Abbey Road
GROUP

TECHNICAL INFORMATION REPORT
CASCADE CHRISTIAN SCHOOL

815 21st Street East
Puyallup, Washington

Job #03-143

RYAN M. JEFFRIES
3834[illegible]

5-6-16

March, 2016
Revised May 2016

Prepared for:
Cascade Christian School
815 21st Street East
Puyallup, WA 98372

923 Shaw Road, Puyallup, WA 98372
P.O. Box 1224, Puyallup, WA 98371
(253) 435-3699 / Fax (253) 446-3159

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APPENDIX

1.0 PROJECT OVERVIEW

The proposed Cascade Christian School Improvement project is located at 815 21st Street East, east of 21st Street East, in Puyallup, WA. The project is another phase of work that was designed as part of the previously approved TIR dated November 1995, which specified the original design of the school project. This report will supply additional data for this phase of the Cascade Christian School but the previously approved TIR should be referenced for the overall project construction, see Appendix. The improvements proposed to the site in this phase extend improvements to an area onsite that has been a pre-loaded (for future building construction) grassed area. This area will have a new building constructed on it. Onsite utilities are stubbed to this open area where the new building is to be constructed. As previously stated, the original design accounted for the future construction of this building.

The site is also situated within a portion of Section 35, Township 20 North, Range 4 East, Willamette Meridian, City of Puyallup, and Pierce County Washington. Please see Figure 2 for a more accurate depiction of the location of the project site.

The existing storm drainage pond will handle the detention requirements for the project. The storm drainage pond was designed to the detention requirements in effect at the time of development. The SBUH methodology has been used in the sizing of the existing facility.

The soils are delineated as Briscott Loam by the NCRS Web Soil Survey, see Figure 3. There are no wetlands on the site. The site is shown on the FEMA FIRM Community Panel Number 530144 0005 B and the site is designated as "ZONE AO" (Depth 1), see Appendix for FIRM Panel. The site is within the Deer Creek and Puyallup River drainage basin.

Stormwater from the developed site will be conveyed through the existing developments storm conveyance system to a bio-swale and then a detention pond and released to the storm drain conveyance system in 21st Street East through an outlet system onsite. Then surface water is conveyed north to Deer Creek and the Puyallup River on the north side of East Pioneer.

This Technical Information Report identifies how the existing and proposed site development improvements stormwater impacts are mitigated with the existing pond as designed.

2.0 CONDITIONS AND REQUIREMENTS SUMMARY

The following is a response to each of the core requirements delineated in the 2005 SWMM.

Minimum Requirement No.1 – Storm Water Site Plan: The project will prepare a Storm Water Site Plan per the requirements of the City of Puyallup.

Minimum Requirement No. 2 – Construction Stormwater Pollution Prevention: A Stormwater Pollution Prevention Plan will be prepared for the project to comply with Elements #1 through 12, DOE Manual, Volume I, Section 2.5. Element #10 Dewatering will not be needed for the project. The other 11 elements will be addressed in the SWPPP.

Minimum Requirement No. 3 – Source Control of Pollution: The project is a commercial project and source control Minimum Requirement #3 is applicable.

Minimum Requirement No. 4 Preservation of Natural Drainage System and Outfalls: The project site will discharge stormwater through the existing conveyance system onsite.

Minimum Requirement No. 5 – On-Site Stormwater Management: All stormwater runoff generated from the developed on-site impervious and pervious areas will be routed to the existing stormwater quantity (detention pond) and quality facilities (bio-swale). Roof downspouts stubs are provided and will be utilized.

Minimum Requirement No. 6 – Runoff Treatment: The project provides basic water quality treatment in a bio-filtration swale. The bio-swale portion of the pond is sized for the proposed developed condition. The design of the bio-swale is 200' long, 8' wide and sloped at 0.5%.

Minimum Requirement No. 7 – Flow Control: The project provides stormwater detention as dictated by the flow control design requirements at the time of the original construction; flow control of the existing pond is designed to release the developed flows at the following rates:
Dev Q2 =< 50% Ex.Q2
Dev Q10 = < Ex.Q10
Dev Q100 =< Ex.Q100
The pond volume has been as-built and the pond has the required volume of 55,461 cubic feet, see Stormwater Calculations in Appendix.

Minimum Requirement No. 8 – Wetland Protection: There are no wetlands on the project. This requirement does not apply.

Minimum Requirement No. 9 – Basin/Watershed Planning: The project is within the Deer Creek Basin. No specific basin plan exists that we are aware of. However, the Ecology's 2008 water quality assessment placed Deer Creek in Category 5 (Needs a TMDL) for fecal coliform bacteria. The assessment did not identify any other parameters of concern.

Minimum Requirement No. 10 – Operation and Maintenance: The owner has assumed the maintenance and operation of the stormwater facilities located on the site. The storm facilities has been on-line for about 20 years and have been maintained by the owner. A Stormwater Maintenance Manual for the project is included in the Appendix.

Optional Guidance No. 1 – Financial Liability: Financial guarantees will be provided, if necessary. The existing facilities are being connected to but only a limited amount of new roof drains are proposed at this time.

3.0 OFF-SITE ANALYSIS

See approved TIR dated November 1995. At the time of the original construction of the site, the offsite storm conveyance system was improved. The flows discharge to Deer Creek. The downstream conveyance system has capacity for the tributary area to it.

4.0 FLOW CONTROL AND WATER QUALITY FACILITY ANALYSIS AND DESIGN

4.1 Existing Site Hydrology

See approved TIR dated November 1995 in Appendix. For the purposes of this report, the existing condition is considered to be that condition that existing before the school was constructed (1995) and is described as follows:

The site is mostly flat pasture land with few trees. The site is drained by Deer Creek, which has been relocated to the east side of 25th Street. The existing topography does not allow the proposed site and surrounding land to drain tot eh relocated creek across 25th Street. The area drains north to Pioneer Way and into Deer Creek on the north side of Pioneer Way.

4.2 Developed Site Hydrology

Runoff from the improvements and existing site will be or are collected and conveyed to the onsite storm bio-swale and detention pond. See approved TIR dated November 1995 for additional information on the developed site hydrology. The bio-swale and detention pond mitigate the site's surface water runoff before discharge to the downstream conveyance system. The new building is to be collected and conveyed to the existing bio-wale and detention pond. The following data was used in the approved modeling of the existing onsite storm facilities:

West Basin Original Design (Parking Lot and Buildings)
Total Area: 8.33 acres
Impervious Area: 7.83 acres, CN 98
Pervious Area: 0.50 acres, CN 89
Soils Type: Briscot, Type D
Time of Concentration: 6.0 minutes
Flow Rates: Q 6mo = 2.35 cfs
Q2 = 3.93 cfs
Q10 = 5.89 cfs
Q100 = 8.06 cfs

As shown on the Proposed Basin Map Exhibit in the 1995 Stormwater TIR Report (see report in appendix), the impervious surface area accounted for at the time of design is more than the impervious surface area proposed now by inspection; in addition, for your information a West Basin Map showing the revised site plan with tributary area calculations is provided, see Appendix demonstrating the fact that the original design impervious area is greater than that proposed now. In summary, there is more landscaping proposed now than previously and the building proposed is smaller than what was accounted for. Therefore, the existing pond design is adequately sized with this current proposal as per the 1990 King County Manual.

West Basin with Current Site Plan (Parking Lot and Buildings)
Total Area: 8.33 acres
Total Impervious Area: 6.583 acres, CN 98
  Building Area: 2.225 acres, CN 98
  Paving Area: 3.6743 acres, CN 98
  Sidewalk Area: 0.4038 acres, CN 98
  Pond Area: 0.2799 acres, CN 100
Total Pervious Area: 1.747 acres, CN 89
  Landscaping Area: 1.7470 acres, CN 89

East Basin Original Design (Athletic Fields) Does not change
Total Area: 8.75 acres
Impervious Area: 0.75 acres, CN 98
Pervious Area: 8.00 acres, CN 89
Soils Type: Briscot, Type D
Time of Concentration: 40.9 minutes
Flow Rates: Q 6mo = 0.58 cfs
  Q2 = 1.41 cfs
  Q10 = 2.60 cfs
  Q100 = 4.02 cfs

4.3 Performance Standards

See approved TIR dated November 1995. In summary, the following SBUH control standards were implemented in the original design:

Dev Q2 = < 50% Ex.Q2
Dev Q10 = < Ex.Q10
Dev Q100 = < Ex.Q100

4.4 Flow Control System

Detention storage is provided in the onsite storm pond, see approved TIR dated November 1995. The required volume of 55,461 cubic feet has been verified in the existing pond, see Storm Calculations in Appendix.

4.5 Downspout Controls

Downspouts are to be connected to the existing stubs provided for the building construction proposed at this time. The roof drain lines are 8" at a minimum slope of 0.5%.

4.6 Water Quality System

The existing bio-swale provides water quality mitigation as per the requirements. See approved TIR dated November 1995 for additional information.

4.7 Overflow System

The detention system and downstream conveyance system was provided during the original construction. See approved TIR dated November 1995.

5.0 CONVEYANCE SYSTEM ANALYSIS AND DESIGN

Runoff from this phase will be collected in a series of catch basins and tight lined to the storm pond constructed as part of the previous work. The conveyance system was designed in accordance with the City of Puyallup requirements at the time of construction. Calculations are provided in the 1995 TIR, see Appendix. See approved TIR dated November 1995 for additional information.

6.0 SPECIAL REPORTS AND STUDIES

See approved TIR dated November 1995 prepared by AHBL, Inc. in Appendix. Additionally, a Geotechnical Engineering report prepared by Earth Consultants, Inc. July 7, 1995 is provided in the Appendix. Further, a Limited Geotechnical Site Evaluation letter prepared by Krazan & Associates, Inc. on March 4, 2008 is included in the Appendix. Also, an "ADDENDA 1" to the TIR dated December 13, 1995 is included in the Appendix. Finally, a Stormwater Maintenance Manual for the project is included in the Appendix. All reports are provided as a reference and back-ground information.

7.0 OTHER PERMITS

Building permit.

8.0 TESC ANALYSIS AND DESIGN

The TESC plans prepared for the project show the requirements for the project. The site will have silt fences and catch basin inserts

- *Cover Measures:* Cover measures will consist of mulching, and erosion control seeding. Cover measures are specified on the TESC plans.
- *Traffic Area Stabilization:* The site will utilize the existing paved parking lot for the construction entrances. This shown on the engineering plans.
- *Sediment Retention:* All sediment controls of catch basins inserts are shown on the plan. The storm drain bio-swale detention pond (permanent facilities) will also function as mitigating facilities.
- *Surface Water Control:* The site currently drains to the storm detention pond. Additional swales and sediment ponds are not needed..
- *Maintenance:* Maintenance requirements are detailed in the TESC notes on the engineering plans.
- *Final Stabilization:* Upon completion of the project, all disturbed areas will be stabilized and Best Management Practices removed, if appropriate.

9.0 BOND QUANTITIES, FACILITY SUMMARIES, AND DECLARATION OF COVENANT

Proposed facilities are minimal (roof drain lines) and the existing storm facilities are already subject to the legal documents in-place including the maintenance and operations manual. If required, new documents will be submitted for the private facilities.

10.0 OPERATIONS AND MAINTENANCE MANUAL

See approved TIR dated November 1995.

FIGURE 1
TECHNICAL INFORMATION REPORT (TIR) WORKSHEET

King County Department of Development and Environmental Services
TECHNICAL INFORMATION REPORT (TIR) WORKSHEET

Part 1 PROJECT OWNER AND PROJECT ENGINEER

Project Owner Cascade Christian School

Address 815 21st Street East

Puyallup, WA 98372

Phone

Project Engineer Ryan Jeffries, PE

Company Abbey Road Group Land Development Services Co.

Address/Phone 923 Shaw Road, Suite A

Puyallup, WA 98372 / (253) 435-3699

Part 2 PROJECT LOCATION AND DESCRIPTION

Project Name

Cascade Christian School

Location

Township 20 N

Range 4 E

Section 35

Project Size: Work Limits = 2 acres

Part 3 TYPE OF PERMIT APPLICATION

- ☐ Subdivision HPA
- ☐ Short Subdivision
- ☐ Grading
- ☒ Commercial
- ☐ Other

Part 4 OTHER REVIEWS AND PERMITS

- ☐ DFW HPA
- ☐ COE 404
- ☐ DOE Dam Safety
- ☐ FEMA Floodplain
- ☐ COE Wetlands
- ☐ Shoreline Management
- ☐ Rockery
- ☐ Structural Vaults
- ☐ Other

Part 5 SITE COMMUNITY AND DRAINAGE BASIN

Community

Puyallup

Drainage Basin

Deer Creek

Part 6 SITE CHARACTERISTICS

- ☐ River
- ☐ Stream
- ☐ Critical Stream Reach
- ☐ Depressions/Swales
- ☐ Lake
- ☐ Steep Slopes
- ☐ Floodplain
- ☐ Wetlands
- ☐ Seeps/Springs
- ☒ High Groundwater Table
- ☐ Groundwater Recharge
- ☐ Other

Part 7 SOILS

Soil Type	Slopes	Erosion Potential	Erosive Velocities
Briscott Loam	0% to 3%	Slight	NA

☐ Additional Sheets Attached

Part 8 DEVELOPMENT LIMITATIONS

REFERENCE	LIMITATION/SITE CONSTRAINT
☐	
☐	
☐	
☐	
☐ Additional Sheets Attached	

Part 9 ESC REQUIREMENTS

MINIMUM ESC REQUIREMENTS DURING CONSTRUCTION	MINIMUM ESC REQUIREMENTS AFTER CONSTRUCTION
☐ Sedimentation Facilities	☒ Stabilize Exposed Surface
☐ Stabilized Construction Entrance	☒ Remove and Restore Temporary ESC Facilities
☐ Perimeter Runoff Control	☒ Clean and Remove All Silt and Debris
☐ Clearing and Grading Restrictions	☒ Ensure Operation of Permanent Facilities
☒ Cover Practices	☐ Flag Limits of SAO and Open Space Preservation Areas
☒ Construction Sequence	☐ Other
☐ Other	

Part 10 SURFACE WATER SYSTEM

☐ Grass Lined Channel	☐ Tank	☐ Infiltration	Method of Analysis SBUH
☒ Pipe System	☐ Vault	☐ Depression	
☐ Open Channel	☐ Energy Dissipater	☐ Flow Dispersal	Compensation/Mitigation of Eliminated Site Storage
☐ Dry Pond	☐ Wetland	☐ Waiver	
☐ Wet Pond	☐ Stream	☐ Regional Detention	

Brief Description of System Operation Stormwater runoff will be collected in a series of existing catch basins and conveyance pipes, conveyed to a bioswale and then a detention pond built as part of the previous work onsite.

Facility Related Site Limitations

Reference	Facility	Limitation

Part 11 STRUCTURAL ANALYSIS

☐ Cast in Place Vault
☐ Retaining Wall
☐ Rockery > 4' High
☐ Structural on Steep Slope
☐ Other ______

Part 12 EASEMENTS/TRACTS

☐ Drainage Easement
☐ Access Easement
☐ Native Growth Protection Easement
☐ Tract
☐ Other ______

Part 13 SIGNATURE OF PROFESSIONAL ENGINEER

I, or a civil engineer under my supervision, have visited the site. Actual site conditions as observed were incorporated into this worksheet and the attachments. To the best of my knowledge the information provided here is accurate.

Ryan M Jeffries

Signed/Dated

FIGURE 2
VICINITY MAP

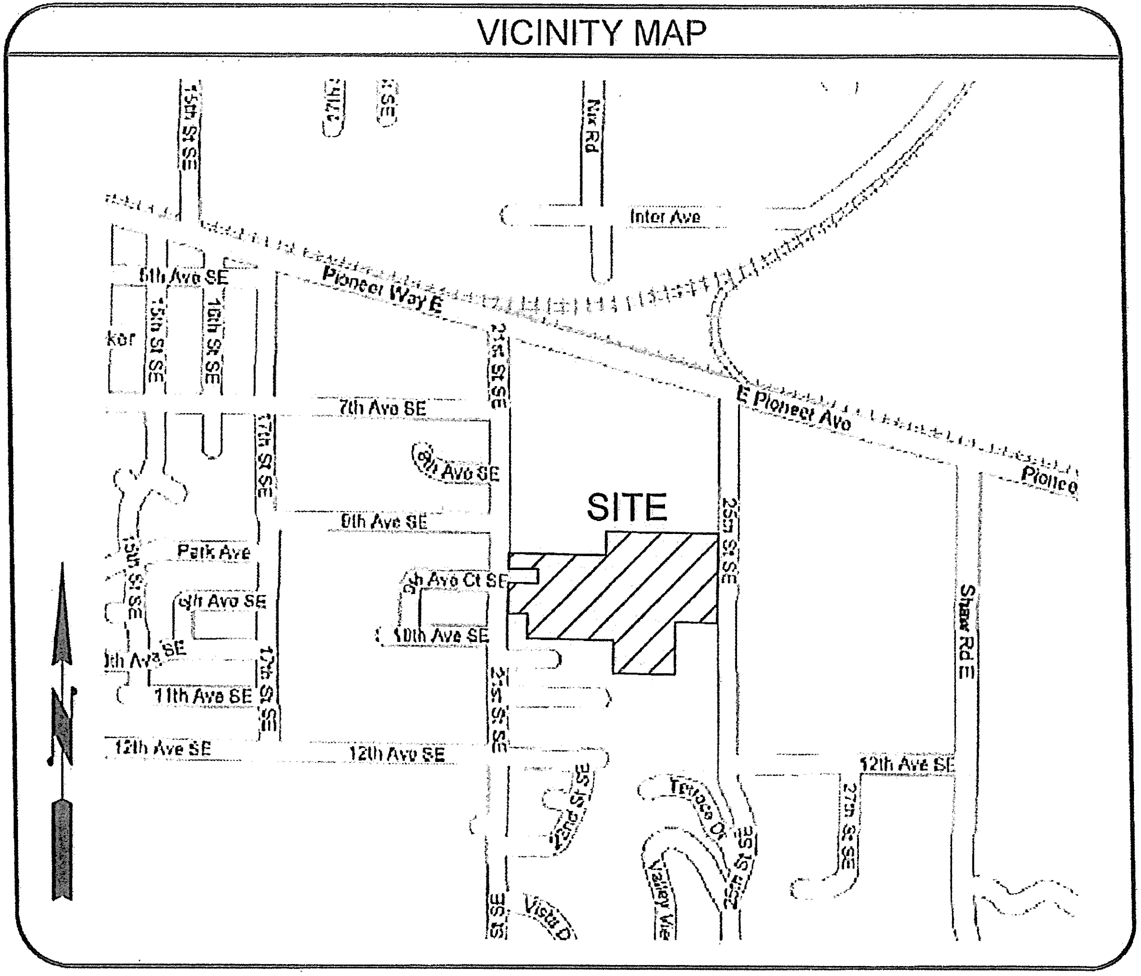
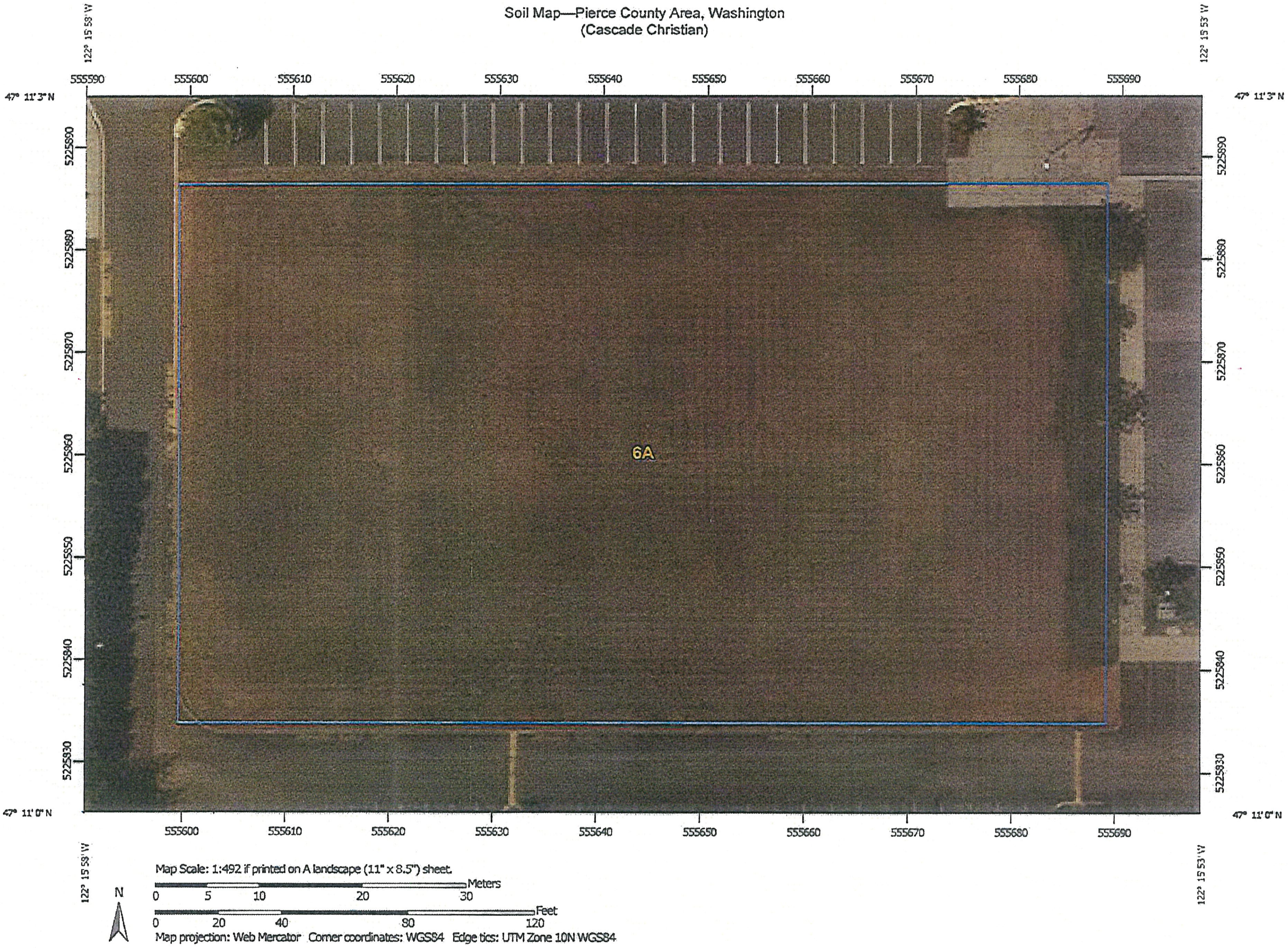


FIGURE 2
VICINITY MAP

FIGURE 3
SOILS MAP & DESCRIPTION And FEMA Panel

Soil Map—Pierce County Area, Washington
(Cascade Christian)



MAP LEGEND

Area of Interest (AOI)
- ☐ Area of Interest (AOI)

Soils
- ☐ Soil Map Unit Polygons
- Soil Map Unit Lines
- ▣ Soil Map Unit Points

Special Point Features
- Blowout
- ☒ Borrow Pit
- Clay Spot
- ◇ Closed Depression
- Gravel Pit
- ∴ Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- ◎ Miscellaneous Water
- ◎ Perennial Water
- ∨ Rock Outcrop
- + Saline Spot
- ⁙ Sandy Spot
- Severely Eroded Spot
- ◇ Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- △ Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- ▨ Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 10, Sep 15, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 8, 2014—Jul 15, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Pierce County Area, Washington (WA653)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
6A	Briscot loam	1.2	100.0%
Totals for Area of Interest		1.2	100.0%

