Subsurface Conditions Data Report
Haul Route and Borrow Areas 3 and 4
Third Runway Project
Sea-Tac International Airport
Seatac, Washington

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Prepared for
HNTB

October 22, 2001
4978-52

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AR 052176

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SUBSURFACE CONDITIONS DATA REPORT
HAUL ROUTE AND BORROW AREAS 3 AND 4
THIRD RUNWAY PROJECT
SEA-TAC INTERNATIONAL AIRPORT
SEATAC, WASHINGTON

INTRODUCTION

This data report presents technical documentation of subsurface conditions, laboratory testing, and relevant geotechnical and hydrogeologic field testing of two Third Runway Borrow Areas and the associated Haul Route. A previous data report (Hart Crowser 1999) documented conditions at Borrow Areas 1, 3, and 4. The current report presents additional data collected since that time and supersedes in these areas the 1999 report for Borrow Areas 3 and 4, as well as provides information about the proposed Haul Route (Hart Crowser 2001). Borrow Areas 3 and 4 have been identified as sources of borrow materials to be used as construction fill for the Third Runway Embankment Project. These borrow areas are located south of the Sea-Tac International Airport, in SeaTac, Washington (refer to Figure 1, Vicinity Map).

Figure 1 shows the general area where we have performed geotechnical and hydrogeologic explorations for this study. Explorations and testing within the borrow areas and along the haul route are characterized in greater detail on Figures 2 and 3. Cross sections showing inferred geologic and hydrogeologic conditions are provided on Figures 4 through 6. Water level data and groundwater elevation contours for the Regional Shallow Aquifer are shown on Figure 7. Groundwater contours for the Perched Water-Bearing Zone in Borrow Areas 3 and 4 are shown on Figure 8.

We have organized this report into several sections. The main text starts with a discussion of site geology and is followed by a discussion of the hydrogeologic conditions and near-surface soil infiltration characteristics obtained from explorations conducted to date. Appendices A through C follow the main text and present results of our subsurface explorations, laboratory data, and hydrogeologic data, respectively, from this and previous investigations.

PURPOSE AND SCOPE

This report presents data collected on soil, glacially deposited materials, and groundwater conditions at Borrow Areas 3 and 4 and along the proposed Haul Route. The purpose of this report is to supplement data presented previously

(Hart Crowser 1999) identifying suitable embankment construction materials, and to support the design and development of the borrow areas and haul route.

The scope of Hart Crowser's work included completion of borings and test pits, the installation of monitoring wells, measurement of groundwater elevations, and performance of infiltration tests. The following paragraphs summarize work completed since the 1999 data report was issued.

Five additional borings were completed at Borrow Area 3 in June 2001. One boring (A3-B22-01) was completed as a monitoring well. The other four borings (A3-B18-01 through A3-B21-01) were used to perform falling head percolation tests and were then abandoned.

Five additional borings and three test pits were completed at Borrow Area 4 in June 2001. Dual-ring infiltrometer tests were performed in each of the test pits. A falling head percolation test was performed at boring A4-B09-01, which was then abandoned. Borings A4-B08-01 and A4-B10-01 were completed as monitoring wells in the perched water-bearing zone. Borings A4-B07-01 and A4-B11-01 were completed as monitoring wells in the Shallow Regional Aquifer.

Three hand-auger borings and two test pits were completed along the Haul Route in June 2001. Falling head percolation tests were performed in the borings and dual-ring infiltrometer tests were performed in the test pits.

GENERALIZED GEOLOGIC DESCRIPTION AND SUBSURFACE SOIL CONDITIONS

This section provides a description of the geologic and subsurface conditions of soils and glacial deposits within the areas shown on Figures 2 and 3, based on our explorations at the site and explorations by others. Previous studies of the local geologic and hydrologic conditions at Borrow Areas 3 and 4 have been accomplished by AGI Technologies (AGI 1995 and 1996).

Generalized Geologic Conditions

The most recent investigations did not result in any new interpretation of generalized geologic conditions in the area. The following findings remain unchanged from the 1999 data report.

The site is located on the Des Moines Drift Plain in the Puget Sound Lowland. Glacial soils have been deposited and extensively reworked by glacial episodes, the most recent being the Vashon Stade of Puget Sound glaciation.

In summary, the following geologic units have been identified at Borrow Areas 3 and 4:

- Fill (variably graded, silt, sand, and gravel);
- Alluvium (peats and silts; and medium dense, fine to medium sand);
- Recessional Outwash (primarily silty, sand and gravel, and/or sandy silt or sandy clay);
- Glacial Till (clayey, silty sand and gravel);
- Advance Outwash (non-silty to silty sand and gravel);
- Lawton Clay (very stiff to hard silt and clay); and
- Puyallup Formation (fine sand and silty sand).

Surficial soils in Borrow Areas 3 and 4 have been mapped as glacial till with localized surficial deposits of recessional outwash. Our explorations within Borrow Areas 3 and 4 suggest that these areas are part of a north-south trending ridge known as a drumlin.

Subsurface Conditions

Our interpretation of subsurface conditions at Borrow Areas 3 and 4 did not change based on new data acquired since 1999. The following section presents text from the 1999 data report, with additional discussion of conditions encountered along the Haul Route.

Subsurface soil and hydrogeologic conditions interpreted from data collected and observations made during explorations at the site, and previously mentioned AGI studies, formed the basis for the information contained within this report. Variations between explorations may occur as irregularities in gradation, moisture content, and density/consistency of soils at the site. The nature and extent of these variations may not become evident until construction. Exploration boring logs for the borrow areas and haul route are presented in Appendix A.

Subsurface conditions encountered in Borrow Areas 3 and 4 (shown on Figures 4 through 6) consist of a thin mantle of recessional outwash over glacial till, which in turn overlies advance outwash materials. These glacial sedimentary sequences overlie earlier deposits of Vashon glacial till, which overlie the

Puyallup Formation. Figure 4 is a generalized north-south cross section through Borrow Areas 3 and 4. Figures 5 and 6 are northwest-southeast and west-east cross sections through Borrow Areas 3 and 4, respectively. Detailed descriptions of the materials we encountered are provided below.

Subsurface conditions encountered along the Haul Route consisted of topsoil and fill over silt, possibly a post-glacial lacustrine deposit. These explorations were less than 10 feet deep. Explorations from the South Aviation Support Area (SASA) study (FAA 1994) located approximately 500 feet to the east indicated a thickness for the silt unit of approximately 10 feet.

Topsoil. This soil was not consistently encountered in our explorations. Typically, the topsoil consists of a loose mixture of silt and sand with roots and other organic material. Topsoil is generally 1/2 to 1 foot thick where encountered. Many of the surficial soils at the site appear to be glacial deposits at different stages of weathering. This is further discussed in the **Recessional Outwash** and **Glacial Till** sections below.

Fill Soils. Fill soils were encountered in both proposed borrow areas and along the haul route, typically associated with paved streets, or general grading associated with past use of the sites. Fill soils are generally loose to medium dense, variable mixtures of silt, sand, and gravel. The density and granular nature of the fill materials resemble the recessional outwash deposits and the fill is sometimes difficult to distinguish from the outwash.

Alluvial Deposits. These sediments occur in the low-lying areas and generally consist of soft/loose, moist to wet, interlayered silt, sand, and peat.

Recessional Outwash. This material is generally slightly silty to silty, slightly gravelly to gravelly sand. Recessional outwash overlies the glacial till, or advance outwash where the glacial till has been eroded. Recessional outwash forms a thin veneer over much of Borrow Areas 3 and 4, generally measuring less than 5 feet thick. Thicker deposits occur in southern portions of Borrow Area 3 which show historical signs of borrow development activities possibly related to previous airport construction.

Where recessional outwash is located at the ground surface, it is in a weathered condition. This layer may become colluvium where deposits are on sufficiently sloping ground.

Glacial Till. The till comprises the predominant glacially overridden unit underlying the surficial materials discussed above. This material is generally comprised of a dense, slightly gravelly to gravelly, silty to very silty sand. The gradation of the till varies both vertically and laterally.

In general, glacial till differs from the overlying recessional outwash by having a higher silt content and much higher density. The top of the glacial till is generally within 5 feet of the ground surface at each of the borrow areas, except in the southern portions of Borrow Area 3. The drumlin feature noted in Borrow Areas 3 and 4 is dominated by glacial till within the central and northern portions of Borrow Area 3. Glacial till is present throughout most of Borrow Area 4. Some weathering has been noted near the surface of the glacial till in explorations in each borrow area.

Advance Outwash Sand. This material is generally dense to very dense, slightly silty, slightly gravelly to gravelly sand. In general, the advance outwash can be distinguished from the glacial till by lower silt content. However, observations at the borrow areas where this material was encountered suggest that some areas of advance outwash may be silty. It occurs beneath the glacial till noted in each borrow area.

Lawton Silt/Pre-Vashon Deposits. The hard silt interpreted to be part of these geologic units in previous studies were not encountered in our explorations, but would likely be encountered at greater depths. These hard silts may be laminated or contain planes of separation (partings). Furthermore, these silt deposits are typically reported to be relatively plastic and are often slickensided (i.e., showing evidence of previous deformation).

Generalized Hydrogeologic Regime

The most recent investigations did not result in any new interpretation of generalized hydrogeologic conditions in the area. The following text is unchanged from the 1999 data report.

On a regional scale, the glacial deposits at depth beneath Borrow Areas 3 and 4 and the Haul Route consist of "relatively permeable" slightly silty to silty sands and gravels, with intervening layers of low-permeability glacial till and predominantly fine-grained sediments (e.g., silt and gravelly, sandy silt). Regional aquifers (indicated below in **bold** type) occur within the glacially derived, below the proposed borrow areas (AGI 1996):

- Fill, Alluvium, Vashon Recessional Outwash - Perched Water-Bearing Zones
- Vashon Till - Aquitard
- Vashon Advance Outwash - **Shallow Regional Aquifer**
- Lawton Clay - Aquitard

- "Third" Coarse-Grained Deposit — **- Intermediate Regional Aquifer**
- Puyallup Formation — - Aquitard
- "Fourth" Coarse-Grained Deposit — **- Deep Regional Aquifer**

Hydrogeologic Conditions

Borrow Areas 3 and 4 and the Haul Route are located within the Des Moines Creek drainage. The glacial till and the advance outwash act as semi-perching layers, allowing some portion of local precipitation to infiltrate down to the underlying Advance Outwash, which is typically more permeable. The Advance Outwash contains a water table known as the Shallow Regional Aquifer, which discharges to Des Moines Creek, and via underflow, into Puget Sound and the Green River valley (AGI 1996).

Groundwater elevation data were collected from explorations in Borrow Areas 3 and 4, which identified a perched water-bearing zone overlying the shallow regional aquifer. Slug testing was performed in Borrow Area 3 to obtain data for estimating hydraulic conductivity values to evaluate the perched water-bearing zone characteristics as they relate to the wetlands and borrow material development. These data and analyses are discussed below. Water levels in these borrow areas vary over time, as indicated in Tables 1 and 2.

The borrow areas are generally situated within the recessional outwash and glacial till deposits sequences, and extend into the upper part of the advance outwash, above the water table referred to as the Shallow Regional Aquifer. Figures 5 and 6 are conceptual cross sections through the Borrow Areas and depict the local perched water-bearing zone and the underlying Shallow Regional Aquifer.

Borrow Areas 3 and 4. Borrow Areas 3 and 4 are located above the Shallow Regional Aquifer. Soil borrow excavations are anticipated to encounter local perched water-bearing zones in Borrow Area 3. Measured groundwater levels and monitoring well elevation data are summarized in Tables 1 and 2.

Our interpretation of groundwater conditions is based on current observations as well as information previously reported (AGI 1995). The reported information included water level observations in two wells previously drilled by AGI which could not be located in the field at the time of our work, as well as notations of wet soils (indicating perched water-bearing zones) in the AGI boring logs.

Hart Crowser installed thirteen monitoring wells in Borrow Areas 3 and 4 in 1998 and 1999, and an additional five monitoring wells in 2001. These wells were used along with observations in four pre-existing wells to improve definition of groundwater conditions. Limited information previously available suggested the borrow areas might be underlain by groundwater with a relatively steep sloping gradient to south (AGI 1995). Current observations based on the available wells indicate a somewhat different picture—a relatively flat perched water-bearing zone in the north part of Borrow Area 3 and in Borrow Area 4 overlies the relatively flat water table in the Shallow Regional Aquifer.

Slug tests were performed in five wells at Borrow Area 3 to estimate the hydraulic conductivity of the perched groundwater zone; the test plot-graphs are presented on Figures C-1 through C-4 in Appendix C.

Haul Route. Groundwater was not observed in any of the explorations along the Haul Route. Seepage was noted in HR-TP02-01 at a depth of 6.5 feet. Explorations from the SASA study near Des Moines Creek encountered groundwater at depths ranging from 5 to 12 feet, with depths generally increasing as the land slopes upward away from the creek.

Groundwater Flow Mapping

Groundwater levels for Borrow Areas 3 and 4 were measured in 22 monitoring wells. Groundwater elevations are contoured on Figure 7 for the Shallow Regional Aquifer, illustrating groundwater flow directions. Groundwater elevations for the perched water-bearing zone are contoured on Figure 8.

Shallow Regional Aquifer. Continuous groundwater flow through Borrow Areas 3 and 4 occurs in the Shallow Regional Aquifer, which underlies both areas and is fed by infiltration from the surface and discontinuous overlying perched water-bearing zones. Groundwater from this aquifer can be seen on Figure 7 to flow eastward toward Des Moines Creek.

Perched Water-Bearing Zone. The perched water-bearing zone apparently extends west of Borrow Areas 3 and 4, based on local surface topography and is recharged by infiltration of rainfall on the higher ground to the west. The resulting perched groundwater flow direction is generally from the west, toward the south and southeast into Borrow Area 3. The overall flow pattern is also affected locally by outward radial flow from the high ground in Borrow Area 4. The perched water-bearing zone appears to pinch out to the north, where the perching horizon gradually rises and intersects ground surface. Approximate groundwater elevation contours for the perched water-bearing zone are illustrated on Figure 8.

Soil Infiltration Characteristics

Infiltration characteristics of soils beneath the locations of proposed stormwater retention and infiltration facilities were evaluated at Borrow Areas 3 and 4 and the Haul Route. Infiltration rates were estimated at each site using a combination of double-ring infiltrometer tests (ASTM Method D 3385, 2000) and falling head percolation tests (EPA 1980).

Infiltrometer tests were performed at the bottom of test pits excavated using a backhoe at locations where the testing horizon was less than 5 feet deep. Falling head percolation tests were performed in borings drilled with a hollow-stem auger drill rig at locations where the testing horizon was greater than 5 feet deep, or in shallow hand-augered borings where site disturbance resulting from a backhoe excavation was deemed unacceptable (e.g., Tyee Golf Course). Results of infiltration tests at the borrow areas and the Haul Route are shown in Table 3.

Borrow Area 3

Four falling head percolation tests were performed in borings A3-B18-01 through A3-B21-10 in the location of a proposed storage and infiltration pond at Borrow Area 3 (Figure 2). The targeted test horizon was at an elevation of 227 feet. Subsurface materials at the site consisted of slightly silty to silty, fine to medium sand from just below ground surface to depths of up to 39 feet (approximate elevation 205 feet). In these four borings the sand extends at least 5 feet below elevation 227 feet. Water levels in the vicinity of the infiltration tests range from elevations of about 210 to about 220 feet.

Measured infiltration rates at Borrow Area 3 range from 0.17 to 1.1 minutes/inch, as shown in Table 3. These rates are consistent with the sandy material encountered at this site.

Borrow Area 4

Three double-ring infiltrometer tests were performed in test pits A4-TP1-01 through A4-TP3-01 in the location of a proposed storage and infiltration pond at Borrow Area 4 (Figure 2). A falling head percolation test was attempted at boring A4-B9-01, but failed due to seepage of water into the bottom of the boring. Test elevations ranged from 290 to 296 feet, with a targeted elevation of 292 feet. Each test pit was extended 5 feet below the test horizon to log the underlying. These materials consisted primarily of silt with varying amounts of sand or gravel and are described as till-like. Groundwater seepage was not noted in any of the test pits; however, groundwater elevations from shallow wells in the vicinity indicate groundwater levels as high as 293.7 feet.

Measured infiltration rates at Borrow Area 4 were much lower than those at Borrow Area 3, ranging from 44 to 170 minutes/inch. These rates are consistent with the till-like sandy silt encountered at this site.

Haul Route

Two double-ring infiltrometer tests were performed in test pits (HR-TP1-01 and HR-TP2-01) along the Haul Route, one each at the location of two proposed ponds (Figure 3). Additionally, three falling head percolation tests were performed in hand-auger borings (HR-B1-01 through HR-B3-01) along a proposed infiltration trench following the Haul Route road alignment. Hand-auger borings were used at these locations to minimize disturbance to the Tyee Golf Course. Groundwater was not encountered in explorations at this site; however, seepage was noted at a depth of 6.5 feet (approximate elevation 246 feet) at HR-TP2-01.

Ponds

Soils encountered at the two pond locations consisted of either topsoil or fill over non-sandy to slightly sandy silt. The silt extended past the infiltration testing horizon an additional 3 to 6 feet to the bottom of each exploration. Measured infiltration rates were very low, ranging from 440 to 480 minutes/inch.

Road Alignment

Soils encountered along the trace of the proposed haul route consisted of approximately 1 foot of silty topsoil over sandy silt. Tests were performed immediately below the topsoil layer. Field personnel were only able to advance the hand-auger borings and collect soil samples for logging between 1 and 3 feet below the testing horizon. Measured infiltration rates ranged from 10.5 to 120 minutes/inch; however, these rates are likely overestimates of longer term infiltration rates due to the presence of the tighter gray silt layer at a depth of approximately 3 feet throughout the site.

USE OF THIS REPORT

Hart Crowser completed this work in general accordance with our change order dated August 3, 2001, and our contract with HNTB referred to as Amendment 22. This report is for the exclusive use of HNTB, the Port of Seattle, and their design consultants for specific application to the Third Runway project and site. We completed this study in accordance with generally accepted geotechnical/hydrogeologic practices for the nature and conditions of the work completed in the same or similar localities, at the time the work was performed. We make no other warranty, express or implied.

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REFERENCES

AGI Technologies 1995. Borrow Source Study, Proposed New Runway, Seattle-Tacoma International Airport, SeaTac, Washington. Draft Report prepared for HNTB, April 3, 1995.

AGI Technologies 1996. Appendix Q-A, Baseline Groundwater Study, Final Environmental Impact Statement, Proposed Master Plan Update, Sea-Tac International Airport, SeaTac, Washington, January 3, 1996.

ASTM 2000. Double Ring Infiltrometer Test, ASTM Method D 3385, Annual Book of ASTM Standards, Soil and Rock (1): D 420-D5799.

EPA 1980. EPA Falling Head Percolation Test Procedure, Design Manual - Onsite Wastewater Treatment and Disposal Systems, U.S. Environmental Protection Agency.

FAA 1994. South Aviation Support Area (SASA), Final Environmental Impact Statement, Technical Appendices. Federal Aviation Administration, Seattle Airports District Office. March 1994.

Hart Crowser 1999. Subsurface Conditions, Data Report, Borrow Areas 1, 3, and 4, Sea-Tac Airport Third Runway. Prepared for HNTB and the Port of Seattle. September 24, 1999.

Hart Crowser 2001. Conceptual Borrow Material Development and Reclamation Plan - Borrow Areas 3 and 4, Sea-Tac International Airport. Prepared for the Port of Seattle. August 15, 2001.

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Table 1 - Borrow Area 3 Water Level Data

	A3-B3-94		A3-B7-94		A3-B8-98		A3-B9-98		A3-B10-98		A3-B11-98		A3-B12-98	
	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet
Top of Monument	-0.90	248.94	*NOT SURVEYED*		-0.35	283.22	-0.55	272.83	-0.30	321.44	-0.75	350.90	-0.40	244.32
Measuring Point	0.00	248.04	0.00	*317.0*	0.00	282.87	0.00	272.28	0.00	321.14	0.00	350.15	0.00	243.92
Ground Level*	1.84	246.2	2.00	*315.0*	2.37	280.5	2.28	270.0	2.54	318.6	1.75	348.4	2.82	241.1
Top of Screen*	38.8	209.2	*94.5*	*222.5*	71.8	211.1	53.8	218.5	87.5	233.6	133.0	217.2	27.6	216.3
Bottom of Well*	50.8	197.2	*104.5*	*212.5*	82.3	200.6	64.2	208.1	97.8	223.3	143.3	206.9	37.9	206.0
Date: 12/28/94	35.1	211.1	87.3	227.7	--	--	--	--	--	--	--	--	--	--
1/26/1995	33.8	212.4	86.6	228.4	--	--	--	--	--	--	--	--	--	--
(ATD)														
5/15/1998	--	--	--	--	51.09	231.78	41.25	231.03	88.16	232.98	120.55	229.60	20.03	223.89
5/22/1998	29.94	218.10	--	--	51.16	231.71	41.15	231.13	*88.16*	232.98	120.35	229.80	20.21	223.71
6/2/1998	30.02	218.02	--	--	51.17	231.70	41.11	231.17	88.13	233.01	120.39	229.76	20.39	223.53
4/23/1999														
4/27/1999														
5/5/1999														
6/14/1999	28.28	219.76	--	--	50.13	232.74	39.69	232.59	87.01	234.13	119.32	230.83	18.71	225.21
7/13/1999	29.10	218.94	--	--	49.66	233.21	40.13	232.15	88.79	232.35	120.06	230.09	19.65	224.27
8/13/1999	29.93	218.11	--	--	50.48	232.39	40.89	231.39	89.50	231.64	120.79	229.36	20.63	223.29
9/14/1999	29.71	218.33	--	--	51.03	231.84	41.21	231.07	88.67	232.47	120.93	229.22	21.57	222.35
10/13/1999	31.40	216.64	--	--	51.80	231.07	41.82	230.46	89.09	232.05	121.27	228.88	22.28	221.64
11/11/1999	31.96	216.08	--	--	52.66	230.21	41.92	230.36	88.62	232.52	120.14	230.01	22.70	221.22
12/10/1999	31.96	216.08	--	--	52.27	230.60	41.99	230.29	88.35	232.79	120.51	229.64	21.63	222.29
1/12/2000	30.09	217.95	--	--	--	--	41.30	230.98	87.57	233.57	119.71	230.44	20.45	223.47
2/15/2000	30.54	217.50	--	--	51.15	231.72	41.23	231.05	87.60	233.54	119.75	230.40	19.88	224.04
3/13/2000	29.78	218.26	--	--	50.53	232.34	40.44	231.84	87.18	233.96	119.35	230.80	19.20	224.72
4/12/2000	29.20	218.84	--	--	50.5	232.37	40.69	231.59	87.56	233.58	119.78	230.37	19.26	224.66
5/10/2000	29.57	218.47	--	--	50.95	231.92	40.97	231.31	87.89	233.25	120.12	230.03	19.87	224.05
6/21/2000	30.38	217.66	--	--	52.01	230.86	41.94	230.34	89.09	232.05	121.34	228.81	20.81	223.11
7/11/2000	30.83	217.21	--	--	52.74	230.13	42.47	229.81	89.63	231.51	121.88	228.27	21.37	222.55
10/13/2000	33.16	214.88	--	--	56.16	226.71	44.60	227.68	91.10	230.04	123.27	226.88	23.69	220.23
1/23/2001	35.00	213.04	--	--	56.77	226.10	44.96	227.32	90.99	230.15	123.10	227.05	24.14	219.78
5/3/2001	35.48	212.56	--	--	55.1	227.77	43.07	229.21	88.96	232.18	121.11	229.04	23.09	220.83
6/01 (ATD)	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Italics = Estimated

Depth* All depths are below measuring point (NOT below the ground surface)

-- Indicates data not available.

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Table 1 - Borrow Area 3 Water Level Data

	A3-B13-99		A3-B14-99		A3-B15-99		A3-B16-99		A3-B17-99		A3-B22-01	
	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet
Top of Monument	-0.31	286.66	-0.28	293.28	-0.26	303.28	-0.61	346.63	-0.48	304.86	--	--
Measuring Point	0.00	286.35	0.00	293.00	0.00	303.02	0.00	346.02	0.00	304.38	0.00	245.67
Ground Level*	1.5	284.9	2.5	290.5	3.3	299.7	2.0	344.0	1.8	302.6	2.07	243.6
Top of Screen*	54.5	231.9	37.5	255.5	22.3	280.7	55.0	291.0	18.3	286.1	31.07	214.6
Bottom of Well*	59.5	226.9	42.5	250.5	27.3	275.7	60.0	286.0	23.3	281.1	41.07	204.6
Date: 12/28/94	--	--	--	--	--	--	--	--	--	--	--	--
1/26/1995	--	--	--	--	--	--	--	--	--	--	--	--
(ATD)	54.5	231.85	38.0	255.00	21.5	281.52	51.0	295.02	18.0	286.38	--	--
5/15/1998											--	--
5/22/1998											--	--
6/2/1998											--	--
4/23/1999	54.65	231.70	37.75	255.25	21.81	281.21	50.6	295.42	18.25	286.13	--	--
4/27/1999	54.69	231.66	37.73	255.27	21.44	281.58	50.65	295.37	18.37	286.01	--	--
5/5/1999	54.87	231.48	37.87	255.13	21.66	281.36	50.76	295.26	18.59	285.79	--	--
6/14/1999	55.52	230.83	38.60	254.40	22.28	280.74	51.23	294.79	19.37	285.01	--	--
7/13/1999	55.94	230.41	39.01	253.99	22.85	280.17	51.82	294.20	19.88	284.50	--	--
8/13/1999	56.45	229.90	39.23	253.77	23.41	279.61	52.54	293.48	20.43	283.95	--	--
9/14/1999	57.08	229.27	38.08	254.92	23.88	279.14	53.16	292.86	20.97	283.41	--	--
10/13/1999	57.79	228.56	40.41	252.59	24.37	278.65	53.79	292.23	21.59	282.79	--	--
11/11/1999	58.71	227.64	41.05	251.95	24.62	278.40	54.23	291.79	22.02	282.36	--	--
12/10/1999	59.31	227.04	39.96	253.04	23.72	279.30	54.76	291.26	22.15	282.23	--	--
1/12/2000	58.87	227.48	39.39	253.61	23.40	279.62	54.78	291.24	21.61	282.77	--	--
2/15/2000	58.51	227.84	38.59	254.41	22.88	280.14	54.65	291.37	20.76	283.62	--	--
3/13/2000	58.02	228.33	39.35	253.65	22.38	280.64	54.20	291.82	19.90	284.48	--	--
4/12/2000	57.53	228.82	39.60	253.40	22.99	280.03	53.97	292.05	20.19	284.19	--	--
5/10/2000	57.87	228.48	40.11	252.89	23.43	279.59	53.92	292.10	20.62	283.76	--	--
6/21/2000	58.69	227.66	40.61	252.39	23.90	279.12	54.33	291.69	21.34	283.04	--	--
7/11/2000	59.12	227.23	40.92	252.08	24.21	278.81	54.51	291.51	21.71	282.67	--	--
10/13/2000	dry	dry	dry	dry	25.27	277.75	55.43	290.59	dry	dry	--	--
1/23/2001	dry	dry	40.74	252.26	25.01	278.01	56.42	289.60	dry	dry	--	--
5/3/2001	dry	dry	40.64	252.36	24.94	278.08	56.90	289.12	dry	dry	--	--
6/01 (ATD)	--	--	--	--	--	--	--	--	--	--	35.0	208.6

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Table 2 - Borrow Area 4 Water Level Data

	A4-B1-94		A4-B2-94		A4-B4-98		A4-B5-98		A4-B6-98		A4-B7-01		A4-B8-01		A4-B10-01		A4-B11-01	
	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet
Top of Monument	-0.50	392.84	*NOT SURVEYED*		-0.35	385.71	-0.30	371.26	-0.26	401.48	--	--	--	--	--	--	--	--
Measuring Point	0.00	392.34	0.00	*345*	0.00	385.36	0.00	370.96	0.00	401.22	0.00	306.83	0.00	310.22	0.00	297.54	0.00	297.13
Ground Level*	1.94	390.4	2.00	*343*	2.36	383.0	2.66	368.3	2.72	398.5	2.43	304.4	1.92	308.3	2.14	295.4	1.63	295.5
Top of Screen*	109.44	282.90	*12*	*333*	97.86	287.50	72.86	298.10	118.52	282.70	74.43	232.40	16.42	293.80	7.14	290.40	63.63	233.50
Bottom of Well*	119.44	272.90	*22*	*323*	108.06	277.30	83.11	287.85	128.72	272.50	84.43	222.40	26.42	283.80	17.14	280.40	73.63	223.50
(ATD)	98.0	292.4	6.5	336.5														
Date: 12/28/94	100.2	290.2	9.9	333.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/26/1995	102.3	288.1	10.9	332.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(ATD)					97.8	285.20	5.3	363.00	104.3	294.20	--	--	--	--	--	--	--	--
5/15/1998	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5/22/1998	100.98	291.36	--	--	93.29	292.07	80.67	290.29	107.37	293.85	--	--	--	--	--	--	--	--
6/2/1998	100.70	291.64	--	--	92.98	292.38	80.43	290.53	106.92	294.30	--	--	--	--	--	--	--	--
6/15/1999	--	--	--	--	90.71	294.65	78.65	292.31	104.97	296.25	--	--	--	--	--	--	--	--
7/13/1999	--	--	--	--	91.09	294.27	78.80	292.16	105.23	295.99	--	--	--	--	--	--	--	--
8/13/1999	--	--	--	--	91.42	293.94	79.08	291.88	105.47	295.75	--	--	--	--	--	--	--	--
9/14/1999	--	--	--	--	91.82	293.54	79.28	291.68	105.80	295.42	--	--	--	--	--	--	--	--
10/13/1999	--	--	--	--	92.27	293.09	79.42	291.54	106.17	295.05	--	--	--	--	--	--	--	--
11/11/1999	100.20	292.14	--	--	92.60	292.76	79.75	291.21	106.61	294.61	--	--	--	--	--	--	--	--
12/10/1999	--	--	--	--	93.13	292.23	Dry	Dry	106.87	294.35	--	--	--	--	--	--	--	--
1/12/2000	--	--	--	--	93.48	291.88	80.56	290.40	107.15	294.07	--	--	--	--	--	--	--	--
2/15/2000	101.10	291.24	--	--	93.71	291.65	Dry	Dry	107.35	293.87	--	--	--	--	--	--	--	--
3/13/2000	101.03	291.31	--	--	93.58	291.78	80.72	290.24	107.23	293.99	--	--	--	--	--	--	--	--
4/12/2000	101.07	291.27	--	--	93.55	291.81	80.70	290.26	107.22	294.00	--	--	--	--	--	--	--	--
5/10/2000	101.01	291.33	--	--	93.46	291.90	80.69	290.27	107.21	294.01	--	--	--	--	--	--	--	--
6/21/2000	100.96	291.38	--	--	93.34	292.02	80.60	290.36	107.19	294.03	--	--	--	--	--	--	--	--
7/11/2000	100.95	291.39	--	--	93.34	292.02	80.62	290.34	107.17	294.05	--	--	--	--	--	--	--	--
10/13/2000	101.21	291.13	--	--	93.79	291.57	dry	dry	107.44	293.78	--	--	--	--	--	--	--	--
1/23/2001	101.67	290.67	--	--	94.52	290.84	dry	dry	108.01	293.21	--	--	--	--	--	--	--	--
5/3/2001	102.64	289.70	--	--	95.46	289.90	dry	dry	108.90	292.32	--	--	--	--	--	--	--	--
6/01 (ATD)	--	--	--	--	--	--	--	--	--	--	73.5	230.90	17.5	290.80	dry	dry	66	229.50
6/29/2001	--	--	--	--	95.93	289.43	dry	dry	109.34	291.88	74.47	232.36	16.49	293.73	10.30	287.24	55.21	241.92
7/31/2001	--	--	--	--	--	--	--	--	--	--	75.50	231.33	16.97	293.25	10.04	287.50	55.50	241.63

Italics = Estimated

Depth* All depths are below measuring point (NOT below the ground surface) - except ATD

-- Indicates data not available.

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Table 3 - Summary of Infiltration Tests
Borrow Areas 3 and 4 and the Haul Route

Borrow Area 3

Boring Number	Ground Surface Elevation in Feet	Boring Depth in Feet	Test Elevation in Feet	Infiltration Rate in minutes/inch
A3-B18-01	240.20	13 + 6.5	227	0.17
A3-B19-01	237.99	11 + 4.5	227	1.1
A3-B20-01	247.27	20 + 5.5	227	0.21
A3-B21-01	245.18	18 + 7.5	227	0.28

Borrow Area 4

Boring Number	Ground Surface Elevation in Feet	Boring Depth in Feet	Test Elevation in Feet	Infiltration Rate in minutes/inch
A4-B09-01	304.78	13 + 6	292	NM

Test Pit Number	Ground Surface Elevation in Feet	Test Pit Depth in Feet	Test Elevation in Feet	Infiltration Rate in minutes/inch
A4-TP01-01	299.76	4 + 5	296	44
A4-TP02-01	294.21	4 + 5	290	140
A4-TP03-01	294.17	4 + 5	290	170

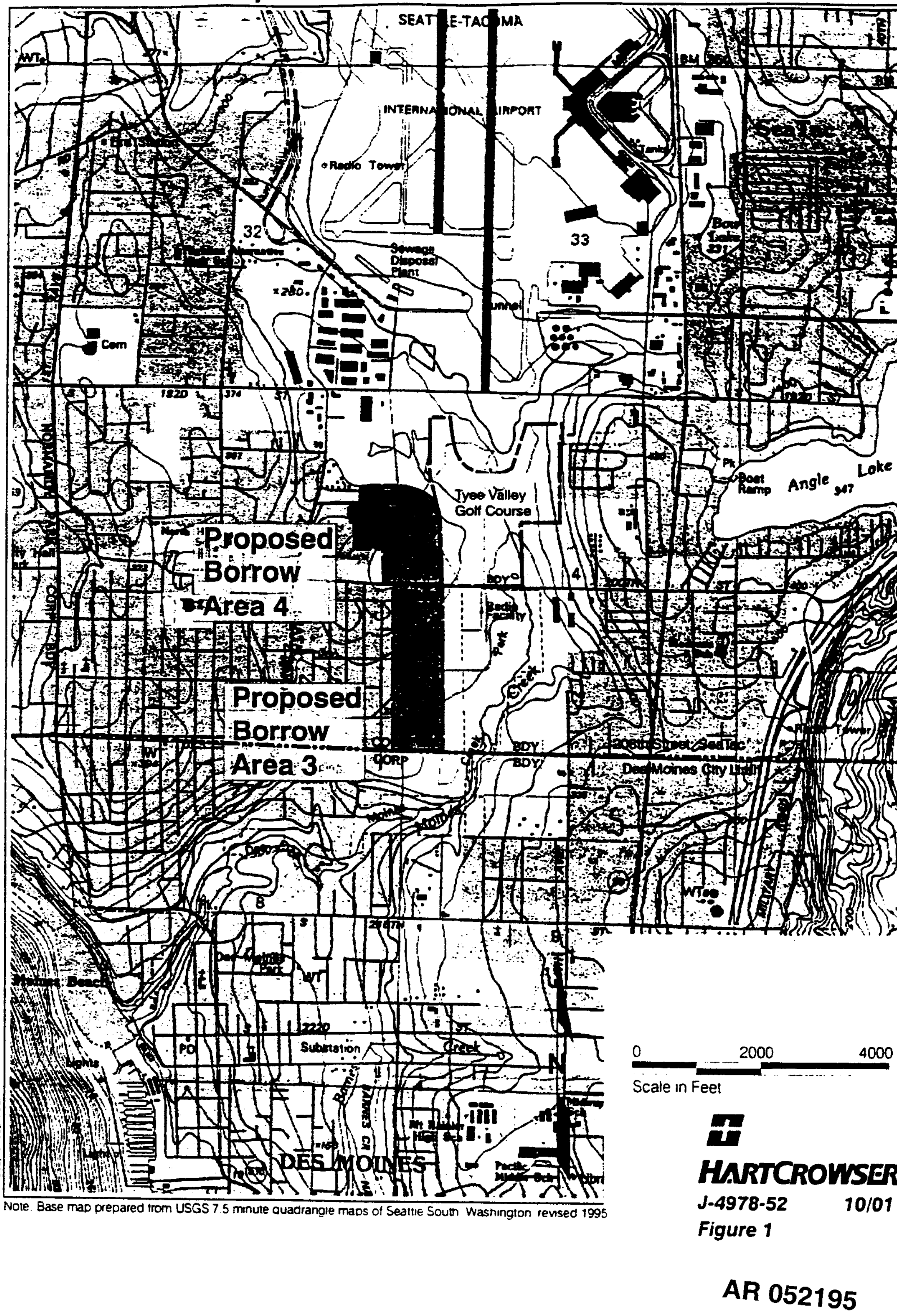
Haul Route

Hand-Auger Boring Number	Ground Surface Elevation in Feet	Boring Depth in Feet	Test Elevation in Feet	Infiltration Rate in minutes/inch
HR-B01-01	252	1 + 2.6	251	10.5
HR-B02-01	250	1 + 3	249	14
HR-B03-01	250	1 + 1	249	120

Test Pit Number	Ground Surface Elevation in Feet	Test Pit Depth in Feet	Test Elevation in Feet	Infiltration Rate in minutes/inch
HR-TP01-01	256	6 + 3	250	480
HR-TP02-01	252	4 + 6	248	440

NM - Not Measured. Slow seepage into the bottom of the boring invalidated testing.
Exploration depths indicate the depth at which infiltration testing was performed, plus the additional depth drilled for soil logging.

