HIGA·BURKHOLDER
ASSOCIATES, LLC
LAND USE PLANNING / CIVIL ENGINEERING

Drainage Report
For
Crown Distributing Site Development Expansion

Prepared for:
Crown Distributing, Inc
c/o Pete Bargreen
3409 Mcdougal Ave.
Everett, Washington 98201

Prepared by:
Mark Davis

Reviewed by:
Jim Kresge, P.E.

September 13, 2005

RECEIVED
SEP 16 2005
Utilities Div.

RECEIVED
SEP 15 2005
COA PLANNING DEPT

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JAMES A. KRESGE
15791

9/12/05

EXPIRES 3/17/06

CONTENTS

DRAINAGE SUMMARY

INTRODUCTION

This report addresses drainage analysis and design for a 64,470 sq. ft addition to the existing Crown Distributing facility. A proposed BLA will create an additional 2.02 acres of land to incorporate the new building expansion.

Some of the existing drainage components used for the original Crown Distributing Building will be modified to handle the placement and construction of the building expansion. The existing detention pond to the south that was designed for the Crown Park Industrial site and 59th Ave NE will be utilized to handle the runoff associated with building expansion and additional paved parking.

There is no need to modify the existing control structure for the existing detention pond because the detention pond still meets current drainage requirements. The existing detention pond walls, configuration and size will not be altered.

Portions of the drainage report, completed by John Cherry (April 5, 2001) concerning the Crown Distributing building within the Crown Park Industrial Park is located in the appendix for reference.

EXISTING CONDITIONS

The Crown Distributing site is located at the southeast corner of the intersection of 172nd St NE (SR 531) and 59th Ave NE. The site is developed with an 80,000 sq.ft. distribution warehouse and office space building surrounded by paved parking. Approximately 95% of the site area is impervious surfacing. The underlying site topography is nearly level that drains to the south. Runoff is captured and conveyed to the south within a series of catch basins and storm-drain pipe.

Per information from Drainage report, dated April 5, 2001 by John Cherry:
An agricultural ditch conveys Edgecomb Creek westward along the south boundary of the Crown Park property, approximately 1300 feet south of 172nd Street. Although portions of the stream reach have been degraded by erosion and loss of streamside buffers, the Department of Fish and Wildlife reports that the creek supports populations of coho salmon, chum salmon and cutthroat trout, and is potential bull trout foraging habitat. Preliminary studies for the long-term development of Crown Park have included consideration of a substantial stream restoration effort.

The SCS Snohomish County Soil Survey identifies the predominant underlying soil types in the proposed construction area as Lynnwood loamy sand at the north end near 172nd Street, Custer fine sandy loam through the center of the site and Norma loam near Edgecomb Creek. Subsurface exploration by Western Geotechnical Consultants, Inc. (see reports in Appendix) confirmed the presence of these soil types and determined a seasonal high water table depth of one to three feet.

Downstream flow path: *All runoff generated on this site drains to an existing detention pond adjacent to Edgecomb Creek on the south boundary of the Crown Park property. At the southwest corner of the property the agricultural ditch conveying the creek waters turns 90° to the south. The ditch follows a straight line south between agricultural fields for one-half mile before turning west for one-quarter mile, then south again for one-half mile. At this point the creek crosses a railroad right-of-way and takes on a more natural character as it meanders south through a residential area en route to Quilceda Creek approximately 2.5 miles south of the Crown Park property. The agricultural ditch within one-quarter mile downstream is typically four feet deep with 2:1 side slopes, although there are numerous irregularities caused by erosion. The bottom is approximately six feet wide and slopes at less than 1%. The ditch is vegetated intermittently with grasses and brush, and the banks have no significant shading vegetation. No culverts or other obstructions lie within one-quarter mile downstream from the Crown Park site.*

DEVELOPED CONDITIONS

The Crown Distributing property will be expanded approximately 2.02 acres as part of a proposed BLA. A 64,740 square foot distribution warehouse addition will be constructed to the existing warehouse building. Additional paved parking area will be provided for the building addition and to provide access circulation. Landscape strips will be provided on the east boundary. Approximately 91% of the area of the new Crown Distributing parcel will have impervious cover following development.

Because of the flat terrain, the distribution facility will be constructed on elevated pads to facilitate stormwater drainage.

DRAINAGE DESIGN

Stormwater from the roof and parking areas will be channeled to catch basins in the east and south parking areas. South of the building in the loading/maneuvering area, stormwater will be permitted to sheet flow over the pavement surface (sloped at 1%) and into a trench drain system that will convey runoff to a series of catch basins paralleling the south edge of the parcel. Runoff is conveyed through storm-drain pipe with a minimum 12-inch diameter near the building and a maximum 18-inch diameter near the south boundary line.

Site runoff continues south through the Crown Park property before releasing into the existing detention pond just north of Edgecomb Creek. See the attached drainage report, dated April 5, 2001, by John Cherry for narrative on the design of the existing detention pond.

The existing detention pond, vegetated filter strip and level spreader will not be altered with this proposal. The detention pond still meets 2001 D.O.E. standards and guidelines. The "Stormshed 2G" program with the Santa Barbara Unit Hydrograph (SBUH) method and Type 1A rainfall distribution was used in the redesign of the existing detention pond. As per D.O.E. requirements, a correction factor of 44% was incorporated into the design volume of the detention pond.

GEOTECHNICAL REPORTS

Western Geotechnical Consultants, Inc.

4181 Saltsprings Drive • Ferndale, WA 98248
Phone (360) 380-2507 • Fax (360) 380-2507

May 23, 2000

Crown Distributing Inc.
3409 McDougall Avenue
Everett, WA 98210

Re: Report
Geotechnical Engineering Investigation
Commercial Distribution Building
Roetcisoender and Parkinson Properties
SE Corner of SR531 and 59th Ave. NE
Arlington, WA

Western Geotechnical Consultants Inc. is pleased to present the results of our geotechnical engineering investigation for the proposed commercial building in Arlington, WA. The investigation was performed in general accordance with our proposal dated March 31, 2000.

The site is located on the southwest corner of SR531 (172nd St. NE) and 59th Ave. NE. Figure 1 is a site plan showing the site layout and approximate building location relative to other site features. The project plan involves construction of a 750,000 square foot commercial distribution facility on the site. The site occupies 101.70 and the building will be located near the northwest corner of the property.

PURPOSE AND SCOPE

The purpose of our investigation for the site included the following services:

- **Drilling 6 borings within the proposed building footprint to obtain design level geotechnical information for use in foundation design and general site development. The borings were advanced to depths ranging between 30 and 45 feet below present grade.**
- **Developing tabulated logs for each boring as to the thickness and depth of each soil unit and describing the soils encountered in accordance with the Unified Soils Classification System (USCS).**
- **Performing field and laboratory testing, as required, for use in our engineering evaluation of the site.**
- Preparing this engineering report including a summary of work performed, and our recommendations for:
  - Foundation design for the proposed facility including allowable bearing pressures and settlement estimates.
  - General site development including rough stripping criteria.

- Cutting and structural fill criteria including the suitability of on site materials for use as structural fill.
- Floor slab support.
- Drainage considerations
- Construction monitoring

GEOLOGY

The following descriptions of the surficial and subsurface geology on the subject property and in the vicinity of the subject property were interpreted from the Surficial Geologic Map of the Port Townsend 30- by 60- Minute Quadrangle. Puget sound Region. Washington (Pessl and others, 1989, Soil Survey of Snohomish County Area Washington, (USDA, 1983), and Ground-Water Resources of Snohomish County Washington, (Newcomb, 1952).

The site and vicinity is underlain by recessional-marine deposits. These deposits consist of sand, gravel, and silt deposited primarily by melt-water from the receding Vashon ice sheet at a time when relative sea level was higher than present Pessl and others (1989) indicate that the deposits in the vicinity of the subject property consist primarily of sand and gravel The results of our boring investigation of the site are consistent with Pessl and others.

The geologic mapping in the area and area well logs indicates that the recessional-marine deposits are underlain by glacial till and ice contact deposits. The till consists of a poorly sorted mixture of rock fragments deposited directly by glacial ice. The finer components include silt, sand and clay in highly variable proportions, constituting a coherent to friable, moderately to highly compact matrix in which the coarser components (gravel and cobbles) are firmly embedded. Our boring investigation (45-feet maximum) did not encounter glacial till or any ice contact deposits.

SEISMIC ZONE

The project site is located in Seismic Zone 3 per the 1997 Uniform Building Code (UBC). Zone 3 seismic loading can cause relatively large differential settlements if liquefiable zones are present.

Field and Laboratory Testing

Field testing involved performing Standard Penetration Tests (SPT) on all samples obtained during drilling. The results of the SPT tests are included on the log of borings which are located in the Appendix to this report.

Laboratory testing included sample inspection under controlled laboratory conditions, determination of moisture content of samples, and grain size tests. Moisture content test results are included on the log of borings and the grain size test results are included in the appendix in the form of grain size distribution curves.

SITE CONDITIONS

Surface Conditions

A geotechnical engineer from our firm traveled to the site between April 26 and April 28, 2000 to oversee the drilling of six borings located within the footprint of the proposed commercial building. The site is nearly flat and is presently being used for raising cattle with an occupied home located near the northwest corner.

Subsurface Conditions

Subsurface conditions at the site were evaluated by drilling a total of 6 borings on within the building site between April 26 and April 28, 2000 using hollow stem auger drilling equipment. Soil samples were collected at approximately 5-foot intervals using a Standard Penetration Test (SPT) sampler driven with a 140-pound hammer using center rods. The hammer was dropped from a height of approximately 30-inches, and was lifted to the drop height by a cable controlled by the driller. The number of blows (drops) required to drive the sampler 18-inches into the undisturbed soil was recorded for use in analyzing the site. The bore holes were backfilled with drill cuttings and bentonite upon completion

The soils encountered in the borings were classified using the Unified Soils Classification System (USCS) and logs were maintained for each boring. Edited boring logs are included in the Appendix along with a USCS Chart explaining soil descriptions.

The borings revealed a relatively uniform subsurface profile consisting of about 18 inches of topsoil, which is underlain by gap graded sandy GRAVEL and gravelly SAND (SP and GP by USCS classification) to the depth of the borings. The sands and gravels are silty at the interface with the topsoil layer. The sands and gravels were saturated below about 3-1/2 feet, which was the location of the water table at the time of our investigation. The sands and gravels graded gray in color below 10-feet, which is indicative of permanent saturation.

Ground Water Conditions

Ground water was encountered at a depth of approximately 3-1 2 feet This depth is consistent with water levels observed in piezometers on site. Based on soil coloration, it appears that the summer low water table is around 10-feet. Nearby piezometers revealed that the seasonal high water table is around 3 1 feet.

Liquefaction Potential

Liquefaction has been recognized and evaluated for many years by geotechnical engineers in other seismically prone areas. With the renewed awareness in recent years that the Puget Sound area is seismically active, there has also been an increased interest in liquefaction potential. Liquefaction is a phenomenon whereby certain soils loose their strength and bearing capacity during ground shaking, such as could occur during earthquakes. General criteria for liquefiable soils are that they be 1) relatively loose, 2) a material with a liquefiable soil gradation, 3) non-plastic, and 4) saturated. Associated with liquefaction is the potential for ground movements or lateral displacements that could cause differential settlements in the foundation soils.

For soils to be liquefiable they must meet all four of the conditions described above. The site soils meet criteria 2 through 4 (see Appended grain size curves) but the soils are generally in a medium dense to dense state (SPT blow counts greater than 25). Borings 4, 5, and 6 had thin strata with blow counts of 18, 19, and 17 respectively but each of these borings had high blow count soils (denser soils) above. These lower values indicate areas of marginal liquefaction potential. We have analyzed these strata for seismic induced settlement potential, and the results are detailed in the Conclusions and Recommendations under the Foundations section to this report.

CONCLUSIONS AND RECOMMENDATIONS

General

We conclude, based on our Geotechnical Investigation, that the site is suitable for construction of the proposed commercial distribution facility using conventional shallow spread foundations provided good construction practices are used and provided our recommendations are followed. The seasonal high ground water table could make winter construction more difficult. Therefore site earthwork and foundation construction would be more easily accomplished if performed during the summer or early fall months. The following sections provide specific recommendations for general site development and foundation design.

Site Preparation

All of the upper organic-rich topsoil should be stripped away from the area to be occupied by the proposed building foundations and other structural improvements. Based on our boring investigation, we estimate that the stripping depth will range from approximately 1-1/2 to 2 feet. Note that there could be localized areas of deeper soft organic soils that we did not encounter during our boring investigation.

Following stripping and site excavations, but prior to placement of any structural fill, qualified personnel should evaluate the exposed subgrade

Fill and Compaction

We anticipate that some structural fill will be required beneath the building or other structural improvements. Structural fill used to obtain final grade elevations should be properly placed and compacted.

The on site sands and gravels would make satisfactory structural fill provided they can be separated from the topsoil and provided they can be drained so adequate compaction can be achieved. If import material is to be used we recommend that the structural fill consist of an imported, clean, well graded sandy gravel material containing less than 5% passing the U.S Standard No. 200 sieve based on a wet sieve analysis of that portion passing the U.S. Standard No. 4 sieve (GW by USCS classification).

Structural fill should be placed in maximum 8- to 10-inch loose horizontal lifts and it should be compacted to 95% of maximum dry density as determined by the ASTM D-1557 test procedure. The structural fill should extend beyond the edges of the foundations by a distance equal to the thickness of the fill beneath the base of the foundations.

Foundations

We recommend that the planned building is supported on isolated spread and continuous footings founded on undisturbed sand and gravel soils or compacted structural fill. Bearing soil that is disturbed during foundation excavation should be recompacted or removed. All soil directly below and around footings should be compacted to at least 95% of maximum dry density (ASTM D-1557 test procedure) prior to placement of forms or reinforcing steel. All continuous and isolated spread footings should have minimum widths of 18 and 24 inches, respectively, and should be founded a minimum of 18 inches below the lowest adjacent final grade for frost protection. All footings supported on properly prepared native sandy gravelly soils or structural fill may be proportioned using a net allowable bearing pressure of 2,500 psf.

The term net allowable bearing pressure refers to the pressure which can be imposed on the soil at foundation level due to the total of all dead plus live loads, exclusive of the weight of the footing or any backfill placed above the footing. These values may be increased by one-third for transient wind or seismic loading.

Settlement of spread foundations depends on the foundation size and bearing pressure as well as the strength and compressibility characteristics of the underlying bearing soils. Two types of settlement are possible for the subject soils, namely 1) short and long-term <u>static</u> settlement and 2) earthquake induced <u>dynamic</u> settlement. The results of our settlement analyses are summarized below.

<u>Settlement from static loading:</u>
We performed static settlement analysis using the following foundation load information.

- Allowable foundation pressure = 2,500 psf.
- Perimeter footings = 6.5 klf maximum at mesanine. This results in a nominal 2.6-foot wide footing.
- Column footings = 200 kips maximum at mesanine. This results in a nominal 9x9-foot column footing.

Based on the size of the proposed foundations, we calculated that the settlement from static loading would be on the order of ½ to 2/3 of an inch. Our estimate was computed, based on soil gradation, density, SPT N-values and experience with similar soil and loading conditions. Because of the generally granular nature of the foundation soils, a large portion of this settlement should occur relatively quickly as the loads are applied during construction. Along with this initial settlement, however, there is the potential for an additional component of settlement from static loading due to the rearrangement of soil grains over time. Our calculations indicate that long term static settlement will be less than 1/4-inch over the next 30-years.

<u>Settlement from Liquefaction</u>
There is a potential for limited liquefaction of a portion of the foundation soils during a strong earthquake. Liquefaction is a phenomenon whereby certain soils loose their strength and bearing capacity during ground shaking, such as could occur during earthquakes. General criteria for liquefiable soils are that they be relatively loose, a material with a liquefiable soil gradation, non-plastic, and saturated. Associated with liquefaction is the potential for ground movement or lateral displacement that could cause differential settlement for the foundation soils.

We encountered medium dense, non-plastic soils in our exploration that have a soil gradation similar to those soils that have been found to liquefy during earthquakes. Lateral displacement can occur when soils lose strength during liquefaction. A relatively flat site such as this will experience minimal lateral movement as compared to sites closer to sloping ground. Consequently, liquefaction at this site would likely result in differential settlements, but lateral displacements are not likely. Furthermore, we would anticipate that the slab foundation proposed for the building would be capable of accommodating a certain amount of differential settlement.

We used empirical procedures proposed by Seed and Tokimatsu to estimate the total amount of settlement that could be expected from seismically induced liquefaction during a strong earthquake. We estimate that this settlement will be around 1 to 1-1/2 inches. Seed and Tokimatsu recommend broadening the range of predicted settlement due to uncertainties in the analytical procedure. We therefore recommend designing the building to accommodate 1 to 2 inches of settlement for a large earthquake on the order of Magnitude 7.5 with a ground acceleration of 0.3 g (UBC, 1997). This is a maximum credible earthquake for the area of which some damage to structures would be expected. We also evaluated liquefaction induced settlement under a magnitude 6.0 earthquake with a ground acceleration of 0.2g. Our calculations indicate that settlement on the order of 1-inch would occur under such seismic loading.

Slab Sub-grade Modulus

We understand that the proposed commercial distribution building will have a slab-on-grade. We have performed a literature review and correlated standard penetration test blow counts to obtain a reasonable stress-strain relationship for the supporting soils. Based on our evaluation of subsurface conditions we recommend a sub-grade modulus of 200 tcf (230 pci) for design of the earth supported floor slab. This value assumes the slab will be constructed over undisturbed native sands and gravels or structural fill and it assumes that the floor slab sub-grade will be prepared as recommended below.

Floor Slab Support

Preparation of the building areas in a manner described in the previous sections of this report should provide an adequate base for floor slab support. We recommend that all earth-supported floor slabs be underlain by 6-inches of compacted, clean, free-draining sandy gravel or gravel with less than 5% passing the No. 200 mesh sieve, based on a wet sieve analysis of that portion passing the No. 4 sieve. The purpose of this layer is to provide uniform support and a capillary break. If desired, a vapor barrier may be placed below the floor slab. The vapor barrier, if used, should be covered with a thin layer of sand or crushed gravel to protect it during concrete placement and to aid in concrete curing. After a sand or crushed gravel layer is placed, it should remain relatively dry. It is important that the 6-inch free draining layer located below the vapor barrier is connected to the footing drain system to promote drain from beneath the floor slab.

Lateral Load Resistance

Lateral loads may be resisted by passive earth pressures and friction between the foundations and the underlying soil. For design purposes, a passive resistance for structural fill placed against the sides of the foundations may be considered equivalent to the pressure developed by a fluid (equivalent fluid pressure) with a density of 250 pcf. This value assumes a non-buoyant conditions that will prevent the buildup of hydrostatic pressure in the structural fill. A coefficient of base friction of 0.40 may be used between the base of the foundation and the underlying soils. If passive resistance is used in conjunction with frictional resistance, we recommend using only ½ of the passive resistance recommended above because it takes much larger strains to mobilize full passive resistance as compared to frictional resistance.

Drainage

Due to the seasonal high water table at the site we recommend placement of a footing drain around the perimeter of the building. Footing drains typically consist of a minimum 4-inch diameter perforated or slotted pipe which is bedded in and surrounded by drain rock. Given the granular nature of the site soils the drain rock should be surrounded by a drainage geotextile (TC Mirafi 4NP or equivalent). The drainpipe should be placed at or below the base of the footing and ½-foot outside the footing. The footing drain should exit in a tightline, which transmits water to the site stormwater system.

Roof drains must not introduce water to the footing drain system, but should transmit collected water to the stormwater system by separate tightline. Final grading should promote surface water runoff away from the building.

Erosion Control

Erosion control during construction of the proposed facilities can be accomplished through placement of proper sedimentation control facilities. We recommend siltation control facilities, consisting of either hay bales or silt fences that are fabricated around the construction areas. Typical details for siltation control facilities using either hay bales or silt fences are attached to this report.

Siltation devices should be placed down gradient of all construction areas and cleared areas to provide siltation control during construction. All siltation control devices should be maintained in operable condition during construction, and left in operable condition until the site has been revegetated and siltation is no longer a threat. At that time the siltation facilities should be removed.

Construction Monitoring

Western Geotechnical Consultants, Inc. should review the final foundation design and grading plans prior to construction to insure conformance with our recommendations. We recommend that a geotechnical engineer or engineering geologist be present to inspect the exposed subgrade before any placement of structural fill. All fill placement and compaction activities should be monitored and documented.

We appreciate the opportunity to be of service to you. Should you have any questions concerning this report or require further information, please contact the undersigned in our office at (360)-380-2507.

Sincerely yours,

Western Geotechnical Consultants, Inc.

Theodore A. Hammer P.E.
Geotechnical Engineer

25570
EXPIRES 12/27/01

File:991454.doc

Attachments: Figure 1 - Site Plan

Appendix – USCS Classification Chart
Log of Boring
Gain Size Distribution Curves

Western Geotechnical Consultants, Inc.

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Phone (360) 380-2507 • Fax (360) 380-2507

APPENDIX

Western Geotechnical Consultants, Inc.