Pierce County Area, Washington

6A—Briscot loam

Map Unit Setting

National map unit symbol: 2hrc
Elevation: 20 to 250 feet
Mean annual precipitation: 30 to 55 inches
Mean annual air temperature: 48 to 50 degrees F
Frost-free period: 160 to 210 days
Farmland classification: Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Briscot and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Briscot

Setting

Landform: Flood plains
Parent material: Alluvium

Typical profile

H1 - 0 to 11 inches: loam
H2 - 11 to 38 inches: stratified fine sand to silt loam
H3 - 38 to 60 inches: sand

Properties and qualities

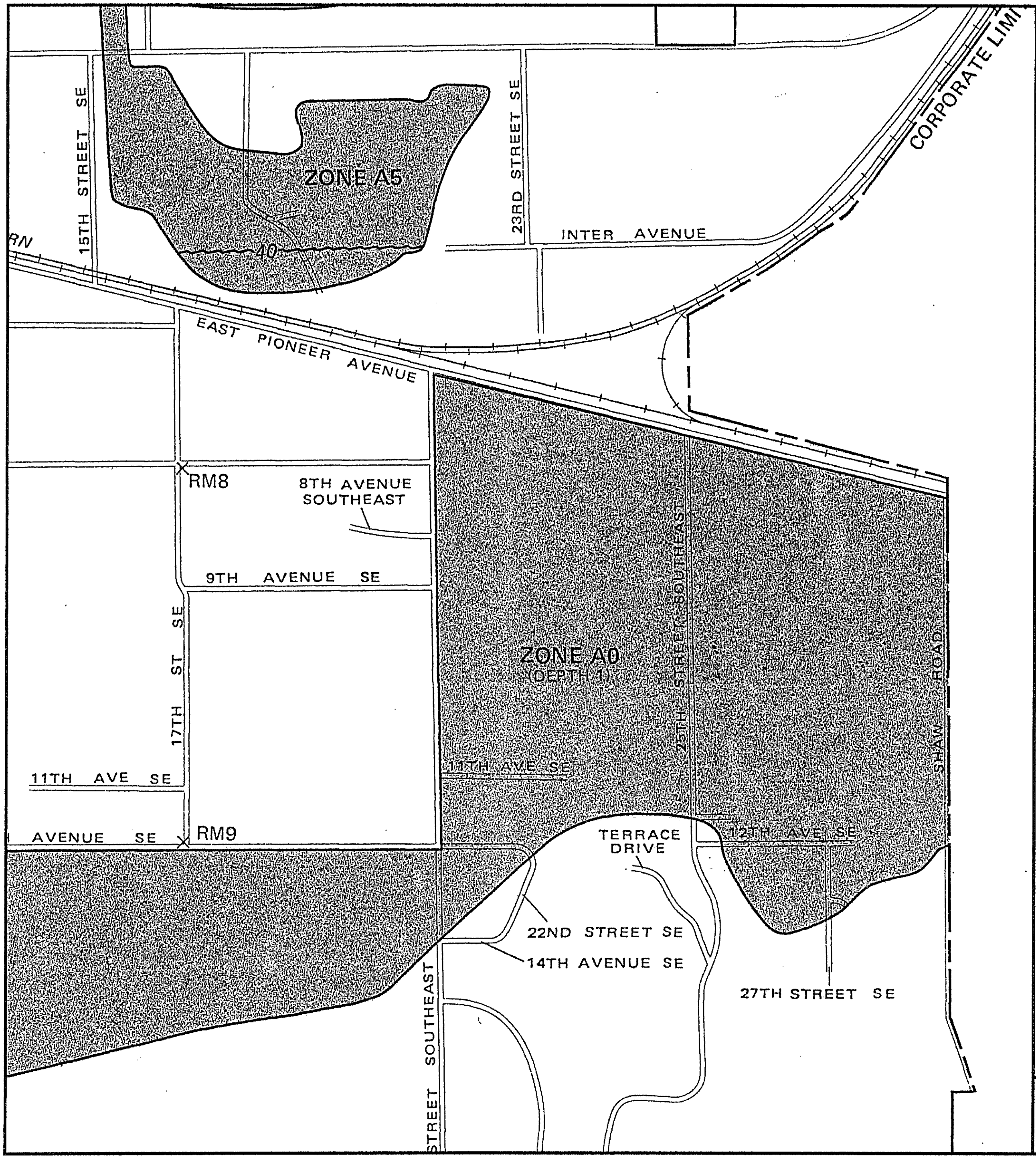
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 12 to 24 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: High (about 11.4 inches)

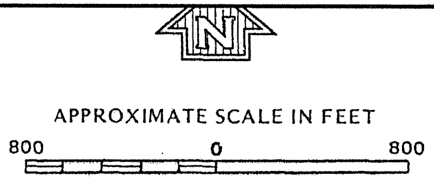
Interpretive groups

Land capability classification (irrigated): 4w
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: B/D
Other vegetative classification: Seasonally Wet Soils (G002XN202WA)

Data Source Information

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 10, Sep 15, 2015





NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

CITY OF
PUYALLUP,
WASHINGTON
PIERCE COUNTY

ONLY PANEL PRINTED
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
530144 0005 B

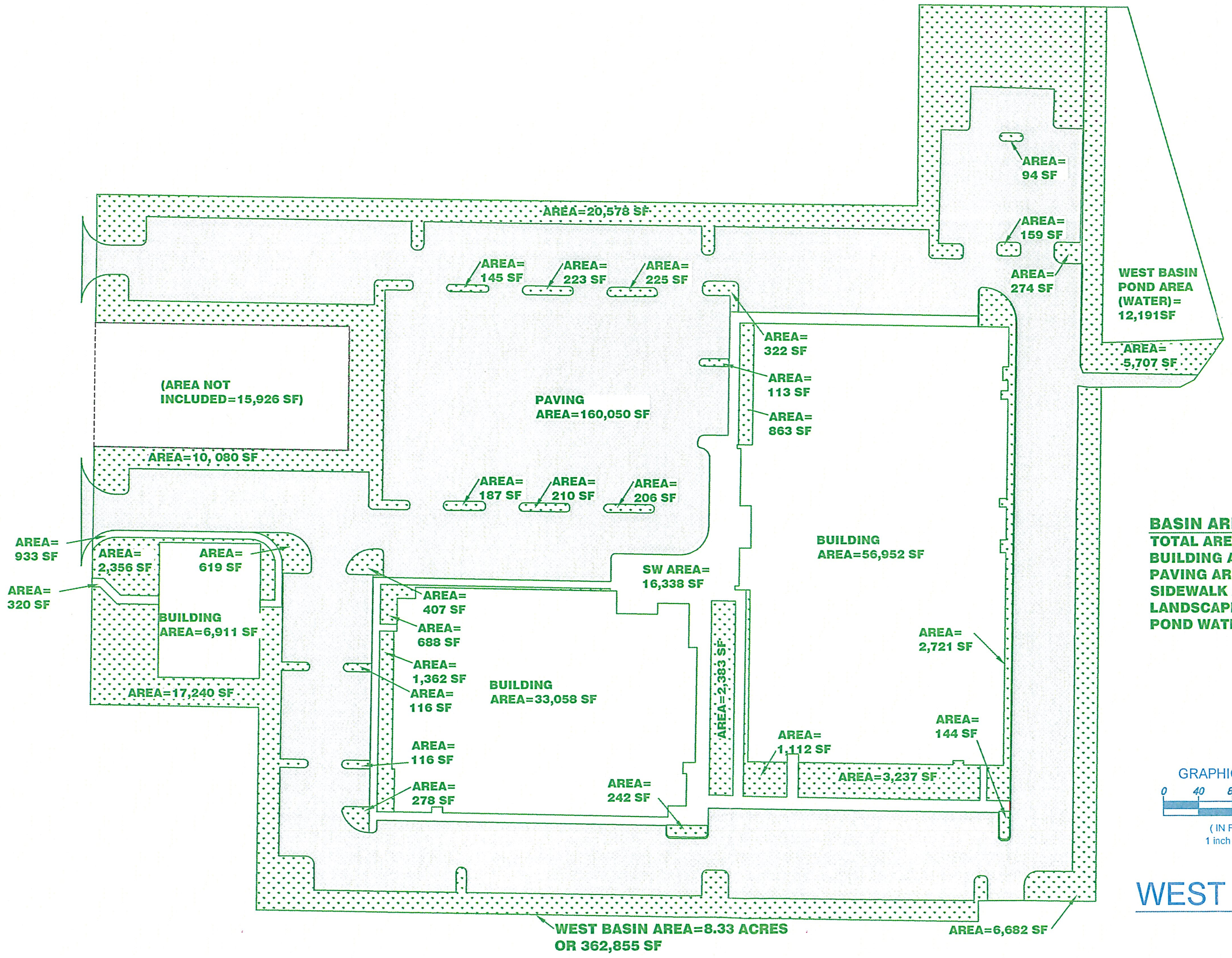
EFFECTIVE DATE:
AUGUST 15, 1980

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

FIGURE 4

STORM CALCULATIONS & WEST BASIN MAP



BASIN AREA SUMMARY

TOTAL AREA: 8.33 AC OR 362,855 SF

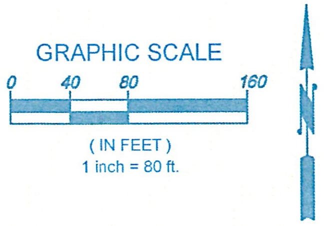
BUILDING AREA: 2.225 AC

PAVING AREA: 3.6743 AC

SIDEWALK AREA: 0.4038 AC

LANDSCAPE AREA: 1.7470 AC

POND WATER AREA: 0.2799 AC



WEST BASIN MAP

Job # 03-143
Date 3-21-16
Subject Pond Volume

Existing Pond Volume Calculation

design over-flow elevation = 61'
design pond bottom = 57'
overflow design 100-yr WSE = 59.46' Vol = 55,461cf
★bioswale = 200' length (design)
8' width (design)
0.5% slope (design)

actual width of swale: varies 2'-8'
actual length of swale: 180'
actual slope of swale: $\frac{58.9-58}{180} = \underline{0.5\%}$

Bioswale needs to be maintained
(remove sediment)

Pond Asbuilt Volume

	El (ft)	Area (sf)	Volume (cf)	Σ Vol (cf)
EL PIPED OUTLET	57.36	0	0	0
	57.50	22,017	3,082	3,082
AREAS INCLUDE BIOSWALE	58.00	23,143	11,290	14,372
	58.50	24,698	11,960	26,332
	59.00	27,859	13,139	39,471
	59.50	29,518	14,344	53,815
	60.00	31,697	15,304	69,119

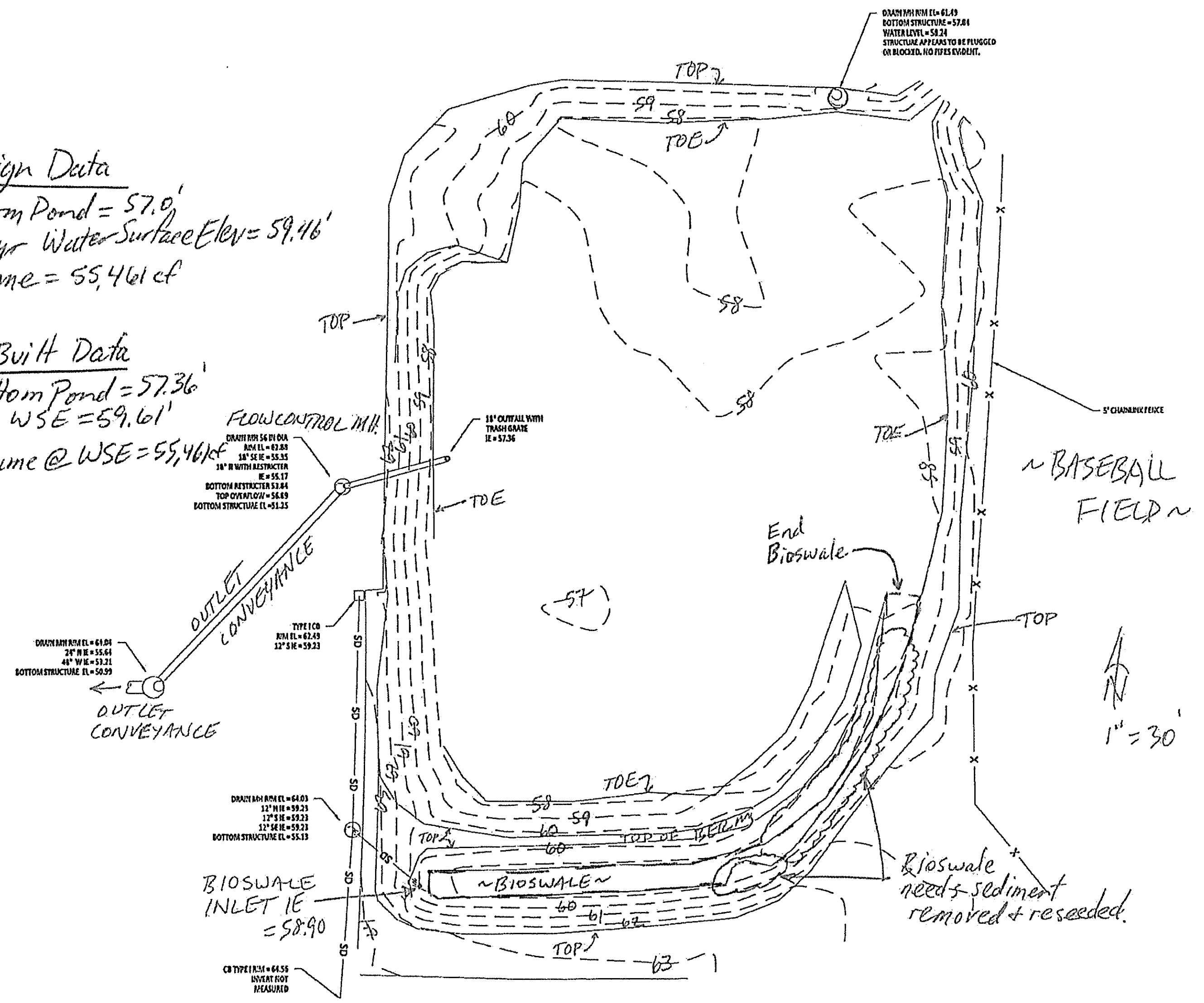
Design Vol. Achieved @ EL 55,461cf
= 59.61'

Design Data

Bottom Pond = 57.0'
100 yr Water Surface Elev = 59.46'
Volume = 55,461 cf

As-Built Data

Bottom Pond = 57.36'
100yr WSE = 59.61'
Volume @ WSE = 55,461cf



STAGE STORAGE TABLE

CUSTOM STORAGE ID No. S
Description:

STAGE	<----STORAGE---->	
(ft)	---cf---	--Ac-Ft-
57.00	0.0000	0.0000
57.10	1236	0.0284
57.20	2471	0.0567
57.30	3707	0.0851
57.40	4943	0.1135
57.50	6178	0.1418
57.60	7414	0.1702
57.70	8650	0.1986
57.80	9886	0.2269
57.90	11121	0.2553
58.00	12357	0.2837
58.10	15126	0.3473
58.20	17895	0.4108
58.30	20665	0.4744
58.40	23434	0.5380
58.50	26203	0.6015
58.60	28972	0.6651
58.70	31742	0.7287
58.80	34511	0.7923
58.90	37280	0.8558
59.00	40049	0.9194
59.10	43401	0.9963
59.20	46752	1.0733
59.30	50103	1.1502
59.40	53454	1.2271
59.50	56805	1.3041
59.60	60156	1.3810
59.70	63507	1.4579
59.80	66858	1.5349
59.90	70210	1.6118
60.00	73561	1.6887
60.00	73561	1.6887

Design Stage Storage of Pond

FIGURE 5
1995 STORMWATER TECHNICAL INFORMATION REPORT

STORMWATER
TECHNICAL INFORMATION REPORT

for

CASCADE CHRISTIAN JUNIOR AND SENIOR HIGH

NOVEMBER 1995

Prepared For:

City of Puyallup
and
Cascade Christian Schools

Prepared By:
Seabrook M. Schilt, Design Engineer
Sean M. Comfort, P.E., Project Manager

Reviewed By:
George J. Lindsay, P.E., Principal

94247.10, Task 12

STORMWATER
TECHNICAL INFORMATION REPORT

for

CASCADE CHRISTIAN JUNIOR AND SENIOR HIGH

NOVEMBER 1995

Prepared For:

City of Puyallup
and
Cascade Christian Schools

GEORGE J. LINDSAY
STATE OF WASHINGTON
13306
REGISTERED PROFESSIONAL ENGINEER
EXPIRES 7/23/97
11/30/95

Prepared By:
Seabrook M. Schilt, Design Engineer
Sean M. Comfort, P.E., Project Manager

Reviewed By:
George J. Lindsay, P.E., Principal

94247.10, Task 12

This analysis is based on data and records either supplied to, or obtained by, *AHBL*. These documents are referenced within the text of the analysis. The analysis has been prepared utilizing procedures and practices within the standard accepted practices of the industry.

AHBL, INC.

TABLE OF CONTENTS

1.0 PROJECT OVERVIEW

1.1 Purpose and Scope

This report accompanies the civil engineering plans for the proposed improvements for Cascade Christian School in Puyallup. The proposed 17-acre project site lies between 25th and 21st Street SE, approximately 1,000 feet south of Pioneer Way. Approximately 41 percent of the site will be impervious area under developed conditions, including the track area. All parking lot paving and drainage will be completed in Phase 1, as shown on the plans. Phase 2 will include the construction of the second building, as shown on the plans. A 100,200-square-foot building is proposed, including the Phase 2 building. Stormwater conveyance and detention are proposed for all paving, buildings, and sport field areas of the project

In addition, roadway improvements are required and will be constructed along 21st Street SE. Due to grading limitations, approximately 0.6 acres of the site will drain to the 21st Street SE drainage system, which eventually reaches the same point as the rest of the drainage from the site.

1.2 Pre-Development Conditions

<u>Existing Site conditions</u>

The site is mostly flat pasture land with few trees. Prior to farming activities, which began in the early 1900's, the area was drained by what is now Deer Creek, which has been relocated to the east side of 25th Street. The existing topography does not allow the proposed site and surrounding land to drain to the relocated creek across 25th street. The area drains north to Pioneer Way and into Deer Creek on the north side of Pioneer Way. Refer to the off-site storm discussion for a description of the existing storm system upstream, downstream, and across the project site.

Fill over the west half of the project site has recently been brought in under previously approved pre-load plans. Erosion control measures have been implemented and are to be maintained during construction of the final design.

Soils

The soils on the site are classified as mostly Briscot Loam with a small area of Puyallup soils as classified by the Soil Conservation Service (SCS) (see soil information Appendix B). A Geotechnical Engineering Study, completed by Earth Consultants, Inc. on July 7, 1995, has also been included as Appendix D for general reference. The upstream and downstream areas of the project basin are also mapped as Briscot soils.

The Geotechnical Study indicates that, based on mottling of the retrieved soil samples, groundwater is likely to be located at depths ranging from three to five feet below existing ground surface during the winter months.

Curve numbers used for runoff calculations have been determined from the soil mapping and field observation. Briscot soils fall into Hydrologic Soil Group D, as indicated by Table III-1.6 of the Stormwater Management Manual for the Puget Sound Basin. For Meadow or Pasture a CN of 89 is given for Group D. The soil mapping only shows a very small portion of the site to be Group B. An existing CN value of 89 for non-pervious areas has been agreed on by the City of Puyallup for the basis for the analysis regarding the subject project and upstream basin areas.

1.3 Post-Development Conditions

Detention and water quality controls will be implemented to mitigate the impacts of the proposed development. Biofiltration has been designed to enhance stormwater quality and to meet City requirements (see calculations Appendix B). Flows from the site, will be discharged to the new and improved downstream drainage system.

The upstream area runoff will be conveyed via a new tightlined system, which will replace the existing system across the site. The upstream drainage areas will bypass the project's proposed biofiltration and detention facilities.

2.0 OFF-SITE DRAINAGE

2.1 Existing System

An extensive, existing drainage system drains the site, as well as properties upstream and downstream. The system was first constructed as a 16-inch cedar box culvert. The system has been maintained and upgraded with a 12-inch concrete pipe, and most recently with an 8-inch perforated pipe. Several laterals connect to the mainline described above. The entire system drains north to Pioneer Way, where it eventually connects with Deer Creek.

Over the years the system was maintained according to SCS requirements. Within the past three years maintenance of the existing system has been lacking and this has resulted in some drainage problems at the northern reaches of the system near Pioneer Way.

A new manhole was installed by the City of Puyallup at the end of the system just before it crosses Pioneer Way. A new 12-inch pipe was installed under Pioneer Way from the new manhole.

The downstream drainage system needs improvements, as it is presently not functioning as intended. Due to a lack of maintenance and the reduced capacity in the existing 8-inch perforated pipe now installed, the capacity of the downstream system is not adequate.

2.2 Off-Site Proposed Storm System

The existing off-site storm system will be replaced from where it enters the south side of the project property. The off-site drainage will then be conveyed across the project site, down 21st Street SE, and across Pioneer Way to an existing storm manhole on the north side of Pioneer Way. The existing structure discharges to Deer Creek.

A drainage investigation and calculations indicate that a 24-inch pipe should be installed across the project site to replace the existing system. Once drainage from upstream and on-site come together after the detention pond a 30-inch pipe is proposed. The 30-inch size is needed primarily because a maximum slope of 0.14% is all that can be obtained down to the discharge point on Pioneer Way. There is a short 24-inch line from the existing structure to Deer Creek with a slope of 4.4 percent ± that has adequate capacity.

The on-site drainage will be detained in the detention pond, but off-site drainage will bypass the detention pond. See the following conveyance section for additional discussion and Appendix B for off-site calculations and backwater analysis.

3.0 DETENTION SYSTEM ANALYSIS DISCUSSIONS

The SBUH method is used to estimate peak runoff for the storm events modeled. The detention pond is designed to release the 2-year storm event at a maximum of 50 percent of the existing 2-year storm peak flow, and release the 10- and 100-year peak events at or below existing storm peak flows according to City requirements. For this project the 10- and 100-year storm events will be released at peak flows less than the existing peak storm events rates. This is a result of the practical design of the control structure configuration and the limited capacity of downstream system during a 100-year storm event. For a 100-year event, 1-foot of freeboard has been provided, which results in an overflow elevation at 61 feet.

The pond has been sized based on the fact that the entire fully-developed site will be flowing to it. There are some small areas that do not flow to the pond (see Grading Plans). The pond is therefore over-detaining the area that does flow to it, this will account for some of the small site areas that do not flow to the pond. See Appendix A for basin and detention pond calculations.

4.0 CONVEYANCE SYSTEM ANALYSIS

A report by David Evans & Associates indicates that the 100-year elevation in Deer Creek is approximately 4 feet deep, or up to approximately elevation 57 feet at the point where site drainage will enter the creek. The David Evans report can be reviewed at the City of Puyallup. The on-site detention pond's lowest bottom elevation is also 57 feet. Deer Creek drains a larger basin, and the 100-year site peak release may not occur at the same time as the highest water level in Deer Creek. This simply indicates that peak flows are less likely to backup than it might first appear.