Site Location Map



Note. Base map prepared from USGS 7.5 minute quadrangle maps of Seattle South Washington revised 1995

497852/497852A.cdr

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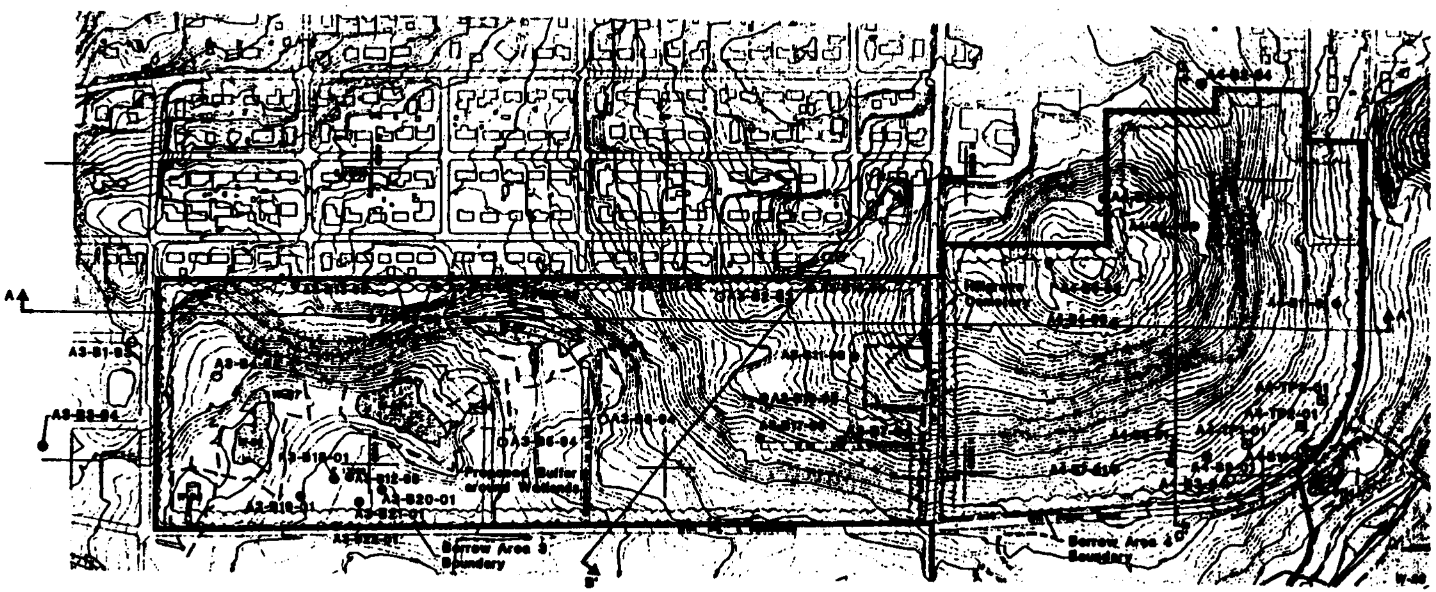
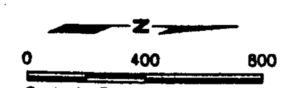
Figure 1

AR 052195

Site Exploration Plan
Borrow Areas 3 and 4



Notes:
1) Base map prepared from drawing provided by HNTB entitled "X_topo.dwg", dated April 4, 2001.
2) Wetland delineation prepared from drawing provided by Parametrix entitled, "W_022001.dwg", dated February 20, 2001.
3) Refer to Figures 4 through 6 for Cross Sections.



Exploration Location and Number

- ●A3-B10-88 Boring with Observation Well (Hart Crowser)
- ●A3-B18-01 Boring (Hart Crowser)
- ●A3-B3-94 Boring with Observation Well (AGI)
- ○A3-B1-93 Boring (AGI)
- ⊠A4-TP1-01 Test Pit (Hart Crowser)

A—A' Cross Section Location and Designation

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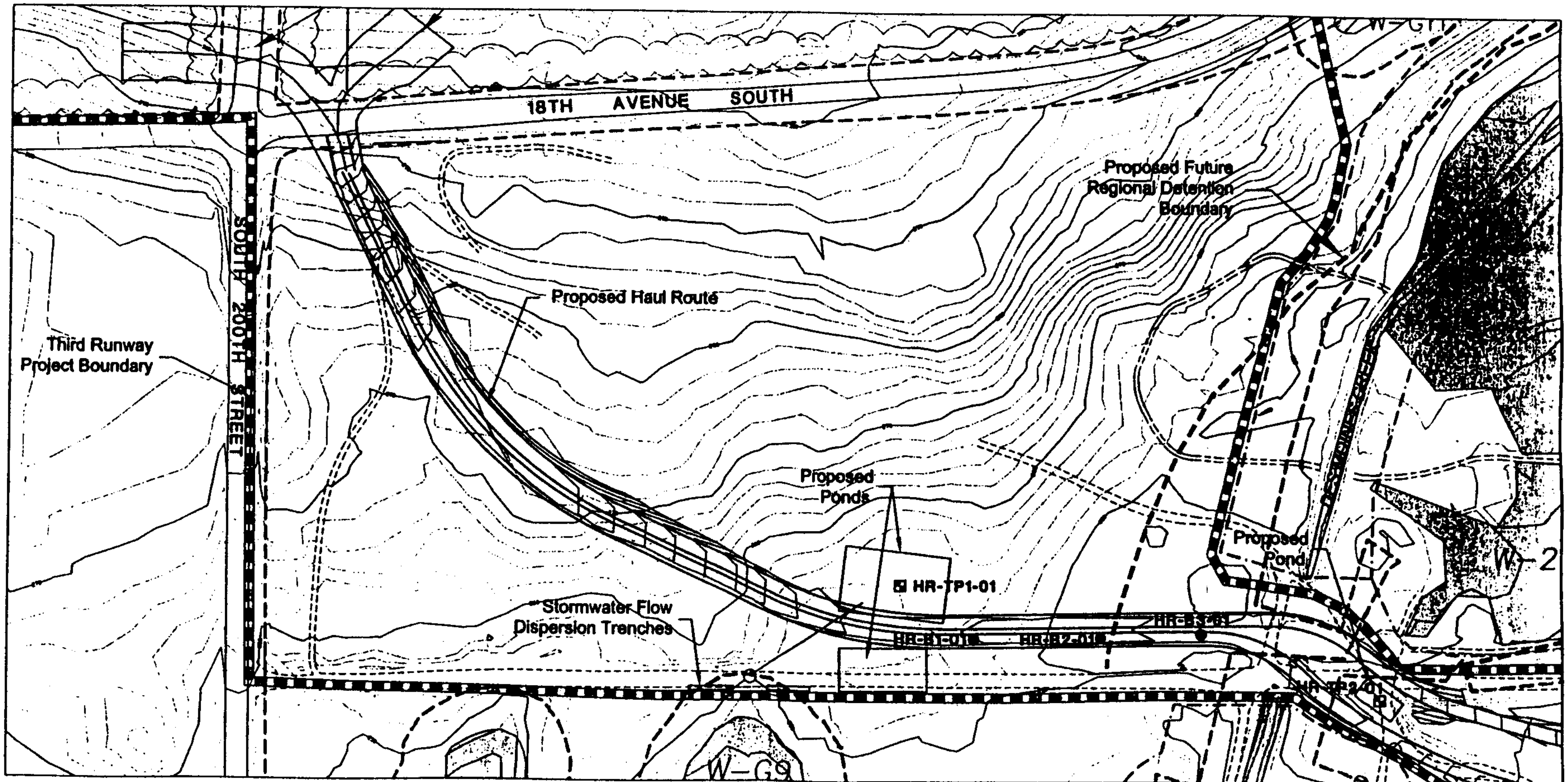
Figure 2

Site Exploration Plan

Haul Route



Notes:
1) Base map prepared from drawing provided by HNTB entitled "X_topo.dwg", dated April 4, 2001.
2) Wetland delineation prepared from drawing provided by Parametrix entitled, "W_022001.dwg", dated February 20, 2001.

Exploration Location and Number

- ⊠ HR-TP1-01 Test Pit (Hart Crowser)
- ● HR-B1-01 Hand Auger Boring (Hart Crowser)

N

0 120 240
Scale in Feet

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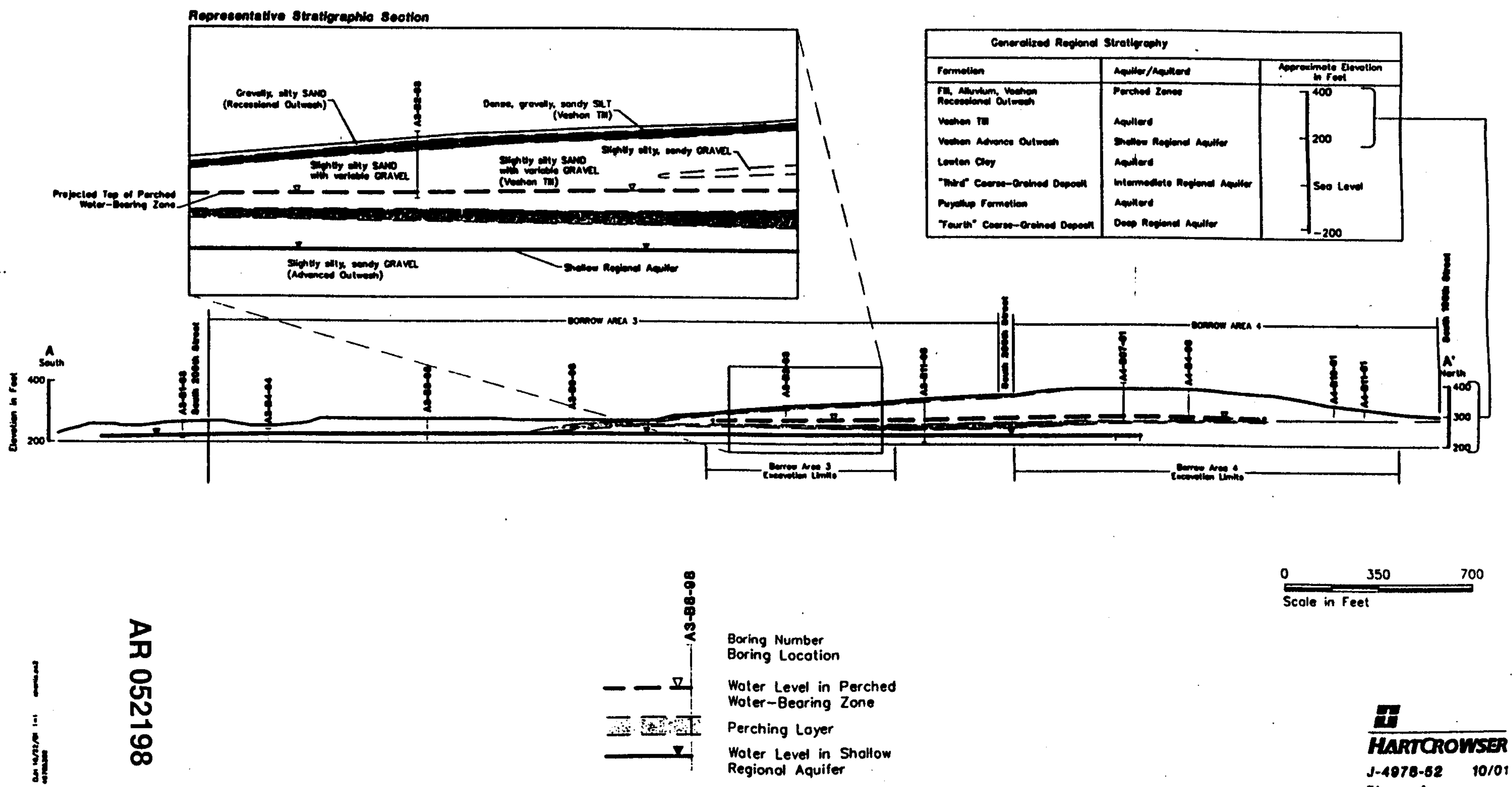
J-4978-52 10/01
Figure 3

AR 052197

Hydrogeologic Cross Section A-A'
Borrow Areas 3 and 4



Generalized Regional Stratigraphy

Formation	Aquifer/Aquitard	Approximate Elevation in Feet
Fill, Alluvium, Vashon Recessional Outwash	Perched Zones	400
Vashon Till	Aquitard	
Vashon Advance Outwash	Shallow Regional Aquifer	200
Lawton Clay	Aquitard	
"Third" Coarse-Grained Deposit	Intermediate Regional Aquifer	Sea Level
Puyallup Formation	Aquitard	
"Fourth" Coarse-Grained Deposit	Deep Regional Aquifer	-200

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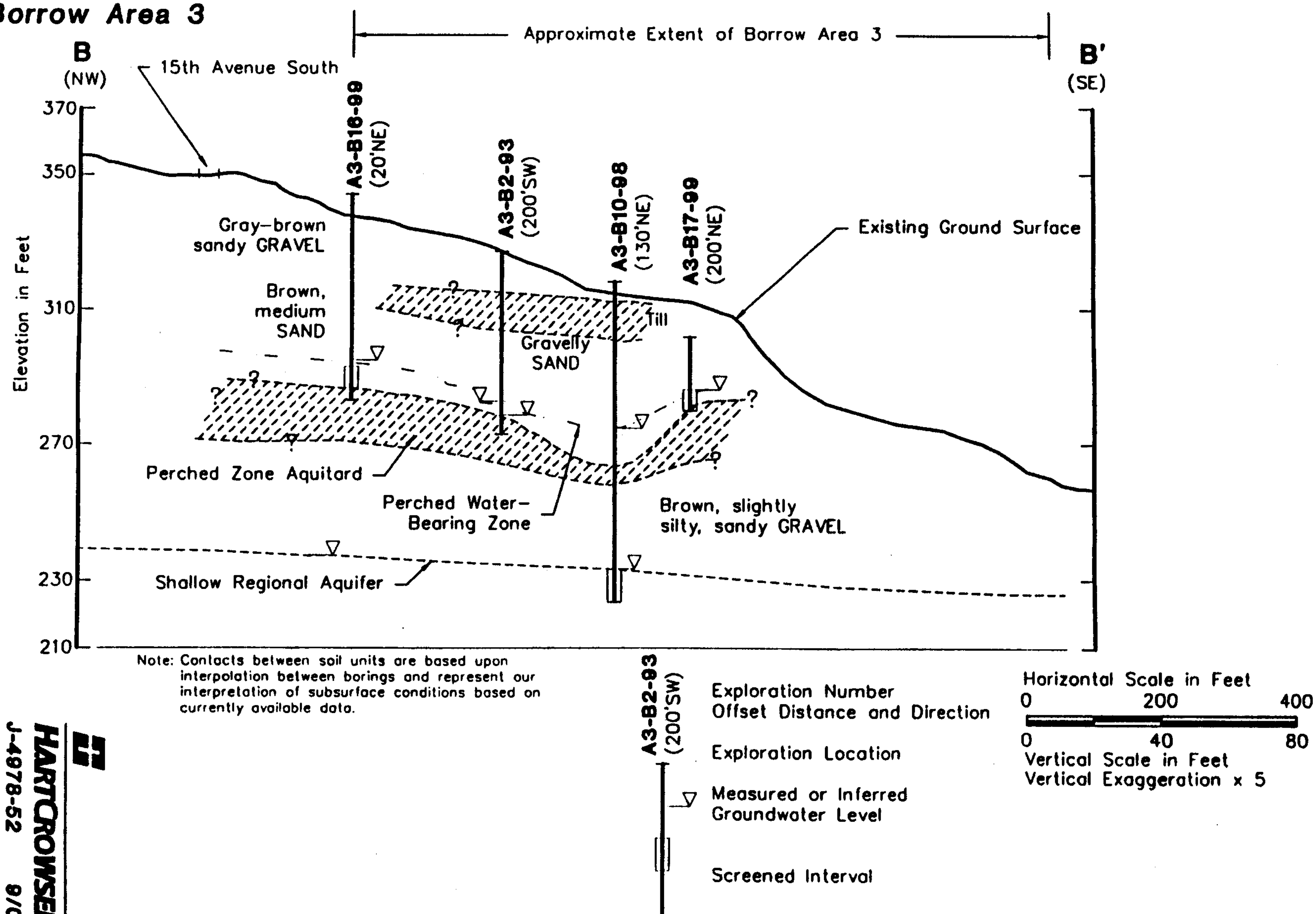
Figure 4

DTN 10/22/01 1=200 charlie-B.pc2 49785216

Hydrogeologic Cross Section B-B'

Borrow Area 3



Note: Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

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Figure 5

AR 052199

DTN 10/22/01 1=1 charlie-8.pc2 49785217

Hydrogeologic Cross Section C-C'

Borrow Area 4

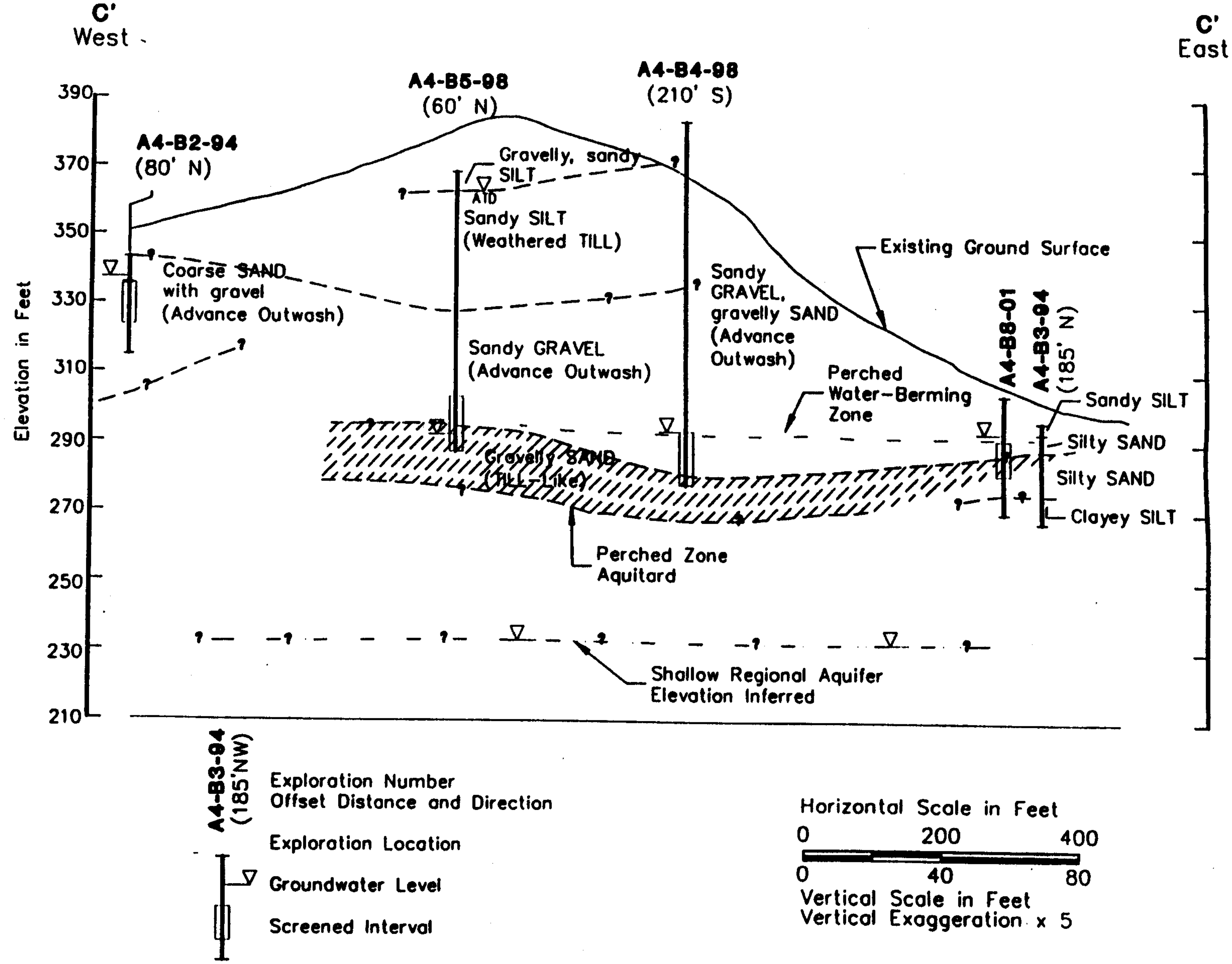

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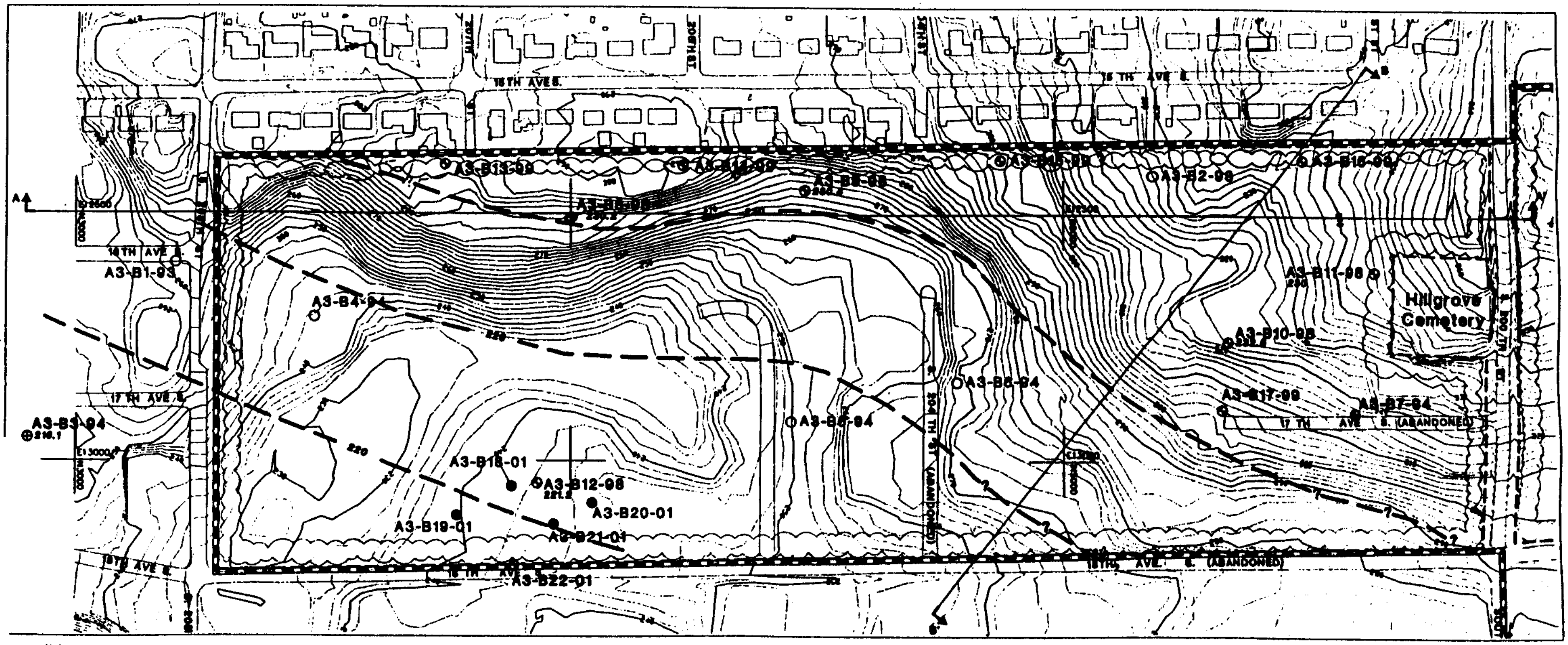
Figure 6

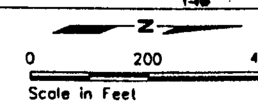
AR 052200

Groundwater Elevation Contour Map - Shallow Regional Aquifer

Borrow Area 3



Notes:
1) Base map prepared from drawing provided by HNTB entitled "X_topo.dwg", dated April 4, 2001.
2) Wetland delineation prepared from drawing provided by Parametrix entitled, "W_022001.dwg", dated February 20, 2001.
3) Refer to Figures 4 and 5 for cross sections.
4) Water levels based on highest observed reading.



Exploration Location and Number

- A3-B10-98 Boring with Observation Well (Hart Crowser)
- A3-B18-01 Boring (Hart Crowser)
- A3-B3-94 Boring with Observation Well (AGI)
- A3-B1-93 Boring (AGI)
- A4-TP1-01 Test Pit (Hart Crowser)

- A A' Cross Section Location and Designation
- 221.2 Measured Shallow Regional Aquifer Groundwater Elevation in Feet
- 220 Shallow Regional Aquifer Water Level Elevation Contour in Feet (June 1998)

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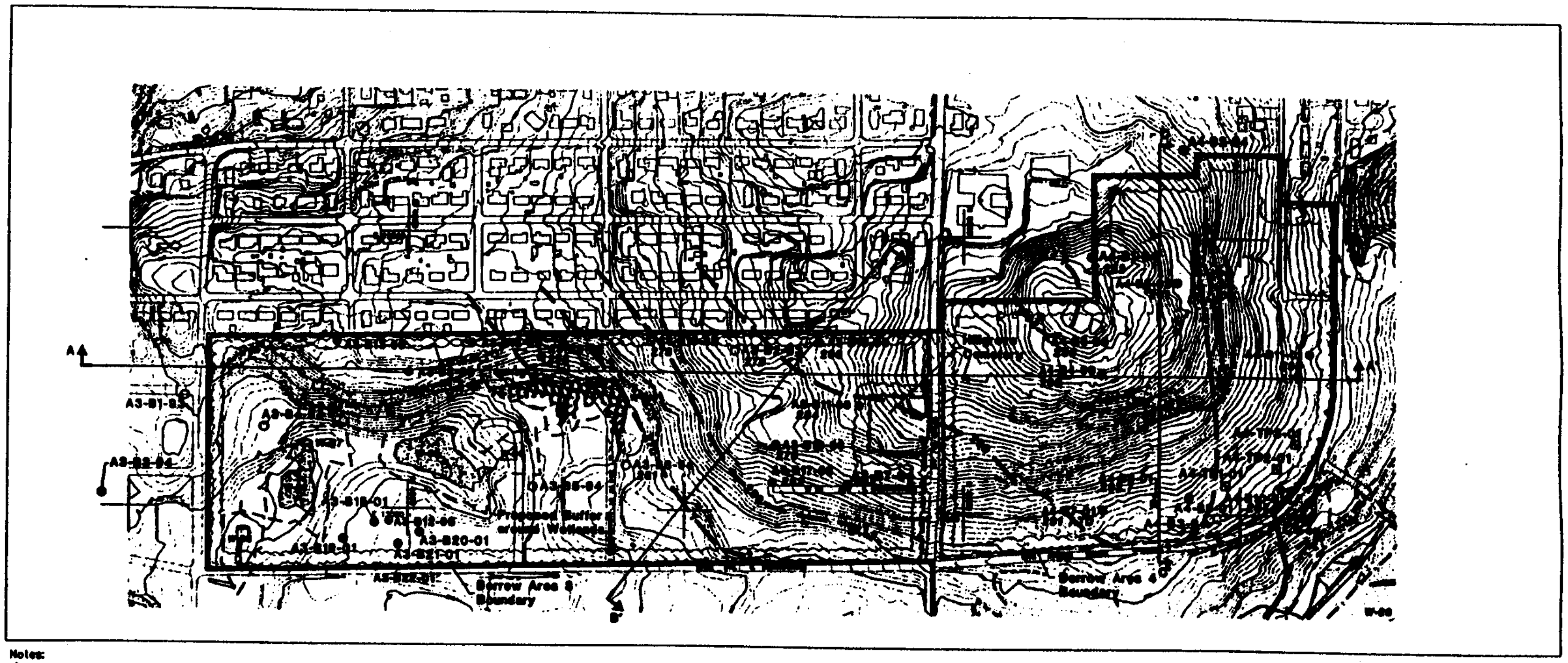
Figure 7

AR 052201

Groundwater Elevation Contour Map - Perched Water-Bearing Zone

Borrow Areas 3 and 4



Notes:

1) Base map prepared from drawing provided by HNTB entitled "X_topo.dwg", dated April 4, 2001.
2) Wetland delineation prepared from drawing provided by Parametrix entitled, "W_022001.dwg", dated February 20, 2001.
3) Refer to Figures 4 through 6 for cross sections.
4) Water levels based on highest observed reading.

N

0 400 800

Scale in Feet

Exploration Location and Number

- ● A3-B10-06 Boring with Observation Well (Hart Crowser)
- ● A3-B18-01 Boring (Hart Crowser)
- ● A3-B3-04 Boring with Observation Well (AGI)
- ○ A3-B1-03 Boring (AGI)
- ⊠ A4-TP1-01 Test Pit (Hart Crowser)

A–A' Cross Section Location and Designation

282 Perched Water-Bearing Zone Groundwater Elevation in Feet

—280— Perched Water-Bearing Zone Groundwater Elevation Contour in Feet

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Figure 8

Appendix A

APPENDIX A
FIELD EXPLORATIONS METHODS AND ANALYSIS

APPENDIX A
FIELD EXPLORATIONS METHODS AND ANALYSIS

This appendix documents the processes Hart Crowser uses in determining the nature of the soils underlying the project site addressed by this report. The discussion includes information on the following subjects:

- Explorations and Their Location;
- The Use of Dual-Wall Percussion Hammer Drilling with Reverse Circulation;
- The Use of Auger Borings;
- Penetration Test Procedures;
- Groundwater Observation Well Installation;
- Excavation of Test Pits; and
- Hand-Auger Borings.

Explorations and Their Location

Subsurface explorations by Hart Crowser for Borrow Areas 3 and 4 consisted of thirteen dual-wall percussion hammer (DWPH borings) which were completed as monitoring wells; ten hollow-stem auger borings, five of which were completed as monitoring wells; and three test pits. The borings were designated A3-B8-98 through A3-B12-98; A3-B13-99 through A3-B17-99; A3-B18-01 through A3-B22-01; A4-B4-98 through A4-B6-98; and A4-B7-01 through A4-B11-01. Test pits were designated A4-TP1-01 through A4-TP3-01. Borings and test pits are designated using a system developed by others for the Third Runway Project Borrow Area Investigations, where 'A3' represents Borrow Area 3, 'B8' represents boring number 8, 'TP1' represents test pit 1, and '98' indicates the year the boring or test pit was completed. Logs for these explorations are presented on Figures A-2 to A-25 at the end of this appendix.

Subsurface explorations by Hart Crowser for the Haul Route consisted of three hand-auger borings. The explorations were designated HR-TP1-01 and HR-TP2-01, HR-B1-01 through HR-B3-01. Logs for these explorations are presented on Figures A-26 and A-27.

Subsurface explorations conducted in 1994 by AGI for Borrow Areas 3 and 4 consisted of ten hollow-stem auger borings, four of which were completed as monitoring wells. The borings were designated A3-B1-94 through A3-B7-94 (Borrow Area 3) and A4-B1-94 through A4-B3-94 (Barrow Area 4); logs are presented as Attachment A-1 to this appendix.

The boring logs within this appendix are the basis of Hart Crowser's interpretation of the drilling, sampling, and testing data. The logs indicate the depth where the characteristics of soils and glacial sedimentary deposits change as follows:

- A hard line is used to show the contact between two geologically distinct units;

- A dashed line is used to show the contact between two dissimilar soils within a specific geologic unit; and

- The words "grades to" are used to mark the location of a gradual change in soil gradation or grain size distribution with increasing depth. Note that the new gradation indicated in this way persists over a distinct interval. Characteristics identified by "grades to" are intended to apply to the remainder of the unit below the notation on the log, or until a different change in gradation is indicated.

In the field, we classified the samples taken from the explorations according to the methods presented on Figure A-1 - Key to Exploration Logs. Attachment A-1 presents AGI's Soil Classification/Legend. These figures provide an explanation of the symbols and abbreviations used in the logs. The remainder of this appendix discusses exploration techniques utilized by Hart Crowser. Additional information on the techniques used by AGI is presented in AGI Technologies (1995).

Location of Explorations. Figures 2 and 3, which follow the main text, show the location of explorations. This report shows the actual locations and ground surface elevations, presented on the exploration logs, as they were established during site surveys by the Port of Seattle, dated May 28, 1998, and May 1999. 2001 explorations at Borrow Areas 3 and 4 were surveyed in June 2001. Explorations along the Haul Route were not surveyed; locations and elevations are based on hand taping from site features and topographic maps.

The Use of Dual-Wall Percussion Hammer Drilling with Reverse Circulation

With depths ranging from 22.0 to 141.2 feet below the ground surface, thirteen dual-wall percussion hammer borings, designated A3-B8-98 through A3-B12-98 and A4-B4-98 through A4-B6-98 were drilled from May 11 to 18, 1998. Explorations A3-B13-99 through A3-B17-99 were drilled later on April 15 to 23, 1999.

These eighteen borings incorporated a 9-inch outside diameter (6-inch inside diameter) dual-wall drive pipe and were advanced with a Becker diesel, piledriving hammer on a truck-mounted drill rig (AP1000). Layne Christensen Company was subcontracted by Hart Crowser to perform the drilling.

Dual-wall percussion hammer drilling with reverse circulation consists of a dual-walled pipe driven with a diesel drive hammer, while air is forced down the annulus of the double-wall drive pipe to the bit. The air returns up the inside pipe, carrying with it a continuous flow of drill cuttings that are discharged to an air cyclone. The air cyclone slows down the velocity of the air and drill-cutting mixture, separates the air from the cuttings, and allows for sample collection from the base of the cyclone.

The driving/drilling and sampling were continuously observed by an engineering geologist from Hart Crowser. Detailed field logs were prepared of each boring and each sample was visually and texturally classified in the field. Samples were collected from the air cyclone at 2-1/2- to 5-foot-depth intervals and placed into plastic bags tied with wire. Samples were collected to fill the plastic bags and represent the 2-1/2- to 5-foot sample collection interval; however, for clarity, cyclone samples are represented as 1-foot-thick samples on the logs. After soil sample collection, they were taken to Hart Crowser's laboratory for further testing.

The Use of Auger Borings

With depths ranging from 15.5 to 84.3 feet below the ground surface, ten hollow-stem auger borings, designated A3-B18-01 through A3-B22-01 and A4-B7-01 through A4-B11-01, were drilled from June 11 to 18, 2001. The borings used a 3-3/8-inch inside diameter hollow-stem auger and were advanced with a truck-mounted drill rig subcontracted by Hart Crowser. The drilling was continuously observed by an engineering geologist from Hart Crowser. Detailed field logs were prepared of each boring. Using the Standard Penetration Test (SPT), we obtained samples at 5-foot-depth intervals.

Penetration Test Procedures

This test is an approximate measure of soil and sediment density and consistency. To be useful, the results must be used with engineering judgment in conjunction with other tests. Penetration tests similar to the Standard Penetration Test (SPT; as described in ASTM D 1586) were performed to obtain disturbed samples. The tests employed a 3-inch outside diameter split-spoon sampler. Using a 140-pound hammer, free-falling about 30 inches (down-hole techniques were used), the sampler is driven into the material for 18 inches. The number of blows required to drive the sampler the last 12 inches only is the penetration resistance. This resistance, or blow count, measures the relative density of granular soils and the consistency of cohesive material. The blow counts are plotted on the boring logs at their respective sample depths.

Samples are recovered from the split-spoon sampler, field classified, and placed into water tight jars. They are then taken to Hart Crowser's laboratory for further testing.

In the Event of Hard Driving

Occasionally very dense materials preclude driving the total 18-inch sample. When this happens, the penetration resistance is entered on logs as follows:

Penetration less than six inches. The log indicates the total number of blows over the number of inches of penetration.

Penetration greater than six inches. The blow count noted on the log is the sum of the total number of blows completed after the first 6 inches of penetration. This sum is expressed over the number of inches driven that exceed the first 6 inches. The number of blows needed to drive the first 6 inches are not reported. For example, a blow count series of 12 blows for 6 inches, 30 blows for 6 inches, and 50 (the maximum number of blows counted within a 6-inch increment for SPT) for 3 inches would be recorded as 80/9.

Groundwater Observation Well Installation

Observation wells were installed in eighteen of the Hart Crowser borings and four of the AGI borings. The Hart Crowser wells were constructed with flush-threaded 2-inch-diameter PVC and 10-foot-long screens (0.020-inch slot size). The following procedure was used to install the wells:

- Following completion of each boring to the target depth, the bottom of each boring was backfilled to the bottom-of-screen depth with cuttings and bentonite chips (as-needed).

- A 2-inch inside diameter, flush-threaded, Schedule 40 PVC screen (0.020-inch slots) and riser pipes were lowered through the dual-wall drive pipe.

- As the drive pipe was pulled out, silica sand (No. 10-20) was placed around and approximately 5 feet above the screened section. The depth to the top of the sand pack was recorded by sounding inside the annular space with a weighted measuring tape.

