT.)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	.02	.005	.002	LL	PL	PI	%			
AP-608-MW	TB-1a	3	5.0 - 6.5							100	97	95	91	82	66	56	52							27		ML*	F4
AP-608-MW	TB-1a	7	25.0 - 26.5						100	99	99	99	97	67	17	5	3.7							4.3		SP	NFS*
AP-608-MW	TB-1a	11	45.0 - 46.5			100	98	97	95	93	88	84	67	16	5	2	1.8							2.3		SP	NFS
AP-608-MW	TB-1a	13	55.0 - 56.5										100	53	6	2	1.3							2.8		SP	NFS
AP-608-MW	TB-1a	15	65.0 - 66.5					100	99	99	99	98	96	49	8	4	3.0							9.7		SP	NFS
AP-608-MW	TB-1a	18	80.0 - 81.5					100	98	97	94	88	79	66	24	12	11							17		SP-SM*	F2*
AP-608-MW	TB-1a	19	85.0 - 86.5			100	94	94	93	92	85	83	81	78	74	67	63				24	15	9	13		CL	F4
AP-608-MW	TB-1a	21	95.0 - 96.5					100	99	99	98	97	96	95	91	84	80				27	16	11	16		CL	F4
AP-611-MW	TB-2c	2	2.5 - 4.0						100	99	98	97	96	87	49	29	27							10		SM*	F3*
AP-611-MW	TB-2c	5	15.0 - 16.5				100	98	97	96	93	88	77	38	7	2	1.2							3.5		SP	NFS
AP-611-MW	TB-2c	8	30.0 - 31.5				100	99	98	97	94	92	86	50	12	5	3.0							5.1		SP	NFS
AP-611-MW	TB-2c	12	50.0 - 51.5		100	82	82	79	79	79	78	76	75	73	70	63	60				27	16	11	11		CL	F4
AP-611-MW	TB-2c	14	60.0 - 61.5							100	98	97	95	93	90	78	72				26	16	10	15		CL	F4
AP-611-MW	TB-2c	16	70.0 - 71.5										100	99	95	82	75				22	14	8	18		CL	F4
AP-611-MW	TB-2c	17	75.0 - 76.5							100	99	99	99	98	96	86	78				24	16	8	15		CL	F4
AP-611-MW	TB-2c	22	100.0 - 101.5								100	99	99	99	97	91	82							20		CL*	F3*
AP-614-MW	TB-3a	3	5.0 - 6.5				100	99	99	97	89	80	67	42	14	5	4.2							5.8		SP	PFS*
AP-614-MW	TB-3a	5	15.0 - 16.5								100	99	97	78	23	4	3.1							4.8		SP	NFS*
AP-614-MW	TB-3a	7	25.0 - 26.5								100	99	99	84	30	8	5.3							4.9		SP-SM*	S2*
AP-614-MW	TB-3a	9	35.0 - 36.5			100	98	96	90	85	68	53	44	27	12	6	5.5	3.3	1.3	0.6				2.4		SP-SM*	S2
AP-614-MW	TB-3a	11	45.0 - 46.5						100	99	98	96	94	86	72	48	42							16		SC*	F3*
AP-614-MW	TB-3a	13	55.0 - 56.5						100	99	99	98	96	94	90	83	79				24	15	9	14	2.682	CL	F4
AP-614-MW	TB-3a	14	60.0 - 61.5					100	99	98	97	95	94	92	88	79	75				27	15	12	13		CL	F4
AP-614-MW	TB-3a	15	65.0 - 66.5																					16		CL*	F4*
AP-614-MW	TB-3a	16	70.0 - 71.5						100	99	98	97	97	95	93	83	79				31	18	13	17		CL	F3
AP-614-MW	TB-3a	17	75.0 - 76.5					100	99	98	96	94	93	90	84	61	53							15		CL*	F3*
AP-614-MW	TB-3a	18	80.0 - 81.5				100	99	99	99	98	94	93	92	88	80	76	52.8	34.9	21.4				17		CL*	F3*
AP-614-MW	TB-3a	19	85.0 - 86.0					100	97	97	94	94	91	68	42	33	30							18		SC*	F3*
AP-614-MW	TB-3a	22	100.0 - 101.5									100	99	87	24	7	6.1							24		SP-SM*	S2*

* Estimated Classification

** The maximum particle size of samples is limited by the I.D. of the sampler opening or the width of the auger flights.

SUMMARY OF SOIL INDEX PROPERTY DATA

KENAI RIVER BLUFF EROSION

SAMPLE IDENTIFICATION				PARTICLE SIZE ANALYSIS (% FINER) **																	ATTERBERG LIMITS			MOIST. CONT.	SPECIFIC GRAVITY	ASTM CLASS.	FROST CLASS.
				STANDARD SIEVE SIZE														(mm)									
HOLE	HOLE	NO.	DEPTH (FT.)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	.02	.005	.002	LL	PL	PI	%			
AP-615-MW	TB-3b	1	75.0 - 76.5				100	99	99	99	98	98	97	96	92	61	51							19		CL*	F3*
AP-617-MW	TB-4a	4	10.0 - 11.5							100	99	97	94	69	22	5	3.9							6.5		SP	NFS*
AP-617-MW	TB-4a	7	25.0 - 26.5								100	99	96	67	22	6	4.3							8.4		SP	NFS*
AP-617-MW	TB-4a	11	45.0 - 46.5				100	98	97	96	93	89	86	83	75	57	54							15		CL*	F3*
AP-617-MW	TB-4a	13	55.0 - 56.5				100	92	90	87	84	81	78	74	69	65	63				31	18	13	13		CL	F3
AP-617-MW	TB-4a	14	60.0 - 61.5					100	98	97	94	92	90	88	82	74	71				33	17	16	15		CL	F3
AP-617-MW	TB-4a	16	70.0 - 71.5			100	98	96	95	95	93	92	91	89	86	78	74				27	16	11	13	2.724	CL*	F3*
AP-617-MW	TB-4a	17	75.0 - 76.5		100	97	96	95	93	89	79	66	65	63	60	54	51	36.2	23.8	15.4				15		CL*	F3*
AP-617-MW	TB-4a	18	80.0 - 81.5					100	99	99	97	96	95	93	89	75	69				24	16	8	14		CL	F4
AP-617-MW	TB-4a	20	90.0 - 91.5				100	99	98	98	96	95	94	92	88	80	76							17		CL*	F3*
AP-620-MW	TB-02	2	2.5 - 4.0						100	99	98	98	96	88	64	27	22							10		SM*	F3*
AP-620-MW	TB-02	4	10.0 - 11.5			100	99	99	97	96	93	87	76	43	12	2	1.7							5.1		SP	NFS
AP-620-MW	TB-02	5	15.0 - 16.5								100	99	96	77	25	5	4.4				NV	NV	NP	4.6	2.716	SP	S2*
AP-620-MW	TB-02	6	20.0 - 21.5							100	99	99	97	83	37	5	3.9							6.0		SP	NFS*
AP-620-MW	TB-02	7	25.0 - 26.5			100	98	97	95	94	90	86	80	52	18	4	3.3							7.6		SP	NFS*
AP-620-MW	TB-02	8	30.0 - 31.5			100	99	98	96	93	88	82	72	42	19	5	3.2							21		SP	NFS*
AP-620-MW	TB-02	10	40.0 - 41.4				100	99	98	98	97	96	94	90	87	83	81				35	21	14	16	2.747	CL	F3
AP-621-MW	TB-03	3	5.0 - 6.5					100	98	95	89	84	79	62	18	3	2.7							6.2		SP	NFS
AP-621-MW	TB-03	5	15.0 - 16.5							100	99	98	94	72	25	5	4.3							7.7		SP	S2*
AP-621-MW	TB-03	6	20.0 - 21.5					100	97	96	92	90	89	81	37	6	3.6							12		SP	NFS*
AP-621-MW	TB-03	8	30.0 - 31.5						100	99	98	97	92	66	29	9	6.5							19		SP-SM*	S2*
AP-622	TB-08	2	2.5 - 4.5										100	99	98	95	94				49	28	21	37		ML	F4
AP-622	TB-08	5	10.5 - 11.5			100	94	87	74	67	52	42	38	30	17	10	9.1							10		GP-GM*	F1*
AP-622	TB-08	6	15.0 - 16.5				100	94	93	92	88	83	79	73	61	52	49				18	12	6	14		SC-SM	F4*
AP-622	TB-08	7	20.0 - 21.5																					14		CL*	F3*
AP-622	TB-08	8	25.0 - 26.5				100	97	97	96	91	90	88	86	82	74	70				25	14	11	14		CL	F4
AP-622	TB-08	9	30.0 - 31.5								100	99	98	97	94	90	88				29	16	13	17		CL	F3

* Estimated Classification

** The maximum particle size of samples is limited by the I.D. of the sampler opening or the width of the auger flights.

SUMMARY OF SOIL INDEX PROPERTY DATA

KENAI RIVER BLUFF EROSION

SAMPLE IDENTIFICATION				PARTICLE SIZE ANALYSIS (% FINER) **																	ATTERBERG LIMITS			MOIST. CONT.	SPECIFIC GRAVITY	ASTM CLASS.	FROST CLASS.
				STANDARD SIEVE SIZE														(mm)									
HOLE	HOLE	NO.	DEPTH (FT.)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#140	#200	.02	.005	.002	LL	PL	PI	%			
AP-623	TB-07	2	2.5 - 4.0																					8.2		SP*	NFS*
AP-623	TB-07	3	5.0 - 6.5								100	99	99	96	26	2	1.6							3.8		SP	NFS
AP-623	TB-07	4	10.0 - 11.5								100	99	98	94	53	14	10							13		SP-SC*	F2*
AP-623	TB-07	5	15.0 - 16.5										100	95	30	3	1.9							22		SP	NFS
AP-624	TB-06	1	0.5 - 1.0			100	95	83	70	64	55	46	43	39	31	26	25	16.9	10.9	7.1				22		GC*	F2
AP-624	TB-06	3	3.0 - 4.0									100	99	98	55	8	4.5							21		SP*	NFS*
AP-624	TB-06	4	5.0 - 5.5																					18		SP*	NFS*
AP-624	TB-06	5	5.5 - 6.5																					18		CL*	F4*
AP-624	TB-06	6	10.0 - 11.5			100	97	94	93	92	90	88	87	86	83	76	72				29	16	13	15		CL	F3
AP-624	TB-06	7	15.0 - 16.0										100	66	18	2	1.3							22		SP	NFS
AP-624	TB-06	8	16.0 - 16.5						100	99	99	98	97	94	87	77	73				26	15	11	17		CL	F4
AP-625	TB-05	1	0.5 - 1.0					100	98	95	90	79	76	71	65	58	55	39.1	25.0	16.0				78		CL-ML*	F4*
AP-625	TB-05	2	2.5 - 4.0				100	99	98	97	96	94	93	91	88	81	77				27	16	11	17		CL	F4
AP-625	TB-05	3	5.0 - 6.5						100	99	98	96	95	93	90	84	81				26	16	10	17		CL	F4
AP-625	TB-05	4	10.0 - 11.5							100	98	97	93	40	10	3	2.3							14		SP	NFS
AP-625	TB-05	5	15.0 - 16.5								100	99	90	37	5	1.4	1.2							20		SP	NFS
AP-626	TB-04	1	0.5 - 1.5					100	98	96	91	82	80	77	72	64	56	35.5	22.6	14.1				25		CL-ML*	F4*
AP-626	TB-04	2	2.5 - 4.0			100	90	90	89	89	88	87	86	85	77	58	51				19	13	6	28		CL-ML	F4
AP-626	TB-04	3	5.0 - 6.5				100	98	97	96	94	93	92	90	85	76	72				27	16	11	15		CL	F4
AP-626	TB-04	5	10.5 - 11.5				100	99	99	97	94	92	89	58	24	5	3.9							16		SP	S2*
AP-626	TB-04	6	15.0 - 16.0							100	99	99	96	45	17	6	4.9							20		SP	S2*
AP-627	TB-01	2	2.5 - 4.0					100	98	97	95	93	90	87	77	64	59							17		CL*	F3*
AP-627	TB-01	3	5.0 - 6.5				100	99	97	96	92	86	85	83	80	72	68	47.3	30.5	19.1				15		CL*	F3*
AP-627	TB-01	4	10.0 - 11.5					100	99	99	98	97	96	94	91	74	68				29	17	12	17		CL	F4
AP-627	TB-01	6	20.0 - 21.5				100	99	99	98	97	95	94	91	85	62	54							17		CL*	F3*

* Estimated Classification

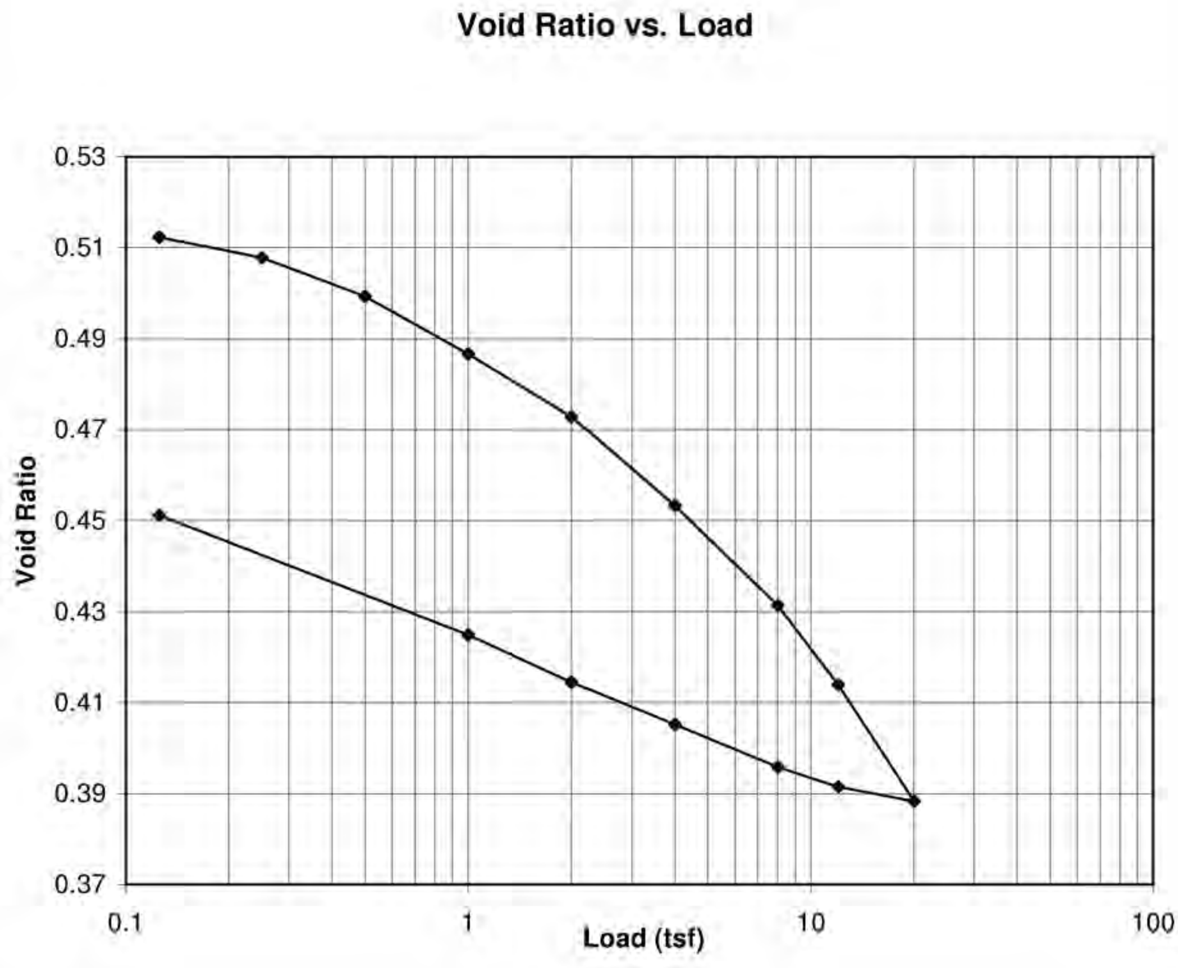
** The maximum particle size of samples is limited by the I.D. of the sampler opening or the width of the auger flights.

R&M Laboratory Test Report - One-Dimensional Consolidation

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-620-MW (TB-02)	Sampled by:	PKH	Date Sampled:	11/13/2006
Sample No.:	10	Received by:	RJM	Date Received:	11/17/2006
Depth:	40 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/12/2006	Lab #:	534
Test Method:	ASTM D 2435 - 04 - One-Dimensional Consolidation Properties of Soils				

Sample Diameter (in)	2.40
Sample Height (in)	1.01
Specific Gravity	2.747
Liquid Limit	35
Plasticity Index	14

	Initial	Final
Dry Density (pcf)	113.2	118.1
Moisture (%)	17.3%	20.9%
Void Ratio	0.514	0.451
Saturation (%)	93%	100%



DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

CONSOLIDATION TEST DATA

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-07

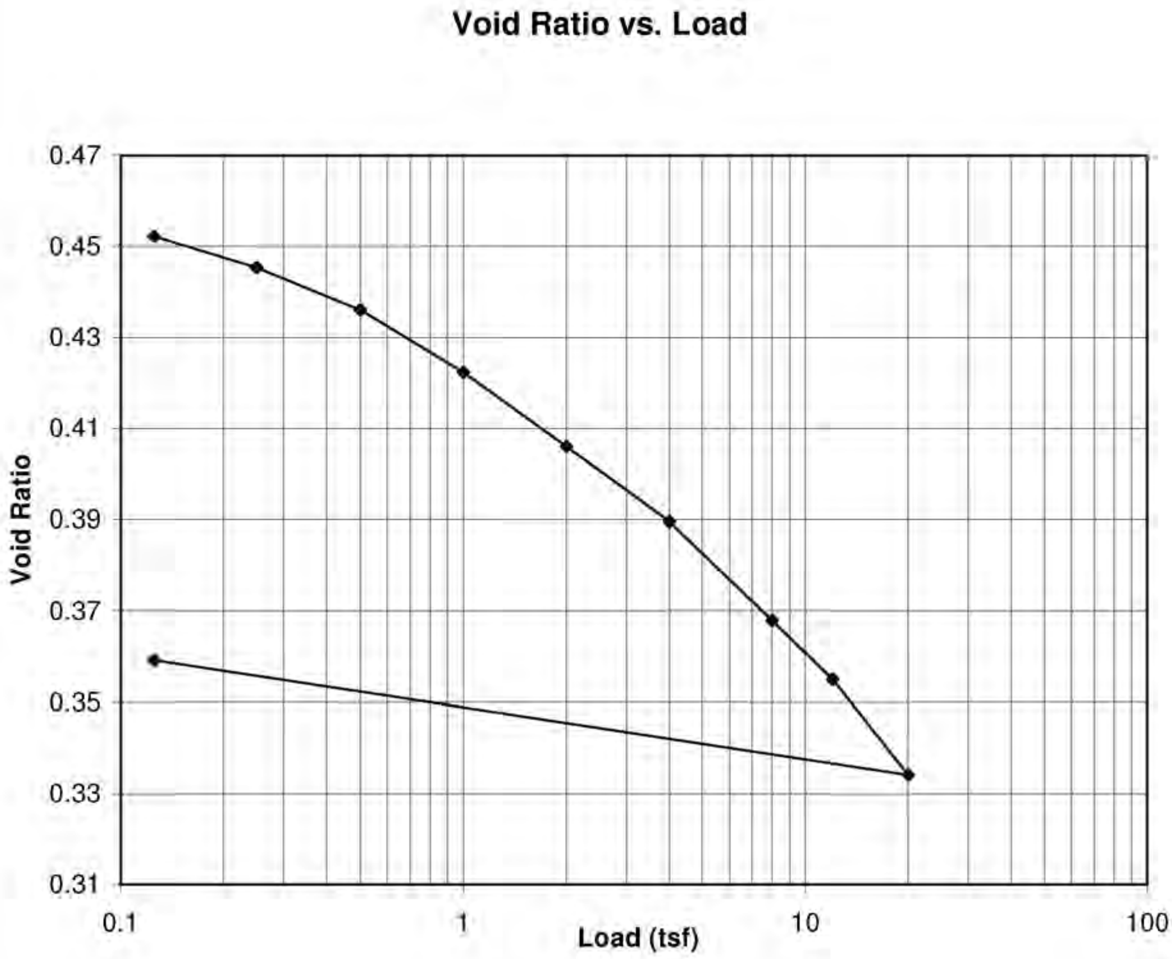
R&M Laboratory Test Report - One-Dimensional Consolidation

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-617-MW (TB-4a)	Sampled by:	PKH	Date Sampled:	11/19/2006
Sample No.:	16	Received by:	RJM	Date Received:	11/21/2006
Depth:	70 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/7/2006	Lab #:	534

Test Method: ASTM D 2435 - 04 - One-Dimensional Consolidation Properties of Soils

Sample Diameter (in)	2.40
Sample Height (in)	1.01
Specific Gravity	2.724
Liquid Limit	27
Plasticity Index	11

	Initial	Final
Dry Density (pcf)	116.8	117.8
Moisture (%)	15.1%	15.7%
Void Ratio	0.455	0.359
Saturation (%)	90%	100%



DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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KENAI RIVER BLUFF EROSION
KENAI, ALASKA