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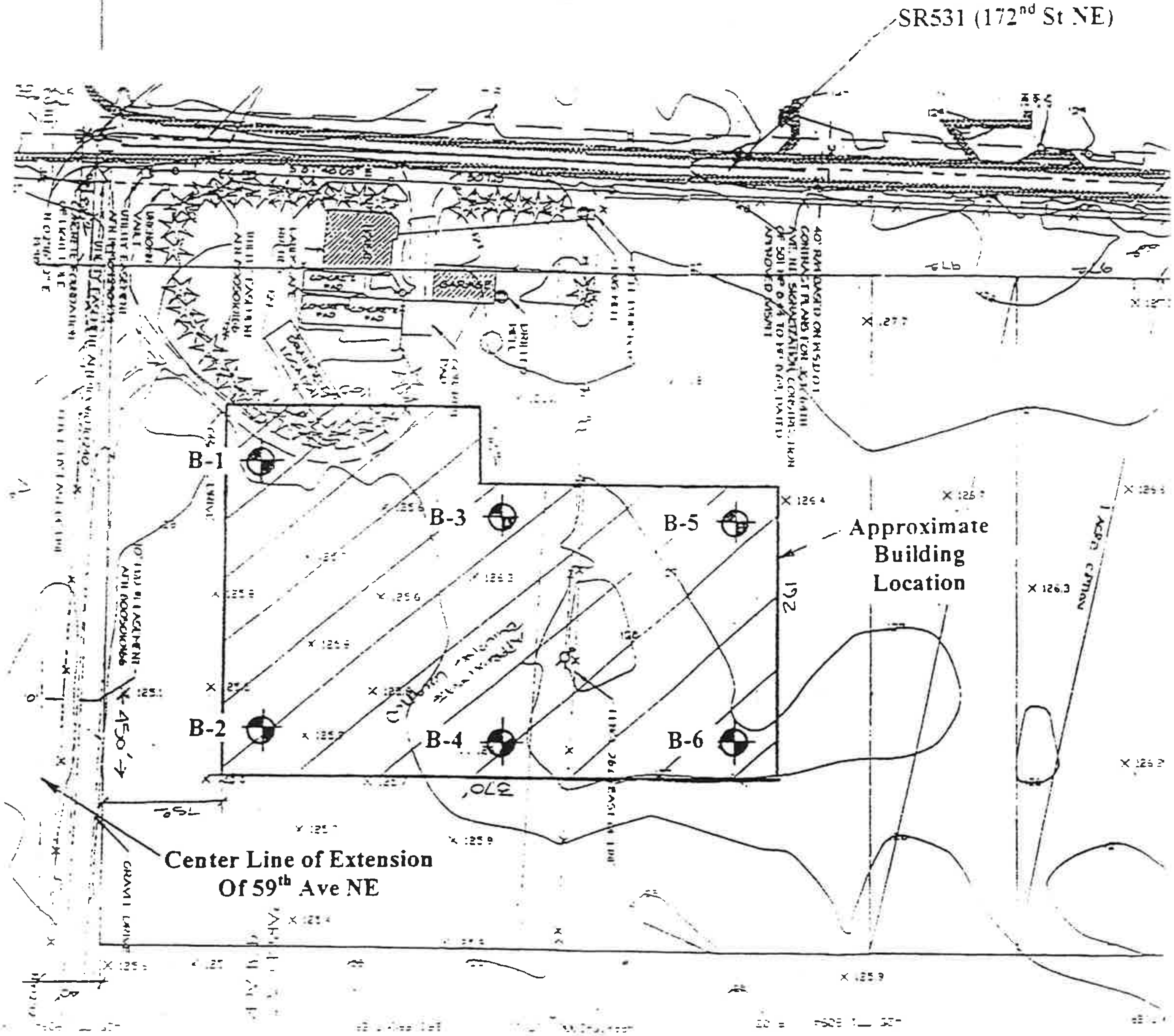
Figure 1

Site Plan & Boring Locations
Commercial Distribution Building
SE Corner of SR531 & 59TH Ave NE
Arlington, WA



Source:

BCF Frontier, Inc.
Lynnwood, WA

Key:

B-1 ⊕ **Boring Location**

UNIFIED SOIL CLASSIFICATION CHART (USCS)

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES) <5%	▦	GW	WELL-GRADED GRAVELS, GRAVEL SAND MIXTURES, LITTLE OR NO FINES
			▦	GP	POORLY-GRADED GRAVELS, GRAVEL SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION <u>RETAINED</u> ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES) <12%	▦	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			▦	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SANDS (LITTLE OR NO FINES) <5%	⁘	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF MATERIAL IS <u>LARGER</u> THAN NO. 200 SIEVE SIZE	MORE THAN 50% OF COARSE FRACTION <u>PASSING</u> NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES) <12%	▥	SM	SILTY SANDS, SAND-SILT MIXTURES
			▨	SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT <u>LESS</u> 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 SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT <u>GREATER</u> THAN 50	▥	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
MORE THAN 50% OF MATERIAL IS <u>SMALLER</u> THAN NO. 200 SIEVE SIZE			▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			▨	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			≈	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

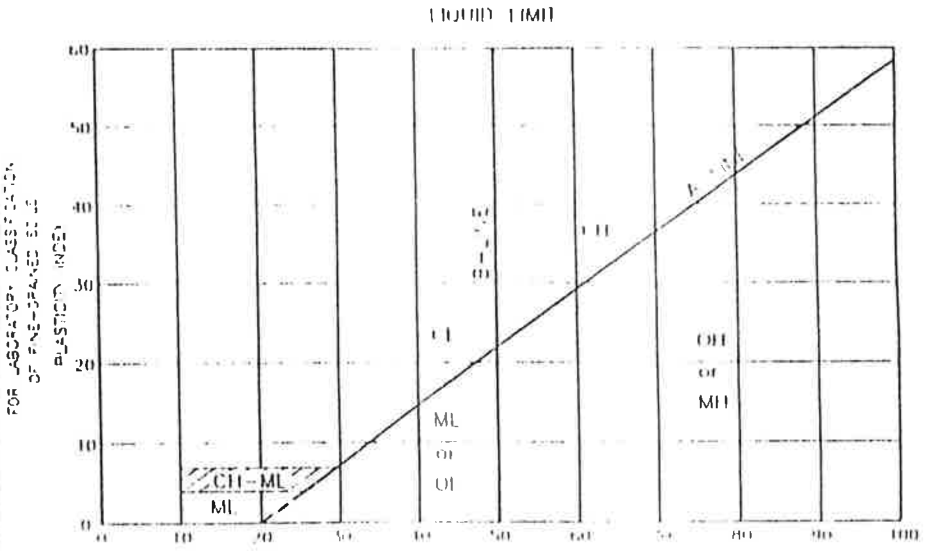
GRADATION CHART

MATERIAL SIZE		PARTICLE SIZE			
		LOWER LIMIT		UPPER LIMIT	
		MILLIMETERS	SIEVE SIZE	MILLIMETERS	SIEVE SIZE
SAND	FINE	0.074	#200 •	0.42	#40 •
	MEDIUM	0.42	#40 •	2.00	#10 •
	COARSE	2.00	#10 •	4.76	#4 •
GRAVEL	FINE	4.76	#4 •	19.1	3/4" •
	COARSE	19.1	3/4" •	76.2	3" •
COBBLES		76.2	3" •	304.8	12" •
BOULDERS		304.8	12" •	914.4	

• U.S. STANDARD • CLEAR SQUARE OPENINGS

5 - 12% FINES (SILT & CLAY) DUAL CLASS

PLASTICITY CHART



Western Geotechnical Consultants, Inc.

4181 Saltsprings Drive • Ferndale, WA 98248
Phone (360) 380-2507 • Fax (360) 380-2507

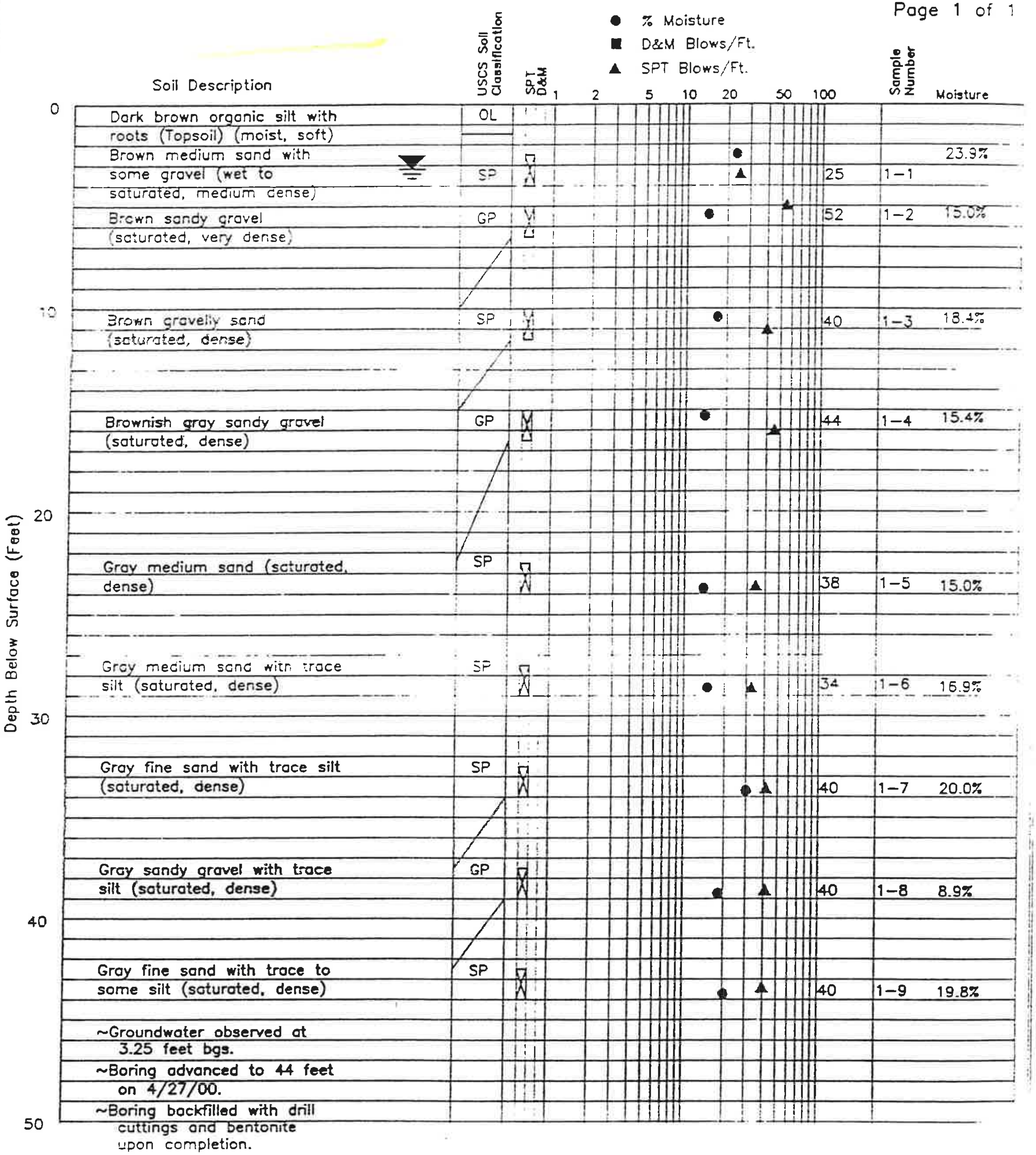
Key to Test Pit Logs Using the
Unified Soil Classification System

DATE 5/11/95
SCALE H: N/A
V: N/A

A:TEST PITS

Boring B-1
Page 1 of 1

● % Moisture
■ D&M Blows/Ft.
▲ SPT Blows/Ft.



Soil Description	USCS Soil Classification		Sample Number	Moisture
Dark brown organic silt with roots (Topsoil) (moist, soft)	OL			
Brown medium sand with some gravel (wet to saturated, medium dense)	SP	25	1-1	23.9%
Brown sandy gravel (saturated, very dense)	GP	52	1-2	15.0%
Brown gravelly sand (saturated, dense)	SP	40	1-3	18.4%
Brownish gray sandy gravel (saturated, dense)	GP	44	1-4	15.4%
Gray medium sand (saturated, dense)	SP	38	1-5	15.0%
Gray medium sand with trace silt (saturated, dense)	SP	34	1-6	16.9%
Gray fine sand with trace silt (saturated, dense)	SP	40	1-7	20.0%
Gray sandy gravel with trace silt (saturated, dense)	GP	40	1-8	8.9%
Gray fine sand with trace to some silt (saturated, dense)	SP	40	1-9	19.8%

~Groundwater observed at 3.25 feet bgs.

~Boring advanced to 44 feet on 4/27/00.

~Boring backfilled with drill cuttings and bentonite upon completion.

LOGGED BY: RPB
DRILLER: SUBTERRANEAN
DRILLING METHOD: M-R & HSA

DATE DRILLED: 4-27-00
HOLE DIAMETER: VARIED
HOLE DEPTH: SEE LOG

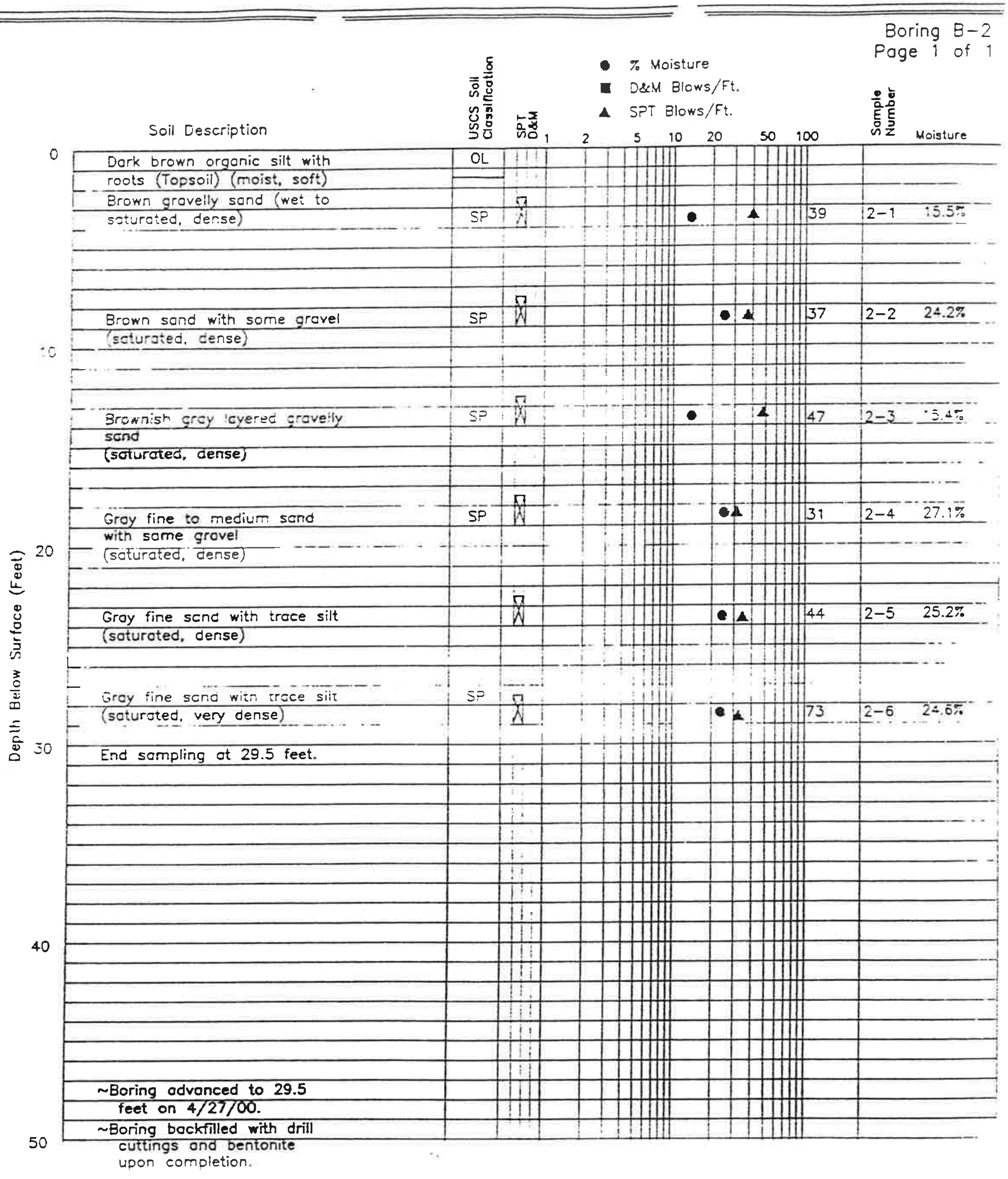
Soils classified visually using the Unified Soils Classification System. Please see USCS Key to Boring Logs for descriptions.

JOB NO.: N/A
DESIGNED BY: RPB
DRAWN BY: RPB
CHECKED BY: TAH

WESTERN GEOTECHNICAL CONSULTANTS, INC

BORING LOG B-I
CROWN DEVELOPMENT PROPERTY
ARLINGTON, WASHINGTON

DATE: 5/4/00
SCALE: H: N/A V: N/A



Soil Description	USCS Soil Classification		Sample Number	Moisture
Dark brown organic silt with roots (Topsoil) (moist, soft)	OL			
Brown gravelly sand (wet to saturated, dense)	SP	39	2-1	15.5%
Brown sand with some gravel (saturated, dense)	SP	37	2-2	24.2%
Brownish gray layered gravelly sand (saturated, dense)	SP	47	2-3	15.4%
Gray fine to medium sand with some gravel (saturated, dense)	SP	31	2-4	27.1%
Gray fine sand with trace silt (saturated, dense)		44	2-5	25.2%
Gray fine sand with trace silt (saturated, very dense)	SP	73	2-6	24.6%
End sampling at 29.5 feet.				

~Boring advanced to 29.5 feet on 4/27/00.

~Boring backfilled with drill cuttings and bentonite upon completion.

LOGGED BY: RPB
DRILLER: SUBTERRANEAN
DRILLING METHOD: HSA

DATE DRILLED: 4-27-00
HOLE DIAMETER: 8-INCH
HOLE DEPTH: SEE LOG

Soils classified visually using the Unified Soils Classification System. Please see USCS Key to Boring Logs for descriptions.

JOB NO.: N/A
DESIGNED BY: RPB
DRAWN BY: RPB
CHECKED BY: TAH

WESTERN GEOTECHNICAL CONSULTANTS, INC

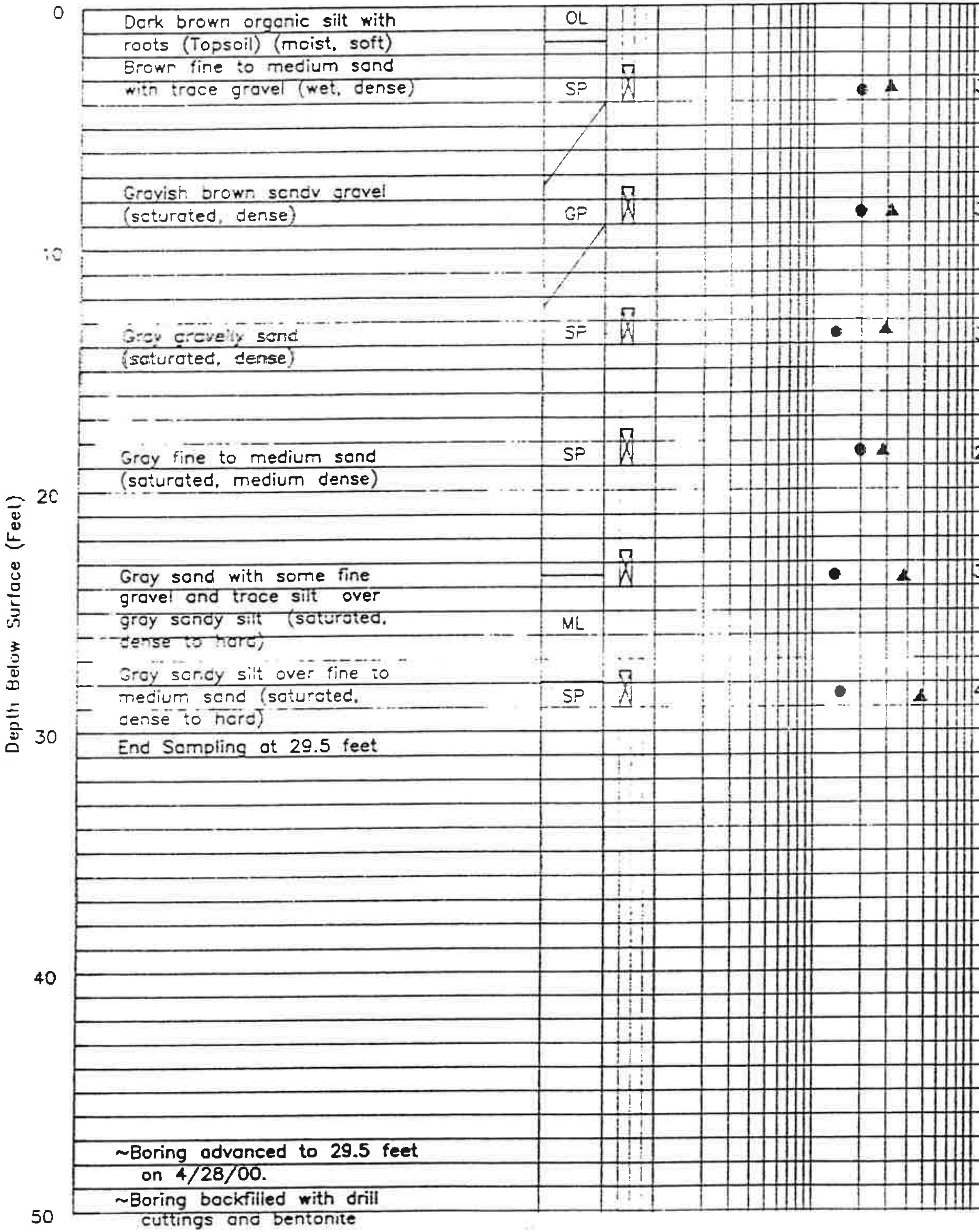
BORING LOG B-2
CROWN DEVELOPMENT PROPERTY
ARLINGTON, WASHINGTON

DATE: 5/4/00
SCALE: H: N/A V: N/A

Boring B-3
Page 1 of 1

● % Moisture
■ D&M Blows/Ft.
▲ SPT Blows/Ft.

Soil Description	USCS Soil Classification	SPT D&M		Sample Number	Moisture
Dark brown organic silt with roots (Topsoil) (moist, soft)	OL				
Brown fine to medium sand with trace gravel (wet, dense)	SP		32	3-1	20.4%
Grayish brown sandy gravel (saturated, dense)	GP		33	3-2	19.9%
Gray gravelly sand (saturated, dense)	SP		30	3-3	15.7%
Gray fine to medium sand (saturated, medium dense)	SP		28	3-4	20.9%
Gray sand with some fine gravel and trace silt over gray sandy silt (saturated, dense to hard)	ML		38	3-5	15.9%
Gray sandy silt over fine to medium sand (saturated, dense to hard)	SP		47	3-6	16.0%
End Sampling at 29.5 feet					



~Boring advanced to 29.5 feet on 4/28/00.

~Boring backfilled with drill cuttings and bentonite upon completion.

LOGGED BY: RPB
DRILLER: SUBTERRANEAN
DRILLING METHOD: HSA

DATE DRILLED: 4-28-00
HOLE DIAMETER: 8-INCH
HOLE DEPTH: SEE LOG

Soils classified visually using the Unified Soils Classification System. Please see USCS Key to Boring Logs for descriptions.

JOB NO.: N/A
DESIGNED BY: RPB
DRAWN BY: RPB
CHECKED BY: TAH

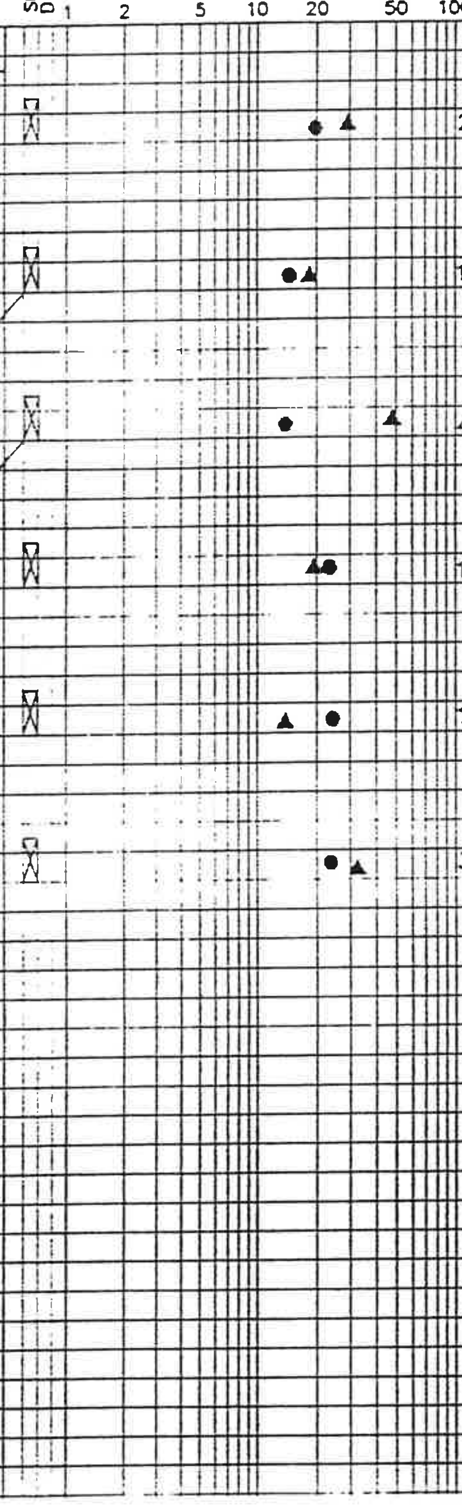
WESTERN GEOTECHNICAL CONSULTANTS, INC

BORING LOG B-3
CROWN DEVELOPMENT PROPERTY
ARLINGTON, WASHINGTON

DATE: 5/4/00
SCALE: H: N/A V: N/A

Boring B-4
Page 1 of 1

● % Moisture
■ D&M Blows/Ft.
▲ SPT Blows/Ft.