- The annular space of the well was sealed between the top of the sand pack to the bottom of the surface monument by placing bentonite chips in the hole.

- A concrete surface seal was then placed above the bentonite seal at ground surface, and a stickup-mounted monument set in concrete was placed over the finished groundwater observation well.

As-built construction details for observation wells are shown schematically on the respective logs.

Excavation of Test Pits

Five test pits, designated HR-TP1-01, HR-TP2-01, and A4-TP1-01 through A4-TP3-01 were excavated across the site with a tractor-mounted backhoe subcontracted by our firm. The sides of these excavated pits offer direct observation of the subgrade soils. The test pits were located by and excavated under the direction of an engineering geologist from Hart Crowser. The geologist observed the soil exposed in the test pits and reported the findings on a field log. He noted groundwater levels or seepage during excavation. The density/consistency of the soils (as presented parenthetically on the test pit logs to indicate their having been estimated) is based on visual observation only as disturbed soils cannot be measured for in-place density in the laboratory.

The test pit logs are presented on Figures A-25 and A-26.

Hand-Auger Borings

Three borings, designated HR-B1-01 through HR-B1-03, were drilled by a Hart Crowser geologist along the Haul Route using a hand-auger. These borings were drilled to conduct falling head infiltrometer tests. The geologist observed the soil cuttings from the borings and reported the findings on a field log. The density/consistency of the soils (as presented parenthetically on the boring logs to indicate their having been estimated) is based on visual observation only as disturbed soils cannot be measured for in-place density in the laboratory. The boring logs for these hand-auger borings are presented on Figure A-27.

F:\docs\jobs\497852\BA3&4DataReport.doc

Key to Exploration Logs

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance.
Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 - 4	Very soft	0 - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling Test Symbols

BORING SAMPLES

- ☒ Split Spoon
- ⍂ Shelby Tube
- ▥ Cuttings
- ◫ Core Run
- * No Sample Recovery
- P Tube Pushed, Not Driven

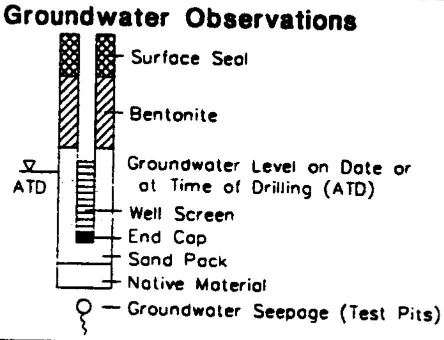
TEST PIT SAMPLES

- ☒ Grab (Jar)
- ◿ Bag
- ⍂ Shelby Tube

Test Symbols

GS	Grain Size Classification
CN	Consolidation
UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits Water Content in Percent Liquid Limit Natural Plastic Limit
PID	Photoionization Detector Reading
CA	Chemical Analysis
DT	*In Situ* Density Test

Groundwater Observations



1=1 A-1 STANDARD

HARTCROWSER

4978-52 9/01

Figure A-1

AR 052210

Boring Log A3-B8-98

Soil Descriptions

Ground Surface Elevation in Feet: 280.5

(Medium dense to very dense), damp, light brown, slightly gravelly SAND over damp, gray to tan, slightly silty, fine SAND with occasional gravel. (Recessional; Type 3)

— Grades to non-gravelly.

— Grades to moist, tan, very silty (Type 5)

— Grades to slightly silty (Type 3)

— Grades to very silty and color changes to light brown. (Type 5)

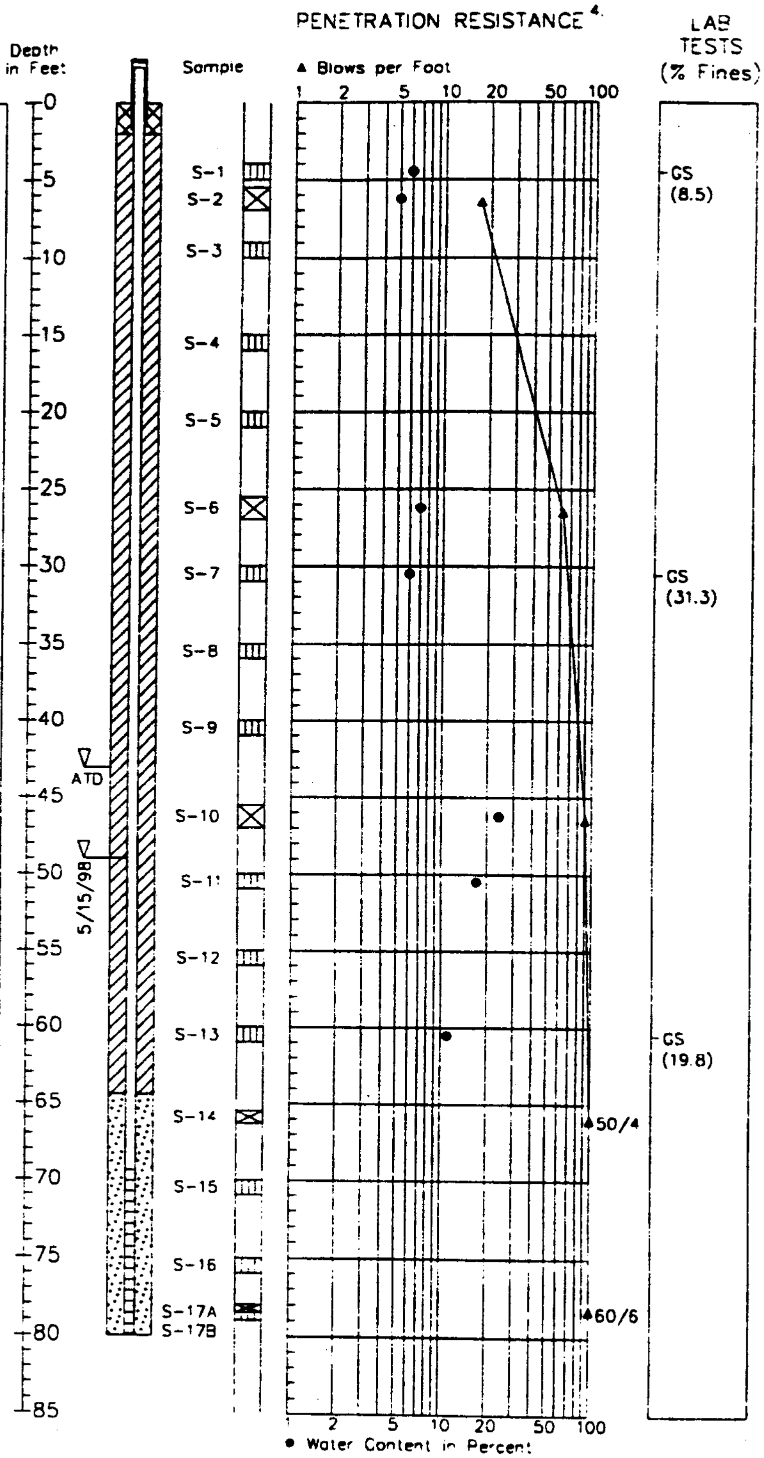
— Grades to slightly silty. (Type 3)

— Grades to wet, brown, silty, very gravelly. (Type 4)

(Very dense), wet, brown, slightly silty, sandy GRAVEL. (Recessional; Type 2)

— Grades to very sandy.

Bottom of Boring at 80.0 Feet. Completed 5/11/98.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

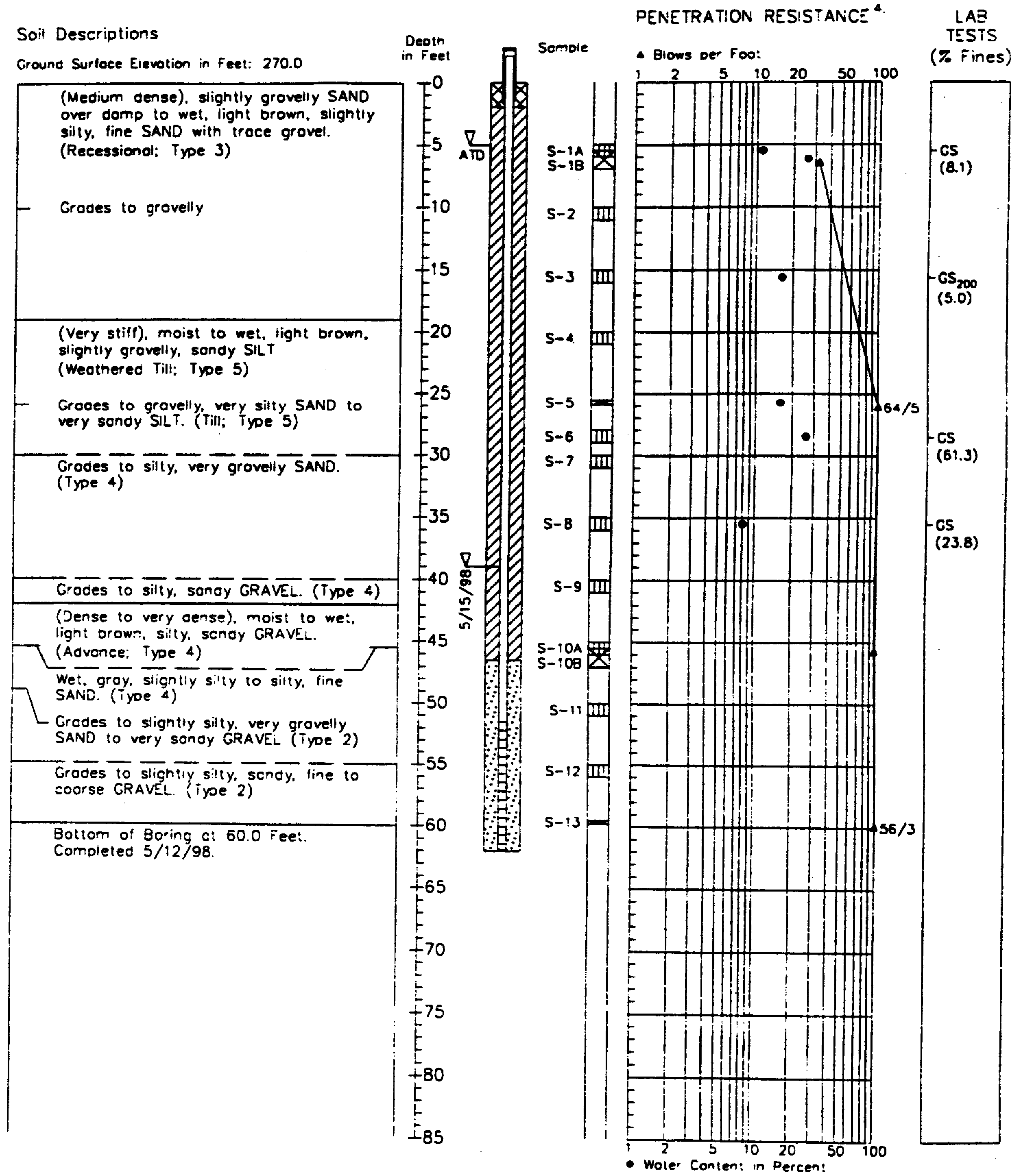
HARTCROWSER

J-4978 5/98

Figure A-2

4978 A3b08.dwg nel 8/30/01

Boring Log A3-B9-98



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

4978 A3b09.dwg hel 8/30/01

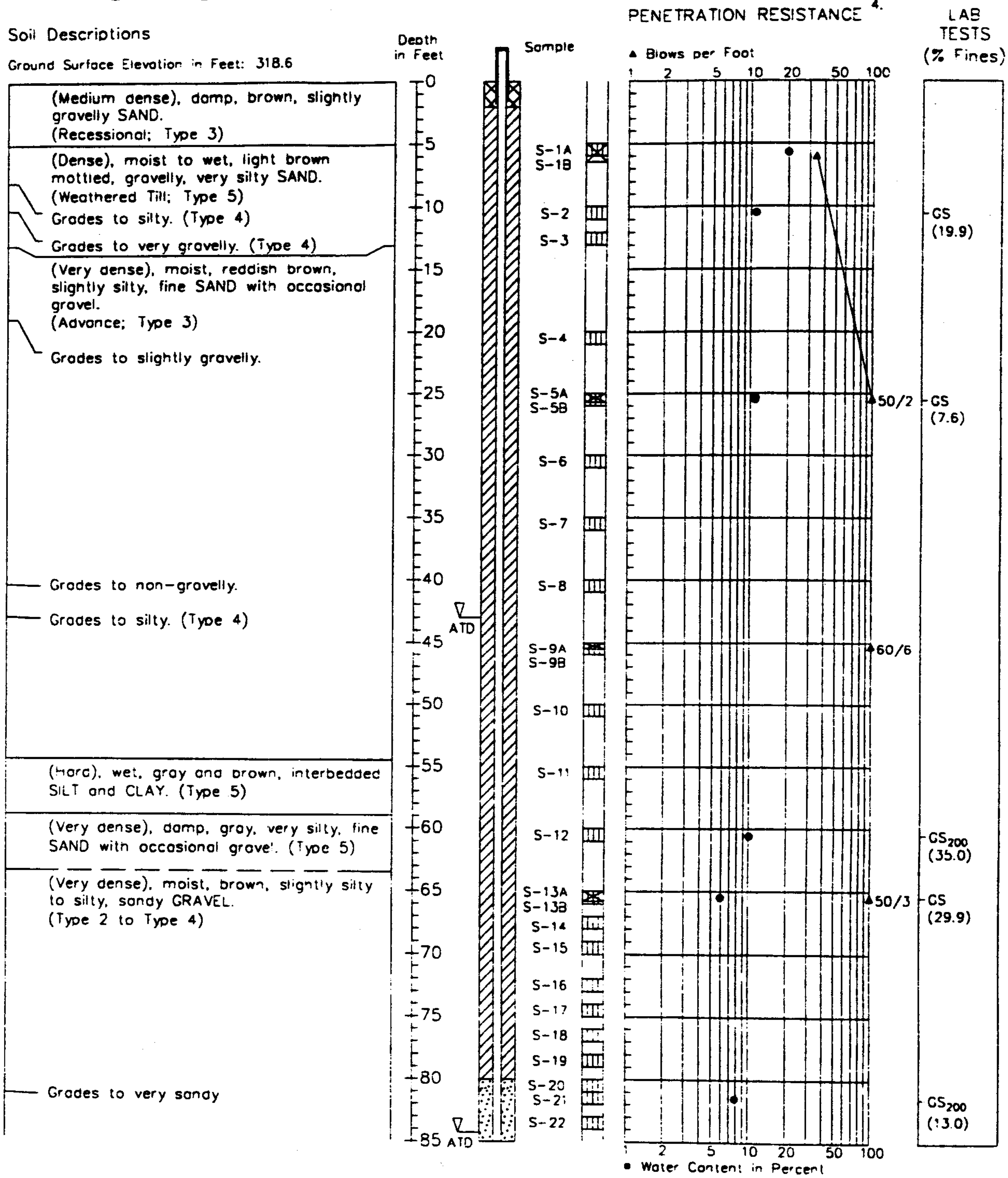
HARTCROWSER

J-4978 **5/98**

Figure A-3

AR 052212

Boring Log A3-B10-98



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

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J-4978 5/98

Figure A-4 1/2

AR 052213

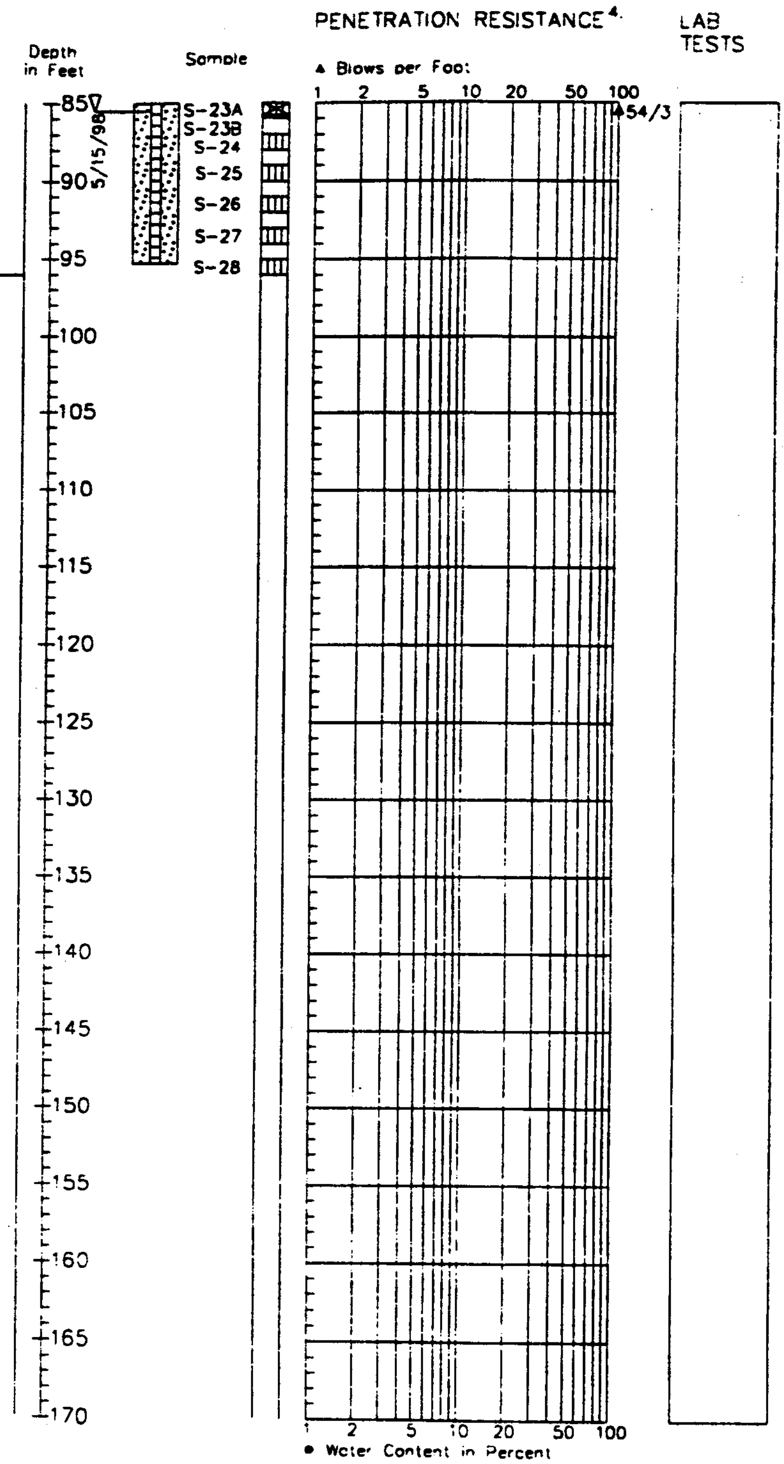
4978 A3b10 dwg hel 8/30/01

Boring Log A3-B10-98

Soil Descriptions

(Very dense), wet, brown, slightly silty to silty, sandy GRAVEL. (Type 2 to Type 4)

Bottom of Boring at 96.0 Feet.
Completed 5/12/98.

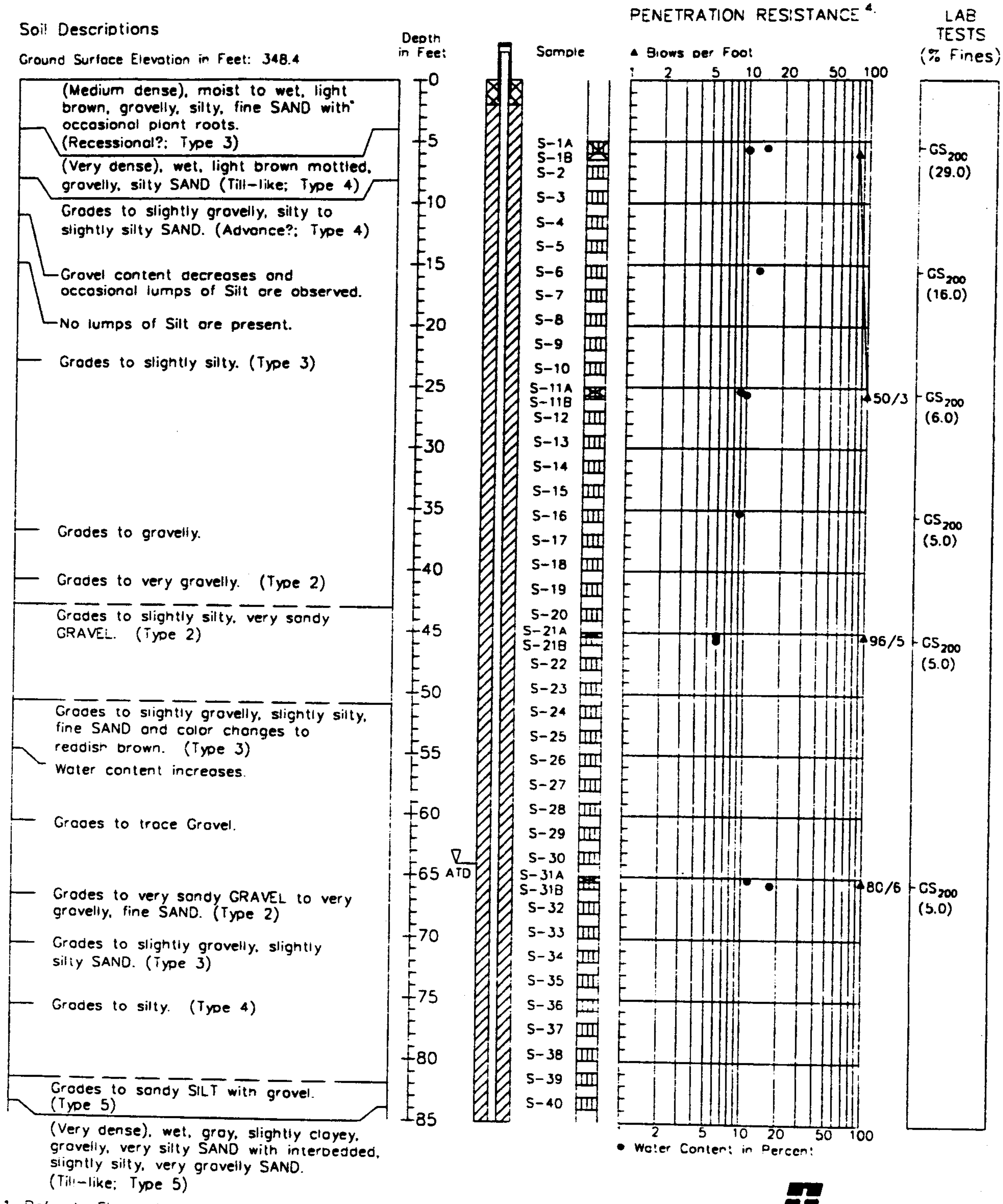


1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

HARTCROWSER

J-4978 5/98
Figure A-4 2/2

Boring Log A3-B11-98



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

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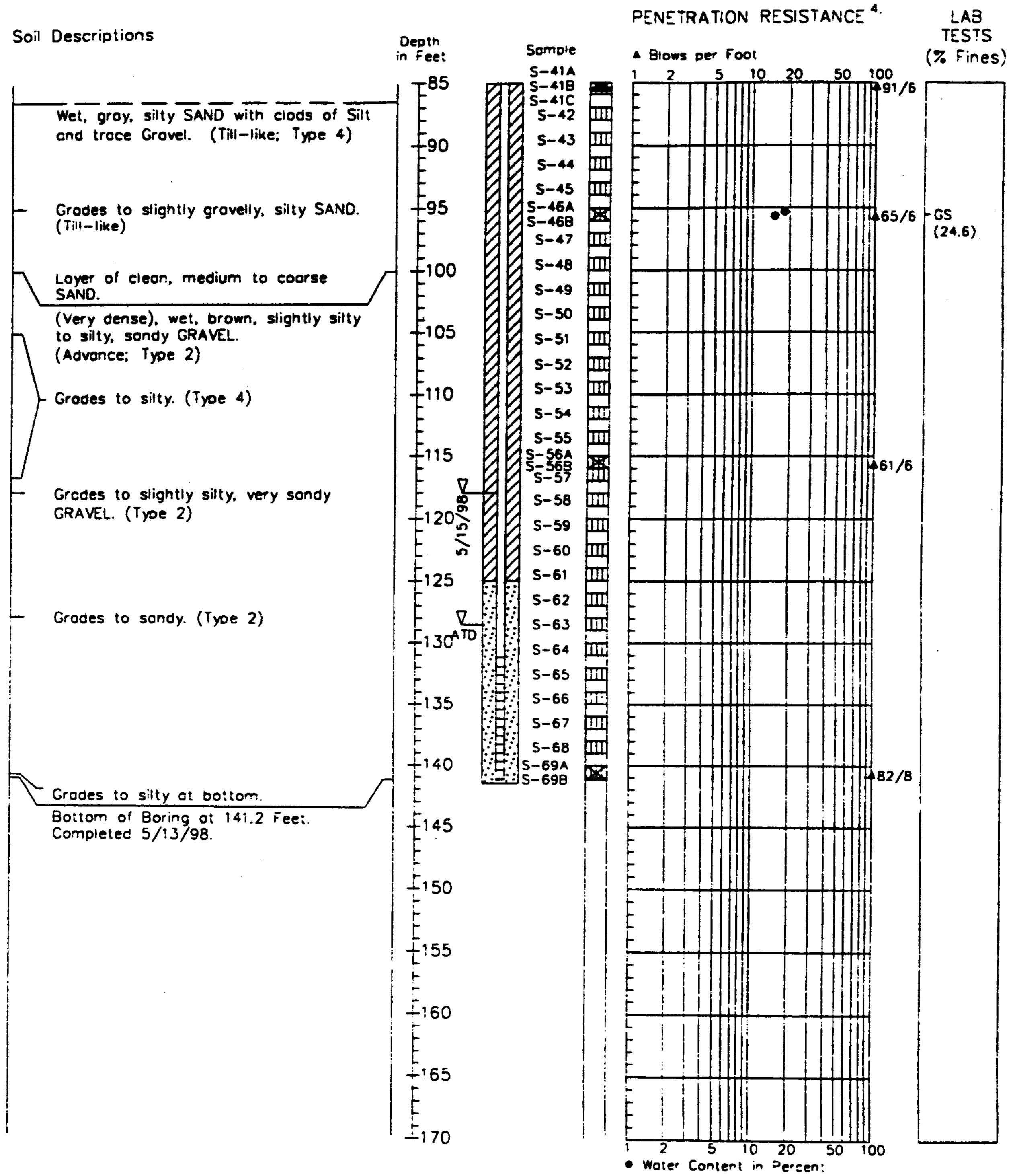
J-4978 **5/98**

Figure A-5 **1/2**

AR 052215

Boring Log A3-B11-98



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

4978 A3b11x.dwg hel

HARTCROWSER

J-4978 **5/98**

Figure A-5 **2/2**

Boring Log A3-B12-98

Soil Descriptions

Ground Surface Elevation in Feet: 241.1

(Medium dense to very dense), damp, brown, silty, fine SAND with plant roots near surface. (Recessional; Type 4)

Grades to slightly silty, slightly gravelly (Type 3)

Grades to gravelly

Grades to trace gravel and color changes to gray.

Grades to non-gravelly.

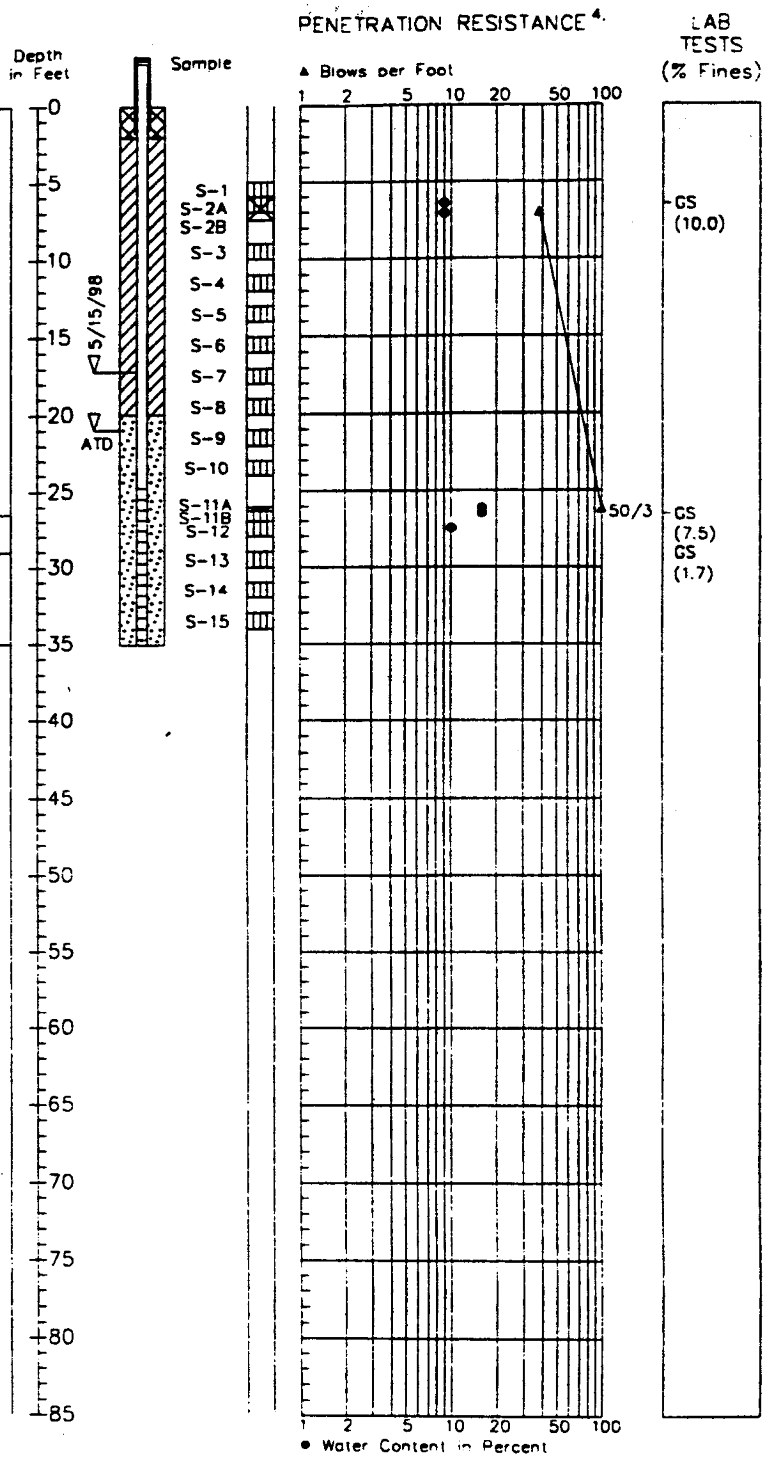
Grades to gravelly

Grades to very sandy, fine to coarse GRAVEL. (Type 1)

Grades slightly silty, gravelly SAND. (Type 3)

Grades to no Gravel

Bottom of Boring at 35.0 Feet. Completed 5/14/98.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

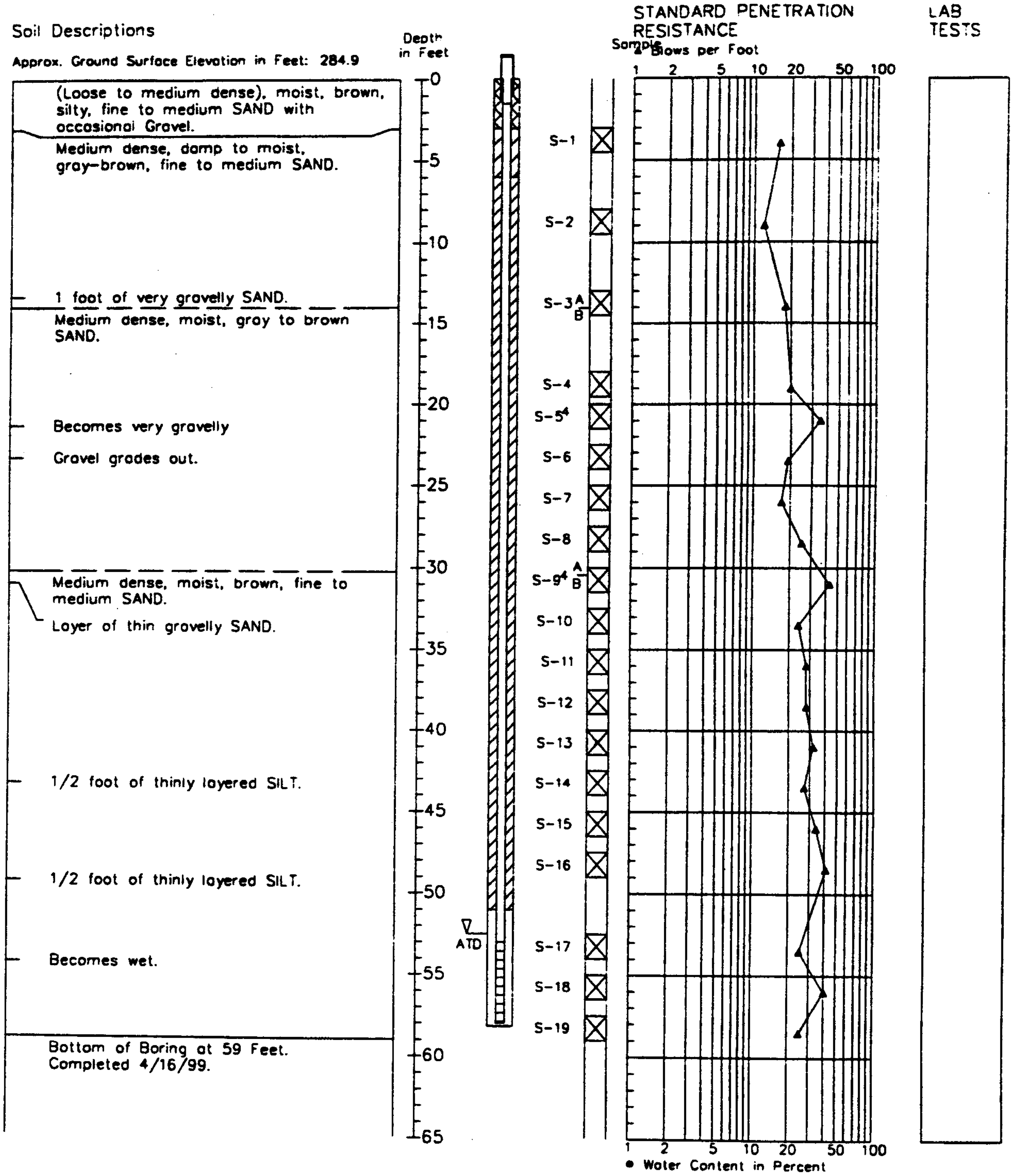
4978 A3b12.dwg hel

HARTCROWSER

J-4978 5/98

Figure A-6

Boring Log A3-B13-99



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts may not be representative of density due to gravel.

DTN 10/2/01 1=1 (xref)XXXX0000/Default.pcp
497802/Boring A3-B13-99

HARTCROWSER
J-4978-02 4/99
Figure A-7

AR 052218

Boring Log A3-B14-99

Soil Descriptions

Ground Surface Elevation in Feet: 290.5

Medium dense, damp to moist, gray-brown, slightly gravelly, medium SAND.

Gravel grades out.

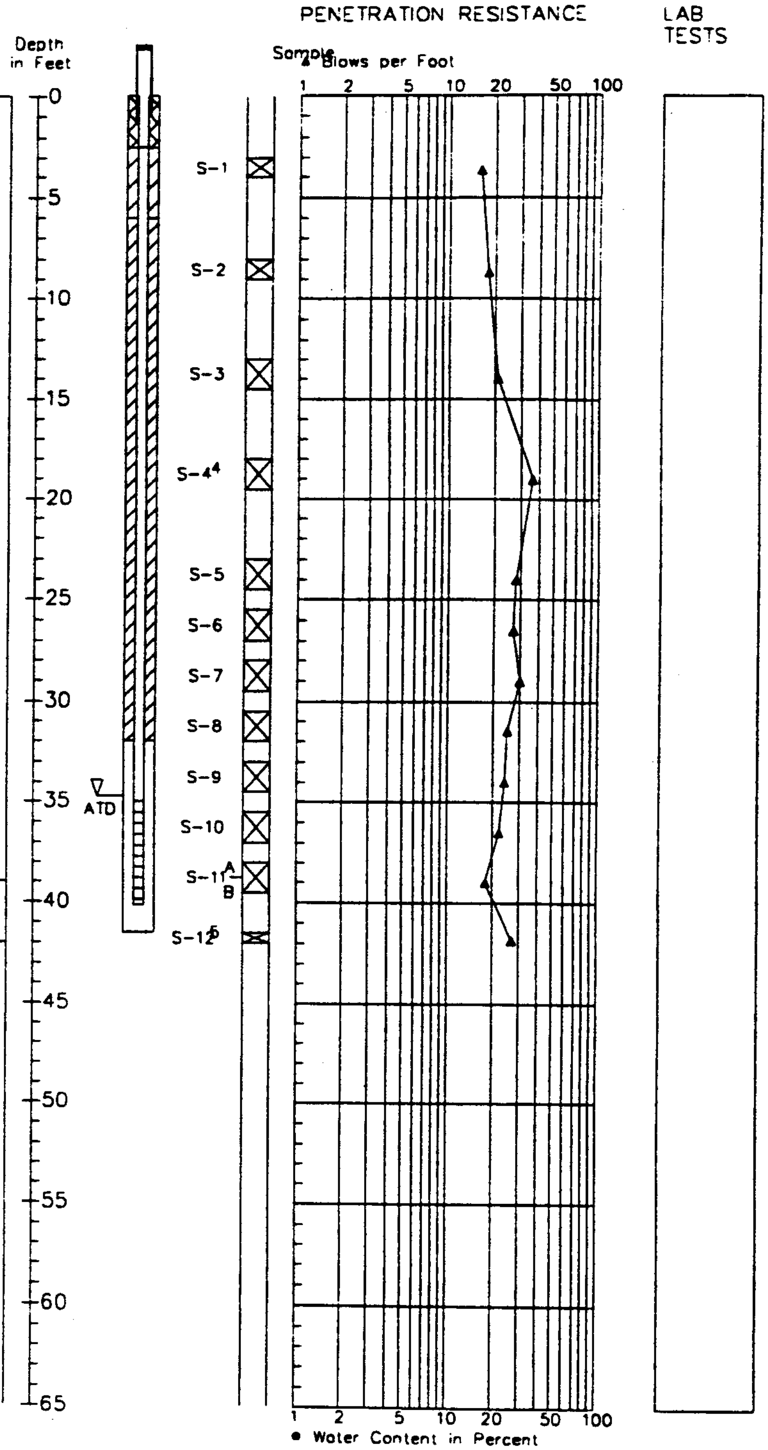
Occasional gravel.