CONSOLIDATION TEST DATA

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-08

R&M Laboratory Test Report - One-Dimensional Consolidation

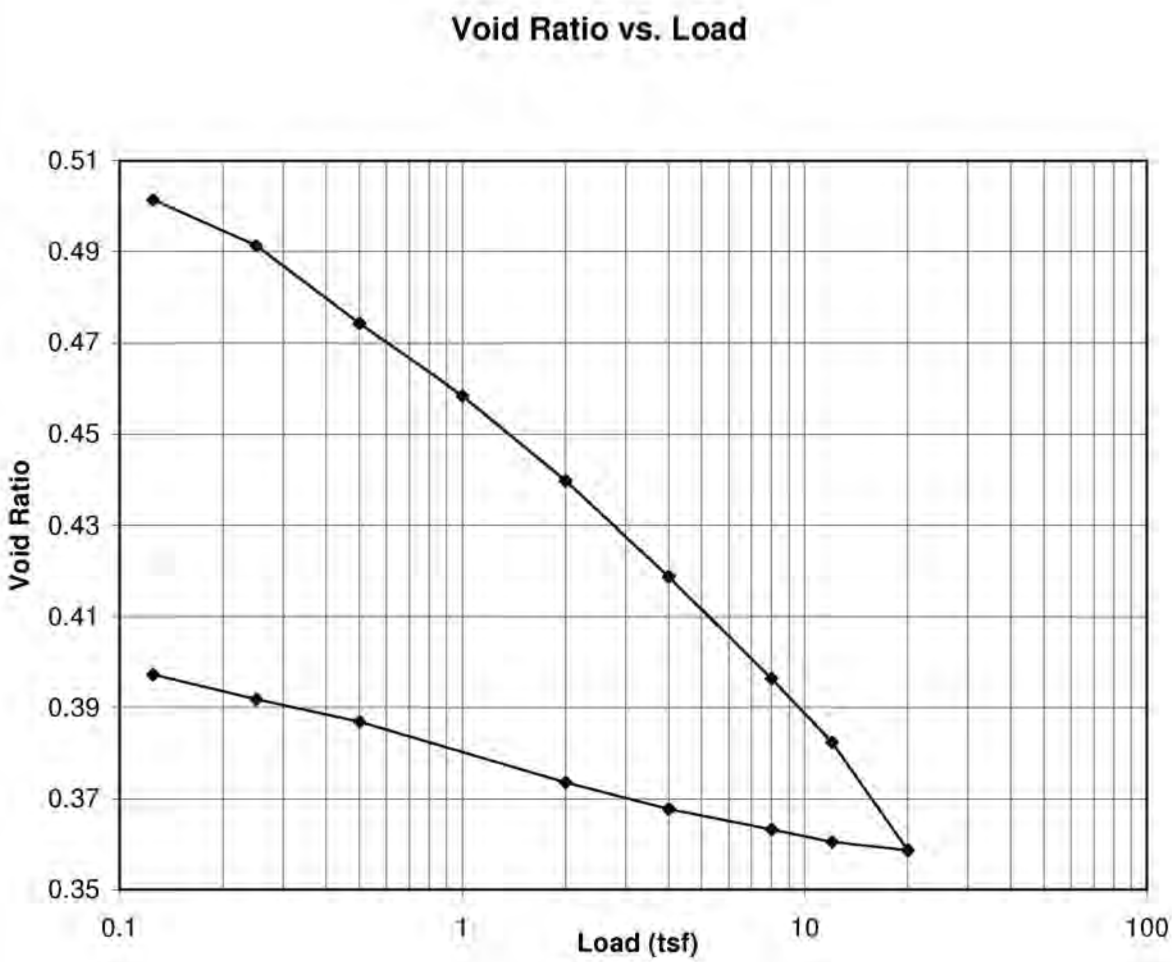
Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-625 (TB-05)	Sampled by:	PKH	Date Sampled:	11/15/2006
Sample No.:	3	Received by:	RJM	Date Received:	11/21/2006
Depth:	5 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Lean Clay with Sand	Date Completed:	12/22/2006	Lab #:	534

Test Method: ASTM D 2435 - 04 - One-Dimensional Consolidation Properties of Soils

Sample Diameter (in)	2.40	
Sample Height (in)	1.01	
Specific Gravity	2.73	assumed
Liquid Limit	26	
Plasticity Index	10	

	Initial	Final
Dry Density (pcf)	112.8	121.9
Moisture (%)	15.8%	17.2%
Void Ratio	0.510	0.397
Saturation (%)	84%	100%

Note, after testing the specimen was found to contain a gravel particle with a thickness of 0.5 inches.



DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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KENAI RIVER BLUFF EROSION
KENAI, ALASKA

CONSOLIDATION TEST DATA

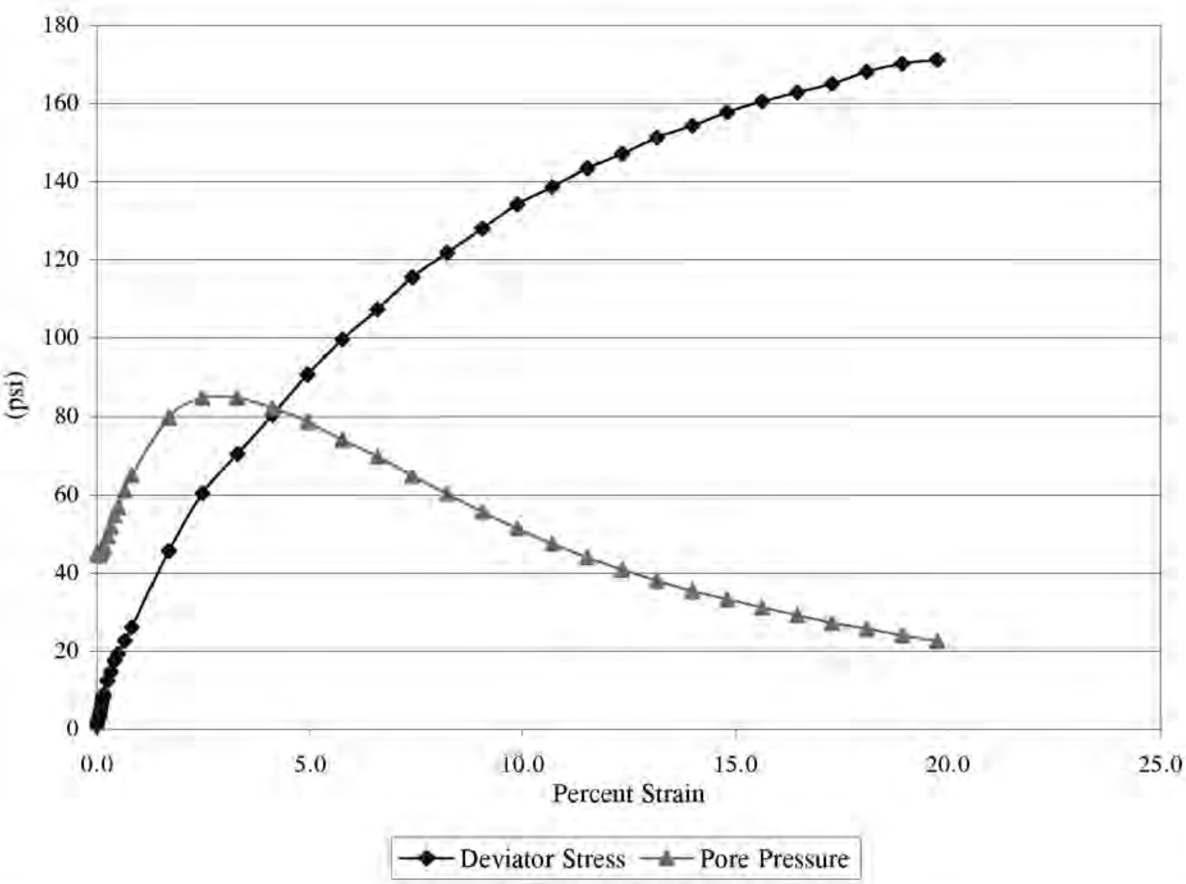
FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-09

R&M Laboratory Test Report - CU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-614-MW (TB-3a)	Sampled by:	PKH	Date Sampled:	11/11/2006
Sample No.:	13	Received by:	RJM	Date Received:	11/17/2006
Depth:	55 ft	Tested by:	RMP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/8/2006	Lab #:	534

Test Method: ASTM D 4767 - 02 - Consolidated Undrained Compression Test for Cohesive Soils

Initial Dry Density	121.9 pcf
Initial Moisture Content	14.3 %
Final Moisture Content	13.9 %
Initial Height	6.08 inches
Initial Diameter	2.33 inches
Effective Confining Pressure	44.5 psi
Back Pressure	44.7 psi
B Pore Pressure Parameter	0.96
T_{50}	144 min
Load Rate	0.0055 in/min



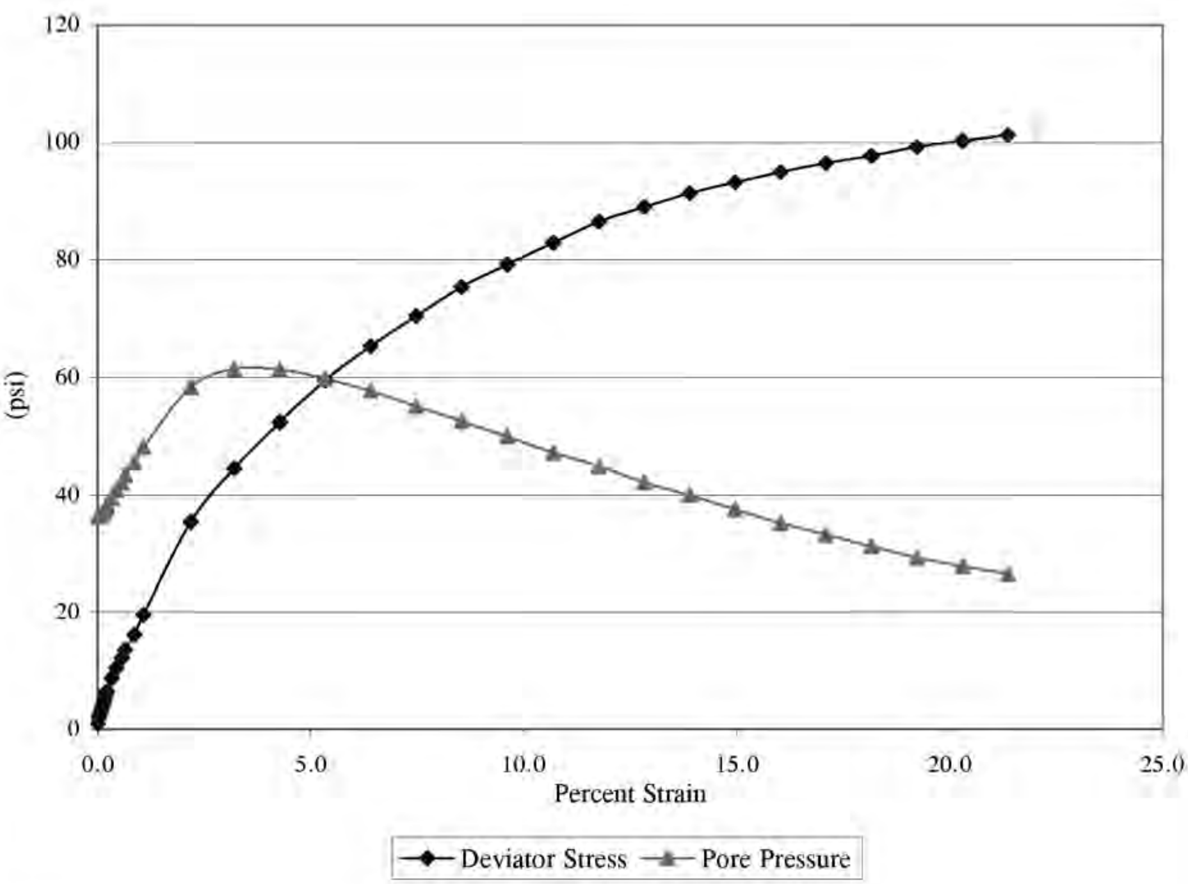
DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES		GRID: KENAI
DATE: JAN. 2007	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	CU TRIAXIAL TEST DATA	PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-10

R&M Laboratory Test Report - CU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-614-MW (TB-3a)	Sampled by:	PKH	Date Sampled:	11/11/2006
Sample No.:	14	Received by:	RJM	Date Received:	11/17/2006
Depth:	60 ft	Tech Assigned:	RMP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/14/2006	Lab #:	534

Test Method: ASTM D 4767 - 02 - Consolidated Undrained Compression Test for Cohesive Soils

Initial Dry Density	124.9 pcf
Initial Moisture Content	13.2 %
Final Moisture Content	14.8 %
Initial Height	4.68 inches
Initial Diameter	2.33 inches
Effective Confining Pressure	32.1 psi
Back Pressure	35.4 psi
B Pore Pressure Parameter	0.97
T_{50}	70 min
Load Rate	0.0057 in/min



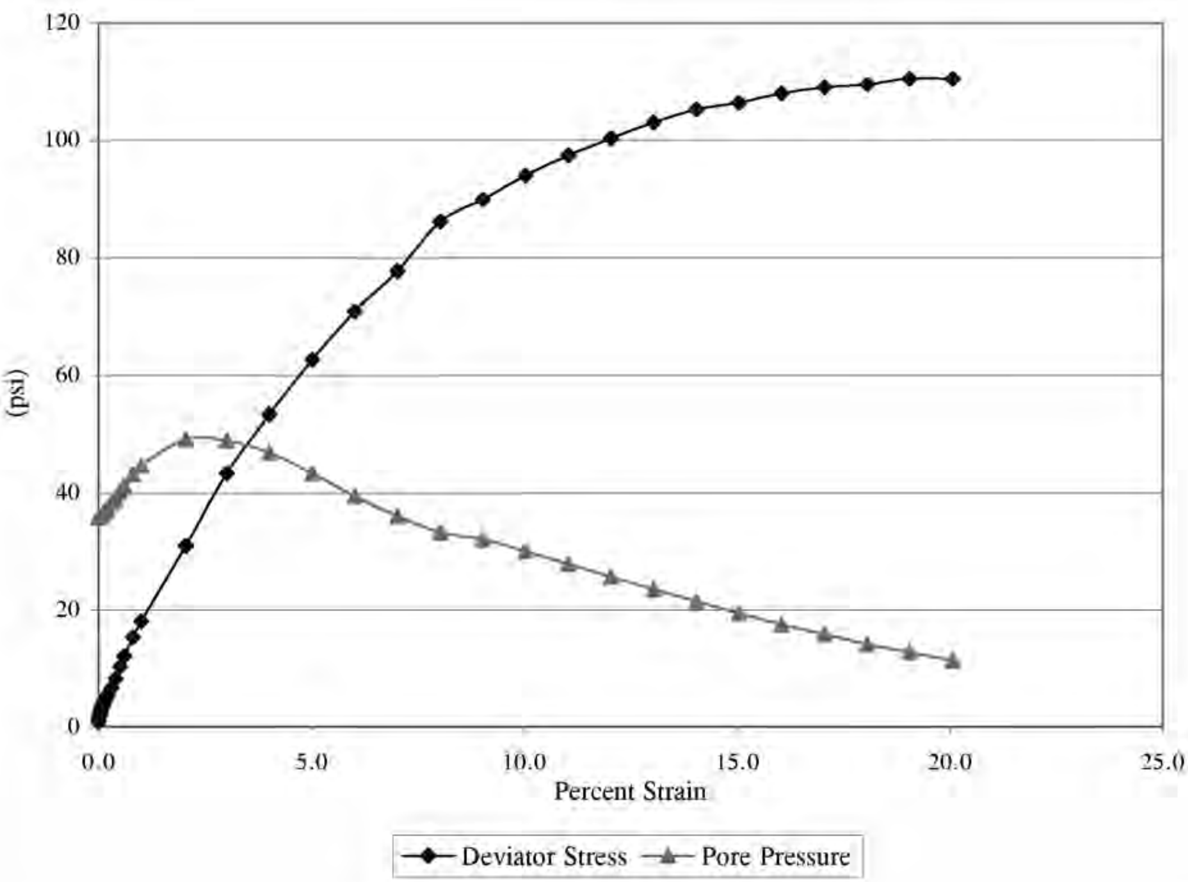
DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES	KENAI, ALASKA	GRID: KENAI
DATE: JAN. 2007	CONSTRUCTION SERVICES	CU TRIAXIAL	PROJ.NO: 1209.10
SCALE: N.T.S.	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	TEST DATA	DWG.NO: C-11

R&M Laboratory Test Report - CU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-614-MW (TB-3a)	Sampled by:	PKH	Date Sampled:	11/11/2006
Sample No.:	15	Received by:	RJM	Date Received:	11/17/2006
Depth:	65 ft	Tech Assigned:	RMP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/20/2006	Lab #:	534

Test Method: ASTM D 4767 - 02 - Consolidated Undrained Compression Test for Cohesive Soils

Initial Dry Density	117.4 pcf
Initial Moisture Content	15.7 %
Final Moisture Content	15.9 %
Initial Height	4.98 inches
Initial Diameter	2.36 inches
Effective Confining Pressure	15.5 psi
Back Pressure	34.5 psi
B Pore Pressure Parameter	0.97
T_{50}	90 min
Load Rate	0.0066 in/min



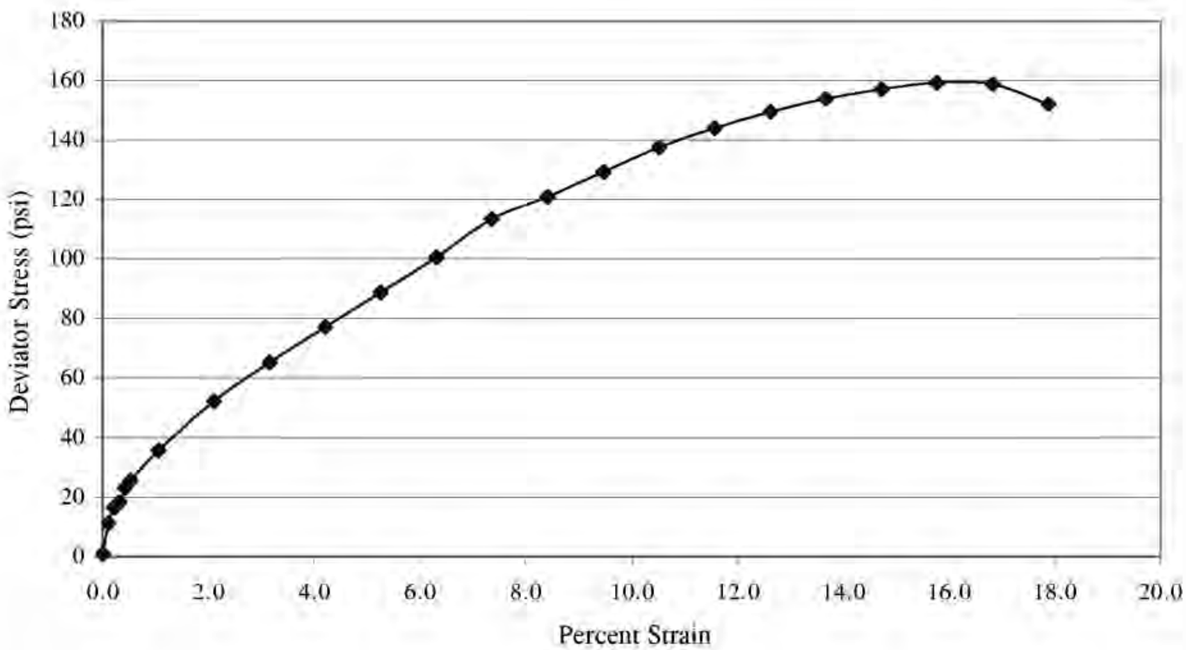
DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES	CU TRIAXIAL TEST DATA	GRID: KENAI
DATE: JAN. 2007	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707		PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-12

R&M Laboratory Test Report - UU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-611-MW (TB-2c)	Sampled by:	PKH	Date Sampled:	11/15/2006
Sample No.:	12	Received by:	RJM	Date Received:	11/20/2006
Depth:	50 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/21/2006	Lab #:	534

Test Method: ASTM D 2850 - 03 - Unconsolidated Undrained Triaxial Compression Test on Cohesive Soils

Initial Dry Density	122.2 pcf
Initial Moisture Content	13.8 %
Initial Height	4.76 inches
Initial Diameter	2.34 inches
Effective Confining Pressure	10.0 psi
Back Pressure	0.0 psi
B Pore Pressure Parameter	NA
T_{50}	NA
Load Rate	0.044 in/min



DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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KENAI RIVER BLUFF EROSION
KENAI, ALASKA