A backwater analysis has been completed for the downstream storm system for a 100-year storm event. This analysis estimates the hydraulic grade elevation at the pond to be just less than elevation 60 feet, which leaves 1-foot of freeboard on-site during a coincident peak 100-year flow for both Deer Creek and the site. There is flushing velocity greater than 2 feet per second in the 30-inch pipe.

All on-site storm pipe flowing to the detention pond is 12-inch pipe with a ½-percent minimum slope. A worst case backwater calculation indicates that no structures will overflow during a 100-year storm event. No overflow occurs in the 24-inch upstream storm main. See the last part of Appendix B for backwater calculations.

The biofiltration swale has been designed to be 8 feet wide and 200 feet long. The 8 feet in width is the maximum required by City standards. Residence time has been calculated to be 13 minutes, which exceeds the 9 minutes required. See Appendix B for bioswale calculations.

5.0 EROSION CONTROL

Interceptor ditches with rock check dams have been provided. Silt fence is also in place under the previously approved pre-load plans. The ditches and overland flow is directed to the detention pond, which will function as a sediment pond until the site is stabilized. All existing erosion control measures are to be maintained until the site is stabilized.

6.0 CONCLUSIONS

The proposed project will provide mitigation of the stormwater impacts to the area. The existing downstream drainage course will be replaced with a new tightlined system to convey runoff from the project and other properties. The project itself will not increase existing peak flows even beyond a 100-year storm event, since detention with a controlled release will be constructed for runoff from the project.

AHBL, Inc.

Seabrook M. Schilt
Design Engineer

SMS/oeb

9424710c.rep
November 1995

APPENDIX A

Basin & Detention Pond Calculations

Time of Concentration Calculation Table

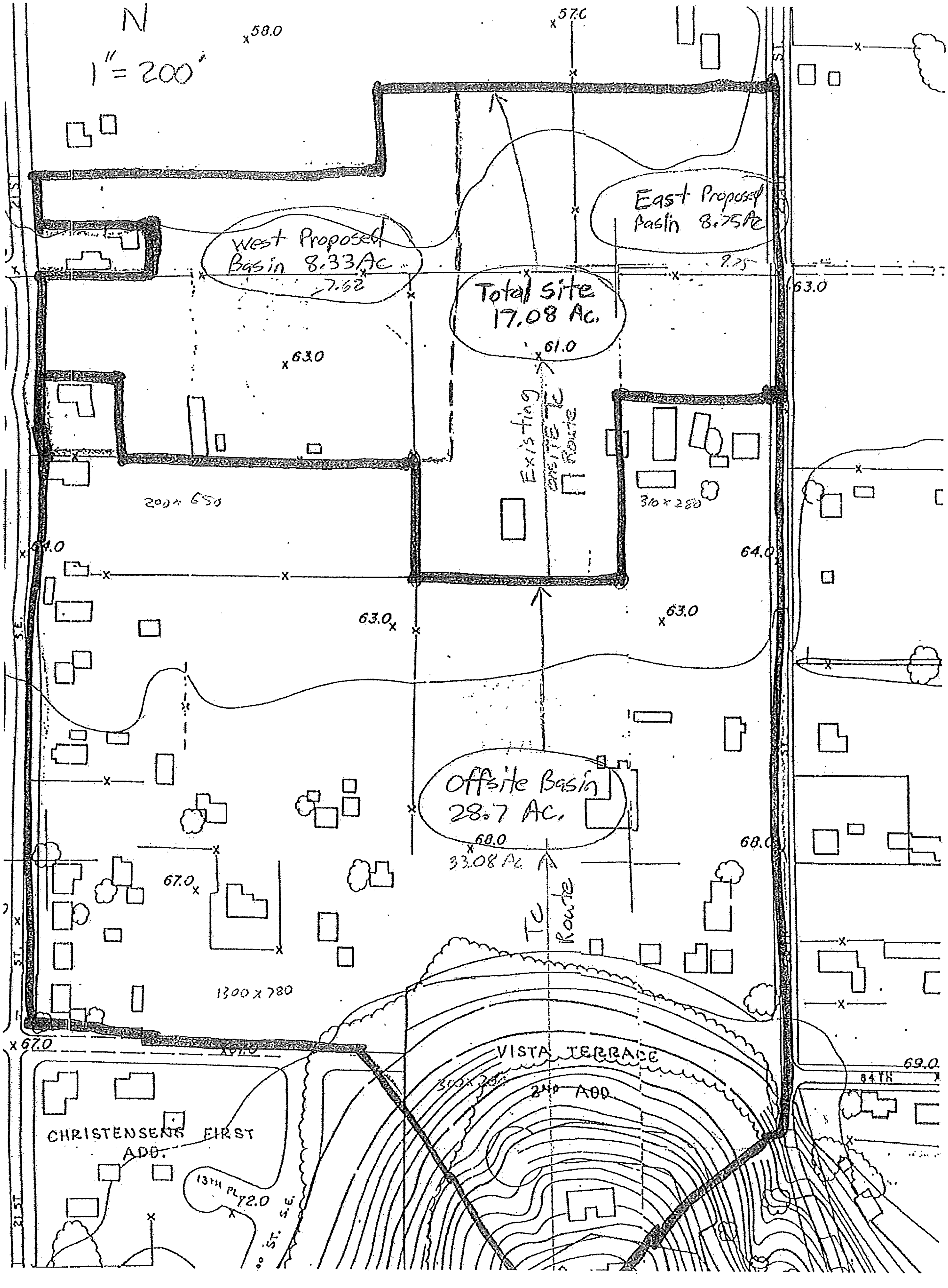
$T = \frac{0.42(n_s L)^{0.8}}{(\sqrt{P_2})(S_o)^{0.4}}$ For Sheet Flow $T = \frac{L}{60(1.49/n)R^{2/3}\sqrt{So}}$ For Other Flows

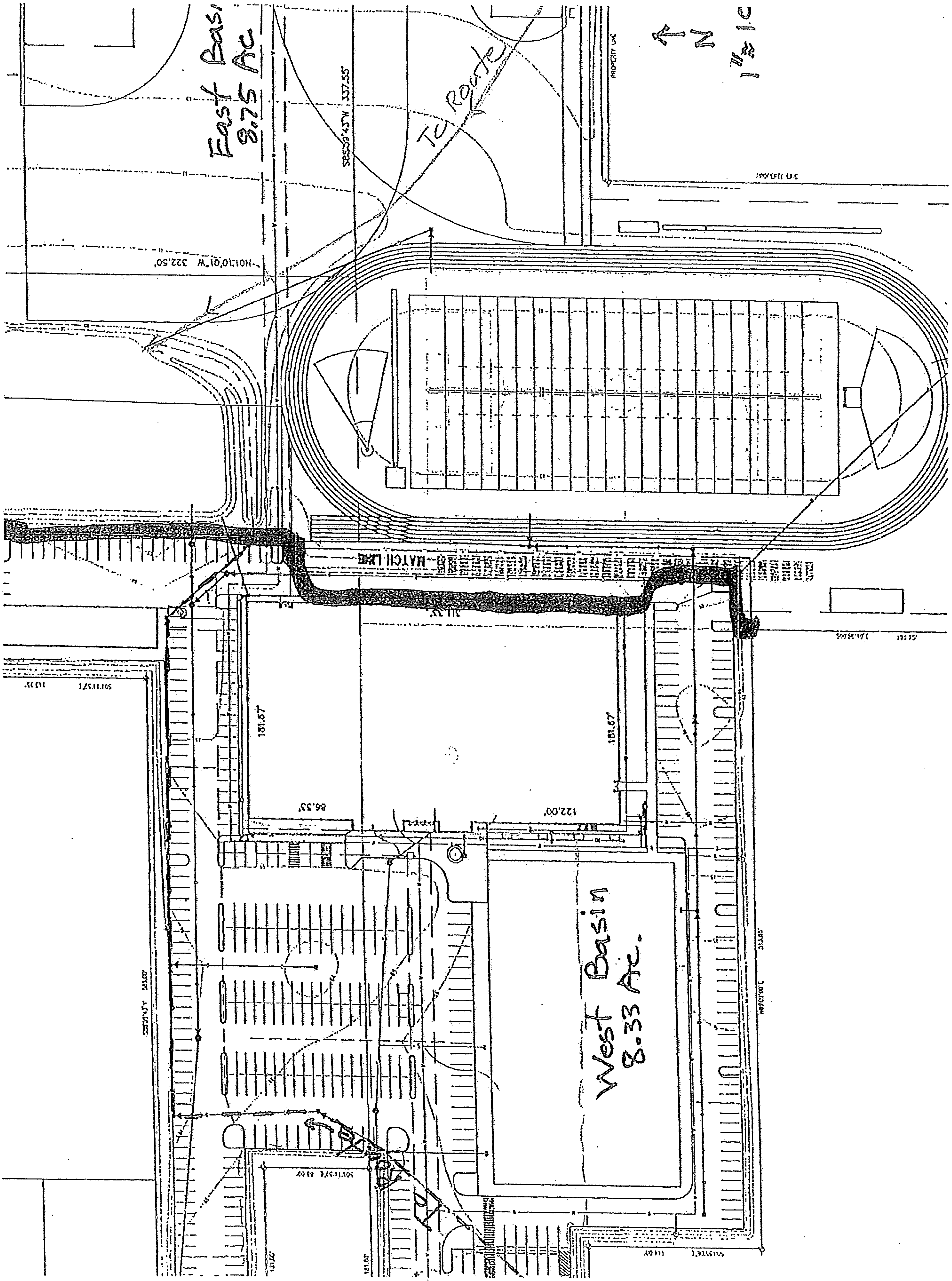
* R not applicable to sheet flow (enter 0 for sheet flow)
R = 0.1 for shallow concentrated flow (after sheet flow)
R = 0.2 for Intermittent Channel Flow (at the beginning of channels)
R = 0.4 for Channel Flow (continuous stream)

(P2yr) 2.00 "	Length L (ft)	Slope So (ft/ft)	Assumed R,*	Roughness n	Time, T (minutes)
Existing Onsite					
Section 1	300	0.009	0	0.150	41.08
Section 2	566	0.004	0.1	0.030	13.94
				TC	55.0
Prop. Parking & Bldg.		(Onsite West)			
Section 1	200	0.010	0	0.011	3.52
Section 2	700	0.005	0.4	0.012	2.45
				TC	6.0
Prop. Athletic Fields		(Onsite East)			
Section 1	300	0.010	0	0.150	39.38
Section 2	270	0.012	0.1	0.012	1.54
				TC	40.9
Upstream					
Section 1	300	0.005	0	0.150	51.97
Section 2	900	0.005	0.1	0.012	7.93
				TC	59.9

See Basin Exhibits for TC Routes

Filename: STORM1.XLS 11/29/95 4:05 PM


N
1" = 200'
58.0
57.0
West Proposed Basin 8.33 Ac
7.62
East Proposed Basin 8.75 Ac
9.75
63.0
Total site 17.08 Ac.
61.0
63.0
Existing ONSITE Tc Route
200 x 650
310 x 280
64.0
64.0
63.0
63.0
Offsite Basin 28.7 Ac.
68.0
33.08 Ac
68.0
67.0
Tc Route
1300 x 780
67.0
VISTA TERRACE 2ND ADD
69.0
84TH
CHRISTENSENS FIRST ADD.
13TH PL
72.0
21 ST.
S.E.
21 ST
ST. S.E.


East Basin
8.75 Ac
To Route
N
1" ≈ 1C
West Basin
8.33 Ac.
MATCH LINE
181.67'
181.67'
86.33'
122.00'
N01°10'01"W 322.50'
S85°39'45"W 337.55'
PROPERTY LINE

Time of Concentration Calculation Table

$T = \frac{0.42(n_s L)^{0.8}}{(\sqrt{P_2})(S_o)^{0.4}}$ For Sheet Flow $\quad$ $T = \frac{L}{60(1.49/n)R^{2/3}\sqrt{So}}$ For Other Flows

* R not applicable to sheet flow (enter 0 for sheet flow)
R = 0.1 for shallow concentrated flow (after sheet flow)
R = 0.2 for Intermittent Channel Flow (at the beginning of channels)
R = 0.4 for Channel Flow (continuous stream)

(P2yr)	Length	Slope	Assumed	Roughness	Time, T
2.00 "	L (ft)	So (ft/ft)	R,*	n	(minutes)
Existing Onsite					
Section 1	300	0.009	0	0.150	41.08
Section 2	566	0.004	0.1	0.030	13.94
				TC	55.0
Prop. Parking & Bldg.		(Onsite West)			
Section 1	200	0.010	0	0.011	3.52
Section 2	700	0.005	0.4	0.012	2.45
				TC	6.0
Prop. Athletic Fields		(Onsite East)			
Section 1	300	0.010	0	0.150	39.38
Section 2	270	0.012	0.1	0.012	1.54
				TC	40.9
Upstream					
Section 1	300	0.005	0	0.150	51.97
Section 2	900	0.005	0.1	0.012	7.93
				TC	59.9
Phase I Roof					
Section 1	100	0.010	0	0.150	16.35
Section 2	500	0.005	0.4	0.012	1.75
				TC	18.1

See Basin Exhibits for TC Routes

```
===========================================================================
                              BASIN SUMMARY


BASIN ID: A            NAME: 2YROFFSITE
SBUH METHODOLOGY
TOTAL AREA.......:   28.70 Acres      BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:     USER1          PERVIOUS AREA
PRECIPITATION....:    2.00 inches       AREA..:    25.00 Acres
TIME INTERVAL....:     10.00 min        CN....:    89.00
TIME OF CONC.....:   59.90 min        IMPERVIOUS AREA
ABSTRACTION COEFF:    0.20              AREA..:     3.70 Acres
                                        CN....:    98.00
PEAK RATE:     4.04 cfs   VOL:    2.69 Ac-ft   TIME:     490 min




BASIN ID: B            NAME: 10YROFFSITE
SBUH METHODOLOGY
TOTAL AREA.......:   28.70 Acres      BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:     USER1          PERVIOUS AREA
PRECIPITATION....:    2.90 inches       AREA..:    25.00 Acres
TIME INTERVAL....:     10.00 min        CN....:    89.00
TIME OF CONC.....:   59.90 min        IMPERVIOUS AREA
ABSTRACTION COEFF:    0.20              AREA..:     3.70 Acres
                                        CN....:    98.00
PEAK RATE:     7.39 cfs   VOL:    4.59 Ac-ft   TIME:     490 min




BASIN ID: C            NAME: 100YROFFSITE
SBUH METHODOLOGY
TOTAL AREA.......:   28.70 Acres      BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:     USER1          PERVIOUS AREA
PRECIPITATION....:    3.90 inches       AREA..:    25.00 Acres
TIME INTERVAL....:     10.00 min        CN....:    89.00
TIME OF CONC.....:   59.90 min        IMPERVIOUS AREA
ABSTRACTION COEFF:    0.20              AREA..:     3.70 Acres
                                        CN....:    98.00
PEAK RATE:    11.32 cfs   VOL:    6.82 Ac-ft   TIME:     490 min
```

```
======================================================================
                           BASIN SUMMARY


BASIN ID: D               NAME: 6MONTHONSITEW
SBUH METHODOLOGY
TOTAL AREA.......:      8.33 Acres        BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:        USER1           PERVIOUS AREA
PRECIPITATION....:      1.28 inches         AREA..:     0.50 Acres
TIME INTERVAL....:       10.00 min          CN....:    89.00
TIME OF CONC.....:      6.00 min          IMPERVIOUS AREA
ABSTRACTION COEFF:      0.20                AREA..:     7.83 Acres
                                            CN....:    98.00
PEAK RATE:     2.35 cfs   VOL:    0.71 Ac-ft  TIME:      470 min



BASIN ID: E               NAME: 2YRONSITEW
SBUH METHODOLOGY
TOTAL AREA.......:      8.33 Acres        BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:        USER1           PERVIOUS AREA
PRECIPITATION....:      2.00 inches         AREA..:     0.50 Acres
TIME INTERVAL....:       10.00 min          CN....:    89.00
TIME OF CONC.....:      6.00 min          IMPERVIOUS AREA
ABSTRACTION COEFF:      0.20                AREA..:     7.83 Acres
                                            CN....:    98.00
PEAK RATE:     3.93 cfs   VOL:    1.20 Ac-ft  TIME:      470 min



BASIN ID: F               NAME: 10YRONSITEW
SBUH METHODOLOGY
TOTAL AREA.......:      8.33 Acres        BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:        USER1           PERVIOUS AREA
PRECIPITATION....:      2.90 inches         AREA..:     0.50 Acres
TIME INTERVAL....:       10.00 min          CN....:    89.00
TIME OF CONC.....:      6.00 min          IMPERVIOUS AREA
ABSTRACTION COEFF:      0.20                AREA..:     7.83 Acres
                                            CN....:    98.00
PEAK RATE:     5.89 cfs   VOL:    1.82 Ac-ft  TIME:      470 min
```

```
==========================================================================
                        BASIN SUMMARY

BASIN ID: G              NAME: 100YRONSITEW
SBUH METHODOLOGY
TOTAL AREA.......:     8.33 Acres       BASEFLOWS:     0.00 cfs
RAINFALL TYPE....:       USER1          PERVIOUS AREA
PRECIPITATION....:     3.90 inches        AREA..:      0.50 Acres
TIME INTERVAL....:      10.00 min         CN....:     89.00
TIME OF CONC.....:     6.00 min         IMPERVIOUS AREA
ABSTRACTION COEFF:     0.20               AREA..:      7.83 Acres
                                          CN....:     98.00
PEAK RATE:    8.06 cfs   VOL:    2.51 Ac-ft  TIME:      470 min



BASIN ID: H              NAME: 6MONTHONITEE
SBUH METHODOLOGY
TOTAL AREA.......:     8.75 Acres       BASEFLOWS:     0.00 cfs
RAINFALL TYPE....:       USER1          PERVIOUS AREA
PRECIPITATION....:     1.28 inches        AREA..:      8.00 Acres
TIME INTERVAL....:      10.00 min         CN....:     89.00
TIME OF CONC.....:    40.90 min         IMPERVIOUS AREA
ABSTRACTION COEFF:     0.20               AREA..:      0.75 Acres
                                          CN....:     98.00
PEAK RATE:    0.58 cfs   VOL:    0.38 Ac-ft  TIME:      490 min



BASIN ID: I              NAME: 2YRONSITEE
SBUH METHODOLOGY
TOTAL AREA.......:     8.75 Acres       BASEFLOWS:     0.00 cfs
RAINFALL TYPE....:       USER1          PERVIOUS AREA
PRECIPITATION....:     2.00 inches        AREA..:      8.00 Acres
TIME INTERVAL....:      10.00 min         CN....:     89.00
TIME OF CONC.....:    40.90 min         IMPERVIOUS AREA
ABSTRACTION COEFF:     0.20               AREA..:      0.75 Acres
                                          CN....:     98.00
PEAK RATE:    1.41 cfs   VOL:    0.80 Ac-ft  TIME:      490 min
```

```
=======================================================================
                          BASIN SUMMARY


BASIN ID: J              NAME: 10YRONSITEE
SBUH METHODOLOGY
TOTAL AREA.......:    8.75 Acres      BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:      USER1         PERVIOUS AREA
PRECIPITATION....:    2.90 inches       AREA..:      8.00 Acres
TIME INTERVAL....:      10.00 min       CN....:    89.00
TIME OF CONC.....:   40.90 min        IMPERVIOUS AREA
ABSTRACTION COEFF:    0.20              AREA..:      0.75 Acres
                                        CN....:    98.00
PEAK RATE:     2.60 cfs   VOL:    1.37 Ac-ft  TIME:      480 min



BASIN ID: K              NAME: 100YRONSITEE
SBUH METHODOLOGY
TOTAL AREA.......:    8.75 Acres      BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:      USER1         PERVIOUS AREA
PRECIPITATION....:    3.90 inches       AREA..:      8.00 Acres
TIME INTERVAL....:      10.00 min       CN....:    89.00
TIME OF CONC.....:   40.90 min        IMPERVIOUS AREA
ABSTRACTION COEFF:    0.20              AREA..:      0.75 Acres
                                        CN....:    98.00
PEAK RATE:     4.02 cfs   VOL:    2.05 Ac-ft  TIME:      480 min



BASIN ID: L              NAME: 100 YR 12-INCH CONVEY CHECK
SBUH METHODOLOGY
TOTAL AREA.......:    2.70 Acres      BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:      USER1         PERVIOUS AREA
PRECIPITATION....:    3.90 inches       AREA..:      0.20 Acres
TIME INTERVAL....:      10.00 min       CN....:    89.00
TIME OF CONC.....:    6.00 min        IMPERVIOUS AREA
ABSTRACTION COEFF:    0.20              AREA..:      2.50 Acres
                                        CN....:    98.00
PEAK RATE:     2.60 cfs   VOL:    0.81 Ac-ft  TIME:      470 min
```

Cascade Christian School

Detention Pond Sizing Calculations

STAGE STORAGE TABLE

CUSTOM STORAGE ID No. S

Description:

STAGE	<----STORAGE---->		STAGE	<----STORAGE---->		STAGE	<----STORAGE---->		STAGE	<----STORAGE---->	
(ft)	---cf---	--Ac-Ft-	(ft)	---cf---	--Ac-Ft-	(ft)	---cf---	--Ac-Ft-	(ft)	---cf---	--Ac-Ft-
57.00	0.0000	0.0000	57.80	9886	0.2269	58.60	28972	0.6651	59.40	53454	1.2271
57.10	1236	0.0284	57.90	11121	0.2553	58.70	31742	0.7287	59.50	56805	1.3041
57.20	2471	0.0567	58.00	12357	0.2837	58.80	34511	0.7923	59.60	60156	1.3810
57.30	3707	0.0851	58.10	15126	0.3473	58.90	37280	0.8558	59.70	63507	1.4579
57.40	4943	0.1135	58.20	17895	0.4108	59.00	40049	0.9194	59.80	66858	1.5349
57.50	6178	0.1418	58.30	20665	0.4744	59.10	43401	0.9963	59.90	70210	1.6118
57.60	7414	0.1702	58.40	23434	0.5380	59.20	46752	1.0733	60.00	73561	1.6887
57.70	8650	0.1986	58.50	26203	0.6015	59.30	50103	1.1502	60.00	73561	1.6887

STAGE DISCHARGE TABLE

MULTIPLE ORIFICE ID No. D
Description:
Outlet Elev: 57.00
Elev: 57.00 ft Orifice Diameter: 5.8900 in.
Elev: 58.50 ft Orifice 2 Diameter: 8.0000 in.

STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------
57.00	0.0000	57.80	0.8420	58.60	1.7401	59.40	3.1061
57.10	0.2977	57.90	0.8931	58.70	2.0042	59.50	3.2253
57.20	0.4210	58.00	0.9414	58.80	2.2143	59.60	3.3396
57.30	0.5156	58.10	0.9874	58.90	2.3961	59.70	3.4495
57.40	0.5954	58.20	1.0313	59.00	2.5595	59.80	3.5556
57.50	0.6657	58.30	1.0734	59.10	2.7096	59.90	3.6582
57.60	0.7292	58.40	1.1139	59.20	2.8495	60.00	3.7577
57.70	0.7877	58.50	1.1530	59.30	2.9812		

```
                    Cascade Christian School
=====================================================================
                    LEVEL POOL TABLE SUMMARY


                              MATCH INFLOW -STO- -DIS- <-PEAK->    STORAGE
<--------DESCRIPTION--------> (cfs)  (cfs) --id- --id- <-STAGE> id VOL (cf)
===========================================================================
6 MONTH .....................  0.00   2.85    S     D     57.74 16  9088.05 cf
2 YEAR ......................  0.00   5.21    S     D     58.43 17 24304.99 cf
10 YEAR .....................  0.00   8.30    S     D     58.86 18 36182.14 cf
100 YEAR ....................  0.00  11.79    S     D     59.46 19 55461.12 cf
```

HYDROGRAPH SUMMARY

	HYD NUM	PEAK RUNOFF RATE cfs	TIME OF PEAK min.	VOLUME OF HYDRO cf\AcFt	Contrib Area Acres		
	1	4.041	490	117119 cf	28.70	2yr	upstream offsite
	2	7.387	490	200071 cf	28.70	10yr	
	3	11.321	500	296915 cf	28.70	100yr	
	4	2.349	470	31094 cf	8.33	6 month	Parking Lot & BLDGS.
	5	3.928	470	52298 cf	8.33	2 yr	
	6	5.890	470	79137 cf	8.33	10 yr	
	7	8.058	470	109134 cf	8.33	100yr	
	8	0.576	490	16550 cf	8.75	6month	Athletic Fields
	9	1.406	490	34683 cf	8.75	2 yr	
	10	2.604	480	59818 cf	8.75	10 yr	
Hyd#	11	4.021	480	89238 cf	8.75	100 yr	
4+8 =	12	2.852	480	47644 cf	17.08	6month	combined developed site (Hydros added)
5+9 =	13	5.209	480	86981 cf	17.08	2yr	
6+10 =	14	8.296	480	138955 cf	17.08	10yr	
7+11 =	15	11.794	480	198372 cf	17.08	100yr	
	16	0.810	660	47644 cf	17.08	6 month	Control structure discha
	17	1.130	790	86981 cf	17.08	2yr	
	18	2.328	650	138955 cf	17.08	10yr	
	19	3.183	660	198372 cf	17.08	100y	
3+19 =	20	13.798	520	495287 cf	45.78		

100 year flow to downstream system
Includes proposed site and upstream areas
This Flow use for downstream HGL calcs.

Note:
The 6 month Storm was routed to Show that
the water quality storm does not backup into
the bioswale.

APPENDIX B

Bioswale and Backwater Calculations

Size Biofiltration Swale

Note:
All bold numbers are entered directly and this computer spreadsheet calculates the rest.

Bioswale Storm

S.C.S Type-1A Distribution	6	Month 24 Hour Storm		
Total Precipitation	1.28	inches		
Time of Concentration	6.0	minutes		
Pervious area	0.50	acres	CN =	89
Impervious area	7.83	acres	CN =	98
Peak flow = 2.35 cfs				

Flow (Q2)	**2.35**	cfs
slope (s)	**0.50%**	(bottom slope for for biofiltration design)
depth (y)	**0.25**	
Mannings n	**0.2**	per City Requirement
Sides (z)	**4**	
Actual Length	**200**	ft. (desired length is 200 ft.)

Required bottom width (b) calculation

$Q = (1.49/n) \times A \times R^{2/3} \times \sqrt{S}$ (mannings equation)

$A = (b + zy)y$ (Fig. 4.3.7E common sections)

$R = A/(b + 2y\sqrt{1+z^2})$ (Fig. 4.3.7E common sections)

$$Q = (1.49/n) \times [\sqrt{(b+zy)y] \times [b+zy)y / b+2y(1+z^2})]^{2/3} \times \sqrt{S}$$

All variables in the above equation are given except "b"

"b" is solved for using a computer spreadsheet function to obtain
a trail and error solution of b = 44.21 feet, for a desired length of 200 feet.
check Q = 2.349 cfs, OK same as given
max bottom required = 8.0 ft.

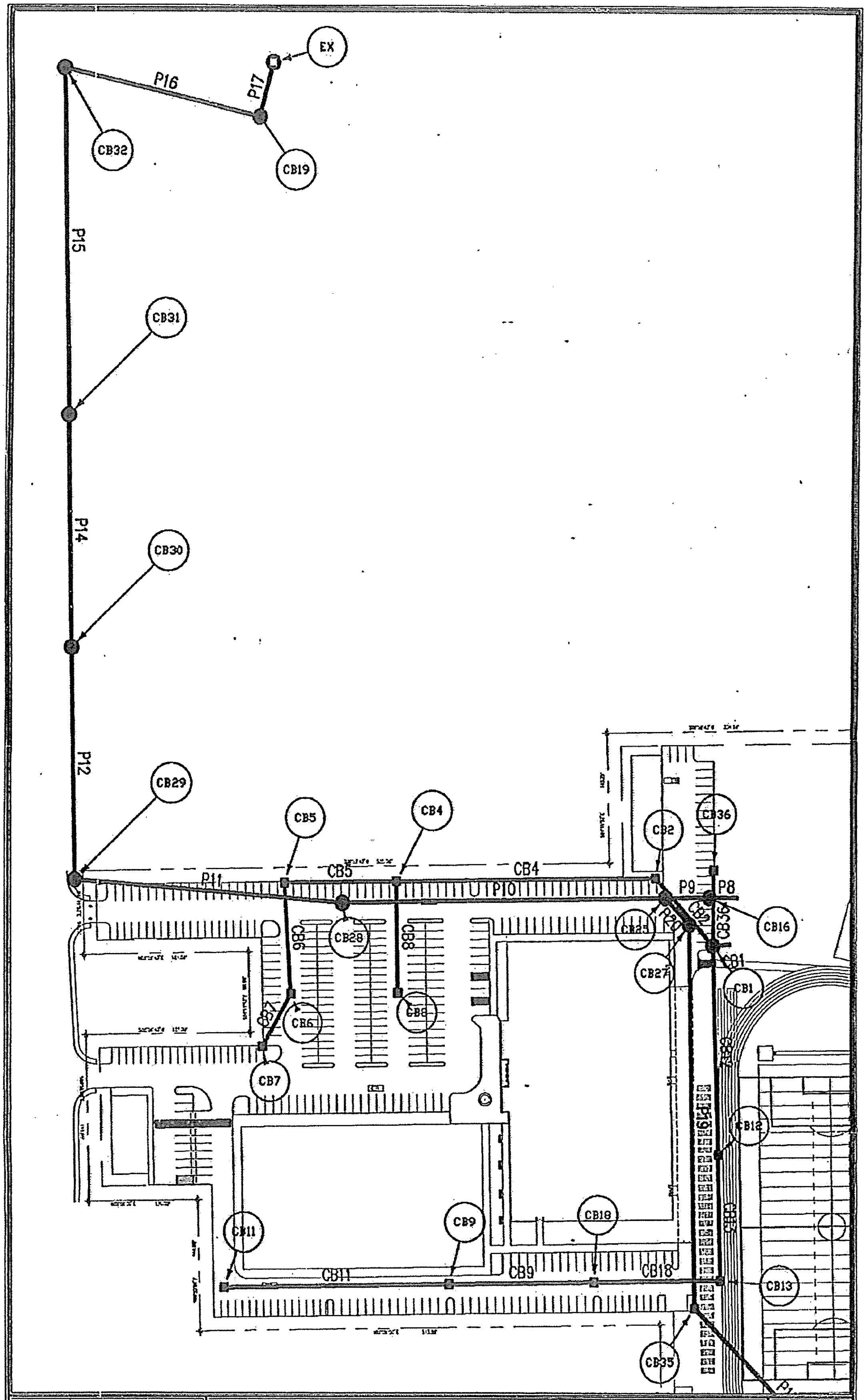
Velocity Check

Flow Depth	mannings n	SLOPE ft/ft	Velocity fps	flow Q cfs
0.25	0.2	0.005	0.25	0.57

Residence Time 13.1 mins.

Calcs. by SMS
Filename GENERAL.XLS Tab BIOSWALE 11/3/95 5:00 PM

FILENAME: J:\C\94247\AVORKS.DWG UPDATED: NOV 10 1995 15:34:35
CREATED: JUL 28 1995 14:01:24 PLOTTED: NOV 10 1995 15:35:17



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LAND PLANNERS • LANDSCAPE ARCHITECTS
[illegible]
[illegible]

PIPE REACH EXHIBT

REFERENCE FOR STORM REPORT BACKWATER CALCULATIONS

```
==============================================================================
                              REACH SUMMARY

Hydraulic Gradeline for Reach H1 (Downstream 30" pipe)
<-FROM-> <--TO--> <FLOW>  floss Ent_HGL EntLoss ExtLoss  OutLet   Inlet AppHead BndHead JunHead HeadWtr -cb/mh-
-------- --------    cfs  -loss- -Elev-- --loss- --loss- --Elev- --Elev- --loss- --loss- --loss- --Elev- --Rim--
=================================================================================================================
                  100yr downstream Flow                         Approximate 100yr
EX                                                              HGL in Deer Creek   57.00
CB19     EX        13.80   0.06   57.06    0.06    0.12   57.24   54.98    0.12    0.16    0.00   57.28   63.00
CB32     CB19      13.80   0.21   57.50    0.06    0.12   57.68   55.29    0.12    0.16    0.00   57.72   63.00
CB31     CB32      13.80   0.37   58.09    0.06    0.12   58.27   55.82    0.12    0.00    0.00   58.15   63.00
CB30     CB31      13.80   0.25   58.39    0.06    0.12   58.58   56.18    0.12    0.00    0.00   58.46   63.00
CB29     CB30      13.80   0.24   58.70    0.06    0.12   58.88   56.54    0.12    0.14    0.00   58.91   63.00
CB28     CB29      13.80   0.29   59.19    0.06    0.12   59.38   56.96    0.12    0.16    0.00   59.42   63.00
CB25     CB28      13.80   0.34   59.76    0.06    0.12   59.95   57.46    0.20    0.09    0.03   59.86   63.00

 Network Reach L1
   REACH <-AREA> <-DIA>   LENGTH  SLOPE < n   > DSGN  Q % PIPE Ndepth %Depth    Vact    Vfull C_Area
     ID    (Ac)   (ft)     (ft)  ft/ft ------  (cfs)  ------  (ft)  ------   (fps)    (fps)
=========================================================================================
     P10   45.78   2.50   359.68 0.0014 0.0120   13.80  77.21   1.74  69.58    3.78     3.74
     P11   45.78   2.50   299.15 0.0014 0.0120   13.80  76.83   1.73  69.32    3.80     3.75
     P12   45.78   2.50   254.52 0.0014 0.0120   13.80  76.55   1.73  69.12    3.81     3.77
     P14   45.78   2.50   255.51 0.0014 0.0120   13.80  76.70   1.73  69.22    3.81     3.76
     P15   45.78   2.50   380.95 0.0014 0.0120   13.80  77.18   1.74  69.55    3.79     3.74
     P16   45.78   2.50   222.24 0.0014 0.0120   13.80  77.08   1.74  69.49    3.79     3.74
     P17   45.78   2.50    61.77 0.0039 0.0120   13.80  46.18   1.25  50.19    5.65     6.25
```

```
==========================================================================
                                REACH SUMMARY


Hydraulic Gradeline for Reach H24  24" upstream Storm line.
<-FROM-> <--TO--> <FLOW>  floss Ent_HGL EntLoss ExtLoss  OutLet   Inlet AppHead BndHead JunHead HeadWtr -cb/mh-
-------- --------   cfs  -loss- -Elev-- --loss- --loss- --Elev- --Elev- --loss- --loss- --loss- --Elev- --Rim--
======================================================================================================================
CB25                                                                                                 59.86
CB27     CB25       11.32   0.08   59.94    0.10    0.20   60.25   57.54    0.20    0.07    0.00   60.11) ~~100.00~~
CB35     CB27       11.32   0.89   61.01    0.10    0.20   61.31   58.09    0.20    0.07    0.00   61.18)  ~~65.00~~
EX1      CB35       11.32   0.60   61.78    0.10    0.20   62.08   58.46    0.00    0.00    0.00   62.08) ~~100.00~~
                                                                                                     Rim Elev.
                                                                                                     SEE Plan


Network Reach L24
   REACH <-AREA> <-DIA>   LENGTH  SLOPE < n  > DSGN  Q % PIPE Ndepth %Depth   Vact    Vfull C_Area
     ID    (Ac)   (ft)     (ft)  ft/ft ------ (cfs)  ------  (ft)  ------  (fps)   (fps)
==========================================================================================
    P18   28.70   2.00   280.56 0.0013 0.0120   11.32 >=100% Pressure flow   3.60    3.14
    P19   28.70   2.00   421.63 0.0013 0.0120   11.32 >=100% Pressure flow   3.60    3.12
    P20   28.70   2.00    39.69 0.0015 0.0120   11.32 >=100% Pressure flow   3.60    3.36
```

REACH SUMMARY

```
Hydraulic Gradeline for Reach H12 Main 12" onsite (Worst Case)
<-FROM-> <--TO--> <FLOW>  floss Ent_HGL EntLoss ExtLoss  OutLet   Inlet AppHead BndHead JunHead HeadWtr -cb/mh-
-------- --------   cfs  -loss- -Elev-- --loss- --loss- --Elev- --Elev- --loss- --loss- --loss- --Elev- --Rim--
================================================================================================================
CB1                                                                                           59.86
CB2      CB1       2.60   0.44   60.32    0.09    0.17   60.58   60.04    0.17    0.08    0.00   60.48   63.52
CB4      CB2       2.60   1.20   61.81    0.09    0.17   62.07   61.48    0.17    0.00    0.00   61.90   63.06
CB5      CB4       2.60   0.55   62.46    0.09    0.17   62.71   62.11    0.17    0.23    0.00   62.77   63.69
CB6      CB5       2.60   0.55   63.32    0.09    0.17   63.57   62.72    0.17    0.04    0.00   63.44   64.30
CB7      CB6       2.60   0.30   63.74    0.09    0.17   64.00   63.05    0.00    0.00    0.00   64.00   64.63
```

```
Network Reach L12
   REACH <-AREA> <-DIA>   LENGTH  SLOPE < n   > DSGN  Q % PIPE Hdepth %Depth   Vact    Vfull C_Area
     ID    (Ac)   (ft)     (ft)   ft/ft ------  (cfs)  ------  (ft)  ------   (fps)   (fps)
=============================================================================================
    CB7    2.70   1.00    66.07 0.0050 0.0120    2.60  88.46   0.78  77.93    3.96     3.84
    CB6    2.70   1.00   121.64 0.0050 0.0120    2.60  88.28   0.78  77.78    3.97     3.85
    CB5    2.70   1.00   126.07 0.0050 0.0120    2.60  88.44   0.78  77.91    3.96     3.85
    CB4    2.70   1.00   287.93 0.0050 0.0120    2.60  88.40   0.78  77.88    3.97     3.85
    CB2    2.70   1.00    98.25 0.0059 0.0120    2.60  81.37   0.72  72.49    4.27     4.18
```

Calculations for slope and velocity

$Q = 1.486 / n \times R^{2/3} \times S^{1/2}$

Bold Numbers entered directly

Pipe Dia. (D)	**30.00 "**	**24.00 "**	**12.00 "**
Manning's n (n)	**0.012**	**0.012**	**0.012**
Slope (S)	**0.14%**	**0.13%**	**0.50%**
Depth (Y)	1.74'	1.92'	0.77'
Qactual	13.79 cfs	9.47 cfs	2.58 cfs
Vactual	3.79 cfs	3.06 cfs	3.95 cfs
	fps	fps	fps

Q(Full)	16.63 cfs	8.84 cfs	2.73 cfs
V(Full)	3.39 cfs	2.81 cfs	3.47 cfs
	fps	fps	

12" onsite conveyance capacity

30" downstream system

24" offsite upstream
Note head condition
required for 100 year
conveyance.
See Backwater Calc.

Project: 94322.10 Les Schwab, calcs. by SMS
Filename GENERAL.XLS Tab Pipe Flows 11/29/95 3:53 PM

Roof Area Phase I BLDG.

Cascade Christian School

S.C.S Type-1A Distribution 100 Year 24 Hour Storm

Total Precipitation 3.90 inches

Time of Concentration 18.1 minutes

Pervious area	0.00	acres	CN = 85
Impervious area	1.28	acres	CN = 98
Total	1.28		

Peak flow = 1.03 cfs

Total Volume 16900 cf

Filename HYDS-TC.XLS 11/29/95 4:14 PM

APPENDIX C

Soil Mapping and CN Selection

NGTON — SHEET NUMBER 23

Soil Mapping

Ocotech

[illegible] also says UCS SM to ML

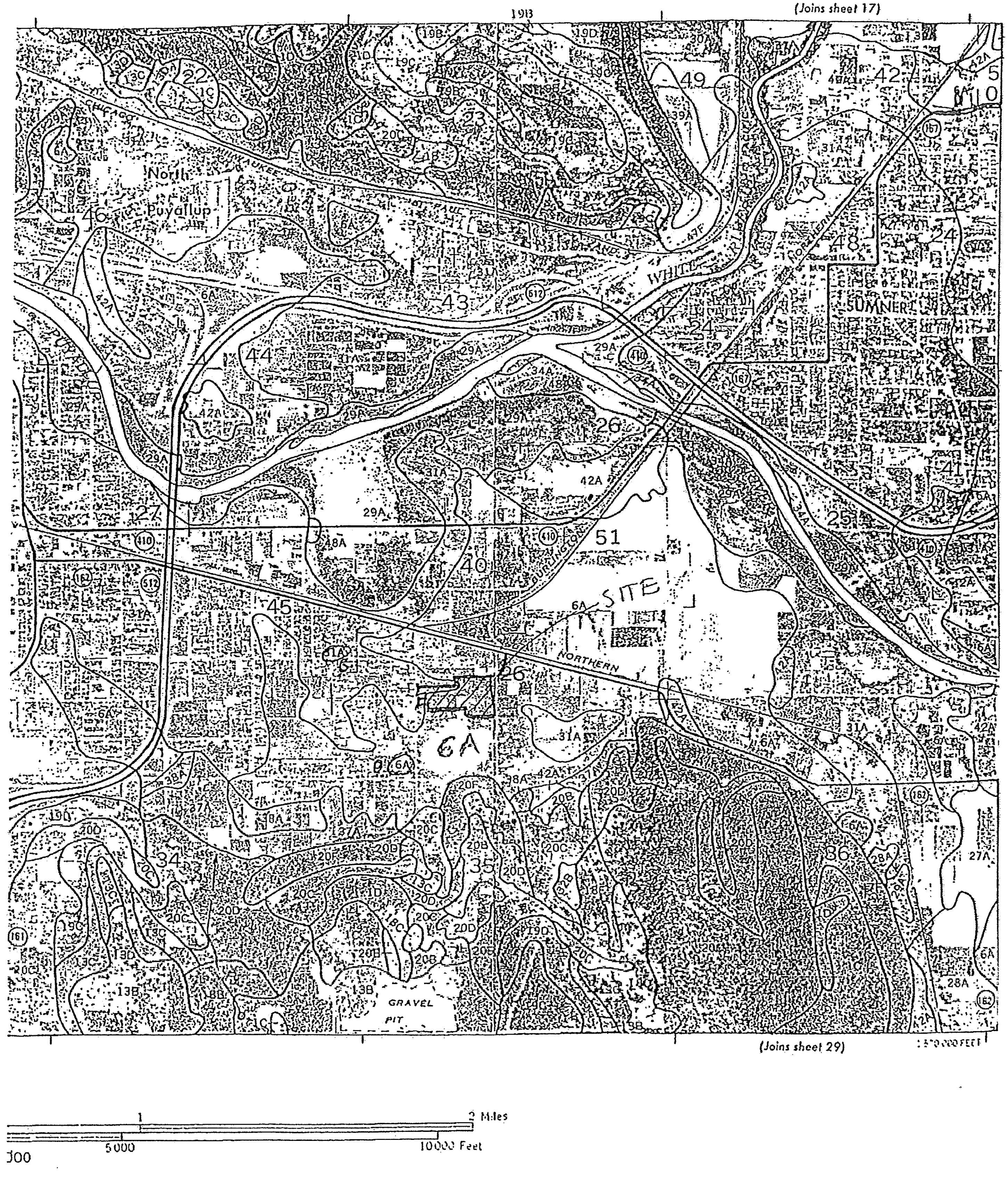

TABLE 11.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS

[The symbol < means less than; > means greater than. The erosion tolerance factor (T) is for the entire profile. Absence of an entry means data were not estimated]

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Risk of corrosion		Erosion factors	
						Uncoated steel	Concrete	K	T
	In	In/hr	In/in	pH					
Alderwood:									
1B, 1C, 1D	0-7	0.6-2.0	0.07-0.11	5.6-6.0	Low	Moderate	Moderate	0.20	2
	7-38	0.6-2.0	0.07-0.11	5.6-6.0	Low	Moderate	Moderate	0.20	
	38-60	---	---	---	---	---	---	---	
Aquic Xerofluvents:									
2A	0-60	---	---	---	---	---	---	---	---
Barneston:									
3B, 3C, 3D, 3E	0-13	6.0-20	0.06-0.08	<4.5-5.5	Low	Moderate	Moderate	0.15	1
	13-60	>20	0.03-0.05	5.6-6.0	Low	Low	Low	0.10	
Bellingham:									
4A	0-4	0.06-0.2	0.20-0.24	5.1-6.5	High	High	Moderate	---	---
	4-60	0.06-0.2	0.20-0.24	5.6-7.3	High	High	Moderate	---	
Bow:									
5B, 5C, 5D	0-7	0.2-0.6	0.19-0.21	5.6-6.5	Moderate	High	Moderate	0.28	5
	7-26	0.06-0.2	0.16-0.18	5.6-6.0	High	High	Moderate	0.24	
	26-60	0.06-0.2	0.05-0.08	6.1-6.5	Low	Moderate	Moderate	0.24	
Briscot:									
6A	0-11	0.6-2.0	0.20-0.24	5.6-6.5	Low	High	Moderate	---	---
	11-60	0.2-0.6	0.16-0.20	6.1-7.3	Low	Moderate	Moderate	---	
Briscot variant:									
7A	0-13	2.0-6.0	0.15-0.19	5.6-6.0	Low	Moderate	Moderate	---	---
	13-54	0.6-2.0	0.08-0.12	5.6-6.0	Low	Moderate	Moderate	---	
	54-60	>20	0.03-0.05	5.6-6.0	Low	Moderate	Moderate	---	
Buckley:									
8A	0-10	0.6-2.0	0.20-0.24	5.6-6.0	Low	High	Moderate	---	---
	10-60	0.06-0.2	0.12-0.14	5.6-6.5	Low	High	Moderate	---	
Chehalis:									
9A	0-17	0.6-2.0	0.19-0.21	6.1-7.3	Low	Moderate	Low	---	---
	17-55	0.2-0.6	0.19-0.21	6.1-7.3	Low	Moderate	Low	---	
	55-63	0.2-0.6	0.15-0.21	6.1-7.3	Low	Moderate	Low	---	
Cinebar:									
10C, 10D, 10E	0-14	0.6-2.0	0.18-0.25	6.1-6.5	Low	Moderate	High	0.28	5
	14-60	0.6-2.0	0.19-0.25	5.6-6.0	Low	Moderate	Moderate	0.55	
Coastal beaches:									
11A.									
Dupont:									
12A	0-72	0.2-0.6	0.19-0.21	4.5-5.5	Low	High	High	---	---
Everett:									
13B, 13C, 13D	0-8	6.0-20	0.08-0.12	5.6-6.0	Low	Moderate	Moderate	0.17	2
	8-19	6.0-20	0.05-0.08	5.6-6.0	Low	Moderate	Moderate	0.10	
	19-60	>20	0.02-0.05	5.6-6.0	Low	Moderate	Moderate	0.10	
14B	0-8	6.0-20	0.08-0.10	5.6-6.0	Low	Moderate	Moderate	0.17	5
	8-20	6.0-20	0.06-0.08	5.6-6.0	Low	Moderate	Moderate	0.10	
	20-60	>20	0.04-0.06	5.6-6.0	Low	Low	Moderate	0.10	
Greenwater:									
15A	0-19	2.0-6.0	0.06-0.08	5.6-6.0	Low	Moderate	Moderate	---	---
	19-61	0.6-2.0	0.05-0.07	5.6-6.0	Low	Moderate	Moderate	---	
Harstine:									
16B, 16C, 16D, 16E	0-31	0.6-2.0	0.07-0.09	5.1-6.0	Low	Moderate	Moderate	0.20	2
	31-60	---	---	---	---	---	---	---	
Hydraquents:									
17A	0-60	---	---	---	---	---	---	---	---

See footnotes at end of table.

structure; hard, firm, very sticky and plastic; common fine to medium roots; few very fine pores; less than 5 percent gravel; medium acid (pH 5.8); clear smooth boundary. (3 to 7 inches thick)

B&A—7 to 26 inches; the A2 portion of the horizon is dark grayish brown (10YR 4/2) silty clay loam, occupies 10 to 15 percent of the horizon, and is 1 to 3 millimeters wide on ped surfaces. The B portion is grayish brown (2.5YR 5/2) silty clay and light brownish gray (2.5YR 7/2) clay; many medium prominent strong brown (7.5YR 5/6) mottles; moderate fine subangular blocky structure parting to moderate very thin platy; very hard, firm, very sticky and plastic; few very fine roots along vertical ped faces; few very fine and fine pores; thick continuous clay films in pores; less than 5 percent gravel; medium acid (pH 5.8); clear wavy boundary. (10 to 20 inches thick)

B2tg—26 to 34 inches; grayish brown (2.5Y 5/2) sandy clay, light gray (2.5Y 7/2) dry; many medium prominent strong brown (7.5YR 5/6) mottles along horizontal planes; massive; very hard, firm, sticky and plastic; few very fine roots; patchy clay films; slightly acid (pH 6.2); gradual wavy boundary. (7 to 10 inches thick)

IIC—34 to 60 inches; dark grayish brown (10YR 4/2) gravelly loam, light brownish gray (10YR 6/2) dry; massive; very hard, friable, slightly sticky and slightly plastic; 15 to 25 percent gravel; slightly acid (pH 6.2).