Soil Description	USCS Soil Classification		Sample Number	Moisture
Dark brown organic silt with roots (Topsoil) (moist, soft)	OL			
Brown medium sand (wet to saturated, dense)	SP	23	4-1	20.7%
Brownish gray sand with some fine gravel (saturated, medium dense)	SP	18	4-2	16.6%
Gray gravelly sand with slight layering of sand and gravel (saturated, dense)	GP	47	4-3	13.4%
Gray fine and medium sand, layered (saturated, medium dense)	SP	19	4-4	20.6%
Gray fine sand with trace silt and gravel (saturated, medium dense)	SP	15	4-5	22.5%
Gray medium sand with occasional gravel (saturated, dense)	SP	31	4-6	22.2%
End Sampling at 29.5 feet				

~Groundwater observed at 3.5 feet bgs.

~Boring advanced to 29.5 feet on 4/28/00.

~Boring backfilled with drill cuttings and bentonite upon completion.

LOGGED BY: RPB
DRILLER: SUBTERRANEAN
DRILLING METHOD: HSA

DATE DRILLED: 4-28-00
HOLE DIAMETER: 8-INCH
HOLE DEPTH: SEE LOG

Soils classified visually using the Unified Soils Classification System. Please see USCS Key to Boring Logs for descriptions.

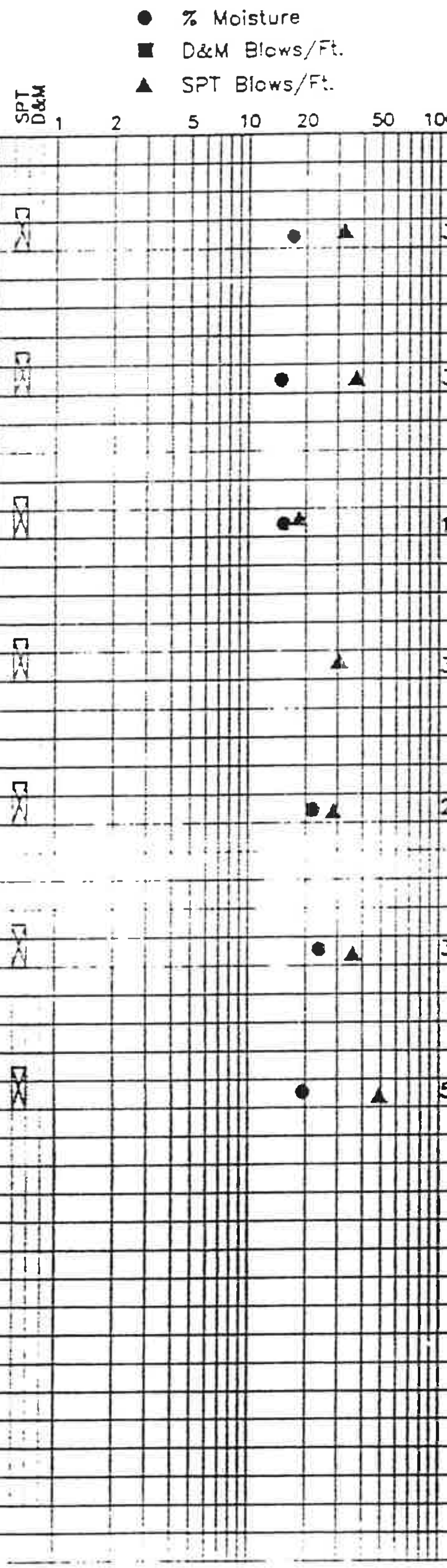
JOB NO.:	N/A
DESIGNED BY:	RPB
DRAWN BY:	RPB
CHECKED BY:	TAH

WESTERN GEOTECHNICAL CONSULTANTS, INC

BORING LOG B-4
CROWN DEVELOPMENT PROPERTY
ARLINGTON, WASHINGTON

DATE: 5/4/00
SCALE: H: N/A V: N/A

Boring B-5
Page 1 of 1



Depth Below Surface (Feet): 0, 10, 20, 30, 40, 50

Soil Description	USCS Soil Classification	SPT D&M		Sample Number	Moisture
Dark brown organic silt with roots (Topsoil) (moist, soft)	OL				
Brown medium sand over sandy gravel (wet to saturated, dense)	SP GP		31	5-1	18.0%
Gray gravelly sand with (saturated, dense)	SP		37	5-2	15.4%
Gray fine to medium sand with some gravel (saturated, medium dense)	SP		19	5-3	16.9%
Gray fine to medium sand (saturated, dense)	SP		31	5-4	
Gray fine to medium sand with trace silt (saturated, medium dense)	SP		28	5-5	20.8%
Gray layered fine sand with silt and medium sand with trace gravel (saturated, dense)	SP		38	5-6	22.8%
Gray fine to medium sand with trace silt (saturated, very dense)	SP		50	5-7	19.9%
End Sampling at 34 feet					

~Groundwater observed at 3.25 feet bgs.

~Boring advanced to 34 feet on 4/28/00.

~Boring backfilled with drill cuttings and bentonite upon completion.

LOGGED BY: RPB
DRILLER: SUBTERRANEAN
DRILLING METHOD: HSA

DATE DRILLED: 4-28-00
HOLE DIAMETER: 8-INCH
HOLE DEPTH: SEE LOG

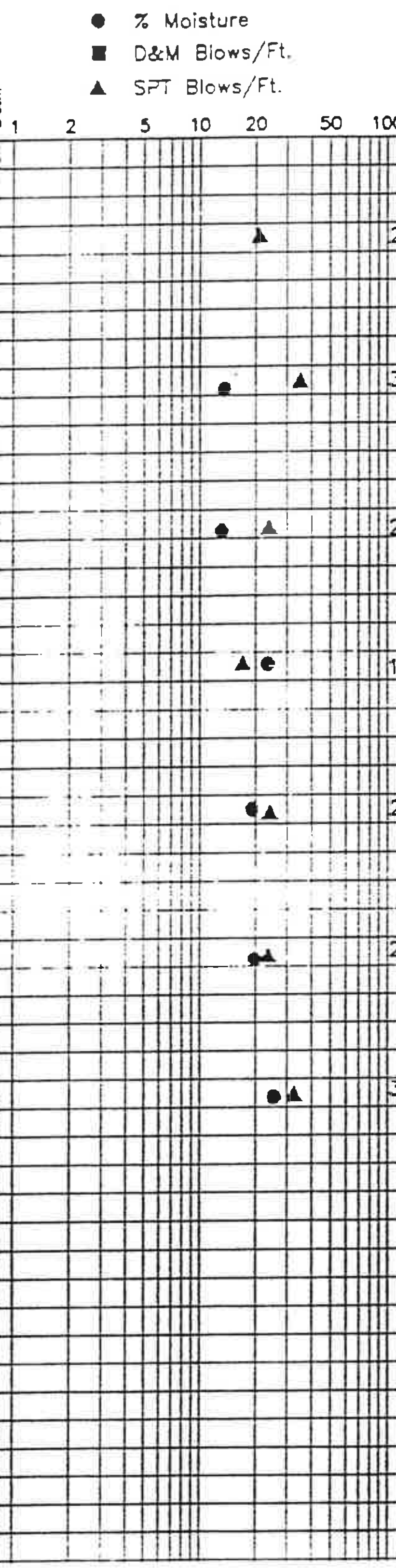
Soils classified visually using the Unified Soils Classification System. Please see USCS Key to Boring Logs for descriptions.

JOB NO.: N/A
DESIGNED BY: RPB
DRAWN BY: RPB

WESTERN GEOTECHNICAL CONSULTANTS, INC

BORING LOG B-5
CROWN DEVELOPMENT PROPERTY
ARLINGTON, WASHINGTON

Boring B-6
Page 1 of 1



Depth Below Surface (Feet): 0, 10, 20, 30, 40, 50

Soil Description	USCS Soil Classification	SPT D&M	Blows/Ft.	Sample Number	Moisture
Dark brown organic silt with roots (Topsoil) (moist, soft)	OL				
Brown medium sand over gravelly sand (wet, medium dense)	SP	SPT	21	6-1	
Grayish brown sandy gravel (saturated, dense)	GP	SPT	34	6-2	14.0%
Grayish brown sandy gravel with some silt (saturated, medium dense)	GP	SPT	23	6-3	13.8%
Gray fine to coarse sand with occasional gravel (saturated, medium dense)	SP	SPT	17	6-4	22.7%
Gray fine sand with trace silt (saturated, dense)	SP	SPT	24	6-5	22.3%
Gray fine sand with trace silt (saturated, dense)	SP	SPT	22	6-5	20.1%
Gray fine to medium sand with trace silt (saturated, dense)	SP	SPT	36	6-6	24.0%
End Sampling at 34.0 feet					

~Boring advanced to 34 feet on 4/28/00.

~Boring backfilled with drill cuttings and bentonite upon completion.

LOGGED BY: RPB
DRILLER: SUBTERRANEAN
DRILLING METHOD: HSA

DATE DRILLED: 4-28-00
HOLE DIAMETER: 8-INCH
HOLE DEPTH: SEE LOG

Soils classified visually using the Unified Soils Classification System. Please see USCS Key to Boring Logs for descriptions.

JOB NO.: N/A
DESIGNED BY: RPB
DRAWN BY: RPB
CHECKED BY: TAH

WESTERN GEOTECHNICAL CONSULTANTS, INC

BORING LOG B-6
CROWN DEVELOPMENT PROPERTY
ARLINGTON, WASHINGTON

DATE: 5/4/00
SCALE: H: N/A V: N/A

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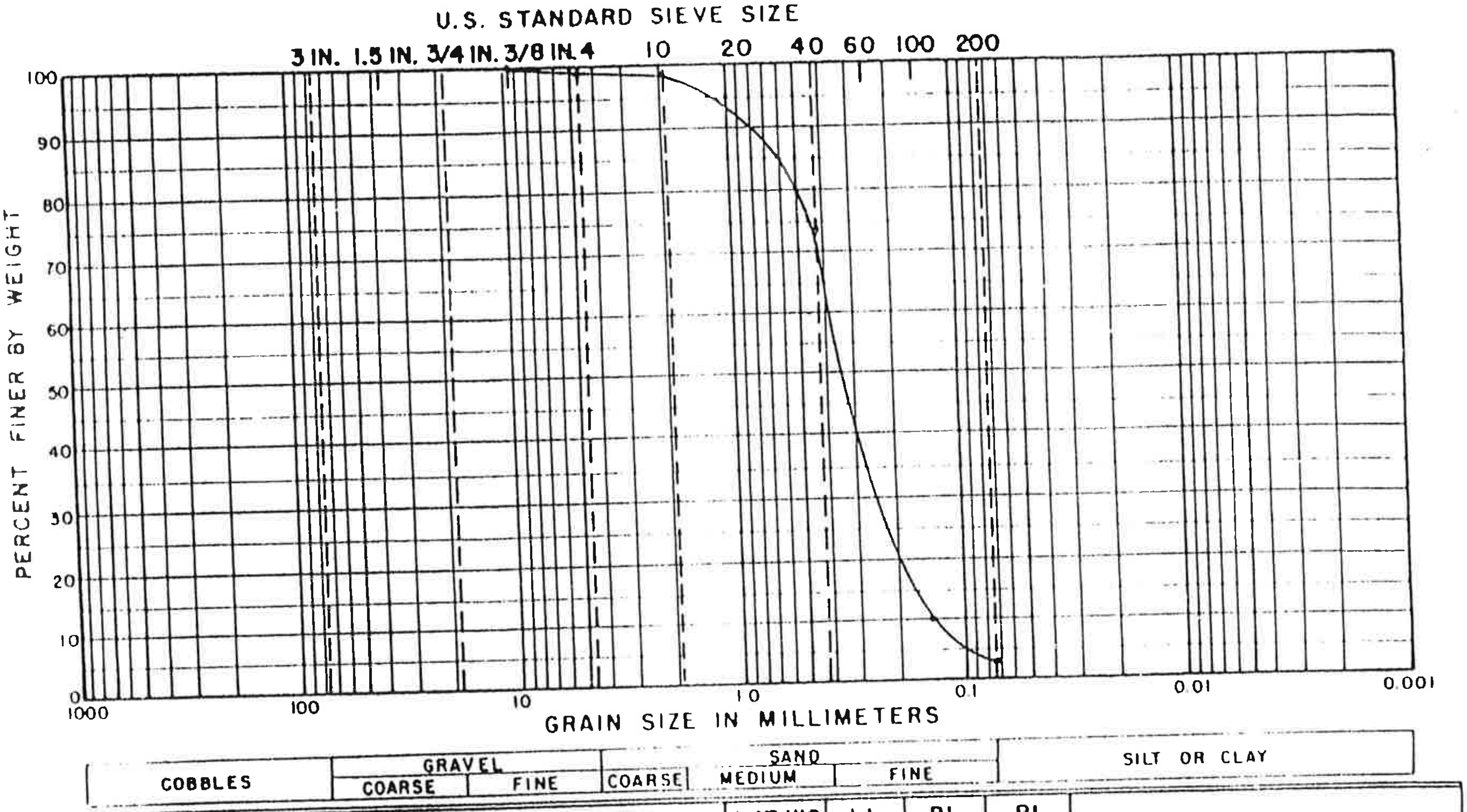

Boring	DEPTH	CLASSIFICATION		NAT. WC	LL	PL	PI	
B-2	22.5'	SP	Fine to Medium SAND					

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GRADATION CURVE

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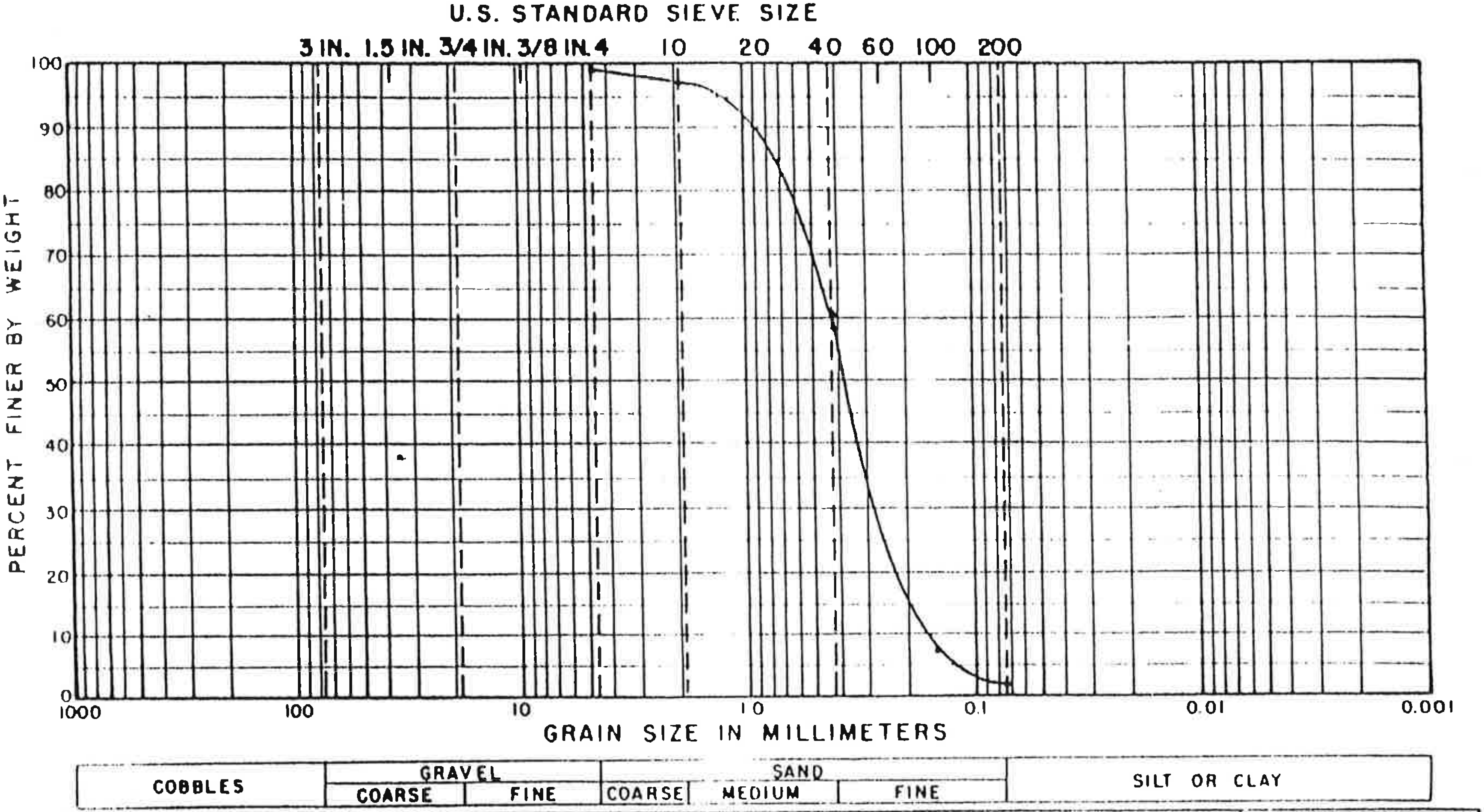

Boring	DEPTH	CLASSIFICATION		NAT. WC	LL	PL	PI	
B-3	17.5'	SP	Fine to Medium SAND					

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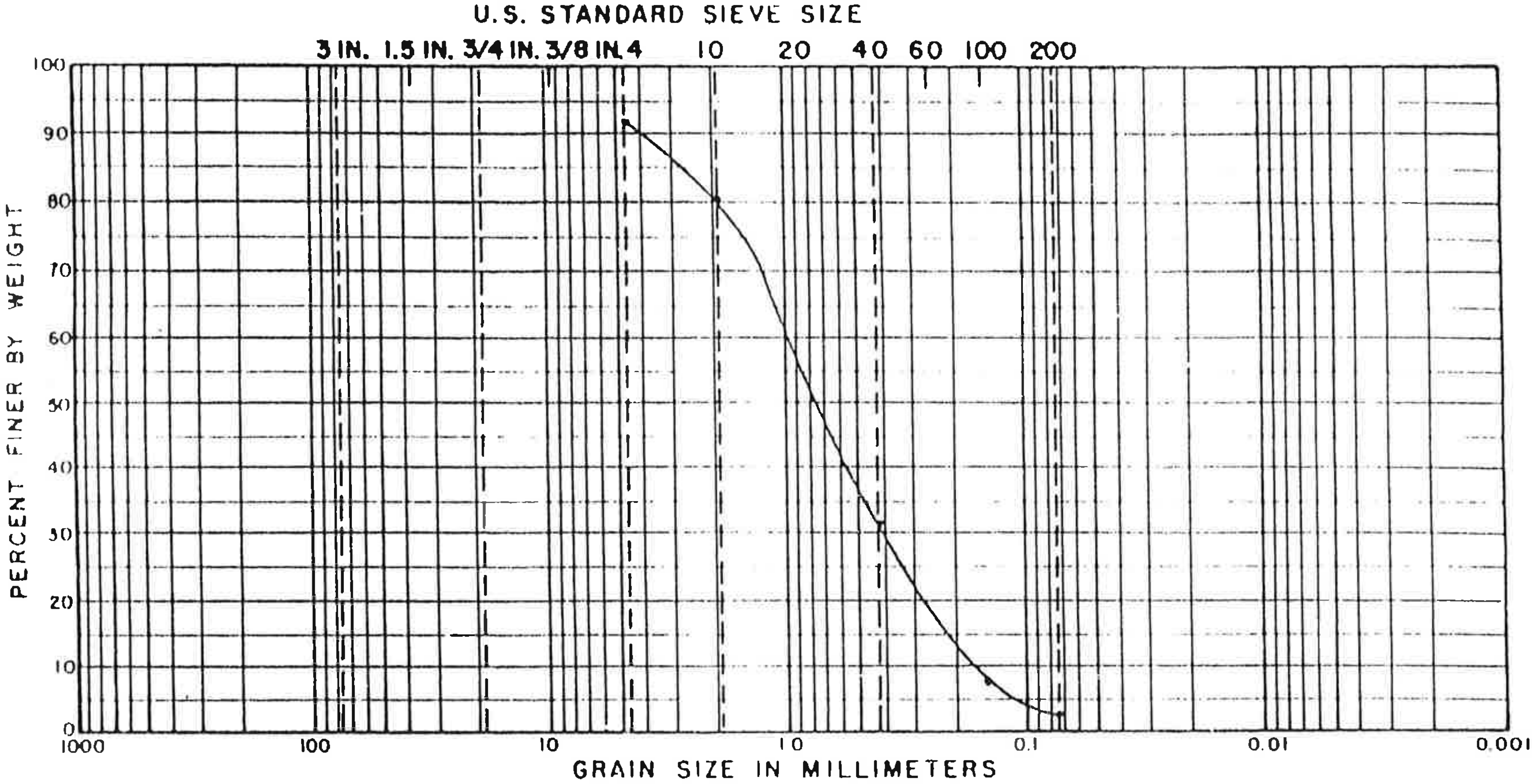

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Boring	DEPTH	CLASSIFICATION		NAT. WC	LL	PL	PI	
B-4	17.5'	SP	SAND, Trace gravel					

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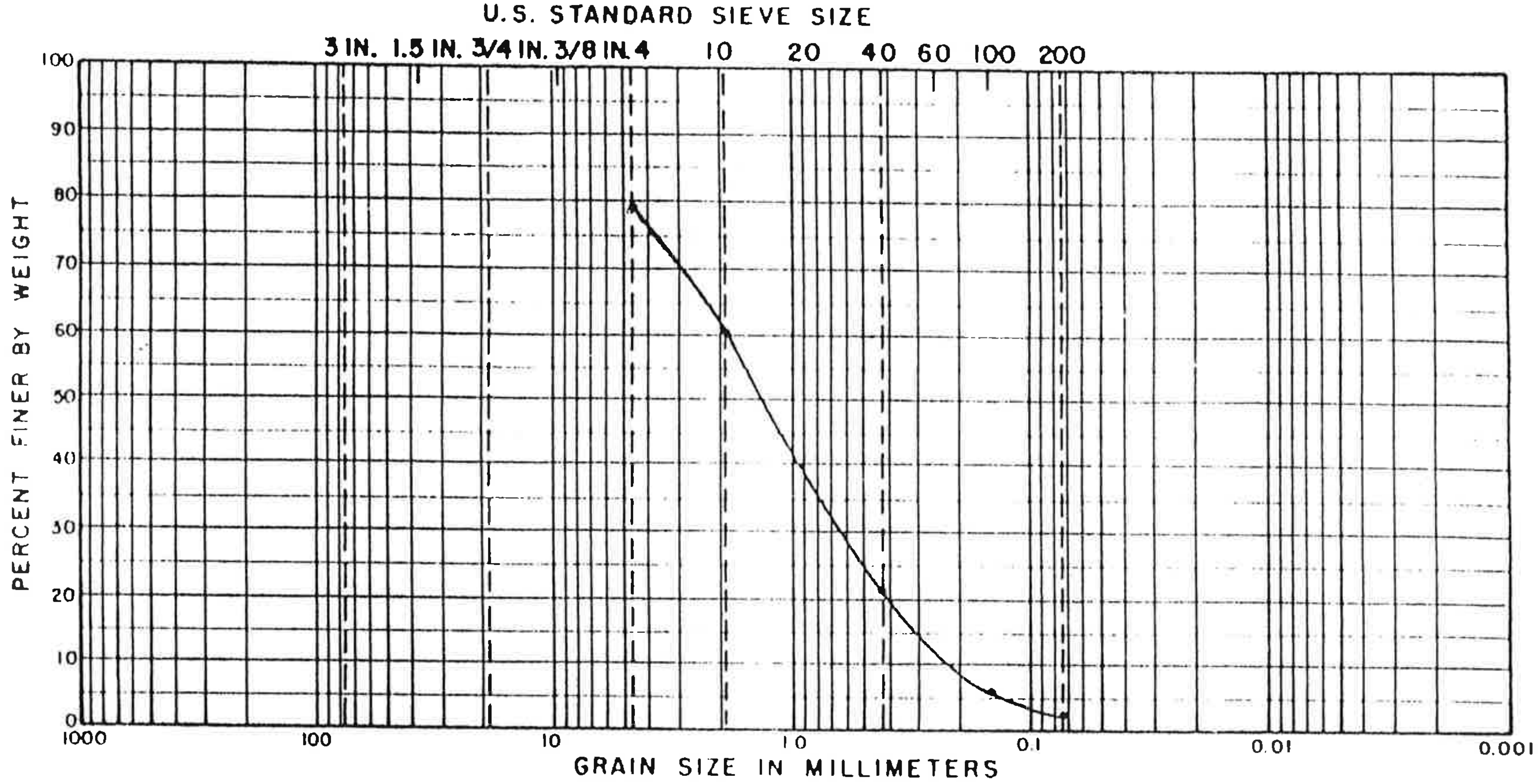