Becomes wet.

Medium dense, wet, gray-brown, silty, fine SAND interbedded with very stiff, gray-brown, fine, sandy SILT.

9 inches of Heave.

Bottom of Boring at 42 Feet.
Completed 4/15/99.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts may not be representative of density due to gravel.
5. Blow count may not be representative due to heave.

DTN 10/2/01 1=1 (xref)XXXX0000/Default.pcp
497802/Boring A3-B14-99.dwg

HARTCROWSER
J-4978-02 4/99
Figure A-8

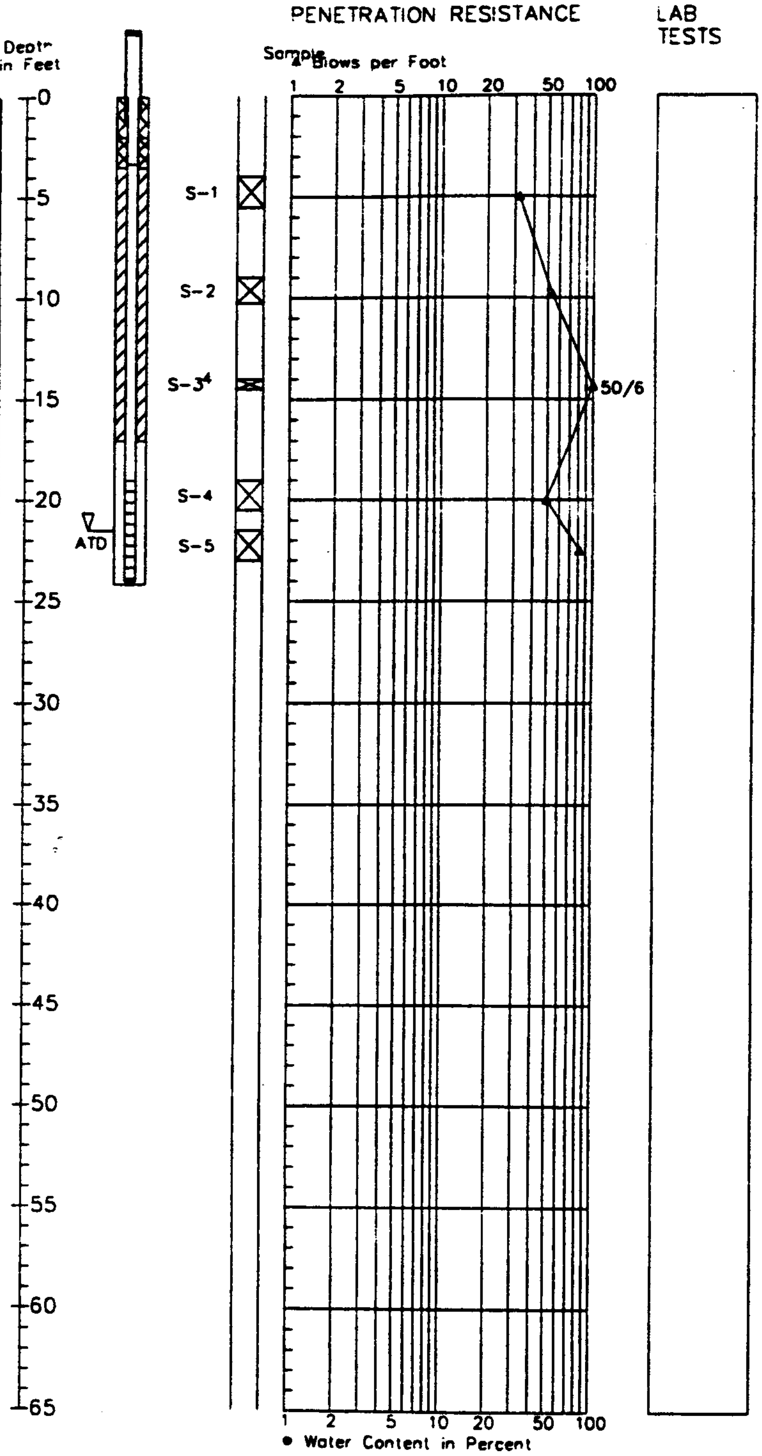
AR 052219

Boring Log A3-B15-99

Soil Descriptions

Ground Surface Elevation in Feet: 299.7

Depth in Feet	Soil Descriptions
0	Dense, damp to moist, brown, silty, gravelly SAND.
~17	Dense, moist to wet, brown SAND to slightly silty SAND.
~23	1/2-foot-thick layer of slightly sandy SILT.
24	Bottom of Boring at 24 Feet. Completed 4/23/99.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts may not be representative due to gravel.

DIN 10/2/01 1=1 (xref)XXXX0000/Default.pcp
497802/Boring A3-B15-99.dwg

HARTCROWSER

J-4978-02 4/99

Figure A-9

AR 052220

Boring Log A3-B16-99

Soil Descriptions

Ground Surface Elevation in Feet: 344.0

(Loose to medium dense), damp, brown, gravelly, silty SAND to gravelly SAND with abundant organic material.

Becomes dense to very dense.

Very dense, moist, gray-brown, very sandy GRAVEL.

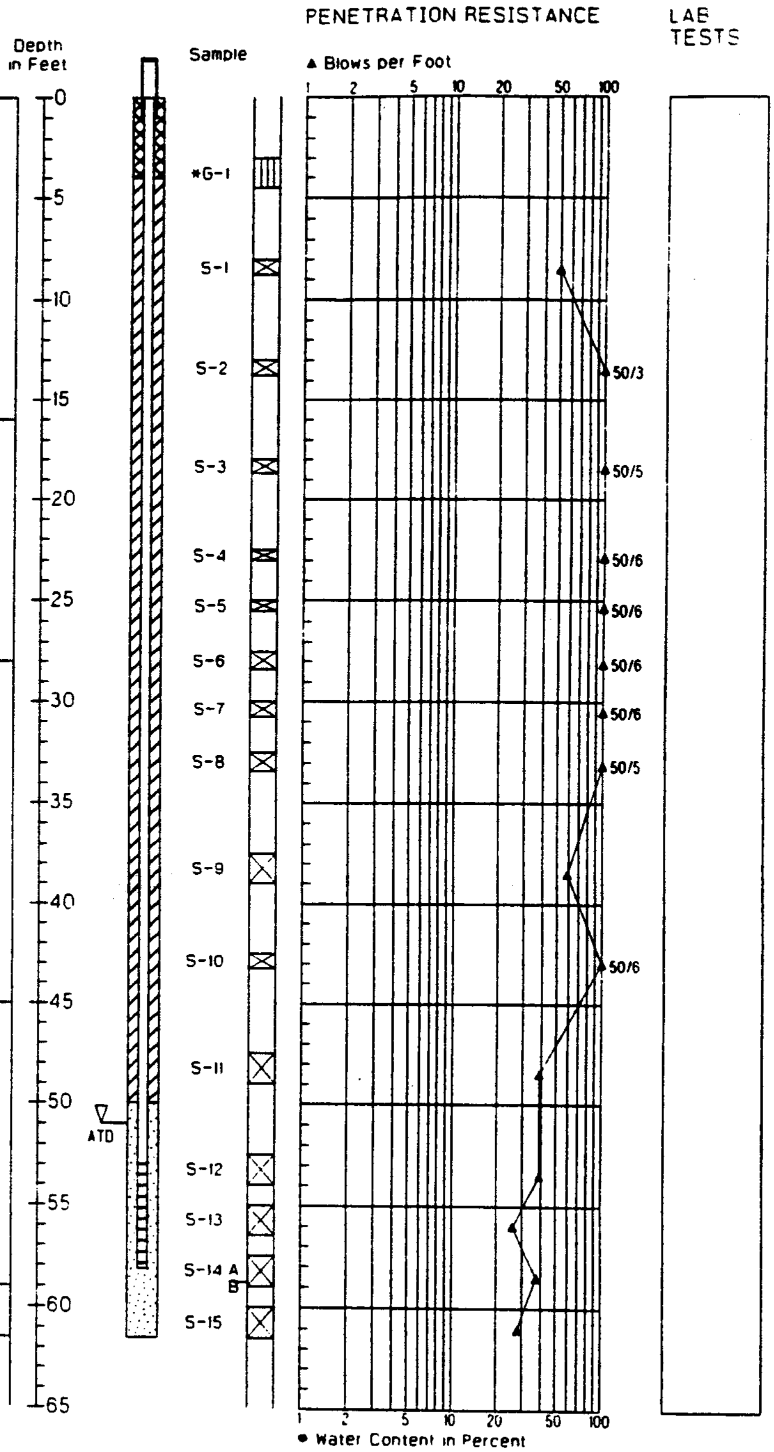
Very dense, damp to moist, brown SAND.

Becomes gravelly to very gravelly.

Dense, wet, brown, medium SAND.

Very stiff, damp to moist, brown SILT to slightly sandy SILT.

Bottom of Boring at 61.5 Feet.
Completed 4/22/99.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-02 4/99

Figure A-10

AR 052221

Boring Log A3-B17-99

Soil Descriptions

Ground Surface Elevation in Feet: 302.6

Stiff, damp, brown, slightly sandy, slightly gravelly SILT with occasional roots.

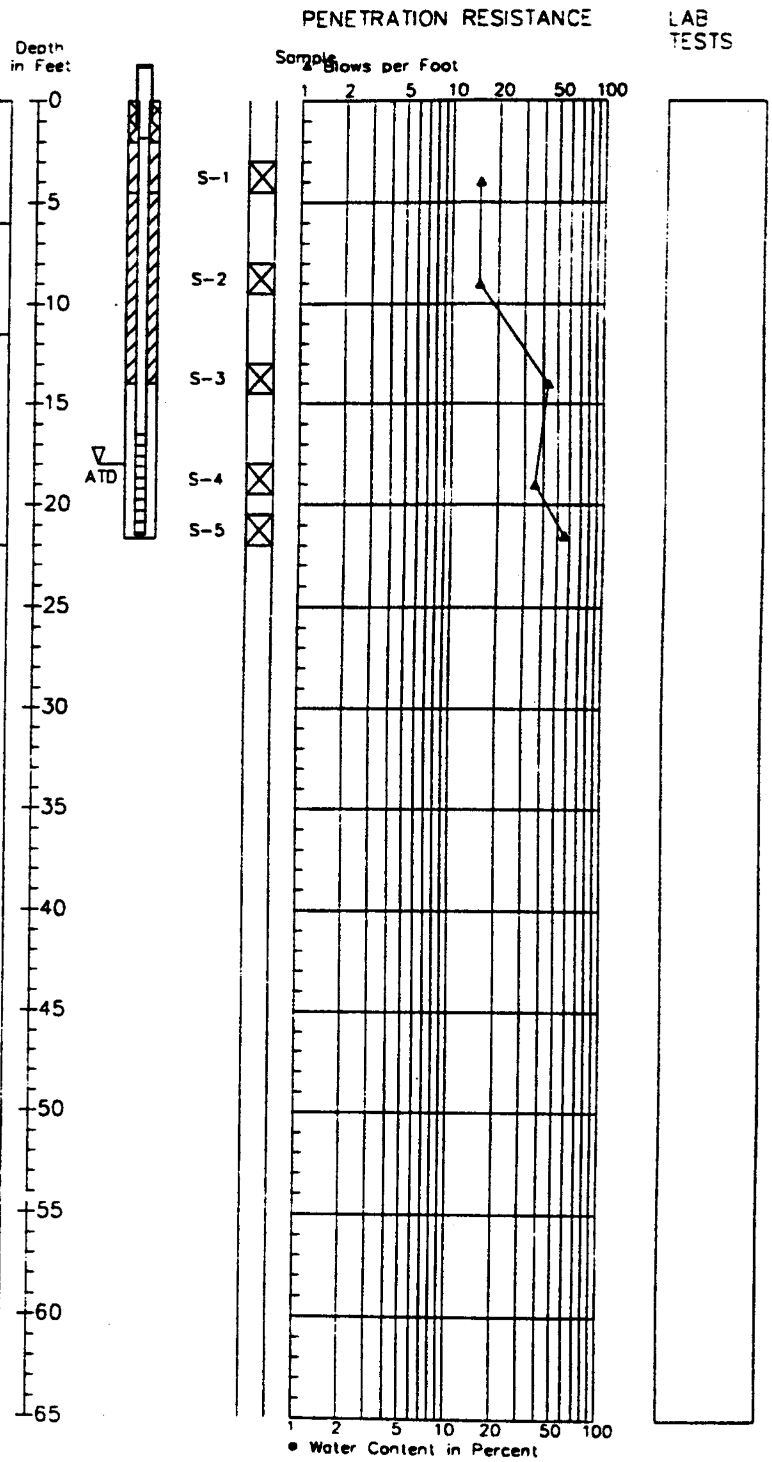
Stiff, moist, brown, slightly silty, gravelly SAND with abundant roots.

Dense, moist to wet, brown SAND.

Becomes wet.

Becomes very dense.

Bottom of Boring at 22 Feet.
Completed 4/22/99.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-4978-02 4/99
Figure A-11

DTN 10/2/01 1=1 (xref)XXXX0000/Default.pcp
497802/Boring A3-B17-99.dwg

Boring Log A3-B18-01

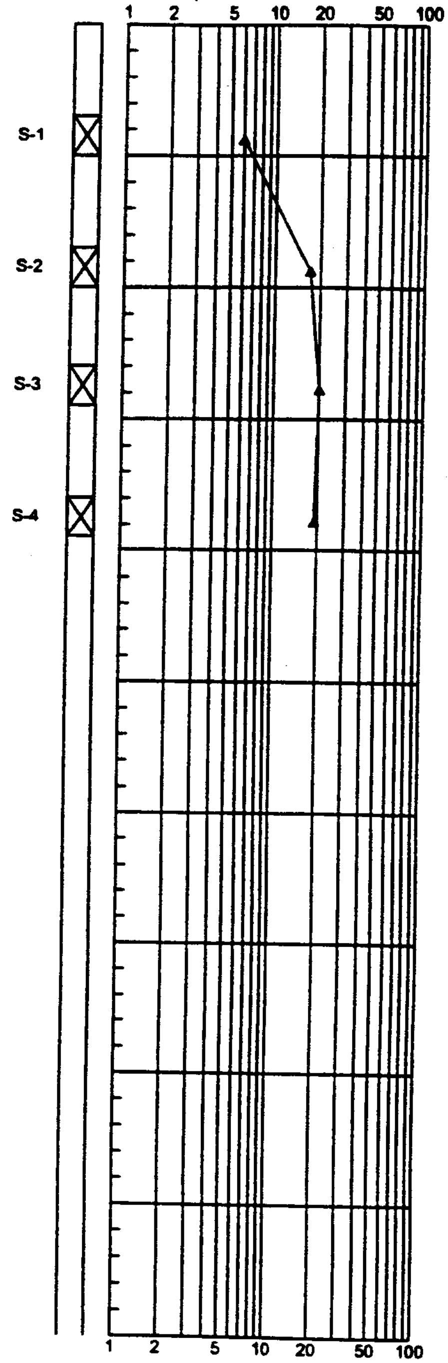
Soil Descriptions
Approx. Ground Surface Elevation in Feet: 240.2

Depth in Feet

0	Loose to medium dense, moist, brown, slightly silty, fine to medium SAND with trace gravel.
~18	Grades to wet.
19.5	Bottom of Boring at 19.5 Feet. Completed 06/18/01.

STANDARD PENETRATION RESISTANCE

LAB TESTS



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-4978-52 06/01
Figure A-12

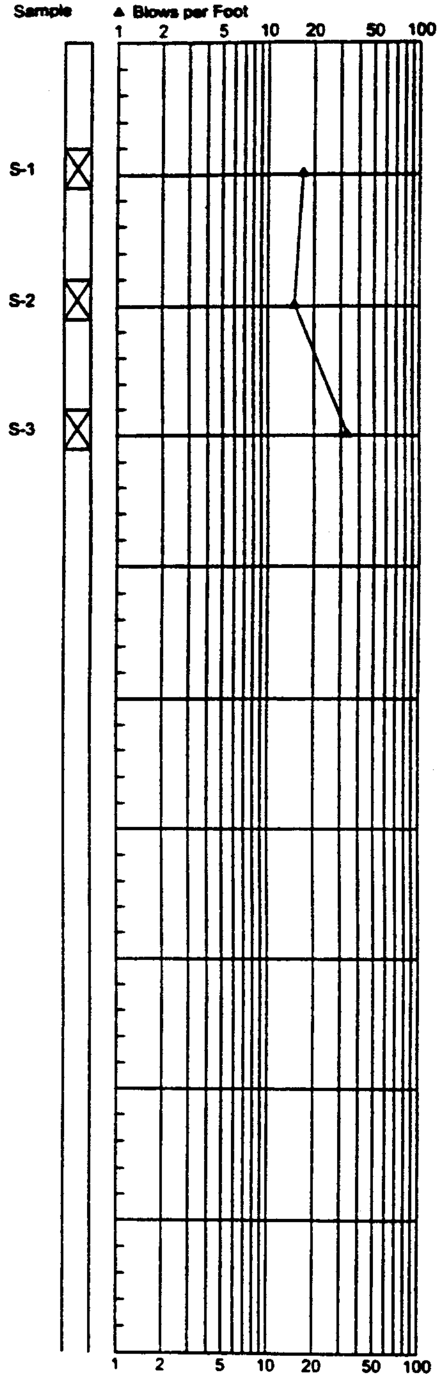
Boring Log A3-B19-01

Soil Descriptions
Approx. Ground Surface Elevation in Feet: 238.0

Soil Descriptions	Depth in Feet
Medium dense, moist, reddish brown, silty, fine to medium SAND.	0
Grades to gray-brown.	10
Becomes gravelly.	15
Bottom of Boring at 15.5 Feet. Completed 06/18/01.	15.5

STANDARD PENETRATION RESISTANCE

LAB TESTS



BORING LOG 497852B GPJ HC_CORP.GDT 8/30/01

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-4978-52 06/01
Figure A-13

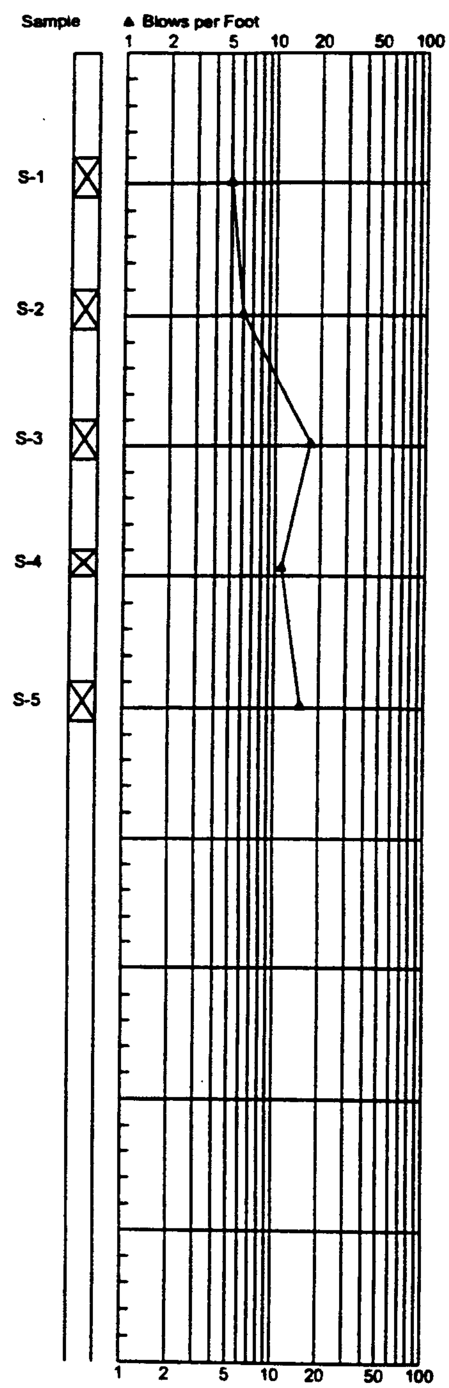
AR 052223.01

Boring Log A3-B20-01

Soil Descriptions
Approx. Ground Surface Elevation in Feet: 247.3

Depth in Feet

Depth (ft)	Soil Description
0	Loose to medium dense, moist, brown, slightly gravelly, slightly silty, fine to medium SAND.
15	Becomes gravelly.
19	Becomes non-gravelly.
25.5	Bottom of Boring at 25.5 Feet. Completed 06/18/01.



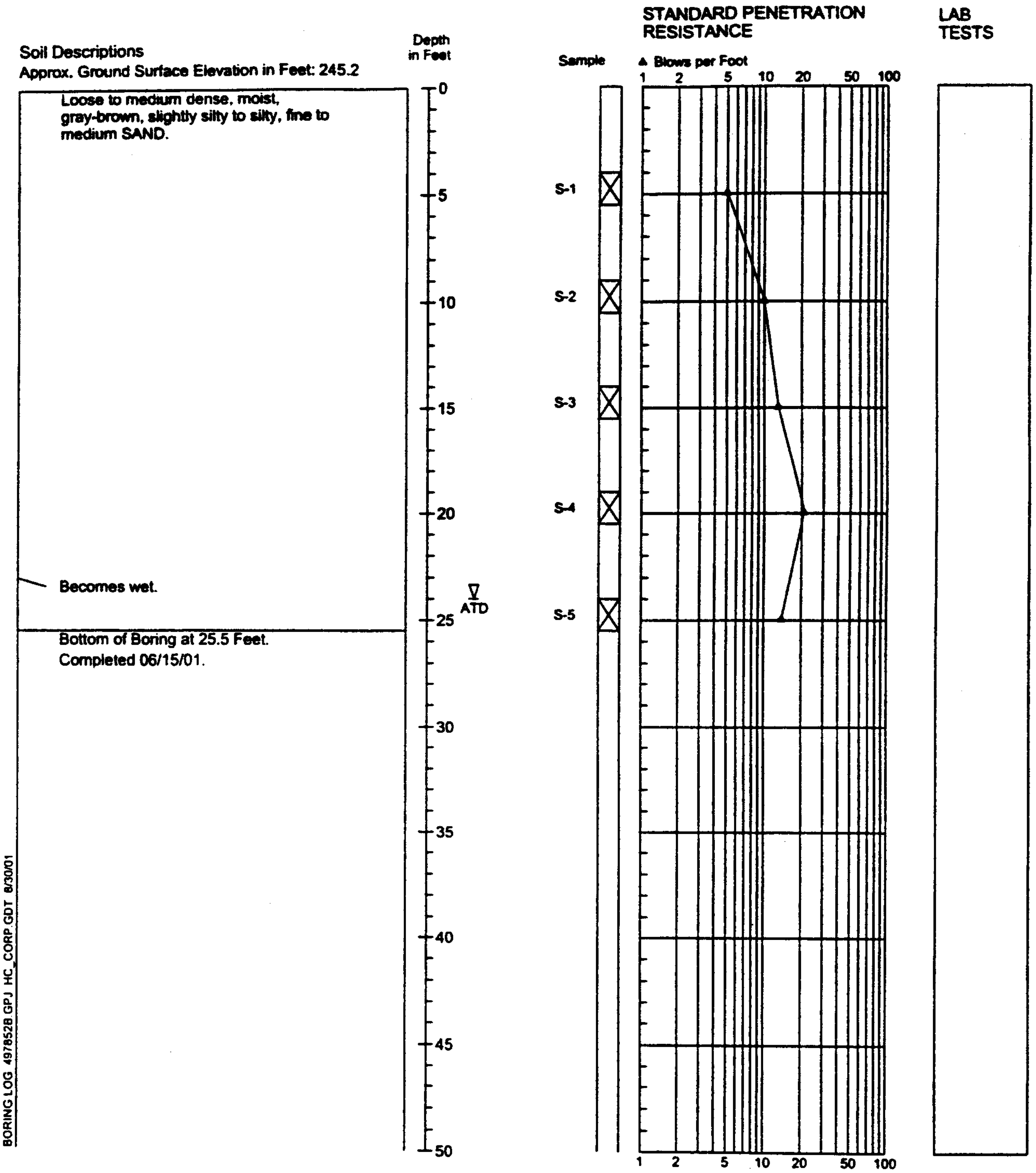
LAB TESTS

BORING LOG 497852B.GPJ HC_CORP.GDT 10/2/01

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-4978-52 06/01
Figure A-14

Boring Log A3-B21-01



BORING LOG 497852B GPJ HC_CORP.GDT 8/30/01

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

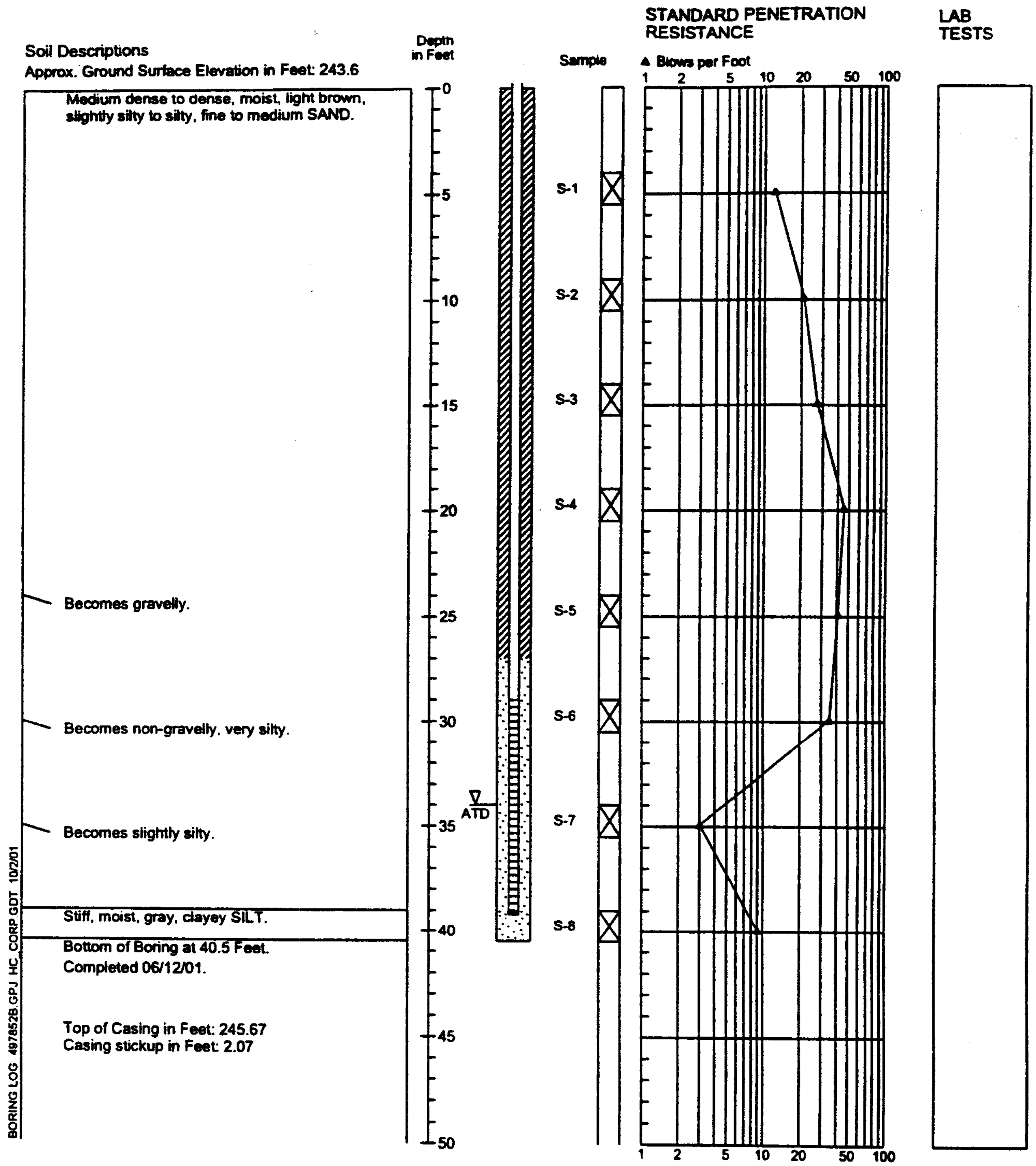
HARTCROWSER

J-4978-52 06/01

Figure A-15

AR 052224

Monitoring Well Log A3-B22-01



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-52 *06/01*

Figure A-16

Boring Log A4-B4-98

Soil Descriptions

Ground Surface Elevation in Feet: 383.0

(Dense to very dense), moist, light brown, slightly silty to silty SAND to gravelly SAND. (Recessional; Type 3)

(Very dense), moist, tan, slightly silty, very sandy GRAVEL to very gravelly SAND. (Advance; Type 2)

Grades to slightly silty, non-gravelly to gravelly, fine to medium SAND. (Type 3)

SAND becoming slightly finer and grades to trace gravel.

Sand becomes slightly coarser

Sand becomes slightly finer and grades to slightly gravelly.

Grades to gravelly.

Grades to trace gravel.

Grades to slightly gravelly.

Silt content decreases.

Grades very gravelly (Type 2)

Grades to wet, brown, clean to slightly silty, sandy GRAVEL. (Type 1)

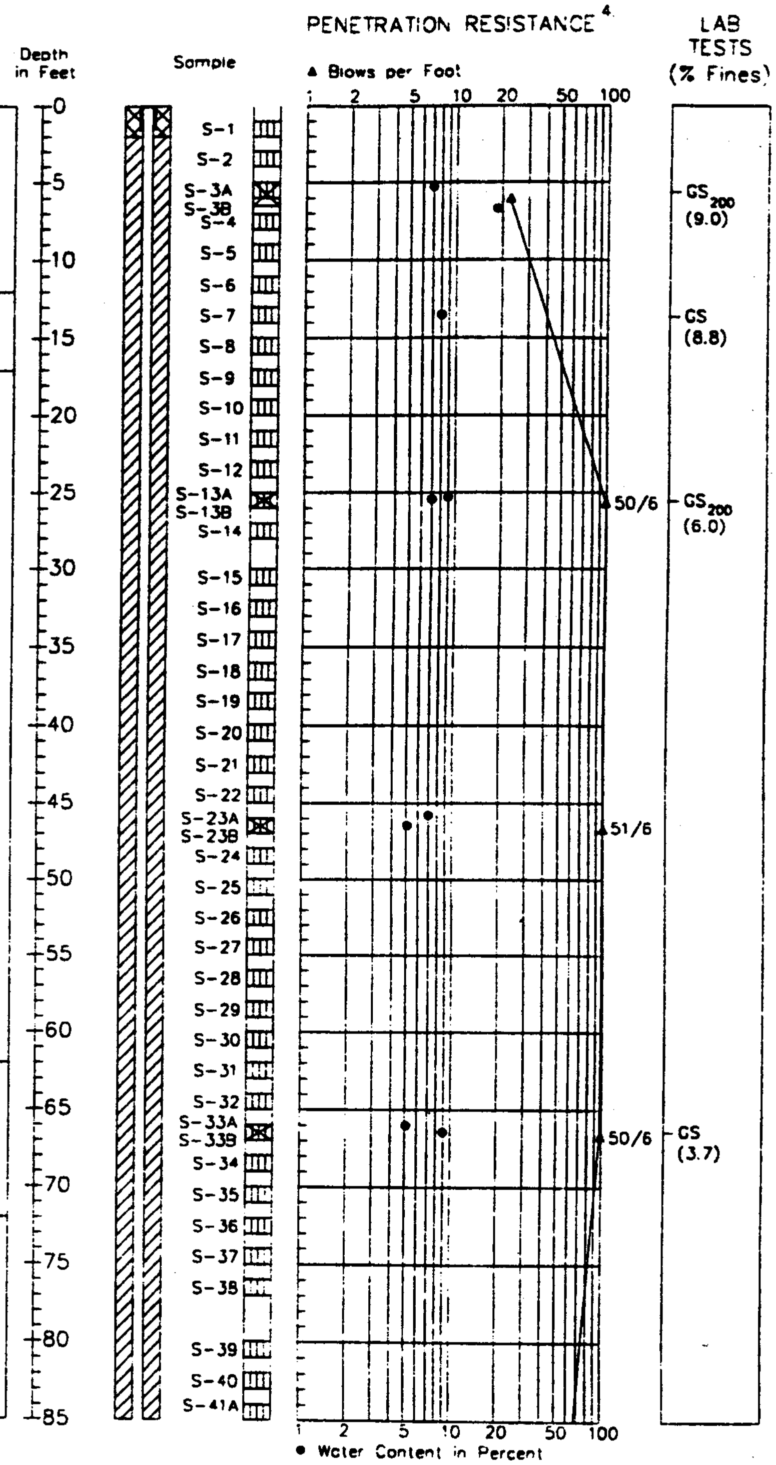
Grades to very sandy GRAVEL .

Grades gravelly to very gravelly, fine to medium SAND. (Type 1)

Grades to gravelly, fine SAND.

Grades to very gravelly, fine to coarse SAND.

Grades to gravelly, fine to medium SAND.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

4978 A4b04 dwg hel 8/30/01

HARTCROWSER

J-4978 **5/98**

Figure A-17 **1/2**

AR 052226

Boring Log A4-B4-98

Soil Descriptions

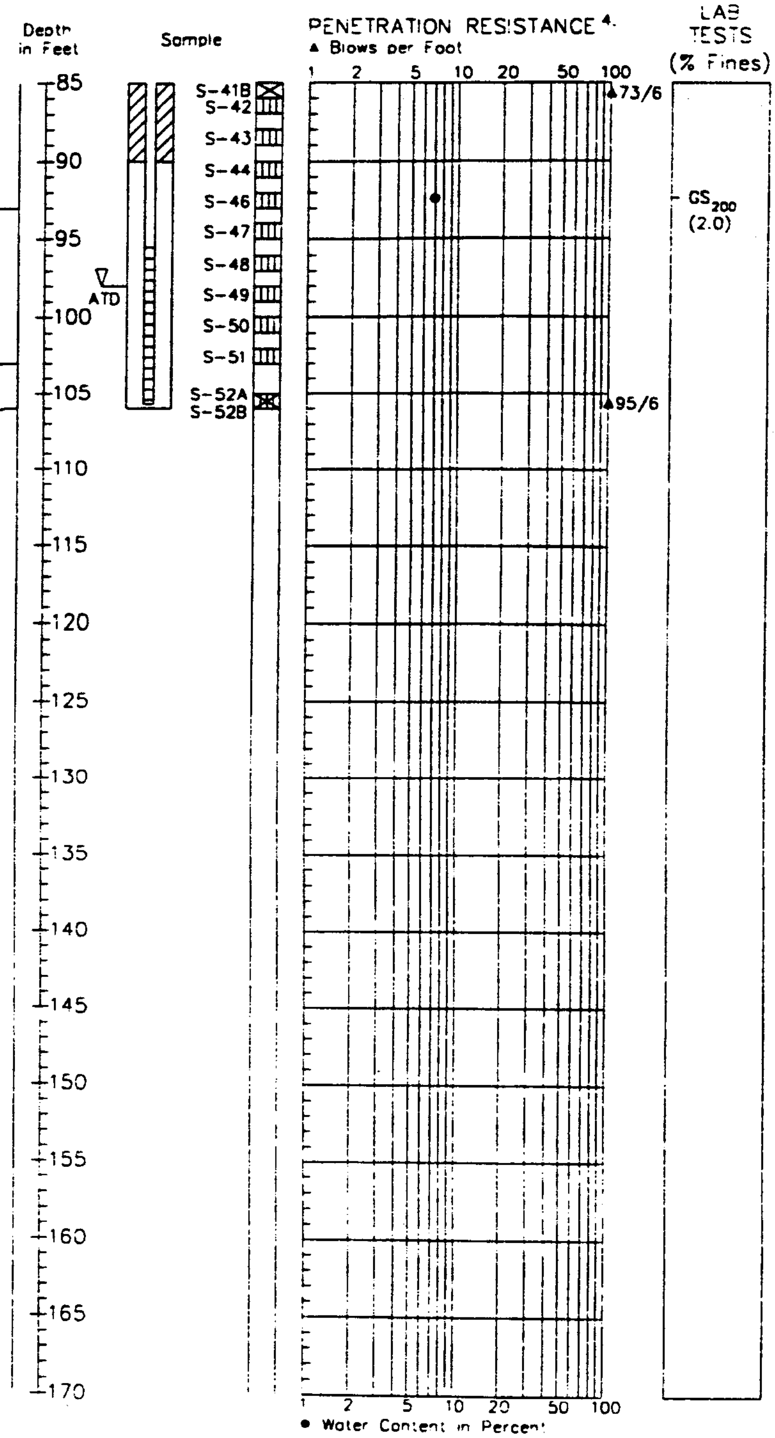
Grades to fine SAND. (Type 1)

Grades to slightly gravelly.