Coarse fragments make up less than 15 percent of the upper part of the profile and from 15 to 25 percent of the lower part.

The A1 horizon has value of 2 or 3 moist, 4 through 6 dry, and chroma of 2 or 3. It is silt loam, loam, or clay loam. The A2 horizon has value of 3 or 4 moist, 6 or 7 dry, and chroma of 1 or 2 moist or dry. It is silt loam, clay loam, or silty clay loam. The B&A horizon is mottled with strong brown and yellowish brown. The B portion has hue of 10YR or 2.5Y and value of 4 or 5 moist and 6 through 8 dry. It is silty clay or clay. The B2tg horizon has hue of 2.5Y or 10YR and value of 5 through 8 dry. The B2tg horizon has strong brown or yellowish brown mottles. It is sandy clay loam, sandy clay, or silty clay loam. The IIC horizon has colors similar to those of the B horizon. It is loam, silty clay loam, sandy clay, or silty clay.

Briscot series

The Briscot series consists of somewhat poorly drained soils that formed in alluvium. Briscot soils are on flood plains of the Puyallup and Stuck River valleys. Slopes are 0 to 2 percent. The mean annual precipitation is 35 to 50 inches, and the mean annual air temperature is about 50 degrees F.

Typical pedon of Briscot loam, 1,320 feet east and 943 feet north of the southwest corner of section 30, T. 20 N., R. 5 E.:

Ap1—0 to 6 inches; dark brown (10YR 3/3) loam, brown (10YR 5/3) dry; weak very fine and fine subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common roots; medium acid (pH 6.0); clear smooth boundary. (6 to 8 inches thick)

Ap2—6 to 11 inches; dark brown (10YR 4/3) loam, brown (10YR 5/3) dry; moderate medium subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; common roots; few very fine pores; slightly acid (pH 6.2); abrupt smooth boundary. (4 to 6 inches thick)

C1g—11 to 15 inches; dark grayish brown (10YR 4/2) fine sandy loam, grayish brown (10YR 5/2) dry; common fine distinct yellowish red (5YR 4/6) mottles; weak medium subangular blocky structure; soft, very friable, nonsticky and slightly plastic; common roots; few very fine pores; slightly acid (pH 6.2); abrupt smooth boundary. (4 to 6 inches thick)

C2g—15 to 29 inches; dark grayish brown (10YR 4/2) silt loam, pale brown (10YR 6/3) dry; common fine distinct yellowish red (5YR 4/6) mottles; moderate medium subangular blocky structure; hard, firm, sticky and plastic; few roots; many very fine and few fine pores; moderately thick dark reddish brown (5YR 3/3) silt deposits in pores; slightly acid (pH 6.4); abrupt smooth boundary. (14 to 16 inches thick)

C3g—29 to 38 inches; very dark grayish brown (10YR 3/2) medium sand, grayish brown (10YR 5/2) dry; common fine distinct yellowish red (5YR 4/6) mottles; single grained; loose, very friable, nonsticky and nonplastic; very few roots; neutral (pH 6.8); abrupt smooth boundary. (8 to 10 inches hick)

C4g—38 to 58 inches; gray (10YR 5/1) silty clay loam, light gray (10YR 7/2) dry; common fine distinct yellowish red (5YR 4/6) and yellowish brown (10YR 5/6) mottles; massive; very hard, very firm, very sticky and very plastic; common very fine and few fine pores; thick dark reddish brown (5YR 3/4) silty deposits in pores; neutral (pH 6.8); abrupt smooth boundary. (18 to 22 inches thick)

C5g—58 to 65 inches; very dark grayish brown (10YR 3/2) sand, grayish brown (10YR 5/2) dry; common fine distinct yellowish red (5YR 4/6) mottles; single grained; loose, very friable, nonsticky and nonplastic; slightly acid (pH 6.4).

The Ap horizon has chroma of 2 or 3 moist or dry and is loam or very fine sandy loam. It has granular or blocky structure. The C horizon has value of 3 through 5 moist and 5 through 7 dry. Mottles range in hue from 2.5YR through 10YR and in chroma from 2 to 6. The C horizon may contain layers of loamy fine sand, very fine sand, loam, and silty clay in the upper part.

Briscot variant

The Briscot variant consists of moderately well drained soils that formed in alluvium. These soils are on flood plains along South Prairie and Ohop Creeks. Slopes range from 0 to 3 percent. The mean annual precipitation is 35 to 50 inches, and the mean annual air temperature is about 50 degrees F.

Typical pedon of Briscot loam, variant, 2,895 feet west and 1,362 feet south of northwest corner of section 23, T. 19 N., R. 5 E.:

Ap—0 to 6 inches; dark brown (10YR 3/3) loam, brown (10YR 5/3) dry; moderate medium granular structure; hard, friable, slightly sticky and slightly plastic; many fine and very fine roots; medium acid (pH 5.8); clear smooth boundary. (6 to 9 inches thick)

AC—6 to 13 inches; dark brown (10YR 3/3) loam, brown (10YR 5/3) dry; moderate fine and medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many fine and very fine roots; very few medium pores; medium acid (pH 5.8); clear smooth boundary. (4 to 8 inches thick)

C1—13 to 32 inches; dark yellowish brown (10YR 3/4) sandy loam, yellowish brown (10YR 5/4) dry; massive; soft, friable, slightly sticky and slightly plastic; common very fine roots; common fine and few medium pores; medium acid (pH 6.0); abrupt smooth boundary. (18 to 22 inches thick)

C2—32 to 36 inches; brown (10YR 4/3) sand, pale brown (10YR 6/3) dry; single grained; loose; few very fine roots; medium acid (pH 6.0); abrupt smooth boundary. (3 to 5 inches thick)

C3—36 to 54 inches; dark gray (10YR 4/1) fine sandy loam, light brownish gray (10YR 6/2) dry; common medium prominent yellowish red (5YR 4/6) mottles; massive; soft, friable, slightly sticky and slightly plastic; very few very fine roots; common fine pores; medium acid (pH 6.0); abrupt smooth boundary. (10 to 22 inches thick)

C4—54 to 60 inches; dark gray (10YR 4/1) very gravelly sand, gray (10YR 6/1) dry; single grained; loose, nonsticky; medium acid (pH 6.0).

The Ap and AC horizons have chroma of 2 or 3 moist or dry and are loam or sandy loam. The C horizon has chroma of 1 to 4 moist or dry. In some pedons the lower part of the C horizon is coarse sand. Reaction is medium acid to slightly acid.

Table III-1.6 Hydrologic Soil Groups for Soils in the Puget Sound Basin

Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group
Agnew	C	Colter	C
Ahl	B	Custer	ND
Aits	C	Dabob	ND
Alderwood	C	Delphi	D
Arents, Alderwood	B	Dick	ND
Arents, Everett	B	Dimal	D
Ashoe	B	Dupont	D
Baldhill	B	Earlmont	C
Barneston	C	Edgewick	C
Baumgard	B	Eld	B
Beausite	B	Elwell	B
Belfast	C	Esquatzel	B
Bellingham	D	Everett	A
Bellingham variant	C	Everson	D
Boistfort	B	Galvin	D
Bow	D	Getchell	A
Briscot	D	Giles	B
Buckley	C	Godfrey	D
Bunker	B	Greenwater	A
Cagey	C	Grove	C
Carlsborg	ND	Harstine	C
Casey	ND	Hartnit	ND
Cassolary	C	Hoh	ND
Cathcart	B	Hoko	ND
Centralia	B	Hoodsport	ND
Chehalis	B	Hoogdal	C
Chesaw	A	Hoypus	ND
Cinebar	B	Huel	ND
Clallam	C	Indianola	ND
Clayton	B	Jonas	B
Coastal beaches	variable	Jumpe	ND
Kapowsin	C/D	Kalaloch	C
Katula	C	Renton	D
Kilchis	C	Republic	B
Kitsap	C	Riverwash	variable
Klaus	ND	Rober	C
Klone	ND	Salal	C
Lates	C	Salkum	B
Lebam	B	Sammamish	D
Lummi	ND	San Juan	ND
Lynnwood	ND	Scamman	D
Lystair	ND	Schneider	B
Mal	C	Seattle	D
Manley	B	Sekiu	ND
Mashel	B	Semiahmoo	D
Maytown	C	Shalcar	D
McKenna	D	Shano	B
McMurray	ND	Shelton	C
Melbourne	B	Si	C
Menzel	ND	Sinclair	C
Mixed Alluvial	variable	Skipopa	D
Molson	B	Skykomish	B
Mukilteo	C/D	Snahopish	ND
Naff	B	Snohomish	D
Nargar	A	Solduc	B
National	ND	Sollecks	ND
Neilton	A	Spana	D

Table III-1.3 SCS Western Washington Runoff Curve Numbers
(Published by SCS in 1982) Runoff curve numbers for selected agricultural, suburban and urban land use for Type 1A rainfall distribution, 24-hour storm duration.

LAND USE DESCRIPTION		CURVE NUMBERS BY HYDROLOGIC SOIL GROUP - mostly			
		A	B	C	D
Cultivated land(1):	winter condition	86	91	94	95
Mountain open areas:	low growing brush & grasslands	74	82	89	92
Meadow or pasture:		65	78	85	89
Wood or forest land:	undisturbed	42	64	76	81
Wood or forest land:	young second growth or brush	55	72	81	86
Orchard:	with cover crop	81	88	92	94
Open spaces, lawns, parks, golf courses, cemeteries, landscaping.					
Good condition:	grass cover on ≥75% of the area	68	80	86	90
Fair condition:	grass cover on 50-75% of the area	77	85	90	92
Gravel roads & parking lots:		76	85	89	91
Dirt roads & parking lots:		72	82	87	89
Impervious surfaces, pavement, roofs etc.		98	98	98	98
Open water bodies:	lakes, wetlands, ponds etc.	100	100	100	100
Single family residential(2):					
Dwelling Unit/Gross Acre	%Impervious(3)	Separate curve number shall be selected for pervious & impervious portions of the site or basin			
1.0 DU/GA	15				
1.5 DU/GA	20				
2.0 DU/GA	25				
2.5 DU/GA	30				
3.0 DU/GA	34				
3.5 DU/GA	38				
4.0 DU/GA	42				
4.5 DU/GA	46				
5.0 DU/GA	48				
5.5 DU/GA	50				
6.0 DU/GA	52				
6.5 DU/GA	54				
7.0 DU/GA	56				
PUD's, condos, apartments, commercial businesses & industrial areas	%impervious must be computed				

(1) For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Sec. 4, Hydrology, Chapter 9, August 1972.
(2) Assumes roof and driveway runoff is directed into street/storm system.
(3) The remaining pervious areas (lawn) are considered to be in good condition for these curve numbers.

APPENDIX D

Geotech Report

GEOTECHNICAL ENGINEERING STUDY
CASCADE CHRISTIAN SCHOOLS
SECONDARY CAMPUS
21ST STREET EAST
PUYALLUP, WASHINGTON

E-6932

July 7, 1995

PREPARED FOR
CASCADE CHRISTIAN SCHOOLS

Douglas S. Lynne

Douglas S. Lynne
Staff Engineer

Kyle R. Campbell, P.E.
Manager of Geotechnical Services

KYLE R. CAMPBELL

7/7/95

EXPIRES 11/19/96

Earth Consultants, Inc.
1805 - 136th Place Northeast, Suite 201
Bellevue, Washington 98005
(206) 643-3780

IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE/The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays, cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include: the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise, *your geotechnical engineering report should not be used*:

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership, or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their report's development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact.* For this reason, *most experienced owners retain their geotechnical consultants through the construction stage*, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly-changing natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, *give contractors ready access to the complete geotechnical engineering report* prepared or authorized for their use. Those who do not provide such access may proceed under the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are *not* exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. Your geotechnical engineer will be pleased to give full and frank answers to your questions.

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE has developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

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PRACTICING IN THE GEOSCIENCES
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0788/3M

Earth Consultants Inc.
Geotechnical Engineers, Geologists & Environmental Scientists

July 7, 1995

E-6932

Cascade Christian Schools
306 North Meridian
Puyallup, Washington 98371-8634

Attention: Mr. Don Johnson

Dear Mr. Johnson:

We are pleased to submit our report titled "Cascade Christian Schools Secondary Campus, 21st Street East, Puyallup, Washington." This report presents the results of our field exploration, selective laboratory tests, and engineering analyses. The purpose and scope of our study was outlined in our work order dated June 6, 1995.

In general, our study indicates that the site ground conditions consists of loose to medium dense alluvial soils which have been deposited by the nearby Puyallup River. The alluvial soils consist of silty sand, sandy silt, and poorly graded sands.

Based on the encountered conditions, it is our opinion the proposed structures may be supported by conventional foundations following successful completion of a preload program. These recommendations, along with other geotechnically related aspects of the project, are discussed in more detail in the text of the attached report.

We appreciate this opportunity to have been of service to you during this initial phase of project development, and we look forward to working with you in future phases. Should you or your consultants have any questions about the content of this report, or if we can be of further assistance, please call.

Very truly yours,

EARTH CONSULTANTS, INC.

Kyle R. Campbell, P.E.
Manager of Geotechnical Services

DSL/KRC/kml

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GEOTECHNICAL ENGINEERING STUDY
CASCADE CHRISTIAN SCHOOLS SECONDARY CAMPUS
21ST STREET EAST
PUYALLUP, WASHINGTON

E-6932

INTRODUCTION

General

This report presents the results of the geotechnical engineering study for the proposed Cascade Christian Schools Secondary Campus, in Puyallup, Washington. The general location of the site is shown on the Vicinity Map, Plate 1. The purpose of this study was to explore the subsurface conditions at the subject property and based on the conditions encountered to develop geotechnical recommendations for the proposed site development.

Project Description

At the time our study was performed, the site, proposed building locations, existing structures and test pit locations were approximately as shown on the Test Pit Location Plan, Plate 2.

Based on information provided by AHBL, we anticipate the buildings to be two-stories in height and either concrete tilt-up or concrete masonry unit (CMU) construction. Grades are anticipated to be raised about four to five feet in the building areas and up to three feet for the parking areas.

While no specific building load data are presently available, based on our experience with similar construction, we estimate maximum building wall and column loads will be as follows:

- Wall loads - 3-5 kips per lineal foot
- Column loads - 75 kips
- Slab loads - 150 pounds per square foot (psf)

If any of the above design criteria are incorrect or change, or the thickness of fill to be placed changes, we should be consulted to review the recommendations contained in this report. In any case, we recommend that Earth Consultants, Inc. (ECI) be retained to perform a general review of the final design.

SITE CONDITIONS

Surface

The subject site is located between 21st Street East and 25th Street East in Puyallup, Washington, as indicated on the Vicinity Map, Plate 1. The site is bounded on the north and south by rural pasture, to the east by 25th Street East and to the west by 21st Street East.

The roughly twelve-acre site is irregular in shape and is currently being used as pasture land. The ground surface is relatively level with topographic relief of generally less than about two feet. Vegetative cover consists primarily of grass with some patches of trees and heavier brush. There are several old structures on the site in various states of disrepair. These structures appear to have been associated with the use of the site as pasture or farming.

Subsurface

The site was explored by excavating twelve (12) test pits at the approximate locations shown on Plate 2. Please refer to the test pit logs, Plates A2 through A13, for a more detailed description of the conditions encountered at each location explored. A description of the field exploration methods and laboratory testing program is included Appendix A. The following is a generalized description of the subsurface conditions encountered.

Based on our exploration, the site is underlain by loose to medium dense, interbedded sands and silts. The surface soils observed during our exploration, ranged from silty sand (Unified Soil Classification SM) to silt (ML). These soils typically graded to a poorly graded sand (SP) or poorly graded sand with silt (SP-SM) at depths ranging from four to ten feet beneath the existing grades. The poorly graded sands were observed to the maximum exploration depth of twelve and one-half (12.5) feet.

These soils appear to be fluvial deposits from the nearby Puyallup river. Fluvial deposits typically are coarser where the stream bed load was deposited and finer where the stream overflowed its banks and deposited the suspended load. The flood deposits also normally have rootlets and wood debris scattered throughout the layer.

Groundwater

Groundwater seepage levels did not have time to stabilize within the test pits. Based on mottling of the retrieved soil samples, groundwater is likely to be located at depths ranging from three to five feet below the existing ground surface during the winter months. Very slow to heavy groundwater seepage was observed at depths ranging from five and one-half (5.5) to eleven and one-half (11.5) feet below the existing ground surface.

The groundwater seepage levels encountered in the test pits are not static; thus one may expect fluctuations in the level and volume depending on the season, amount of rainfall, surface water runoff, and other factors. Generally, the water level is higher and the amount of flow is greater, in the wetter winter months.

DISCUSSION AND RECOMMENDATIONS

General

Given the encountered soil characteristics, in our opinion, the primary geotechnical development concerns will be obtaining adequate support for the proposed buildings while limiting the magnitude and effect of anticipated settlements.

Based on the observed soil conditions, it is our opinion that the anticipated settlement of the buildings is in the range of two to three inches. We recommend the use of a preload or surcharge program in order to pre-induce the majority of the anticipated settlements. Following successful completion of a surcharge program, settlements are anticipated to be less than one inch. With successful completion of a preload program, settlements are anticipated to be in the range of one inch to one and one-half inches. The majority of the settlements would occur during construction as the dead loads are applied.

Based on the anticipated filling of the site, we anticipate the buildings will be entirely supported by structural fill with about two feet of structural fill beneath the footings.

These and other geotechnically related aspects of the project are discussed in more detail in the following sections of the report.

This report has been prepared for specific application to this project in a manner consistent with that level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area for the exclusive use of Cascade Christian Schools and their representatives. No warranty, expressed or implied, is made. We recommend that this report, in its entirety, be included in the project contract documents for the information of the contractor.

Site Preparation and General Earthwork

Depending upon final grades, some building and pavement areas may need to be stripped and cleared of all sod and topsoil, and any other surface vegetation. Stripping can be limited depending on the amount of fill to be placed. In building areas where two feet or more of structural fill will be present below footing subgrade elevations, stripping is not necessary. However, the existing grass must be mowed and the cuttings removed. In road and parking areas to receive more than one foot of structural fill, the existing grass can be similarly mowed and the cuttings removed. Heavy brush should be stripped in all fill areas. Stripped materials should be removed from the site and disposed, or "lost" in landscaping berms, as desired. The stripped material should not be mixed with any materials to be used as structural fill.

Following the stripping operation, fills required to attain site grades can be placed. The ground surface where foundations, slabs or structural fill are to be placed should be firm and stable, or compacted to a competent non-yielding condition. These areas should be observed by a representative of ECI to ensure adequate bearing conditions are available. Proofrolling may be required in some areas. Soil in any loose or soft areas, if re-compacted and still yielding, should be over excavated and replaced with structural fill to a depth that will provide a stable base beneath the foundation. Typically, a depth of two feet is adequate for this purpose.

Structural fill is defined as any compacted fill placed under buildings, roadways, slabs, pavements, or any other load bearing areas. Structural fill under floor slabs and footings should be placed in thin horizontal lifts not exceeding twelve (12) inches in loose thickness. Each lift must be compacted to at least 90 percent of laboratory maximum dry density, determined in accordance with ASTM Test Designation D-1557-78 (Modified Proctor). Fill under pavements and walks should be placed in similar thin horizontal lifts and, with the exception of the upper twelve (12) inches, be compacted to at least 90 percent of maximum density. The top twelve (12) inches should be compacted to at least 95 percent maximum density.

The existing near surface native soils are moisture sensitive due to their relatively high fines content, and were also above optimum moisture content at the time of our exploration. As such, in an exposed condition they will become disturbed from normal construction activity especially when in a wet or saturated condition. Once disturbed, in a wet condition, they will be unsuitable for support of floor slabs and pavements. Therefore, during construction, where these soils are exposed and will support new construction, care must be exercised not to disturb their condition. If disturbed conditions develop, the affected soils must be removed and replaced with structural fill or crushed rock. The use of a geotextile fabric, such as Mirafi 600-X, can be used to help stabilize the yielding area. Given the conditions described above, a summer earthwork construction schedule is recommended. If this is not possible, some budget contingency should be allowed for additional earthwork to replace unstable soil.

Laboratory tests indicate the majority of near surface soils expected to be exposed in the excavations have in excess of 23 percent fines and a natural moisture content ranging from 9 to 37 percent. As mentioned above, due to the relatively high fines and natural moisture contents, it is our opinion this soil would not be suitable for use as a structural fill in its present condition. Unless the moisture content can be lowered to near optimum conditions, any native soil excavated from foundation or utility areas should either be removed from the site or used in non-structural areas.

If the on-site soil is exposed to moisture and cannot be adequately compacted then it may be necessary to use an imported free-draining granular fill. Fill for this purpose and for use in wet weather should consist of a fairly well graded granular material having a maximum size of three inches and no more than five percent fines passing the No. 200 sieve based on the minus 3/4-inch fraction.

