Washington State
Department of Transportation

Memorandum

March 21, 2008

TO:	B. Khaleghi Bridge and Structures Office
FROM:	T. M. Allen/P. J. Palmerson E&EP Geotechnical Division, 47365
SUBJECT:	S. E. 78th to Newport Way Vic. Widening SR-900 MP 21.01; XL-2033 Tibbetts Creek Bridge Widening (#900/29) Foundation Recommendations

INTRODUCTION

GENERAL

Per your request, we are providing foundation recommendations for the Tibbets Creek Bridge Widening (Bridge #900/29) associated with the SR-900, S.E. 78th St. to Newport Way Vic. Widening Project. The project site is located in the city of Issaquah, Washington and is shown on Figure 1, Appendix A. The following memorandum presents the results of our site reconnaissance, subsurface explorations, and engineering analyses. Specifically, geotechnical recommendations are prepared for bridge foundation support, wingwalls, and construction considerations.

The analyses, conclusions, and recommendations provided in this report are based on the project description, and site conditions existing at the time of our site visits. The exploratory borings are assumed to be representative of the subsurface conditions at the proposed bridge abutments. If during construction, subsurface conditions differ from those described in the explorations, we should be advised immediately so that we may reevaluate our recommendations and provide assistance.

PROJECT DESCRIPTION

At present, the existing Bridge #900/29 carries SR-900 traffic over the Tibbetts Creek. The existing bridge is a single span structure supported on driven 13-inch CIP piles. The existing bridge has three lanes with two foot shoulders and a $29^{1}/_{2}$ foot span length. After widening the bridge to both sides, the final configuration will consist of 4, 11-foot wide lanes an 8-foot shoulder, a 5-foot bike lane and a $10^{1}/_{2}$ –foot wide sidewalk. We understand the proposed unfactored axial loads (dead load plus live load) for the widened sections are approximately 471 kips for the right side and 206 kips for the left side.

SUBSURFACE CONDITIONS

Subsurface conditions in the project area were explored by WSDOT drill crews. Appendix A, Figure 2 shows a plan view of the site with boring locations and Figure 3 shows our interpretation of the subsurface conditions. Appendix B includes a detailed discussion of our exploration program and logs of test borings. Boring logs should be made available to all prospective bidders and included in the contract documents.

SOIL CONDITIONS

Based on our test borings, the bridge site is generally underlain by sand and gravel. Borings AB-18-06 and AB-19-06 encountered embankment fill on top of the native deposits. In both test holes, natural deposits were encountered from about 5 feet below the ground surface near elevation 82 to 86 feet to the limits explored, or approximately elevation 15 feet.

For simplicity and design purposes, the materials encountered in the test borings have been grouped into three classification units. The groupings are based primarily on engineering properties and material classification. A profile, with subsurface information at the site, is shown on Figure 3 in Appendix A. The three units are as follows:

<u>Unit 1</u>: - Very loose to medium dense silty sand and gravel. This unit is interpreted to be fill associated with the existing bridge and roadway and is present to approximately elevations 77 to 81 feet.

<u>Unit 2</u>: – Medium to very dense well to poorly graded to silty sand and gravel. This unit is interpreted to be alluvium deposited by Tibbetts Creek. These deposits are present from the original ground surface near elevation 81 feet to approximately elevation 52 feet in boring AB-18-06 and elevation 45 feet in boring and AB-19-06.

<u>Unit 3</u>: – Dense to very dense silty sand. This unit is interpreted to be glacial till. This was encountered in both borings to the maximum depth explored of approximately 15 feet.

GROUNDWATER

Groundwater was observed in boring AB-18-06 near elevation 82 feet and in boring AB-19-06 near elevation 78 feet at the time of drilling. An open standpipe piezometer was installed in boring AB-18-06 and monitored monthly from June of 2006 to December 2007. The water table elevation varied in this time period between a low of elevation 80 feet and a high of elevation 84 feet. It is anticipated that groundwater conditions will change in response to rainfall, time of year, creek level and other factors.

SEISMOLOGICAL CONSIDERATIONS

DESIGN EARTHQUAKE PARAMETERS

For the seismic design of the bridge, a peak bedrock acceleration coefficient of 0.31g is recommended. The peak ground acceleration coefficient is based on the peak bedrock acceleration shown on the United States Geological Survey National Seismic Hazard Map (2002). The peak bedrock acceleration is based on an earthquake with a mean magnitude of 6.50. Design response spectra presented in the AASHTO guide specifications for seismic design of highway bridges are considered appropriate for seismic design of the new structure. A Type II Soil Profile response spectrum, with a Site Coefficient of 1.2 is recommended.

To obtain the seismic earth pressure for the design of the wingwalls and to perform the liquefaction analysis a peak ground acceleration of 0.35 was used. This value includes an amplification factor based on the general soil type at the site. The modification is based on Site Class D (Stewart et. al.).

The recommended acceleration coefficients are based on an expected ground motion at the project site that has a 10 percent probability of exceedance in a 50-year period (475-year return period).

LIQUEFACTION POTENTIAL

Soil liquefaction is a phenomenon whereby saturated soil deposits temporarily lose strength and behave as a viscous fluid in response to cyclic loading. Soil types considered at the highest risk of liquefaction during a seismic event are loose to medium dense, sandy soils.

Lateral spreading results when the shear strength of the liquefied soil is incrementally exceeded by the inertial forces induced during an earthquake. The result of lateral spreading is typically horizontal movement of non-liquefied soils located above liquefied soils, in addition to the liquefied soils themselves.

We do not anticipate liquefaction or lateral spreading at the site.

GEOTECHNICAL CONCLUSIONS AND RECOMMENDATIONS

FOUNDATION SUPPORT

General

Based on the results of the subsurface explorations, we recommend using spread footings to support the widened sections of the Tibbetts Creek Bridge. Spread footings will be the most economical option to construct as well as avoiding a number of existing and proposed buried utilities.

It is our understanding that the structure components will be designed using Load and Resistance Factor Design (LRFD).

Approach Fill

Minor amounts (less than 5 feet) of embankment fill are anticipated for the widening to match the existing grade. We do not anticipate any appreciable settlement for the embankment fills.

Abutments

For the wingwalls we recommend the following soil properties in Table 1 be used to estimate the forces.

Table 1. Lateral Earth Pressure Coefficients and Soil Parameters

Parameter	Value
Unit Weight (γ)	130 pcf
Soil Friction (ϕ_f) Piers 1 & 4	36°
Active Earth Pressure (K_a)	0.23
Passive Earth Pressure (K_p)	3.5
Seismic Earth Pressure (K_{ae})	0.35
Coefficient of Sliding (tan δ)	0.7

Approach Slabs

The existing bridge does not have approach slabs. From a geotechnical standpoint, approach slabs are not necessary at this structure. Other issues such as design speed, average daily traffic (ADT) or accommodation of certain bridge structure details may supersede the geotechnical reasons for deleting the approach slabs. If approach slabs are planned for the widened section of the bridge, the approach slabs should be provided for the full bridge width.

Foundation Recommendations

We have included a graph of nominal bearing capacity versus footing width for the Strength, Extreme and Service Limit States on Figure 4 in Appendix A. The nominal bearing capacity is based on a total settlement of less than 1 inch. Based on the loading and the soil conditions, we estimate total settlement to be less than 1 inch. We anticipate the bulk of the settlement to occur during construction. Post construction settlement should be negligible.