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Boring	DEPTH	CLASSIFICATION		NAT. WC	LL	PL	PI	
B-5	12.5'	SP	Gravelly SAND					

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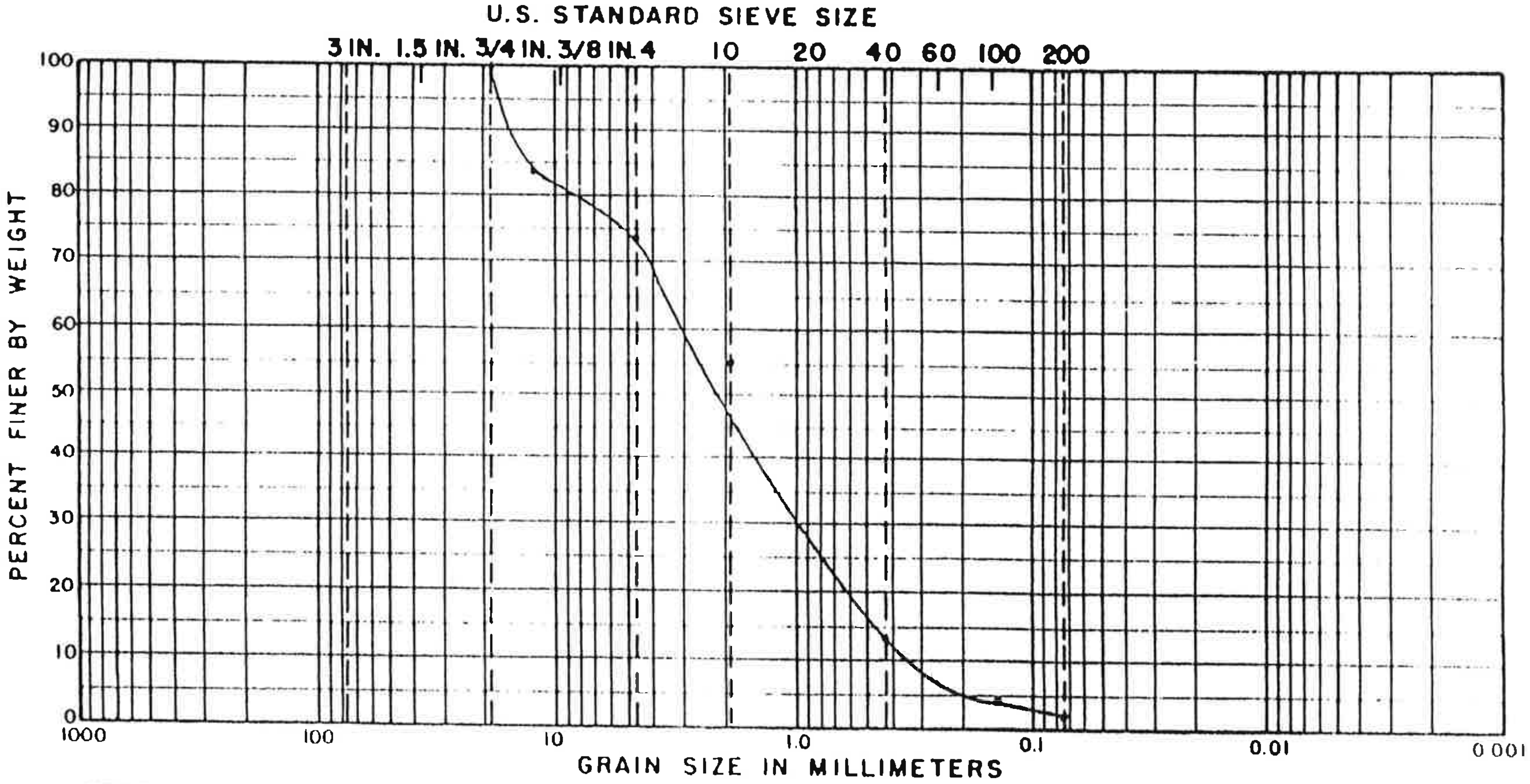

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Boring	DEPTH	CLASSIFICATION		NAT. WC	LL	PL	PI	
B-6	7.5'	SP	Gravelly SAND					

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GRADATION CURVE

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December 4, 1999

Crown Developmnt
3409 McDougal Avenue
Everett, WA 98210

Re: Geotechnical Investigation
Storm Water Detention Facilities and General Site Development Criteria
Roetcisoender and Parkinson Properties
SW Corner of Intersection of SR531 and 67th Ave. NE
Arlington, WA

Western Geotechnical Consultants, Inc. is pleased to present the results of our subsurface site investigation conducted at the above referenced property. On October 22, 1999 a geotechnical engineer from our firm traveled to the site to oversee the excavation of 7 test pits across the property. The site occupies 101.70 acres and a 660 X 660 (10-acre) portion of the site along the west side of the property is being considered for storm water detention facilities. The detention facility area is located immediately to the southeast of the intersection of SR 531 and 59th Ave NE. Figure 1 is a site plan showing the general property layout together with the approximate test pit locations

The purpose of our investigation was to obtain subsurface soil and groundwater information for use in evaluating the feasibility of constructing detention facilities on the site and to obtain information for general site development. Specifically the scope of our services included:

- Excavating and logging seven test pits, 4 of which were within the 10-acre potential detention pond location and 3 additional test pits across the site to determine soil and groundwater variability. We also excavated test pits on adjacent properties to gain greater coverage of soil and groundwater conditions.
- Developing continuous logs of subsurface soil and groundwater conditions encountered. Soils encountered were classified in accordance with the Unified Soils Classification System (USCS).
- Perform engineering analysis and laboratory testing as deemed necessary in developing our conclusions and recommendations.
- Preparation of this report including a summary of work performed and our conclusions and recommendations regarding detention pond design parameters and general geotechnical issues associated with development of the site.

Site Conditions

Surface Conditions

The site is relatively flat, and the property is approximately 101.7 acres in size. The property is mostly grass covered with some low bush (blackberries) and occupied houses near the northwest and northeast corners of the property. Figure 1 is a site plan showing the site layout together with our test pit locations and other relevant site features.

Subsurface Conditions

Subsurface conditions were evaluated by excavating a total of seven test pits to a maximum depth of 9.0 feet at the approximate locations shown on the Site Plan, Figure 1. Soils encountered were classified using the Unified Soils Classification System (USCS) and a continuous log of soil and ground water conditions were maintained for each test pit. Edited, tabulated test pit logs are attached to this report, together with a description of the Unified Soils Classification System. The test pits revealed a relatively uniform subsurface soil profile across the site consisting of 0.9 to 1.4 feet of organic SILT and roots (topsoil) over 1 to 3 feet of silty SAND with variable amounts of gravel (SM by Unified Soils Classification System (USCS)) Under this layer was relatively clean, fine to coarse SAND with trace to some gravel (SP by USCS) to the depth of the explorations. The SP soils were typically moist grading wet with a static water table measured at 3.7 to 6.6 feet below the ground surface.

Ground Water

Piezometers were installed in each of the test pits, and piezometric readings were taken on November 12, 1999 at test pits 1 through 4 (the proposed detention basin location). Groundwater was encountered in all of the explorations at depths ranging from 3.7 to 6.6 feet below ground surface. Within the 10-acre detention basin area the water table varied between 3.7 and 6.6 feet (see Test Pits 1-4). The piezometers were read after significant rainfall had occurred. Additional readings will be taken throughout the winter, but values recorded for test pits 1 through 4 are anticipated to be close to the seasonal high water table. Regarding the proposed detention basin area, the water table is deepest along the north side, becoming shallower to the south. The remainder of the 101.70 acre site appears to become much shallower to the east rising to 4 feet below the ground surface at Test Pit 7 (see Figure 1). Piezometers were installed in each of the test pits for future monitoring of the groundwater elevation The piezometers will be used to establish the seasonal high water table

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Conclusions and Recommendations

General

Based on our geotechnical engineering investigation, we conclude that the site will likely be suitable for development of the type proposed, provided our recommendations are followed and provided good construction practices are followed. The area contains a relatively high groundwater table, which is problematic for storm water detention facilities. Adjacent to 172nd St. NE (north side of property) the water table appears to be around 6 feet below the ground surface. This value will be verified through additional piezometer readings this winter. Our preliminary information suggests that storm water facilities should be relocated to along the north side of the property, oriented in the east-west direction. The following sections provide recommended soil and groundwater parameters for stormwater detention design and general site development.

Stormwater Detention

The subject property is relatively flat and it covers over 100 acres. The proposed stormwater control location is the westernmost 10 acres of the site though it appears that the facility should be shifted to the north. We excavated a total of 4 test pits within the proposed storm water control area along with 3 additional test pits across the remainder of the site. Piezometers were installed in all of the test pits for future monitoring of groundwater. The groundwater table at the time of our investigation (October 22, 1999) was logged at 6.7 to 7.8 feet below grade. Subsequent piezometer readings (November 12, 1999) revealed that the water table in the proposed storm water location (west side) varies between 3.7 towards the south and 6.6 feet towards the north.

The piezometers are intended to demonstrate the seasonal high water level. Once the seasonal high water level has been established, we may be retained to perform field infiltration tests at the design base elevation of the detention facilities, which is required to be 3 feet above the seasonal high groundwater level. Based on the test results, recommended infiltration rates for use in design of storm water facilities will be issued under a separate report.

Western Geotechnical Consultants, Inc.

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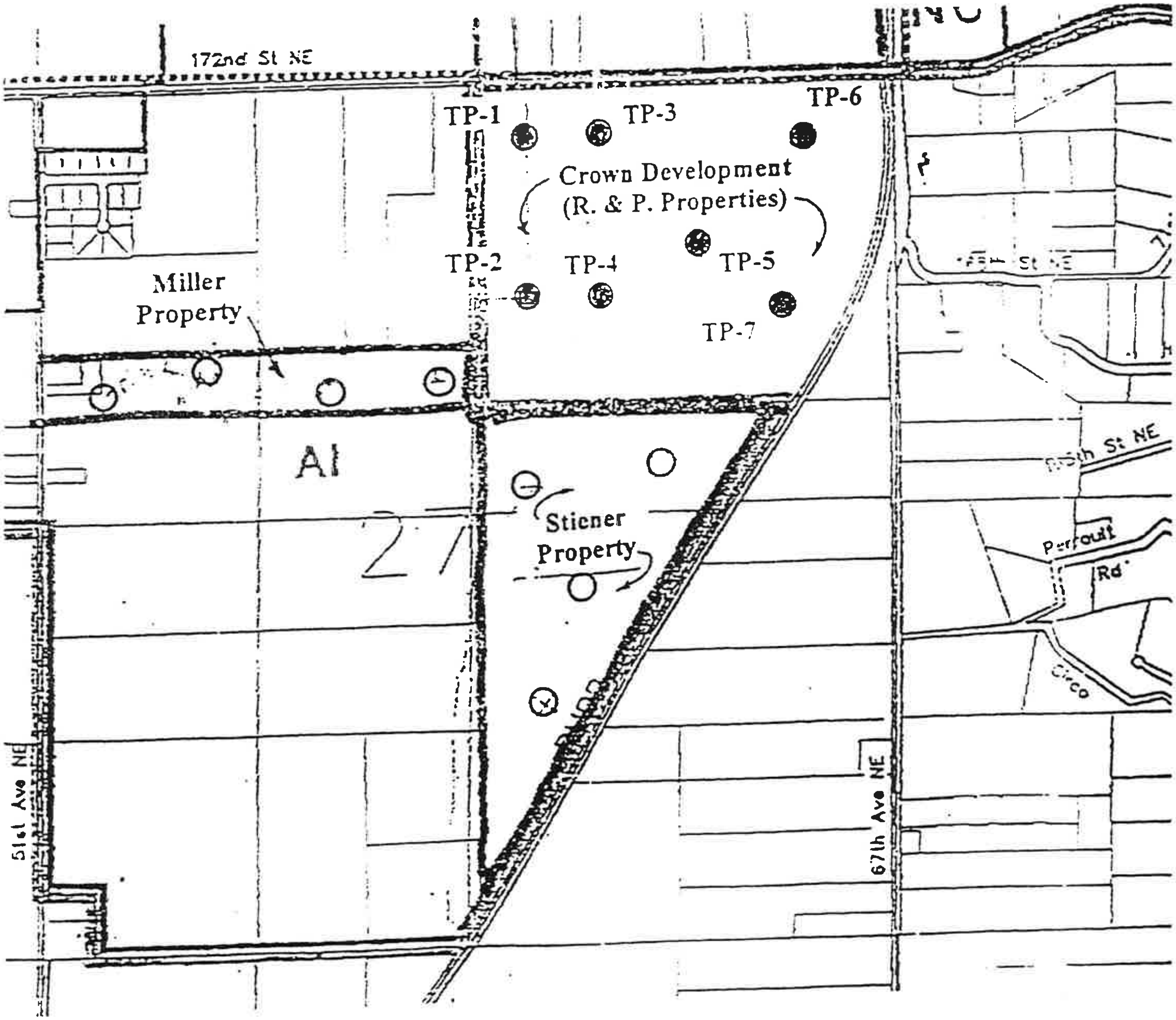
North

Figure 1

Site Plan
Crown Development
Roetcisoender & Parkinson Properties
Arlington, WA



Drainage

We recommend that an exterior footing drain system be constructed around the perimeter of all building foundations. The footing drain system is typically constructed with a perforated or slotted pipe placed in clean, free-draining gravel with less than 3% by weight passing the U.S. No. 200 sieve size, based on a wet sieve analysis of that portion passing the U.S. No. 4 Sieve. The perforated or slotted pipe should be placed at or below the level of the base of the footings and 1/2 foot outside the footings.

The footing drains should discharge to the storm drainage system. Roof drainage must not be introduced into the perimeter footing drain, but should be discharged separately to the storm drainage system by tightline. The final ground surface should be graded away from the buildings to promote surface runoff away from the footing drain system.

We appreciate the opportunity to be of assistance to you on this project. If you have any questions regarding the contents of this report, or if we can be of further assistance, please contact our office.

Sincerely,

Western Geotechnical Consultants, Inc.

Theodore A. Hammer, P.E.
Geotechnical Engineer

Attachment: Figure 1, Site Plan Sketch
USCS Classification Chart
Tabulated Test Pit Logs

cc: Higa Engineering, Inc.

File:991451

General Site Development

The site is large and it contains a relatively high groundwater table. The seasonal high groundwater level is yet to be determined but is expected to be considerably less than 6 feet below grade in building and parking areas. We make the following general site development recommendations in addition to stormwater detention.

Site Preparation

All topsoil or other organic or soft material must be striped away from areas to be occupied by building foundations, paved areas, or other structural improvements. Based on our test pit explorations, we estimate that the stripping depth will be 1 to 1-1/4 feet. Note that there could be isolated areas with deeper pockets of organic material (root balls, etc.) or soft soils beneath structures that we did not encounter in our very limited test pit investigation.

Fill and Compaction

We have assumed that some structural fill may be required beneath structures and/or paved areas. Structural fill may be required to obtain proper elevation for the design of storm water detention facilities. Structural fill used to obtain final grade elevations for footings and other structural improvements (pavements, floor slabs, etc.), must be properly placed and compacted.

Structural fill is defined as any non-organic, predominantly granular soil that is placed in maximum 8- to 10- inch loose, horizontal lifts and compacted to 95% of maximum dry density as determined by the ASTM D-1557 test procedure. The on-site native sandy soils could be used as structural fill provided the moisture content can be properly controlled and adequate compaction can be achieved.

Foundation

The on site soils will support moderately light structures using conventional shallow spread footings. Typical 1 to 2 story structures without heavy column loads would be considered moderately light structures. Due to the limited depth and coverage of our test pits, an evaluation of foundations for heavily loaded structures was beyond the scope of this study. Test pit coverage was not extensive since the site layout is still in the preliminary planning state. Once plan specifications are known, it may be necessary to excavate additional test pits at known building locations or drill borings if heavy foundation loads will be part of the design.

UNIFIED SOIL CLASSIFICATION CHART (USCS)

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS **LARGER** THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION **RETAINED** ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES) <5%	◯	GW	WELL-GRADED GRAVELS, GRAVEL SAND MIXTURES, LITTLE OR NO FINES
			◯	GP	POORLY-GRADED GRAVELS, GRAVEL SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES) <12%	◯	GM	SILTY GRAVELS, GRAVEL-SAND SILT MIXTURES
			◯	GC	CLAYEY GRAVELS, GRAVEL SAND CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION **PASSING** NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES) <5%	⁘	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			⁘	SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES) <12%	▥	SM	SILTY SANDS, SAND-SILT MIXTURES
			▨	SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS **SMALLER** THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT **LESS** THAN 50	▥	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS NO CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▥	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT **GREATER** THAN 50	▥	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			▨	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			░	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENT

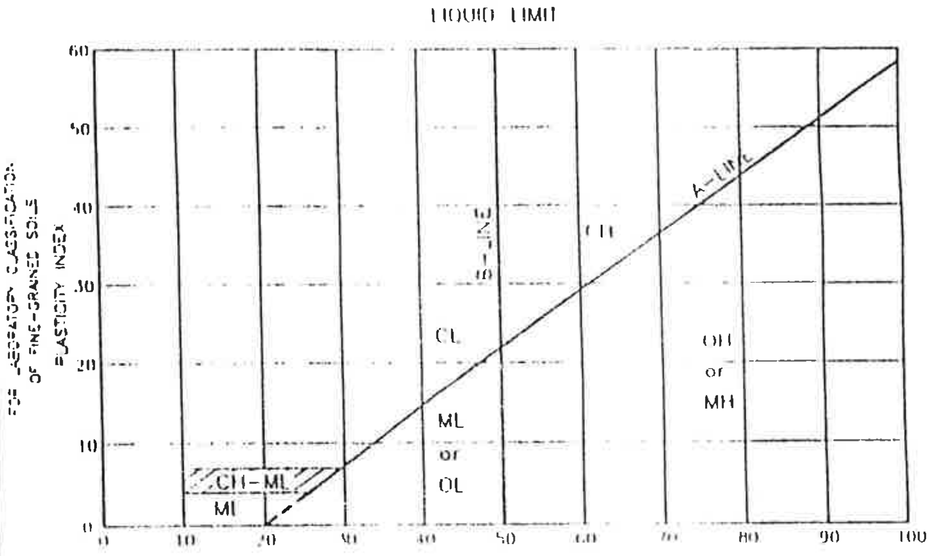
GRADATION CHART

MATERIAL SIZE		PARTICLE SIZE			
		LOWER LIMIT		UPPER LIMIT	
		MILLIMETERS	SIEVE SIZE	MILLIMETERS	SIEVE SIZE
SAND	FINE	0.074	#200 •	0.42	#40 •
	MEDIUM	0.42	#40 •	2.00	#10 •
	COARSE	2.00	#10 •	4.76	#4 •
GRAVEL	FINE	4.76	#4 •	19.1	3/4" •
	COARSE	19.1	3/4" •	76.2	3" •
COBBLES		76.2	3" •	304.8	12" •
BOULDERS		304.8	12" •	914.4	

• U.S. STANDARD • CLEAR SQUARE OPENINGS

5–12% FINES (SILT & CLAY) DUAL CLASS

PLASTICITY CHART



Western Geotechnical Consultants, Inc.

4181 Saltsprings Drive • Ferndale, WA 98248
Phone (360) 380-2507 • Fax (360) 380-2507

Key to Test Pit Logs Using the
Unified Soil Classification System

DATE: 5/11/95
SCALE: [illegible]
Y. IVA

A-TEST PITS.

Table A-1
Log of Test Pits

file:991451
Crown Distribution

Test Pit No.	Depth Interval (feet)	USCS Class	Soil Description	Sample No./ Depth (feet)	Water Content (%)	Pocket Pen. (Kg/sq. cm)
TP-1	0.0-1.2	OL	Dark brown sandy organic SILT and roots (soft, slightly moist) (topsoil)			
	1.2-2.8	SM	Brown silty fine to medium SAND (relatively compact, slightly moist)	1-1/2.0	7.9%	
	2.8-5.0	SP	Gray fine to medium SAND, trace gravel (relatively compact, slightly moist)	1-2/4.0	6.2%	
	5.0-9.0	SP/SW	Gray gravelly fine to coarse SAND (wet) (seepage at 7.8 feet)	1-3/6.0	13.8%	

Notes:

- Test Pit terminated on 10/22/99 at 9.0 feet
- Test Pit backfilled upon completion
- Groundwater encountered at 7.8 feet on 10/22/99.
- Piezometer installed
- Water level measured at 6.6 feet on 11/12/99.