UU TRIAXIAL
TEST DATA

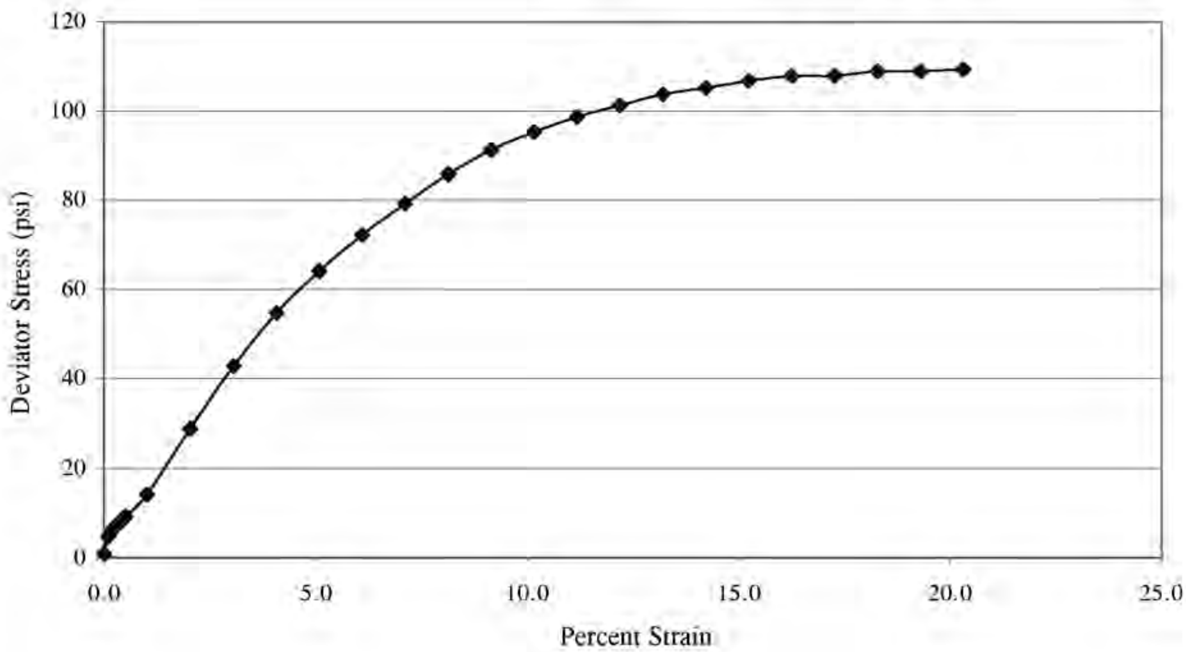
FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-13

R&M Laboratory Test Report - UU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-611-MW (TB-2c)	Sampled by:	PKH	Date Sampled:	11/15/2006
Sample No.:	14	Received by:	RJM	Date Received:	11/20/2006
Depth:	60 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/22/2006	Lab #:	534

Test Method: ASTM D 2850 - 03 - Unconsolidated Undrained Triaxial Compression Test on Cohesive Soils

Initial Dry Density	121.6 pcf
Initial Moisture Content	14.2 %
Initial Height	4.92 inches
Initial Diameter	2.37 inches
Effective Confining Pressure	20.0 psi
Back Pressure	0.0 psi
B Pore Pressure Parameter	NA
T_{50}	NA
Load Rate	0.047 in/min



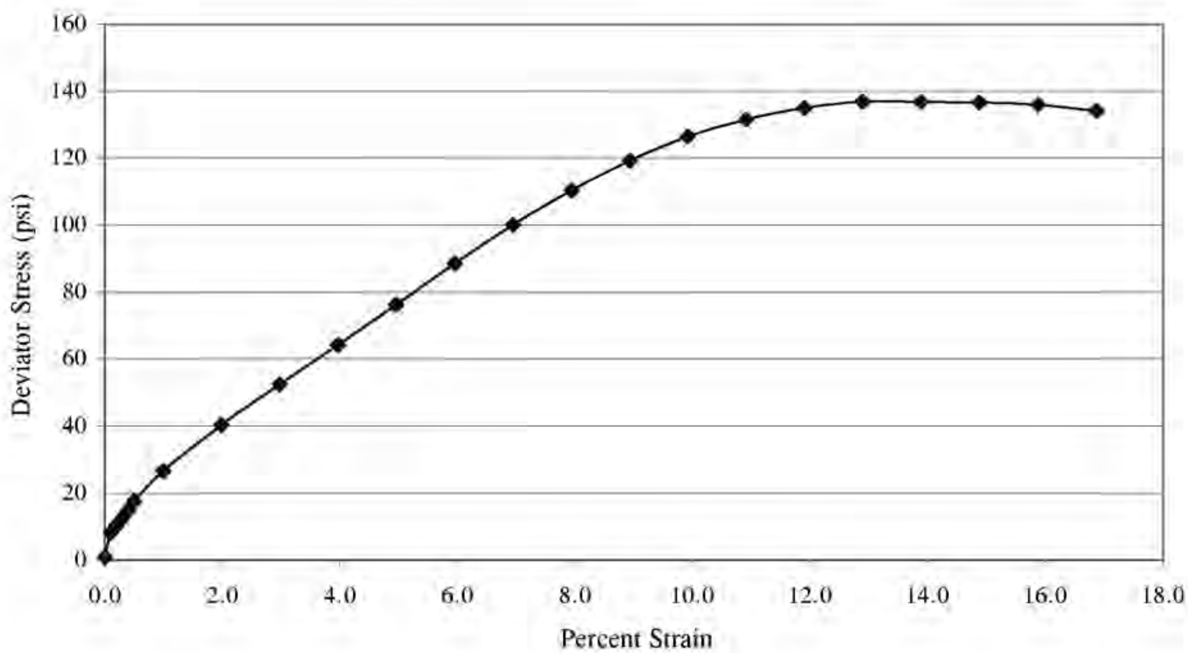
DWN: P.K.H.	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES		GRID: KENAI
DATE: JAN. 2007	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	UU TRIAXIAL TEST DATA	PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-14

R&M Laboratory Test Report - UU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-611-MW (TB-2c)	Sampled by:	PKH	Date Sampled:	11/15/2006
Sample No.:	16	Received by:	RJM	Date Received:	11/20/2006
Depth:	80 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/22/2006	Lab #:	534

Test Method: ASTM D 2850 - 03 - Unconsolidated Undrained Triaxial Compression Test on Cohesive Soils

Initial Dry Density	115.3 pcf
Initial Moisture Content	17.0 %
Initial Height	5.04 inches
Initial Diameter	2.37 inches
Effective Confining Pressure	30.0 psi
Back Pressure	0.0 psi
B Pore Pressure Parameter	NA
T_{50}	NA
Load Rate	0.046 in/min



DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

R&M CONSULTANTS, INC.
ENGINEERING • SURVEYING • EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

UU TRIAXIAL
TEST DATA

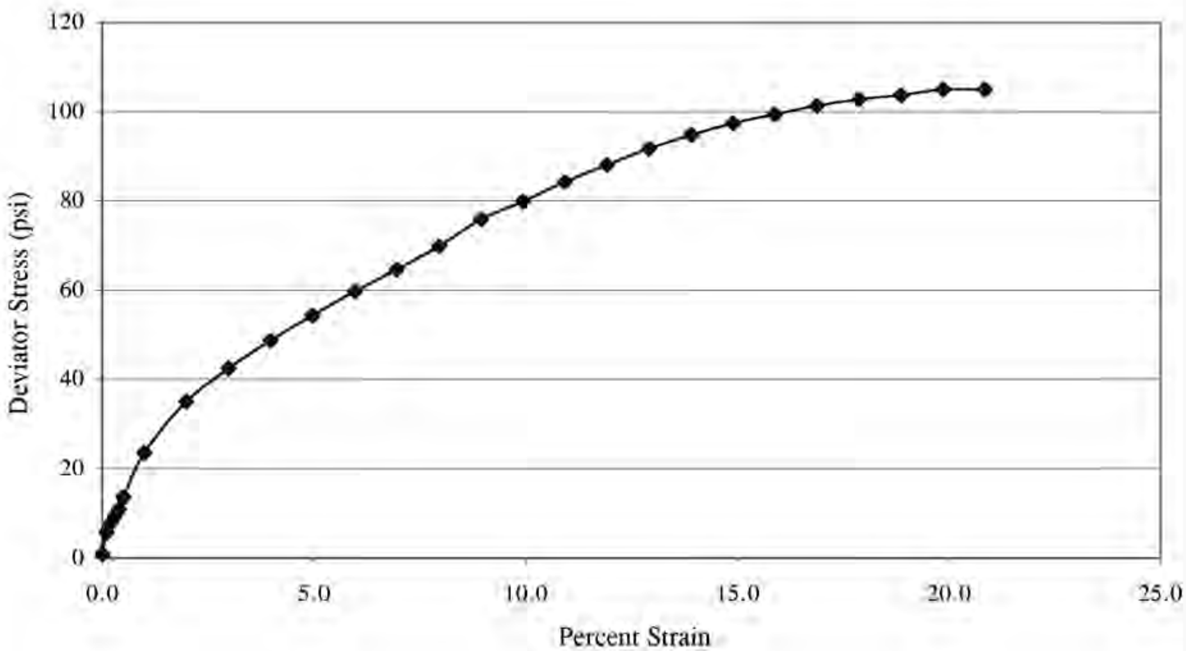
FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-15

R&M Laboratory Test Report - UU Triaxial

Client:	USACE	Project:	Kenai Bluff Erosion Study		
Test Hole:	AP-617-MW (TB-4a)	Sampled by:	PKH	Date Sampled:	11/19/2006
Sample No.:	13	Received by:	RJM	Date Received:	11/20/2006
Depth:	55 ft	Tested by:	KJP	R&M Project #:	1209.10
Description:	Sandy Lean Clay	Date Completed:	12/26/2006	Lab #:	534

Test Method: ASTM D 2850 - 03 - Unconsolidated Undrained Triaxial Compression Test on Cohesive Soils

Initial Dry Density	115.6 pcf
Initial Moisture Content	17.1 %
Initial Height	5.04 inches
Initial Diameter	2.42 inches
Effective Confining Pressure	40.0 psi
Back Pressure	0.0 psi
B Pore Pressure Parameter	NA
T_{50}	NA
Load Rate	0.047 in/min



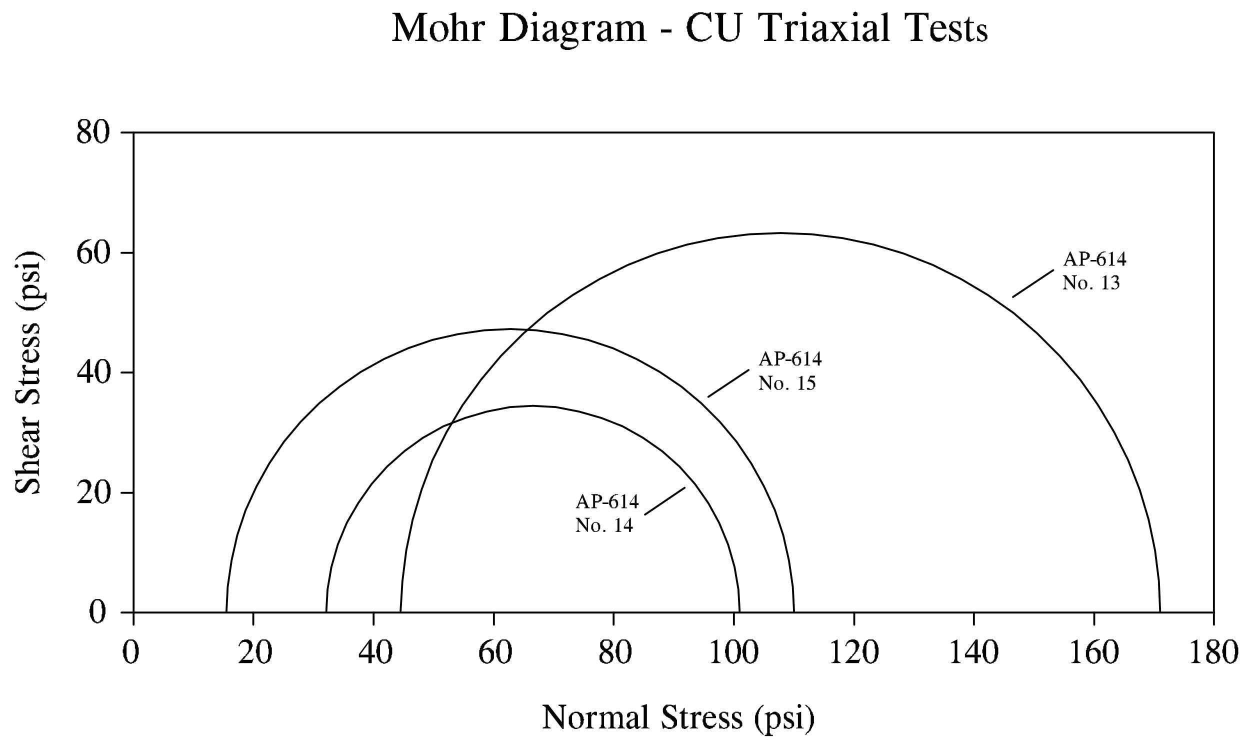
DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

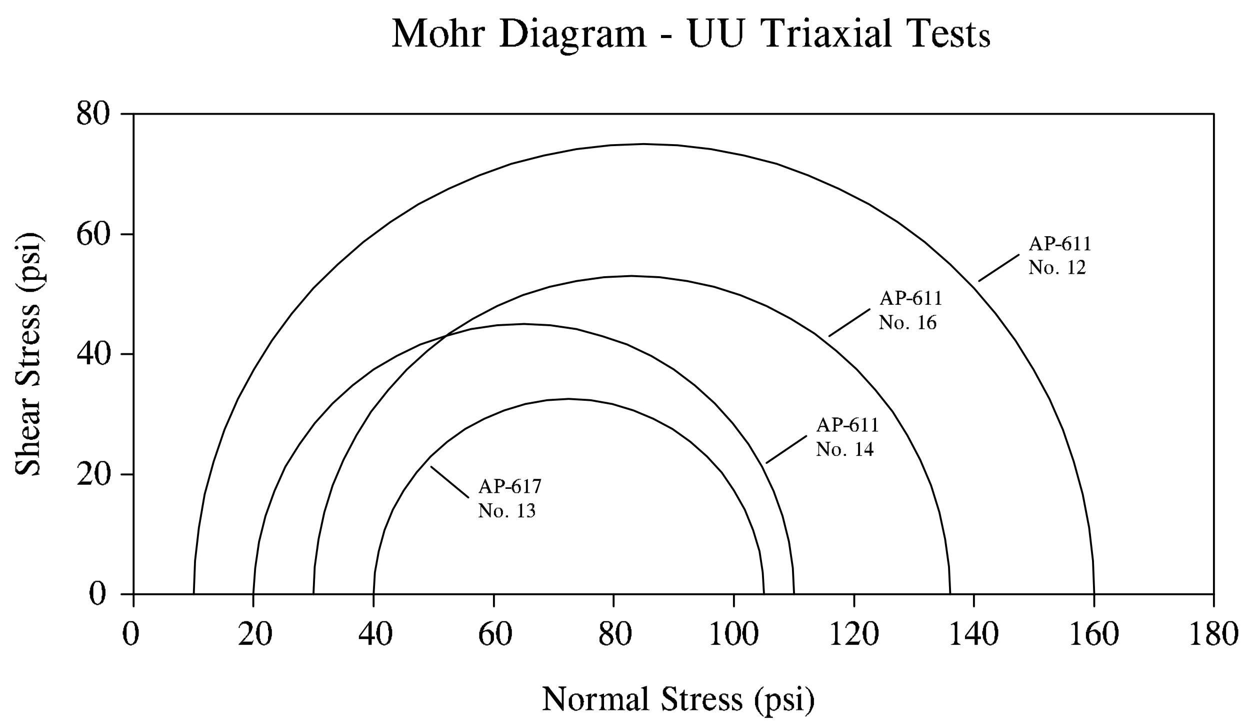
R&M CONSULTANTS, INC.
ENGINEERING • SURVEYING • EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

UU TRIAXIAL
TEST DATA

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-16





DWN: R.M.P	R&M CONSULTANTS, INC.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	FB: NA
CKD: C.H.R.	ENGINEERING • SURVEYING • EARTH SCIENCES CONSTRUCTION SERVICES		GRID: KENAI
DATE: FEB. 2007	9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707	MOHR DIAGRAMS	PROJ.NO: 1209.10
SCALE: N.T.S.			DWG.NO: C-17

Permeability Test Results

ASTM D 2434-68(2000) Permeability of Granular Soils (Constant Head)

Test Hole	Sample No.	Depth (ft)	Soil Description	Dry Density (pcf)	K (ft/sec)
AP-620-MW (TB-02)	5	15	Poorly Graded Sand with Gravel	95.3	1.3×10^{-4}
AP-621-MW (TB-03)	4	10	Poorly Graded Sand with Gravel	98.6	1.8×10^{-4}
AP-621-MW (TB-03)	6	20	Poorly Graded Sand with Gravel	100.5	1.3×10^{-4}

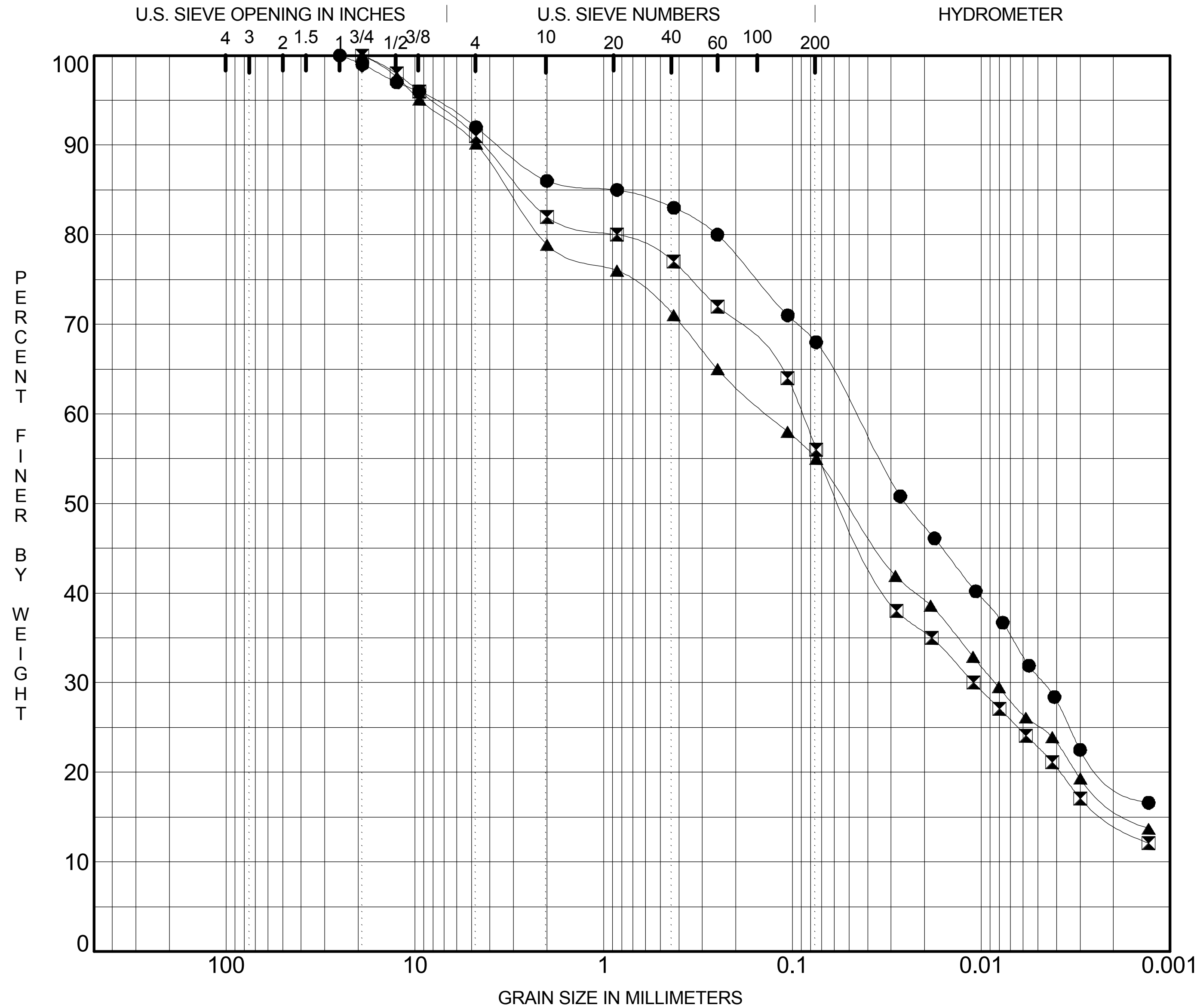
DWN:	P.K.H.
CKD:	C.H.R.
DATE:	FEB. 2007
SCALE:	N.T.S.