Grades to very gravelly SAND to very sandy GRAVEL. (Type 1)

(Very dense), wet, gray to tan, silty, gravelly SAND. (Till-like; Type 4)

Bottom of Boring at 106.0 Feet.
Completed 5/18/98.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

4978 A4b04x.dwg hel

HARTCROWSER

J-4978 5/98

Figure A-17 2/2

Boring Log A4-B5-98

Soil Descriptions

Ground Surface Elevation in Feet: 368.3

(Medium dense), moist to wet, brown, gravelly, silty SAND. (Type 4)

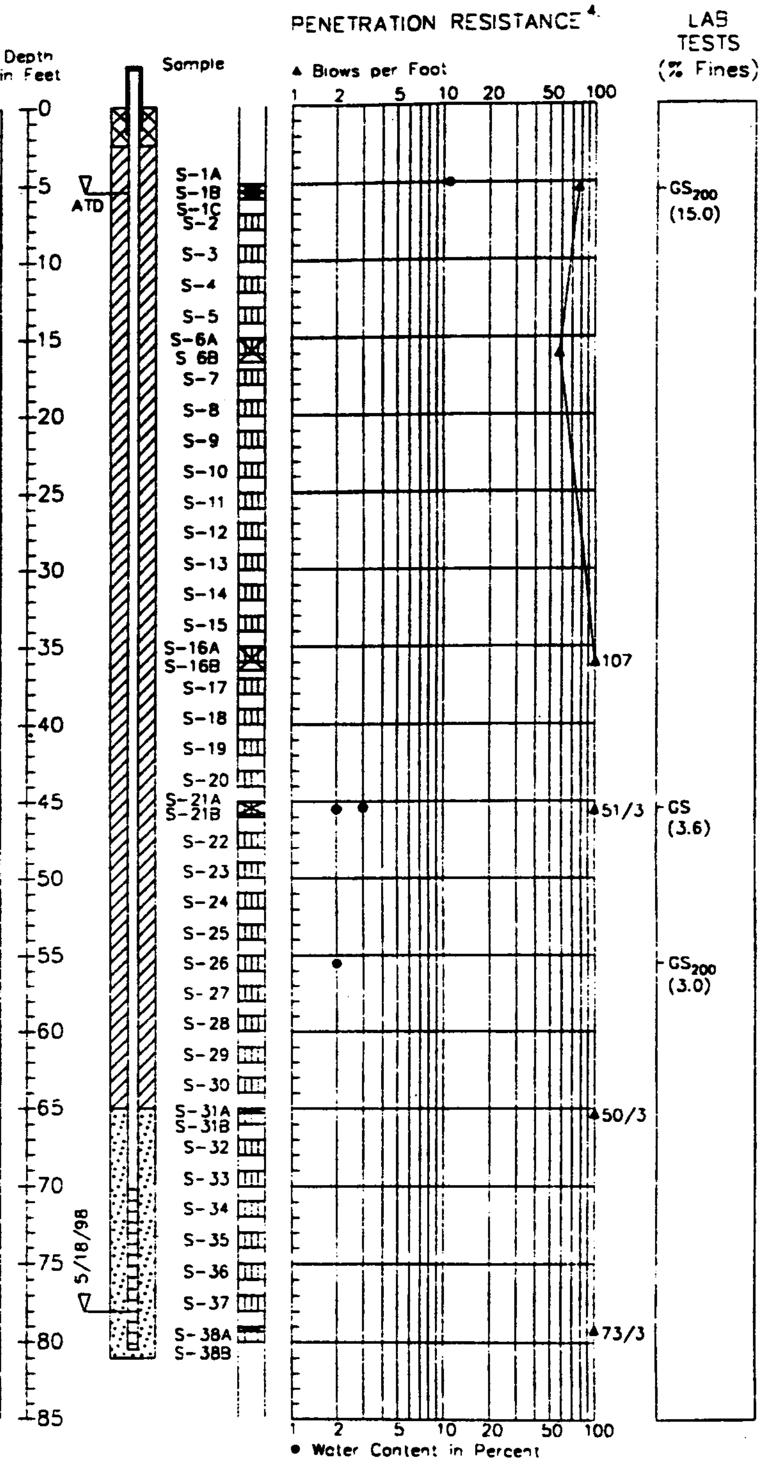
(Hard), moist to wet, tan to brown mottled, slightly gravelly, sandy SILT. (Weathered Till; Type 5)
Grades to non-gravelly, non-sandy.
Color changes to gray.
Color changes to brown.
Color changes to gray.

Note: Silt is typically non-plastic with occasional thin layers of plastic silt or clay.

(Very dense), damp, light brown, slightly silty, gravelly, fine SAND. (Advance; Type 3)
Grades to slightly gravelly.
Grades to very gravelly to gravelly, fine to medium SAND. (Type 1 to Type 2)
Grades to very gravelly, fine to coarse SAND to very sandy, fine GRAVEL.
Grades to gravelly, fine to medium SAND.
Grades to slightly gravelly.
Grades to gravelly.
Grades to slightly gravelly.
Grades to very gravelly.
Grades to very sandy GRAVEL.

(Very dense), damp to moist, gray, silty, gravelly SAND. (Till; Type 4)

Bottom of Boring at 81.0 Feet. Completed 5/15/98.



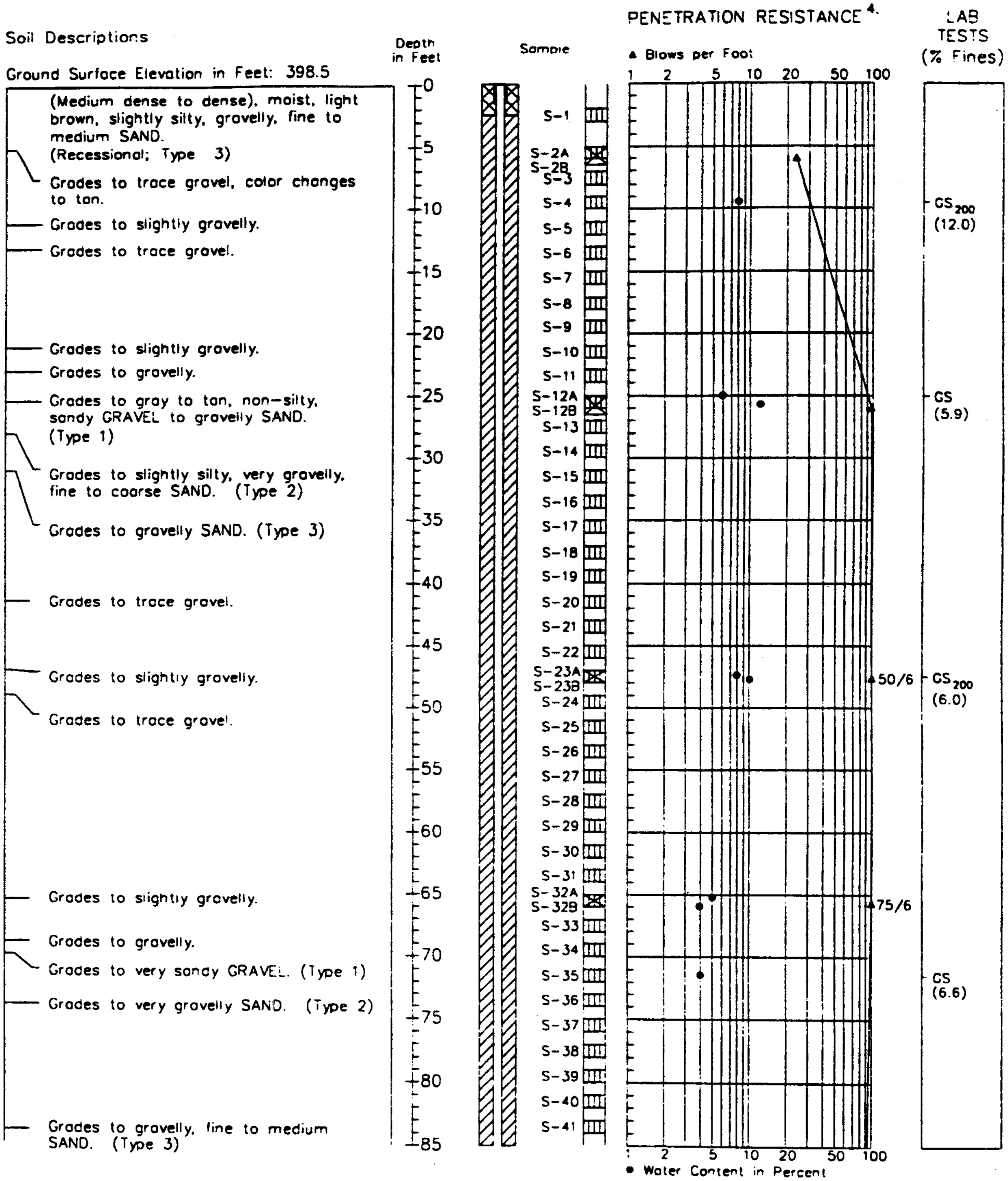
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

4978 A4b05 dwg hel

HARTCROWSER
J-4978 5/98
Figure A-18

AR 052228

Boring Log A4-B6-98



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

4978 A4b06.dwg hei

HARTCROWSER

J-4978 5/98

Figure A-19 1/2

AR 052229

Boring Log A4-B6-98

Soil Descriptions

- Grades to slightly gravelly.
- Grades to trace gravel.

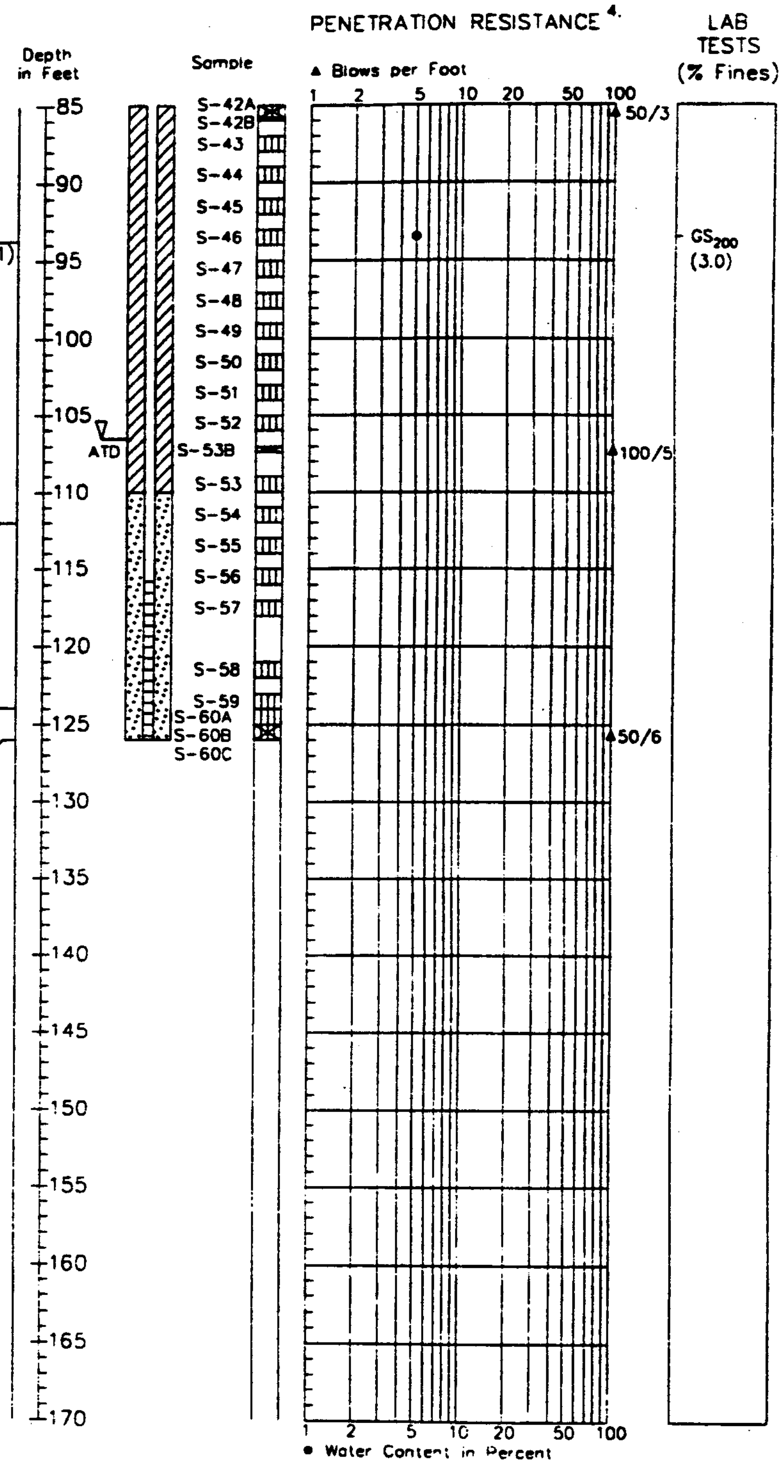
- Grades to gravelly with trace silt. (Type 1)
- Grades to very gravelly.
- Grades to sandy GRAVEL.
- Grades to very sandy, fine to coarse GRAVEL.
- Grades to slightly gravelly, medium to coarse SAND. (Type 1)
- Grades to gravelly, fine to medium SAND.
- Grades to sandy GRAVEL.

Grades to slightly silty, gravelly SAND. (Type 3)

- Grades to no gravel.

(Very dense), wet, gray to tan, gravelly, silty SAND. (Till; Type 4)

Bottom of Boring at 126.0 Feet.
Completed 5/18/98.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Blow counts are for 140 pound hammer and 3-inch-diameter split-spoon sampler (i.e., Not conforming to ASTM D 1586) using down-hole techniques.
5. Refer to text for soil types.

4978 A4b06s dwg hel

HARTCROWSER

J-4978 5/98
Figure A-19 2/2

AR 052230

Monitoring Well Log A4-B7-01

Soil Descriptions
Approx. Ground Surface Elevation in Feet: 304.4

Medium dense, moist to wet, brown, very gravelly SAND.

Grades to silty SAND.

Grades to non-silty SAND.

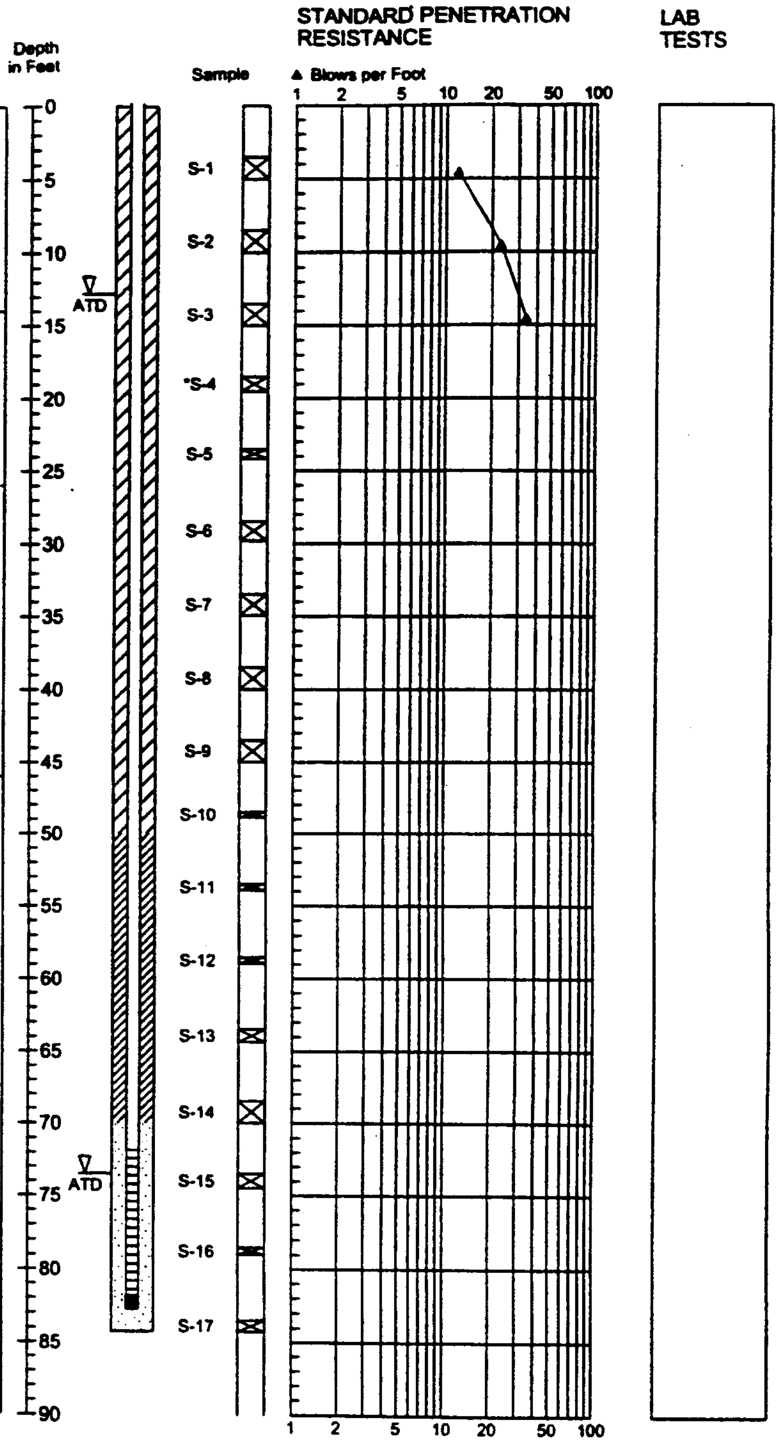
Hard, damp to dry, light brown to gray, slightly sandy to sandy, slightly gravelly to gravelly SILT.

Hard, dry to damp, blue-gray, clayey SILT.

Very dense, dry to damp, brown, non-silty to slightly silty, very sandy GRAVEL to very gravelly SAND.

Becomes wet.

Bottom of Boring at 84.3 Feet.
Completed 06/12/01.



Top of Casing in Feet: 306.83
Casing stickup in Feet: 2.43

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-4978-52 06/01
Figure A-20

Monitoring Well Log A4-B8-01

Soil Descriptions
Approx. Ground Surface Elevation in Feet: 308.3

Dense, moist, mottled gray and brown, slightly gravelly, silty, fine SAND.

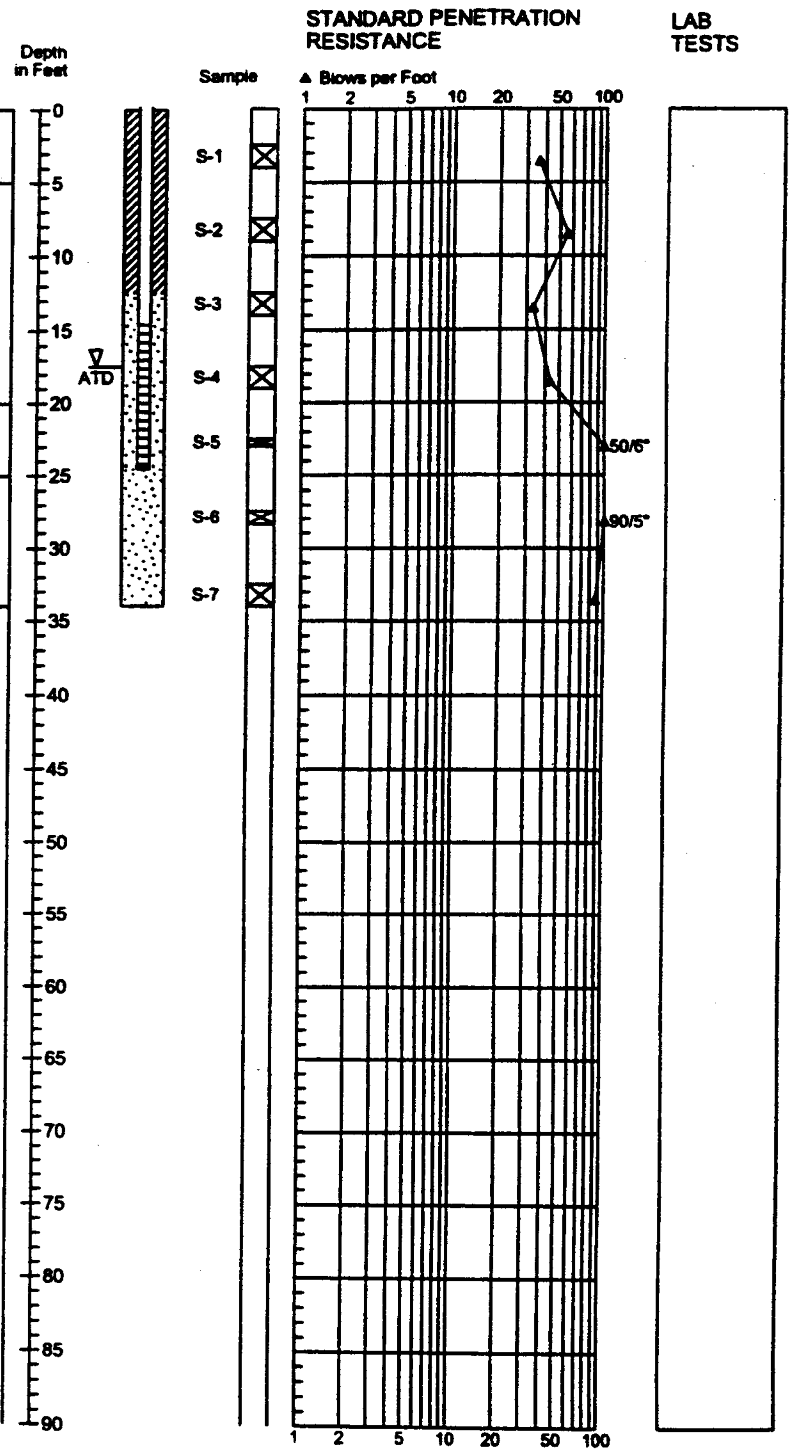
Dense to very dense, moist to wet, gray-brown, slightly silty to silty, fine to medium SAND.

Very dense, moist, light gray, slightly gravelly, silty, fine SAND. (TILL-like)

Hard, moist, gray, slightly sandy to clayey SILT.

Bottom of Boring at 34.0 Feet.
Completed 06/11/01.

Top of Casing in Feet: 310.22
Casing stickup in Feet: 1.92



BORING LOG 497852M.GPJ HC_CORP.GDT 10/2/01

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-4978-52 06/01
Figure A-21

AR 052232

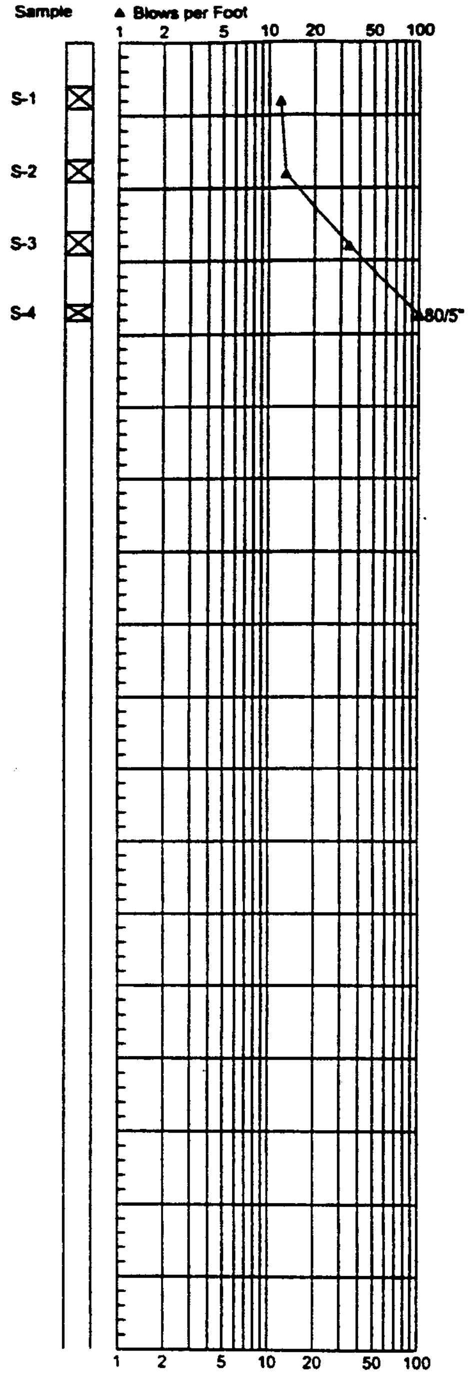
Boring Log A4-B9-01

Soil Descriptions
Approx. Ground Surface Elevation in Feet: 304.8

Soil Descriptions	Depth in Feet
Medium dense to very dense, moist to wet, brown-gray, non-gravelly to slightly gravelly, silty, fine SAND.	0 – 19.0
Bottom of Boring at 19.0 Feet. Completed 06/15/01.	19.0

STANDARD PENETRATION RESISTANCE

LAB TESTS



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

BORING LOG 497852M.GPJ HC_CORP.GDT 8/30/01

HARTCROWSER
J-4978-52 06/01
Figure A-22

AR 052233

Monitoring Well Log A4-B10-01

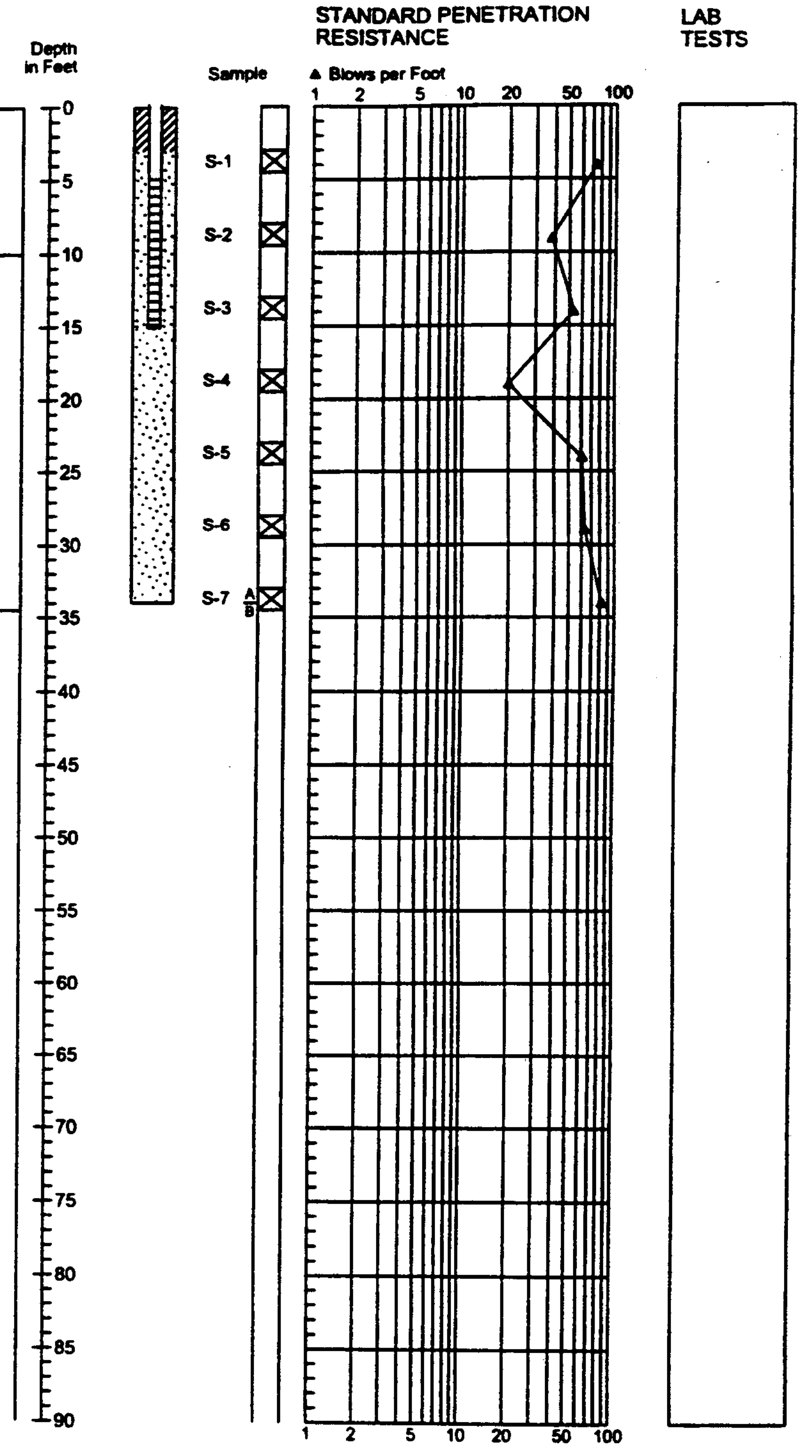
Soil Descriptions
Approx. Ground Surface Elevation in Feet: 295.4

Dense to very dense, moist, gray-brown to gray, slightly gravelly, silty, fine SAND with 1-inch SAND or SILT layers. (TILL-like)

Very stiff to hard, moist, gray, sandy SILT.

Clayey SILT at a depth of 34 feet.
Bottom of Boring at 34.5 Feet.
Completed 06/11/01.

Top of Casing in Feet: 297.54
Casing stickup in Feet: 2.14



BORING LOG 497852M.GPJ HC_CORP.GDT 10/2/01

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-4978-52 06/01
Figure A-23

AR 052234

Monitoring Well Log A4-B11-01

Soil Descriptions
Approx. Ground Surface Elevation in Feet: 295.5

Medium dense, wet, brown, gravelly, coarse SAND.

Stiff to hard, damp, brown to gray, slightly sandy, slightly gravelly to gravelly SILT.

Medium dense, wet, brown, gravelly, medium to coarse SAND.

Very stiff to hard, damp, blue-gray, very silty CLAY to very clayey SILT.

Dense to very dense, dry to moist, brown, non-gravelly to very gravelly SAND.

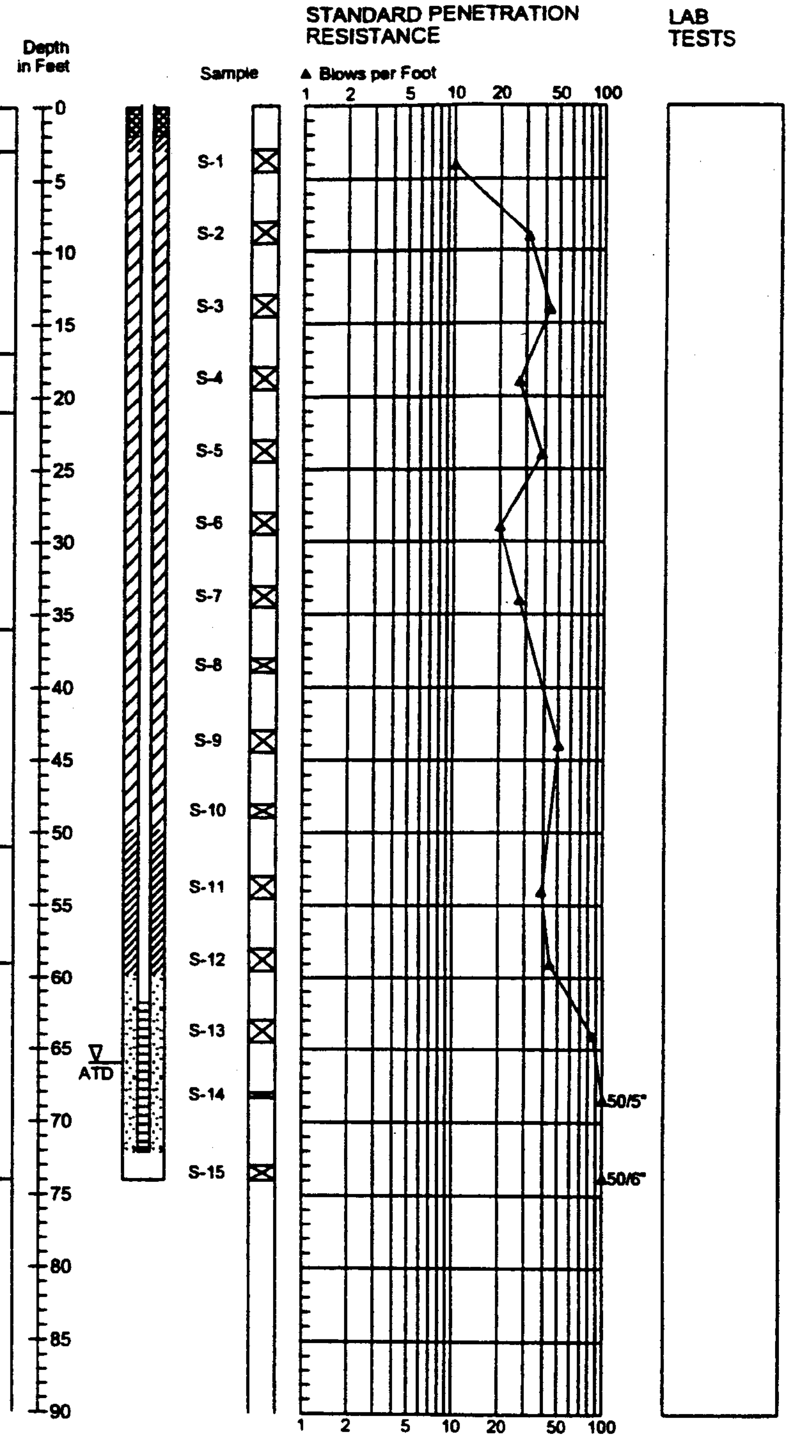
Hard, moist to wet, brown, gravelly SILT.

Dense to very dense, moist to wet, gray, slightly silty, fine SAND.

Grades to coarse SAND and sandy GRAVEL.

Bottom of Boring at 74.0 Feet.
Completed 06/13/01.

Top of Casing in Feet: 297.13
Casing stickup in Feet: 1.63



BORING LOG 497852M.GPJ HC_CORP.GDT 10/2/01

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-4978-52 06/01
Figure A-24

AR 052235

Test Pit Log A4-TP1-01

Sample: S-1, S-2, S-3, S-4

Depth in Feet: 0–10

SOIL DESCRIPTIONS
Approx. Ground Surface Elevation in Feet:: 299.8

(Medium stiff), moist to wet, dark brown SILT with roots.

(Stiff to hard), moist, light brown, trace to slightly gravelly, sandy to very sandy SILT. Red mottling below 2 feet.

(Hard), damp, gray, slightly sandy, gravelly SILT.

Bottom of Exploration at 9.0 Feet.
Completed 06/15/01.

Test Pit Log A4-TP2-01

Sample: S-1, S-2, S-3, S-4, S-5

Depth in Feet: 0–10

SOIL DESCRIPTIONS
Approx. Ground Surface Elevation in Feet:: 294.2

(Soft), moist, dark brown, sandy SILT with roots.

(Medium dense), damp to moist, brown, gravelly SAND.

(Hard), moist, mottled light brown, slightly sandy, clayey SILT.

(Very stiff to hard), moist to damp, light brown, sandy, gravelly SILT.

Becomes gray-brown.

Bottom of Exploration at 9.0 Feet.
Completed 06/15/01.

Test Pit Log A4-TP3-01

Sample: S-1, S-2, S-3, S-4

Depth in Feet: 0–10

SOIL DESCRIPTIONS
Approx. Ground Surface Elevation in Feet:: 294.2

(Soft), moist, medium brown, slightly sandy, gravelly SILT with roots.

(Very stiff), moist, light brown, slightly gravelly SILT.

(Hard), moist, mottled light brown, slightly clayey SILT.

(Hard), damp, gray-brown, slightly sandy, gravelly SILT. (TILL-like)

Bottom of Exploration at 9.0 Feet.
Completed 06/15/01.

3 LOGS PER PAGE 497852T.GPJ HC_CORP.GDT 8/30/01

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

HARTCROWSER

J-4978-52 06/01

Figure A-25

Test Pit Log HR-TP1-01

Sample: S-1 (about 0.5–1 ft), S-2 (about 2.5–3 ft), S-3 (about 5.5–6 ft)

SOIL DESCRIPTIONS
Approx. Ground Surface Elevation in Feet:: 256

Depth in Feet	Soil Descriptions
0	(Medium stiff), dark brown, moist, slightly sandy SILT.
1.5	(Stiff), light brown, moist SILT.
5	(Medium stiff), gray, moist, slightly sandy SILT.
9	Bottom of Exploration at 9.0 Feet.

Completed 07/24/01.

Infiltration test at a depth of 6.0 feet.