Table A-1
Log of Test Pits

file:991451

Test Pit No.	Depth Interval (feet)	USCS Class.	Soil Description	Sample No./ Depth (feet)	Water Content (%)	Pocket Pen. (Kg/sq. cm)
TP-2	0.0-1.3	OL	Dark brown sandy organic SILT (soft, slightly moist) (topsoil)			
	1.3-3.0	SM	Brown silty fine to medium SAND (relatively compact, slightly moist)			
	3.0-8.0	SP	Gray fine to medium SAND, trace gravel (relatively compact, slightly moist) (wet at 5 feet) (increased gravel at 7 feet) (seepage at 7.0 feet)	2-1/3.4 2-2/5.0 2-3/7.3	4.0% 11.9% 15.7%	

Notes:

- Test Pit terminated on 10/22/99 at 8.0 feet
- Test Pit backfilled upon completion
- Groundwater encountered at 7.0 feet on 10/22/99
- Piezometer installed
- Water level measured at 4.0 feet on 11/12/99

file:991451

Table A-1

Log of Test Pits

Test Pit No.	Depth Interval (feet)	USCS Class.	Soil Description	Sample No./ Depth (feet)	Water Content (%)	Pocket Pen. (Kg/sq. cm)
TP-3	0.0-1.4	OL	Dark brown sandy organic SILT (soft, slightly moist) (topsoil)			
	1.4-2.4	SM	Brown silty fine SAND (moist, relatively compact)	3-1/2.0	7.8%	
	2.4-8.8	SP	Gray fine to medium SAND, trace gravel (relatively compact, slightly moist) (increase gravel at 4-1/2 feet) (grades wet at 6.3 feet) (seepage at 7.7 feet) (gravelly zones)	3.2/3.5 3-3/6.6	6.8% 9.1%	

Notes:

- Test Pit terminated on 10/22/99 at 8.8 feet
- Test Pit backfilled upon completion
- Groundwater encountered at 7.7 feet on 10/22/99
- Piezometer installed
- Water level measured at 6.1 feet on 11/12/99

file:991451

Table A-1

Log of Test Pits

Test Pit No.	Depth Interval (feet)	USCS Class.	Soil Description	Sample No./ Depth (feet)	Water Content (%)	Pocket Pen. (Kg/sq. cm)
TP-4	0.0-0.9	OL	Dark brown sandy organic SILT (soft, slightly moist) (topsoil)			
	0.9-3.6	SM	Brown fine to medium SAND with some silt (relatively compact, slightly moist)			
	3.6-7.0	SP	Gray fine to medium SAND, trace gravel (relatively compact, moist) (grades wet at 5.5 feet) (increased gravel) (seepage at 6.7 feet)	4-1/3.9 4-2/5.6	6.3% 10.2%	

Notes:

- Test Pit terminated on 10/22/99 at 7.1 feet
- Test Pit backfilled upon completion
- Groundwater encountered at 6.7 feet on 10/22/99
- Piezometer installed
- Water level measured at 3.7 feet on 11/12/99

file:991451

Table A-1
Log of Test Pits

Test Pit No.	Depth Interval (feet)	USCS Class.	Soil Description	Sample No./ Depth (feet)	Water Content (%)	Pocket Pen. (Kg/sq. cm)
TP-5	0.0-1.2	OL	Dark brown sandy organic SILT (soft, slightly moist) (topsoil)			
	1.2-3.8	SM	Brown silty fine SAND (moist, relatively compact)			
	3.8-6.4	SP/SM	Gray fine to coarse SAND trace gravel and silt (wet) (seepage at 5.0 feet)	5-1/4.0	13.7%	

Notes:

- Test Pit terminated on 10/22/99 at 6.4 feet
- Test Pit backfilled upon completion
- Groundwater encountered at 5.0 feet on 10/22/99
- Piezometer installed

file:991451

Table A-1
Log of Test Pits

Test Pit No.	Depth Interval (feet)	USCS Class.	Soil Description	Sample No./ Depth (feet)	Water Content (%)	Pocket Pen. (Kg/sq. cm)
TP-6	0.0-1.0	OL	Dark brown sandy organic SILT (soft, slightly moist) (topsoil)			
	1.0-2.2	SP	Gray fine to coarse SAND, trace gravel			
	2.2-3.9	SM	gray silty fine SAND			
	3.9-6.4	SP	Gray fine to medium SAND, trace gravel (relatively compact, wet) (caving at 5.3 feet, wet) (seepage at 6.2 feet)	6-1/4.1	13.3%	

Notes:

- Test Pit terminated on 10/22/99 at 6.4 feet
- Test Pit backfilled upon completion
- Groundwater encountered at 6.2 feet on 10/22/99
- Piezometer installed

Table A-1
Log of Test Pits

file:991451

Test Pit No.	Depth Interval (feet)	USCS Class.	Soil Description	Sample No./ Depth (feet)	Water Content (%)	Pocket Pen. (Kg/sq. cm)
TP-7	0.0-1.1	OL	Dark brown sandy organic SILT (soft, slightly moist) (topsoil)			
	1.1-2.0	ML	Gray fine sandy, clayey SILT (moist)			
	2.0-4.9	SP	Gray fine to medium SAND, trace gravel (relatively compact, wet) (seepage at 4.0 feet)	7-1/3.9	24.6%	

Notes:

- Test Pit terminated on 10/22/99 at 4.9 feet
- Test Pit backfilled upon completion
- Groundwater encountered at 4.0 feet on 10/22/99
- Piezometer installed

Western Geotechnical Consultants, Inc.

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Phone (360) 380-2507 • Fax (360) 380-2507

February 29, 2000

Crown Development
3409 McDougal Avenue
Everett, WA 98210

Re: Supplemental Letter Report
Seasonal High Water Table Determination &
Preliminary Foundation Design Criteria
Roetcisoender and Parkinson Properties
SW Corner of Intersection of SR531 and 67th Ave. NE
Arlington, WA

This supplementary report provides supporting data for the determination of the seasonal high water table and supplemental foundation design information for our geotechnical investigation report dated December 4, 1999. Additional foundation design information provided in this letter report is based on our previous soils investigation.

Seasonal High Water Table

We performed a Geotechnical feasibility study at the subject site on October 22, 1999 (report issued December 4, 1999). The investigation included excavation of 7 test pits across the site and two additional test pits on adjacent properties. We installed piezometers in each of the test pits at that time and we have monitored water levels on three occasions since that time (11/12/99, 12/8/99 and 2/5/00). Figure 1 is a site plan sketch showing the approximate piezometer locations. Based on our piezometer readings, it is our opinion that we have determined the seasonal high ground water table for the site.

The seasonal high water levels are tabulated below.

Piezometer #	Distance to water table below ground surface (feet)
P#C 1	3.1
P#C 2	2.0
P#C 3	2.7
P#C 4	2.2
P#C 5	0.7
P#C 6	2.8
P#C 7	1.1
P#S 1	Piezometer lost
P#M 1	1.3

Foundation Design Criteria

We understand that a one-story 175,000 square foot warehouse building will be constructed on the northwest corner of the property. Test Pit 1 from our geotechnical report dated December 4, 1999 was excavated within the footprint of the proposed building. Based on test pit information the site is underlain by about 1 foot of topsoil, which is underlain by about 2 feet of silty sand (SM by USCS classification). This layer is underlain by fine to medium sands and gravelly fine to coarse sands. As indicated in our December 4, 1999 report, typical 1 to 2 story structures without heavy column loads can be founded on conventional shallow spread foundations. We recommend that shallow spread foundations be limited to an allowable bearing pressure of 2,000 psf. This bearing pressure assumes relatively light foundation loads (perimeter footings not to exceed about 2-feet and column footings not to exceed 4-feet by 4-feet). If foundation loads exceed these values, we should be informed so we can reevaluate our recommendations. An evaluation of liquefaction potential at the site was beyond the scope of our services.

We appreciate the opportunity to be of assistance to you on this project. If you have any questions regarding the contents of this letter report, or if we can be of further assistance, please contact our office.

Sincerely,

Western Geotechnical Consultants, Inc.

Theodore A. Hammer, P.E.
Geotechnical Engineer

Attachment: Figure 1, Site Plan Sketch with
Piezometer Locations

File:991452

Western Geotechnical Consultants, Inc.

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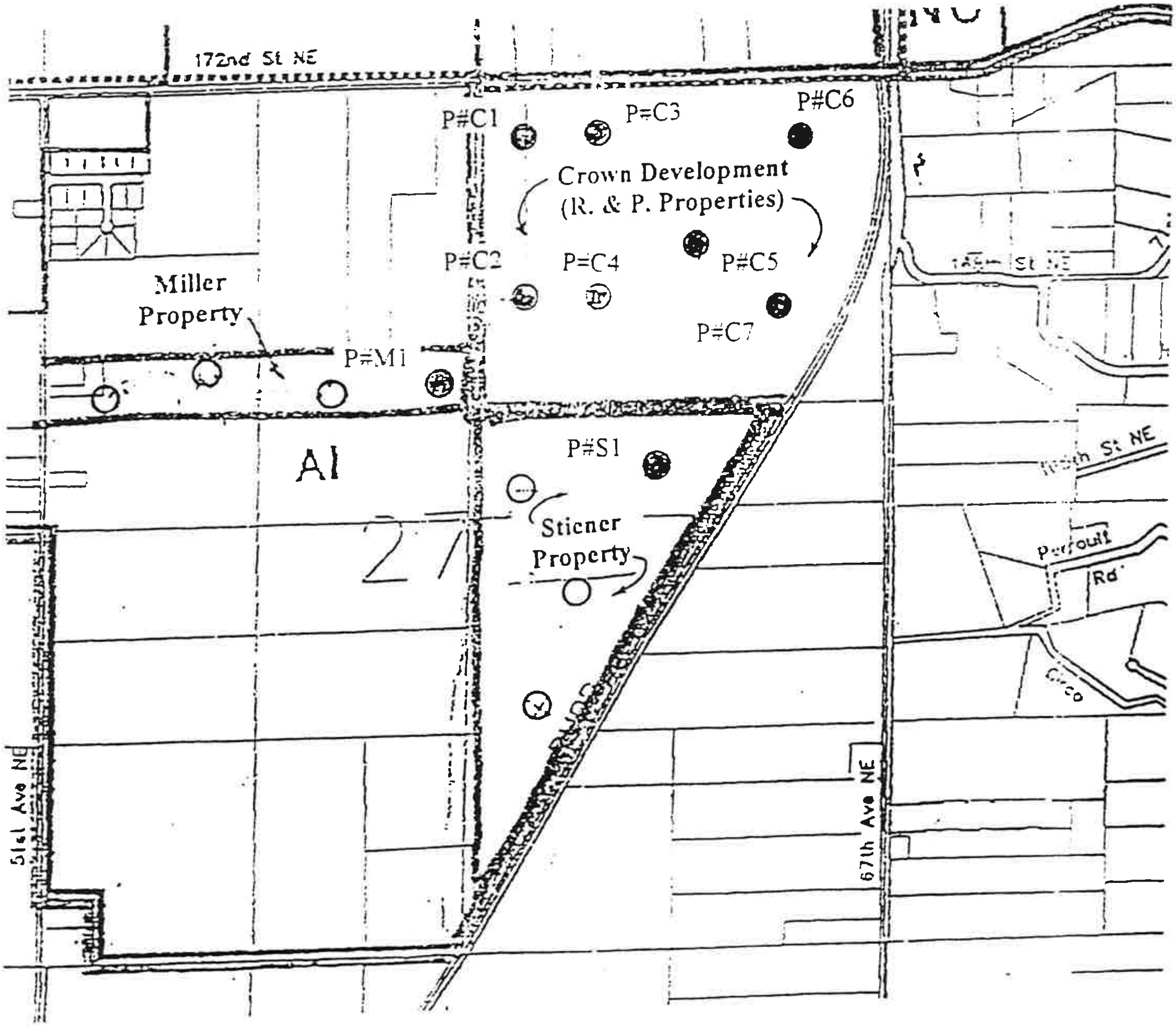
Figure 1

Site Plan & Piezometer Locations
Crown Development
Roetcisoender & Parkinson Properties
Arlington, WA

North



CROWN DISTRIBUTING
RUNOFF CURVE NUMBER CALCULATIONS
PRE DEVELOPED CONDITIONS

Total Area Tributary to Existing Detention (Acres):... 11.020

Soil Name and Hydrologic Soil Group		Cover Description	Runoff Curve Number RCN	Area (Acres) A	RCN x A
Name	HSG				
Custer	C	Assume no new construction	86	9.000	774.000
Custer	C	Grass Area (Post BLA)	86	2.020	173.720
					0.000
		Totals		11.020	947.720

Runoff Curve Number = (RCN x A) / A: 86.00

Runoff Curve Number Used in Basin Calculations.. 86.00

IMPERVIOUS AREA

Soil Name and Hydrologic Soil Group		Cover Description	Runoff Curve Number RCN	Area (Acres) A	RCN x A
Name	HSG				
Custer	C	Impervious Areas	98	0.000	0.000
					0.000
		Totals		0.000	0.000

Runoff Curve Number = (RCN x A) / A: 0.00

Runoff Curve Number Used in Basin Calculations.. 0.00

**The tributary area was considered grass for the purpose of determining the correct runoff rate to match in the detention pond anaylsis.

CROWN DISTIBUTING
RUNOFF CURVE NUMBER CALCULATIONS
POST DEVELOPED CONDITIONS

TRIBUTARY TO DETENTION POND
PERVIOUS AREAS

Total Area (Acres):.. 11.020

Soil Name and Hydrologic Soil Group		Cover Description	Runoff Curve Number RCN	Area (Acres) A	RCN x A
Name	HSG				
Custer	C	Grass and Landscaping	86	1.020	87.720
					0.000
		Totals		1.020	87.720

Runoff Curve Number = (RCN x A) / A: 86.00

Runoff Curve Number Used in Basin Calculations... 86.00

TRIBUTARY TO DETENTION POND
IMPERVIOUS AREAS

Impervious Area Per Lot (Square Feet):.. 0

Number of Lots Tributary to Detention Basin:.. 0

Soil Name and Hydrologic Soil Group		Cover Description	Runoff Curve Number RCN	Area (Acres) A	RCN x A
Name	HSG				
Custer	C	Ex. Building, Parking, Off-site Road	98	8.200	803.600
Custer	C	Building Expansion (Post BLA)	98	1.800	176.400
		Totals		10.000	980.000

Runoff Curve Number = (RCN x A) / A: 98.00

Runoff Curve Number Used in Basin Calculations... 98.00

CROWN DISTRIBUTING EXISTING DETENTION POND STAGE / STORAGE CALCULATIONS - LIVE STORAGE						
W.S ELEV.	SURFACE AREA	AVG. AREA	DEPTH	INCREM. VOLUME	TOTAL VOLUME	DESIGN VOLUME
121.50	110,910.00				0.00	0.00
		113,010.00	0.50	56,505.00		
122.00	115,110.00				56,505.00	23,080.00
		120,545.00	1.00	120,545.00		
123.00	125,980.00				177,050.00	122,950.00
		127,465.00	1.00	127,465.00		
124.00	128,950.00				304,515.00	211,470.00

NOTE: The total storage volume has been oversized per D.O.E. Standards

Percentage of Impervious Area to Total Site Area:..		91%
Total Impervious Area (Acres):..	10.000	
Total Area (Acres):..	11.020	
Correction Factor, From Figure 2.1 DOE Manual)..		1.44

CROWN DISTRIBUTING
FILTER STRIP CALCULATIONS

Project Description	
Worksheet	FILTER STRIP - WQ FLOW
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth
Input Data	

Mannings Coefficient	0.45	DOE Manual, Volume V, Table 9.1, pg. 9-4
Slope	0.0050 ft/ft	
Bottom Width	100.00 ft	
Discharge	0.22 cfs	6-Month Storm

Results	
Depth	0.06 ft
Flow Area	6.10 ft²
Wetted Perimeter	100.2 ft
Top Width	100.00 ft
Critical Depth	1.00E-02 ft
Critical Slope	16.93636 ft/ft
Velocity	0.0400 ft/s
Velocity Head	0.00E+00 ft
Specific Energy	0.06 ft
Froude Number	0.03
Flow Type	Subcritical

Required Residence Time, Tr (min.):...............	22.00	DOE Manual, Volume V, Table 9.1, pg. 9-4
Proposed Residence Time, Tp:(min.):.............	41.67	
Tp = L/V		
Length of Filter Strip, L (feet):.........................	100.00	
Velocity, V(fps):..	0.04	
Velocity, V(fpm):...	2.40	

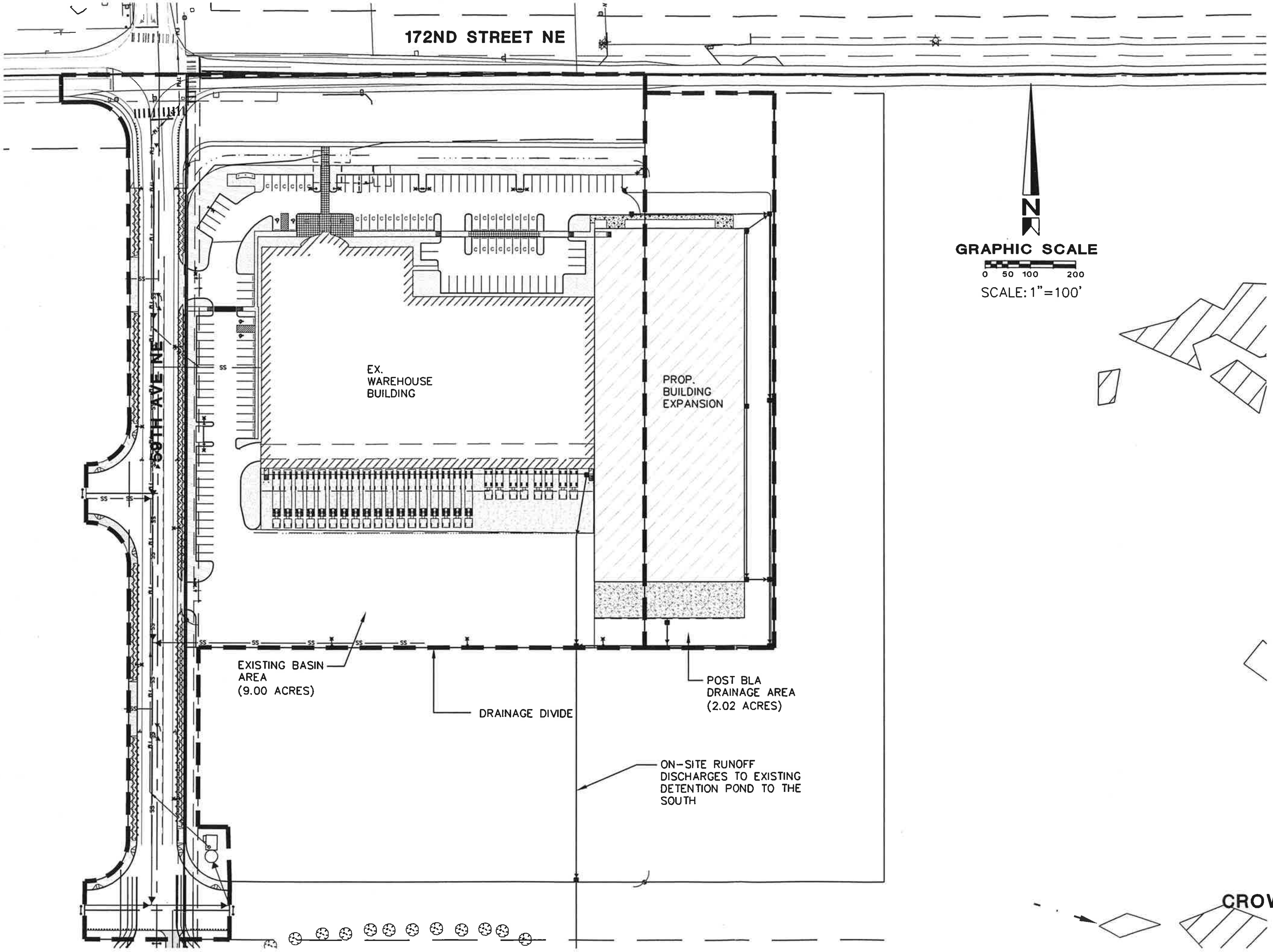
CROWN DISTRIBUTING
FILTER STRIP CALCULATIONS

CROWN DISTRIBUTING
FILTER STRIP CALCULATIONS

Project Description	
Worksheet	FILTER STRIP - 100YR FLOW
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth
Input Data	

Mannings Coefficient	0.45	DOE Manual, Volume V, Table 9.1, pg. 9-4
Slope	0.0050 ft/ft	
Bottom Width	100.00 ft	
Discharge	2.14 cfs	100yr Storm

Results	
Depth	0.24 ft
Flow Area	23.88 ft^2
Wetted Perimeter	100.48 ft
Top Width	100.00 ft
Critical Depth	0.0200 ft
Critical Slope	10.17949 ft/ft
Velocity	0.0900 ft/s
Velocity Head	0.000000 ft
Specific Energy	0.24 ft
Froude Number	0.03
Flow Type	Subcritical



DRAINAGE BASIN MAP FOR CROWN DISTRIBUTING

SCALE: 1"=100'

Revised Drainage Report and NPDES Stormwater Pollution Prevention Plan for Crown Park / Crown Distributing Site Development

Prepared for:
Crown Park, L.L.C
c/o Greg Blunt
Crown Distributing, Inc.
c/o Greg Blunt & Gary Parkinson
3409 McDougall Avenue
Everett, WA 98201

Prepared by:
John W. Cherry, P.E.
April 5, 2001

JOHN W. CHERRY
4-5-01

EXPIRES 6/21/2001

CONTENTS

DRAINAGE SUMMARY

INTRODUCTION

This report addresses drainage analysis and design for two related projects:

- The first phase of the development of Crown Park, an industrial park projected to encompass as much as 65 acres at full buildout. This phase consists of construction of a 950-foot access street and related drainage improvements at the west end of the property.
- The development of a 5.75-acre warehouse/distributing facility and related drainage improvements adjacent to the access street for Crown Distributing, Inc., the industrial park's first tenant.

Although these projects are being managed separately under separate ownership, they share common drainage facilities. The drainage analysis and design have been integrated into a single system serving both projects.

The design was complicated by a seasonally high water table and by the nearly level terrain, long distances to the natural discharge point and the high proportion of impervious surface proposed.

Higa Burkholder staff conducted several field investigations in spring, summer and fall of 2000 and winter of 2001, including inspection of soils, ground cover, topography and typical drainage patterns and facilities in the vicinity. Additional field investigation was conducted by Western Geotechnical Consultants, Inc. Their reports are included in the Appendix of this report.

EXISTING CONDITIONS

The site is located on a pasture fronting on the south side of 172nd Street NE (SR 531), southeast of the Arlington Airport. An existing house and outbuilding and associated driveway and landscaping occupy the northwest corner of the property and a mobile home occupies the southwest corner. The remainder of the site is in pasture grass. The nearly-level site drains to the south at a slope of approximately 0.5%.

An agricultural ditch conveys Edgecomb Creek westward along the south boundary of the Crown Park property, approximately 1300 feet south of 172nd Street. Although portions of the stream reach have been degraded by erosion and loss of streamside buffers, the Department of Fish and Wildlife reports that the creek supports populations of coho salmon, chum salmon and cutthroat trout, and is potential bull trout foraging habitat. Preliminary studies for the long-term development of Crown Park have included consideration of a substantial stream restoration effort.

A second stream and associated wetlands have been identified on the Crown Park property, but they lie well to the east of the currently proposed work and will not be impacted.

The SCS Snohomish County Soil Survey identifies the predominant underlying soil types in the proposed construction area as Lynnwood loamy sand at the north end near 172nd Street, Custer fine sandy loam through the center of the site and Norma loam near Edgecomb Creek.

Lynnwood soils are highly permeable and well drained, but Custer and Norma soils are typically poor-draining near the surface and subject to seasonally high water tables.

Subsurface exploration by Western Geotechnical Consultants, Inc. (see reports in Appendix) confirmed the presence of these soil types and determined a seasonal high water table depth of one to three feet.

Downstream flow path: All runoff generated on this site drains to Edgecomb Creek on the south boundary of the Crown Park property. At the southwest corner of the property the agricultural ditch conveying the creek waters turns 90° to the south. The ditch follows a straight line south between agricultural fields for one-half mile before turning west for one-quarter mile, then south again for one-half mile. At this point the creek crosses a railroad right-of-way and takes on a more natural character as it meanders south through a residential area en route to Quilceda Creek approximately 2.5 miles south of the Crown Park property. The agricultural ditch within one-quarter mile downstream is typically two to four feet deep with 2:1 side slopes, although there are numerous irregularities caused by erosion. The bottom is approximately six to ten feet wide and slopes at less than 1%. The ditch is vegetated intermittently with grasses and brush, and the banks have little significant shading vegetation. No culverts or other obstructions lie within one-quarter mile downstream from the Crown Park site.