We recommend the top of the spread footings be placed below elevation 77.9 feet for the left side widening and below 74.1 feet for the right side widening. These elevations are based on a scour analysis provided by HQ Hydraulics in a memorandum dated July 31st, 2007.

Resistance Factors for Spread Footing Design

Table 2 provides the appropriate resistance factors (ϕ) for the designated limit state.

Table 2. Resistance Factors for Spread Footing Design

Limit State	Resistance Factor (ϕ)		
	Bearing (ϕ_{bc})	Shear Resistance to Sliding (ϕ_τ)	Passive Pressure Resistance to Sliding (ϕ_{ep})
Strength	0.45	0.80	0.50
Service	1.0	N/A	N/A
Extreme Event	1.0	1.0	1.0

Soil Spring Constants for Spread Footing Design

We recommended that equivalent spring constants for the spread footing foundations be determined by the method outlined in section 7.2.4 of FHWA Report No. FHWA-IP-87-6 entitled: Seismic Design and Retrofit for Highway Bridges.

To evaluate the soil response and development of forces in the Extreme Event Limit State, we have provided foundation soil shear modulus (G) and Poisson's ratio (μ). The values for shear strain levels of 0.02 to 0.2% can be found in Table 2. These shear strain values span the typical strain levels for large magnitude earthquakes.

Table 3. Shear Modulus (G) and Poisson's Ratio (μ)

Parameter	Shear Strain (%)	
	0.02	**0.20**
Shear Modulus (tsf)	1000	330
Poisson's Ratio	0.29	0.29

CONSTRUCTION CONSIDERATIONS

Groundwater will be present above the bottom of footing elevation; therefore the excavation will require dewatering. A concrete seal will not be permitted in order to maintain adequate clearance between the bottom of footing and the underground utilities.

Due to the granular nature of the foundation soils, it is unlikely that a sump will adequately dewater the excavation. The Contractor should be prepared to dewater the excavation with wellpoints or another approved method.

The stability of any temporary excavations is the responsibility of the contractor.

If you have questions or require further information, please contact Tony Allen at (360) 709-5450 or Pete Palmerson at (360) 709-5418.