Test Pit Log HR-TP2-01

Sample: S-1 (about 0–0.5 ft), S-2 (about 1–1.5 ft), S-3 (about 1.5–2 ft), S-4 (about 3–3.5 ft), S-5 (about 7.5–8 ft)

SOIL DESCRIPTIONS
Approx. Ground Surface Elevation in Feet:: 252

Depth in Feet	Soil Descriptions
0	(Dense), damp, brown, sandy GRAVEL. (FILL)
1.25	(Dense), damp, dark brown, sandy GRAVEL. (FILL)
1.75	(Medium dense), damp, brown, slightly gravelly, fine SAND. (FILL)
3	(Stiff), damp, black, sandy SILT with organic material and roots.
3.5	(Loose), damp to wet, gray, slightly sandy SILT.
6–7	Seeps and sloughing.
10	Bottom of Exploration at 10.0 Feet.

Completed 07/24/01.

Infiltration test at a depth of 4.0 feet.

2 LOGS PER PAGE 497852TP GPJ HC_CORP GDT 10/2/01

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

HARTCROWSER

J-4978-52 07/01

Figure A-26

Hand-Auger Boring Log HR-B1-01

Sample: S-1 (0–1.0 ft), S-2 (2.5–3.0 ft)

Depth in Feet	SOIL DESCRIPTIONS Approx. Ground Surface Elevation in Feet:: 252
0	Grass over (medium stiff), moist, brown, sandy SILT with roots.
1	(Medium stiff), wet, brown, sandy SILT.
2	(Stiff), moist, brown, slightly sandy SILT.
3.6	Bottom of Exploration at 3.6 Feet. Completed 07/24/01. Infiltration test at a depth of 1.0 foot.

Hand-Auger Boring Log HR-B2-01

Sample: S-1, S-2, S-3

Depth in Feet	SOIL DESCRIPTIONS Approx. Ground Surface Elevation in Feet:: 250
0	Grass over (medium stiff), brown, sandy SILT with grass.
1	(Medium stiff), black, wet to moist, slightly sandy SILT.
3	(Soft), gray, moist SILT.
4	Bottom of Exploration at 4.0 Feet. Completed 07/24/01. Infiltration test at a depth of 1.0 foot.

Hand-Auger Boring Log HR-B3-01

Sample: S-1

Depth in Feet	SOIL DESCRIPTIONS Approx. Ground Surface Elevation in Feet:: 250
0	Grass over (medium stiff), moist, brown, sandy SILT with occasional gravel (0.25-1.25-inch) and roots.
2	Bottom of Exploration at 2.0 Feet. Completed 07/24/01. Refusal at a depth of 2.0 feet due to gravel. Infiltration test at a depth of 1.0 foot.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

HARTCROWSER

J-4978-52 07/01

Figure A-27

ATTACHMENT A-1
AGI FIGURES

UNIFIED SOIL CLASSIFICATIONS SYSTEM

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS More than half is larger than No. 200 Sieve	GRAVELS More than half coarse fraction is larger than No. 4 sieve size	Clean gravels with little or no fines	GW	Well graded gravels, gravel-sand mixtures
			GP	Poorly graded gravels, gravel-sand mixtures
		Gravels with over 12% fines	GM	Silty Gravels, poorly graded gravel-sand-silt mixtures
			GC	Clayey gravels, poorly graded gravel-sand-clay mixtures
	SANDS More than half coarse fraction is larger than No. 4 sieve size	Clean sands with little or no fines	SW	Well graded sands, gravelly sands
			SP	Poorly graded sands, gravelly sands
		Sands with over 12% fines	SM	Silty sand, poorly graded sand-silt mixtures
			SC	Clayey sands, poorly graded sand-clay mixtures
FINE GRAINED SOILS More than half is smaller than No. 200 Sieve	SILTS AND CLAYS Liquid limit less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic clays and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomacious fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils

SAMPLE

- ■ "Undisturbed"
- ⊡ Bulk/Grab
- □ Not Recovered
- ◫ Recovered, Not Retained

CONTACT BETWEEN UNITS

- ——— Well Defined Change
- ——— Gradational Change
- - - - Obscure Change
- ▬▬ End of Exploration

BLOWS PER FOOT

Hammer is 140 pounds with 30-inch drop, unless otherwise noted

- S - SPT Sampler (2.0-Inch O.D.)
- T - Thin Wall Sampler (2.8-Inch Sample)
- H - Split Barrel Sampler (2.4-Inch Sample)

MOISTURE DESCRIPTION

- Dry - Considerably less than optimum for compaction
- Moist - Near optimum moisture content
- Wet - Over optimum moisture content
- Saturated - Below water table, in capillary zone, or in perched groundwater

PHYSICAL PROPERTY TESTS

- Consol - Consolidation
- LL - Liquid Limit
- PL - Plastic Limit
- Gs - Specific Gravity
- SA - Size Analysis
- TxS - Triaxial Shear
- TxP - Triaxial Permeability
- Perm - Permeability
- Po - Porosity
- MD - Moisture/Density
- DS - Direct Shear
- VS - Vane Shear
- Comp - Compaction

- UU - Unconsolidated, Undrained
- CU - Consolidated, Undrained
- CD - Consolidated, Drained

AGI TECHNOLOGIES

Soil Classification/Legend

HNTB/Runway Borrow Source Study
SeaTac, Washington

PLATE **A1**

PROJECT NO. [illegible] DRAWN [illegible] DATE [illegible] APPROVED REVISED DATE

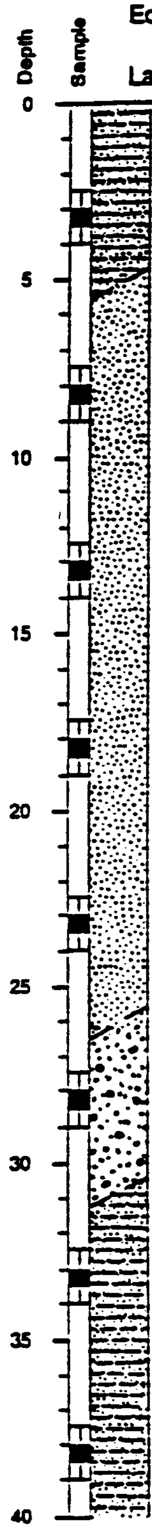
AR 052240

P.O.S. Coordinates: E 12600 N 3200

Equipment Canterra CT-450

Land Surface Elevation 260 feet Date 12/17/93

aboratory 'ests	loisture ontent (%)	ry _ensity (pcf)	Blows per Foot
			17
			17
			14
			18
MD	3.7	100	14
			20
SA	6.4	97	16
MD	4.4	96	19



BROWN SILTY SAND (SM) medium dense, moist; fine to medium grained (Recessional Outwash Unit 2).

GRAY SAND (SP) medium dense, moist; fine to medium grained, with a trace of gravel and silt (Recessional Outwash Unit 1).

GRAY SAND (SW) medium dense, moist; fine to coarse grained (Recessional Outwash Unit 1).

GRAY SILTY SAND (SM) medium dense, moist; fine grained (Recessional Outwash Unit 2).

Becomes very fine grained, with pockets of light brown silt.

AGI TECHNOLOGIES

Log of Area 3 Boring 1 (0-40') A3-B1-93

HNTB/Runway Borrow Source Study

SeaTac, Washington

PLATE **A16a**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,190.202	KM/SES		18 January 94	DFF	27 Mar 95

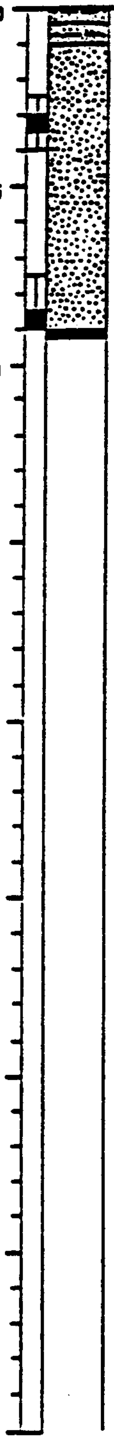
LA3B1-2.PM5

P.O.S. Coordinates: E 12600 N 3200

Equipment Canterra CT-450

Land Surface Elevation 260 feet Date 12/17/93

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth
				40
			16	
				45
			24	
				50
				55
				60
				65
				70
				75
				80



GRAY SAND (SP) medium dense, wet to saturated; fine grained (Recessional Outwash Unit 1).

Groundwater encountered at 43 feet during drilling.

AGI TECHNOLOGIES

Log of Area 3 Boring 1 (40-49') A3-B1-93

HNTB/Runway Borrow Source Study

SeaTac, Washington

PLATE **A16b**

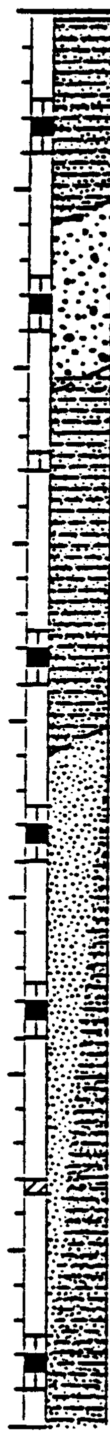
JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14.190.208	KM/SES		18 January 94	DFF	27 Mar 95

P.O.S. Coordinates: E 12420 N 5780

Equipment Canterra CT-450

Land Surface Elevation 327 feet Date 12/17/93

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth	Description
				0	Pavement. RED BROWN SILTY SAND (SM) loose, dry; fine grained, with a trace of fine gravel and roots (Recessional Outwash Unit 2).
			5		
				5	GRAY GRAVELLY SAND (SW) dense, dry; fine to coarse grained (Recessional Outwash Unit 1).
			48		
				10	GRAY BROWN SILTY SAND (SM) very dense, moist; fine to medium grained, with gravel (Till Unit 1).
			50/3"		
				15	
MD	7.5	131	86/11"		
				20	GRAY SAND (SP-SM) dense, moist to wet; fine to coarse grained, with gravel and silt (Advance Outwash Unit 1).
SA	11.6	122	49		
				25	
			70/10"		Becomes fine grained.
				30	
			75/9"		
				35	
			68		
				40	



AGI TECHNOLOGIES

Log of Area 3 Boring 2 (0-40') A3-B2-93

HNTB/Runway Borrow Source Study

SeaTac, Washington

PLATE **A17a**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,190.208	KM/SES		18 January 94	DFF	27 Mar 95

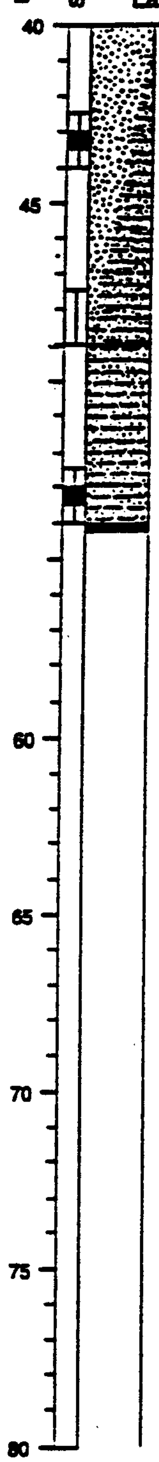
AR 052243

P.O.S. Coordinates: E 12420 N ~~5780~~ 5180? See Table 1

Equipment Canterra Ct-450

Land Surface Elevation 327 feet Date 12/17/93

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
SA	9.3	101	58
			45
			53



BROWN SILTY SAND (SM) very dense, saturated; very fine grained, with pockets of brown silt.

Groundwater encountered at 49 feet during drilling.

AGI TECHNOLOGIES

Log of Area 3 Boring 2 (40-54') A3-B2-93

HNTB/Runway Borrow Source Study

SeaTac, Washington

PLATE **A17b**

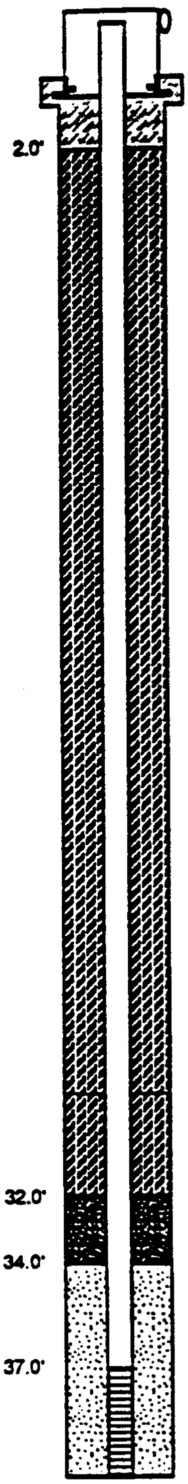
JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,190.208	KM/SES		18 January 94	DFF	27 Mar 95

LA3B1-2.PM6

P.O.S. Coordinates: N 2930 E 12,950

Equipment Mobile B-61

Land Surface Elevation 250 feet Date 12/2/94



Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Description
				BROWN SAND (SP) medium dense, moist; fine to medium grained, with a trace of gravel (Recessional Outwash - Unit 1).
MD	5.4	101	11	
MD,SA	6.8	94	9	Becomes loose.
MD	3.7	95	15	Becomes gray and medium dense.
COMP				
				BROWN SILTY SAND (SM) medium dense, moist; gravelly silt interbeds (Recessional Outwash - Unit 2).
MD,SA	15.6	112	14	
				RED BROWN SAND (SP) medium dense, moist; fine grained (Recessional Outwash - Unit 1).
MD	11.6	96	18	
MD,SA	6.2	102	17	
MD	22.3	101	44	Becomes gray, dense, and fine to medium grained.
MD	23.6	99	19	Becomes medium dense and saturated, with silt.

Depth (feet): 0, 5, 10, 15, 20, 25, 30, 35, 40

AGI TECHNOLOGIES

Log of Area 3 Boring 3 (0-40') A3-B3-94

HNTB/Runway Borrow Source Study
SeaTac, Washington

PLATE **A18a**

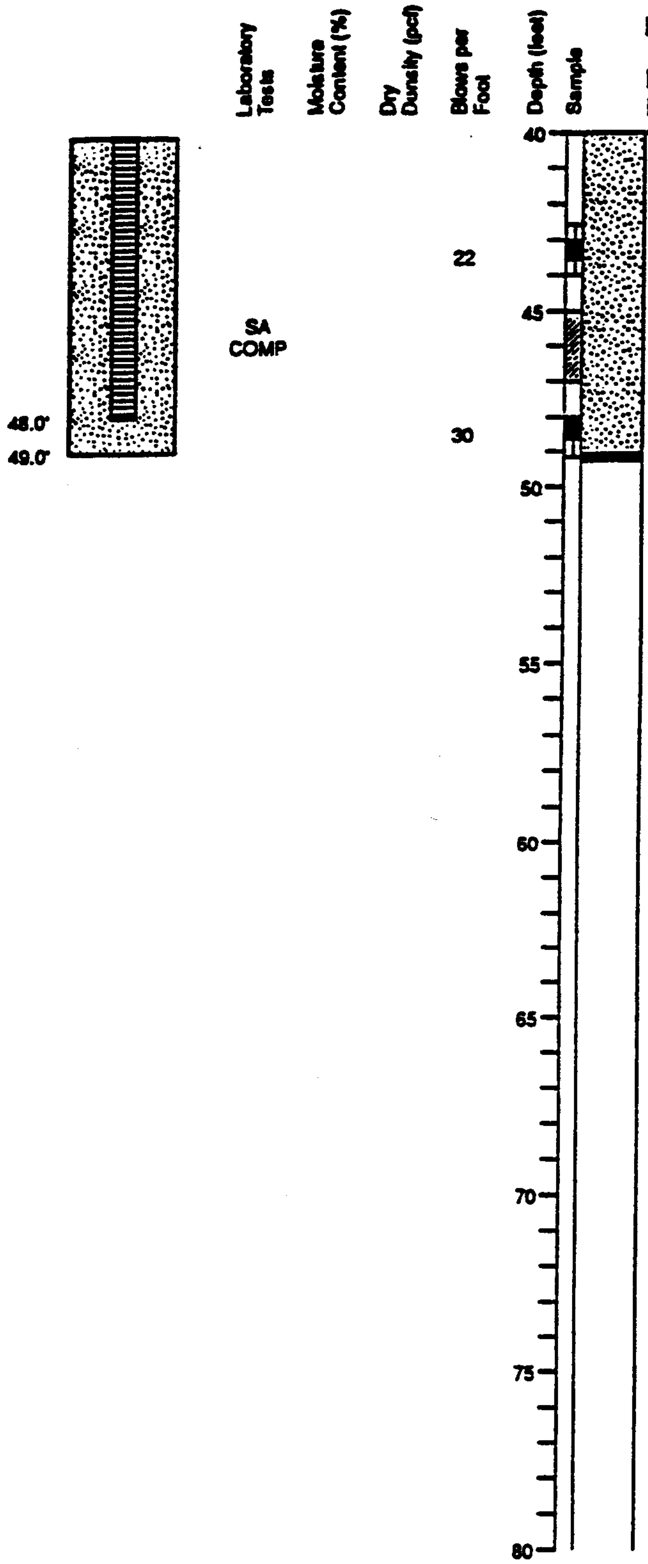
H3mw.cdr	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
	14.190.208	ECR	6 December 94			

AR 052245

P.O.S. Coordinates: N 2930 E 12,950

Equipment Mobile B-61

Land Surface Elevation 250 feet Date 12/2/94



Groundwater encountered at 37.5 feet during drilling.

Boring converted into piezometer on 12/2/94.

AGI TECHNOLOGIES

Log of Area 3 Boring 3 (40-49') A3-B3-94

HNTB/Runway Borrow Source Study

SeaTac, Washington

PLATE A18b

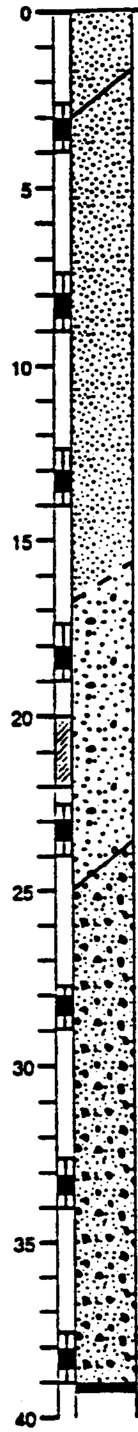
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H3-40.cdr	14.190.208	ECR	6 December 94			

AR 052246

P.O.S. Coordinates: N 3480 E 12,710

Equipment: Mobile B-61

Land Surface Elevation: 243 feet   Date: 12/2/94



Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Description
				BROWN SAND (SP) loose, wet; fine to medium grained, with organic material (Recessional Outwash - Unit 1).
MD	2.5	104	21	GRAY BROWN SAND (SP) medium dense, moist; fine to coarse grained, with a trace of gravel (Recessional Outwash - Unit 1).
MD	13.4	96	16	
MD	4.6	99	24	Becomes red brown.
MD,SA	2.9	132	29	GRAY SAND (SW) dense, moist; fine to coarse grained, with gravel and a trace of silt (Recessional Outwash - Unit 2).
COMP				
MD,SA	5.7	144	90	Becomes very dense, wet; with fine to medium gravel.
				GRAY GRAVEL (GW) very dense, saturated; fine to coarse grained, with sand and a trace of silt (Recessional Outwash - Unit 2).
			60	
				Becomes brown.
MD,SA	6.8	142	80	
MD	4.4	132	81	Groundwater encountered at 25.5 feet during drilling. Boring backfilled with bentonite and cuttings on 12/2/94.

AGI TECHNOLOGIES

Log of Area 3 Boring 4 A3-B4-94

HNTB/Runway Borrow Source Study
SeaTac, Washington

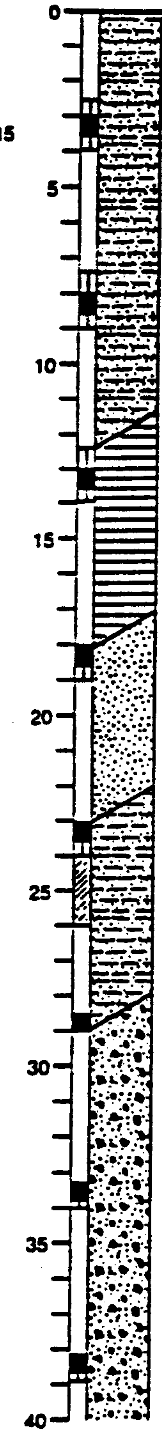
PLATE **A19**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H3mw.cdr	14.190.208	ECR	6 December 94			

P.O.S. Coordinates: N 4450 E 12,920

Equipment Mobile B-61

Land Surface Elevation 252 feet Date 12/2/94



Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Description
				BROWN SILTY SAND (SM) medium dense, wet; fine to medium grained, with some organics (Recessional Outwash - Unit 2).
MD,SA		16.4	11115	
				Becomes gray, with some gravel.
			31	
				GRAY CLAY (CL) hard, moist; with sand and some fine gravel (Recessional Outwash - Unit 2).
MD,LL PL	20.4	107	29	
				BROWN SAND (SP) very dense, moist; fine to medium grained, with a trace of gravel (Advance Outwash - Unit 1).
			50/4"	
				RED BROWN SILTY SAND (SM) dense, wet; fine grained (Advance Outwash - Unit 2).
MD,SA COMP	17.4	104	33	
			50/6"	BROWN GRAVEL (GP) very dense, wet; fine to medium grained, with sand and a trace of silt (Advance Outwash - Unit 3).
MD,SA	7.6	134	50/4"	Becomes gray.
			50/6"	Becomes saturated.

AGI TECHNOLOGIES

Log of Area 3 Boring 5 (0-40') A3-B5-94

HNTB/Runway Borrow Source Study
SeaTac, Washington

PLATE **A20a**

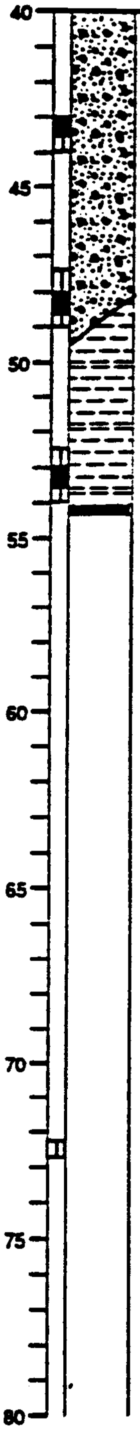
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H3mw.cdr	14,190.208	ECR	6 December 94			

P.O.S. Coordinates: N 4450 E 12,920

Equipment Mobile B-61

Land Surface Elevation 252 feet Date 12/2/94

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth (feet)
MD	7.0	144	50/4"	
			50/4"	
			37	



GRAY SILT (ML) hard, moist; with fine sand (Pre-Vashon Drift).

Groundwater encountered at 41 feet during drilling.

Boring backfilled with bentonite and cuttings on 12/2/94.

AGI TECHNOLOGIES

Log of Area 3 Boring 5 (40-54') A3-B5-94

HNTB/Runway Borrow Source Study

SeaTac, Washington

PLATE **A20b**

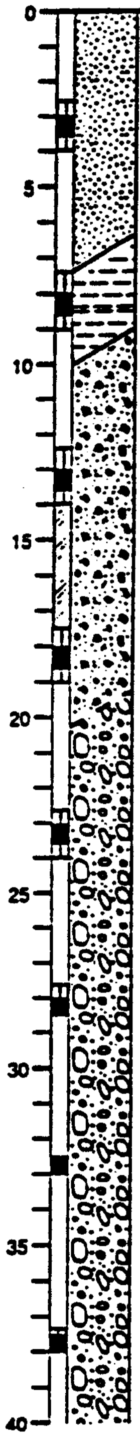
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H3-40.cdr	14,190.208	ECR	6 December 94			

P.O.S. Coordinates: N 4785 E 12,840

Equipment Mobile B-61

Land Surface Elevation 268 feet Date 12/3/94

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
MD	10.2	126	37
			30
MD,SA	2.1	131	53
COMP			
			81
MD	9.8	132	87
			50/3"
MD,SA	13.7	110	50/5"
			50/4"



BROWN SAND (SP) dense, moist; fine to medium grained, mottled, with gravel and silt (Recessional Outwash - Unit 1).

GRAY SILT (ML) hard, moist; mottled (Recessional Outwash - Unit 2).

GRAY GRAVEL (GP) very dense, moist; fine grained, with silt (Advance Outwash - Unit 3).

GRAY GRAVEL (GW-GM) very dense, wet; fine to coarse grained, with sand and silt (Advance Outwash - Unit 3).

AGI TECHNOLOGIES

Log of Area 3 Boring 6 (0-40') A3-B6-94

HNTB/Runway Borrow Source Study

SeaTac, Washington

PLATE **A21a**

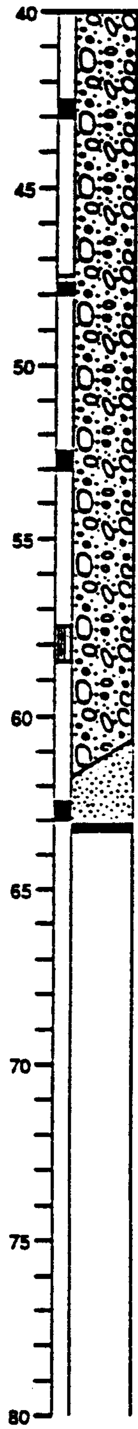
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H3mw.cdr	14,190.208	ECR	6 December 94			

P.O.S. Coordinates: N 4785 E 12,840

Equipment: Mobile B-61

Land Surface Elevation: 268 feet Date: 12/3/94

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth (feet)
MD,SA	8.2	136	50/5"	~43
			50/4"	~48
			50/6"	~53
			50/3"	~58
			50/3"	~63



Becomes saturated

GRAY SAND (SP) very dense, saturated; with fine gravel (Advance Outwash - Unit 1).

Groundwater encountered at 51 feet during drilling.

Boring backfilled with bentonite and cuttings on 12/3/94.

AGI TECHNOLOGIES

Log of Area 3 Boring 6 (40-63') A3-B6-94

HNTB/Runway Borrow Source Study
SeaTac, Washington

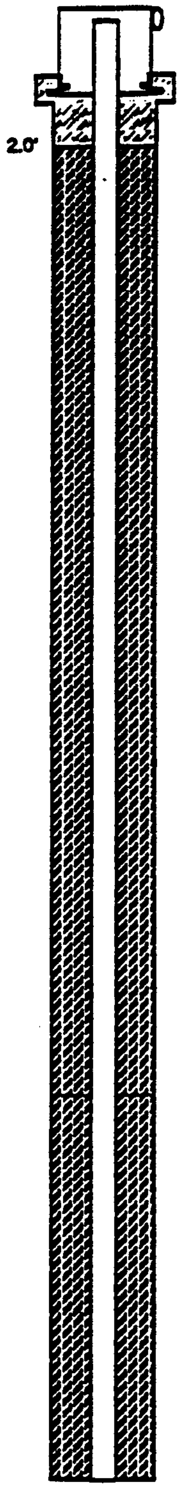
PLATE **A21b**

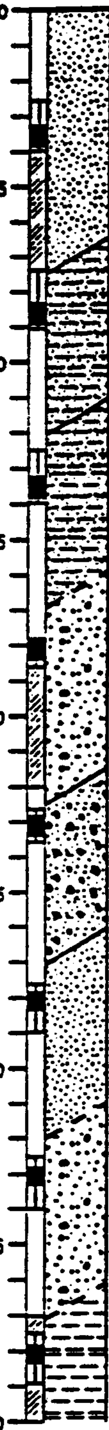
H3-40.cdr | PROJECT NO. 14,190.208 | DRAWN ECR | DATE 6 December 94 | APPROVED | REVISED | DATE

P.O.S. Coordinates: N 5590 E 12,900

Equipment: Mobile B-61

Land Surface Elevation: 315 feet   Date: 12/22/94





Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
MD,SA COMP	12.3	99	4
			13
MD,SA	13.7	120	70
SA,COMP	8.6		50/6"
MD	5.8	129	50/5"
			62
MD,SA	15.5	111	13
COMP			50/6"

Depth (feet): 0, 5, 10, 15, 20, 25, 30, 35, 40

▽ 278

BROWN SAND (SP) loose, moist; fine to medium grained, with a trace of fine gravel and silt (Recessional Outwash - Unit 1).

BROWN SILTY SAND (SM) medium dense, moist; fine to coarse grained, with gravel (Recessional Outwash - Unit 2).

BROWN SAND (SM) very dense, wet; fine to coarse grained, with gravel (Advance Outwash - Unit 1).

BROWN SAND (SW-SM) very dense, wet; fine to coarse grained, with gravel and silt (Advance Outwash - Unit 1)

BROWN GRAVEL (GP) very dense, moist; fine to coarse grained gravel, medium grained sand (Advance Outwash - Unit 3).

BROWN SAND (SP) very dense, moist; fine to medium grained (Advance Outwash - Unit 1).

BROWN SAND (SW-SM) medium dense, saturated; fine to coarse grained, with fine gravel and silt (Advance Outwash - Unit 1).

BROWN SANDY SILT (ML) hard, saturated, fine grained (Advance Outwash - Unit 2).

AGI TECHNOLOGIES

Log of Area 3 Boring 7 (0-40') A3-B7-94

HNTB/Runway Borrow Source Study
SeaTac, Washington

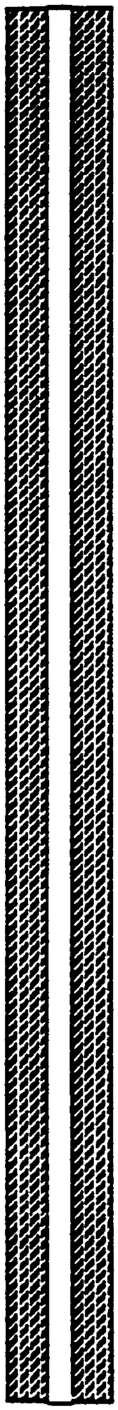
PLATE **A22a**

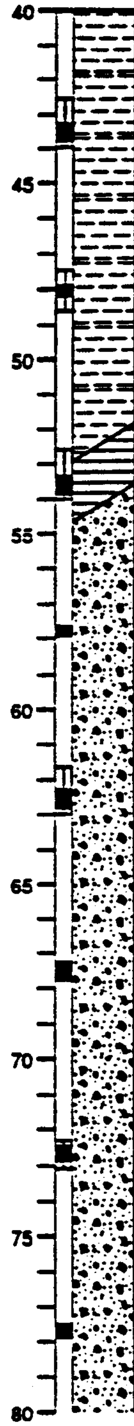
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H3mw.cdr	14,190.208	ECR	6 December 94			

P.O.S. Coordinates: N 5590 E 12,900

Equipment Mobile B-61

Land Surface Elevation 315 feet Date 12/22/94





Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
MD,SA	24.5	100	54
			50/4"
			50/5"
MD,SA	6.8	130	50/6"
			50/5"
MD	5.7	116	50/3"
			50/3"
MD,SA	8.3	115	50/3"

GRAY CLAY (CL) hard, moist: with some fine gravel (Advance Outwash - Unit 2).

BROWN GRAVEL (GP-GM) very dense, wet: fine to medium grained gravel, with sand and pockets of silt (Advance Outwash - Unit 3).

AGI TECHNOLOGIES

Log of Area 3 Boring 7 (40-80') A3-B7-94

HNTB/Runway Borrow Source Study
SeaTac, Washington

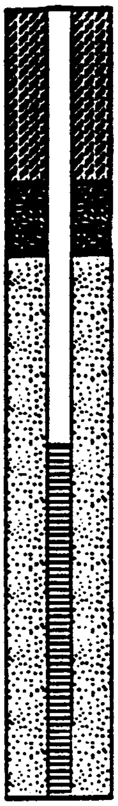
PLATE A22b

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H3-40.cdr	14,190.208	ECR	6 December 94			

P.O.S. Coordinates: N 5590 E 12,900

Equipment Mobile B-61

Land Surface Elevation 315 feet Date 12/22/94



Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth (feet)
				80
			50/6"	
				85
MD	20.4	103	50/2"	
				90
			50/2"	
				95
			50/4"	
				100
				105
				110
				115
				120

Becomes saturated.

DARK GRAY GRAVEL (GW) very dense, saturated; fine to coarse grained gravel, with some sand and silt (Advance Outwash - Unit 3).

Groundwater encountered at 82 feet during drilling.

Perched groundwater encountered at 33 feet during drilling.

Boring converted into piezometer on 12/22/94.

AGI TECHNOLOGIES

Log of Area 3 Boring 7 (80-102.5') A3-B7-94

HNTB/Runway Borrow Source Study

SeaTac, Washington

PLATE A22c

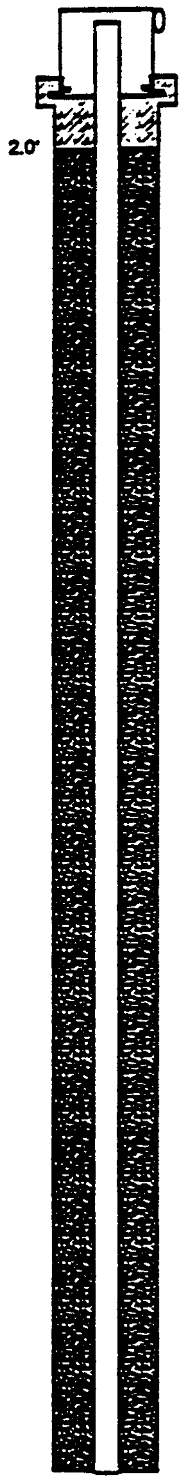
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H3-80.ccr	14,190.208	ECR	6 December 94			

AR 052254

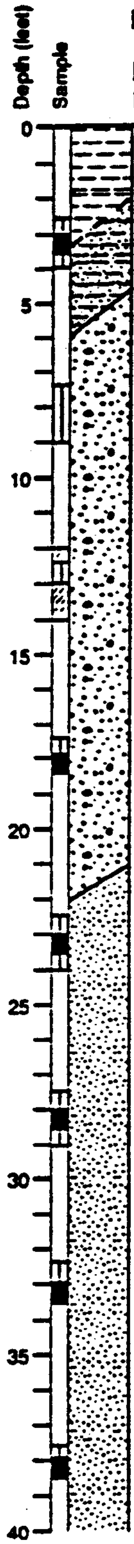
P.O.S. Coordinates: N 6465 E 12,070

Equipment Mobile B-61

Land Surface Elevation 395 feet Date 12/21/94



Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
MD,SA	20.5	85	9
			67
SA, COMP			50/6"
SA	7.5		50/5"
MD	7.1	11.5	67
			50/5"
MD,SA	6.3	106	50/6"
			50/5"



DARK BROWN SILT (ML) medium stiff, moist; with some sand and organics (Alluvium).

REDDISH BROWN SILTY SAND (SM) loose, moist; fine to coarse grained, with gravel (Alluvium).

GRAY SAND (SW-SM) very dense, moist; fine to coarse grained, with gravel and silt (Advance Outwash - Unit 1).

GRAY SAND (SP) very dense, moist; fine grained, with trace silt (Advance Outwash - Unit 1).

AGI TECHNOLOGIES

Log of Area 4 Boring 1 (0-40') A4-BI-94

HNTB/Runway Borrow Source Study
SeaTac, Washington

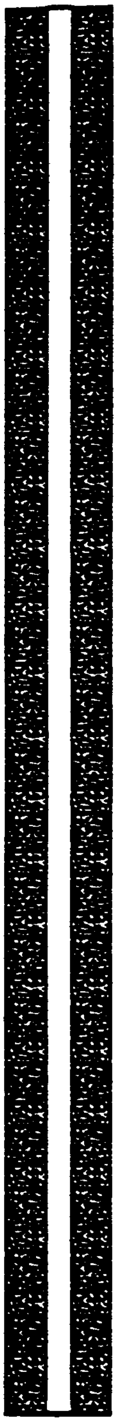
PLATE **A23a**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H4mw.cdr	14,190.208	ECR	6 December 94			

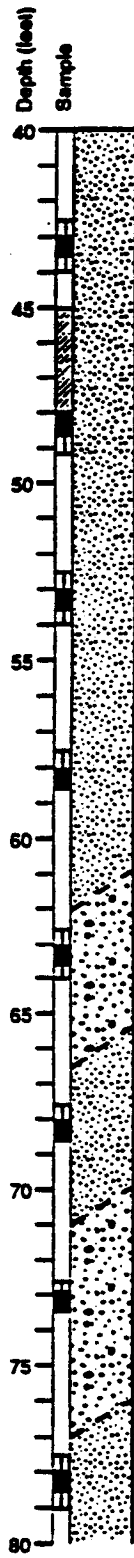
P.O.S. Coordinates: N 6465 E 12,070

Equipment Mobile B-61

Land Surface Elevation 395 feet Date 12/21/94



Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
MD	5.1	105	84
COMP			
			50/5"
MD	10.2	112	50/5"
			50/5"
MD,SA	8.2	115	34
			50/5"
			50/3"
MD,SA	5.6	109	50/4"



GRAY SAND (SW) very dense, moist; fine to coarse grained, with silt and a trace of fine gravel (Advance Outwash - Unit 1).

GRAY SAND (SP) very dense, moist; fine grained (Advance Outwash - Unit 1).

GRAY SAND (SW) very dense, wet; fine to coarse grained, with fine gravel (Advance Outwash - Unit 1).

GRAY SAND (SP-SM) very dense, wet; fine to medium grained, with trace fine gravel and silt (Advance Outwash - Unit 1).