Preload Program

The preload program is designed to pre-consolidate the compressible soil underlying the site. The structural fill placed to raise the site grades should be placed to the finish floor elevation. The preload fill should extend at least five feet beyond the perimeter of the buildings. The side slopes of the fill should not be inclined steeper than 1H:1V. If a wet weather construction schedule is planned, the preload fill should meet the requirements of a wet weather fill as discussed in the *Site Preparation and General Earthwork* section of this study. The structural fill placed as preload material must have a minimum unit weight of one hundred twenty (120) pcf.

The settlement induced by the preload is anticipated to be two to three inches, as mentioned earlier. Based on the soil stratigraphy observed during our site exploration, we anticipate the duration of the preload program to be about two to three weeks. A smaller magnitude of settlement than estimated would indicate the soils have been pre-consolidated and soil conditions are better than anticipated. Conversely, a larger settlement than that estimated would indicate the soil conditions are worse than anticipated, and that additional time and measurements should be taken to obtain satisfactory results.

In order to verify the magnitude and rate of induced settlement, it is necessary to monitor the settlement. The settlement monitoring program should include placing settlement markers on the existing site subgrade before any fill is placed, monitoring them through and after completion of fill placement, until settlements cease or are considered to be within tolerable limits. More specific details of this program are presented below:

- Settlement markers should be placed on the native subgrade of the building pads before any fill is placed. Five to six markers should be installed within each building footprint. ECI can supply and install these markers. (A typical detail is provided on Plate 3).
- A baseline reading is obtained on each marker and is referenced to a temporary benchmark located on a feature that will be unaffected by the fill-induced settlements.
- The fills are then placed. Settlement readings are taken at relatively short intervals during this process, since this phase generates relatively large and rapid settlement.
- Once the fill operation is complete, readings are obtained on a periodic basis, typically weekly, until the settlement ceases or is judged by the geotechnical engineer to be within the limits given in the *Foundations* section.
- Each set of settlement readings are plotted graphically against time to determine the magnitude and rate of settlement, and are matched against the predicted magnitudes and rates to verify the accuracy of earlier estimates and to make any appropriate modifications.

ECI should be retained to acquire the settlement readings. If another organization obtains the readings, the information should be provided to us as quickly as possible after their acquisition for plotting and interpretation. This will help avoid any misinterpretation or misunderstanding regarding the success of the preload program.

A major concern in the settlement monitoring program is the maintenance of settlement markers. In our experience, earthwork equipment (dozers and trucks) often damage or destroy markers at a very high rate. This adds to the project costs in that they need to be replaced and it makes the information obtained less reliable. To avoid this scenario, it is suggested that the project specifications include a requirement that the earthwork contractor is required to immediately replace any damaged settlement markers and have the settlement readings reobtained at his own cost. This requirement makes the earthwork contractor more conscious of the importance of the preload program and will aid in maintaining the integrity of the monitoring program.

If future expansion of the buildings is anticipated, the preload should extend at least twenty (20) feet in the direction of the future addition. This extended preload is needed to reduce the possibility of settlement of the then-existing building from future building or surcharge loads.

As mentioned in the *Foundations* section, the post-construction settlement can be reduced with the use of a surcharge program. In general the surcharge program is performed as indicated for the preload program; however, additional fill should be placed as a surcharge to a maximum height of two feet above the finish floor elevation. This fill is intended to equal, or exceed, building loads. As with the preload program, the duration of the surcharge is anticipated to be on the order of two to three weeks.

Fill for landscaping purposes should not be placed near the building since additional fill could induce further settlements after the building is constructed. If such fill is planned, the preload should be extended to five feet beyond the planned landscape fill, or a lightweight fill, such as "hog fuel" should be used.

Foundations

Following successful completion of a preload, or surcharge, program, it is our opinion that the proposed buildings can be supported by spread footings bearing on a minimum of two feet of structural fill. As previously mentioned, it appears that the fills required to bring the site to grade will apparently provide the minimum two feet of structural fill beneath the footings. In areas where there will be less than two feet of structural fill separating the footings from the native soil, the native soil should be overexcavated to a depth that will provide the minimum depth of structural fill.

We recommend perimeter footings be bottomed a minimum depth of eighteen (18) inches below final exterior grade. Interior spread footings may be bottomed at a depth of twelve (12) inches below finish grade elevation.

Footings founded on the compacted structural fill may be designed using an allowable bearing capacity of two thousand five hundred (2,500) pounds per square foot (psf). Loading of this magnitude would have a theoretical factor of safety in excess of three against an actual shear (bearing capacity) failure. A one-third increase in the above allowable soil bearing pressures can be used when considering short-term transitory wind or seismic loads.

Without completion of a surcharge or preload program, we anticipate post-construction to be on the order of two to three inches with differential settlement of about one inch to one and one-half inches. With structural loading as expected after successful completion of a preload program, post-construction total settlement of approximately one to one and one-half inches is expected with differential settlements of approximately one-half to one inch. With successful completion of a surcharge program, post-construction total settlement of approximately one inch is expected, with differential settlements of approximately one-half of an inch.

Lateral loads can be resisted by friction between the foundation and the supporting native or compacted fill subgrade or by passive earth pressure acting on the buried portions of the foundations. The foundations must be poured "neat" against the existing soil or backfilled with a compacted fill meeting the requirements of structural fill:

- Passive pressure = 350 pcf equivalent fluid weight
- Coefficient of friction = 0.40

Note that the above values include a factor of safety of 1.5.

All footing excavations should be examined by a representative of ECI, prior to placing forms or rebar, to verify that conditions are as anticipated in this report. Due to the moisture sensitive nature of the site soils, care should be taken to protect the bearing surface.

Seismic Design Considerations

The Puget Sound region is classified as Seismic Zone 3 by the Uniform Building Code (UBC). The largest earthquakes in the Puget Sound are widespread and have been subcrustal events, ranging in depth from 50 to 70 miles. Such deep events have not exhibited surface faulting.

The UBC earthquake regulations contain a static force procedure and a dynamic force procedure for design base shear calculations. Based on the encountered soil conditions, it is our opinion that a site coefficient of 1.4 should be used for the static force procedure, as outlined in Section 1628 of the 1994 UBC. For the dynamic force procedure outline in Section 1629 of the 1994 UBC, the curve for deep cohesionless or stiff clay soils (soil type 2) should be used on Figure 16-3, Normalized Response Spectra Shapes.

Liquefaction is a phenomenon in which soils lose all shear strength for short periods of time during an earthquake. The effects of liquefaction may be large total and/or differential settlement for structures with foundations founded in the liquefying soils. Groundshaking of sufficient duration results in the loss of grain to grain contact and rapid increase in pore water pressure, causing the soil to behave as a fluid for short periods of time. To have potential for liquefaction, a soil must be cohesionless with a grain size distribution of a specified range (generally sands and silt); it must be loose to medium-dense; it must be below the groundwater table; and it must be subject to sufficient magnitude and duration of groundshaking.

Based on the subsurface information obtained during our field exploration and laboratory testing, it is our opinion that the potential for liquefaction of the soils at this site is moderate. However, based on the current plan, foundations will be bottomed a minimum of five to six feet above the liquefiable zone. In our opinion, settlement resulting from liquefaction would likely be in the range of the estimated post-construction settlements discussed in a previous section of this study.

Slab-on-Grade Floors

Based on the planned filling of the site, we anticipate that the slab-on-grade floors will be entirely supported by about four feet of structural fill. Should loose fill be encountered at slab subgrade, it should be recompacted to the requirements of structural fill.

Concrete slabs resting on soil ultimately cause the moisture content of the underlying soils to rise. This results from continued capillary rise and the ending of normal evapotranspiration. As concrete is permeable, moisture will eventually penetrate the slab unless some protection is provided. Therefore, the slab should be provided with a capillary break of a minimum of four inches of free-draining sand or gravel. In addition, in areas where slab moisture is undesirable, a vapor barrier such as a 6-mil plastic membrane should be placed beneath the slab. Two inches of damp sand should be placed over the membrane for protection during construction and to aid in curing of the concrete.

Concrete toppings or additives and synthetic moisture-resistant membranes may be used in lieu of a 6-mil plastic membrane in areas where moisture is undesirable. Information on the product usage, installation and warranty should be obtained from the manufacturer if these products are used.

Excavations and Slopes

The following information is provided solely as a service to our client. Under no circumstances should the information provided below be interpreted to mean ECI is assuming responsibility for construction site safety or the contractor's activities; such responsibility is not being implied and should not be inferred.

As mentioned previously, we do not anticipate that major cuts will be needed to achieve the proposed building subgrade elevations. It appears that there is adequate room for any building or utility excavation slopes to be laid back at safe angles using an open cut method, provided the excavation slopes are no greater than the limits specified in local, state and federal safety regulations. Based on the conditions observed in our test pits, the site soils are classified Type C by OSHA, and as such, temporary cuts greater than four feet in height should be sloped at an inclination no steeper than 1.5H:1V (Horizontal:Vertical).

If slopes of this inclination, or flatter, cannot be constructed, temporary shoring may be necessary. This shoring will help protect against slope or excavation collapse, and will provide protection to workmen in the excavation. If temporary shoring is required, we will be available to provide shoring design criteria, if requested. We also recommend that all cut slopes be examined by Earth Consultants, Inc. during excavation to verify that conditions are as anticipated.

All permanent cut and fill slopes should be inclined no steeper than 2H:1V or flatter. Permanently-exposed slopes should be seeded with an appropriate species of vegetation to reduce erosion and improve stability of the surficial layer of soil.

Site Drainage

Depending on the time of year of the earthwork, groundwater seepage may be encountered at relatively shallow depths of three to five feet below the existing ground level. Thus, foundation and utility excavations which extend to or below these levels may encounter this seepage. We do not expect the site groundwater levels will present any major construction related problems unless winter construction is planned. Site soils are fined grained and poorly drained. Thus, surface run-off will pond on the ground surface and construction traffic will disturb these soils quickly.

If seepage is encountered in the foundation excavations during construction, the bottom of the excavation should be sloped to one or more shallow sump pits. The collected water can then be pumped from these pits to a positive and permanent discharge, such as a nearby storm drain. Depending on the magnitude of such seepage, it may also be necessary to interconnect the shallow sump pits by a system of shallow connector trenches.

The construction area should be graded such that surface water is directed off the site. Water should not be allowed to stand in any area where buildings, slabs or pavements are to be constructed. During construction, loose surfaces should be sealed at night by compacting the surface to reduce the potential for moisture infiltration into the soils.

Final site grades should allow for drainage away from the building foundations. We suggest that the ground be sloped at a gradient of three percent for a distance of at least ten feet away from the buildings except in areas that are to be paved, which can be sloped at a gradient of two percent.

Due to the poor drainage conditions of the near surface site soils, we recommend that all the buildings be provided with perimeter footing drains. The drains should be placed just below the invert of the footings, with a gradient sufficient to initiate flow. A typical detail is provided on Plate 4.

Under no circumstances should roof downspout drain lines be connected to the footing drain system. All roof downspouts must be separately tightlined to discharge. Sufficient cleanouts should be installed at strategic locations to allow for periodic maintenance of the footing drain and downspout tightline systems.

We understand a detention pond is proposed north of the football and soccer field. We anticipate this pond will require cuts of up to about three to four feet in order to provide adequate detention storage for the project. Cuts of this depth will likely expose poorly graded sand or silty sand. In our experience, these soil types have permeabilities in the range of 0.1 to 0.0001 centimeters per second (cm/sec). If permeabilities in this range are excessive, we can provide alternative recommendations.

Utility Support and Backfill

The site soils anticipated to be exposed in utility excavations should provide adequate support for utilities. Some recompaction, or replacement, of soils exposed in the base of the utility excavations may be necessary should very loose conditions be encountered. If seepage is encountered in utility excavations, it should be collected and removed from the trench to reduce the potential for creating unstable subgrade conditions.

Adequate compaction of utility trench backfill is a major concern in reducing the potential for settlement along utility alignments, particularly in pavement areas. It is important that each section of utility line be adequately supported in the bedding material. The material should be hand tamped to ensure support is provided around the pipe haunches. Fill should be carefully placed and hand tamped to at least twelve (12) inches above the crown of the pipe before any compaction equipment is used over the pipe. The remainder of the trench backfill should be placed in lifts having a loose thickness of less than twelve (12) inches. A typical utility trench backfill section and compaction requirements for load supporting and non-load supporting areas is presented as Plate 5.

Trench backfill beneath building, parking and roadway areas should consist imported materials, provided they are near the optimum moisture content. We recommend using structural fill due to the moisture sensitive nature of the site soils as described earlier.

Pavement Areas

The adequacy of site pavements is related in part to the condition of the underlying subgrade. To provide a properly prepared subgrade for pavements, we recommend the subgrade be treated and prepared as described in the Site Preparation Section of this report. This means at least the top twelve (12) inches of the subgrade should be compacted to 95 percent of the maximum dry density (per ASTM D-1557-78) and be stable. It is possible that some localized areas of soft, wet or unstable subgrade may still exist after this process. Therefore, replacement with structural fill or crushed rock may be needed to stabilize these localized areas.

The following pavement sections are recommended for lightly loaded areas:

- Two inches of asphalt concrete (AC) over four inches of crushed rock base (CRB) material, or
- Two inches of AC over three inches of asphalt treated base (ATB) material.

Heavier truck or bus traffic areas will require thicker sections depending upon site usage, pavement life and site traffic. As a general rule, the following sections can be considered for truck-trafficked areas:

- Three inches of AC over six inches of CRB, or
- Three inches of AC over four inches of ATB.

Asphalt concrete (AC), asphalt treated base (ATB), and crushed rock base (CRB) materials should conform to WSDOT specifications. All rock base should be compacted to at least 95 percent of the ASTM D-1557-78 laboratory test standard.

LIMITATIONS

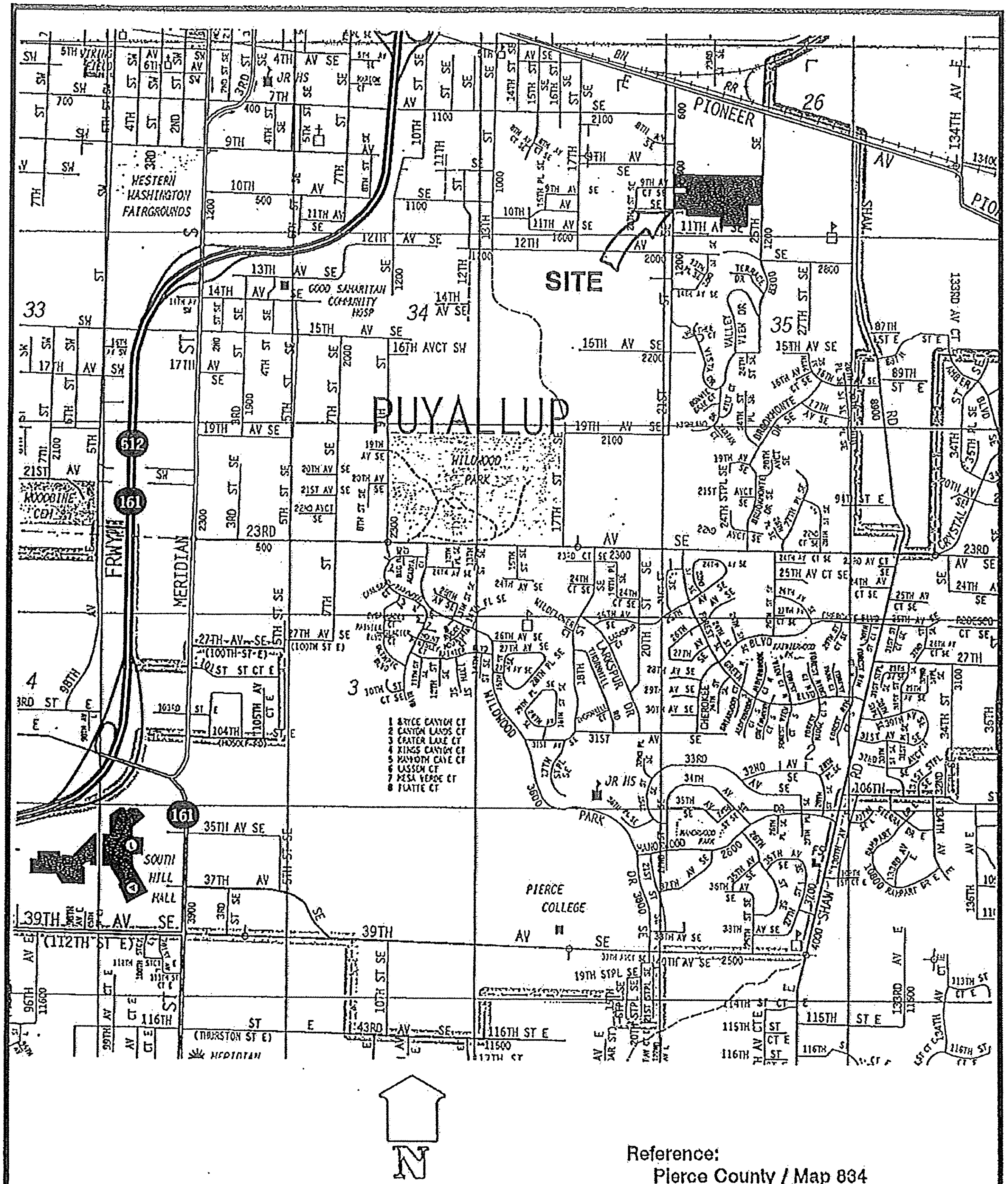
Our recommendations and conclusions are based on the site materials observed, selective laboratory testing and engineering analyses, the design information provided us by your architect, and our experience and engineering judgement. The conclusions and recommendations are professional opinions derived in a manner consistent with that level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area. No warranty is expressed or implied.

The recommendations submitted in this report are based upon the data obtained from the test pits. Soil and groundwater conditions between test pits may vary from those encountered. The nature and extent of variations between our exploratory locations may not become evident until construction. If variations then appear, ECI should be requested to reevaluate the recommendations of this report and to modify or verify them in writing prior to proceeding with the construction.

Additional Services

We recommend that ECI be retained to perform a general review of the final design and specifications to verify that the earthwork and foundation recommendations have been properly interpreted and implemented in the design and in the construction specifications.

We also recommend that ECI be retained to provide geotechnical services during construction. This is to observe compliance with the design concepts, specifications or recommendations and to facilitate design changes in the event subsurface conditions differ from those anticipated prior to the start of construction. Because of the settlement-sensitive nature of this project we do not accept responsibility for the performance of the foundation or earthwork unless we are retained to review the construction drawings and specifications, and to provide construction observation and testing services.



Reference:
Pierce County / Map 834
By Thomas Brothers Maps
Dated 1996

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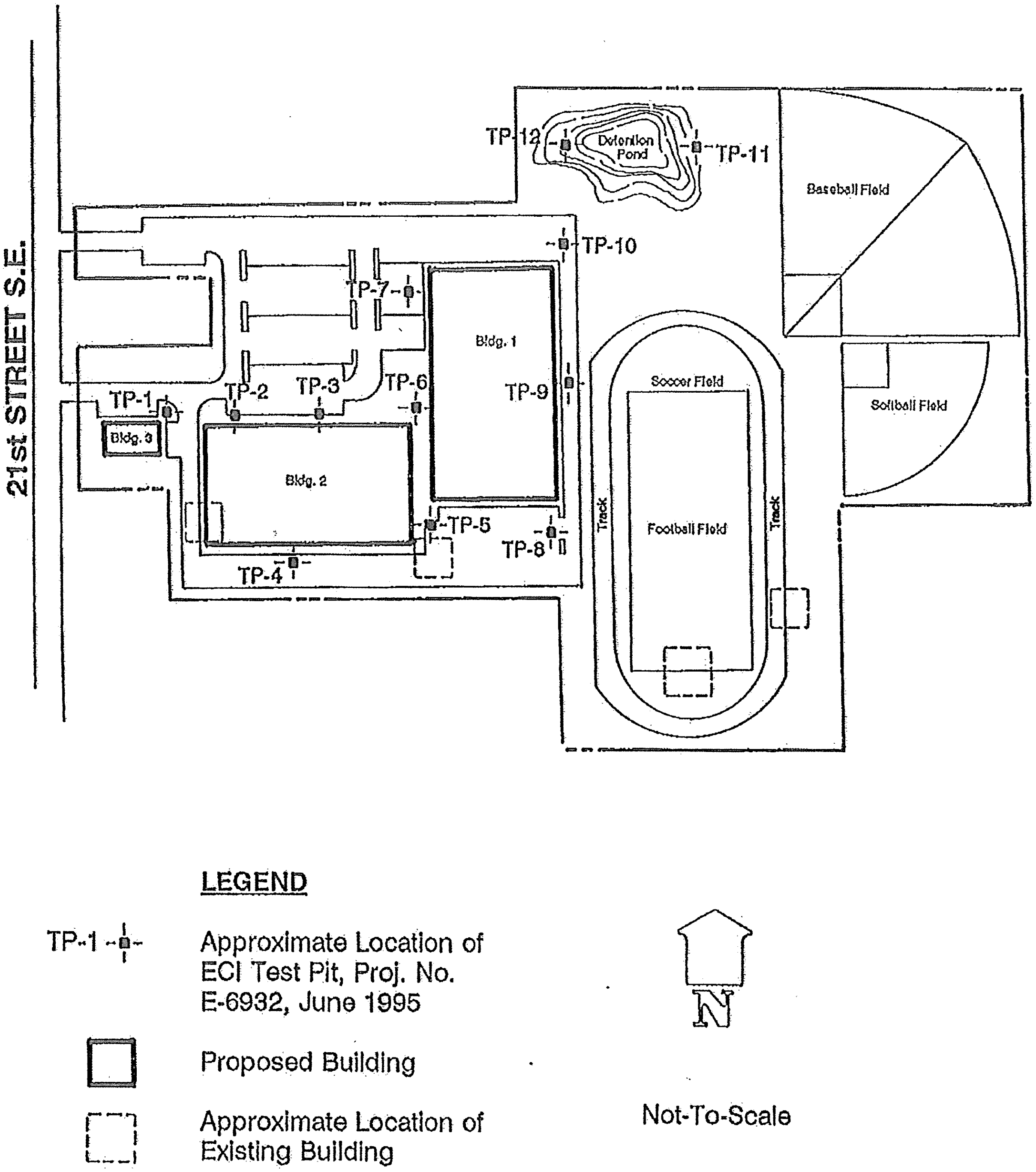
Vicinity Map
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Drwn. GLS	Date June '95	Checked DSL	Date 6/21/95	Plate 1



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Test Pit Location Plan
Cascade Christian School
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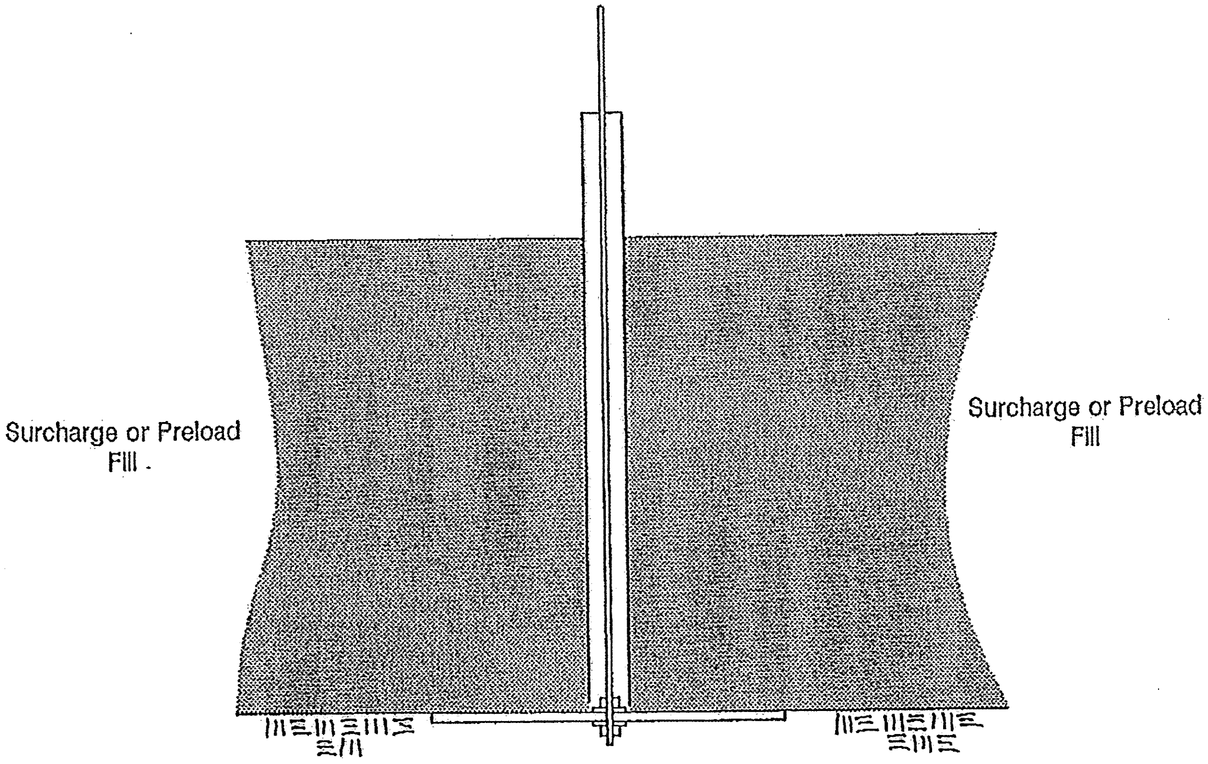
Proj. No. 6932	Drwn. GLS	Date June '95	Checked DSL	Date 6/21/95	Plate 2

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING



STANDARD NOTES

1) Base consists of 3/4 inch thick, 2 foot by 2 foot plywood with center drilled 5/8 inch diameter hole.
2) Bedding material, if required, should consist of Traction Sand.
3) Marker rod is 1/2 inch diameter steel rod threaded at both ends.
4) Marker rod is attached to base by nut and washer on each side of base.
5) Protective sleeve surrounding marker rod should consist of 2 inch diameter plastic tubing. Sleeve is NOT attached to rod or base.
6) Additional sections of steel rod can be connected with threaded couplings.
7) Additional sections of plastic sleeve can be connected with press-fit plastic couplings.
8) Steel marker rod should extend at least 6 inches above top of plastic sleeve.
9) Marker should extend at least 2 feet above top of fill surface.