Prepared by: Pete Palmerson
Geotechnical Engineer

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3/21/08

EXPIRES 1/27/08

Reviewed by: Jim Cuthbertson
Chief Foundation Engineer

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03/21/08

EXPIRES 03-13-10

Tony M. Allen

Agency Approving Authority: Tony Allen
State Geotechnical Engineer

TMA/pjp

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N. Dbaibo, NB 82-29

APPENDIX A
FIGURES

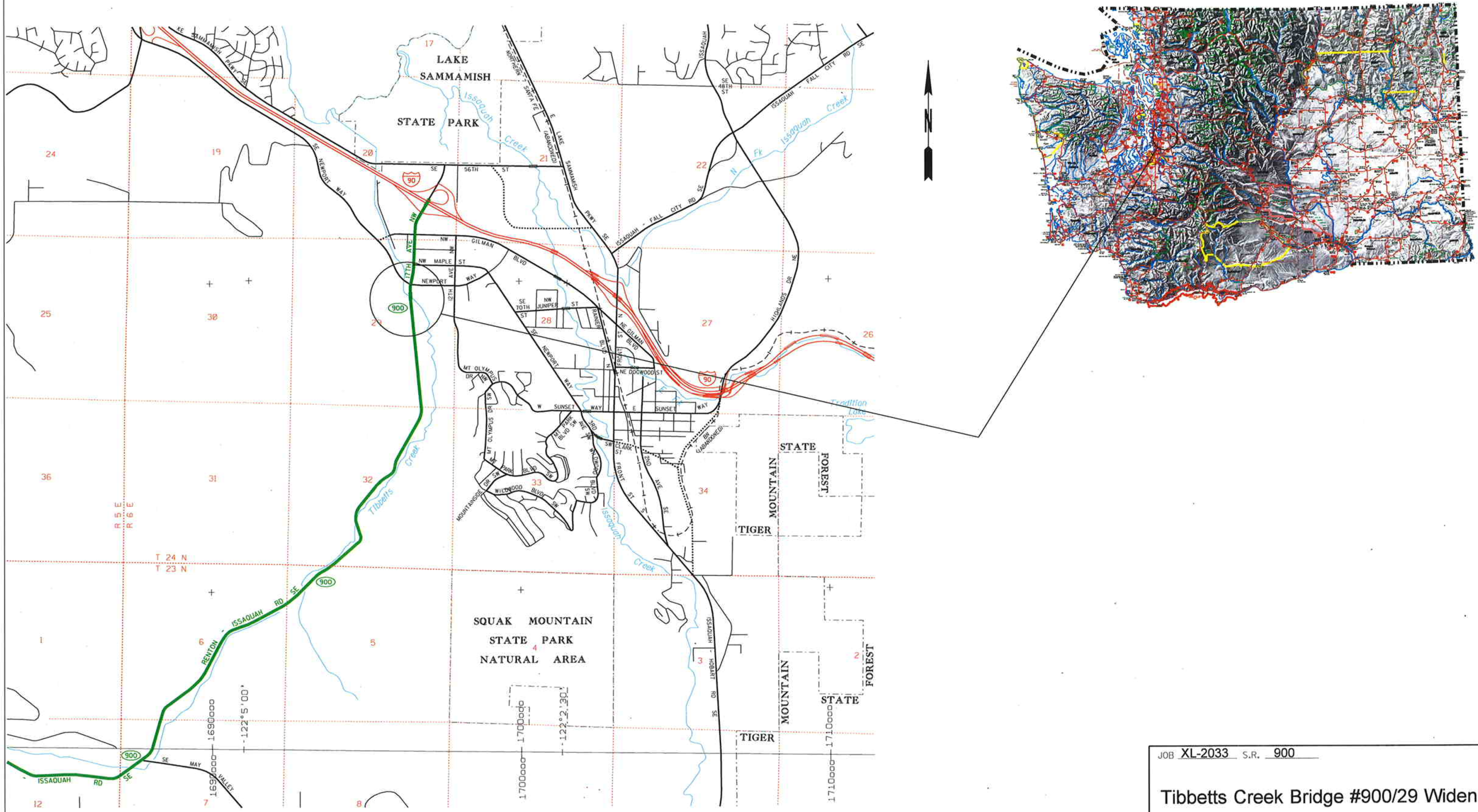

Figure 1: Vicinity Map

JOB XL-2033 S.R. 900

Tibbetts Creek Bridge #900/29 Widening

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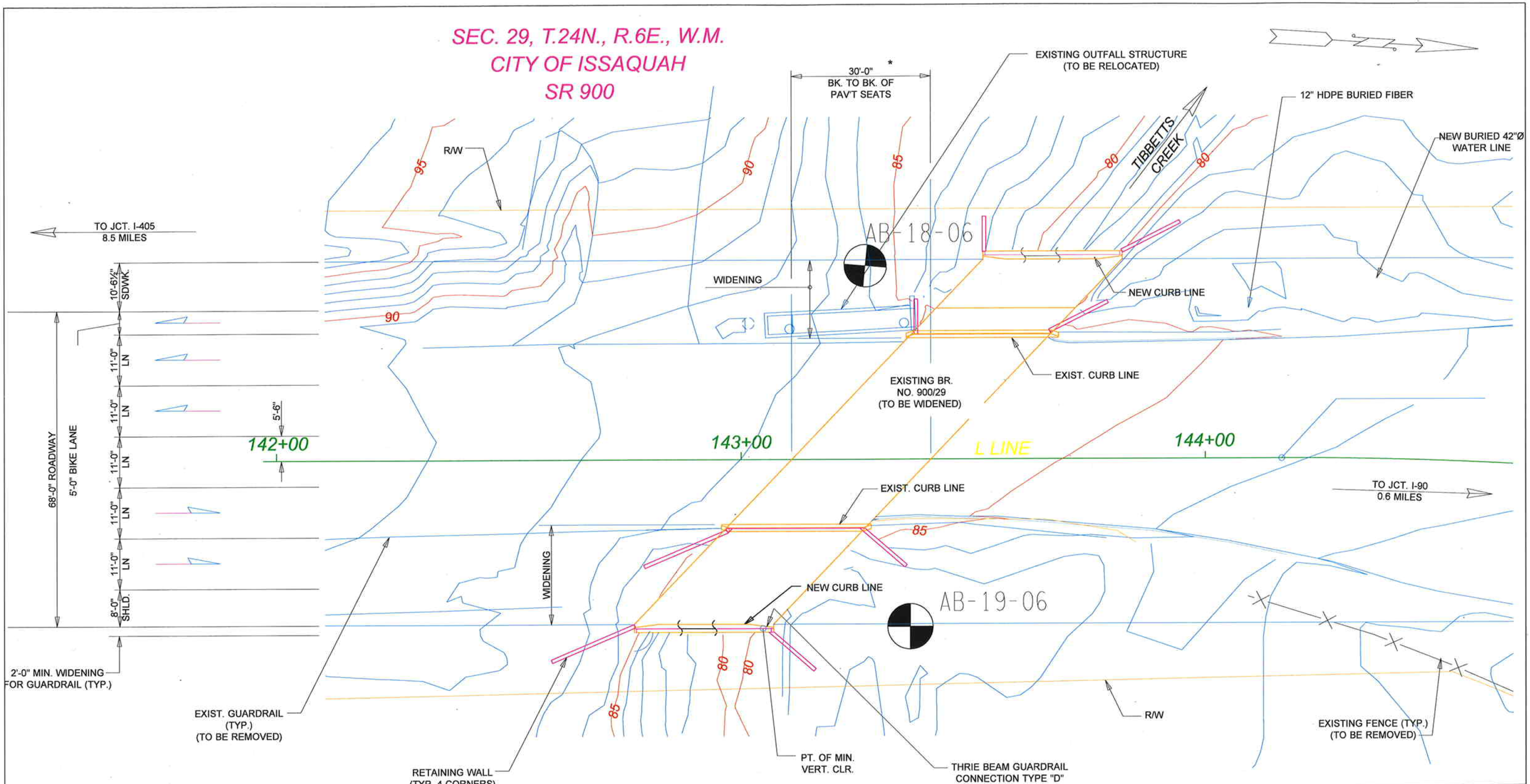
GEOTECHNICAL DIVISION

DATE 3/2008
SCALE 1=20' VERT.
1=20' HORIZ.
SHEET ____ OF ____
DRAWN BY WM



JOB XL-2033 S.R. 900

Tibbetts Creek Bridge #900/29 Widening

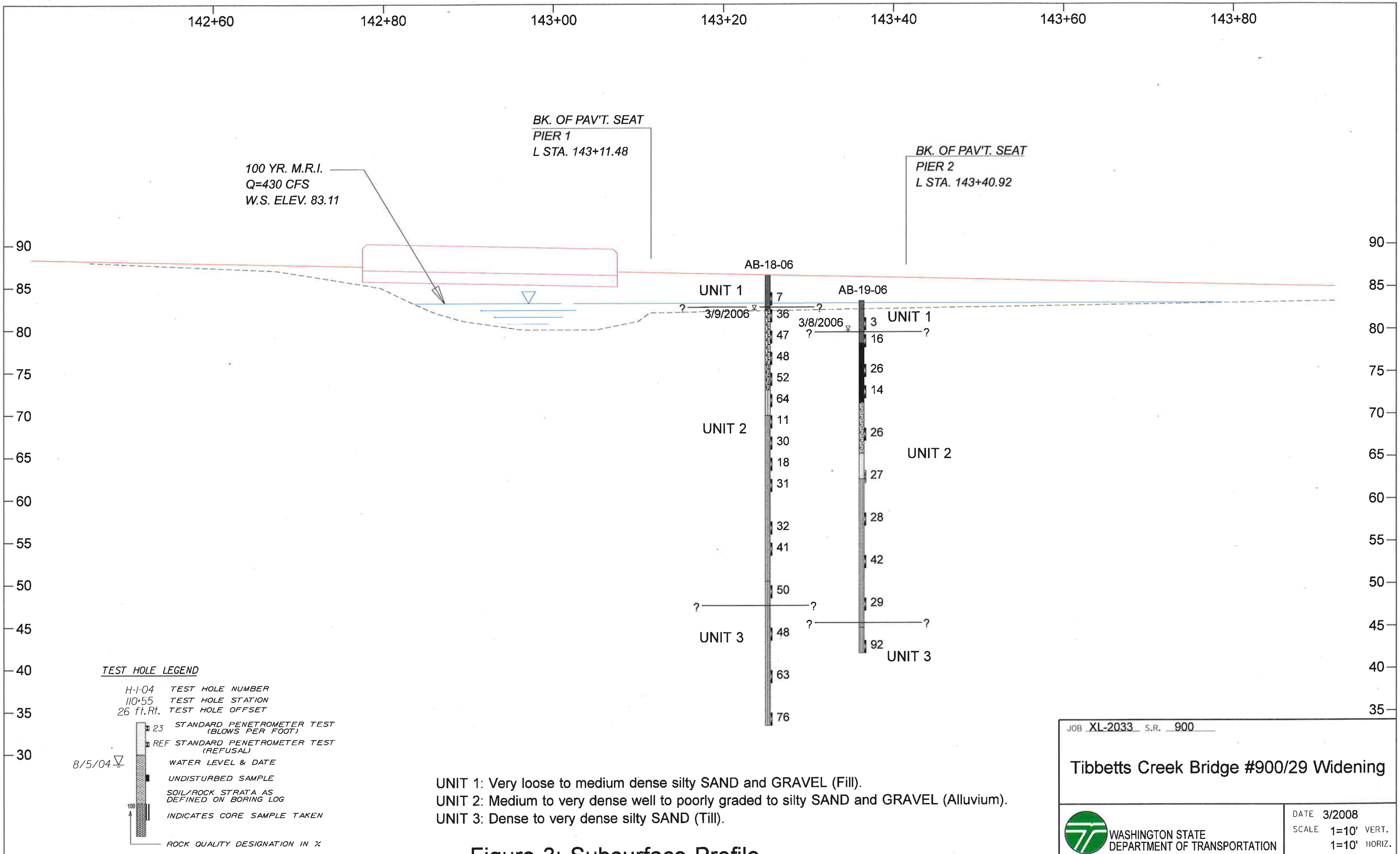
WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

GEOTECHNICAL DIVISION

DATE 3/2008
SCALE 1=20' VERT.
1=20' HORIZ.
SHEET ____ OF ____
DRAWN BY WM

Figure 2: Boring Location Plan

900-29 dgn 3/20/2008 10:29:48 AM



UNIT 1: Very loose to medium dense silty SAND and GRAVEL (Fill).
UNIT 2: Medium to very dense well to poorly graded to silty SAND and GRAVEL (Alluvium).
UNIT 3: Dense to very dense silty SAND (Till).