R&M
R&M CONSULTANTS, INC.
ENGINEERING • SURVEYING • EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI RIVER BLUFF EROSION
KENAI, ALASKA

PERMEABILITY
TEST RESULTS

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-18



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	AP-627	3	5.0 - 6.5	CL*	F3*	15%					
⧗	AP-626	1	0.5 - 1.5	CL-ML*	F4*	25%					
▲	AP-625	1	0.5 - 1.0	CL-ML*	F4*	78%					

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	AP-627	3	25.000	0.047	0.005		8	24	68	47.3
⧗	AP-626	1	19.000	0.089	0.011		9	35	56	35.5
▲	AP-625	1	19.000	0.135	0.008		10	35	55	39.1

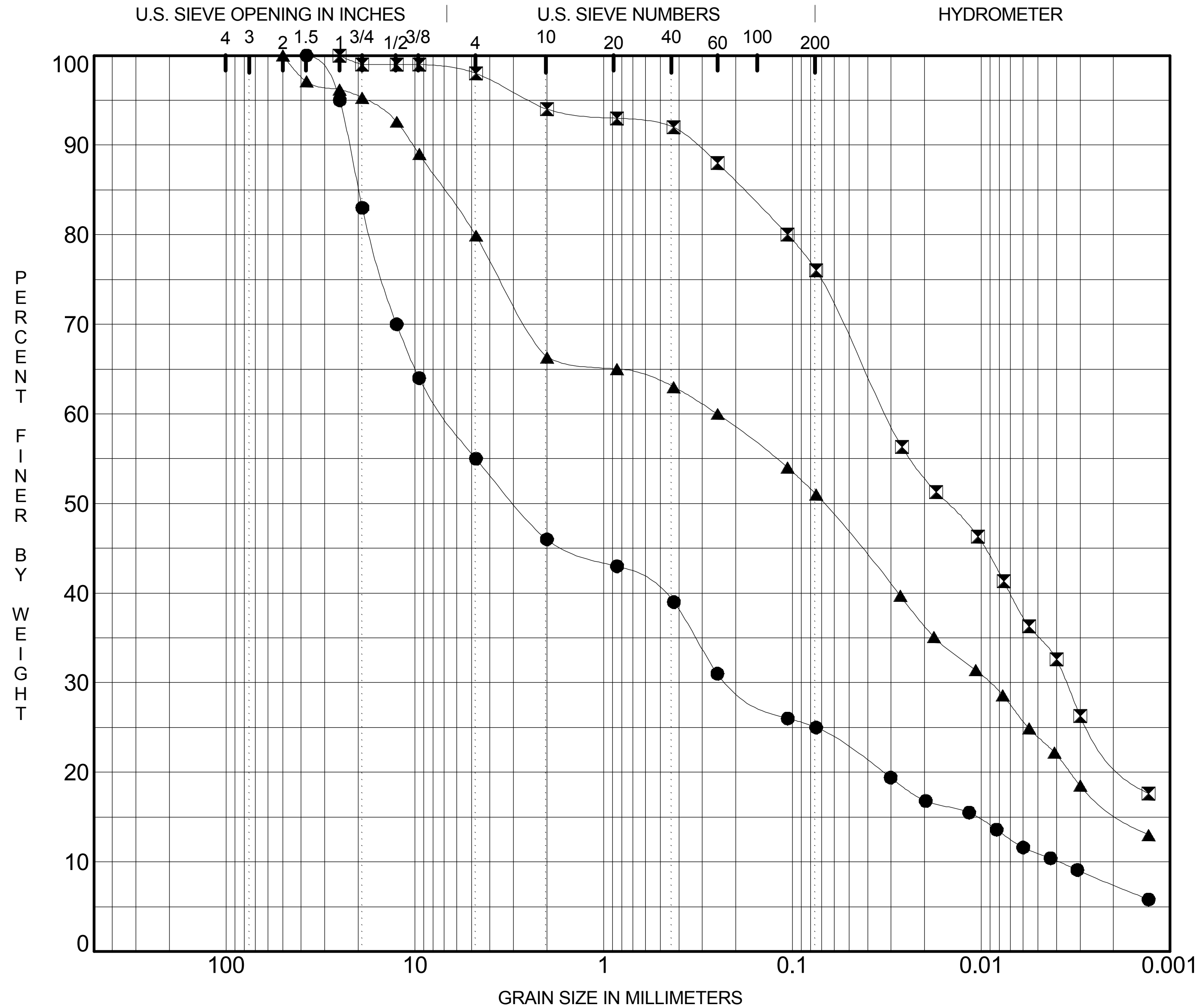
*Estimated Classification

DWN:	R.M.P.
CKD:	C.H.R.
DATE:	FEB. 07
SCALE:	N.T.S.

R&M CONSULTANTS, INC.
ENGINEERING ∘ SURVEYING ∘ EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI BLUFF EROSION
KENAI, ALASKA
GRADATION CURVES
(TILL W/24 HR. HYDROMETER)

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-19



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Borehole	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	AP-624	1	0.5 - 1.0	GC*	F2	22%				1.63	1795.52
⧗	AP-614-MW	18	80.0 - 81.5	CL*	F3*	17%					
▲	AP-617-MW	17	75.0 - 76.5	CL*	F3*	15%					

	Borehole	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	AP-624	1	37.500	6.981	0.211	0.004	45	30	25	16.9
⧗	AP-614-MW	18	25.000	0.032	0.004		2	22	76	52.8
▲	AP-617-MW	17	50.000	0.25	0.009		21	28	51	36.2

*Estimated Classification

DWN:	R.M.P.
CKD:	C.H.R.
DATE:	FEB. 07
SCALE:	N.T.S.

R&M CONSULTANTS, INC.
ENGINEERING ∘ SURVEYING ∘ EARTH SCIENCES
CONSTRUCTION SERVICES
9101 Vanguard Drive, Anchorage, Alaska 99507 (907) 522-1707

KENAI BLUFF EROSION
KENAI, ALASKA

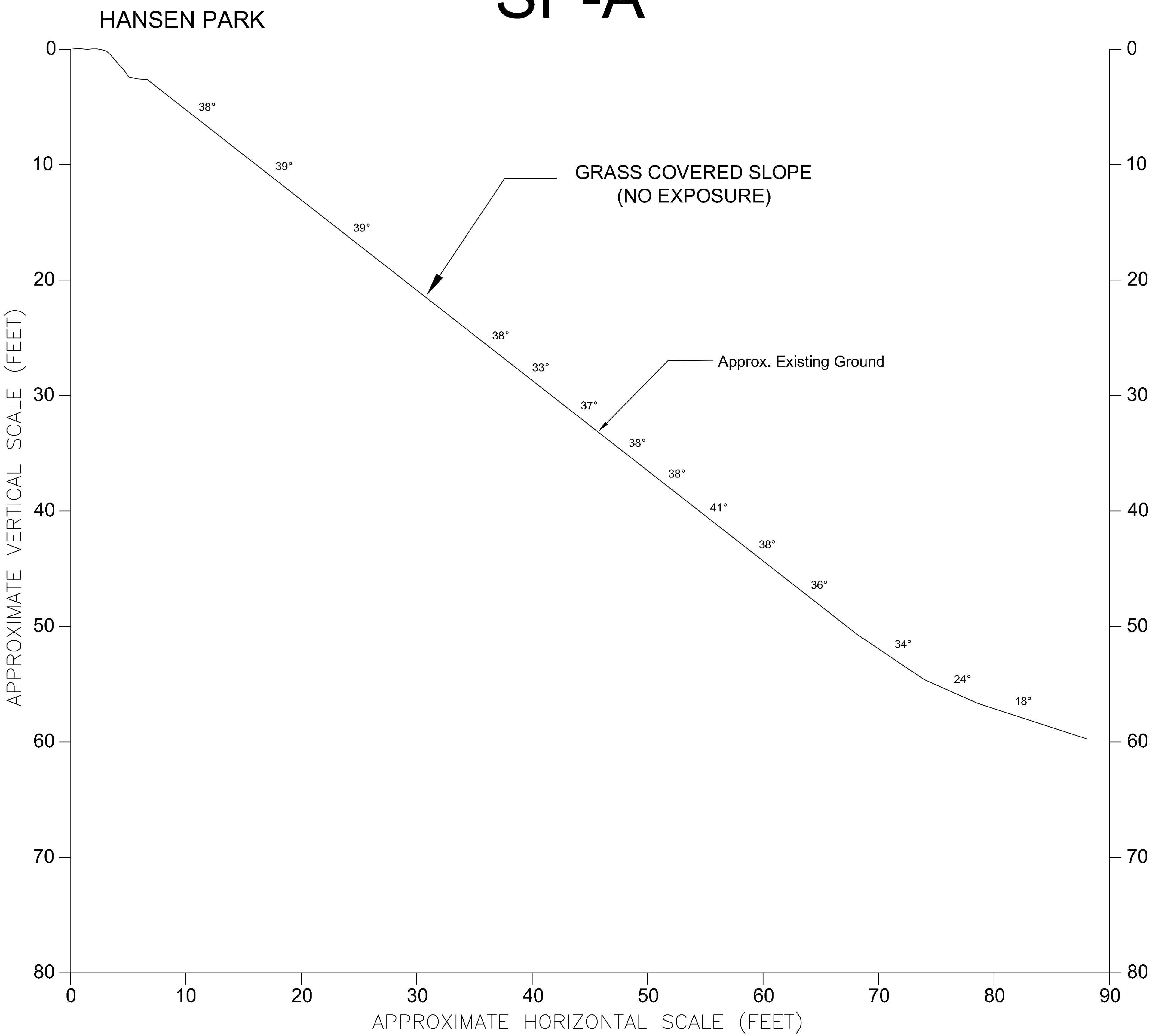
GRADATION CURVES
(TILL W/24 HR. HYDROMETER)

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	C-20

APPENDIX D
SOIL PROFILES

CORPS OF ENGINEERS U. S. ARMY

SP-A



LOOKING NORTH ACROSS CEMETERY CREEK AT SP-A.
ICINGS WERE OBSERVED IN THE TREES ON EITHER SIDE
OF THE GRASSY STRIP IN NOVEMBER, 2006.
5 OCT. 2006

LEGEND

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

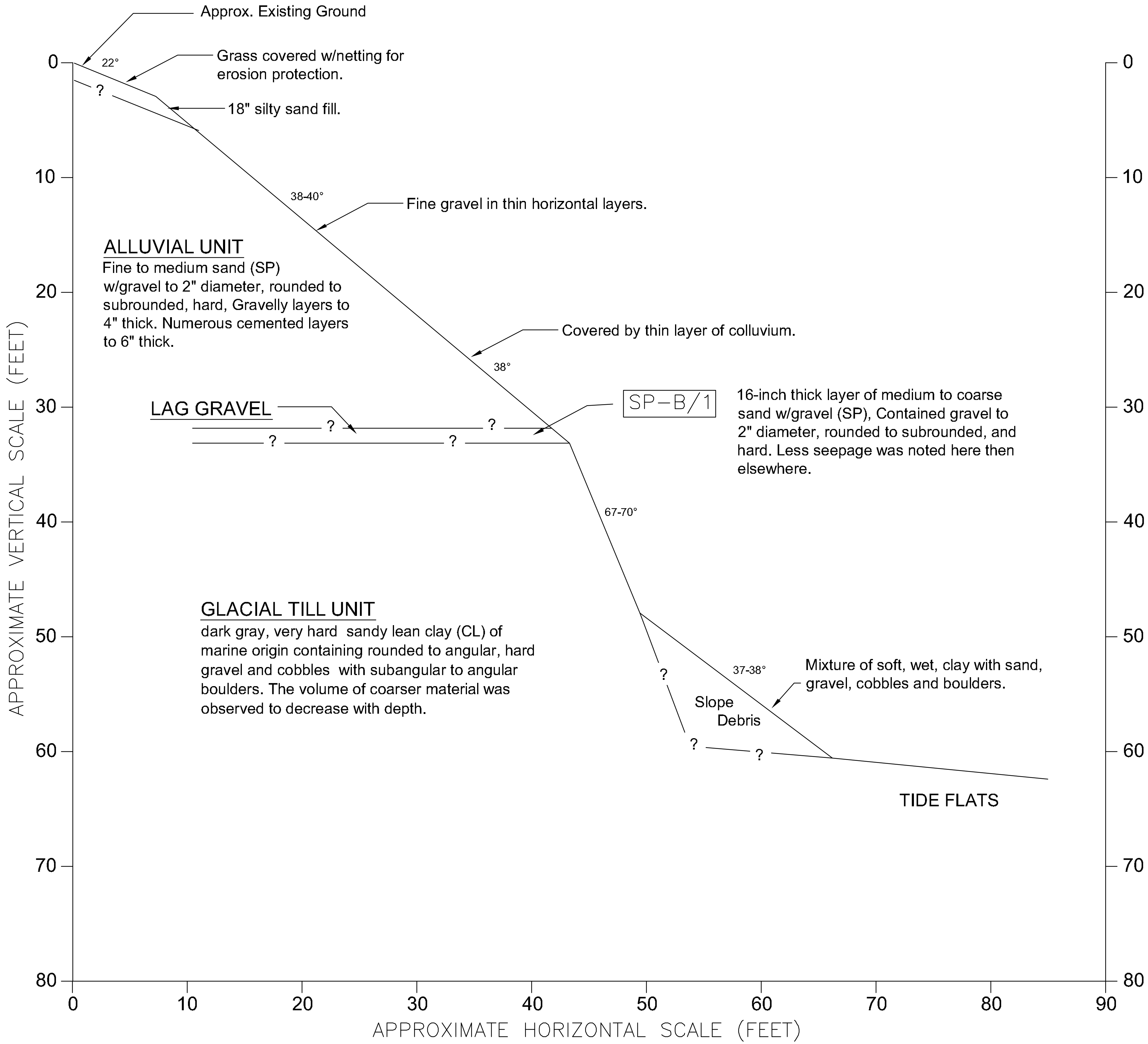
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE
SUBMITTED: C.H.R.	SP-A

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D-01

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

SP-B



LOOKING NORTH AT SP-B. THE SLABS AT THE BASE OF THE SLOPE CONSIST OF ASPHALT.
10 OCT. 2006

LEGEND

SP−A/1 SAMPLE NO. AND APPROX. LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB−05−D−0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

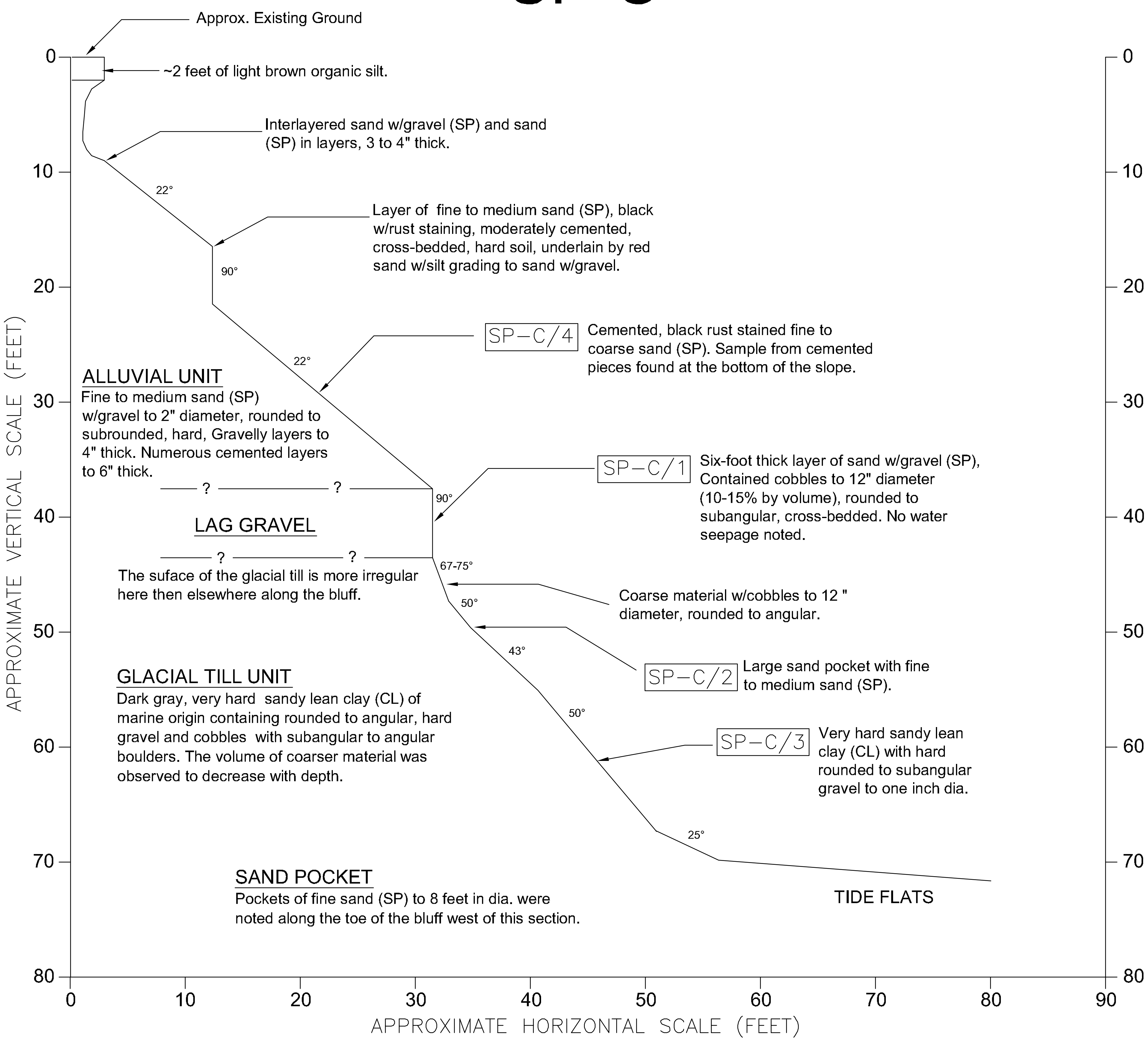
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE
SUBMITTED: C.H.R.	SP−B

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D−02

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

SP-C



LOOKING NORTH AT SP-C. UPPER SLOPES ARE STEEPER THAN ELSEWHERE, APPARENTLY DUE TO CEMENTATION. THE PRESENCE OF THIS CEMENT MAY BE BLOCKING WATER FLOW OUT OF THE SLOPE IN THIS AREA. WHAT APPEAR TO BE LARGE DARK GRAY BOULDERS AT THE BOTTOM OF THE BLUFF ARE COMPOSED OF VERY HARD CLAY.
12 OCT. 2006

LEGEND

SP–A/1 — SAMPLE NO. AND APPROX. LOCATION

36° — APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB–05–D–0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

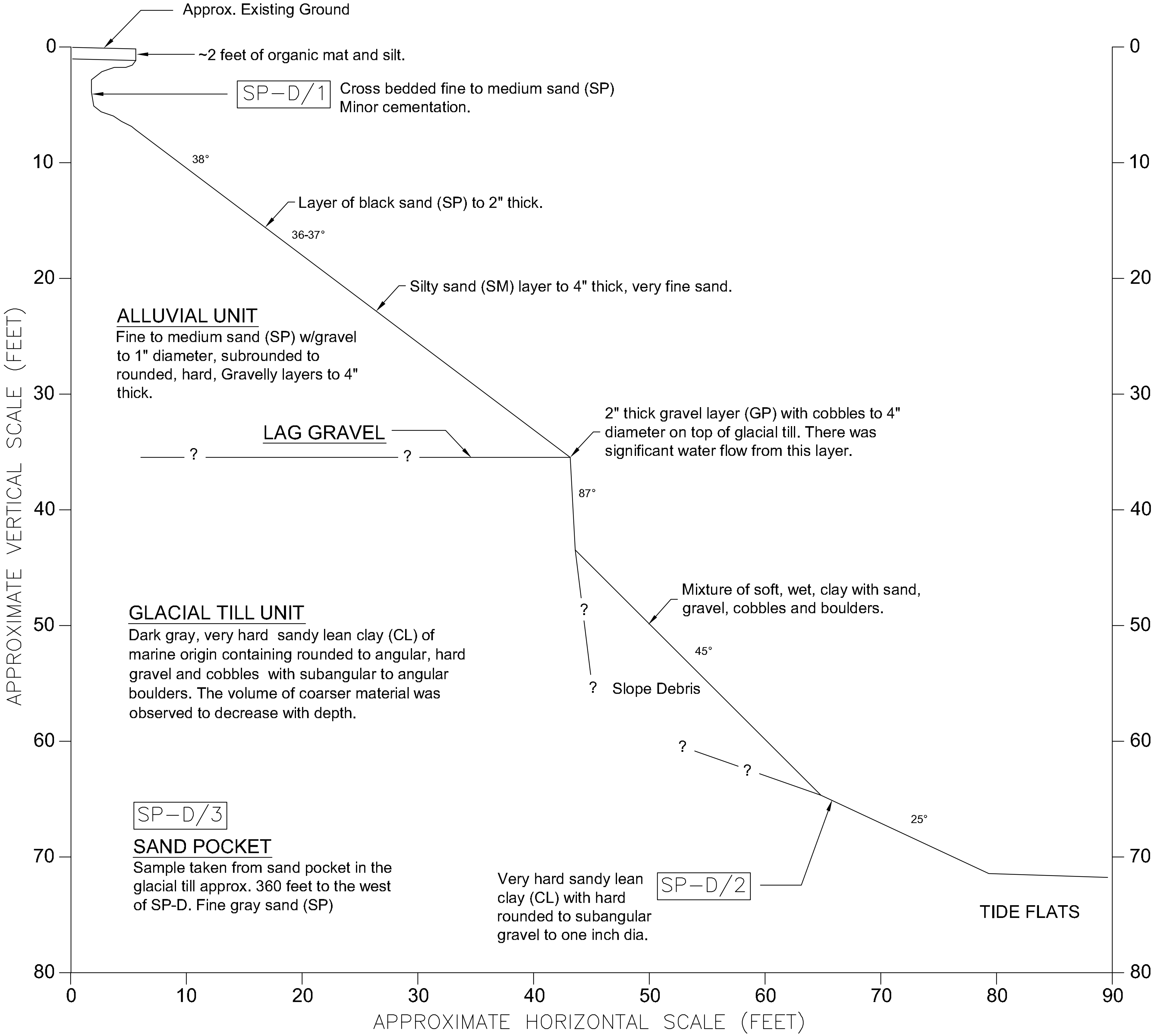
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE SP–C
SUBMITTED: C.H.R.	