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TYPICAL SETTLEMENT MARKER DETAIL
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Drwn. GLS	Date June '95	Checked DSL	Date 6/21/95	Plate 3

APPENDIX A

E-6932

FIELD EXPLORATION

Our test pit exploration was performed on June 15, 1995. The subsurface conditions at the site were explored by excavating twelve test pits to a maximum depth of twelve and one-half (12.5) feet below the existing ground surface. The test pits were excavated using a rubber-tire-mounted backhoe.

The approximate test pit locations were determined by visual estimation based on property lines and existing nearby features. The locations of the test pits should be considered accurate only to the degree implied by the method used. These approximate locations are shown on the Test Pit Location Plan, Plate 2. The field exploration was continuously monitored by an engineer from our firm, who classified the soils encountered and maintained a log of each test pit, obtained representative samples, and observed pertinent site features.

All samples were visually classified in accordance with the Unified Soil Classification System which is presented on Plate A1, Legend. Logs of the test pits are presented on Plates A2 through A13. The final logs represent our interpretations of the field logs and the results of the laboratory tests on field samples. The stratification lines on the logs represent the approximate boundaries between soil types. In actuality, the transitions may be more gradual. Representative soil samples were placed in closed containers and returned to our laboratory for further examination and testing.

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTION
Coarse Grained Soils More Than 50% Material Larger Than No. 200 Sieve Size	Gravel And Gravelly Soils More Than 50% Coarse Fraction Retained On No. 4 Sieve	Clean Gravels (little or no fines)	▨	GW gw	Well-Graded Gravels, Gravel-Sand Mixtures, Little Or No Fines
			▨	GP gp	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little Or No Fines
		Gravels With Fines (appreciable amount of fines)	▨	GM gm	Silty Gravels, Gravel-Sand-Silt Mixtures
			▨	GC gc	Clayey Gravels, Gravel-Sand-Clay Mixtures
	Sand And Sandy Soils More Than 50% Coarse Fraction Passing No. 4 Sieve	Clean Sand (little or no fines)	▨	SW sw	Well-Graded Sands, Gravelly Sands, Little Or No Fines
			▨	SP sp	Poorly-Graded Sands, Gravelly Sands, Little Or No Fines
		Sands With Fines (appreciable amount of fines)	▨	SM sm	Silty Sands, Sand-Silt Mixtures
			▨	SC sc	Clayey Sands, Sand-Clay Mixtures
Fine Grained Soils More Than 50% Material Smaller Than No. 200 Sieve Size	Silts And Clays	Liquid Limit Less Than 50	▨	ML ml	Inorganic Silts & Very Fine Sands, Rock Flour, Silty-Clayey Fine Sands; Clayey Silts w/ Slight Plasticity
			▨	CL cl	Inorganic Clays Of Low To Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean
			▨	OL ol	Organic Silts And Organic Silty Clays Of Low Plasticity
	Silts And Clays	Liquid Limit Greater Than 50	▨	MH mh	Inorganic Silts, Micaceous Or Diatomaceous Fine Sand Or Silty Soils
			▨	CH ch	Inorganic Clays Of High Plasticity, Fat Clays
			▨	OH oh	Organic Clays Of Medium To High Plasticity, Organic Silts
Highly Organic Soils			▨	PT pt	Peat, Humus, Swamp Soils With High Organic Contents

Topsoil	▨	Humus And Duff Layer
Fill	▨	Highly Variable Constituents

The discussion in the text of this report is necessary for a proper understanding of the nature of the material presented in the attached logs.

DUAL SYMBOLS are used to indicate borderline soil classification.

C	TORVANE READING, tsf
qu	PENETROMETER READING, tsf
W	MOISTURE, % dry weight
P	SAMPLER PUSHED
*	SAMPLE NOT RECOVERED
pcf	DRY DENSITY, lbs. per cubic ft.
LL	LIQUID LIMIT, %
PI	PLASTIC INDEX

I 2" O.D. SPLIT SPOON SAMPLER

II 24" I.D. RING OR SHELBY TUBE SAMPLER

‖ WATER OBSERVATION WELL

▽ DEPTH OF ENCOUNTERED GROUNDWATER DURING EXCAVATION

▼ SUBSEQUENT GROUNDWATER LEVEL W/ DATE

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LEGEND

Proj. No. 6932 | Date June '95 | Plate A1

Test Pit Log

Project Name: Cascade Christian School			Sheet 1 of 1
Job No. 6932	Logged by: DSL	Date: 6/15/95	Test Pit No.: TP-1
Excavation Contactor: By Client			Ground Surface Elevation:
Notes:			

	W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	Surface Conditions: Depth of topsoil and sod 6", grass
					SM	Brown silty fine SAND, loose, wet
	28.6		1			
			2			
			3			-decrease in fines
			4			
	24.4		5			-becomes loose to medium dense
			6		SP-SM	Grades to dark gray poorly graded fine to medium SAND with silt, loose to medium dense, wet
			7			
			8		⊻	-slight caving
			9			-becomes water bearing -slow to moderate seepage at 8'
	26.5		10			-severe caving
			11			Test pit terminated at 11.0 feet below existing grade. Slow to moderate groundwater seepage encountered at 8 feet during excavation.

TPL 6932 6/23/95

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Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Dwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate A2

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

Test Pit Log

Project Name: Cascade Christian School

Sheet 1 of 1

Job No. 6932

Logged by: DSL

Date: 6/15/95

Test Pit No.: TP-2

Excavation Contactor: By Client

Ground Surface Elevation:

Notes:

W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	Surface Conditions: Depth of topsoil and sod 8", grass
				SM	Brown silty fine SAND, loose, moist
9.4		1			
		2			
		3			
28.8		4			-becomes wet
		5			
		6		SP-SM	Grades to gray poorly graded medium SAND with silt, loose to medium dense, wet
		7			
		8			
25.1		9		▽	-slow to moderate seepage -becomes water bearing
		10			
37.3		11			
		12			Test pit terminated at 12.0 feet below existing grade. Slow to moderate groundwater seepage encountered at 9 feet during excavation.

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Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Dwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate A3

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

TPL 6932 6/30/95

Test Pit Log

Project Name: Cascade Christian School			Sheet 1 of 1
Job No. 6932	Logged by: DSL	Date: 6/15/95	Test Pit No.: TP-3
Excavation Contactor: By Client			Ground Surface Elevation:
Notes:			

W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	Surface Conditions: Depth of topsoil and sod 8", grass
	▨			SM	Brown silty fine SAND, loose, wet
37.2	▨	1			
	▨	2			
	▨	3			-becomes loose to medium dense and gray
	▨	4			
32.2	▨	5			
	▨	6			
	▨	7			
	▨	8		SP-SM	Grades to gray poorly graded medium SAND with silt, loose to medium dense, wet -slow seepage at 8'
	▨	9			
29.5	▨	10			
	▨	11			
39.5	▨	12		∇	-slow to moderate seepage
					Test pit terminated at 12.0 feet below existing grade. Slow to moderate groundwater seepage encountered at 12 feet during excavation.

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Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Dwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate A4

TPL 6932 6/23/95

Test Pit Log

Project Name: Cascade Christian School			Sheet 1 of 1
Job No. 6932	Logged by: DSL	Date: 6/15/95	Test Pit No.: TP-4
Excavation Contactor: By Client			Ground Surface Elevation:
Notes:			

W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	Surface Conditions: Depth of topsoil and sod 8", grass
				SM	Brown silty fine SAND, loose, wet
11.7		1			
		2			
		3			-becomes loose to medium dense and gray
		4			
32.0		5			
		6			-moderate caving
		7		SP-SM	Grades to gray poorly graded fine to medium SAND with silt, loose to medium dense, wet
		8			-very slow seepage at 8'
27.6		9			
		10			-severe caving
		11		∇	-moderate seepage
					Test pit terminated at 11.5 feet below existing grade. Very slow to moderate groundwater seepage encountered at 11 feet during excavation.

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Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Dwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate A5

TPL 6932 6/23/95

Test Pit Log

Project Name: Cascade Christian School
Sheet 1 of 1
Job No. 6932
Logged by: DSL
Date: 6/15/95
Test Pit No.: TP-5
Excavation Contactor: By Client
Ground Surface Elevation:
Notes:

	W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	Surface Conditions: Depth of topsoil and sod 6", grass
					SM/ML	Brown sandy SILT / silty fine SAND, loose, wet
	18.5		1			
			2			
			3			
						-becomes loose to medium dense and gray
	32.3		4			
			5			
			6		SP-SM	Grades to gray poorly graded fine to medium SAND with silt, loose to medium dense, wet
			7			
	28.7		8			
			9			
			10			
			11			-severe caving
			12			Test pit terminated at 12.0 feet below existing grade. No groundwater seepage encountered during excavation.

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Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932
Dwn. GLS
Date June '95
Checked DSL
Date 6/22/95
Plate A6

TPL 6932 6/23/95

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

Test Pit Log

Project Name:
Cascade Christian School

Sheet 1 of 1

Job No. 6932

Logged by: DSL

Date: 6/15/95

Test Pit No.: **TP-6**

Excavation Contactor:
By Client

Ground Surface Elevation:

Notes:

Surface Conditions: Depth of topsoil and sod 6", grass

	W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	Description
	30.3		0–4.5		SM	Brown silty fine SAND, loose, wet -severe caving
	26.1 25.0		4.5–8.5		SP-SM ▽	Grades to gray poorly graded fine to medium SAND with silt, loose to medium dense, wet -becomes water bearing -slow to moderate seepage
						Test pit terminated at 8.5 feet below existing grade. Slow to moderate groundwater seepage encountered at 6 feet during excavation.

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Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Dwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate A7

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

Test Pit Log

Project Name: Cascade Christian School				Sheet 1 of 1
Job No. 6932	Logged by: DSL	Date: 6/15/95	Test Pit No.: **TP-7**	
Excavation Contactor: By Client			Ground Surface Elevation:	
Notes:				

W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	Surface Conditions: Depth of topsoil and sod 6", grass
	▥	0		SM	Brown silty fine SAND, loose, wet
22.1	▥	1			
	▥	2			
	▥	3			-becomes loose to medium dense and gray
	▥	4			
23.5	▨	5		SP ▽	Dark gray poorly graded medium SAND, loose to medium dense, water bearing
	▨	6			-moderate seepage
	▨	7			-severe caving
					Test pit terminated at 7.5 feet below existing grade. Moderate groundwater seepage encountered at 5.5 feet during excavation.

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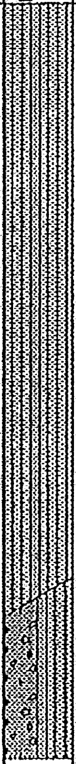
Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Dwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate A8

Test Pit Log

Project Name: Cascade Christian School			Sheet 1 of 1
Job No. 6932	Logged by: DSL	Date: 6/15/95	Test Pit No.: **TP-8**
Excavation Contactor: By Client			Ground Surface Elevation:
Notes:			



W (%)	Depth Ft.	Sample	USCS Symbol	Surface Conditions: Depth of topsoil and sod 6", grass
			SM	Brown silty fine SAND, loose, moist to wet
15.3	1			
	2			
	3			-becomes dark gray and loose to medium dense
	4			
31.0	5			
	6			
	7			-decrease in fines content
	8			
30.4	9		▽	-slow seepage
	10		SP-SM	Grades to gray poorly graded fine to medium SAND with silt, loose to medium dense, wet to water bearing
	11			-minor caving
	12			
				Test pit terminated at 12.5 feet below existing grade. Slow groundwater seepage encountered at 9 feet during excavation.

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Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Dwn. GLs	Date June '95	Checked DSL	Date 6/22/95	Plate A9

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

Test Pit Log

Project Name: Cascade Christian School
Sheet 1 of 1

Job No. 6932
Logged by: DSL
Date: 6/15/95
Test Pit No.: **TP-9**

Excavation Contactor: By Client
Ground Surface Elevation:

Notes:

W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	Surface Conditions: Depth of topsoil and sod 6", grass
				SM	Brown silty fine SAND, loose, wet
31.8		1			
		2			
		3			
		4			-becomes loose to medium dense and gray
		5		SP-SM	Dark gray poorly graded fine to medium SAND with silt, loose to medium dense, wet to water bearing
25.6		6			-severe caving
		7		∇	-slow to moderate seepage
		8			Test pit terminated at 8.0 feet below existing grade. Slow to moderate groundwater seepage encountered at 7 feet during excavation.

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Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Dwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate A10

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

Test Pit Log

Project Name: Cascade Christian School			Sheet 1 of 1
Job No. 6932	Logged by: DSL	Date: 6/15/95	Test Pit No.: **TP-10**
Excavation Contactor: By Client			Ground Surface Elevation:
Notes:			

Surface Conditions: Depth of topsoil and sod 6", grass

W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	
	▨			SM	Brown SILT with sand, loose, wet
35.9	▨	1			
	▨	2			-becomes loose to medium dense and gray
	▨	3			
	▨	4			-becomes sandy
36.9	▨	5			
	▥	6		ML	Gray SILT loose to medium dense, wet
55.9	▥	7			-trace organics and wood debris
	▩	8		SP	Gray poorly graded medium SAND, loose to medium dense, wet
	▩	9			
19.5	▩	10			
	▩	11		⊻	-becomes water bearing
		12			Test pit terminated at 12.0 feet below existing grade. Slow to moderate groundwater seepage encountered at 11.5 feet during excavation.

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Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Dwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate A11

Test Pit Log

Project Name: Cascade Christian School	Sheet 1 of 1

Job No. 6932	Logged by: DSL	Date: 6/15/95	Test Pit No.: **TP-11**
Excavation Contactor: By Client			Ground Surface Elevation:

Notes:

Surface Conditions: Depth of topsoil and sod 8", grass

W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	
				SM	Brown silty fine SAND, loose, wet
35.1		1			
		2			
		3			
		4			
33.5		5			
35.2		6		ML	Gray SILT, loose to medium dense, wet -rootlets
		7		SM	Grades to gray silty fine SAND, loose to medium dense, wet
		8		▽	
32.9		9			-extremely slow seepage -trace organics

Test pit terminated at 9.0 feet below existing grade. Very slow groundwater seepage encountered at 8 feet during excavation.

TPL 6932 6/30/95

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Test Pit Log
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Dwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate A12

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

Test Pit Log

Project Name: Cascade Christian School		Sheet 1 of 1
Job No. 6932	Logged by: DSL	Date: 6/15/95
Test Pit No.: **TP-12**		
Excavation Contactor: By Client		Ground Surface Elevation:

Notes:

Surface Conditions: Depth of topsoil and sod 6", grass

W (%)	Graphic Symbol	Depth Ft.	Sample	USCS Symbol	
34.6	▥	0–4		SM	Brown silty fine SAND, loose, wet -6" layer of poorly graded sand with silt -becomes loose to medium dense and gray
23.6 26.6	▨	4–7		SP ▽	Grades to black poorly graded fine to medium SAND, loose to medium dense, water bearing -severe caving -moderate to heavy seepage
		7			Test pit terminated at 7.0 feet below existing grade. Moderate to heavy groundwater seepage encountered at 5 feet during excavation.

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Test Pit Log
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Puyallup, Washington

Proj. No. 6932	Dwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate A13

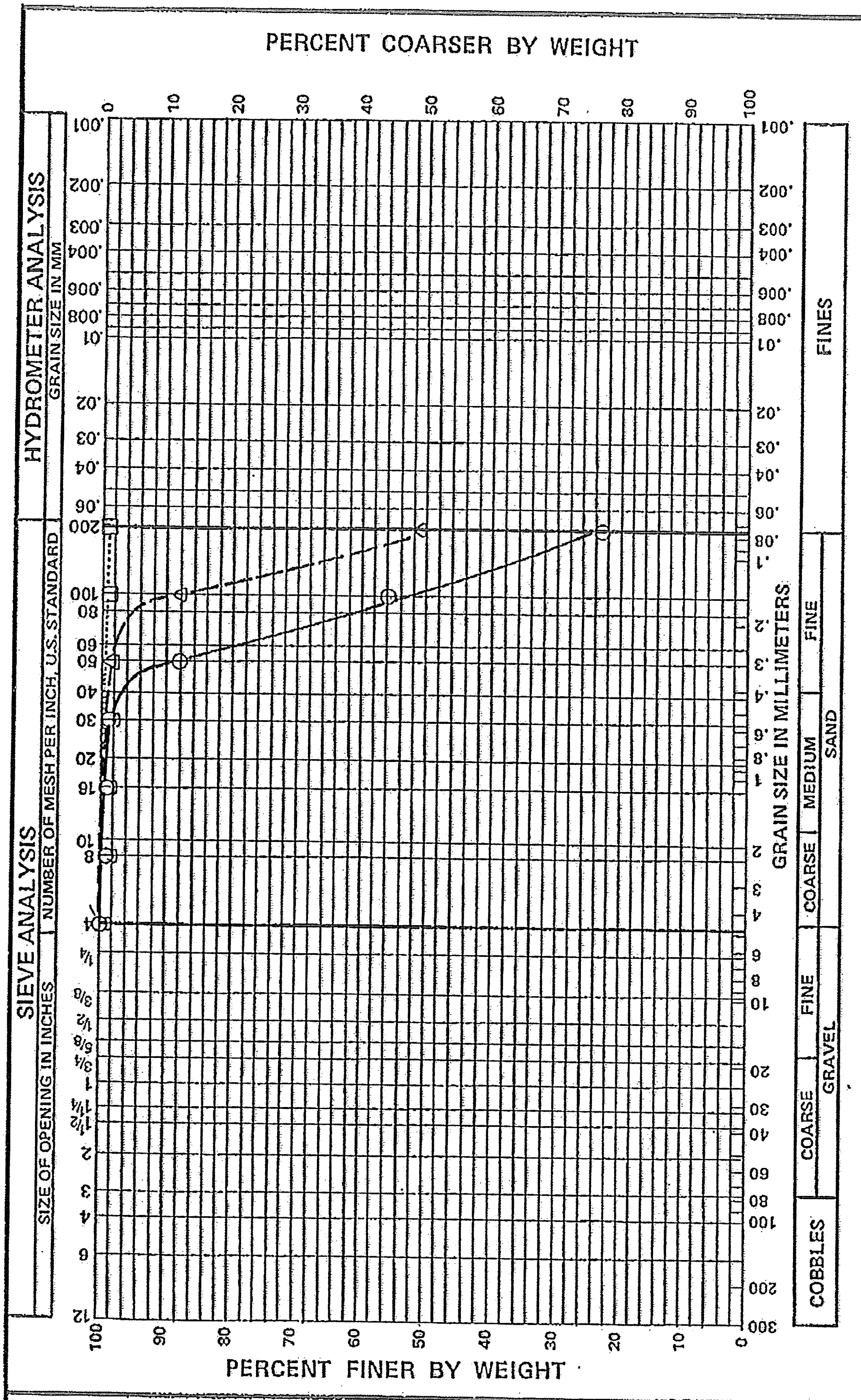
Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

TPL 6932 6/23/95

APPENDIX B

E-6932

LABORATORY TEST RESULTS



KEY	Boring or Test Pit No.	DEPTH (ft.)	USCS	DESCRIPTION	Moisture Content (%)	LL	PL
○———	TP-1	5	SM	Brown silty SAND	24.4	--	--
△— — —	TP-5	1	ML	Brown sandy SILT	18.5	--	--
□········	TP-11	6	ML	Gray SILT	35.2	--	--