Figure 3: Subsurface Profile

JOB XL-2033 S.R. 900

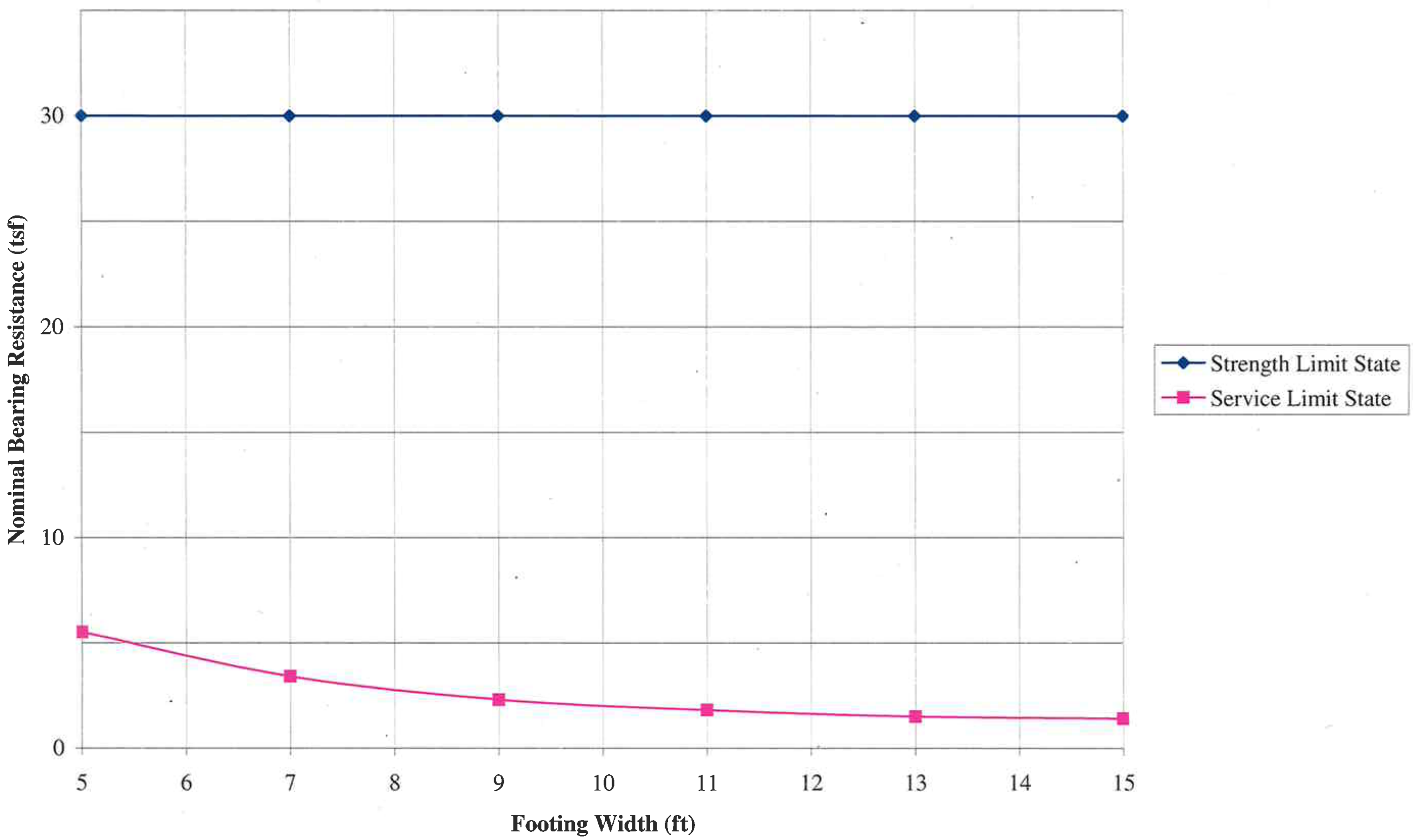
Tibbetts Creek Bridge #900/29 Widening

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

GEOTECHNICAL DIVISION

DATE 3/2008
SCALE 1=10' VERT.
1=10' HORIZ.
SHEET ____ OF ____
DRAWN BY WM

Tibbetts Creek Widening Nominal Bearing Resistance



Service Limit State Based on 1-inch of Settlement.

Figure 4

APPENDIX B
FIELD EXPLORATION

Field Explorations

The field exploration program for the bridge widening advanced two exploratory borings. The approximate exploration locations are shown on Figure 2 in Appendix A. Logs of test borings are attached. These logs should be included in the contract documents.

Geotechnical drilling for the exploratory borings was performed using a CME 45 skid-mounted drill rig. Test holes were advanced to depths between 42 and 53 feet below the ground surface using mud rotary drilling methods. At each location, soil samples were obtained using a SPT (Standard Penetration Test) sampler, in general accordance with ASTM D-1586. SPTs are obtained by driving a 2-inch OD, 1.4-inch ID split-spoon sampler 18-inches into the soil with a 140-pound hammer. The number of blows required to achieve each 6 inches of penetration is recorded and the soil's SPT resistance, or N-value, is calculated as the number of blows required to achieve the final 12 inches of penetration. Each drill rig is equipped with an automatic trip hammer to drive the split-spoon sampler. The automatic hammers on these two rigs are rated at approximately 80 percent efficiency, as compared to approximately 60 percent for manual hammers.

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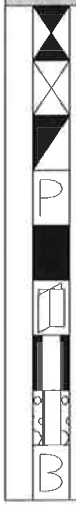
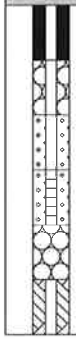
Test Boring Legend

Sampler Symbols



Standard Penetration Test
Oversized Penetration Test (Dames & Moore, California)
Shelby Tube
Piston Sample
Washington Undisturbed
Vane Shear Test
Core
Becker Hammer
Bag Sample

Well Symbols



Cement Surface Seal
Piezometer Pipe in Granular Bentonite Seal
Piezometer Pipe in Sand
Well Screen in Sand
Granular Bentonite Bottom Seal
Inclinometer Casing in Concrete Bentonite Grout

Laboratory Testing Codes

UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
UC	Unconfined Compression Test
DS	Direct Shear Test
CN	Consolidation Test
GS	Grain Size Distribution
MC	Moisture Content
SG	Specific Gravity
OR	Organic Content
DN	Density
AL	Atterberg Limits
PT	Point Load Compressive Test
SL	Slake Test
DG	Degradation
LA	LA Abrasion
HT	Hydrometer Test

Soil Density Modifiers

Gravel, Sand & Non-plastic Silt		Elastic Silts and Clay	
SPT Blows/ft	Density	SPT Blows/ft	Consistency
0-4	Very Loose	0-1	Very Soft
5-10	Loose	2-4	Soft
11-24	Medium Dense	5-8	Medium Stiff
25-50	Dense	9-15	Stiff
>50	Very Dense	16-30	Very Stiff
(REF)	Refusal	31-60	Hard
		>60	Very Hard

Angularity of Gravel & Cobbles

Angular	Coarse particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Coarse grained particles are similar to angular but have rounded edges.
Subrounded	Coarse grained particles have nearly plane sides but have well rounded corners and edges.
Rounded	Coarse grained particles have smoothly curved sides and no edges.