AGI TECHNOLOGIES

Log of Area 4 Boring 1 (40-80') A4-B1-94
HNTB/Runway Borrow Source Study
SeaTac, Washington

PLATE **A23b**

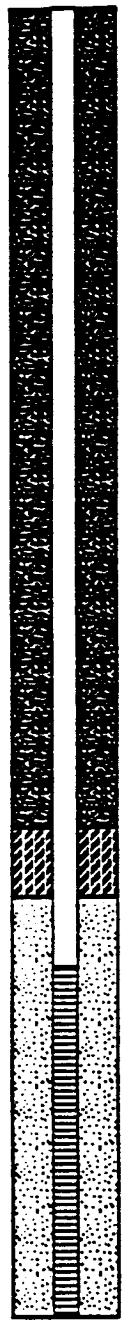
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H4-40.cdr	14,190.208	ECR	6 December 94			

AR 052256

P.O.S. Coordinates: N 6465 E 12,070

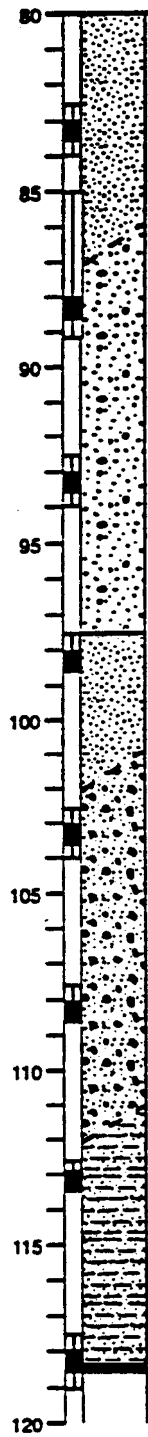
Equipment Mobile B-61

Land Surface Elevation 395 feet Date 12/21/94



Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
			50/5"
			50/3"
MD,SA	6.8	110	50/5"
			50/6"
MD	11.0	127	50/6"
			50/3"
			50/6"
			50/3"

Depth (feet) / Sample



GRAY SAND (SW) very dense, wet; fine to coarse grained, with gravel and a trace of silt (Advance Outwash - Unit 1).

GRAY SAND (SP) very dense, saturated, fine to medium grained, with silt interbeds (Advance Outwash - Unit 1).

BROWN GRAVEL (GP-GM) very dense, saturated; fine to coarse grained, with sand and silt (Advance Outwash - Unit 3).

BROWN SILTY SAND (SM) very dense, saturated; fine grained (Advance Outwash - Unit 2).

Color changes to dark gray.

Groundwater encountered at 98 feet during drilling.
Boring converted into piezometer on 12/22/94.

AGI TECHNOLOGIES

Log of Area 4 Boring 1 (80-118.3') A4-B1-94
HNTB/Runway Borrow Source Study
SeaTac, Washington

PLATE **A23c**

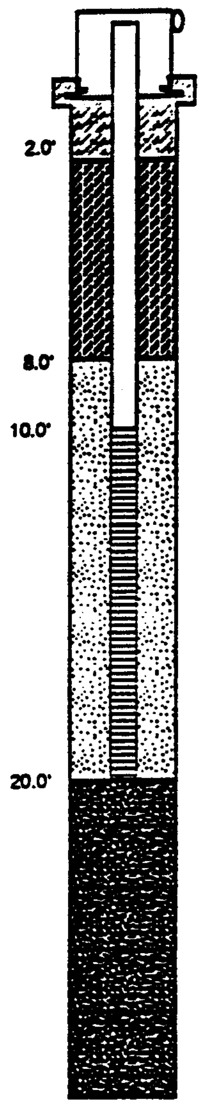
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H4-30.cdr	14,190.208	ECR	6 December 94			

AR 052257

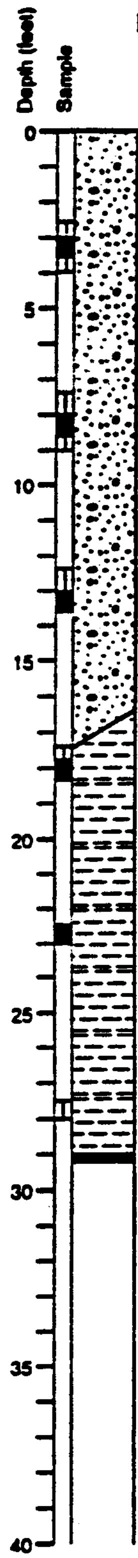
P.O.S. Coordinates: N 6790 E 11,680

Equipment Mobile B-61

Land Surface Elevation 343 feet Date 12/5/94



Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
MD,SA	6.2	119	41
			50/3"
MD,SA	13.3	119	50/6"
			44
			50
MD,PL, LL	25.1	103	49



BROWN SAND (SW) dense, dry; fine to coarse grained, with gravel and a trace of silt (Advance Outwash - Unit 1).

Becomes very dense, saturated.

GRAY SILT (ML) hard, moist (Pre-Vashon Drift).

Groundwater encountered at 6.5 feet during drilling.

Boring converted into piezometer on 12/5/94.

AGI TECHNOLOGIES

Log of Area 4 Boring 2 A4-B2-94

HNTB/Runway Borrow Source Study

SeaTac, Washington

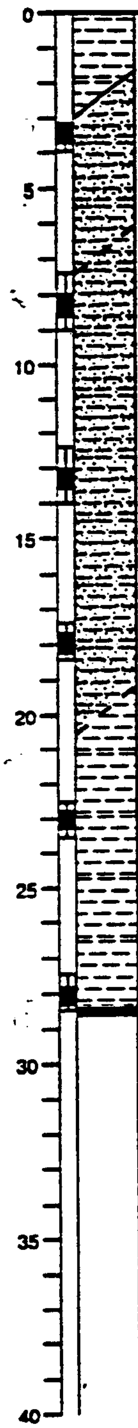
PLATE **A24**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H4mw.cdr	14,190.208	ECR	6 December 94			

P.O.S. Coordinates: N 6890 E 13,015

Equipment Mobile B-61

Land Surface Elevation 296 feet Date 12/5/94



Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Description
				DARK BROWN SANDY SILT (ML) medium dense, wet; with organic material (Weathered Till).
MD	15.7	94	10	BROWN SILTY SAND (SM) medium dense, moist; fine to medium grained, mottled, with gravel and organic material (Weathered Till).
			40	GRAY SILTY SAND (SM) dense, moist; fine to coarse grained, with gravel (Till - Unit 1).
MD,SA	9.4	134	96	Becomes very dense, wet.
			50/6"	
				GRAY CLAYEY SILT (ML) very hard, moist; laminated (Pre-Vashon Drift).
MD,PL, LL	7.7	110	50/6"	
			50/4"	

Groundwater not encountered during drilling.

Boring backfilled with bentonite and cuttings on 12/5/94.

AGI TECHNOLOGIES

Log of Area 4 Boring 3 A4-B3-94

HNTB/Runway Borrow Source Study

SeaTac, Washington

PLATE **A25**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H4mw.cdr	14.190.208	ECR	6 December 94			

Appendix B

APPENDIX B
LABORATORY TESTING PROGRAM

APPENDIX B
LABORATORY TESTING PROGRAM

Hart Crowser completed a laboratory testing program to evaluate the basic index and geotechnical engineering properties of the site soils. Disturbed bag samples from the drill rig cyclone and jar samples from penetration tests were selected for laboratory testing with the following items in mind:

- Suitability of soils for use as wet weather fill;
- Soils representative of the geologic unit;
- Consistency within a geologic unit; and
- Sampling soils generally within the depth of the proposed excavation (based on existing information).

The tests performed and the procedures followed are outlined below.

Soil Classification

Field Observation and Laboratory Analysis. Soil samples from the explorations were visually classified in the field and then taken to our laboratory where the classifications were verified in a relatively controlled laboratory environment. Field and laboratory observations include density/consistency, moisture condition, and grain size and plasticity estimates.

The classifications of selected samples were checked by laboratory tests such as grain size analyses and 200 wash. Classifications were made in general accordance with the Unified Soil Classification (USC) System, ASTM D 2487, as presented on Figure B-1.

Water Content Determinations

Water contents were determined for specific samples recovered in the explorations in general accordance with ASTM D 2216, as soon as possible following their arrival in our laboratory. Water contents were not determined for very small samples nor samples where large gravel contents would result in values considered unrepresentative. The results of these tests are plotted at the respective sample depth on the exploration logs. In addition, water contents are routinely determined for samples subjected to other testing. These are also presented on the exploration logs.

Water contents were compared for samples of cuttings from the drill cyclone bag samples with water contents obtained from conventional SPT split-spoon samples, as shown on the drill logs. In some, but not all, cases it appeared that the cuttings samples were slightly drier than the SPT samples, as might be expected. Superficially it appears that the more silty samples typically exhibited less drying due to drill action compared to coarser-grained samples. In general we recommend that moisture content of SPT samples be considered more representative of *in situ* conditions compared to those of cuttings samples.

Grain Size Analysis (GS)

Grain size distribution was analyzed on representative samples in general accordance with ASTM D 422. Wet sieve analysis was used to determine the size distribution greater than the U.S. No. 200 mesh sieve. The size distribution for particles smaller than the No. 200 mesh sieve was determined by the hydrometer method for a selected number of samples. The results of the tests are presented as curves on Figures B-2 through B-7 plotting percent finer by weight versus grain size.

200-Wash (GS_{200})

Several samples were subjected to a modified grain size classification known as a 200-wash. The portion of individual samples passing the 3/4-inch sieve was "washed" through the No. 200 mesh sieve to determine the relative percentages of coarse- and fine-grained material in the samples. The tests were performed in general accordance with ASTM D 1140. The results are presented on the boring logs.

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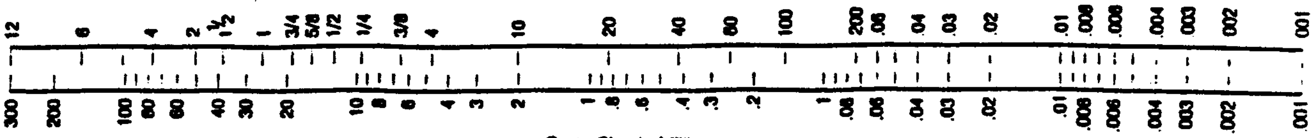
Unified Soil Classification (USC) System

Soil Grain Size

Size of Opening in Inches	Number of Mesh per Inch (US Standard)	Grain Size in Millimetres



Grain Size in Millimetres

COBBLES	GRAVEL	SAND	SILT and CLAY
Coarse-Grained Soils			Fine-Grained Soils

Coarse-Grained Soils

G W	G P	G M	G C	S W	S P	S M	S C
Clean GRAVEL <5% fines		* GRAVEL with >12% fines		Clean SAND <5% fines		* SAND with >12% fines	
GRAVEL >50% coarse fraction larger than No. 4				SAND >50% coarse fraction smaller than No. 4			
Coarse-Grained Soils >50% larger than No. 200 sieve							

G W and S W $\left(\frac{D_{60}}{D_{10}}\right)$ >4 for G W, >6 for S W & $1 \leq \left(\frac{(D_{30})^2}{D_{10} \times D_{60}}\right) \leq 3$

G P and S P Clean GRAVEL or SAND not meeting requirements for G W and S W

G M and S M Atterberg limits below A line with PI <4

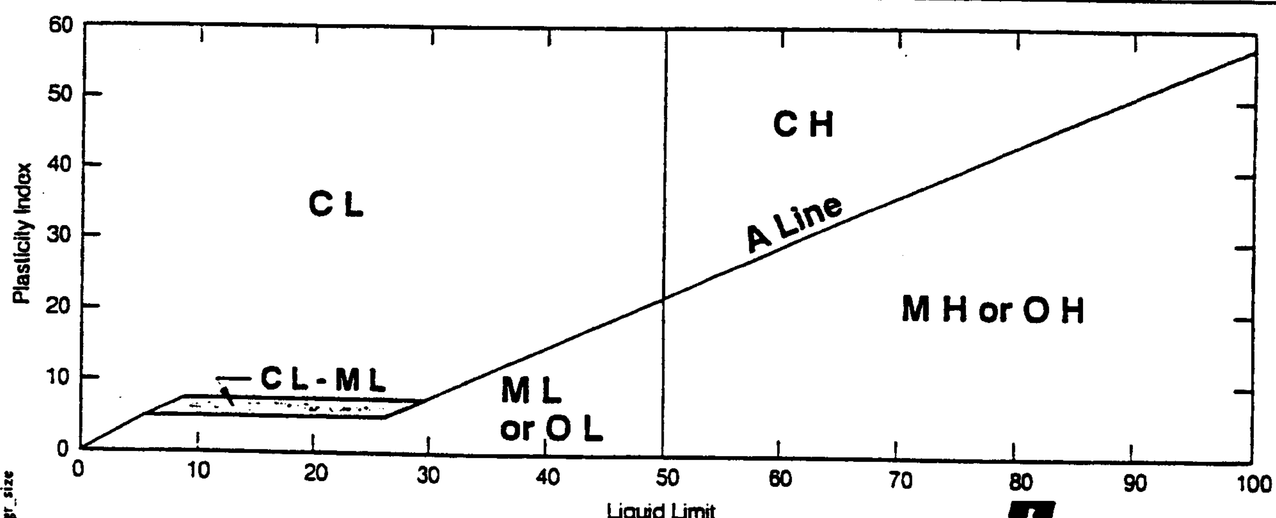
G C and S C Atterberg limits above A Line with PI >7

* Coarse-grained soils with percentage of fines between 5 and 12 are considered borderline cases required use of dual symbols.

D_{10}, D_{30}, and D_{60} are the particles diameter of which 10, 30, and 60 percent, respectively, of the soil weight are finer.

Fine-Grained Soils

M L	C L	O L	M H	C H	O H	Pt
SILT	CLAY	Organic	SILT	CLAY	Organic	Highly Organic Soils
Soils with Liquid Limit <50%			Soils with Liquid Limit >50%			
Fine-Grained Soils >50% smaller than No. 200 sieve						



Core\forms\gr_size

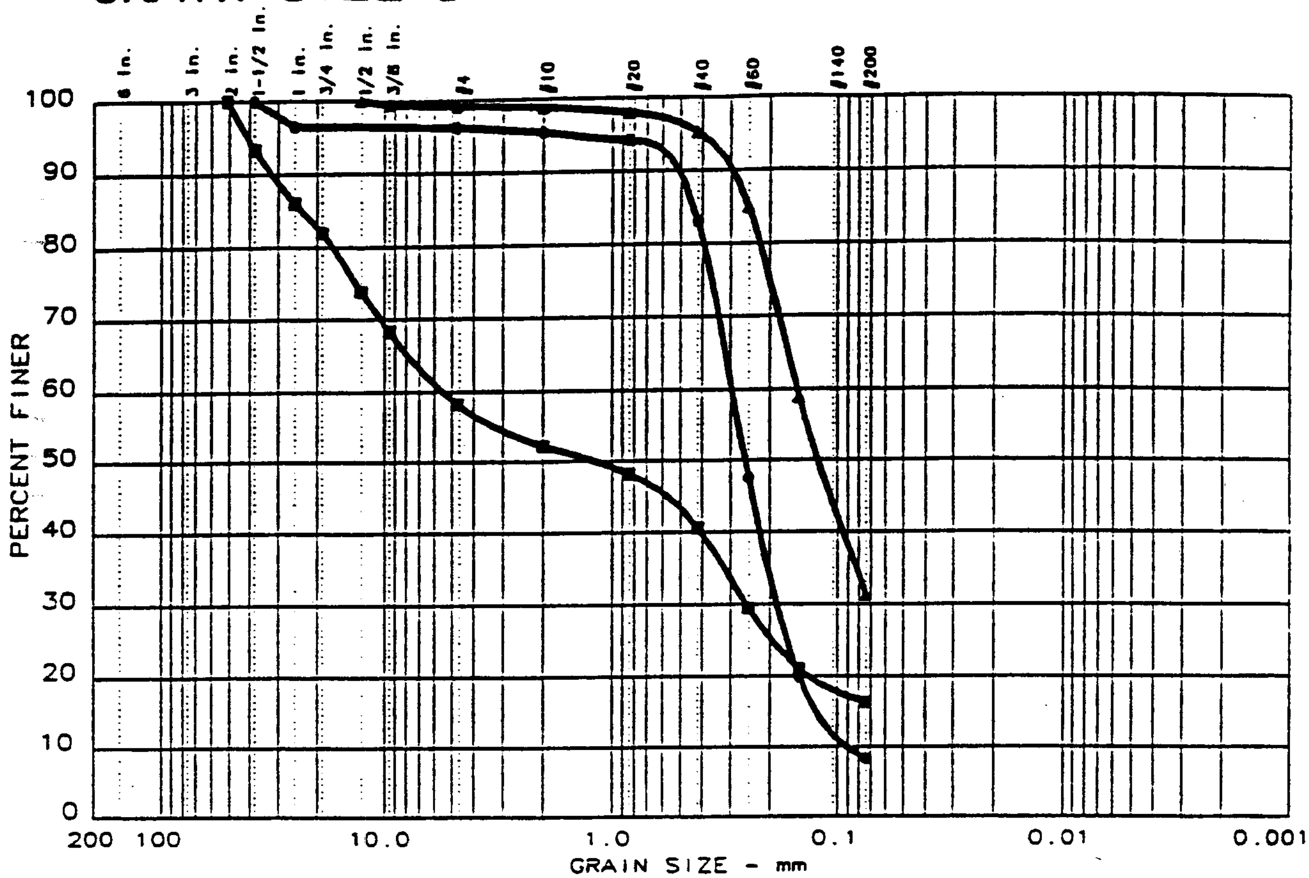
HARTCROWSER

J-4978-02 8/99

Figure B-1

AR 052264

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	3.6	88.1	8.3	
▲	0.0	0.8	67.9	31.3	
■	0.0	41.7	42.1	16.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.44	0.30	0.26	0.188	0.1255	0.0909	1.31	3.2
▲			0.25	0.15	0.12					
■			23.17	5.50	1.17	0.254				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Slightly silty SAND	SP-SM	6%
▲ Very silty SAND	SM	6%
■ Silty, very gravelly SAND	SM	11%

Remarks:

Project: 3rd Runway

● Location: A3-B8-98, S-1, Depth 5 Feet

▲ Location: A3-B8-98, S-7, Depth 30 Feet

■ Location: A3-B8-98, S-13, Depth 60 Feet

AR 052265

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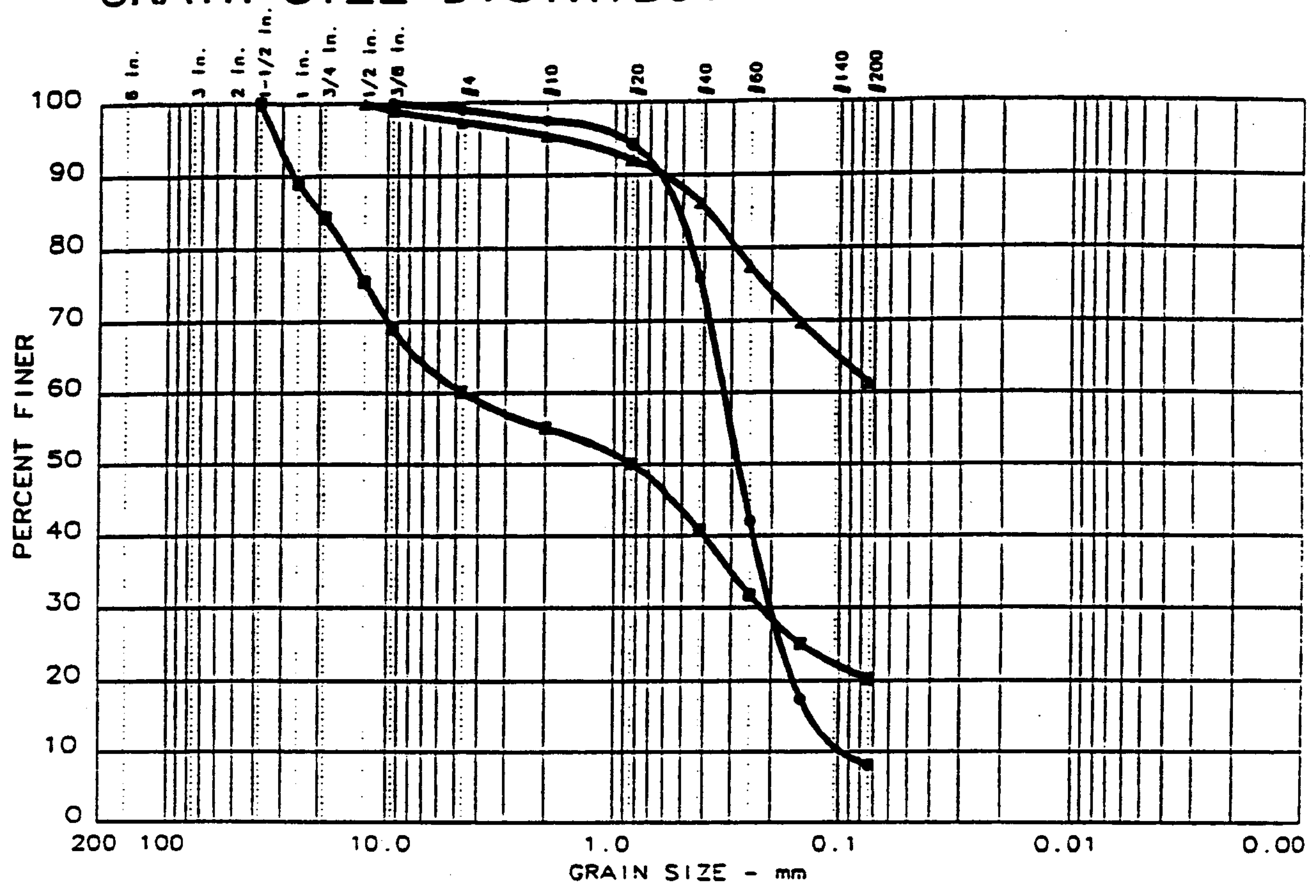
J-4978-02 5/14/98

Figure B-2

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	1.0	90.9	8.1	
▲	0.0	2.7	36.0	61.3	
■	0.0	39.8	40.0	20.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.52	0.33	0.28	0.203	0.1354	0.0981	1.29	3.3
▲			0.38							
■			19.72	4.62	0.83	0.221				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Slightly silty SAND	SP-SM	11%
▲ Very sandy SILT	ML	26%
■ Silty, very gravelly SAND	SM	8%

Remarks:

Project: 3rd Runway

- ● Location: A3-B9-98, S-1A, Depth 5 Feet
- ▲ Location: A3-B9-98, S-6, Depth 28 Feet
- ■ Location: A3-B9-98, S-8, Depth 35 Feet

AR 052266

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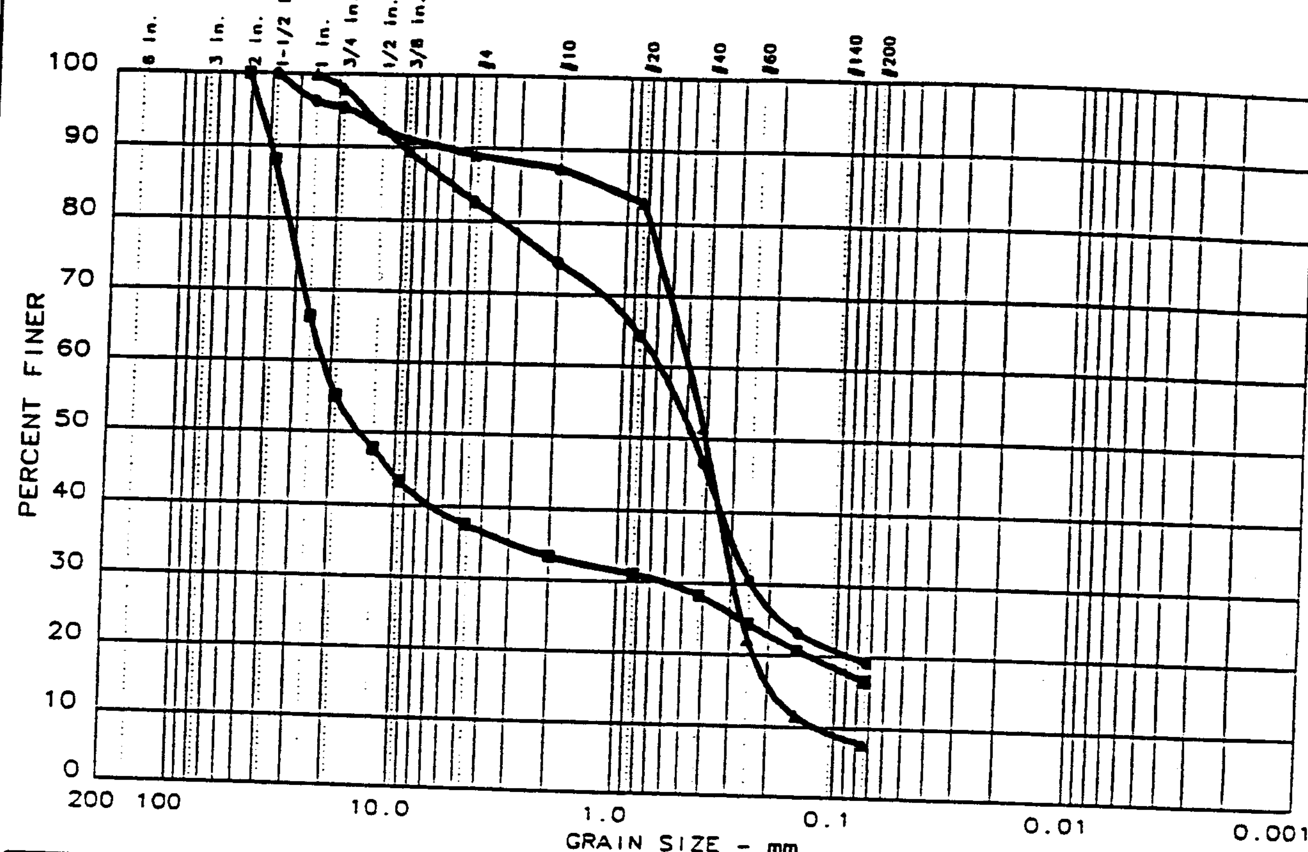
Figure B-3

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	17.3	63.6	19.1	
▲	0.0	11.0	81.3	7.7	
■	0.0	62.4	21.0	16.6	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			5.96	0.67	0.46	0.242				
▲			1.24	0.50	0.41	0.293	0.1936	0.1180	1.47	4.2
■			35.77	21.98	14.69	0.578				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Gravelly, silty SAND	SM	11%
▲ Slightly silty, slightly gravelly SAND	SP-SM	11%
■ Silty, sandy GRAVEL	GM	6%

Remarks:

Project: 3rd Runway

- ● Location: A3-B10-98, S-2, Depth 10 Feet
- ▲ Location: A3-B10-98, S-5A, Depth 25 Feet
- ■ Location: A3-B10-98, S-13A, Depth 65

AR 052267

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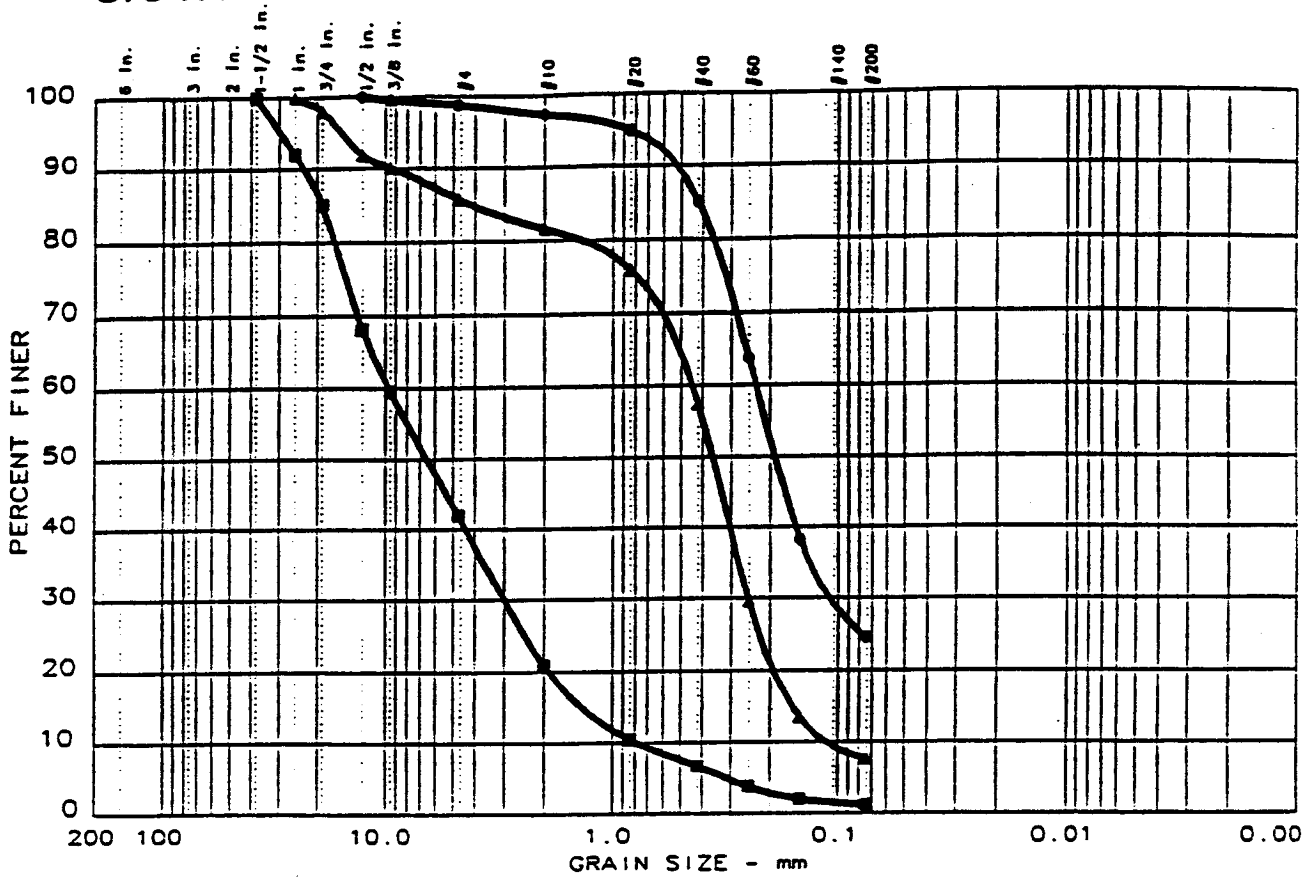
Figure 9-4

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	1.2	74.2	24.6	
▲	0.0	14.3	78.1	7.6	
■	0.0	58.0	40.8	1.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.42	0.23	0.19	0.111				
▲			4.22	0.44	0.36	0.251	0.1603	0.1135	1.25	3.9
■			19.03	9.65	6.52	2.982	1.3630	0.7754	1.19	12.4

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Silty SAND	SM	18%
▲ Slightly silty, gravelly SAND	SP-SM	16%
■ Very sandy GRAVEL	GW	10%

Remarks:

Project: 3rd Runway

- ● Location: A3-B11-98, S-46A, Depth 95 Feet
- ▲ Location: A3-B12-98, S-11A, Depth 25 Feet
- ■ Location: A3-B12-98, S-12, Depth 27 Feet

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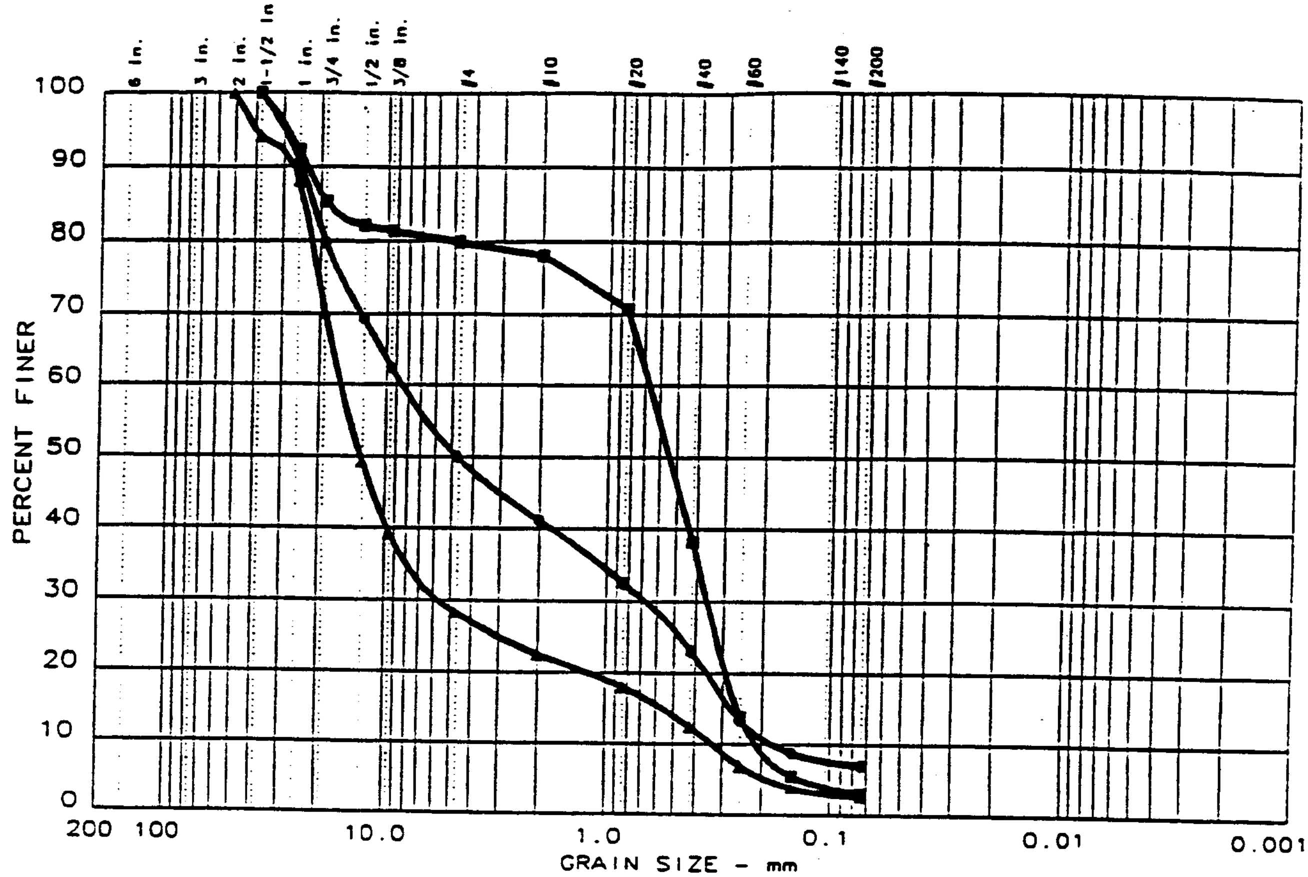
Figure 8-5

AR 052268

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	49.9	42.9	7.2	
▲	0.0	71.7	25.6	2.7	
■	0.0	20.1	76.7	3.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			21.83	8.49	4.72	0.667	0.2748	0.1816	0.29	46.8
▲			23.88	16.01	12.87	5.682	0.5553	0.3308	6.10	48.4
■			18.62	0.67	0.54	0.361	0.2585	0.2150	0.91	3.1

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Slightly silty, very sandy GRAVEL	GP-GM	8%
▲ Sandy GRAVEL	GP	5%
■ Gravelly SAND	SP	2%

Remarks:

Project: 3rd Runway
- ● Location: A4-B4-98, S-7, Depth 13 Feet
- ▲ Location: A4-B4-98, S-33A, Depth 66 Feet
- ■ Location: A4-B5-98, S-21A, Depth 45 Feet

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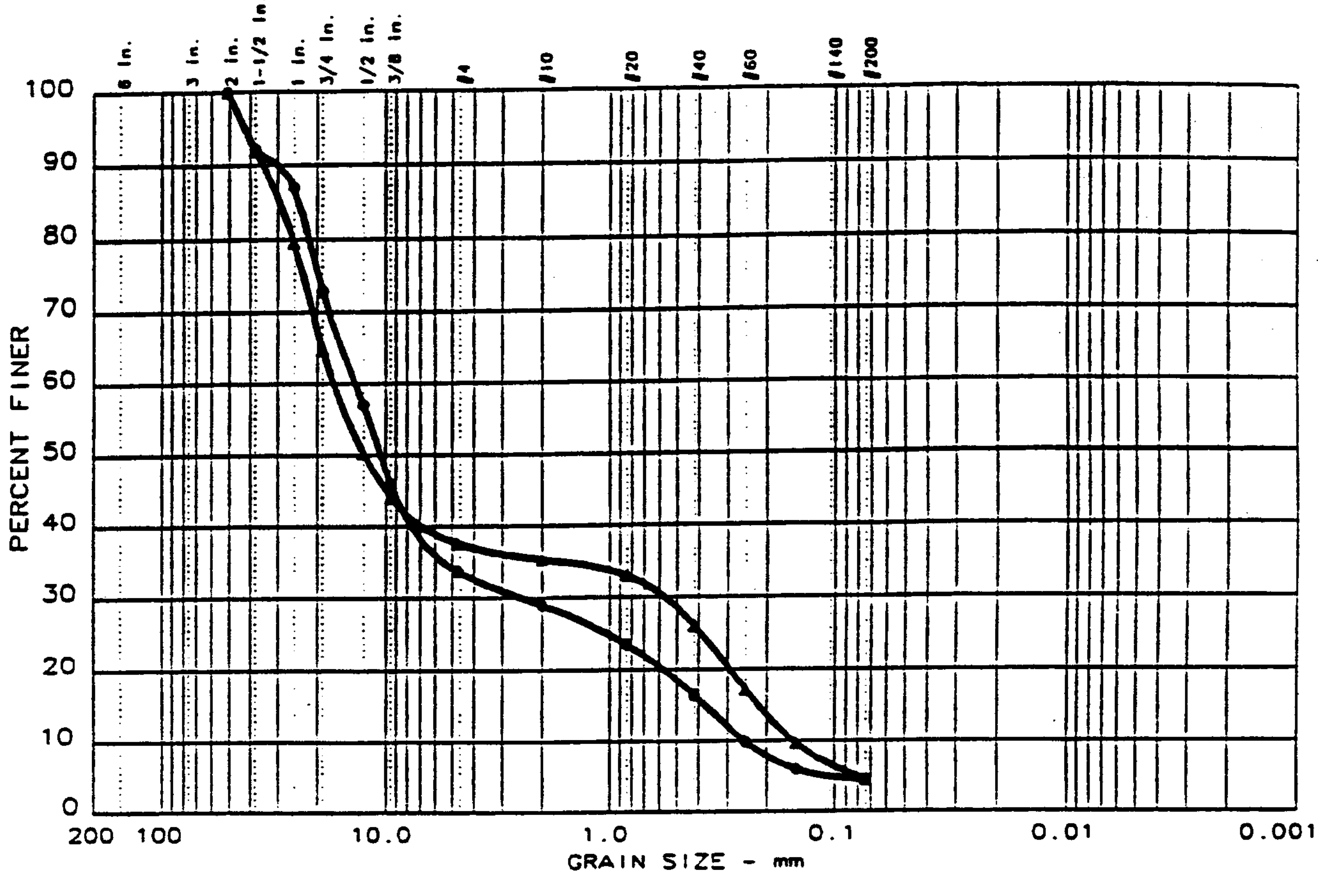
J-4978-02 5/21/98

Figure B-6

AR 052269

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	66.2	29.4	4.4	
▲	0.0	62.3	33.3	4.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			24.13	13.72	10.63	2.380	0.3728	0.2521	1.64	54.5
▲			29.17	17.12	12.55	0.560	0.2205	0.1526	0.12	112.2

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Sandy GRAVEL	GW	6%
▲ Very sandy GRAVEL	GP	4%

Remarks:

Project: 3rd Runway

● Location: A4-B6-98, S-12A, Depth 25 Feet

▲ Location: A4-B6-98, S-35, Depth 35 Feet

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J-4978-02 5/21/98

Figure B-7

Appendix C

APPENDIX C
BORROW AREA 3 PERCHED WATER-BEARING ZONE
SLUG TEST ANALYSIS

APPENDIX C
BORROW AREA 3 PERCHED WATER-BEARING ZONE
SLUG TEST ANALYSIS

This appendix documents the process Hart Crowser uses in conducting slug tests for purposes of evaluating the perched water-bearing zone in Borrow Area 3. The discussion addresses the Hydraulic Conductivity Testing (Slug Testing) conducted in four wells.