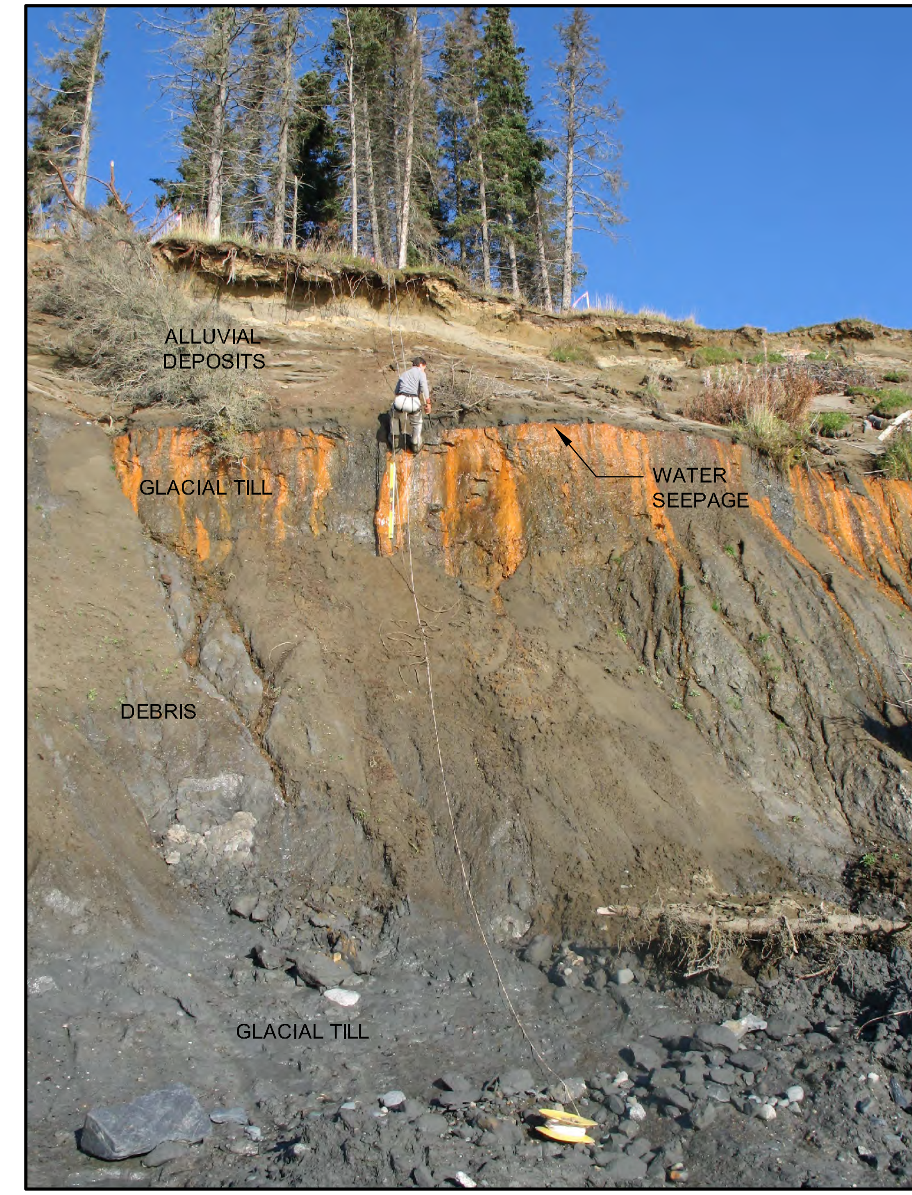
DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D–03

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

CORPS OF ENGINEERS U. S. ARMY

SP-D





LOOKING NORTH AT SP-D. ORANGE RUST STAINING WAS FOUND ON THE GLACIAL TILL IN AREAS WHERE SIGNIFICANT WATER FLOWS OUT OF THE LAG GRAVEL.
12 OCT. 2006

LEGEND

SP–A/1	SAMPLE NO. AND APPROX. LOCATION
36°	APPROX. LOCATION OF MEASURED SLOPE ANGLE

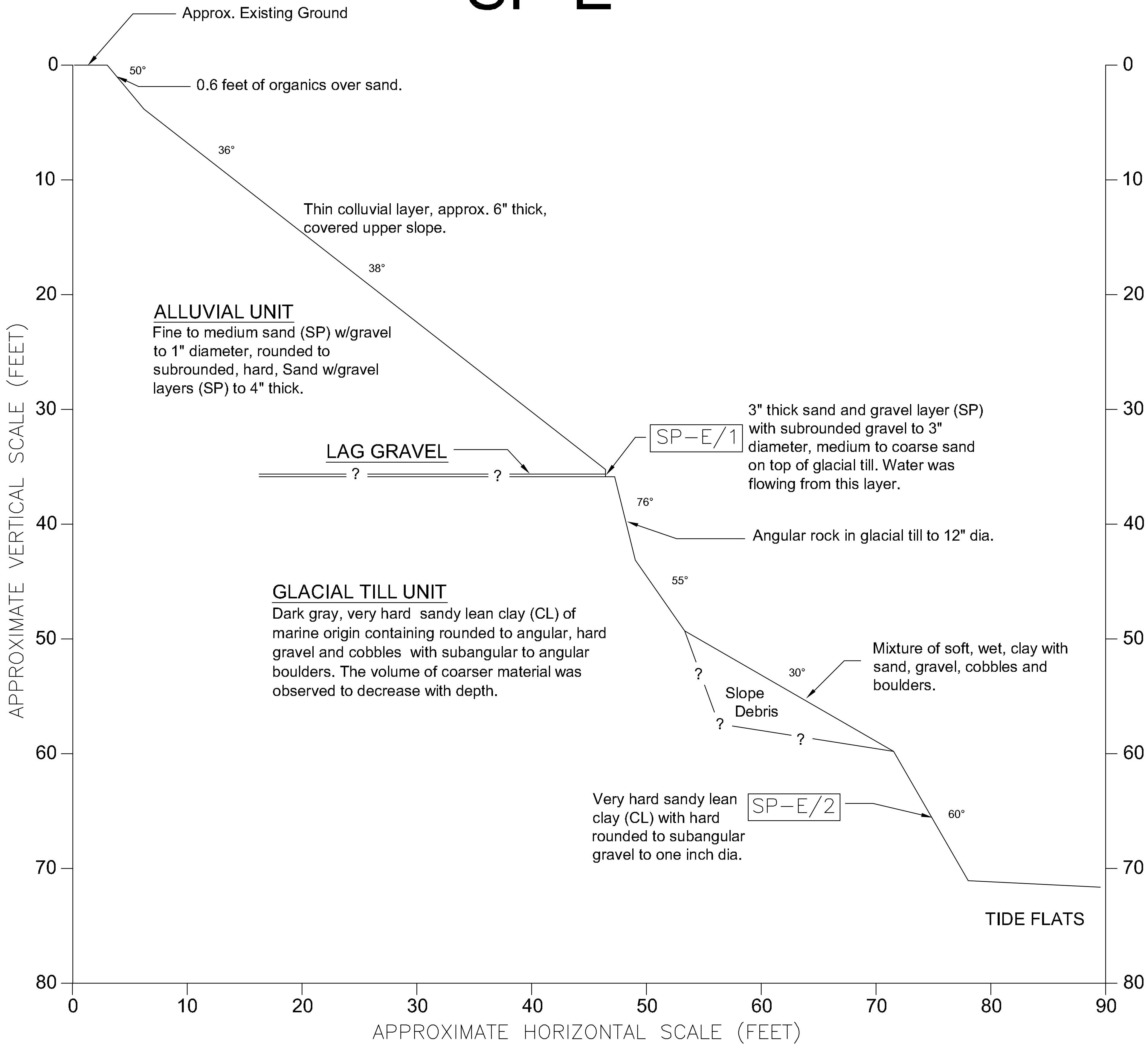
R&M CONSULTANTS, INC.

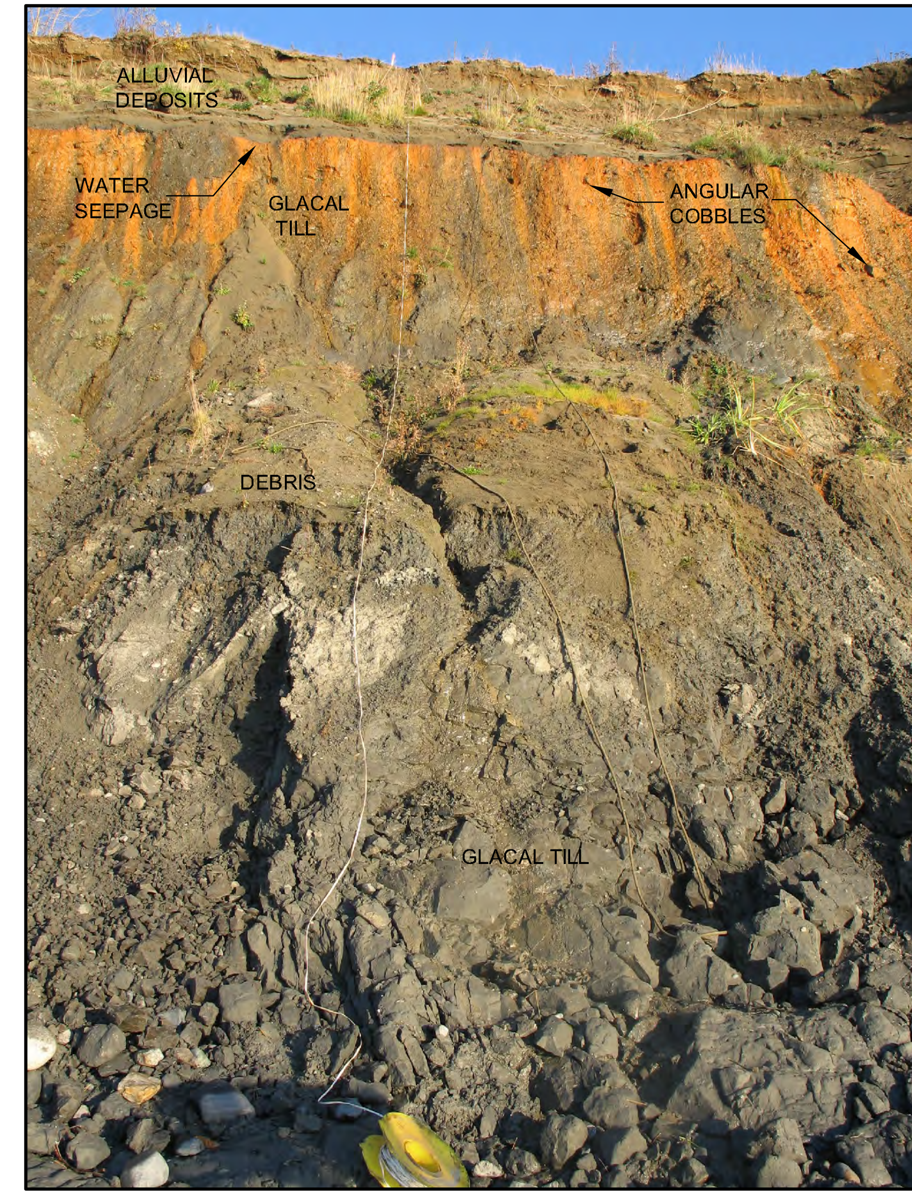
CONTRACT NO. W911KB–05–D–0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA		ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA	
DESIGNED: P.K.H. DRAWN: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA		
CHECKED: C.H.R. SUBMITTED: C.H.R.	GENERALIZED SOIL PROFILE SP–D		
DATE: OCT. 2006	R&M NO. 1209.10	SCALE: AS SHOWN	DWG. NO. D–04

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

CORPS OF ENGINEERS U. S. ARMY

SP-E





LOOKING NORTH AT SP-E. THE GLACIAL TILL EXHIBITS THE CHARACTERISTICS OF SOFT BEDROCK SUCH AS JOINTS AND OTHER STRUCTURAL FEATURES.
13 OCT. 2006

LEGEND

SP-A/1 — SAMPLE NO. AND APPROX. LOCATION

36° — APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

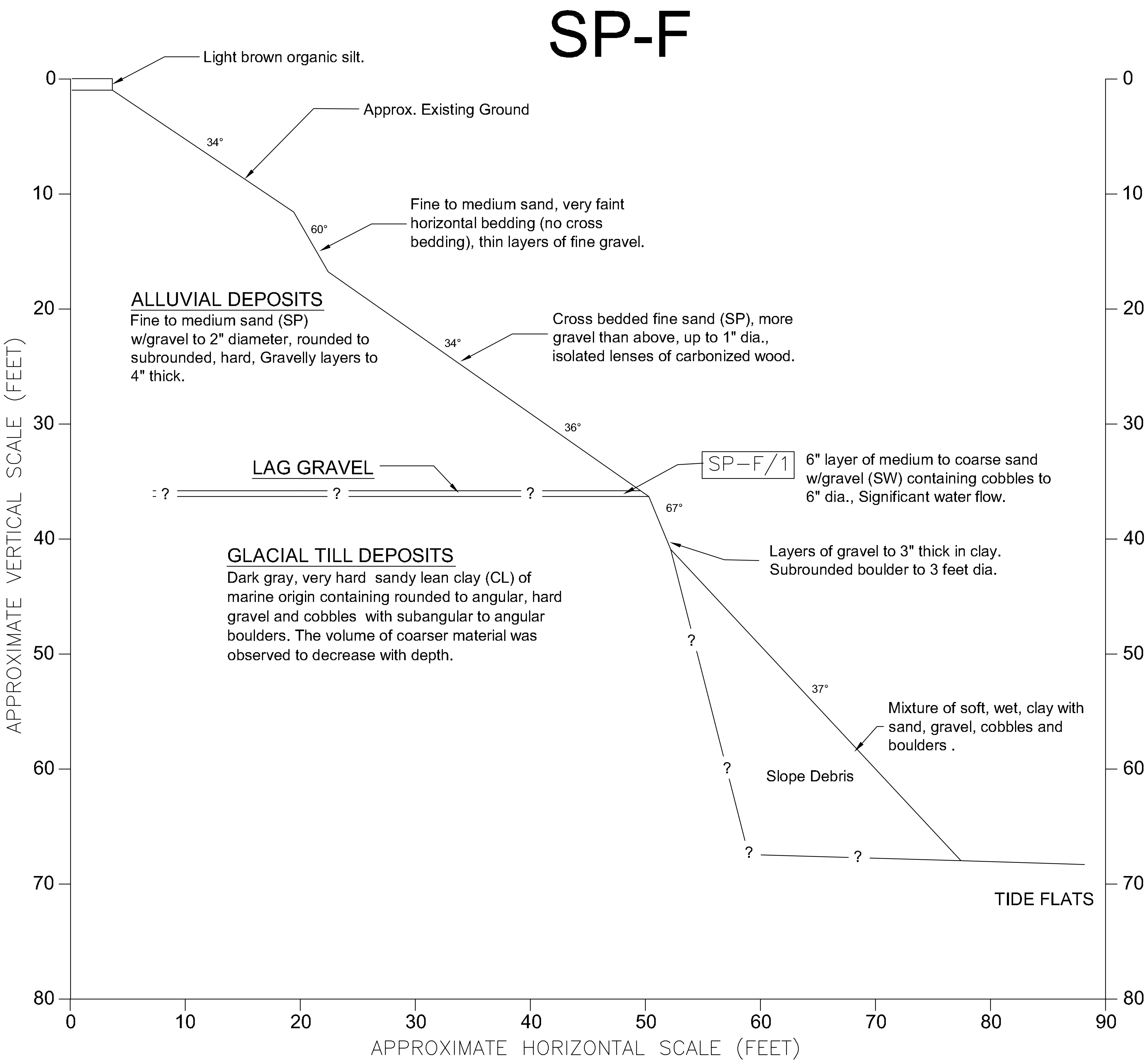
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE SP-E
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D-05

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

SP-F



LOOKING NORTH AT SP-F. WATER FLOW IS HIGHER FROM LOW SPOT ON TOP OF GLACIAL TILL. OLD DRAINAGE CHANNELS ON TOP OF GLACIAL TILL MAY CONCENTRATE WATER FLOW IN SOME AREAS.
10 OCT. 2006

LEGEND

SP-A/1 — SAMPLE NO. AND APPROX. LOCATION

36° — APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.
DRAWN: P.K.H.
CHECKED: C.H.R.
SUBMITTED: C.H.R.

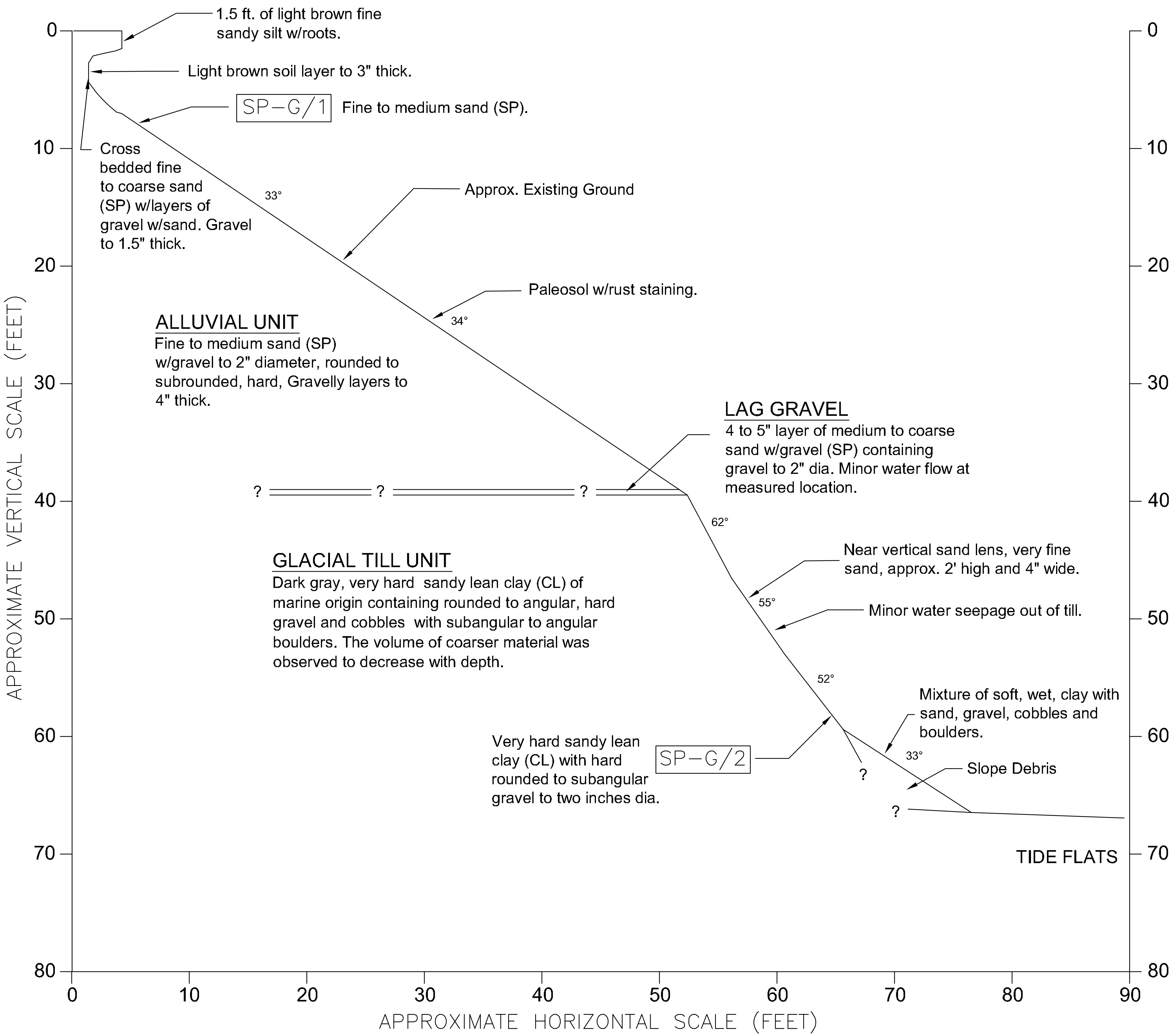
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

GENERALIZED SOIL PROFILE
SP-F

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D-06

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

SP-G



LOOKING NORTH AT SP-G. MOST OF THE EXPOSURE IS COVERED BY A THIN LAYER OF SAND. NOTE CHUNKS OF DARK GRAY CLAY AT BASE OF SLOPE.
10 OCT. 2006

LEGEND

SP–A/1 SAMPLE NO. AND APPROX. LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