Soil Moisture Modifiers

Dry	Absence of moisture; dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible free water

Soil Structure

Stratified	Alternating layers of varying material or color at least 6mm thick; note thickness and inclination.
Laminated	Alternating layers of varying material or color less than 6mm thick; note thickness and inclination.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, somtimes striated.
Blocky	Cohesive soil that can be broken down into smaller angular lumps which resist further breakdown.
Disrupted	Soil structure is broken and mixed. Infers that material has moved substantially - landslide debris.
Homogeneous	Same color and appearance throughout.

HCl Reaction

No HCl Reaction	No visible reaction.
Weak HCl Reaction	Some reaction with bubbles forming slowly.
Strong HCl Reaction	Violent reaction with bubbles forming imediately.

Degree of Vesicularity of Pyroclastic Rocks

Slightly Vesicular	5 to 10 percent of total
Moderately Vesicular	10 to 25 percent of total
Highly Vesicular	25 to 50 percent of total
Scoriaceous	Greater than 50 percent of total

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Test Boring Legend

Grain Size

Fine Grained	< 1mm	Few crystal boundaries/grains are distinguishable in the field or with hand lens.
Medium Grained	1mm to 5mm	Most crystal boundaries/grains are distinguishable with the aid of a hand lens.
Coarse Grained	> 5mm	Most crystal boundaries/grains are distinguishable with the naked eye.

Weathered State

Term	Description	Grade
Fresh	No visible sign of rock material weathering; perhaps slight discoloration in major discontinuity surfaces.	I
Slightly Weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than its fresh condition.	II
Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a continuous framework or as core stones.	III
Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as discontinuous framework or as core stone.	IV
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	V
Residual Soil	All rock material is converted to soil. The mass structure and material fabric is destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI

Relative Rock Strength

Grade	Description	Field Identification	Uniaxial Compressive Strength approx
R1	Very Weak	Specimen crumbles under sharp blow from point of geological hammer, and can be cut with a pocket knife.	150-3500 psi
R2	Moderately Weak	Shallow cuts or scrapes can be made in a specimen with a pocket knife. Geological hammer point indents deeply with firm blow.	3500-7500 psi
R3	Moderately Strong	Specimen cannot be scraped or cut with a pocket knife, shallow indentation can be made under firm blows from a hammer.	7500-15000 psi
R4	Strong	Specimen breaks with one firm blow from the hammer end of a geological hammer.	15000-30000 psi
R5	Very Strong	Specimen requires many blows of a geological hammer to break intact sample.	Greater than 30000 psi

Discontinuities

Spacing

Very Widely	Greater than 3 m
Widely	1 m to 3 m
Moderately	0.3 m to 1 m
Closely	50 mm to 300 mm
Very Closely	Less than 50 mm

RQD (%)

$$\frac{100(\text{length of core in pieces} > 100\text{mm})}{\text{Length of core run}}$$

Condition

Excellent	Very rough surfaces, no separation, hard discontinuity wall
Good	Slightly rough surfaces, separation less than 1 mm, hard discontinuity wall.
Fair	Slightly rough surfaces, separation greater than 1 mm, soft discontinuity wall.
Poor	Slickensided surfaces, or soft gouge less than 5 mm thick, or open discontinuities 1 to 5 mm.
Very Poor	Soft gouge greater than 5 mm thick, or open discontinuities greater than 5 mm.

Fracture Frequency (FF) is the average number of fractures per 300 mm of core.
Does not include mechanical breaks caused by drilling or handling.