Hydraulic Conductivity Testing (Slug Testing)

Hydraulic conductivity testing was performed using the slug test method for explorations A3-13-99 through A3-17-99. In this method, the water level (hydraulic head) in the well is rapidly raised or lowered, and the rate at which it returns to its initial state is used to calculate hydraulic conductivity for the formation surrounding the well screen. Data were collected using an Aquistar data logger in conjunction with a Instrumentation Northwest PSI9000 pressure transducer. Tests were conducted as follows:

A transducer was set in the well and allowed to equilibrate with ambient conditions, and background water level data were collected.

One or two slug rods (solid PVC rods) were rapidly introduced into the well (causing a near-instantaneous rise in water level), to initiate a falling head test. Water level data were collected in logarithmically increasing time increments using the data logger and transducer. For wells where depth to water was small, a falling head test was not attempted.

Water level in the well was allowed to re-equilibrate.

The slug rod or rods were rapidly pulled from the well (causing a near-instantaneous drop in water level) to initiate a rising head test. Water level data were collected in logarithmically increasing time increments using the data logger and transducer.

Most of the wells responded reasonably quickly, and therefore multiple slug tests were performed for most wells.

Data were pre-processed as described in Butler (1998), and hydraulic conductivity values were estimated using the method of Bouwer and Rice (1976) for unconfined aquifers. The estimated values are reported in this appendix as Table C-1. Figures C-1 through C-4 include rising/falling head curves showing assumed parameters used to estimate hydraulic conductivity values.

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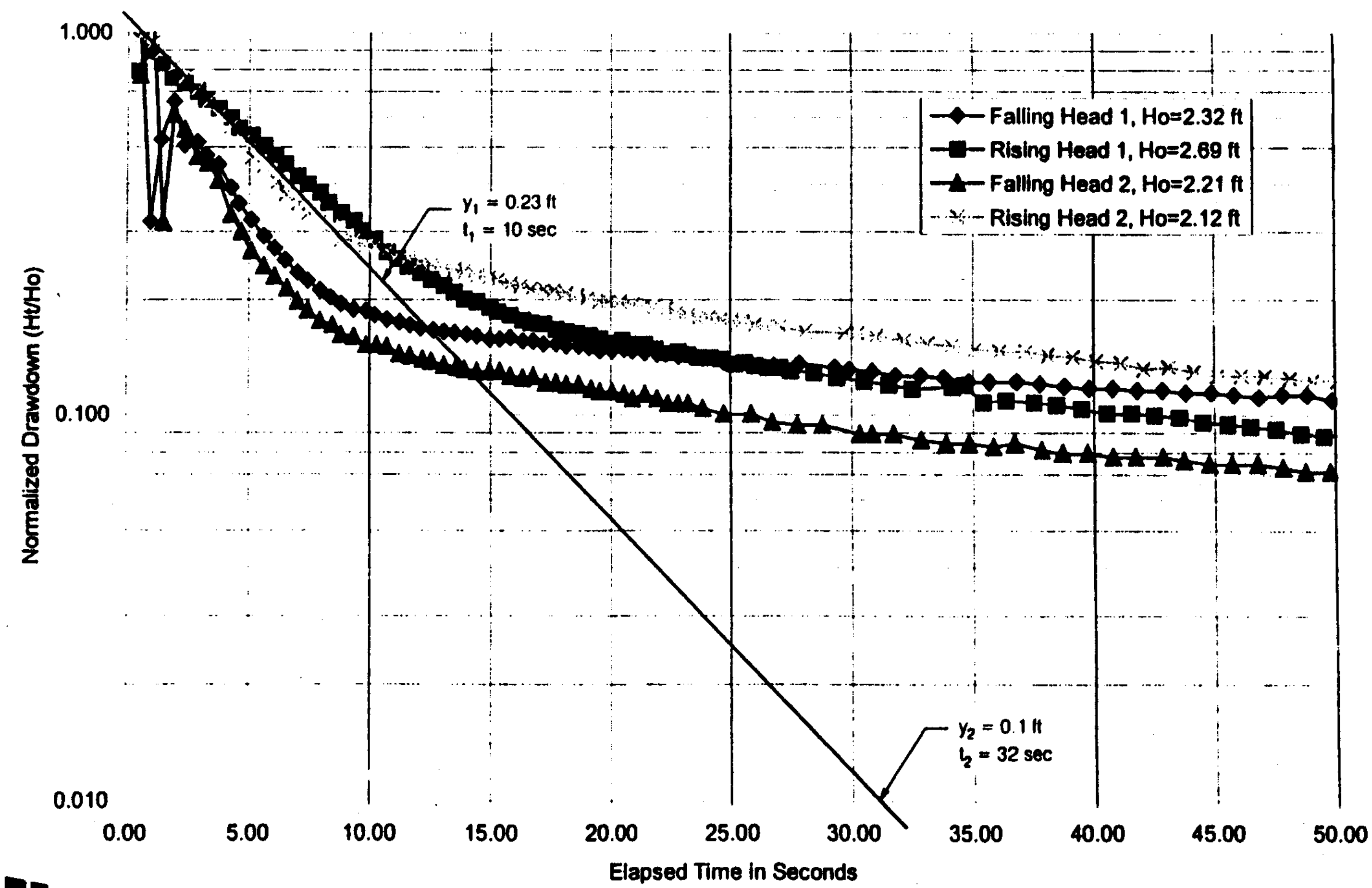
Table C-1 - Hydraulic Conductivity Calculations for Wells in Unconfined Aquifer
Proposed Borrow Area 3

	A3-B13-99	A3-B15-99	A3-B16-99	A3-B17-99
Well Depth in Feet	**58**	**24**	**58**	**21.5**
Screen Length in Feet	**5**	**5**	**5**	**5**
Depth to Screen in Feet	**53**	**19**	**53**	**16.5**
Depth to Aquitard in Feet	**56.5**	**23**	**59**	**21.75**
Depth to Water in Feet	**53.04**	**18.28**	**47.04**	**17.6**
Depth to Sandpack in Feet	**51**	**17**	**50**	**14**
H in Feet	3.46	4.72	11.96	4.15
n	**0.3**	**0.3**	**0.3**	**0.3**
r_c in Feet	**0.083**	**0.083**	**0.167**	**0.083**
r_w in Feet	**0.333**	**0.333**	**0.500**	**0.333**
r_eff in Feet	0.195	0.195	0.167	0.195
L_e in Feet	4.96	5	5	3.9
L_w in Feet	4.96	5.72	10.96	3.9
y1 in Feet	**0.23**	**0.07**	**0.6**	**0.33**
t1 in Seconds	**10**	**20**	**0**	**0**
y2 in Feet	**0.01**	**0.001**	**0.001**	**0.062**
t2 in Seconds	**32**	**65**	**43.5**	**2500**
L_e/r_w	14.88	15	10	11.7
A	2.0	2.0	1.8	1.9
B	0.3	0.3	0.3	0.3
C	1.4	1.4	1.2	1.3
Fully Penetrating Well				
ln(R_e/r_w)	2.001	2.088	2.106	1.804
K in cm/s	3.3E-02	2.3E-02	2.6E-02	1.8E-04
	F-M SAND	Fine SAND	Med. SAND	Fine SAND

Notes:
Bold values to be entered manually.
A, B, and C coefficients are calculated using regression equations of Van Rooy, 1988.

Log of Normalized Drawdown vs. Time for A3-B13-99



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Area3slug.xls

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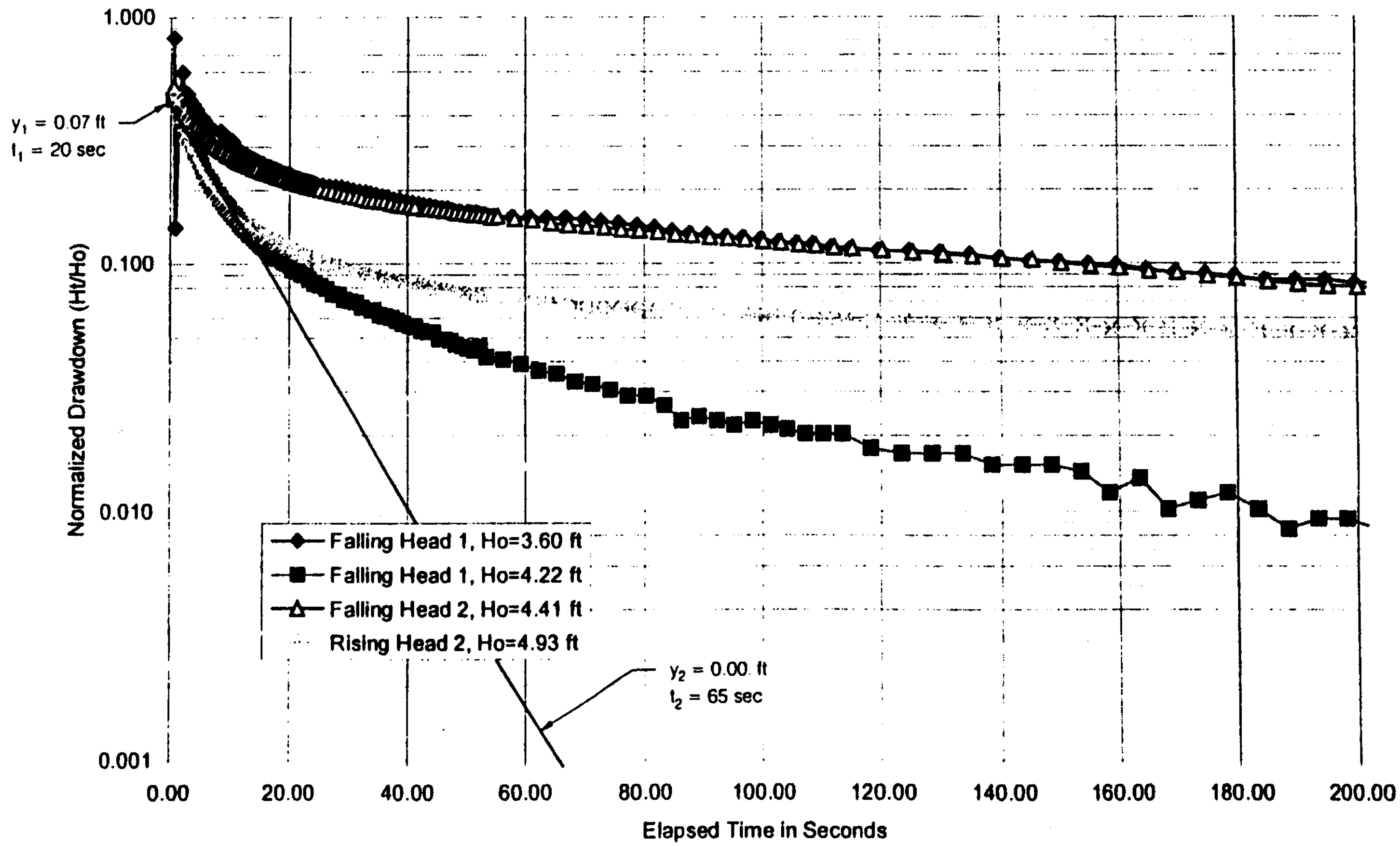
J-4978-02 8/99
Figure C-1

AR 052276

Log of Normalized Drawdown vs. Time for A3-B15-99



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J-4978-02 8/99

Figure C-2

AR 052277

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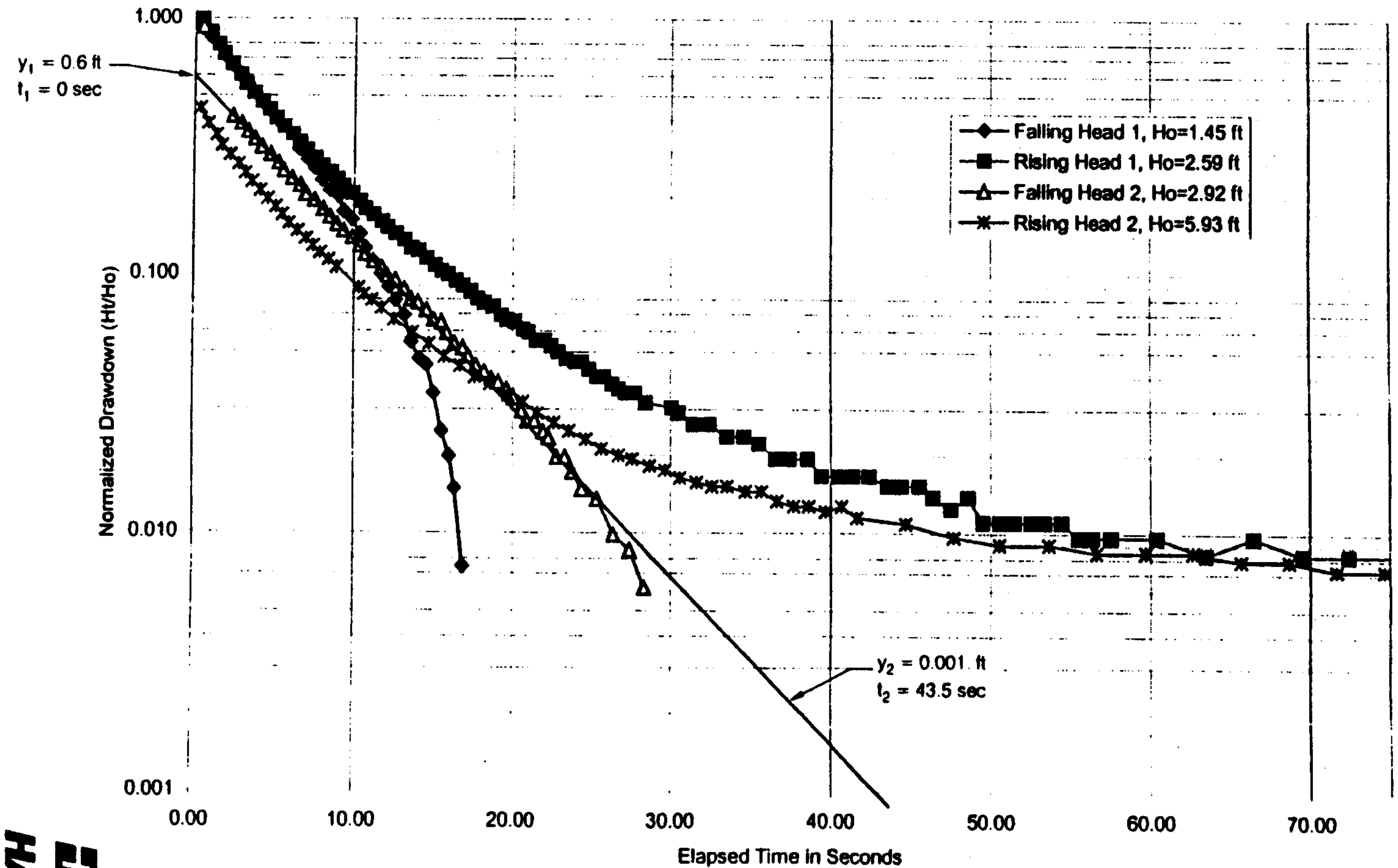
Area3slug xls

Log of Normalized Drawdown vs. Time for A3-B16-99



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J-4978-02 8/99

Figure C-3

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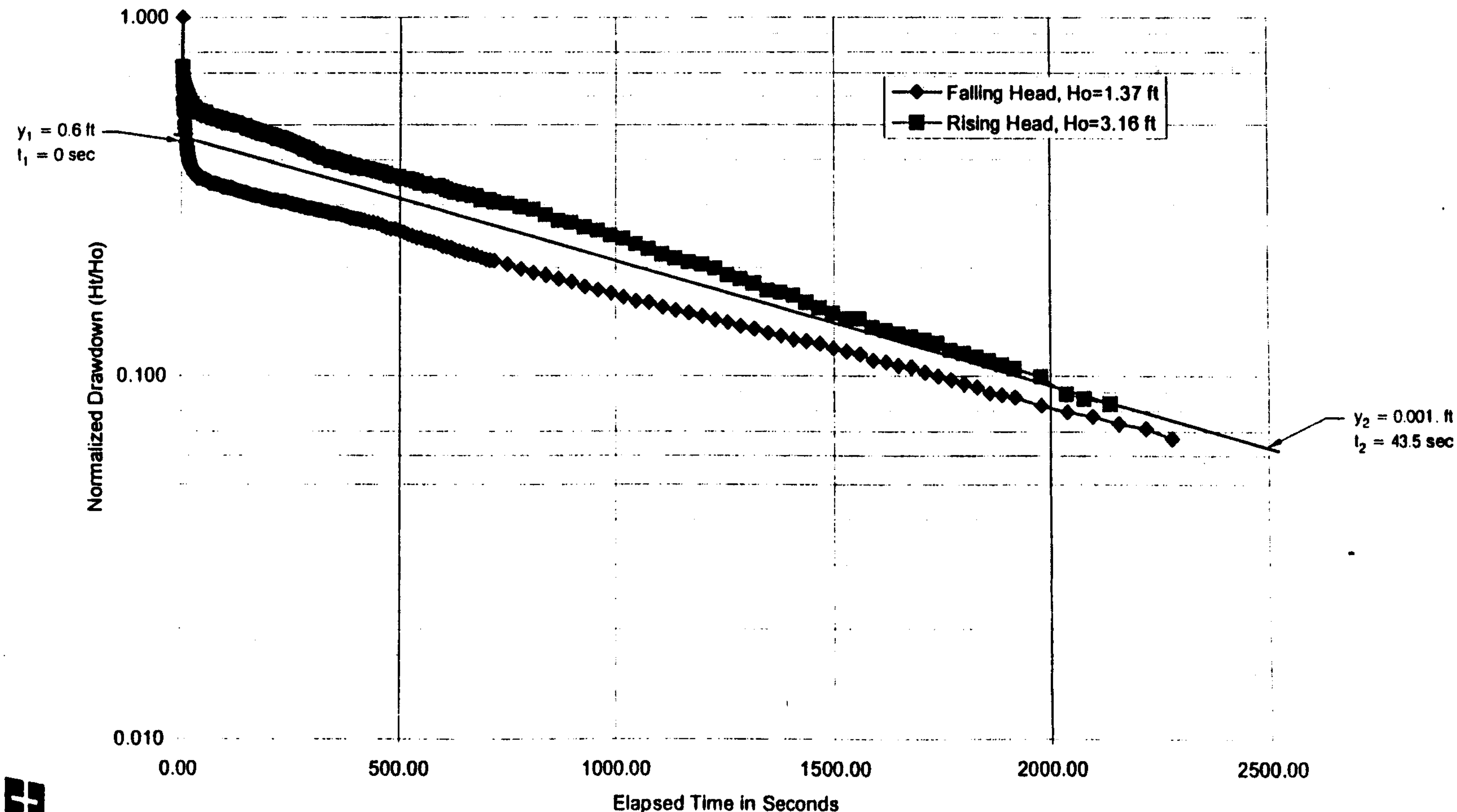
Area3slug xls

Log of Normalized Drawdown vs. Time for A3-B17-99



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Area3slug.xls

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J-4978-02 8/99
Figure C-4

AR 052279

Port of Seattle

October 2, 2001

Ms. Ann Kenny
Washington Department of Ecology
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

Re: Seattle-Tacoma International Airport
Washington Department of Ecology
§ 401 Water Quality Certification
Order #1996-4-02325
Condition F.1

Dear Ms. Kenny:

The Port of Seattle presents the attached documents to the Washington Department of Ecology in satisfaction of the above noted Order, Condition F.1. Condition F.1 requires, among other things, that the Port prepare "proposed construction BMPs to prevent interception of contaminated ground water by utility corridors and a plan to monitor potential contaminant transport to soil and ground water via subsurface utility lines".

Please review the two attached documents, *Proposed Construction BMPs To Prevent Interception of Contaminated Ground Water by Utility Corridors*, and *Plan to Monitor Potential Contaminant Transport to Soil and Ground Water via Subsurface Utility Lines*. If you have any questions or comments, please feel free to refer comments and questions to Paul Agid, 206-439-6604, agid.p@portseattle.org.

Sincerely,

Elizabeth Leavitt
Manager, Aviation Environmental Programs

xc: Agid, Newlon

Seattle-Tacoma
International Airport
P.O. Box 68727
Seattle, WA 98168 U.S.A.
TELEX 703433
FAX (206) 431-5912

Seattle Tacoma International Airport
§401 Water Quality Certification #1996-4-02325
Condition F.1

Proposed Construction BMPs
To Prevent Interception of Contaminated Ground Water by Utility Corridors

In accordance with the Washington State Department of Ecology (Ecology) Water Quality Certification for U.S. Army Corps of Engineers Public Notice 1996-4-02325, Condition F. 1, the Port of Seattle (Port) submits this proposal for Best Management Practices (BMPs) for prevention of migration of contaminated ground water via subsurface utility lines at the Seattle-Tacoma International Airport (STIA). A draft of this BMP proposal is due to Ecology no later than September 30, 2001.

Best Management Practices for prevention of migration of contaminated ground water by newly constructed utility corridors will consist of, and will be implemented by modification of standard utility construction design guidelines and specifications. The following construction techniques will be specified for future construction of subsurface utilities below paved areas in the principal aviation operations and maintenance area (AOMA) of STIA. Subject subsurface utilities include, but are not limited to, electrical and communications ductbanks, and pipelines for carrying fuel, water, sanitary sewage, stormwater, and Industrial Waste System drainage.

1. Standard construction specifications will be developed for application to all construction projects located in areas within the AOMA where contaminated ground water is present at the designed construction depth.

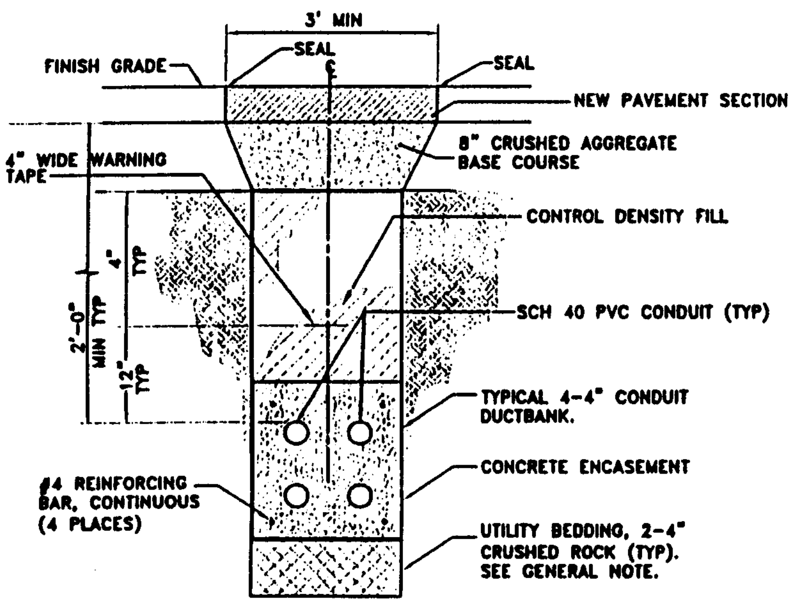
2. The standard specification will include a requirement for the contractor to dewater utility trenches and other construction excavations that contain contaminated ground water, and to appropriately manage the water removed by disposal to an appropriately licensed facility or similar option.

3. The standard specification will include a requirement that utility backfill be constructed such that any ground water present at the utility depth not be transported along the utility, within the utility backfill material acting as a preferential flow pathway. The potential for transport in backfill will be minimized by use of construction techniques and/or materials that reduce utility backfill permeability. Generic engineering designs for preventing transport will be offered as examples, such as:

    a. Construct backfill by placing controlled density fill (a lean concrete mixture), or similar low permeability material, into the entire utility trench, to the bottom of the pavement base course layer.

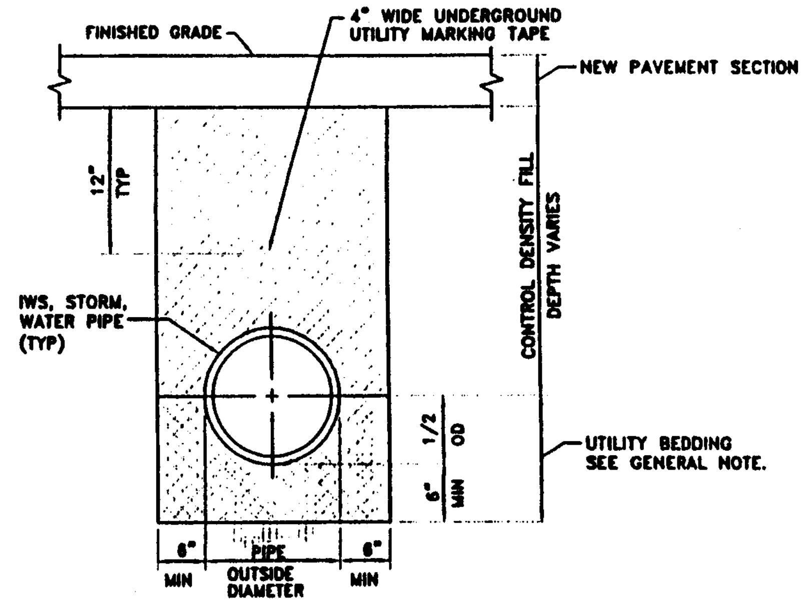
    b. Construct backfill by placing standard pipe bedding material for a maximum depth of 6" plus one-half of the diameter of the utility pipe (except as noted below); backfill the remainder of the trench to the bottom of the pavement base course layer with controlled density fill or similar low permeability material; at a maximum interval of 500' along the utility alignment, eliminate the pipe bedding material and construct full trench profile concrete dams. (Illustrations of typical utility installation construction drawings consistent with option 3.b. are provided in Figure 1.)

Project-specific construction designs will be developed consistent with the standard specifications to meet the site-specific engineering requirements of the planned construction.



TYPICAL SECTION

TYPICAL ELECTRICAL/COMMUNICATION DUCTBANK
UNDER ALL PAVED AREAS
SCALE: NTS



TYPICAL SECTION

PIPE BEDDING AND TRENCH BACKFILL
UNDER ALL PAVED AREAS
SCALE: NTS

GENERAL NOTE

UTILITY AND DUCTBANK BEDDING MATERIAL ELIMINATED AT 500' INTERVALS AND REPLACED BY FULL DEPTH CONCRETE OR CONTROL DENSITY FILL (CDF) BARRIER.

FIGURE 1

TYPICAL UTILITY SECTIONS

Seattle Tacoma International Airport
§401 Water Quality Certification #1996-4-02325
Condition F.1

Plan to Monitor Potential Contaminant Transport to Soil and Ground Water via Subsurface Utility Lines

1. INTRODUCTION AND BACKGROUND

In accordance with the Washington State Department of Ecology (Ecology) Water Quality Certification (WQC) for U.S. Army Corps of Engineers Public Notice 1996-4-02325, Condition F. 1, the Port of Seattle (Port) submits this plan to monitor for potential contaminant transport via subsurface utility lines (SULs) at the Seattle-Tacoma International Airport (STIA). A draft of this Subsurface Utility Line Monitoring Plan (SUL Monitoring Plan) is due to Ecology no later than September 30, 2001.

Ecology has requested this plan in response to concems expressed by members of the public commenting on the proposed issuance of the Water Quality Certification. The commenter assert that the permeable backfill with which subsurface utilities are sometimes constructed may act as preferred pathways for migration of contaminated ground water to the Third Runway Embankment drain layer, and from the drain layer to area surface waters.

A related document, *Draft Technical Memorandum, Analysis of Preferential Ground Water Flow Paths Relative to Proposed Third Runway, Seattle-Tacoma International Airport*, prepared by Associated Earth Sciences, Inc. dated June 19, 2001 (AESI, 2001) provides the foundation and supporting data for the development of this SUL Monitoring Plan. The SUL Monitoring Plan presents a methodology to further evaluate the nature of SULs at appropriate contaminated ground water sites and the potential that these SULs act as preferential contaminant transport pathways. The planned monitoring approach will, in a first phase, evaluate contaminated sites, associated ground water presence and flow properties, and the properties of constructed SULs. The evaluation will demonstrate the probabilities that contaminated sites could act as contaminant sources to SULs, and that SULs could act as migration pathways for those contaminants. The second phase of the monitoring program will be developed at the conclusion of the first phase evaluation. Under the second phase, the Port will develop and implement field monitoring activities that are demonstrated appropriate by results of the first phase. The second phase plan will be provided to Ecology for review and approval.

2. SITE EVALUATION

a. Ground Water in Perched Zones and in the Qva Aquifer

The SUL Monitoring Plan will focus on the potential that select contaminated sites act as sources of contamination to SULs. The typical as-built construction depth of STIA SULs is between 5 to 10 feet below ground surface. The SUL Monitoring Plan will therefore concentrate on sites that contain impacted perched ground water that could enter SULs.

Sites that contain perched ground water provide the greatest probability for SUL transport of contamination. Perched ground water occurs in isolated, discontinuous zones. Perched zones are typically found within the range of about 10 – 35 feet below ground surface. Due to the shallow depth of perched zones, perched ground water has the greatest potential to intersect SULs and move along permeable backfill material

Transport along SUL backfill of contaminated ground water in the regional Qva aquifer is improbable for several reasons:

- Ground water levels in the Qva aquifer at STIA are typically at a depth between 55 to 90 feet below ground surface, which is well below the depth of typical SULs.

- Impacted Qva ground water has been well documented and is contained within the AOMA; the maximum migration of impacted ground water is no greater than 550 feet in length from its contaminant source area.

- Ground water data generated from monitoring wells completed downgradient from known Qva impacted ground water sites are below Model Toxics Control Act (MTCA) standards and, therefore, provide a defined plume boundary.

Therefore, monitoring for contaminant transport by SULs in the Qva aquifer is not planned.

b. SUL Monitoring Plan Site Selection

Locations with contaminated ground water that may have a reasonable potential for migration by SUL are defined by the following criteria:

- Site contains perched ground water;
- Perched ground water is impacted above MTCA standards;
- SULs intersect the site footprint.

Data indicate that five sites within the STIA principal aviation operations and maintenance area (AOMA) contain impacted perched ground water that has exceeded MTCA Method A or Method B clean up standards (AESI, 2001). Sites that are impacted by previous fuel releases and contain fuel related compounds in the perched ground water system elevated above MTCA standards include the United/Continental Fuel Farm, Pan Am Avgas Tanks, Northwest Airlines Bulk Fuel Farm, and the Delta Auto Gas Cluster. In addition two areas in the AOMA, the Northwest Airlines Former Hangar Tanks and Monitoring well AGC-5 at the Delta Autogas Cluster site, represent areas that contain solvent impacted perched ground water. Each of the five sites meets the criteria listed above and are proposed for further detailed evaluation regarding shallow contaminant transport mechanisms via SULs.

3. SUBSURFACE UTILITY LINE INFORMATION

As part of previous evaluations, SULs have been identified throughout STIA and compiled on a base map (AESI, 2001). SULs that have been identified include: existing and proposed fuel lines, electric lines, Industrial Waste System (IWS) lines, sewer lines, storm drains, water lines, and Satellite Transit System (STS) and Baggage Tunnels. A number of these SULs are constructed within the boundaries of impacted perched ground water of the five sites presented in Section 2. The following additional detail will be compiled from available documentation for SULs at each of the subject sites.

a. Utility line depth – Typical utility depth is 5 to 10 feet below ground surface, with a typical maximum depth of 20 feet below ground surface. Engineering drawings will be researched to identify the as-built construction depth of each SUL intersecting the subject sites.

b. Utility line backfill composition – Information on the type of backfill material used for infill of the SUL will be compiled, if available.

c. Utility line excavation slope – The elevation of the as-built SUL excavation will be researched and information compiled, if available.

d. Construction Observations - Records will be researched to determine if observations were recorded during construction activities regarding soil or ground water contamination, saturated soil conditions, soil type, SUL condition, etc. Observations of recent capital improvement construction projects (e.g., those associated with the South Terminal Expansion Project (STEP)) will provide useful information regarding observed subsurface conditions in the vicinity of historic contaminated sites and older SULs. Available information will be summarized for each subject site.

4. GEOLOGIC/GROUND WATER CONDITIONS

Existing data and field observations of the geologic and ground water conditions at each of the subject sites will be evaluated in detail in regards to its influence on potential contaminant migration pathways. Cross sections will be developed for each site to graphically depict the relationship of geologic and ground water conditions in relationship to SULs. The analysis will focus on the following elements:

a. Fill or Native Soil Types in Relation to Utility Line – The soil conditions surrounding SULs at each site will be evaluated. Interpretations will be developed based on surrounding soil borings and well logs regarding the nature of fill or native soil types. This information will be evaluated in relation to the as-built construction depth of the SULs.

b. Slope of Till or Impervious Surface – The slope of the glacial till surface or any identified impervious surface will be evaluated. The effect of the slope of the low permeability surface will be analyzed regarding its effect on the control of perched ground water flow directions.

c. Depth to Perched Ground Water – The depth to perched ground water will be compiled from shallow monitoring well water level data and observations made on associated environmental and soil boring logs. This data will be correlated to a common vertical datum to allow for the calculation of the elevation of the ground water surface.

d. Perched Ground Water Flow Direction – For each site evaluated, the perched ground water flow directions will be determined and a contour map showing the flow directions will be developed. Typical wet season and dry season perched ground water elevations will be used to determine any change in flow direction as a result of seasonal precipitation fluctuations.

e. Relationship of Perched Ground Water to Utility Line Excavation – The depth to perched ground water will be compared to the as-built excavation depth of various SULs intersecting subject sites. An evaluation will be made concerning the ability of the SULs to act as a potential contaminant transport pathway. Particular consideration will be made during the evaluation of the ability of the SULs to transport contaminant via perched ground water towards the proposed Third Runway Embankment project area.

5. Report

A report will be developed which presents the findings outlined in the SUL Monitoring Plan. The report will present graphical maps which show ground water and geological conditions in relation to SULs, tabulated information on select SULs, and an evaluation regarding the potential of the SULs to act as preferential pathways for contaminant transport. Conclusions will be developed and an appropriate scope of work and work plan for any appropriate follow-on monitoring will be developed for Ecology review and approval.