DEVELOPED CONDITIONS

A 950-foot extension of 59th Avenue NE will be constructed along the west boundary of the property. This access street will be 44 feet wide with curbs and gutters and will have sidewalks and planter strips on both sides. The street will terminate in a temporary hammerhead. Some minor pavement widening will occur on 172nd Street NE at the north end of the development to accommodate a new left-turn lane, and a five-foot-wide paved walkway will be constructed parallel to the arterial.

The Crown Distributing property will be developed with an 80,000 sq. ft. distribution warehouse and office space, surrounded by paved parking. Landscape strips will be provided on the west, north and east boundaries. Parking will be provided for approximately 140 vehicles for employees and visitors. Loading docks will be arrayed along the south side of the building to accommodate up to 26 trucks ranging in size up to semi-trailer tractor rigs. A 1.25 acre paved maneuvering area will be provide for the trucks' use. Approximately 95% of the area of the Crown Distributing parcel will have impervious cover following development.

Because of the flat terrain, both the street and the distribution facility will be constructed on elevated pads to facilitate stormwater drainage.

DRAINAGE DESIGN

Stormwater from parking areas will be channeled to catch basins in the west, north and east parking areas. South of the building in the loading/maneuvering area, stormwater will be permitted to sheet flow over the pavement surface (sloped at 1%) into a series of trench drains near the center of the area. The trench drains have been selected and configured to handle runoff from a 100-year storm.

The 1.8-acre warehouse roof drains toward its south edge, where downspouts will be connected to drain manifolds tightlined to nearby catch basins. Footing drains will be tightlined separately to the storm drainage system.

The catch basins on the west side of the site drain to the storm system to be constructed in 59th Avenue. The east side of the site drains to the southeast corner. The 59th Avenue storm system, along with portions of the on-site system, will consist of oversized culverts laid at 0.25%. The unusually flat slope was necessary to work with the excessively flat terrain and the long distances the stormwater must be conveyed. The calculations in the appendix demonstrate that oversizing the pipes adequately compensates for the flat slopes in meeting both capacity and minimum velocity requirements.

Both the 59th Avenue storm system and the east-side drainage system will discharge to a shallow, flat-bottomed 2.75-acre detention pond. The pond has been sized per D.O.E. guidelines to provide storage for runoff from a 100-year, 24-hour design storm over the entire 7.6 acre area to be developed. The outlet structure was designed to release stormwater at rates not exceeding the current runoff rate for the 10-year and 100-year 24-hour design storms, and not exceeding one-half the current rate for a 2-year 24-hour design storm. After the initial design, the pond volume was expanded horizontally by 50% to provide a safety factor based on the percentage of impervious cover per D.O.E. guidelines.

At the request of the FAA and their USDA wildlife advisor, the bottom six inches of the pond will be covered with quarry spalls. Detention storage for a six-month, 24-hour storm will be provided in the voids (30% by volume) between the rocks to avoid attracting birds to open water. The pond was modeled in WaterWorks using a stage-storage routine that reduced the input incremental areas in the bottom six inches by 70% to approximate the actual volume in the voids.

The two pipe discharges to the pond will be routed through catch basins fitted with oil separation tees and pillows and provided with extra-deep catches to capture sediments from the relatively slow-moving stormwater in the flat pipes. The discharge points themselves will be encircled by stands of planted cattails to provide additional water quality treatment. We anticipate that whatever sediments reach the pond will be deposited close to the outfalls, simplifying maintenance requirements. A berm along the long axis of the pond will lengthen residence time and prevent short-circuiting of stormwater.

The pond will be lined to prevent infiltration or groundwater intrusion. Calculations in the appendix determined the necessary depth of backfill required to counter potential groundwater uplift forces.

The detention pond will discharge to a 100-foot-long level spreader designed to disperse the flow over a lightly-sloping 30-foot vegetated filter strip. Beyond the filter strip the flow will disperse into an excavated level area 100 feet wide and 120 feet long adjacent to the channel of Edgecomb Creek. This area will be planted with wet-tolerant grasses and shrubs to provide shade and filtering duff for the flow before it reaches the creek.

The flat slopes and long distances on this site necessitated designing the detention pond in such a way that it could back up into the 18-inch storm system to a depth of six inches during extreme storm events. In normal operation even during extreme events, however, the stored stormwater cannot overflow either the pond banks or any upstream catch basins. There also is some potential for Edgecomb Creek to flood the flow dispersal area during unusual high water events. The creation of this area will provide a backwater relief area for the creek.

CONCLUSION

The proposed project will replace nine acres of pasture with an engineered stormwater collection and treatment system. An additional eight acres in the area between the distribution facility and Edgecomb Creek also will be removed from pasture use as a result of the proposed development. The elimination of active livestock pasture can be expected to reduce nutrient loadings in Edgecomb Creek to some degree, while reducing streambank erosion associated with livestock operations along the 600 feet of creek frontage affected by the current project. Additionally, the detention pond will discharge biofiltered stormwater at peak rates somewhat lower than the calculated peak rates currently released to the creek.

For these reasons, we anticipate this project will have a beneficial net impact on Edgecomb Creek.

EROSION RISK ASSESSMENT & PROPOSED CONTROL METHODS

The risk of significant erosion impacts on this site and downstream during construction is low because:

- The site is nearly level, limiting surface water movement and erosion potential. No defined drainage channels exist to concentrate flow.
- A 150-foot vegetated buffer along Edgecomb Creek will not be disturbed except as needed for enhancement.
- Existing pasture to the east and west of the construction site will not be disturbed.
- Site construction runoff will be filtered through straw bales, filter fabric fences and pasture grass before reaching Edgecomb Creek.

Temporary erosion control measures recommended at this time include a gravel construction entrance to prevent tracking debris onto 172nd Street NE, sediment barriers around catch basins, straw bale barriers where effective, silt fences around site disturbances, an outlet filter on the detention pond and dispersion of runoff into adjacent pastures where feasible. Permanent erosion control in the form of hydroseeding exposed soil (with interim mulching as needed) is specified in the detailed T.E.S.C. plan included in the accompanying construction plans. The detailed T.E.S.C. plan also provides recommendations specific to winter grading and contingency measures for unanticipated site conditions.

NPDES STORMWATER POLLUTION PREVENTION PLAN SUMMARY

NOTE: The Crown Distributing site construction plan set that accompanies this report incorporates Washington State D.O.E. NPDES requirements for a Stormwater Pollution Prevention Plan (SWPPP). The complete plan set and this report constitute an SWPPP per the requirements of Section II-4 of D.O.E.'s Puget Sound Stormwater Management Manual.

- **Project description:** A warehouse/distribution facility to be constructed on a 5.75-acre site, associated with adjacent construction of a 950-foot street extension and associated drainage improvements. Approximately 30,000 cu. yds. of fill material will be imported to raise the site for drainage purposes.
- **Existing site conditions:** Existing house and mobile home with associated outbuildings, driveway and landscaping. Remainder of site is in pasture. Site slopes south at less than 1%. No wetlands or defined drainage channels on the site other than Edgecomb Creek along south boundary.
- **Adjacent areas:** Site lies along south side of 172nd Street NE (SR 531), approximately 1.75 miles west of Interstate 5 near the Smokey Point area of Arlington. Surrounding area is predominately agricultural south of 172nd Street and industrial (including Arlington Airport) north of 172nd Street. No anticipated deleterious stormwater impact on adjacent properties.
- **Soils:** North end: Lynnwood loamy sand, permeability 2.0-20.0 in/hr, erosion hazard slight. Center of site: Custer fine sandy loam, permeability 0.2-0.6 in/hr near surface, greater than 20 in/hr below three feet depth. South end near creek: Norma loam, permeability less than 6 in/hr.
- **Critical areas:** Edgecomb Creek and 150-foot buffer at south end of site.
- **Erosion and sediment control BMPs:** Flat terrain limits surface transport of storm water. Proposed T.E.S.C. measures include: Straw bale barriers and silt fences as shown in construction plans. Detention pond outlet filter. Dispersion of runoff into adjacent pasture where feasible. All facilities to be in place before other construction commences. Hydroseeding of exposed soil is required. Details and locations are specified in the T.E.S.C. plan in the accompanying construction plan set.
- **Permanent stabilization:** All exposed graded surfaces shall be hydroseeded per specifications in accompanying construction plans.
- **Stormwater management considerations:** All stormwater from site will be captured, treated in biofiltration swales and held in a detention pond designed to release into Edgecomb Creek at peak rates less than or equal to pre-development rates per D.O.E. guidelines.
- **Maintenance:** Requirements for monitoring and maintenance of sedimentation and erosion control facilities are detailed in the T.E.S.C. plan in the accompanying construction plan set.
- **Calculations:** Supporting calculations for the design of the on-site stormwater system are appended to this drainage/SWPPP report.

Non-ESC BMPs required: The T.E.S.C. plan in the accompanying construction plan set instructs contractor to use industry best management practices to prevent pollutants from entering drainage channels and to dispose of solid waste in accordance with local regulations.

APPENDIX

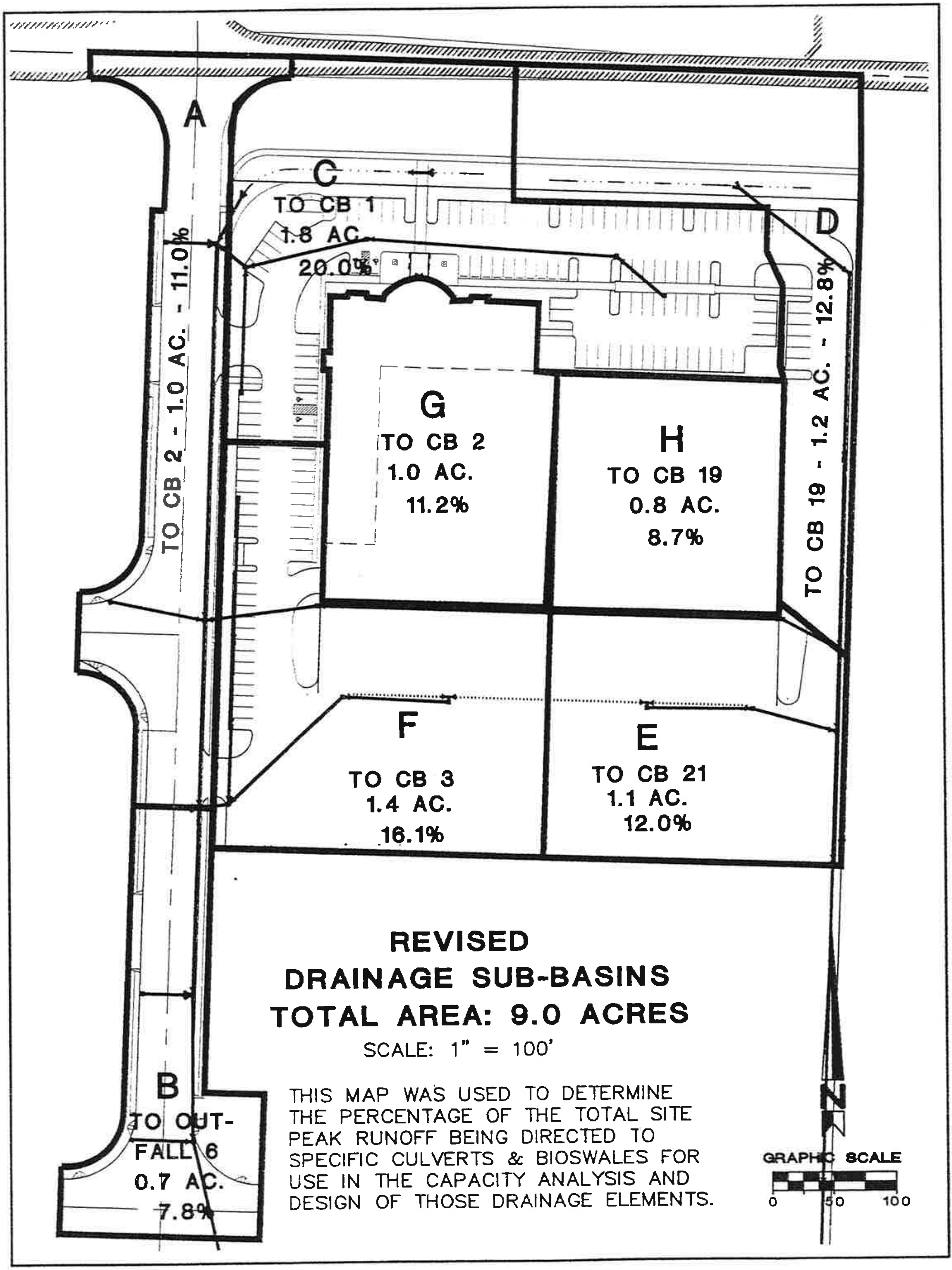
Summary of Analysis and Design Parameters & Results
Sub-Basin Map & Culvert Sizing Analysis
Vegetated Filter Strip Analysis
Detention Pond Design Calculations
Soils Information
Geotechnical Reports

SUMMARY OF DRAINAGE ANALYSIS & DESIGN PARAMETERS & RESULTS

Total development area	9.0 acres
Existing ground cover	Pasture (CN 86)
Developed basin ground cover	Assumed 100% impervious (CN 98)
SCS soil types	Custer fine sandy loam (Group C) Norma loam (Group C) Lynnwood loamy sand (Group B)
2-year, 24-hour rainfall	1.8 inches
10-year. 24-hour rainfall	2.6 inches
100-year. 24-hour rainfall	3.7 inches
Existing time of concentration	61 minutes
Developed time of concentration	5.0 minutes (minimum assumed)
Peak flows, existing conditions	
2-year, 24-hour storm	0.60 cfs
10-year, 24-hour storm	1.35 cfs
100-year, 24-hour storm	2.55 cfs
Peak flows, developed conditions	
6-month, 24-hour storm	1.80 cfs
2-year. 24-hour storm	3.04 cfs
10-year, 24-hour storm	4.56 cfs
100-year, 24-hour storm	6.65 cfs
Peak discharge rates, developed conditions	
6-month, 24-hour storm	0.24 cfs
2-year, 24-hour storm	0.28 cfs
10-year, 24-hour storm	0.67 cfs
100-year, 24-hour storm	1.45 cfs
Live storage required	48,783 cu. ft.
Live storage provided	73,175+ cu. ft
WaterWorks definition modes defined	Trapezoidal basin, stage/storage Combined 3.50" orifice, 60" notch (weir)
Maximum live storage water depth	0.96 feet
Maximum pond side slope	3:1
Minimum freeboard	1 foot
Vegetated filter strip	
Slope	1%
Width	100 ft.
Flow length	30 ft.
Design flow depth	½ inch
Culverts	
Minimum slope	0.25%
Minimum velocity, flowing full	3.0 fps

SUB-BASIN MAP

CULVERT SIZING
WORST-CASE
ANALYSIS



REVISED DRAINAGE SUB-BASINS

TOTAL AREA: 9.0 ACRES

SCALE: 1" = 100'

THIS MAP WAS USED TO DETERMINE THE PERCENTAGE OF THE TOTAL SITE PEAK RUNOFF BEING DIRECTED TO SPECIFIC CULVERTS & BIOSWALES FOR USE IN THE CAPACITY ANALYSIS AND DESIGN OF THOSE DRAINAGE ELEMENTS.

PIPE ANALYSIS - SUB-BASINS A, B, C, F, G
Worksheet for Circular Channel

Project Description

Worksheet	SUB-BASIN A, B, C, F, G - 18" HDPE
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Mannings Coefficient	0.012	
Slope	0.002500	ft/ft
Diameter	18	in
Discharge	4.41	cfs

Results

Depth	0.9920	ft
Flow Area	1.2	ft²
Wetted Perimeter	2.85	ft
Top Width	1.42	ft
Critical Depth	0.81	ft
Percent Full	66.1	%
Critical Slope	0.004730	ft/ft
Velocity	3.56	ft/s
Velocity Head	0.20	ft
Specific Energy	1.1885	ft
Froude Number	0.67	
Maximum Discharge	6.12	cfs
Discharge Full	5.69	cfs
Slope Full	0.001502	ft/ft
Flow Type	Subcritical	

Notes: Worst-case scenario: Entire 100-year peak flow from Sub-basins A, B, C, F & G conveyed by flattest section of farthest downstream pipe in Sub-basin B. Pipe will be approximately two-thirds full with velocity exceeding 3 fps.

PIPE ANALYSIS - SUB-BASIN D
Worksheet for Circular Channel

Project Description	
Worksheet	SUB-BASIN D - 12" HDPE
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.012	
Slope	0.008000	ft/ft
Diameter	12	in
Discharge	0.85	cfs

Results		
Depth	0.3381	ft
Flow Area	0.2	ft²
Wetted Perimeter	1.24	ft
Top Width	0.95	ft
Critical Depth	0.39	ft
Percent Full	33.8	%
Critical Slope	0.004864	ft/ft
Velocity	3.64	ft/s
Velocity Head	0.21	ft
Specific Energy	0.5438	ft
Froude Number	1.29	
Maximum Discharge	3.71	cfs
Discharge Full	3.45	cfs
Slope Full	0.000485	ft/ft
Flow Type	Supercritical	

Notes: Worst-case scenario: Entire 100-year peak flow from Sub-basin D conveyed by flattest section of smallest pipe in sub-basin. Pipe will be approximately one-third full with velocity exceeding 3 fps.

PIPE ANALYSIS - SUB-BASINS D, E, & H
Worksheet for Circular Channel

Project Description	
Worksheet	SUB-BASINS D, E, H - 18" HDPE
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.012	
Slope	0.002500	ft/ft
Diameter	18	in
Discharge	2.23	cfs

Results		
Depth	0.6523	ft
Flow Area	0.7	ft²
Wetted Perimeter	2.16	ft
Top Width	1.49	ft
Critical Depth	0.56	ft
Percent Full	43.5	%
Critical Slope	0.004245	ft/ft
Velocity	3.02	ft/s
Velocity Head	0.14	ft
Specific Energy	0.7944	ft
Froude Number	0.76	
Maximum Discharge	6.12	cfs
Discharge Full	5.69	cfs
Slope Full	0.000384	ft/ft
Flow Type	Subcritical	

Notes: Worst-case scenario: Entire 100-year peak flow from Sub-basins D, E & H conveyed by flattest section of 18" pipe to pond. Pipe would be approximately half-full. At 90% full velocity would exceed 3 fps.

PIPE ANALYSIS - SUB-BASIN F (15")
Worksheet for Circular Channel

Project Description	
Worksheet	SUBBASIN F - 15" HDPE
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.012	
Slope	0.002500	ft/ft
Diameter	15	in
Discharge	1.07	cfs

Results		
Depth	0.4743	ft
Flow Area	0.4	ft²
Wetted Perimeter	1.66	ft
Top Width	1.21	ft
Critical Depth	0.41	ft
Percent Full	37.9	%
Critical Slope	0.004452	ft/ft
Velocity	2.51	ft/s
Velocity Head	0.10	ft
Specific Energy	0.5719	ft
Froude Number	0.74	
Maximum Discharge	3.76	cfs
Discharge Full	3.50	cfs
Slope Full	0.000234	ft/ft
Flow Type	Subcritical	

Notes: Worst-case scenario: Entire 100-year peak flow from Sub-basin F conveyed by flattest section of 15" pipe from west trench drain. Pipe would be less than half-full. At 90% full velocity would exceed 3 fps.

Sub-basin E has a comparable pipe but less flow.

PIPE ANALYSIS - WEST DOWNSPOUT MANIFOLD
Worksheet for Circular Channel

Project Description	
Worksheet	SUB-BASIN G - 12" HDPE
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.012	
Slope	0.005000	ft/ft
Diameter	12	in
Discharge	0.75	cfs

Results		
Depth	0.3583	ft
Flow Area	0.3	ft²
Wetted Perimeter	1.28	ft
Top Width	0.96	ft
Critical Depth	0.36	ft
Percent Full	35.8	%
Critical Slope	0.004828	ft/ft
Velocity	2.97	ft/s
Velocity Head	0.14	ft
Specific Energy	0.4950	ft
Froude Number	1.02	
Maximum Discharge	2.94	cfs
Discharge Full	2.73	cfs
Slope Full	0.000378	ft/ft
Flow Type	Supercritical	

Notes: Worst-case scenario: Entire 100-year peak flow from Sub-basin G (the larger west side of roof) conveyed by flattest section of smallest pipe draining Sub-basin G. Pipe will be less than half full with velocity approximately 3 fps.

Basin H (east side of roof) has a comparable pipe but less flow.

EROSION RISK ASSESSMENT & PROPOSED CONTROL METHODS

The risk of significant erosion impacts on this site and downstream is low because:

- The site is nearly level, limiting surface water movement and erosion potential. No defined drainage channels exist to concentrate flow.
- A 150-foot vegetated buffer along Edgecomb Creek will not be disturbed.
- Site runoff will be filtered through straw bales, filter fabric fences and pasture grass before reaching Edgecomb Creek.

Temporary erosion control measures recommended at this time include a gravel construction entrance to prevent tracking debris onto 172nd Street NE, sediment barriers around catch basins, straw bale barriers in defined swales, silt fences around site disturbances. Permanent erosion control in the form of hydroseeding exposed soil (with interim mulching as needed).