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LOG OF TEST BORING

Start Card R-68350

HOLE No. AB-18-06

Sheet 1 of 3

Job No. 6-917-15628-0

SR 900

Elevation 86.4 ft

Project SR900 - SE 78th Street to Newport Way

Driller Mike

Lic# 2599

Site Address SW side of Tibbetts Creek culvert

Inspector JTL

Start March 9, 2006

Completion March 9, 2006

Well ID# AKK-430

Equipment CME 45

Station

Offset

Hole Dia (inches) Mud Rotary

Method Mud Rotary

Northing 527504.40

Easting 1664685.37

Collected by

Datum

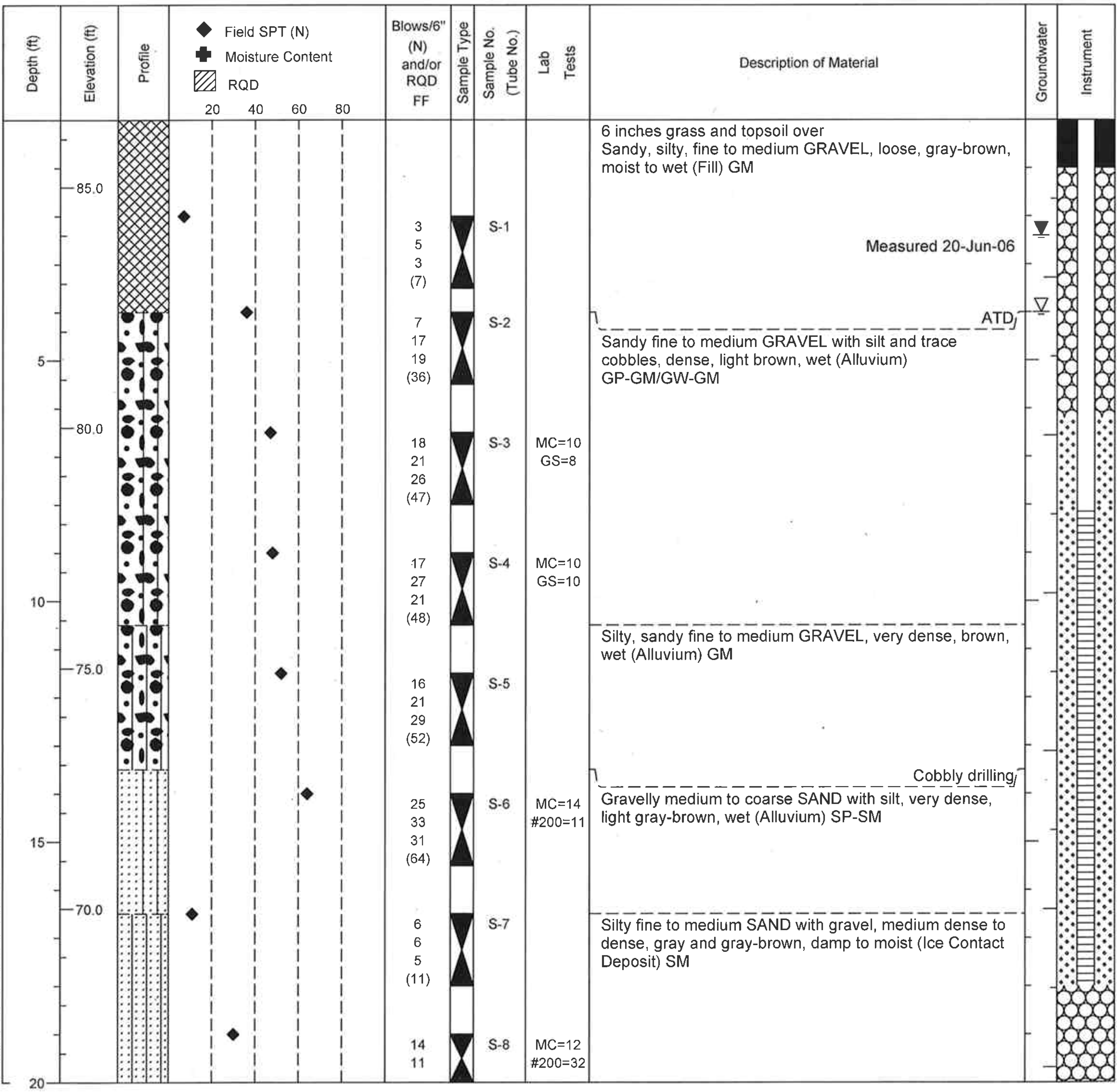
County King

Subsection SE1/4 of the NE1/4

Section 29

Range 6E

Township 24N



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
			6 inches grass and topsoil over Sandy, silty, fine to medium GRAVEL, loose, gray-brown, moist to wet (Fill) GM
3 5 3 (7)	S-1		Measured 20-Jun-06
7 17 19 (36)	S-2		ATD Sandy fine to medium GRAVEL with silt and trace cobbles, dense, light brown, wet (Alluvium) GP-GM/GW-GM
18 21 26 (47)	S-3	MC=10 GS=8	
17 27 21 (48)	S-4	MC=10 GS=10	
			Silty, sandy fine to medium GRAVEL, very dense, brown, wet (Alluvium) GM
16 21 29 (52)	S-5		Cobbly drilling
25 33 31 (64)	S-6	MC=14 #200=11	Gravelly medium to coarse SAND with silt, very dense, light gray-brown, wet (Alluvium) SP-SM
6 6 5 (11)	S-7		Silty fine to medium SAND with gravel, medium dense to dense, gray and gray-brown, damp to moist (Ice Contact Deposit) SM
14 11	S-8	MC=12 #200=32	

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LOG OF TEST BORING

Start Card R-68350

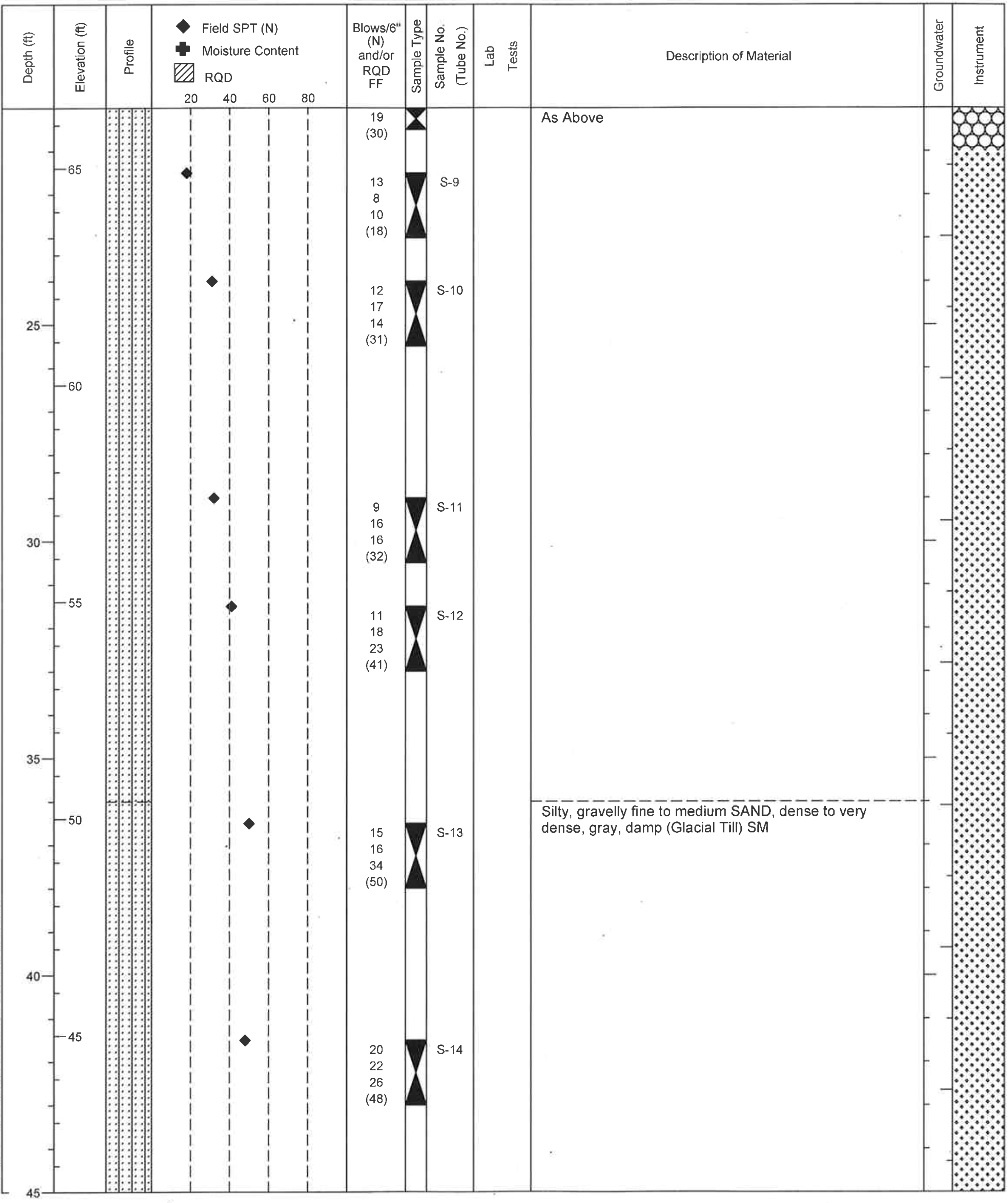
HOLE No. AB-18-06

Job No. 6-917-15628-0 SR 900 Elevation 86.4 ft

Sheet 2 of 3

Project SR900 - SE 78th Street to Newport Way

Driller Mike Lic# 2599



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)
19 (30)	
13 8 10 (18)	S-9
12 17 14 (31)	S-10
9 16 16 (32)	S-11
11 18 23 (41)	S-12
15 16 34 (50)	S-13
20 22 26 (48)	S-14