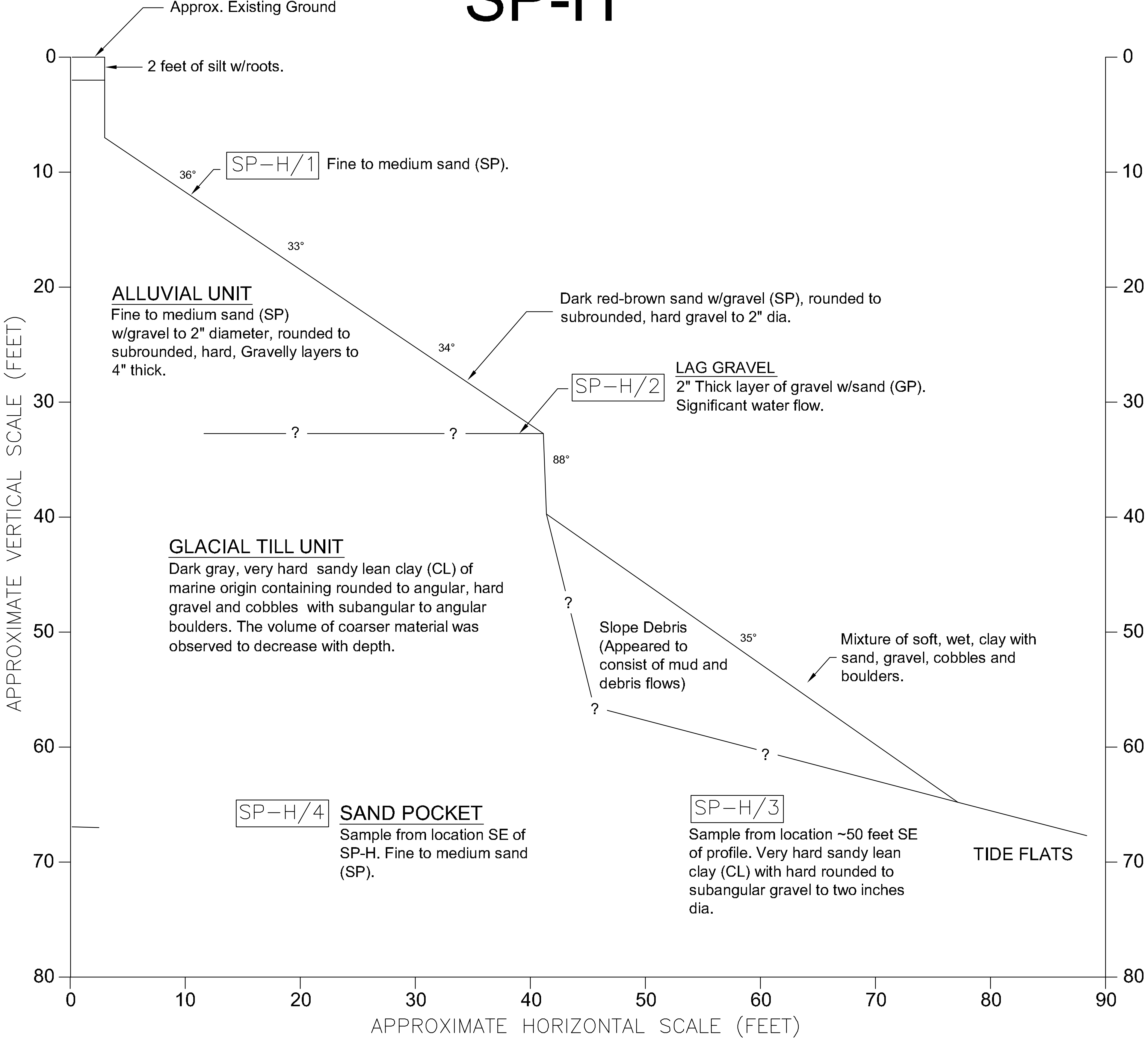
CONTRACT NO. W911KB–05–D–0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

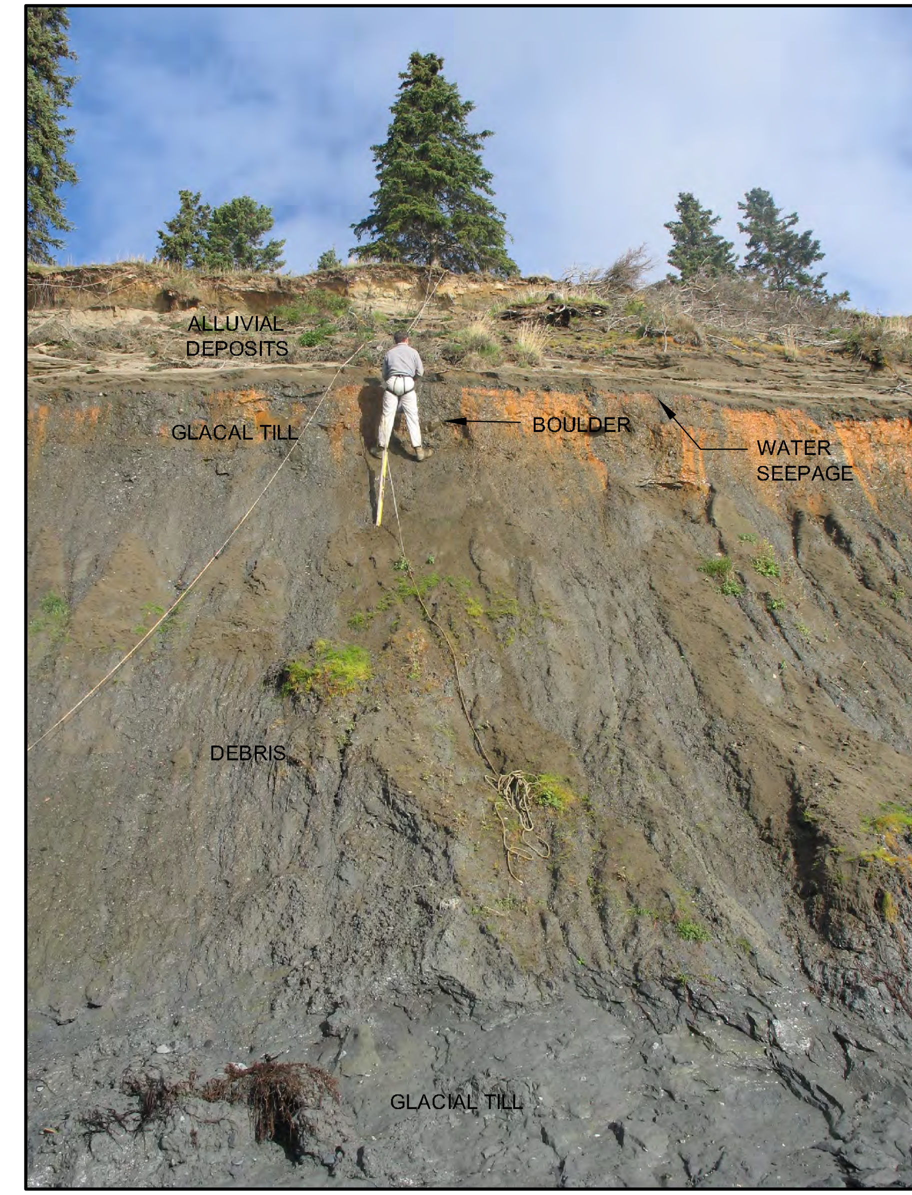
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE
SUBMITTED: C.H.R.	SP–G

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D–07

SP-H





LOOKING NORTH AT SP-H.
12 OCT. 2006

LEGEND

SP–A/1 SAMPLE NO. AND APPROX. LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB–05–D–0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

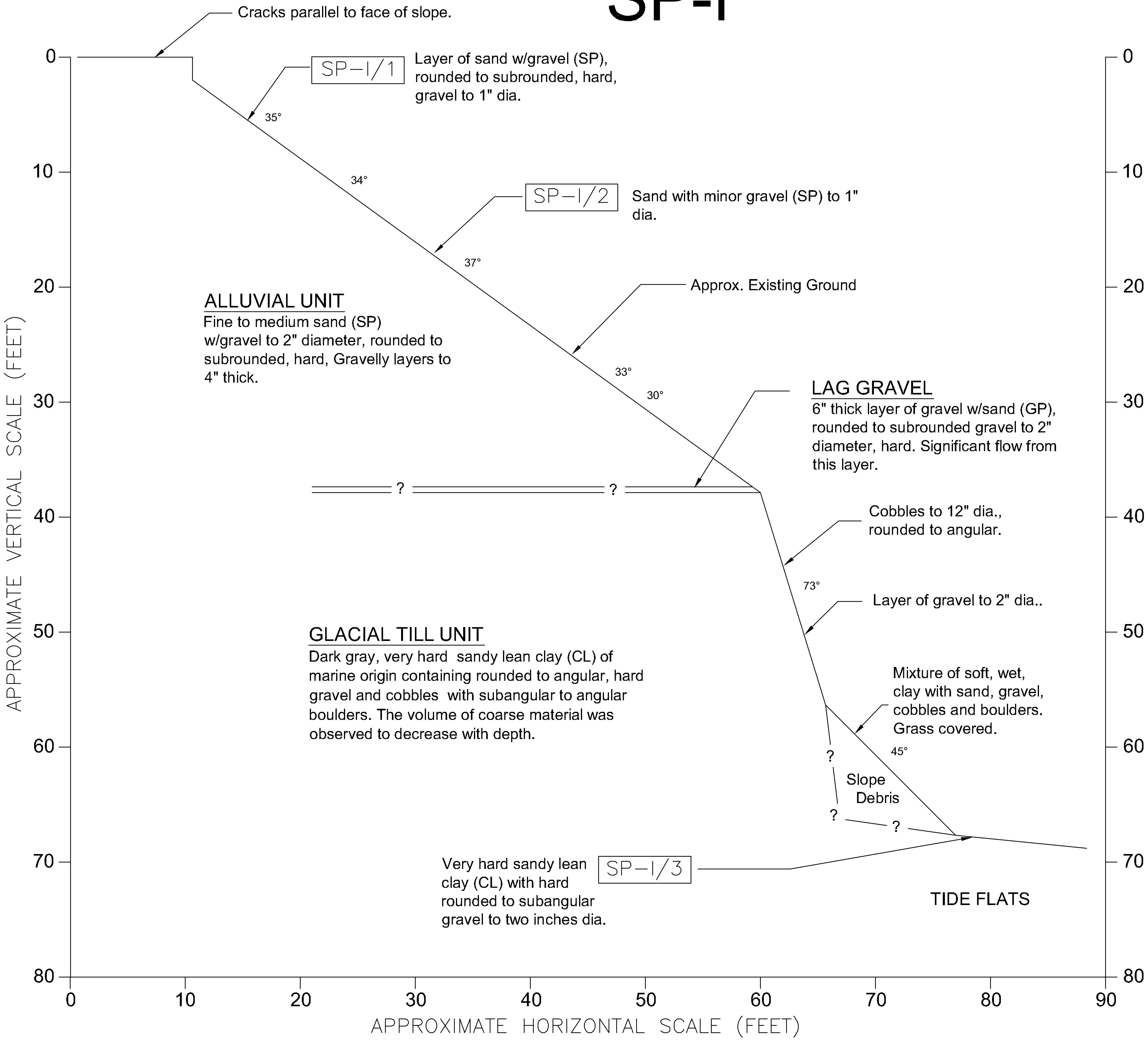
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA
DRAWN: P.K.H.	
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE SP–H
SUBMITTED: C.H.R.	

DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D–08

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

SP-I



LOOKING NORTH AT SP-I. THE AREA NEAR THIS PROFILE APPEARED TO HAVE THE HIGHEST RATE OF FLOW OF ANY LOCATION WITHIN THE STUDY AREA.
12 OCT. 2006

LEGEND

SP-A/1	SAMPLE NO. AND APPROX. LOCATION
36°	APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004
CONTRACTOR R&M CONSULTANTS, INC.
CITY ANCHORAGE STATE ALASKA

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA

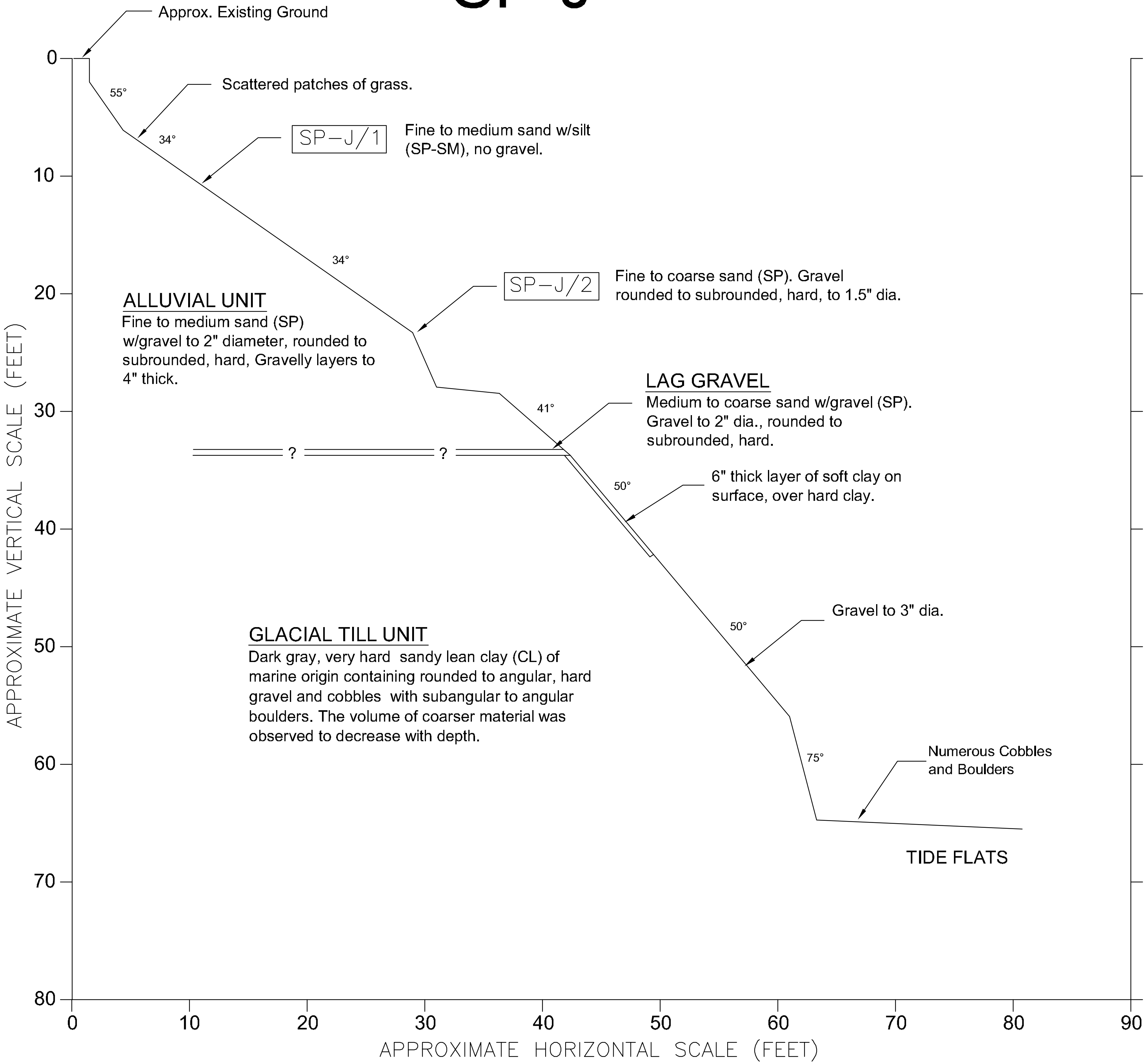
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION
DRAWN: P.K.H.	KENAI, ALASKA
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE
SUBMITTED: C.H.R.	SP-I

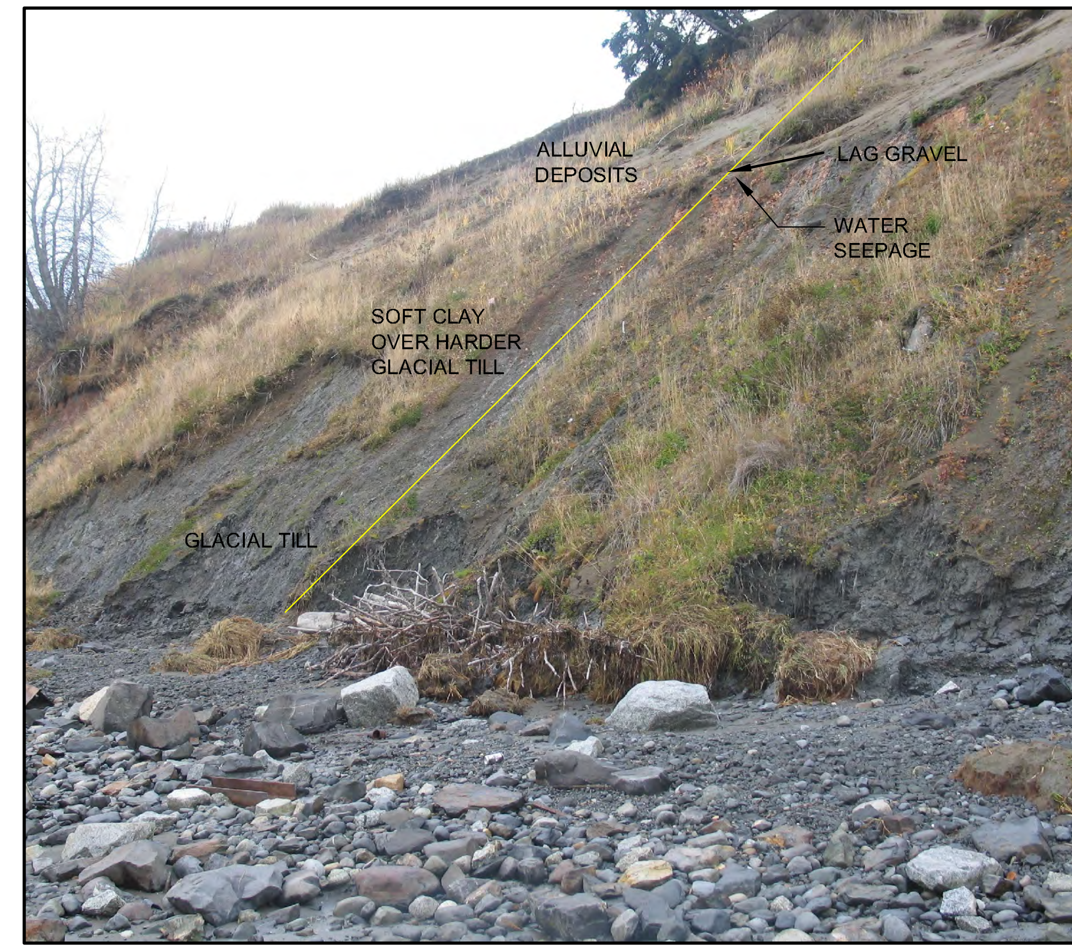
DATE:	R&M NO.	SCALE:	DWG. NO.
OCT. 2006	1209.10	AS SHOWN	D-09

project\1209.10\geo\Soils Profiles, 1=1, 12/19/06 at 15:29 by pkh

CORPS OF ENGINEERS U. S. ARMY

SP-J





LOOKING NORTH AT SP-J.
12 OCT. 2006

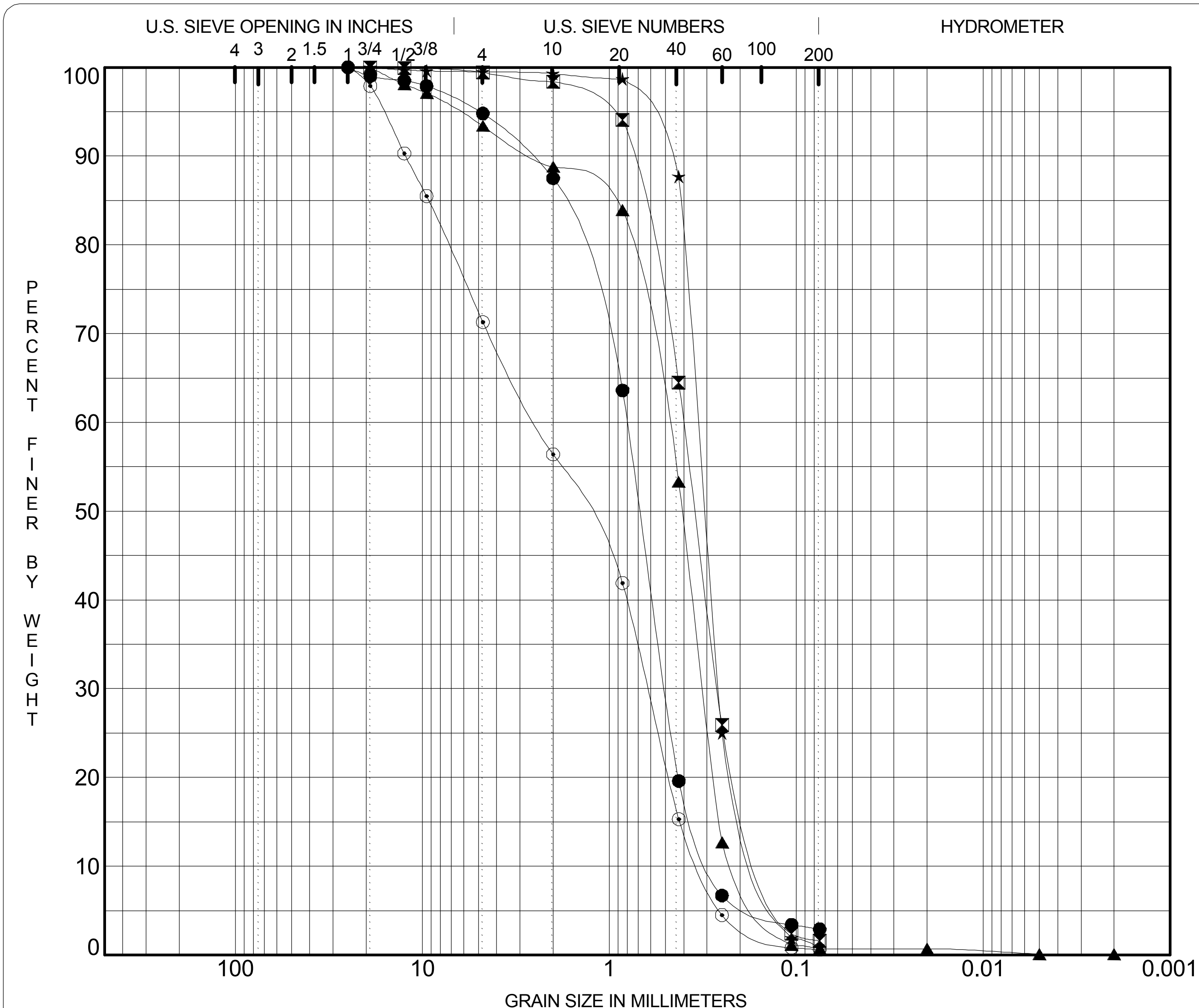
LEGEND

SP-A/1 SAMPLE NO. & APPROX. SAMPLE LOCATION

36° APPROX. LOCATION OF MEASURED SLOPE ANGLE

R&M CONSULTANTS, INC.