APPENDIX

Summary of Results
Detention Pond Design Calculations
Drainage Report (April 5, 2001) by John Cherry

SUMMARY OF RESULTS

Existing Tributary Area: .... 9.000 Acres
Plus Post BLA Area: .... 2.020 Acres
Equals Total Area Tributary to Detention Pond: .... 11.020 Acres

PROPOSED DETENTION POND

2 YEAR STORM

Peak Discharge for Pre Developed Conditions (Retained Area),Q_{ex}: .... 0.64 cfs
Allowable Release Rate From Detention System, $Q_r = Q_{ex}/2$: .... 0.32 cfs
Peak Inflow to Detention Pond: .... 3.25 cfs
Proposed Release Rate: .... 0.30 cfs
Design Water Surface Elevation: 122.29
Approximate Volume of Storage Required (Design Volume): .... 41,017 cf
Approximate Total Volume of Storage Provided (144% of Design Volume): .... 59,064 cf

10 YEAR STORM

Peak Discharge for Pre Developed Conditions (Retained Area),Q_{ex}: .... 1.38 cfs
Allowable Release Rate From Detention System, $Q_r = Q_{ex}$: .... 1.38 cfs
Peak Inflow to Detention Pond: .... 4.99 cfs
Proposed Release Rate: .... 0.91 cfs
Design Water Surface Elevation: 122.41
Approximate Volume of Storage Provided (Design Volume): .... 48,050 cf
Approximate Total Volume of Storage Provided (144% of Design Volume): .... 69,192 cf

100 YEAR STORM

Peak Discharge for Pre Developed Conditions (Retained Area),Q_{ex}: .... 2.59 cfs
Allowable Release Rate From Detention System, $Q_r = Q_{ex}$: .... 2.59 cfs
Peak Inflow to Detention Pond: .... 7.35 cfs
Proposed Release Rate: .... 2.13 cfs
Design Water Surface Elevation: 122.53
Approximate Volume of Storage Provided (Design Volume): .... 55,557 cf
Approximate Total Volume of Storage Provided (130% of Design Volume): .... 80,002 cf

EXISTING Event Summary

Event	Peak Q (cfs)	Peak T (hrs)	Hyd Vol (acft)	Area (ac)	Method	Raintype
WQ Storm	0.1940	10.67	0.2545	11.0200	SBUH	TYPE1A
2 year	0.6403	9.17	0.6434	11.0200	SBUH	TYPE1A
10 year	1.3872	9.00	1.2173	11.0200	SBUH	TYPE1A
100 year	2.5948	8.67	2.0904	11.0200	SBUH	TYPE1A

Record Id: EXISTING

Design Method	SBUH	**Rainfall type**	TYPE1A
Hyd Intv	10.00 min	**Peaking Factor**	484.00
		Abstraction Coeff	0.20
Pervious Area (AMC 2)	11.02 ac	**DCIA**	0.00 ac
Pervious CN	86.00	**DC CN**	0.00
Pervious TC	93.76 min	**DC TC**	0.00 min

Pervious CN Calc

Description	SubArea	Sub cn
Grass Area	11.02 ac	86.00
Pervious Composited CN (AMC 2)		86.00

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet	Grass	300.00 ft	0.40%	0.2400	1.80 in	87.23 min
Shallow	Grass	400.00 ft	0.40%	0.0350		6.53 min
Pervious TC						93.76 min

DEVELOPED Event Summary

Event	Peak Q (cfs)	Peak T (hrs)	Hyd Vol (acft)	Area (ac)	Method	Raintype
WQ Storm	1.8283	8.00	0.7695	11.0200	SBUH	TYPE1A
2 year	3.2530	8.00	1.3452	11.0200	SBUH	TYPE1A
10 year	4.9941	8.00	2.0668	11.0200	SBUH	TYPE1A
100 year	7.3572	8.00	3.0679	11.0200	SBUH	TYPE1A

Record Id: DEVELOPED

Design Method	SBUH	**Rainfall type**	TYPE1A
Hyd Intv	10.00 min	**Peaking Factor**	484.00
		Abstraction Coeff	0.20
Pervious Area (AMC 2)	0.00 ac	**DCIA**	11.02 ac
Pervious CN	0.00	**DC CN**	96.89
Pervious TC	0.00 min	**DC TC**	20.00 min

Directly Connected CN Calc

Description	**SubArea**	**Sub cn**
Impervious Area	10.00 ac	98.00
Landscape and Grass Areas	1.02 ac	86.00
DC Composited CN (AMC 2)		96.89

Directly Connected TC Calc

Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Fixed						20.00 min
Directly Connected TC						20.00min

DETENTION POND
DESIGN CALCULATIONS

Record Id: POND PARAMETERS

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	121.5000 ft	Max El.	124.0000 ft

Stage Volume	
Stage (ft)	**Volume (cf)**
121.50	0.0000
122.00	23080.0000
123.00	83710.0000
124.00	172230.0000

Stage Storage Rating Curve			
121.5000 ft	0.0000 cf	122.8000 ft	71584.0000 cf
121.6000 ft	4616.0000 cf	122.9000 ft	77647.0000 cf
121.7000 ft	9232.0000 cf	123.0000 ft	83710.0000 cf
121.8000 ft	13848.0000 cf	123.1000 ft	92562.0000 cf
121.9000 ft	18464.0000 cf	123.2000 ft	101414.0000 cf
122.0000 ft	23080.0000 cf	123.3000 ft	110266.0000 cf
122.1000 ft	29143.0000 cf	123.4000 ft	119118.0000 cf
122.2000 ft	35206.0000 cf	123.5000 ft	127970.0000 cf
122.3000 ft	41269.0000 cf	123.6000 ft	136822.0000 cf
122.4000 ft	47332.0000 cf	123.7000 ft	145674.0000 cf
122.5000 ft	53395.0000 cf	123.8000 ft	154526.0000 cf
122.6000 ft	59458.0000 cf	123.9000 ft	163378.0000 cf
122.7000 ft	65521.0000 cf	124.0000 ft	172230.0000 cf
		124.0000 ft	172230.0000 cf

Record Id: COMBO

Descrip:	Prototype Structure	Increment	0.10 ft
Start El.	121.5000 ft	Max El.	124.0000 ft
List of Discharge Structures:		ORIFICE NOTCH WIER	

Record Id: ORIFICE

Descrip:	Prototype Structure	Increment	0.10 ft
Start El.	121.5000 ft	Max El.	124.0000 ft
Orif Coeff	0.62	Lowest Orif El.	119.50
Lowest Diam	3.5000 in	Dist to next	0.0000 ft

Record Id: NOTCH WIER

Descrip:	Prototype Structure	Increment	0.10 ft
Start El.	122.3000 ft	Max El.	124.0000 ft
Length		5.00 ft	
Cd	3.1300	Use Constant Cd for calcs	

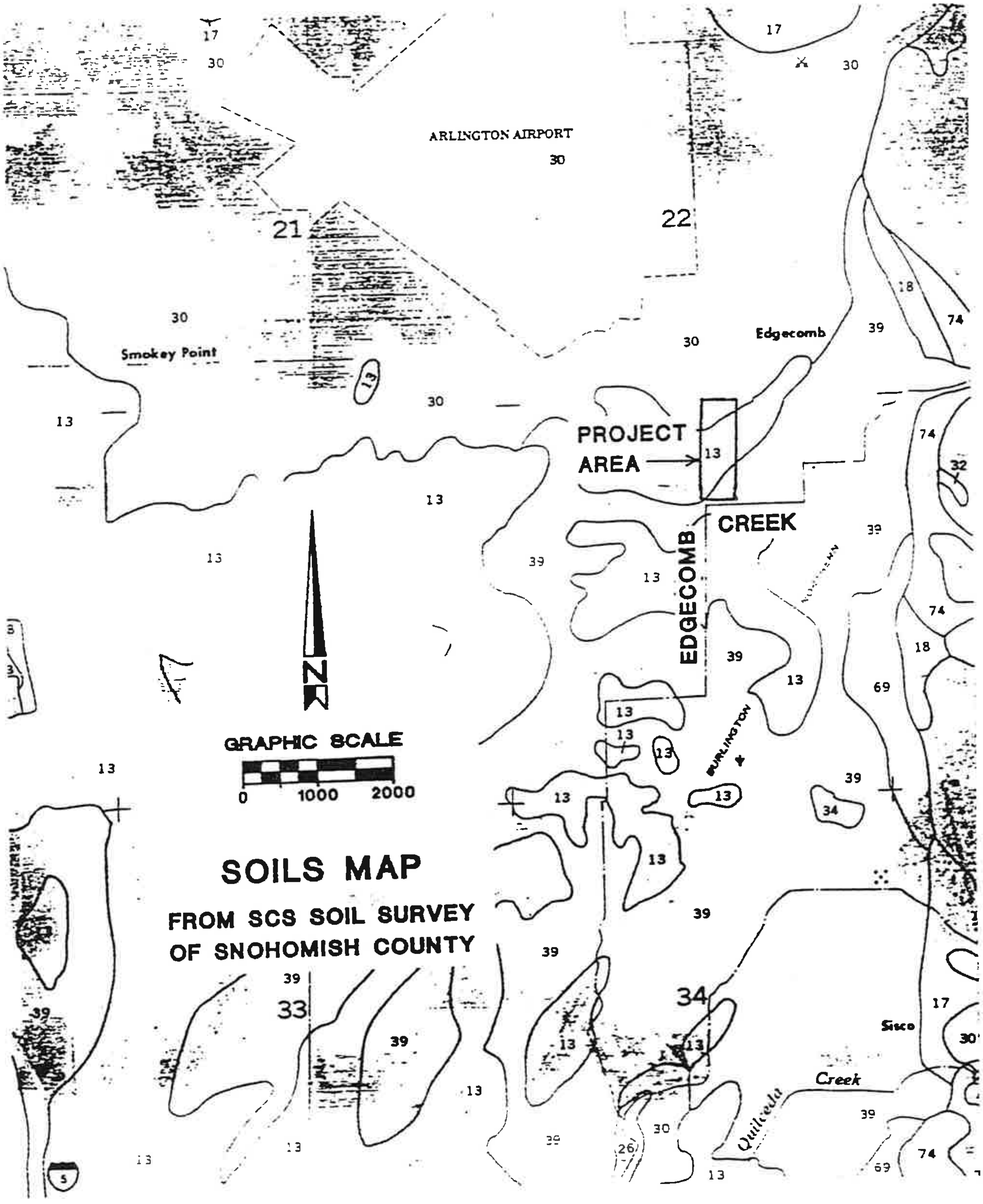
Stage Discharge Rating Curve			
121.5000 ft	0.0000 cfs	122.8000 ft	5.8014 cfs
121.6000 ft	0.1051 cfs	122.9000 ft	7.4922 cfs
121.7000 ft	0.1487 cfs	123.0000 ft	9.3161 cfs
121.8000 ft	0.1821 cfs	123.1000 ft	11.2603 cfs
121.9000 ft	0.2102 cfs	123.2000 ft	13.3145 cfs
122.0000 ft	0.2351 cfs	123.3000 ft	15.4699 cfs
122.1000 ft	0.2575 cfs	123.4000 ft	17.7190 cfs
122.2000 ft	0.2781 cfs	123.5000 ft	20.0550 cfs
122.3000 ft	0.2973 cfs	123.6000 ft	22.4723 cfs
122.4000 ft	0.8083 cfs	123.7000 ft	24.9655 cfs
122.5000 ft	1.7210 cfs	123.8000 ft	27.5299 cfs
122.6000 ft	2.8893 cfs	123.9000 ft	30.1612 cfs
122.7000 ft	4.2599 cfs	124.0000 ft	32.8554 cfs

LPOOLCOMPUTE [DETENTION POND] SUMMARY using Puls

Start of live storage: 121.5000 ft

Event	Match Q (cfs)	Peak Q (cfs)	Peak Stg (ft)	Vol (cf)	Vol (acft)	Time to Empty
WQ Storm	0.0000	0.2230	121.9514	20838.59	0.4784	136.33
2 year	0.3201	0.2965	122.2958	41017.38	0.9416	158.00
10 year	1.3872	0.9164	122.4118	48050.46	1.1031	160.83
100 year	2.5948	2.1377	122.5357	55557.49	1.2754	161.67

SOILS INFORMATION



SOILS MAP

FROM SCS SOIL SURVEY OF SNOHOMISH COUNTY lope where practical. Grazing when the soil is wet esults in compaction of the surface layer, poor tilth, poor infiltration, and excessive runoff.

Periodic mowing and spreading of droppings help to naintain uniform growth and discourage selective grazing. Proper grazing practices and weed control are needed for maximum quality of forage. In some years upplemental irrigation is also needed. Fertilizer is eeded for optimum growth of grasses and legumes. Legumes benefit from applications of agricultural lime.

The main limitation for homesites and septic tank bsorption fields is steepness of slope.

This map unit is in capability subclass IVe.

11—Cathcart loam, 25 to 50 percent slopes. This ery deep, well drained soil is on foothills and mountain oot slopes. It formed in glacial drift derived from sandstone and siltstone and in volcanic ash. Areas are 0 to 200 acres in size. The native vegetation is mainly onifers and hardwoods. Elevation is 50 to 1,000 feet. The average annual precipitation is about 45 inches, the average annual air temperature is about 50 degrees F, nd the average frost-free season in 165 to 185 days.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. The subsoil is dark brown and ellowish brown loam and sandy loam about 27 inches hick. The substratum to a depth of 60 inches or more is olive loam. In some areas the subsoil is sandy clay loam or clay loam. Weathered siltstone is at a depth of 40 to 0 inches in places.

Included in this unit are small areas of Tokul soils on ill plains and Pastik, Winston, and Ragnar soils on terraces and outwash plains. Included areas make up bout 15 percent of the total acreage.

Permeability of this Cathcart soil is moderate. Available water capacity is high. Effective rooting depth is 60 nches or more. Runoff is rapid, and the hazard of water rosion is high.

This unit is used mainly as woodland.

Douglas-fir is the main woodland species on this unit. On the basis of a 100-year site curve, the mean site ndex is 175. On the basis of a 50-year site curve, the mean site index is 130. The mean annual increment at culmination (CMAI) for Douglas-fir at age 60 is 186 cubic eet per acre. Among the trees of limited extent are western hemlock, western redcedar, and Pacific madrone. Among the common forest understory plants are western swordfern, trailing blackberry, red uckleberry, Oregon-grape, and brackenfern.

The main limitation for the harvesting of timber is steepness of slope, which restricts the use of wheeled nd tracked equipment in skidding operations. Cable arding systems generally are safer and disturb the soil ess. Unsurfaced roads and skid trails are soft when wet and they may be impassable during rainy periods. Logging roads require suitable surfacing for year-round use. Rock for road construction is not readily available on this unit.

Establishing plant cover on steep road cut and fill slopes reduces erosion. Steep yarding paths, skid trails, and firebreaks are subject to rilling and gullying unless adequate water bars are provided or they are protected by plant cover.

Brush competition is the main concern for the production of timber. Reforestation can be accomplished by planting Douglas-fir seedlings. When openings are made in the canopy, invading brushy plants, if not controlled, can prevent reforestation.

The main limitation for homesites and septic tank absorption fields is steepness of slope.

This map unit is in capability subclass VIe.

12—Cryohemists, nearly level. These deep, very poorly drained soils are in depressional areas on high mountain ridgetops. The soils formed in material derived mainly from sedges and mosses. Areas are 10 to 30 acres in size. The native vegetation is mainly sedges and mosses. Elevation is 1,800 to 3,700 feet. Slope is 0 to 1 percent. The average annual precipitation is about 95 inches, the average annual air temperature is about 41 degrees F, and the average frost-free season is 85 to 105 days.

Typically, the upper layer is dark grayish brown and very dark gray organic material about 10 inches thick. The next layer is black, very dark grayish brown and dark reddish brown organic material about 26 inches thick. Below this is light gray diatomaceous earth about 3 inches thick over grayish brown and olive gray clay loam that extends to a depth of 60 inches or more. Texture of the lower layer varies widely within short distances. Thickness of the organic material ranges from 16 inches to more than 60 inches.

Included in this unit are small areas of Getchell, Potchub, and Verlot soils on mountainsides and ridgetops. Included areas make up about 15 percent of the total acreage.

Permeability of these Cryohemists is moderately slow. Available water capacity is high. Effective rooting depth is limited by a seasonal water table that is at a depth of 0 to about 10 inches. Runoff is ponded.

This unit is used mainly for wetland wildlife habitat. It provides nesting areas for ducks, heron, and other waterfowl. Plantings of smartweed, wild millet, or bullrush encourage added populations. This unit also provides habitat for muskrats and beavers. Logging in the area may disturb the value of the unit as nesting areas for waterfowl.

This map unit is in capability subclass Vw.

→ **13—Custer fine sandy loam.** This very deep, poorly drained soil is in basins on outwash plains. It formed in glacial outwash. Areas are 15 to 40 acres in size. The native vegetation is mainly conifers and hardwoods. Elevation is near sea level to 150 feet. Slope is 0 to 2 percent. The average annual precipitation is about 40 inches, the average annual air temperature is about 50 degrees F, and the average frost-free season is 150 to 200 days.

Typically, the surface layer is very dark grayish brown fine sandy loam about 9 inches thick. The upper part of the subsoil is loamy fine sand about 7 inches thick. The lower part is gray and olive sand about 19 inches thick and has iron-cemented concretions that form a discontinuous hardpan. The substratum is gray sand about 14 inches thick over gravelly coarse sand that extends to a depth of 60 inches or more. In some areas a hardpan is not present in the subsoil.

Included in this unit are small areas of Indianola soils on terraces, Norma soils in upland drainageways, and Custer soils that have been partially drained. Included areas make up about 15 percent of the total acreage.

Permeability of this Custer soil is moderately slow in the discontinuous hardpan and very rapid below it. Available water capacity is low. Effective rooting depth is limited by a seasonal high water table that is at a depth of about 12 inches. Runoff is very slow. Ponding occurs from November to March.

This unit is used mainly for pasture and as cropland. A few areas are used as woodland.

The main limitation for pasture is wetness. Grazing when the soil in this unit is wet results in compaction of the surface layer. Use of proper stocking rates, pasture rotation, and restricted grazing during wet periods helps to keep the pasture in good condition and protects the soil from erosion. Periodic mowing and spreading of droppings help to maintain uniform growth and discourage selective grazing. Proper grazing practices, weed control, and fertilizer are needed for maximum quality of forage. Fertilizer is needed for optimum growth of grasses and legumes.

The depth to the water table is the main limitation of the soil in this unit for crops such as strawberries. Open ditches and tile drains help to remove excess water. Chiseling or subsoiling may be needed to improve permeability and increase rooting depth. Crops may require supplemental irrigation during the growing season. The organic matter content can be maintained by using all crop residue, plowing under green manure crops, and using a suitable cropping system.

This unit is suited to use as woodland. On the basis of a 50-year site curve, the estimated mean site index for red alder is 90. The estimated mean annual increment at culmination (CMAI) for red alder at 40 years of age is 101 cubic feet per acre.

The main limitation for the harvesting of timber is wetness. The seasonal high water table limits the use of equipment when the soil in this unit is wet. Use of wheeled and tracked equipment when the soil is wet produces ruts, compacts the soil, and damages the roots of trees. Unsurfaced roads and skid trails are soft when wet, and they may be impassable during rainy periods. Logging roads require suitable surfacing for year-round use. Rock for road construction is not readily available on this unit.

The establishment of seedlings is the main concern in the production of timber. The seasonal high water table and ponding reduce root respiration, which results in high seedling mortality. If seed trees are present, natural reforestation of cutover areas by red alder occurs rapidly. Western redcedar may also be suitable for reforestation. Because the rooting depth is restricted by the discontinuous hardpan and the seasonal high water table, trees are subject to windthrow. When openings are made in the canopy, invading brushy plants, if not controlled, can delay reforestation.

The main limitation for homesites is the seasonal high water table. Wetness can be reduced by installing drain tile around footings. The main limitations for septic tank absorption fields are ponding, wetness, and moderately slow permeability. If effluent penetrates below the discontinuous hardpan, seepage into the water table is also a limitation. Cutbanks on this unit are subject to caving in.

This map unit is in capability subclass IVw.

~~**14—Elwell silt loam, 3 to 30 percent slopes.** This moderately deep, moderately well drained soil is on mountainsides and ridgetops. It formed in glacial till and volcanic ash. Areas are 20 to 50 acres in size. The native vegetation is mainly conifers. Elevation is 800 to 1,800 feet. The average annual precipitation is about 70 inches, the average annual air temperature is about 45 degrees F, and the average frost-free season is 130 to 150 days.~~

~~Typically, the surface layer is black silt loam about 2 inches thick. The subsoil is strong brown, brown, and yellowish brown silt loam about 21 inches thick. The substratum is pale olive gravelly fine sandy loam about 4 inches thick. An olive, weakly cemented hardpan is at a depth of about 27 inches. Depth to the hardpan ranges from 20 to 40 inches. In some areas the hardpan is at a depth of more than 40 inches.~~

~~Included in this unit are small areas of Rober and Olomount soils on mountainsides and ridgetops and Skykomish soils on terraces. Included areas make up about 15 percent of the total acreage.~~

~~Permeability of this Elwell soil is moderate to the hardpan and very slow through it. Available water capacity is moderate. Effective rooting depth is 20 to 40 inches. A seasonal perched water table is at a depth of 18 to 36 inches from November to June. Runoff is slow, and the hazard of water erosion is slight.~~

~~This unit is used mainly as woodland, watershed, and wildlife habitat.~~

~~Western hemlock is the main woodland species on this unit. On the basis of a 100-year site curve, the mean site index is 15[illegible]. On the basis of a 50-year site curve, the mean site index is 108. The mean annual increment at culmination (CMAI) for western hemlock at age 50 is 241 cubic feet per acre. Among the trees of limited extent are Douglas-fir, western redcedar, Pacific silver fir, red alder, and bigleaf maple. Among the common forest~~

~~unsurfaced roads and skid trails are soft when wet, and ey are impassable during rainy periods. Logging roads quire suitable surfacing for year-round use. Rock for road construction is not readily available on this unit.~~

~~Establishing plant cover on steep road cut and fill opes reduces erosion. Steep yarding paths, skid trails, d firebreaks are subject to rilling and gullying unless adequate water bars are provided or they are protected plant cover. Following road construction and rvesting, road failure and landslides are likely. cause the rooting depth is restricted by a seasonal perched water table, trees are frequently subject to ndthrow.~~

~~Reforestation can be accomplished by planting Douglas-fir seedlings. If seed trees are present, natural reforestation of cutover areas by red alder occurs adily. When openings are made in the canopy, ading brushy plants, if not controlled, can prevent the establishment of seedlings.~~

~~The main limitations for building sites are steepness of pe, the hazard of hillside slippage, and soil wetness. ainage is needed if buildings with basements and crawl spaces are constructed. Access roads must be signed to control surface runoff and help stabilize cut pes. The soil in this unit may slump readily in cavated areas.~~

~~The main limitations for septic tank absorption fields the seasonal perched water table, slow permeability, d steepness of slope. Conventional septic tank sorption fields often fail or do not function properly.~~

~~This map unit is in capability subclass VIe.~~

0—Lynnwood loamy sand, 0 to 3 percent slopes. is very deep, somewhat excessively drained soil is on terraces and outwash plains. It formed in glacial wash. Areas generally are 10 to 30 acres in size, but w areas are as much as 600 acres. The native vegetation is mainly conifers. Elevation is 50 to 500 feet. The average annual precipitation is about 40 inches, the rage annual air temperature is about 49 degrees F, d the average frost-free season is 180 to 200 days.

Typically, the surface is covered with a mat of leaves, edles, and twigs about 3 inches thick. The surface er is grayish brown loamy sand about 1 inch thick. e upper part of the subsoil is dark brown loamy sand about 14 inches thick. The lower part is dark yellowish wn loamy sand about 14 inches thick. The substratum depth of 60 inches or more is grayish brown sand. some areas the surface layer and subsoil are sandy loam.

cluded in this unit are small areas of Everett, anola, Pastik, and Ragnar soils. Also included are uster soils in basins and soils that have slopes of more than 3 percent. Included areas make up about 15 cent of the total acreage.

ermeability of this Lynnwood soil is rapid. Available water capacity is low. Effective rooting depth is 60 hes or more. Runoff is slow, and the hazard of water sion is slight.

This unit is used mainly as woodland and for urban development. It is also used for hay and pasture.

Douglas-fir is the main woodland species on this unit. On the basis of a 100-year site curve, the mean site index is 158. On the basis of a 50-year site curve, the mean site index is 121. The mean annual increment at culmination (CMAI) for Douglas-fir at age 65 is 168 cubic feet per acre. Among the trees of limited extent are western hemlock and western redcedar. Among the common forest understory plants are western swordfern, brackenfern, deer fern, and red huckleberry.

This unit is well suited to year-round logging. Logging roads require suitable surfacing for year-round use. Rock for road construction is not readily available on this unit.

Reforestation can be accomplished by planting Douglas-fir seedlings. The droughtiness of the surface layer reduces the survival of seedlings. When openings are made in the canopy, invading brushy plants, if not controlled, can delay the establishment of seedlings.

The main limitation for hay and pasture is low available water capacity. Use of proper stocking rates, pasture rotation, and restricted grazing during wet periods helps to keep the pasture in good condition. Proper grazing practices, weed control, and fertilizer are needed for maximum quality of forage. In most years supplemental irrigation is needed. Fertilizer is needed for optimum growth of grasses and legumes.

This unit is suited to use as homesites. The main limitation for septic tank absorption fields is seepage. If the density of housing is moderate to high, community sewage systems are needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems. Cutbanks are not stable and are subject to caving in.

This map unit is in capability subclass IVs.