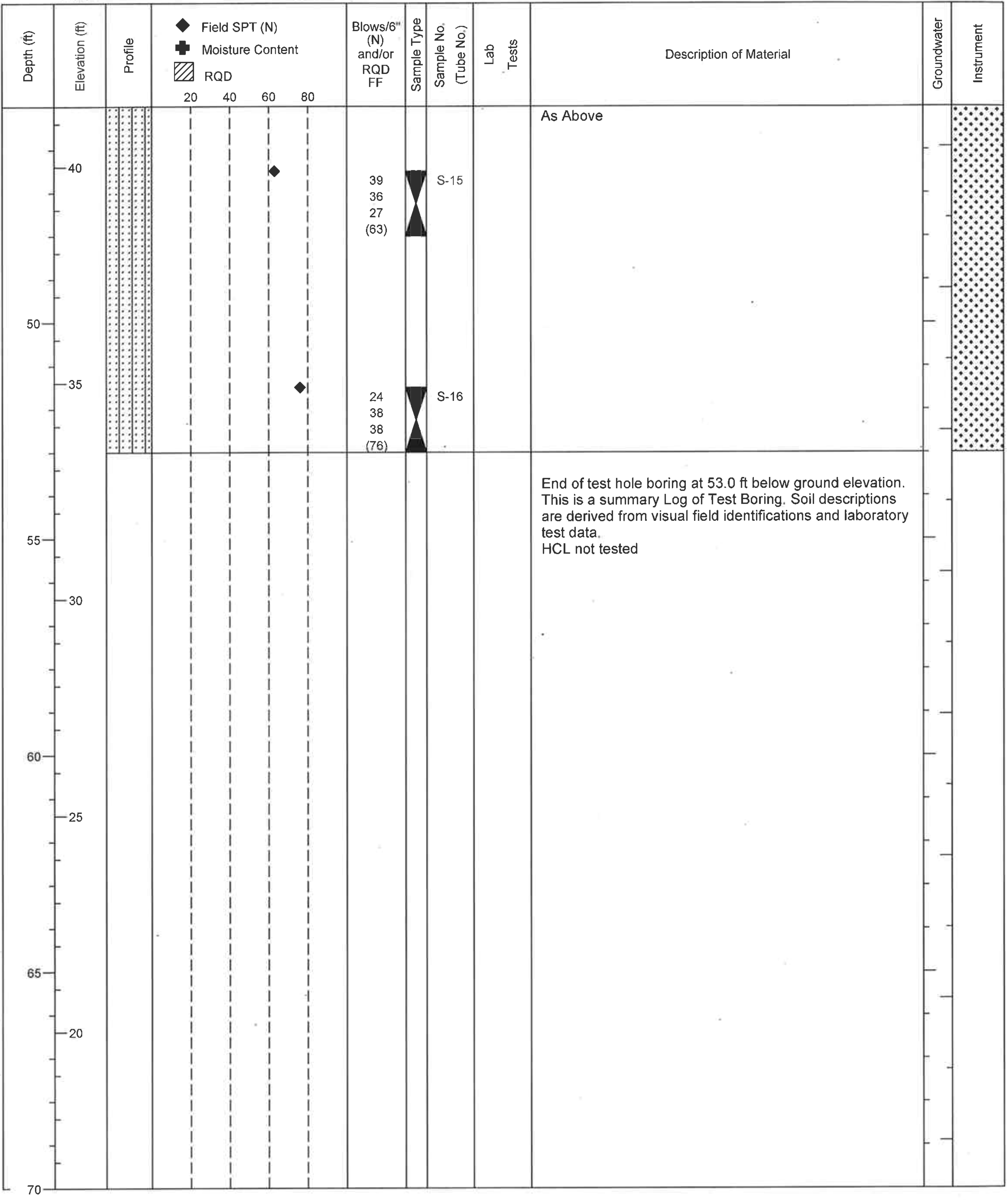
Description of Material

As Above

Silty, gravelly fine to medium SAND, dense to very dense, gray, damp (Glacial Till) SM

LOG OF TEST BORING

Start Card R-68350
HOLE No. AB-18-06
Sheet 3 of 3
Job No. 6-917-15628-0
SR 900
Elevation 86.4 ft
Project SR900 - SE 78th Street to Newport Way
Driller Mike
Lic# 2599



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material
				As Above
39 36 27 (63)		S-15		
24 38 38 (76)		S-16		

End of test hole boring at 53.0 ft below ground elevation. This is a summary Log of Test Boring. Soil descriptions are derived from visual field identifications and laboratory test data.
HCL not tested

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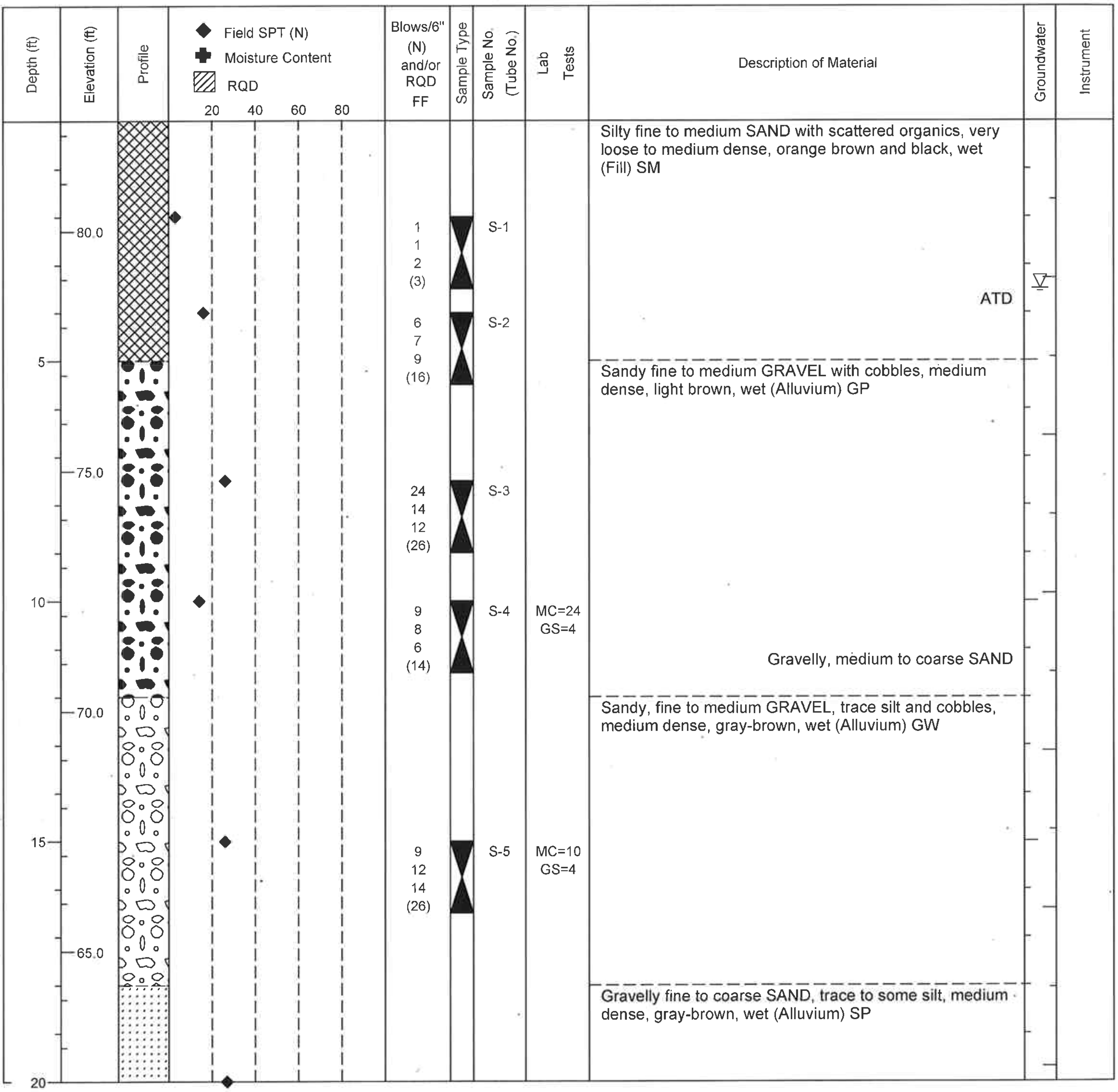
LOG OF TEST BORING