CONTRACT NO. W911KB-05-D-0004 CONTRACTOR R&M CONSULTANTS, INC. CITY ANCHORAGE STATE ALASKA		ALASKA DISTRICT CORPS OF ENGINEERS ANCHORAGE, ALASKA
DESIGNED: P.K.H.	KENAI RIVER BLUFF EROSION KENAI, ALASKA	
DRAWN: P.K.H.		
CHECKED: C.H.R.	GENERALIZED SOIL PROFILE SP-J	
SUBMITTED: C.H.R.		
DATE: OCT. 2006	R&M NO. 1209.10	SCALE: AS SHOWN / DWG. NO. D-10



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-C	4	SURFACE	SP	NFS	9.8				1.09	2.80
⧗	SP-D	1	SURFACE	SP	NFS	0.9				1.25	2.86
▲	SP-G	1	SURFACE	SP	NFS	3.0				0.97	2.42
★	SP-H	1	SURFACE	SP	NFS	1.6				1.41	2.35
⊙	SP-I	1	SURFACE	SP	NFS	2.4				0.48	7.52

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-C	4	25.000	0.803	0.501	0.286	5	92	3	
⧗	SP-D	1	19.000	0.4	0.264	0.14	1	98	2	
▲	SP-G	1	19.000	0.495	0.313	0.205	7	93	1	
★	SP-H	1	19.000	0.336	0.261	0.143	1	99	1	
⊙	SP-I	1	25.000	2.465	0.623	0.328	29	71	1	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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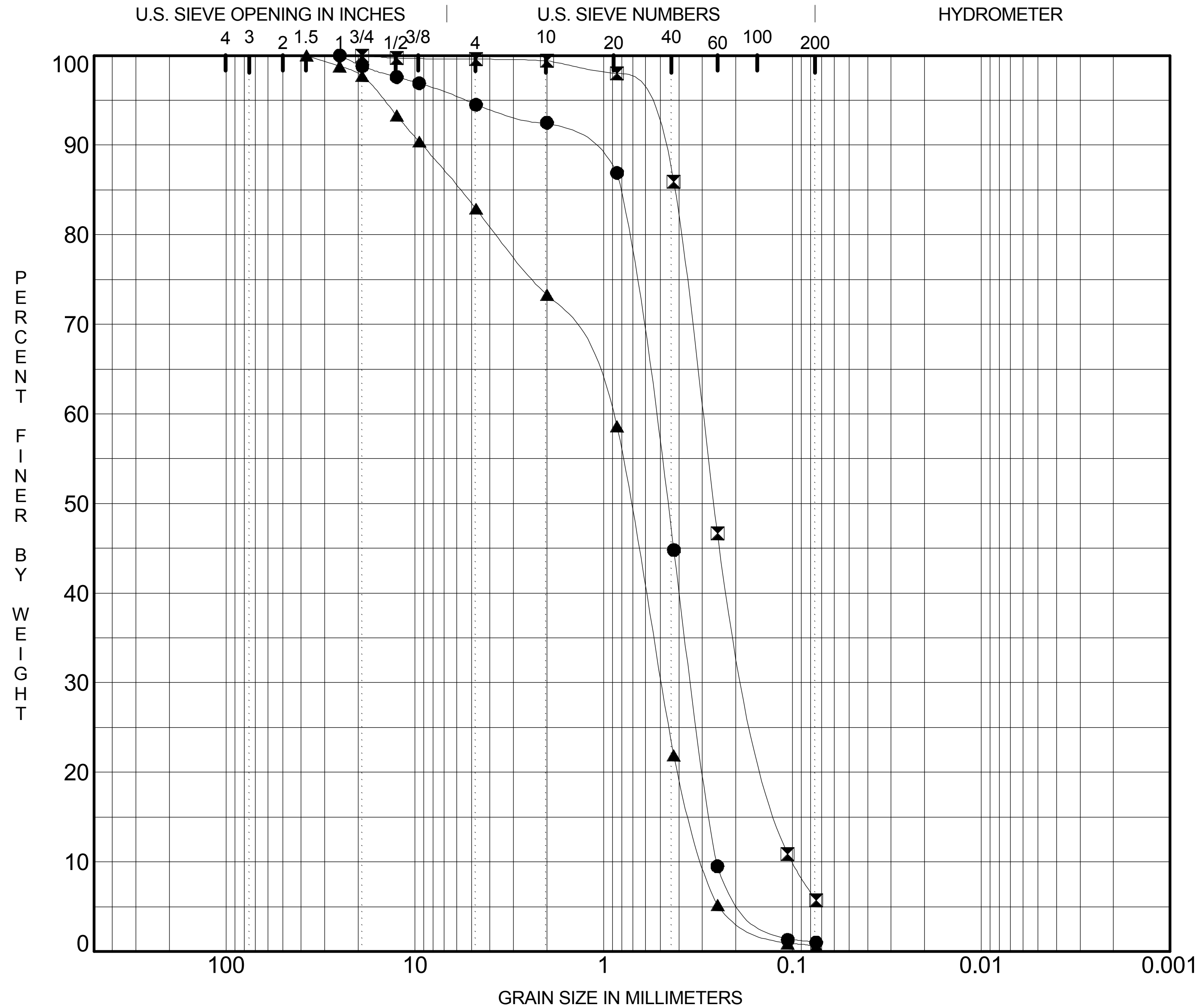
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

ALLUVIAL UNIT GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-11



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-I	2	SURFACE	SP	NFS	5.2				0.84	2.17
⧗	SP-J	1	SURFACE	SP-SM*	S2*	9.9				0.94	3.00
▲	SP-J	2	SURFACE	SP	NFS	4.2				0.91	3.17

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-I	2	25.000	0.546	0.34	0.252	6	94	1	
⧗	SP-J	1	19.000	0.299	0.168	0.1	0	94	6	
▲	SP-J	2	37.500	0.922	0.495	0.291	17	82	1	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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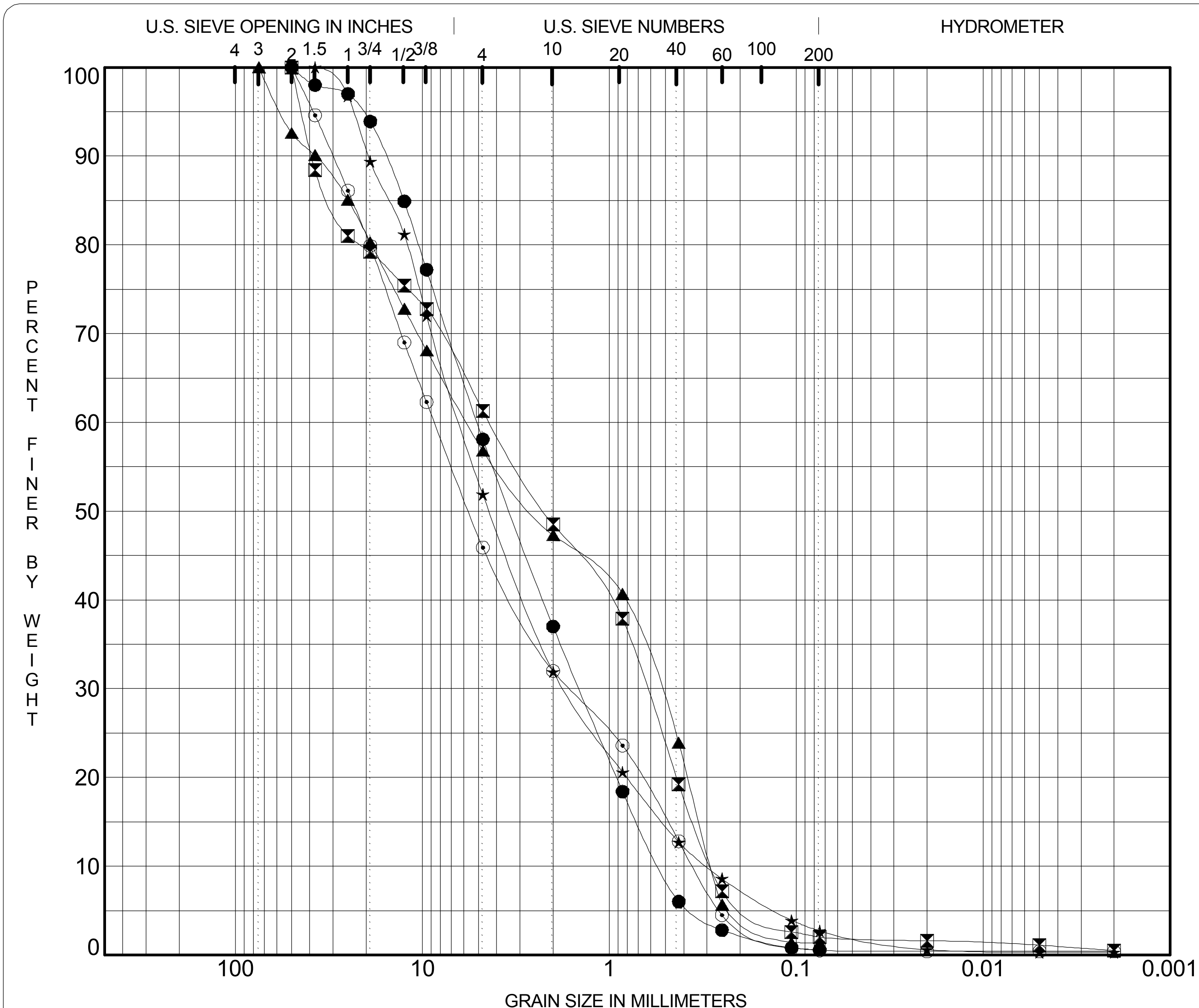
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

ALLUVIAL UNIT
GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-B	1	SURFACE	SP	NFS	5.1				0.78	9.58
⧗	SP-C	1	SURFACE	SP	NFS	3.3				0.33	15.38
▲	SP-E	1	SURFACE	SP	NFS	13				0.18	20.40
★	SP-F	1	SURFACE	SW	NFS	11				1.59	20.96
⊙	SP-H	2	SURFACE	GP	NFS	6.8				0.87	24.26

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-B	1	50.000	5.089	1.449	0.531	42	58	1	
⧗	SP-C	1	50.000	4.351	0.634	0.283	39	59	2	
▲	SP-E	1	75.000	5.78	0.547	0.283	43	56	1	
★	SP-F	1	37.500	6.281	1.732	0.3	48	49	3	
⊙	SP-H	2	50.000	8.62	1.631	0.355	54	45	1	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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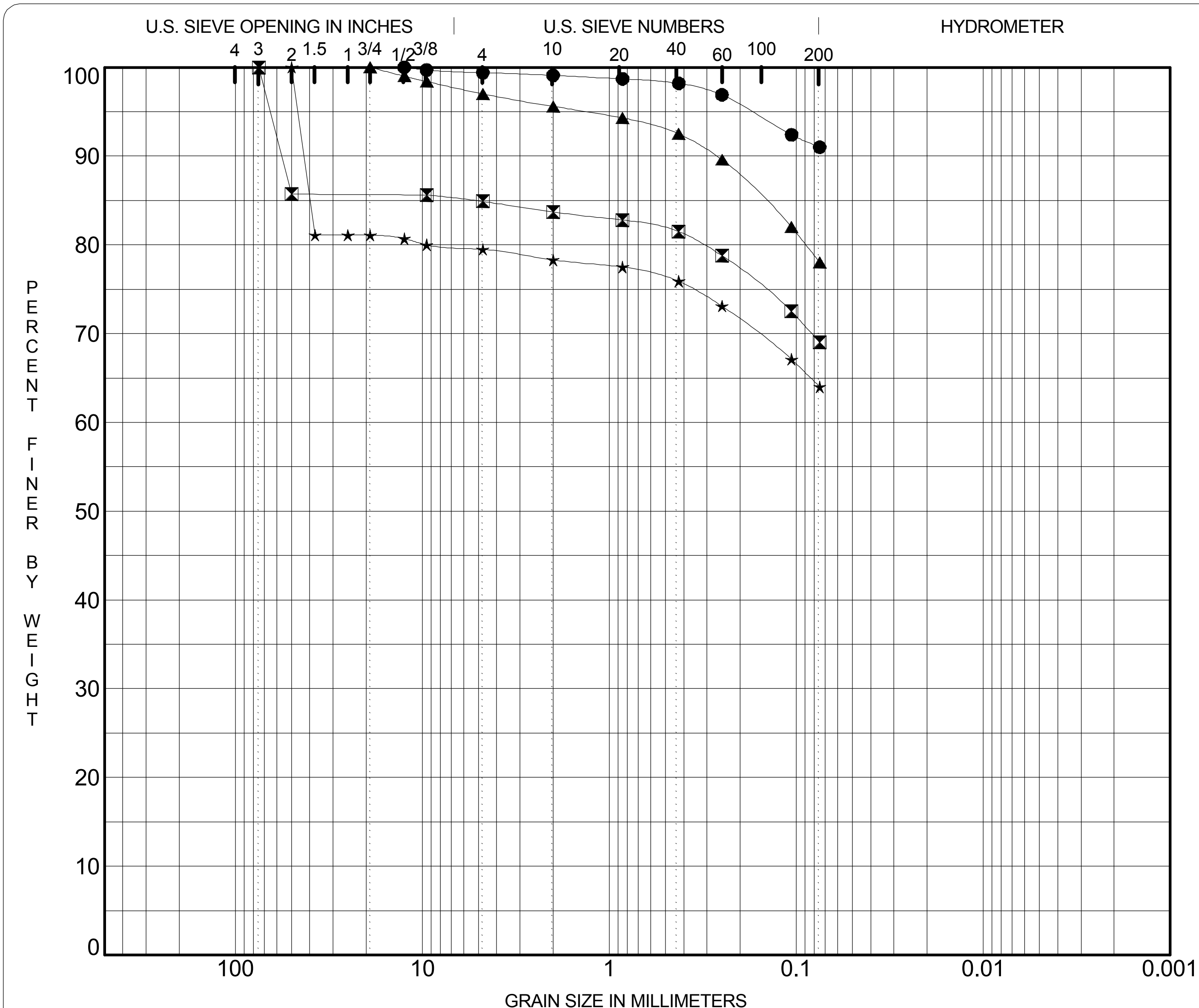
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

LAG GRAVEL
GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-13



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-C	3	SURFACE	CL	F3	16	38	18	20		
⧗	SP-D	2	SURFACE	CL	F4	16	25	14	11		
▲	SP-E	2	SURFACE	CL	F3	14	28	14	14		
★	SP-G	2	SURFACE	CL	F3	11	28	15	13		

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-C	3	12.500				1	8	91	
⧗	SP-D	2	75.000				15	16	69	
▲	SP-E	2	19.000				3	19	78	
★	SP-G	2	50.000				21	16	64	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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CONSTRUCTION SERVICES
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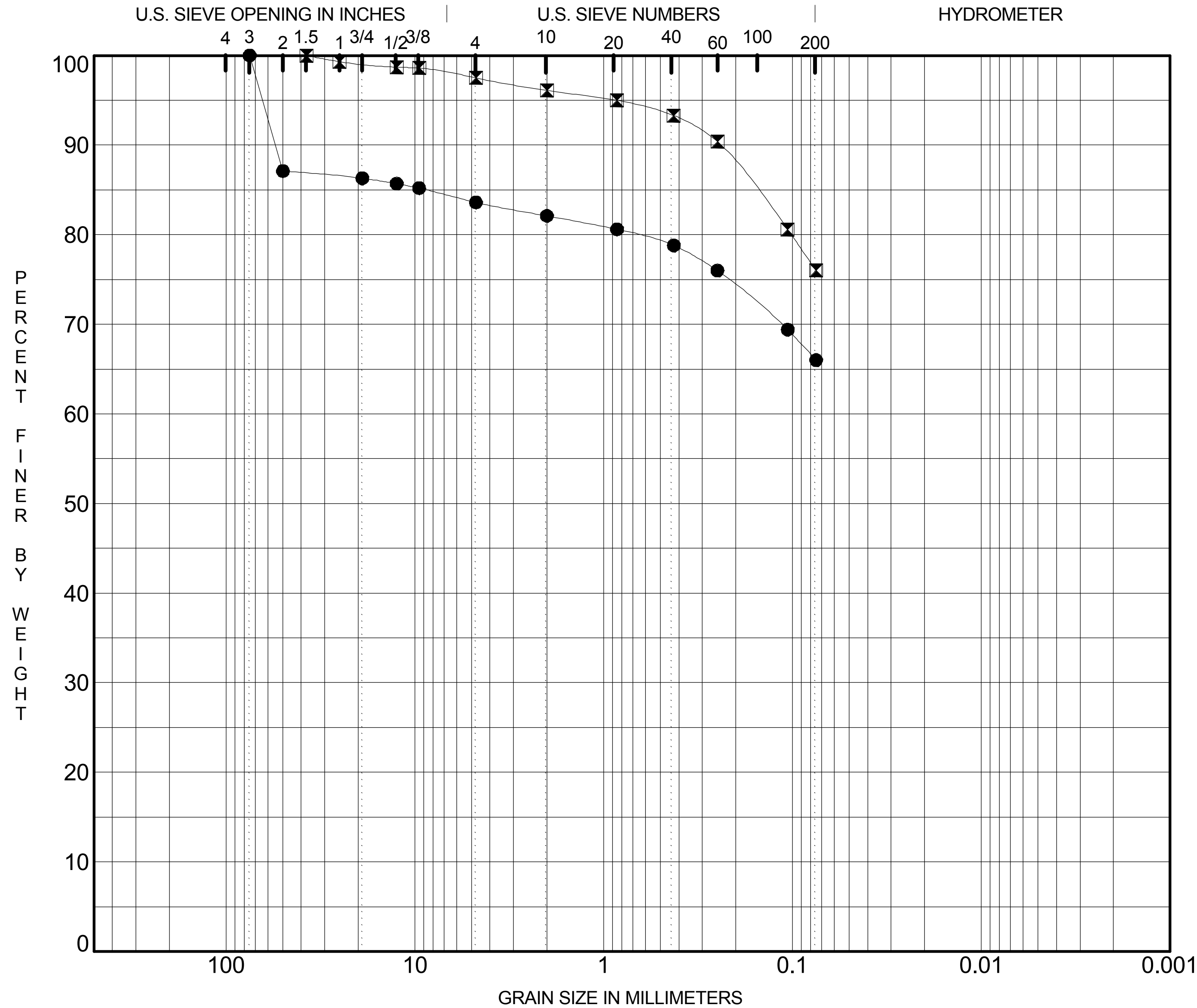
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

GLACIAL TILL UNIT GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-14



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-H	3	SURFACE	CL	F4	15	26	15	11		
⧗	SP-I	3	SURFACE	CL	F4	14	24	14	10		