~~**31—Lynnwood-Nargar complex, 65 to 90 percent slopes.** This map unit is on terrace escarpments. Areas are irregular in shape and are 20 to 200 acres in size. The native vegetation is mainly conifers. Elevation is 400 to 1,200 feet. The average annual precipitation is about 55 inches, the average annual air temperature is about 48 degrees F, and the average frost-free season is 140 to 190 days.~~

~~This unit is about 60 percent Lynnwood loamy sand and about 25 percent Nargar fine sandy loam. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.~~

~~Included in this unit are small areas of Pastik, Everett, Skykomish, and Winston soils on terraces and outwash plains and soils that have a gravelly sandy loam surface layer. Included areas make up about 15 percent of the total acreage.~~

~~The Lynnwood soil is very deep and somewhat excessively drained. It formed in glacial outwash. Typically, the surface is covered with a mat of leaves, needles, and twigs about 3 inches thick. The surface~~

curve, the mean site index is 138. The mean annual increment at culmination (CMAI) for Douglas-fir at age 60 is 195 cubic feet per acre.

Douglas-fir is also the main woodland species on the Lynnwood soil. On the basis of a 100-year site curve, the mean site index is 158. On the basis of a 50-year site curve, the mean site index is 121. The mean annual increment at culmination (CMAI) for Douglas-fir at age 65 is 168 cubic feet per acre.

Among the trees of limited extent on this unit are western hemlock and western redcedar. Red alder is also of limited extent on the Nargar soil. Among the common forest understory plants are western swordfern, brackenfern, ladyfern, deer fern, red huckleberry, vine maple, and salal.

The main limitation for the harvesting of timber is steepness of slope, which restricts the use of wheeled and tracked equipment in skidding operations. Cable yarding systems generally are safer and disturb the soil less. Use of wheeled and tracked equipment when the soils in this unit are wet produces ruts, compacts the soils, and damages the roots of trees. Unsurfaced roads and skid trails are soft when wet, and they may be impassable during rainy periods. Logging roads require suitable surfacing for year-round use. Rock for road construction is not readily available on this unit. Steep yarding paths, skid trails, and firebreaks are subject to rilling and gullying unless adequate water bars are provided or they are protected by plant cover.

Seedling establishment and brush competition are the main limitations for the production of timber. Reforestation can be accomplished by planting Douglas-fir seedlings. If seed trees are present, natural reforestation of cutover areas by red alder occurs readily and natural regeneration of western hemlock occurs periodically on the Nargar soil. The droughtiness of the surface layer of the Lynnwood soil increases seedling mortality, especially on south- and southwest-facing slopes. When openings are made in the canopy, invading brushy plants, if not controlled, can delay the establishment of seedlings on the Lynnwood soil and prevent establishment on the Nargar soil.

This map unit is in capability subclass VIIe.

38—Nargar Variant sandy loam, 3 to 30 percent slopes. This very deep, well drained soil is on terrace escarpments and mountainsides. It formed in sandy alluvium and volcanic ash. Areas are 10 to 80 acres in size. The native vegetation is mainly conifers. Elevation is 800 to 1,800 feet. The average annual precipitation is about 70 inches, the average annual air temperature is about 45 degrees F, and the average frost-free season is 110 to 140 days.

Typically, the surface is covered with a mat of leaves, twigs, and needles about 2 inches thick. The surface layer is very dark grayish brown sandy loam about 4 inches thick. The subsoil is reddish brown, dark brown, and dark yellowish brown sandy loam about 27 inches thick. The substratum to a depth of 60 inches or more is yellowish brown and light olive brown loamy coarse sand and very gravelly coarse sandy loam. In some areas the surface layer and subsoil are sandy loam.

Included in this unit are areas of Skykomish soils on terraces and outwash plains and Elwell soils on mountainsides and ridgetops. Included areas make up about 15 percent of the total acreage.

Permeability of this Nargar Variant soil is moderate to the substratum and rapid through it. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used as woodland.

Western hemlock is the main woodland species on this unit. On the basis of a 100-year site curve, the mean site index is 133. On the basis of a 50-year site curve, the mean site index is 92. The mean annual increment at culmination (CMAI) for western hemlock at age 50 is 205 cubic feet per acre. Among the trees of limited extent are Douglas-fir and western redcedar. Among the common forest understory plants are vine maple, swordfern, red huckleberry, trillium, and brackenfern.

The main limitation for the harvesting of timber is seasonal soil wetness. Use of wheeled and tracked equipment when the soil in this unit is wet produces ruts, compacts the soil, and damages the roots of trees. Unsurfaced roads and skid trails are soft when wet, and they may be impassable during rainy periods. Establishing plant cover on steep road cut and fill slopes reduces erosion.

Seedling mortality and brush competition are the main limitations in the production of timber. Reforestation can be accomplished by planting Douglas-fir seedlings. If seed trees are present, natural reforestation of cutover areas by western hemlock occurs periodically. High soil temperature and low soil moisture content during the growing season cause a high mortality of seedlings, especially on south- and southwest-facing slopes. When openings are made in the canopy, invading brushy plants, if not controlled, can delay reforestation.

The main limitation for homesites is steepness of slope in areas where slopes are more than 15 percent. The main limitations for septic tank absorption fields are steepness of slope and seepage. If the density of housing is moderate to high, community sewage systems may be needed to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems. Cutbanks are not stable and are subject to caving in.

This map unit is in capability subclass IVe.

39—Norma loam. This very deep, poorly drained soil is in depressional areas on outwash plains and till plains. It formed in alluvium. Areas are 10 to 40 acres in size. The native vegetation is mainly hardwood trees. Elevation is 20 to 600 feet. Slope is 0 to 3 percent. The average annual precipitation is about 45 inches, the erage annual air temperature is about 50 degrees F, d the average frost-free season is 150 to 200 days.

Typically, the surface layer is very dark gray loam out 10 inches thick. The subsoil is dark grayish brown ndy loam about 18 inches thick. The substratum to a pth of 60 inches or more is dark gray sandy loam.

Included in this unit are small areas of soils that have surface layer and subsoil of silt loam and soils that ve a gravelly and sandy subsoil. Also included are eas of Bellingham and Custer soils and Terric Medisaprists in depressional areas. Included areas make about 15 percent of the total acreage.

Permeability of this Norma soil is moderately rapid. vailable water capacity is moderate. Effective rooting depth is limited by a seasonal high water table that is at depth of 0 to about 12 inches. Runoff is very slow, and hazard of water erosion is slight. Ponding occurs from November to April. In most areas the water table is tificially drained to a depth of about 3 or 4 feet during growing season, but the soil may be ponded during e rainy season.

This unit is used mainly for hay and pasture and for dlife habitat. It is also used as woodland and cropland.

This unit, when drained, is well suited to use as opland. Proper row arrangement, field ditches, and vegetated outlets are needed to remove excess surface ter. Tile drainage can be used to lower the water table suitable outlet is available.

A suitable cropping system includes 1 or 2 years of sweet corn, 1 to 5 years of raspberries or strawberries, d 3 to 5 years of grasses and legumes. Annual opping with vegetables and growing a winter cover crop is also suitable. Returning all crop residue to the il and using a cropping system that includes grasses, umes, or grass-legume mixtures help to maintain rtility and tilth. Returning crop residue to the soil also reduces compaction. Grain and grasses respond to rogen; legumes respond to phosphorus, boron, sulfur, d lime; and vegetables and berries respond to trogen, phosphorus, and potassium.

This unit, when drained, is well suited to hay and sture. Wetness and submergence limit the choice of ants and the period of cutting or grazing, and they ncrease the risk of damaging crops. Grazing when the soil in this unit is wet results in compaction of the rface layer. Excessive water on the surface can be moved by tile drains where outlets are suitable.

Use of proper stocking rates, pasture rotation, and stricted grazing during wet periods helps to keep the sture in good condition. Proper grazing practices, eed control, and fertilizer are needed for maximum quality of forage. Legumes benefit from applications of ricultural lime. In some years supplemental irrigation is eded.

This unit is suited to the production of red alder. On the basis of a 50-year site curve, the mean site index is 6. The mean annual increment at culmination (CMAI) red alder at age 40 is 128 cubic feet per acre. Among the trees of limited extent are western redcedar, western hemlock, and bigleaf maple. Among the common forest understory plants are western swordfern, brackenfern, trailing blackberry, thimbleberry, and salmonberry.

The main limitation for the harvesting of timber is seasonal soil wetness. A seasonal high water table and ponding limit the use of equipment to dry periods. Use of wheeled and tracked equipment when the soil in this unit is wet produces ruts, compacts the soil, and damages the roots of trees. Unsurfaced roads and skid trails are soft when wet, and they may be impassable. Logging roads require suitable surfacing for year-round use. Rock for road construction is not readily available on this unit.

Seedling mortality and brush competition are the main limitations for the production of timber. If seed trees are present, natural reforestation of cutover areas by red alder occurs periodically. The seasonal high water table and ponding reduce root respiration, which results in high mortality of seedlings. When openings are made in the canopy, invading brushy plants, if not controlled, can delay reforestation. Because the rooting depth is restricted by the seasonal high water table, trees are subject to windthrow.

This unit is poorly suited to urban development. It is subject to ponding.

This map unit is in capability subclass IIIw.

40—Norma Variant loam. This very deep, poorly drained soil is in depressional areas on outwash plains. It formed in glacial outwash. Areas are 10 to 35 acres in size. The native vegetation is mainly conifers and hardwoods. Elevation is 50 to 400 feet. Slope is 0 to 3 percent. The average annual precipitation is about 45 inches, the average annual air temperature is about 50 degrees F, and the average frost-free season is 180 to 200 days.

Typically, the surface layer is dark reddish brown loam about 9 inches thick. The subsoil is light olive gray and grayish brown sandy clay loam about 17 inches thick. The substratum to a depth of 60 inches or more is olive gray sandy loam and loamy sand. In some areas the surface layer is silt loam and silty clay loam, and in some areas the soil is somewhat poorly drained.

Included in this unit are areas of Bellingham, Custer, and Norma soils and Terric Medisaprists in depressional areas and Ragnar soils on outwash plains. Included areas make up about 15 percent of the total acreage.

Permeability of this Norma Variant soil is moderately slow. Available water capacity is moderate. Effective rooting depth is limited by a seasonal high water table that is at a depth of 0 to about 12 inches. Runoff is very slow, and the hazard of water erosion is slight. Ponding occurs from November to April.

This unit is used mainly for hay and pasture. It also is used as woodland. Where drained, it is used as cropland and for urban development.

This unit, where drained, is suited to use as cropland. Proper row arrangement, field ditches, and vegetated

VEGETATED FILTER STRIP ANALYSIS

VEGETATED FILTER STRIP DESIGN

Based on the improved procedure outlined in the final draft (August 2000) of the revised D.O.E. Stormwater Management manual. Volume V, Appendix 8.1 (copy attached).

P-1 Calculated flow rate, 6-month water quality storm (pond release rate):

$Q := 0.24$ cfs

P-2 Slope:

$s := 0.01$ (from Table 8 – 1)

P-3 Vegetation: Clover/grasses

D-1 Design depth of flow (calculated from Manning's equation with known *Q*, *n* and 100-ft. channel width):

$y := 0.0448$ ft.

D-2 Manning's coefficient (from Table 8-1): $n := 0.35$

D-3 Hydraulic design shape: rectangular

D-4 Filter strip width:

$T := 100$ ft.

D-5 Hydraulic area:

$A := T \cdot y$ $A = 4.5$

D-6 Flow velocity:

$V := \frac{Q}{A}$ $V = 0.054$ fps

D-7 Minimum filter strip length:

$t := 540$ sec (9 min. hydraulic residence time from Table 8-1)

$L := V \cdot t$ $L = 28.9$ ft.

Space constraints imposed by the adjacent NGPE limit the officially maintained (mowed) length of the filter strip to 25 feet, but the 1% grade will be extended an additional five feet and planted with the same mix of vegetation as the first 25 feet. This, together with the subsequent 125 feet of vegetated sheet flow path to the creek, will provide sufficient filtration to meet the intent of the D.O.E. requirements.

High flow soil stability analysis (100-year storm):

$Q := 1.45$ cfs (discharge from pond)

$n := 0.033$ (assume minimal resistance from vegetation)

From **D-4**: $R := y$ (depth of flow)

From attached Flowmaster worksheet: $y := 0.03$ ft

$R := 0.03$ ft

Flow velocity:

$$V := \left(\frac{1.49}{n}\right) \cdot R^{0.67} \cdot s^{0.5}$$

$V = 0.43$ fps

This flow velocity is not sufficient to cause erosion on any well-vegetated soil.

Low Flow Analysis -- Vegetated Filter Strip
Worksheet for Rectangular Channel

Project Description

Worksheet	Filter strip -- low flow
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data

Mannings Coefficient	0.350	
Slope	0.010000	ft/ft
Bottom Width	100.00	ft
Discharge	0.24	cfs

Results

Depth	0.0448	ft
Flow Area	4.5	ft²
Wetted Perimeter	100.09	ft
Top Width	100.00	ft
Critical Depth	0.01	ft
Critical Slope	10.032103	ft/ft
Velocity	0.05	ft/s
Velocity Head	4.45e-5	ft
Specific Energy	0.0449	ft
Froude Number	0.04	
Flow Type	Subcritical	

Filter Strip Analysis -- 100 year flow
Worksheet for Rectangular Channel

Project Description	
Worksheet	Filter strip -- high flow
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.033	
Slope	0.010000	ft/ft
Bottom Width	100.00	ft
Discharge	1.45	cfs

Results		
Depth	**0.0320**	**ft**
Flow Area	**3.2**	**ft²**
Wetted Perimeter	**100.06**	**ft**
Top Width	**100.00**	**ft**
Critical Depth	**0.02**	**ft**
Critical Slope	**0.059820**	**ft/ft**
Velocity	**0.45**	**ft/s**
Velocity Head	**3.2e-3**	**ft**
Specific Energy	**0.0352**	**ft**
Froude Number	**0.45**	
Flow Type	**Subcritical**	

DETENTION POND
DESIGN CALCULATIONS

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3/30/01   12:8:40 am                                           page    1
                          CROWN PARK/CROWN DISTRIBUTING
     REVISED DETENTION POND SIZING
     =====================================================================
                                 BASIN SUMMARY


     BASIN ID: DV002        NAME: DEVELOPED SITE 2 YR STORM
     SBUH METHODOLOGY
     TOTAL AREA.......:   9.00 Acres     BASEFLOWS:   0.00 cfs
     RAINFALL TYPE....:    TYPE1A                   PERV           IMP
     PRECIPITATION....:   1.80 inches    AREA..:    0.80 Acres    8.20 Acres
     TIME INTERVAL....:     10.00 min    CN....:   86.00          98.00
                                         TC....:   23.84 min      5.00 min
     ABSTRACTION COEFF:   0.20
     TcReach - Sheet   L:  75.00 ns:0.1500 p2yr: 1.80 s:0.0025
     impTcReach - Channel L:1399.24 kc:17.00 s:0.0025
     PEAK RATE:   3.04 cfs   VOL:   1.12 Ac-ft   TIME:    480 min

     BASIN ID: DV006MO       NAME: DEVELOPED SITE 6 MONTH STORM
     SBUH METHODOLOGY
     TOTAL AREA.......:   9.00 Acres     BASEFLOWS:   0.00 cfs
     RAINFALL TYPE....:    TYPE1A                   PERV           IMP
     PRECIPITATION....:   1.15 inches    AREA..:    0.80 Acres    8.20 Acres
     TIME INTERVAL....:     10.00 min    CN....:   86.00          98.00
                                         TC....:   23.80 min      5.00 min
     ABSTRACTION COEFF:   0.20
     TcReach - Channel L: 825.00 kc:42.00 s:0.0025
     impTcReach - Channel L:1399.24 kc:17.00 s:0.0025
     PEAK RATE:   1.80 cfs   VOL:   0.66 Ac-ft   TIME:    480 min

     BASIN ID: DV010        NAME: DEVELOPED SITE 10 YR STORM
     SBUH METHODOLOGY
     TOTAL AREA.......:   9.00 Acres     BASEFLOWS:   0.00 cfs
     RAINFALL TYPE....:    TYPE1A                   PERV           IMP
     PRECIPITATION....:   2.60 inches    AREA..:    0.80 Acres    8.20 Acres
     TIME INTERVAL....:     10.00 min    CN....:   86.00          98.00
                                         TC....:   23.80 min      5.00 min
     ABSTRACTION COEFF:   0.20
     impTcReach - Channel L:1399.24 kc:17.00 s:0.0025
     PEAK RATE:   4.56 cfs   VOL:   1.71 Ac-ft   TIME:    480 min

     BASIN ID: DV100        NAME: DEVELOPED SITE 100 YR STORM
     SBUH METHODOLOGY
     TOTAL AREA.......:   9.00 Acres     BASEFLOWS:   0.00 cfs
     RAINFALL TYPE....:    TYPE1A                   PERV           IMP
     PRECIPITATION....:   3.70 inches    AREA..:    0.80 Acres    8.20 Acres
     TIME INTERVAL....:     10.00 min    CN....:   86.00          98.00
                                         TC....:   23.80 min      5.00 min
     ABSTRACTION COEFF:   0.20
     impTcReach - Channel L:1399.24 kc:17.00 s:0.0025
     PEAK RATE:   6.65 cfs   VOL:   2.52 Ac-ft   TIME:    480 min
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                         CROWN PARK/CROWN DISTRIBUTING
REVISED DETENTION POND SIZING
=======================================================================
                              BASIN SUMMARY


BASIN ID: EX002        NAME: EXISTING SITE 2 YR STORM
SBUH METHODOLOGY
TOTAL AREA.......:   9.00 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:    TYPE1A                     PERV           IMP
PRECIPITATION....:   1.80 inches    AREA..:    9.00 Acres    0.00 Acres
TIME INTERVAL....:     10.00 min    CN....:   86.00          98.00
                                    TC....:   60.67 min      5.00 min
ABSTRACTION COEFF:   0.20
TcReach - Sheet   L: 300.00 ns:0.1500 p2yr: 1.80 s:0.0050
TcReach - Shallow L: 275.00 ks:11.00 s:0.0050
PEAK RATE:   0.60 cfs  VOL:   0.53 Ac-ft  TIME:    520 min

BASIN ID: EX010        NAME: EXISTING SITE 10 YR STORM
SBUH METHODOLOGY
TOTAL AREA.......:   9.00 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:    TYPE1A                     PERV           IMP
PRECIPITATION....:   2.60 inches    AREA..:    9.00 Acres    0.00 Acres
TIME INTERVAL....:     10.00 min    CN....:   86.00          98.00
                                    TC....:   60.67 min      5.00 min
ABSTRACTION COEFF:   0.20
TcReach - Sheet   L: 300.00 ns:0.1500 p2yr: 1.80 s:0.0050
TcReach - Shallow L: 275.00 ks:11.00 s:0.0050
PEAK RATE:   1.35 cfs  VOL:   0.99 Ac-ft  TIME:    490 min

BASIN ID: EX100        NAME: EXISTING SITE 100 YR STORM
SBUH METHODOLOGY
TOTAL AREA.......:   9.00 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:    TYPE1A                     PERV           IMP
PRECIPITATION....:   3.70 inches    AREA..:    9.00 Acres    0.00 Acres
TIME INTERVAL....:     10.00 min    CN....:   86.00          98.00
                                    TC....:   60.67 min      5.00 min
ABSTRACTION COEFF:   0.20
TcReach - Sheet   L: 300.00 ns:0.1500 p2yr: 1.80 s:0.0050
TcReach - Shallow L: 275.00 ks:11.00 s:0.0050
PEAK RATE:   2.55 cfs  VOL:   1.71 Ac-ft  TIME:    490 min
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                              CROWN PARK/CROWN DISTRIBUTING
      REVISED DETENTION POND SIZING
      ========================================================================
                                   HYDROGRAPH SUMMARY



             PEAK      TIME     VOLUME
      HYD    RUNOFF     OF        OF        Contrib
      NUM     RATE     PEAK     HYDRO        Area
              cfs       min.    cf\AcFt      Acres
      ==============================================
         1     0.283  1450      41421 cf      9.00
         2     0.675   980      60704 cf      9.00
         3     1.451   680      94867 cf      9.00
         4     0.238  1330      28112 cf      9.00

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                              CROWN PARK/CROWN DISTRIBUTING
      REVISED DETENTION POND SIZING
      ========================================================================
                                 STORAGE STRUCTURE LIST


      STORAGE LIST       ID No. STG-STO
      Description: STAGE STORAGE POND


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                              CROWN PARK/CROWN DISTRIBUTING
      REVISED DETENTION POND SIZING
      ========================================================================
                                DISCHARGE STRUCTURE LIST


      COMBINATION DISCHARGE      ID No. COMBO
      Description: COMBO FOR ORIFICE & NOTCH
      Structure: NOTCH        Structure:
      Structure: ORIFICE        Structure:
      Structure:


      NOTCH WEIR             ID No. NOTCH
      Description: OUTLET CONTROL WEIR
      Weir Length: 5.0000 ft.    Weir height (p):   0.8000 ft.
      Elevation  : 122.30 ft.        Weir Increm: 0.10

      MULTIPLE ORIFICE      ID No. ORIFICE
      Description: DISCHARGE ORIFICE IN WEIR
      Outlet Elev:   121.50
      Elev:   119.50 ft     Orifice Diameter:  3.5000 in.
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                                        CROWN PARK/CROWN DISTRIBUTING
        REVISED DETENTION POND SIZING
        ====================================================================
                                          LEVEL POOL TABLE SUMMARY

                            MATCH  INFLOW -STO- -DIS-  <-PEAK->     OUTFLOW STORAGE
DESCRIPTION--------->  (cfs)  (cfs) --id- --id-  <-STAGE> id   (cfs) VOL (cf)

=============================================================================
2 YR ...................0.30   3.04 STG-STO COMBO   122.23  1   0.28 30483.64 cf
10 YR ..................1.35   4.56 STG-STO COMBO   122.37  2   0.67 41578.36 cf
100 YR .................2.55   6.65 STG-STO COMBO   122.46  3   1.45 48782.52 cf
6 MONTH ................1.80   1.80 STG-STO COMBO   122.02  4   0.24 13859.95 cf
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SPILLWAY SIZING FOR DETENTION POND

ASSUMPTION: Pond outlet fails and spillway conveys flow at peak rate of 100-year design storm.

100-year peak rate:

$Q_{100} := 6.65$ cfs

Allowable depth of water over weir:

$H := 0.333$ ft.

Gravity constant:

$g := 32.2$

Broad-crested weir coefficient:

$K := 0.385$

Minimum required length of spillway:

$$L := \frac{Q_{100}}{K \cdot \sqrt{2 \cdot g} \cdot H^{1.5}}$$

$L = 11.2$ ft.

∴ The 12-foot design length of the spillway exceeds the minimum requirement.

DETENTION POND LINER UPLIFT ANALYSIS

ASSUMPTIONS:

Groundwater may reach elevation 123.00, one foot below the surface.

Water density is 62.4 lb/cf

Pond live storage will be dry above outlet at elevation 121.50.

Pond bottom will be covered loosely with a 6-inch layer of quarry spalls above 121.50.

Solid rock density is 165 lb/cf. Spall layer includes 30% voids.

Backfill over liner (below outlet elevation) will be native gravelly sand, wet.

ELEV.	GROUNDWATER DISPLACEMENT (ft)	UPLIFT FORCE (lbs)	FILL DEPTH (ft)	FILL TYPE	DENSITY (pcf)	CUMU-LATIVE WEIGHT	NET FORCE
121.50	1.50	93.60	0.50	QUARRY SPALLS	115.00	57.50	UP
121.00	2.00	124.80	0.50	WET SAND	120.00	117.50	UP
120.50	2.50	156.00	0.50	WET SAND	120.00	177.50	DOWN

Design conclusion: Worst-case groundwater uplift force will be neutralized by weight of 6 inches of quarry spalls above pond outlet elevation and a minimum of 12 inches of native sandy soil backfill between the liner and the outlet.