Start Card S-26354
HOLE No. AB-19-06
Sheet 1 of 2

Job No. 6-917-15628-0 SR 900 Elevation 82.3 ft
Project SR900 - SE 78th Street to Newport Way
Driller Mike Lic# 2599
Site Address NE side of Tibbetts Creek culvert
Inspector JTL
Start March 8, 2006 Completion March 8, 2006 Well ID#
Equipment CME 45
Station Offset Hole Dia (inches) Mud Rotary
Method Mud Rotary
Northing 527516.20 Easting 1664708.44 Collected by
Datum
County King Subsection SE1/4 of the NE1/4 Section 29 Range 6E Township 24N



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests
1 1 2 (3)	S-1	
6 7 9 (16)	S-2	
24 14 12 (26)	S-3	
9 8 6 (14)	S-4	MC=24 GS=4
9 12 14 (26)	S-5	MC=10 GS=4

Description of Material

Silty fine to medium SAND with scattered organics, very loose to medium dense, orange brown and black, wet (Fill) SM

ATD

Sandy fine to medium GRAVEL with cobbles, medium dense, light brown, wet (Alluvium) GP

Gravelly, medium to coarse SAND

Sandy, fine to medium GRAVEL, trace silt and cobbles, medium dense, gray-brown, wet (Alluvium) GW

Gravelly fine to coarse SAND, trace to some silt, medium dense, gray-brown, wet (Alluvium) SP

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LOG OF TEST BORING

Start Card S-26354

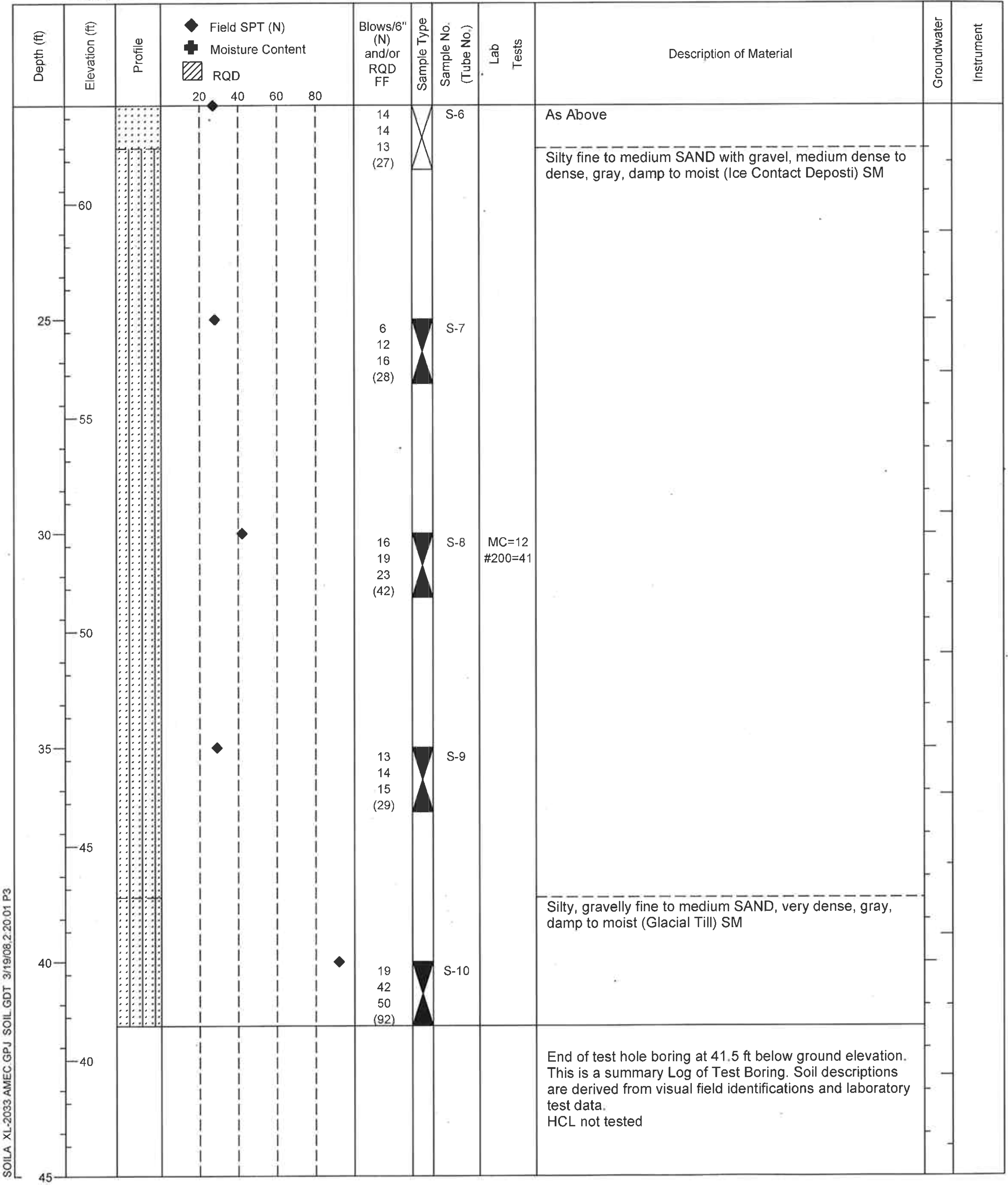
Job No. 6-917-15628-0 SR 900 Elevation 82.3 ft

HOLE No. AB-19-06

Sheet 2 of 2

Project SR900 - SE 78th Street to Newport Way

Driller Mike Lic# 2599



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
14 14 13 (27)	S-6		As Above
			Silty fine to medium SAND with gravel, medium dense to dense, gray, damp to moist (Ice Contact Deposti) SM
6 12 16 (28)	S-7		
16 19 23 (42)	S-8	MC=12 #200=41	
13 14 15 (29)	S-9		
			Silty, gravelly fine to medium SAND, very dense, gray, damp to moist (Glacial Till) SM
19 42 50 (92)	S-10		
			End of test hole boring at 41.5 ft below ground elevation. This is a summary Log of Test Boring. Soil descriptions are derived from visual field identifications and laboratory test data. HCL not tested