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-H	3	75.000				16	18	66	
⧗	SP-I	3	37.500				3	22	76	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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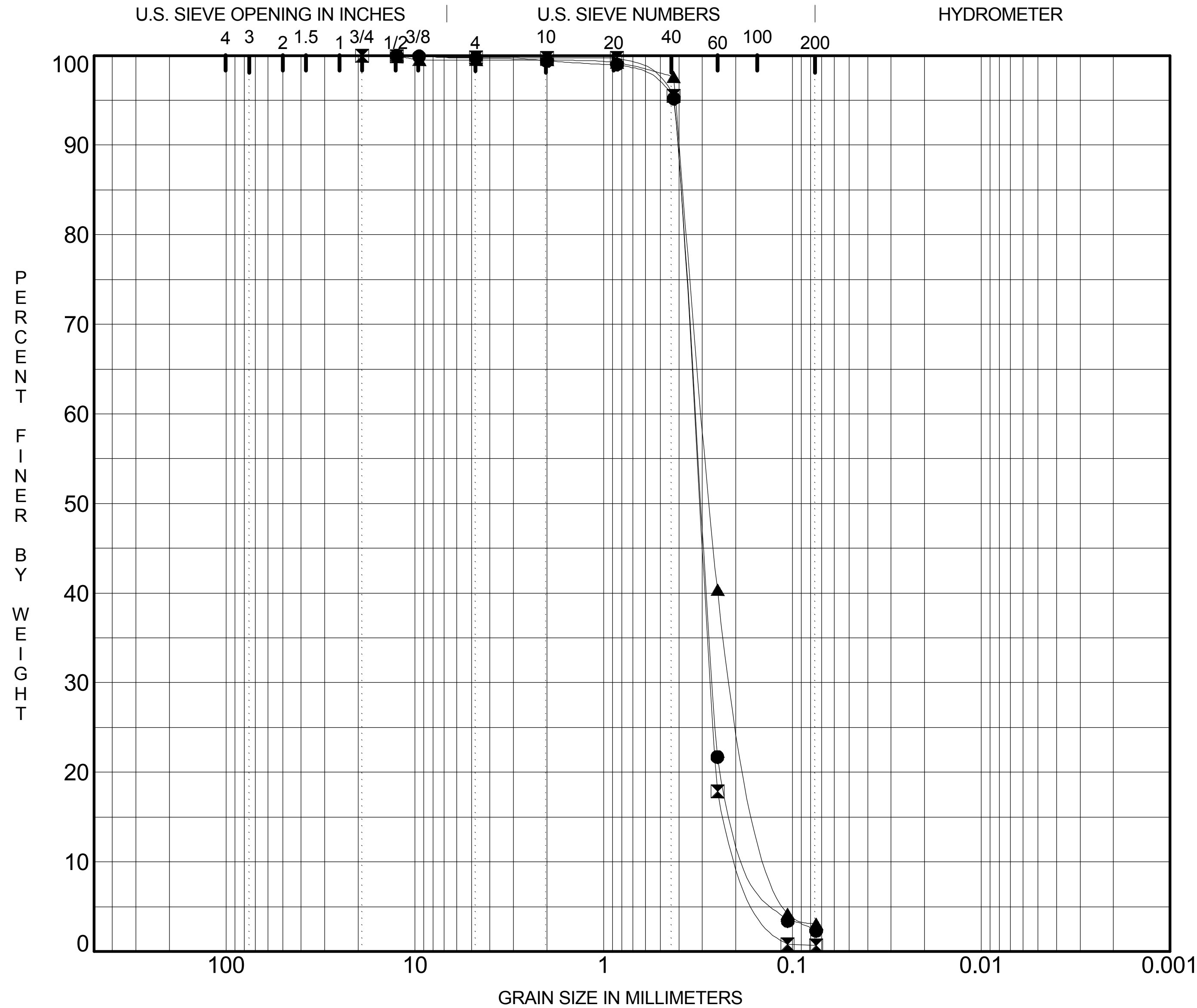
KENAI RIVER BLUFF EROSION
KENAI, ALASKA

GLACIAL TILL UNIT GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-15



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	SOIL PROFILE	Sam. No	Interval	ASTM Class.	FROST Class.	MC%	LL	PL	PI	Cc	Cu
●	SP-C	2	SURFACE	SP	NFS	4.2				1.48	2.28
⧗	SP-D	3	SURFACE	SP	NFS	3.5				1.32	1.98
▲	SP-H	4	SURFACE	SP	NFS	17				1.05	2.47

	SOIL PROFILE	Sam. No	D100	D60	D30	D10	%Gravel	%Sand	%Fines	P.02
●	SP-C	2	12.500	0.33	0.265	0.144	0	97	2	
⧗	SP-D	3	19.000	0.333	0.272	0.168	0	99	1	
▲	SP-H	4	12.500	0.3	0.195	0.122	1	96	3	

*Estimated Classification

DWN:	P.K.H.
CKD:	C.H.R.
DATE:	JAN. 2007
SCALE:	N.T.S.

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CONSTRUCTION SERVICES
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KENAI RIVER BLUFF EROSION
KENAI, ALASKA

SAND POCKETS
GRADATION CURVES

FB:	NA
GRID:	KENAI
PROJ.NO:	1209.10
DWG.NO:	D-16

APPENDIX E
STATEMENT-OF-WORK

REVISED STATEMENT OF WORK

CONTRACT NO. W911KB-05-D-0004

DELIVERY ORDER NO. 0010

GEOTECHNICAL INVESTIGATION KENAI RIVER BLUFF EROSION

KENAI, ALASKA

REVISED 13 SEPTEMBER 2006

1.0 GENERAL

The U.S. Army Corps of Engineers - Alaska District (USACE-AD) is preparing to conduct a geotechnical investigation to provide design information for the Kenai River Bluff Erosion Project. The work described herein is intended to provide specific geotechnical design information for establishing an erosion control method that is technically feasible and satisfies resource agency needs. The work will consist of drilling, logging test borings, laboratory testing, and preparing Geotechnical Findings and Ground Water Monitoring Reports. Ultimately, the geotechnical data obtained will be used, in conjunction with other considerations, in developing the specifications and design criteria for the project.

1.2 Location of Work

The project lies along the bluff on the north bank of the Kenai River from its mouth at Cook Inlet upstream to the Pacific Star Seafood plant. The surface conditions on top of the bluff consist of established business and residential properties with paved streets and utilities. The topography is relatively flat with little vertical relief. The bluff is approximately 70 feet high and very steep, with a slope angle greater than 45° in some areas. There is very little vegetation on the slope of the bluff. A project vicinity map and approximate boring locations are indicated on maps included in the "Geotechnical Scope of Work Kenai River Bluff Erosion Study" prepared by R&M Consultants, Inc. August 2006.

1.3 Work Included

The work to be performed by the Contractor includes, but is not limited to, the tasks described in the following:

- Provide final geotechnical and ground water monitoring well drilling plans

- Provide ground water monitoring well design

- Provide all supervision, labor, materials, tools, equipment, and transportation necessary to perform the fieldwork which includes drilling, disturbed and undisturbed soil sampling, backfilling or grouting of borings, moving between borings, preparation of boring logs, preservation and transportation of soil samples, installation of ground water monitoring wells, and measurement of ground water levels during and periodically after field operations.

- Prior to commencing drilling, obtain all necessary site access and digging permits. USACE-AD will provide a map showing property boundaries. Keith Kornelis, City of Kenai Public Works Manager, can be contacted at 907-283-8232 for assistance with rights of entry permits.

- Provide daily logs of all operations, observations, and measurements, and compile these logs into the specified field report.

- Provide all supervision, labor, materials, tools, equipment, and transportation necessary to perform laboratory testing of soils.

- Provide coordinates and elevations obtained by standard survey techniques for all boring and ground water monitoring wells.

- Provide draft and final Geotechnical Findings Reports presenting the results of drilling, sampling, lab testing, and data interpretation.

- Provide draft and final Ground Water Monitoring Reports presenting ground water measurements.

2.0 DETAILED STATEMENT OF WORK

2.1 Task 1: Work Plan

Before the starting of work, the Contractor shall prepare and submit to USACE-AD a draft work plan. This plan shall describe in detail the Contractor's schedule for completing the work. The work plan shall include the safety, quality control, drilling and sampling, and ground water monitoring plans. The work plan shall describe the operational procedures, the equipment to be used in the work, proposed access and other pertinent information relating to the planning and executing the fieldwork. The work plan must be reviewed and approved by USACE-AD prior to the start of work. Any deviations from the work plan during execution of the work shall be noted in the daily logs and reports.

2.2 Task 2: Geotechnical Investigation

2.2.1 Subtask 2a: Clearing

The Contractor will provide the required clearing of brush and vegetation in a manner and detail sufficient to perform the work. Clearing for access, equipment set up and staging of drilling supplies shall be kept to the minimum required for safe operation. Access shall generally be limited to existing roads, trails and open areas.

2.2.2 Subtask 2b: Drilling and Sampling

The investigation objectives during the drilling and sampling effort are as follows:

- Provide classification and descriptions of the soils and rock.

- Provide the physical and engineering properties of the soils and rock encountered.

- Provide the depth to ground water within depth of investigation.

Borehole logging and sampling shall be accomplished by an experienced geotechnical engineer, engineering technician, or geologist. These individuals and their qualifications shall be identified in the required work plan.

The drilling plan found in the submittal titled "Geotechnical Scope of Work Kenai River Bluff Erosion Study" prepared by R&M shows the approximate locations of proposed geotechnical and groundwater monitoring boring locations. Table 1 presents the adjusted number and depths of borings. After site access issues are resolved the Contractor shall provide a final drilling plan using the depth and number of borings found in Table 1.

Table 1: Proposed Geotechnical and Groundwater Borings

Boring Description	No. Borings	Depth (ft)	Sample Interval	Notes
Geotechnical Boring along Crest of Bluff	2	40	Surface, 2.5 ft. and each 5 ft. interval	Ground water well points installed at base of sand unit
Geotechnical Boring along Crest of Bluff	4	100	Surface, 2.5 ft. and each 5 ft. interval	Ground water well points installed below Clay unit
Geotechnical Boring along Toe of Bluff	6	30	Surface, 2.5 ft. and each 5 ft. interval	
Groundwater Monitoring Boring	4	40	At bottom of well point	Ground water well points installed at base of sand unit
	4	75	At bottom of well point	Ground water well points installed at bluff toe elevation in Clay unit
Totals	**20**	**1120**		

2.2.2.2 Geologic Map of Bluff

Provide a continuous geologic Map of the bluff surface, based on visual inspection. Classify the exposed soil units in accordance with ASTM D 2488 "Description and Identification of Soils (Visual-Manual Procedure), measure and record general soil units and groundwater seepage. Groundwater flow on the face of the bluff shall be measured in at least three places.

2.2.2.3 Drilling Methods and Equipment

Borings shall be drilled with a rotary type machine equipped with a hydraulic feed, and means to maintain an open and clean hole for purposes of sampling and PVC casing installation. The diameters of the borings shall be sufficient to permit the specified sampling, and the installation of 2.0-inch I.D. casing used for ground water monitoring. When gravel, boulders, abandoned man-made obstacles or any other type of obstruction are encountered in drill holes, suitable methods shall be used to drill through such obstructions. The Contractor shall submit for approval requests to bypass obstructions or abandon a hole and drill another hole nearby prior to commencing. The actions taken shall be documented.

2.2.2.4 Sampling in Soil

Grab samples shall be obtained at the surface. Drive samples shall be obtained at 2.5 and 5 feet and at intervals of 5-feet thereafter or at major soil type transitions. Drive samples shall generally be obtained using split-barrel sampling in accordance with ASTM D 1586, "Standard Test Method for Penetration Test and Split Barrel Sampling of Soils". In coarse-grained materials where insufficient penetration and material recovery is obtained using the equipment required by the ASTM 1586 test method, a modified penetration test shall be performed with a 2.5-inch I.D. split-barrel sampler and impact hammer weighing 340 lb. falling 30 inches. Otherwise, all the provisions of ASTM 1586 shall apply.

Up to five undisturbed samples shall be obtained of silt or clay soils in accordance with ASTM D 1587, "Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes". Use 3-inch diameter 36-inch long thin-walled steel sampling tubes.

Each soil sample shall be classified in accordance with ASTM D 2488, "Description and Identification of Soils (Visual-Manual Procedure)". All soil samples shall be handled in accordance with ASTM D 4220, "Standard Practices of Preserving and Transporting Soil Samples". Disturbed samples shall be handled in accordance with ASTM D4220, Group B. Undisturbed samples shall be handled in accordance with ASTM D 4220, Group D.

2.2.2.5 Installation and Monitoring of Ground Water Wells

After completion of drilling and soil sampling the geotechnical and ground water monitoring borings on the crest of the bluff, the Contractor shall install a ground water monitoring well. Each monitoring well shall be constructed to allow for the accurate measurement of ground water depths relative to the top of the well riser. The monitoring wells shall be designed by the Contractor in general accordance with ASTM D 5092, "Design and Installation of Ground Water Monitoring Wells in Aquifers". The well riser pipe shall be constructed of 2-inch I.D. polyvinyl chloride (PVC) pipe. A protective casing shall be installed around the well riser pipe extending a minimum of three feet below and three feet above the top of ground surface.

Depths of individual ground water monitoring wells shall be determined as specified in the approved drilling plan.

The Contractor will be responsible for measuring and providing a report to USACE-AD on ground water levels. The measurements shall be made upon completion of the installation and monthly for one year, with a total of 13 readings for each monitoring well.

2.2.2.6 Backfilling Borings

Geotechnical borings not having ground water monitoring wells installed shall be backfilled with cuttings removed for the borings. Borings shall be sealed near the surface with 25 lbs. of bentonite chips. Requests to use an alternative method and the procedure for such method shall be submitted by the Contractor for approval.

2.2.2.7 Cleanup

The work areas shall be kept in neat and orderly condition at all times. On completion of work, the material removed from the holes and not used as backfill shall be disposed of off site by the Contractor. The Contractor shall leave the area in a clean condition with all equipment and trash removed, all to the satisfaction of USACE-AD.

2.2.3 Subtask 2c: Laboratory Testing

All testing shall be completed in a Corps of Engineers approved laboratory. The Contractor shall transport samples from the site to their laboratory. The Contractor shall select samples representative of the soil types encountered during drilling for testing.

2.2.3.1 Test Procedures and Quantities

Test methods shall correspond to the latest addition of the referenced standard and as modified herein. All tests shall be performed on samples selected by the Contractor. Other tests may be requested based on the soil type encountered.

ASTM Test Procedures	No. of Tests
ASTM D 2487 "Classification of Soils for Engineering Purposes"	100
ASTM C-422 "Particle-Size Analysis of Soils" (24 Hour)	15
ASTM C136 "Sieve Analysis of Fine and Coarse Aggregates" and ASTM C117 "Materials Finer than 75-um (No.200) Sieve in Mineral Aggregates by Washing"	100
ASTM D 2216 "Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock and Soil-Aggregate"	100
ASTM D 4318 "Liquid Limit, Plastic Limit and Plasticity Index of Soils"	12
ASTM D 4767 "Consolidated-Undrained Triaxial Compression Test for Cohesive Soils"	6

ASTM D 2435 "One-Dimensional Consolidation Properties of Soils"	3
ASTM D2434 "Permeability of Granular Soils" (Constant Head)	3

2.3 Reports

2.3.1 Field Logs and Daily Reports

Field Logs

The Contractor shall keep, and furnish to USACE-AD with the final report, copies of an accurate field log of each boring. The log shall show the boring number, the date the boring began and finished, air temperature and weather conditions on each day of drilling, boring coordinates or other location identification, total depth, tools utilized in the drilling and sampling process, collar elevation of the boring hole (if available), description of the material in the boring, depth at which each change in material occurs, depth at which samples were obtained and the type of sample in each instance, penetration resistance, percentage of sample recovery, depth to water table and any other data pertinent to the identification of material or to the strength or consistency of the materials in undisturbed formations.

Daily Reports

The Contractor shall keep continuous logs of all operations, observations, and measurements. These logs will be made available to the USACE-AD on a day-to-day basis to assist in planning subsequent surveys and in planning other exploration activities. These detailed logs shall contain at least the items listed below.

The following gives the minimum requirements for the contents of the daily log:

- Names and affiliations of personnel engaged in the work
- Weather conditions
- All events affecting data acquisition or quality
- Equipment used
- Equipment adjustments, malfunctions, and downtime with explanations
- System calibration details
- Details of check observations and computations
- Dates and times of mobilization and demobilization
- A copy or description of all preliminary data
- All written and verbal instructions issued by USACE-AD and a description of the resolution of any issues
- All other relevant information and occurrences, including a general narrative of the total activity

2.3.3 Final Reports

The following gives the minimum requirements for the contents of the geotechnical findings report:

1. Purpose and scope of investigation including site location descriptions.

2. Description of drilling, sampling and testing equipment and methods used including horizontal and vertical control.

3. Description of pertinent regional and site geology

4. Site surface descriptions and detailed geologic map of bluff

5. Site subsurface descriptions based upon interpretation of test borings, laboratory testing, and other observations on site during the course of the fieldwork.

6. Maps and figures as necessary to support the interpretations and recommendations including as appropriate: location and vicinity maps, boring location maps, geologic map of bluff, interpretive plans and cross sections as appropriate. The drawings provided shall show all survey control as recovered or set, all elevations and features as obtained.

7. Final boring logs:

The boring logs shall be at a scale not smaller than 1:60 and shall contain the following information:

Temporary I. D. (assigned by A/E)
Permanent I. D. (assigned by USACE-AD after completion)
Coordinates and elevation
Names of individuals and firms doing drilling and logging
Type, make and model of drill rig
Size and type of casing and tools
Water table depth(s)
Sampling interval
Lab classification- ASTM D 2487
Field classification (where not lab tested)- ASTM D 2488
Frost susceptibility- TM 5-822-5
Sample drive hammer weight
Sampling device description
Blow count per 6-inch interval
Date(s) of boring

8. Laboratory test reports

9. An appendix containing this statement of work, the approved work plans, the daily reports, the field logs and a discussion of the events, changes to the work plan successes, failures and difficulties encountered during the investigation.

Ground Water Monitoring Report

The following gives the minimum requirements for the contents of the ground water monitoring report:

1. Purpose and scope of investigation including site location descriptions.

2. Description of drilling, sampling and testing equipment and methods used including horizontal and vertical control.

3. Final ground water boring logs:

The boring logs shall be at a scale not smaller than 1:60 and shall contain the following information:

Temporary I. D. (assigned by A/E)
Permanent I. D. (assigned by USACE-AD after completion)
Coordinates and elevation
Names of individuals and finns doing drilling and logging
Type, make and model of drill rig
Size and type of casing and tools
Water table depth(s)
Sampling interval
Lab classification- ASTM D 2487
Field classification (where not lab tested)- ASTM D 2488
Frost susceptibility- TM 5-822-5
Sample drive hammer weight
Sampling device description
Blow count per 6-inch interval
Date(s) of boring

4. Well installation diagrams which include a description of materials from which the well is constructed.

5. Ground water monitoring records which include, date, time, and elevation of water level measured.

Task 3 Test Boring Location Survey

The Contractor shall establish coordinates and elevations for each boring location. The survey shall conform to standards specified in EM 1110-1-1005 Topographic Surveying. Horizontal coordinates shall be surveyed to the nearest 3 foot and elevations for monitoring wells shall be surveyed to the nearest 0.1 foot. Elevations for Geotechnical borings located at the toe of the bluff shall be surveyed to nearest 1 foot. Survey control shall be based on provided information in the appendix. Electronic files which include survey field notes, photos of survey control points, and an AutoCAD drawing with aerial photo will be emailed to the Contractor.

3.0 SAFETY

The Contractor is responsible for the safety of his and the subContractor's personnel, equipment, materials, and the public at all times. Drill holes shall not be left open overnight. A specific safety and accident plan in accordance with EM 385-1-1 shall be submitted with the work plan.

4.0 QUALITY CONTROL

Quality Control Plan (QCP). The Contractor shall propose a system to manage, control, and document the performance of these tasks. The quality control activities shall be documented and included in the final reports. The Contractor shall ensure that the corporate quality policy is understood, implemented, and maintained at all levels in the organization. The Contractor shall perform continuous tracking, checks, representations, adjustments and visualization of his field data for quality control and to establish efficient field procedures. The Contractor is responsible for ensuring that project work proceeds smoothly in accordance with the statement of work and maintaining a continual vigilance for ways to increase efficiency and quality, as well as providing weekly summaries of Quality Control activities.

5.0 SITE INVESTIGATION AND REPRESENTATION:

The Contractor assumes responsibility for all investigations such as the nature and location of the work, the general and local conditions, particularly those bearing upon transportation and the availability of roads and airports, the uncertainties of weather, topography and conditions of the ground, the character of equipment and facilities needed prior to and during prosecution of the work, and all other matters upon which information is reasonably obtainable and which can in any way effect the work or the cost thereof under this modification. Any failure by the Contractor to acquaint himself with all the available information will not relieve him from responsibility for estimating properly the difficulty or cost of successfully performing the work.

6.0 AVAILABILITY OF MATERIALS:

All field notes, sketches, recordings and computations made by the Contractor in completing this work shall be available at all times during the progress of the work for examination by the contracting officer, or his authorized representative. All such material shall become the property of the Government upon completion of the delivery order.

7.0 SCHEDULE:

The required work plan shall be submitted to the Government within 7 days of notice to proceed. Fieldwork shall commence within 30 days of notice to proceed. A draft geotechnical findings report shall be submitted not later than 60 days after notice to proceed. The Government then expects to use 10 days for review and comment. A final Geotechnical Findings Report, including original notes and data shall be submitted 15 days after review and comments are complete. A draft Ground water Monitoring Report shall be submitted 15 days after the final ground water elevation measurement. The Government then expects to use 10 days for review and comment. A final Ground water Monitoring Report shall be submitted 15 days after review and comments are complete.

8.0 DELIVERABLES:

Six copies of all reports shall be delivered to:

U.S. ARMY CORPS OF ENGINEERS, ALASKA DISTRICT
ATTN: CEPOA-EN-ES-SG (Chuck Wilson)
P.O. BOX 6898
ELMENDORF AFB, ALASKA 99506-0898

and shall be accompanied by a letter or shipping form listing the materials being transmitted. In addition to the hard copies, the Contractor shall provide two copies of the reports in Microsoft Word and PDF formats, and all drawings shall be provided in AutoCAD format on compact discs.