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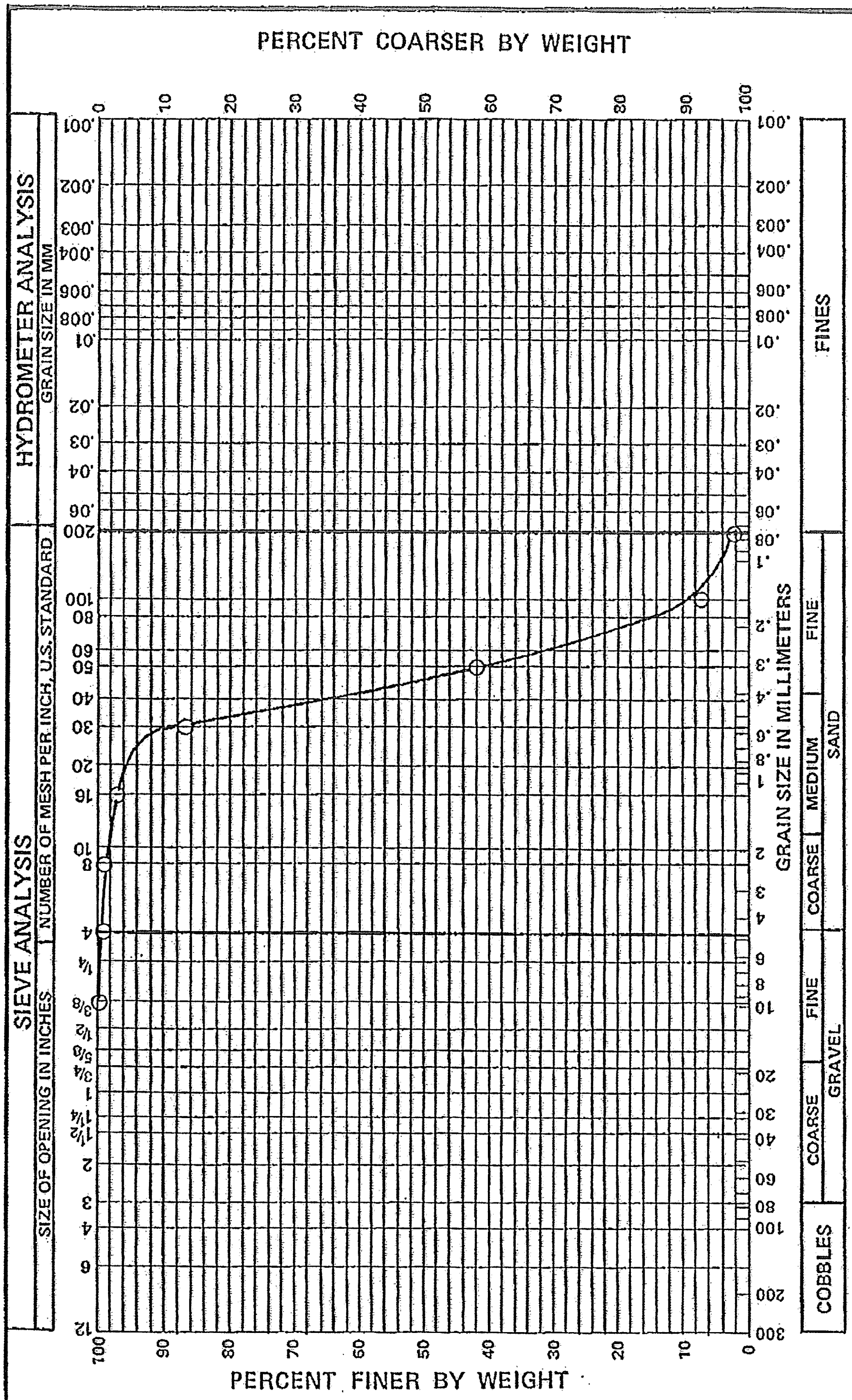
GRAIN SIZE ANALYSES
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Drwn. GLS	Date June'95	Checked DSL	Date 6/22/95	Plate B1



KEY	Boring or Test Pit No.	DEPTH (ft.)	USCS	DESCRIPTION	Moisture Content (%)	LL	PL
○——	TP-12	6	SP	Black poorly graded SAND	26.6	--	--

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GRAIN SIZE ANALYSES
Cascade Christian School
Puyallup, Washington

Proj. No. 6932	Drwn. GLS	Date June '95	Checked DSL	Date 6/22/95	Plate B2

DISTRIBUTION

E-6932

4 Copies	Cascade Christian Schools 306 North Meridian Puyallup, Washington 98371-8634 Attention: Mr. Don Johnson
1 Copy	Brown, Connally, Rowan Architects 222 East 26th Street, Suite 106 Tacoma, Washington 98421 Attention: Mr. Jeff Brown

FIGURE 6
LIMITED GEOTECHNICAL SITE EVALUATION LETTER

Krazan & ASSOCIATES, INC.

GEOTECHNICAL ENGINEERING ∘ ENVIRONMENTAL ENGINEERING
CONSTRUCTION TESTING & INSPECTION

March 4, 2008

KA Project No. 092-08024

CASCADE CHRISTIAN MASTER PLAN
Attn; Job #03-143-1
P.O. Box 207
Puyallup, Washington 98371

RE: Limited Geotechnical Site Evaluation
Cascade Christian School Campus
Parcel No's. 0420351003 & 0420352148
Puyallup, Washington

To Whom It May Concern,

This letter report presents the results of our Limited Geotechnical Site Evaluation for the referenced project.

The purpose of this evaluation is to perform a limited background review of available historical records and published geologic information for the site, and to perform a limited visual site evaluation with regard to the existing site conditions. A Krazan & Associates senior engineering geologist completed the Limited Geotechnical Site Evaluation on February 26, 2008.

The subject site is relatively level and approximately 26.79 acres in total size. The western 17.07 acres is developed with the Cascade Christian School facility and associated parking lots (west side of 25th Street Southeast). The eastern 9.72 acres is undeveloped farm land (east side of 25th Street Southeast).

Based on our review of Earth Consultants, Inc. Geotechnical Engineering Study, Cascade Christian Schools, Secondary Campus, 21st Street East, Puyallup, Washington, dated July 7, 1995, we understand that the existing school facility was constructed on structural fill preload material. This engineering report and school construction was based on the 1994 Unified Building Code (current code at that time). Currently the City of Puyallup is using the 2006 *International Building Code* (2006 IBC).

The United States Geological Survey (USGS) Miscellaneous Field Investigation, Geologic Map of the Puyallup Quadrangle, Washington, indicates that the property is located in an area that is predominantly underlain by Alluvium. The Alluvium consists of interbedded, silt, sandy silt, silty sand, sand, gravel, local areas of peat and clay, and includes lahars from Mount Rainier and rework lahar deposits. The finer material represents overbank material, and local lacustrian deposits, while the coarser materials most likely represent lahars and abandoned channel deposits of the Puyallup River and its tributaries.

We have reviewed the City of Puyallup Municipal Code – Chapter 21.06 – Critical Areas – Article XII - Geologically Hazardous Areas, Geologic Hazards Areas Map, and Pierce County's Seismic hazard Area Map. The above maps indicate that the subject site is designated as a geologic hazardous area and a flood hazard area.

In accordance with the Pierce County Seismic Hazard Map, the site is designated as a potential liquefaction and/or dynamic settlement hazard area. Soil liquefaction is a state where soil particles lose contact with each other and become suspended in a viscous fluid. This suspension of the soil grains results in a complete loss of strength as the effective stress drops to zero. Liquefaction normally occurs under saturated conditions in soils such as sand in which the strength is purely frictional. However, liquefaction has occurred in soils other than clean sand. Liquefaction usually occurs under vibratory conditions such as those induced by seismic events.

To evaluate the liquefaction potential of the site, the following factors should be analyzed:

1) Soil type
2) Groundwater depth
3) Relative soil density
4) Initial confining pressure
5) Maximum anticipated intensity and duration of ground shaking

The currently accepted 2006 *International Building Code* (2006 IBC) requires that liquefaction potential evaluations use the Maximum Considered Earthquake (MCE) selected in accordance with the 2006 *International Building Code* (2006 IBC) Chapter 16 and the U.S. Geological Survey (USGS) Earthquake Hazards Program website. The probabilistic maximum considered earthquake is a 2,500 year event which has a 2 percent probability of being exceeded in 50 years. Currently for this area, the one in 2,500 year event has a peak horizontal ground acceleration of 0.5379g (per U.S. Geological Survey). For the one in 2,500 year event, it is our opinion that there would be a moderate to high potential for liquefaction potential, within the sites underlying soils (dependent on the earthquake's magnitude, depth and location, and the existing soil characteristics and groundwater elevations at the time of the earthquake).

Based on the findings of this limited evaluation, it is our opinion that the combined two parcel subject site is feasible for future construction and development with geotechnical requirements and recommendations. We anticipate that the City of Puyallup will likely require a full geotechnical engineering investigation for the site's future development due to its location within designated Critical Areas, and current code standards. Depending on the proposed development, this would at a minimum require four to six exploratory borings where accessible within the proposed two-story school building area, and possibly six to eight exploratory test pits within the proposed football field and parking lot area on the undeveloped parcel east of 25th Street Southeast. Depending on the proposed development, this would at a minimum require four exploratory borings where accessible within the proposed Junior High Building and Administration Building area on the existing school facility parcel to assess the existing preload and underlying soil conditions. The depth of the borings and test pits, and the final boring and test pit locations will be dependent on the proposed site development.

The geotechnical information presented herein is based upon professional interpretation utilizing standard engineering practices and a degree of conservatism deemed proper for this project. It is not warranted that such information and interpretation cannot be superseded by future geotechnical developments. We emphasize that this letter report is valid for this project as outlined above, and should not be used for any other site.

We hope that this letter report provides the information required at this time. If you have any questions, or if we may be of further assistance, please do not hesitate to contact our office at (425) 485-5519.

Respectfully submitted,
KRAZAN & ASSOCIATES, INC.

State of Washington Licensed Geologist
Engineering Geologist
214
CHRIS J. BEHRENS

Chris Behrens, L.G., L.E.G.
Senior Engineering Geologist

CB/ph

FIGURE 7
”ADDENDA 1” TO THE TIR

Addenda 1 (Dec. 13, 1995)

Contains additional or revised sheets for
STORMWATER
TECHNICAL INFORMATION REPORT

for

CASCADE CHRISTIAN JUNIOR
AND SENIOR HIGH

November 1995

Prepared For:

City of Puyallup
and
Cascade Christian Schools

Prepared By:
Seabrook M. Schilt, Design Engineer
Sean M. Comfort P.E., Project Manager

Reviewed By:
George J. Lindsay, P.E., Principal

94247.10, T-12

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=====================================================================
                          BASIN SUMMARY

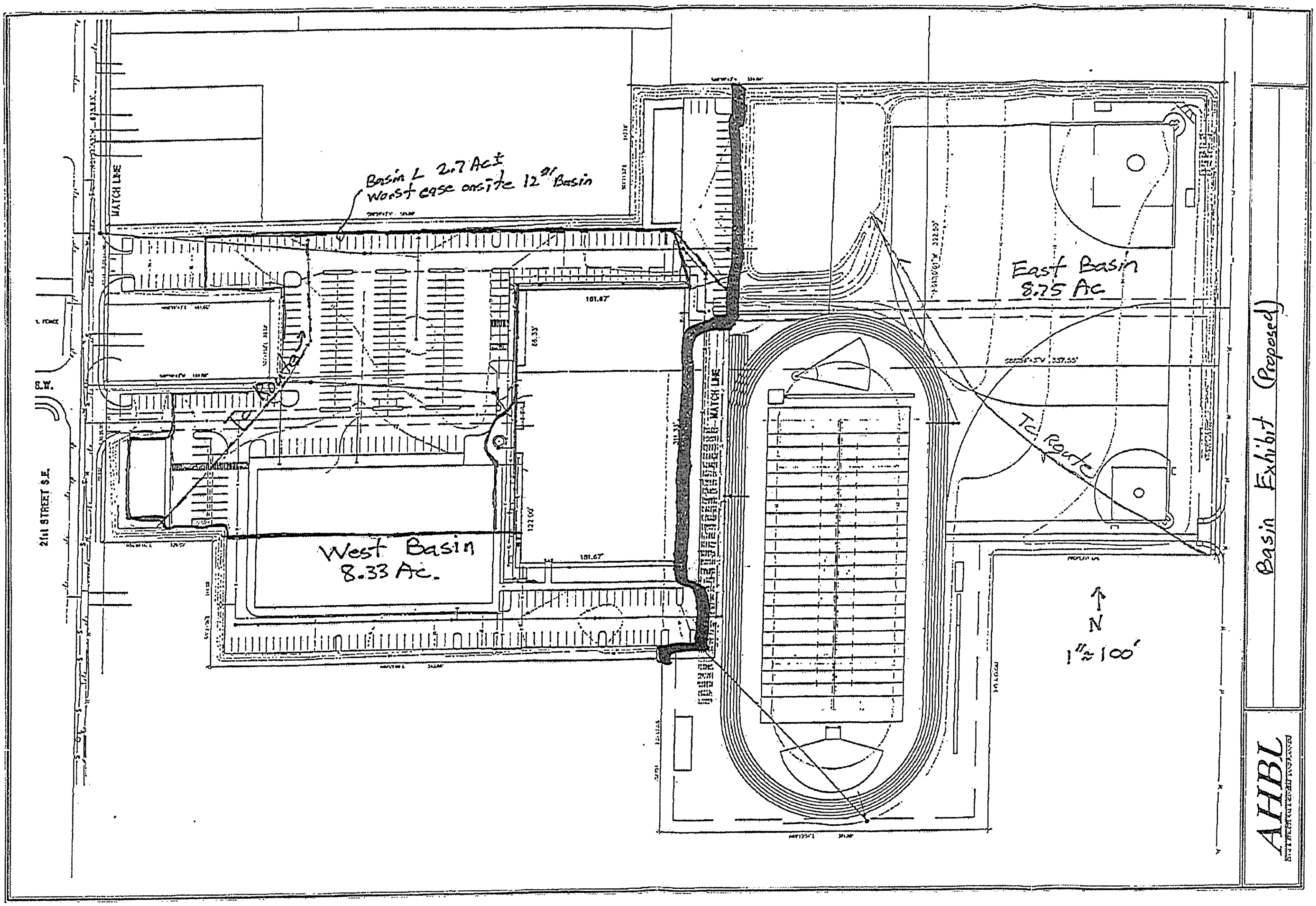

BASIN ID: M            NAME: 100 YR. EXISTING ONSITE
SBUH METHODOLOGY
TOTAL AREA.......:   17.09 Acres      BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:     USER1          PERVIOUS AREA
PRECIPITATION....:    3.90 inches       AREA..:     0.50 Acres
TIME INTERVAL....:     10.00 min        CN....:   89.00
TIME OF CONC.....:   55.00 min        IMPERVIOUS AREA
ABSTRACTION COEFF:    0.20              AREA..:   16.59 Acres
                                        CN....:   98.00
PEAK RATE:    9.04 cfs   VOL:    5.18 Ac-ft  TIME:     480 min



BASIN ID: N            NAME: 10 YR EXISTING ONSITE
SBUH METHODOLOGY
TOTAL AREA.......:   17.09 Acres      BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:     USER1          PERVIOUS AREA
PRECIPITATION....:    2.90 inches       AREA..:     0.50 Acres
TIME INTERVAL....:     10.00 min        CN....:   89.00
TIME OF CONC.....:   55.00 min        IMPERVIOUS AREA
ABSTRACTION COEFF:    0.20              AREA..:   16.59 Acres
                                        CN....:   98.00
PEAK RATE:    6.61 cfs   VOL:    3.76 Ac-ft  TIME:     480 min



BASIN ID: O            NAME: 2 YR EXISTING ONSITE
SBUH METHODOLOGY
TOTAL AREA.......:   17.09 Acres      BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:     USER1          PERVIOUS AREA
PRECIPITATION....:    2.00 inches       AREA..:     0.50 Acres
TIME INTERVAL....:     10.00 min        CN....:   89.00
TIME OF CONC.....:   55.00 min        IMPERVIOUS AREA
ABSTRACTION COEFF:    0.20              AREA..:   16.59 Acres
                                        CN....:   98.00
PEAK RATE:    4.41 cfs   VOL:    2.50 Ac-ft  TIME:     490 min
```


AHBL
Basin Exhibit (Proposed)
East Basin
8.75 Ac.
West Basin
8.33 Ac.
Basin L 2.7 Ac±
Worst case onsite 12" Basin
TC Route
TC Route
N
1" = 100'
MATCH LINE
MATCH LINE
21st STREET S.E.
S.W.
181.67'
181.67'
122.00'
88.33'

AHBL

CIVIL & STRUCTURAL ENGINEERS ∘ LAND PLANNERS ∘ LANDSCAPE ARCHITECTS

Response Memo

TO: Greg Stidham
City of Puyallup, 330 3rd Street SW
Mailing Address
218 West Pioneer Avenue
Puyallup, WA 98371-0187

Project No. 94274.10
Project Name: Cascade Schools

Regarding: Site Plan Review

Date: 12/13/95

The following is an item by item reponse to Gray & Osborne's Dec. 8, 1995 review comments.

1) NA to AHBL

2) a. The hydrograph summary does not include the worst case subbasin for on site 12" conveyance calculations. Basin L is the basin routed through reach H12. This subbasin delineation has been added to the revised Basin Exhibit (Proposed). Flows routed for backwater are correct for Basin L.

b. Even though backup occurs in the upstream 24" line it does not overflow upstream rims as discussed. See plan grades for verification of report HGL grades given.

c. The bioswale calculations which include the roof areas are conservative. There is no reason to redo them unless we wished to reduce the size of the bioswale. Since the swale is the maxim 8' wide redoing the calculations would not allow us to significantly change the size of the design anyway.

3) This information is shown on the basin printouts. 8.58 Ac (50%) of the onsite area has conservatively been used as impervious in the calculations. 3.75 Ac of 28.7 Ac assumed impervious upstream offsite. Existing onsite basin assumed 0.5 Ac. of 17.09 Ac. impervious.

4) Existing basin printouts have been added to the report as addenda.

While these suggestions may be technically correct they do not significantly effect the calculations. it is also arguable that CN of 90 is no more correct and maybe less correct than a CN of 89 for landscape areas on fill areas. I took another look at the impervious area takeoff and the original takeoff is conservative as the landscape Islands were ignored among other things. I used a total of 8.58 acres as impervious onsite This is 50% of the site and covers the pond as well. Redoing the calculations would not change the results within the limits of accuracy for storm water runoff estimates.

6) Office building roof drainage system added as noted.

7) Drainage for driveway areas will be addressed in the offsite road plans yet to be completed. A note to this effect has been added to sheet C2 per our discussion.

8) These existing drains have been approved and installed under the preload plans. A note has been added to the plans calling for the existing pipe to remain.

9) Waterline restraint in fill will be discussed among our staff.

10) Storm notes on sheet C6 do reflect city pipe requirements.

11) Trash rack was called out on C3 instead of C2 and rip rap callout has been added as noted.

12) In the interest of addition emergency storage and protection of adjacent properties an overflow on the pond embankment has not been provided. This does not pose any addition danger since the pond is mostly an excavated hole with a 1 foot high berm providing freeboard. Should the downstream system become plugged, the pond will eventually overflow but the pond sides cannot below eroded below the approximately existing elevation of 60'. The 100 year water elevation in the pond during backwater conditions is calculated to be 59.86'. As discussed eliminating the pond side overflow poses no risk and give an added level of protection before overflowing to adjacent properties.

13) At the time of the first design, 5' was the required berm width. In addition the berm is only 1" high at the border of the pond and is not a significant berm.

14)
- a. City approval blocks added as noted.
- b. North arrow and scale added as noted.
- c. Zoning has been addressed in other documents and SEPA
- d. Bearings and distances are included on the plans

Storm Drainage

The City of Puyallup has recently contracted a consulting firm to model Deer Creek from the Puyallup River to it's headwaters. The model used for storm flow and flooding predictions was SWIM. Flows from this model will be used for design of the open and closed storm drainage conveyance system.

At this time, the model has been calibrated with a typical 2 year storm event and interpolated to simulate the larger events. This could produce an underestimate of the actual flows and associated elevations for the larger storm events, due to errors encountered by interpolation. It would be beneficial for the model to be calibrated with varying levels of storm events this rainey season to account for saturated conditions, fluxing ground water elevations and increased precipitation.

The storm conveyance system, for the off site flows, will require sizing to convey a 100 year storm event. Upstream of East Pioneer Avenue, along the easterly ditch system of 25th Street East, private driveways have undersized culverts, creating a restrictions of flow within the system. These restrictions create flooding of the existing ditch system, overflowing onto private property. If the design for this project can not convey the larger storm events (25 year storm events and up) a backwater effect will create additional flooding along the easterly ditch system of 25th Street East. If the culverts along the easterly side of 25th Street East are every increased additional flows will be encountered through the project and flooding could occur. Therefore, the storm drainage system along East Pioneer will be designed for the 100 year storm event as a minimum level. Refer to Appendix S.D. (Storm Drainage) of this report for sizing of critical culverts, critical ditch sections and modelled flows.

Deer Creek

Deer Creek had a field investigation for presence of fish and potential fish habitat by DEA in August, 1992. A letter report of these findings was submitted to the City and the State Department of Transportation. A copy of this letter report can be found in Appendix D.C. (Deer Creek). In summary, the stream is of low value to fish rearing habitat due to it's lack of: thermal protection through vegetation and depth of flow during the dry season, minimum stream gradient and sinuosity, poor pools/riffles ratio and lack of gravel stream bed mix (spawning habitat).

That portion of Deer Creek scheduled to be relocated to the north side of East Pioneer Avenue, approximately 260-feet, will be mitigated with improved spawning and fish rearing habitat. These mitigated measures discussed with Joe Robel, State Department of Fisheries were: thermal protection (shade trees/shrubs), plunge pools at culvert inlet/outlet, obstructions in ditch bottom to simulate riffle action and

sinuosity and single culvert to route Deer Creek under East Pioneer Avenue (prefer bottomless) and vertical barrier at the junction of Deer Creek and the existing drainage ditch to keep fish in creek and out of drainage ditch.

Mr. Robel suggested tilting the roadway section to the north and not construct the northerly vertical curb and gutter to allow surface runoff to sheet flow into the ditch, creating some bio-filtration. The clear zone required from the WSDOT manual when no vertical curbs are provided is 10-feet to an obstruction. The top of ditch from the widened edge of pavement will be approximately 8-feet, therefore, this alternative does not satisfy WSDOT minimum clear zone requirements. A variation to Mr. Robel's suggestion was created and is labeled Alternative Five, which does provide for some bio-filtration. Refer to Alternative Improvements and Associated Cost section of this report for additional information on Alternative Five.

Sanitary Sewer

A sanitary sewer extension will not be a part of this project. The existing gravity sanitary sewer main within East Pioneer Avenue terminates at 21st Street East. This system gravity flows to the west. At this location the system is less than 5-feet deep and would require a lift station if extended further to the east.

Water System

An existing 4-inch water main east of 17th Street to 21st Street East will be replaced with a 12-inch water main. The remaining system consist of 16-inch, 12-inch and 6-inch water main.

Horizontal and Vertical Alignment

The existing horizontal alignment is basically in a straight alignment and nearly centered within the existing right of way. The proposed alternatives will follow the existing alignment, but centering the section within the right of way. The main reason for not offsetting the roadway to the north, is due to the fact there is limited room available to construct a large ditch channel that can convey the combined flows from the north and south ditch sections. The existing bottom slope of this ditch in some areas is extremely flat. Performing "Preliminary Ditch Sizing" calculations for the split flow from 25th Street and the combined flow, see Appendix S.D. (Storm Drainage), revealed a working ditch area of 19.4 feet to 25 feet will be needed. In the combined flow condition there will be 5.5 feet from the back of curb to the top of the ditch. A 2.5 foot shift would be available to the north, but this is not enough to allow for preserving the southerly ditch and constructing the southerly 5 foot walk. Therefore, the horizontal alignment as it exist will be maintained and widening will occur centered within the right of way for the 44 foot wide section.

SUMMARY OF CULVERT SIZING RESULTS

Culverts sized to convey estimated 100 year flow for Deer Creek (Q = 41 CFS) are:

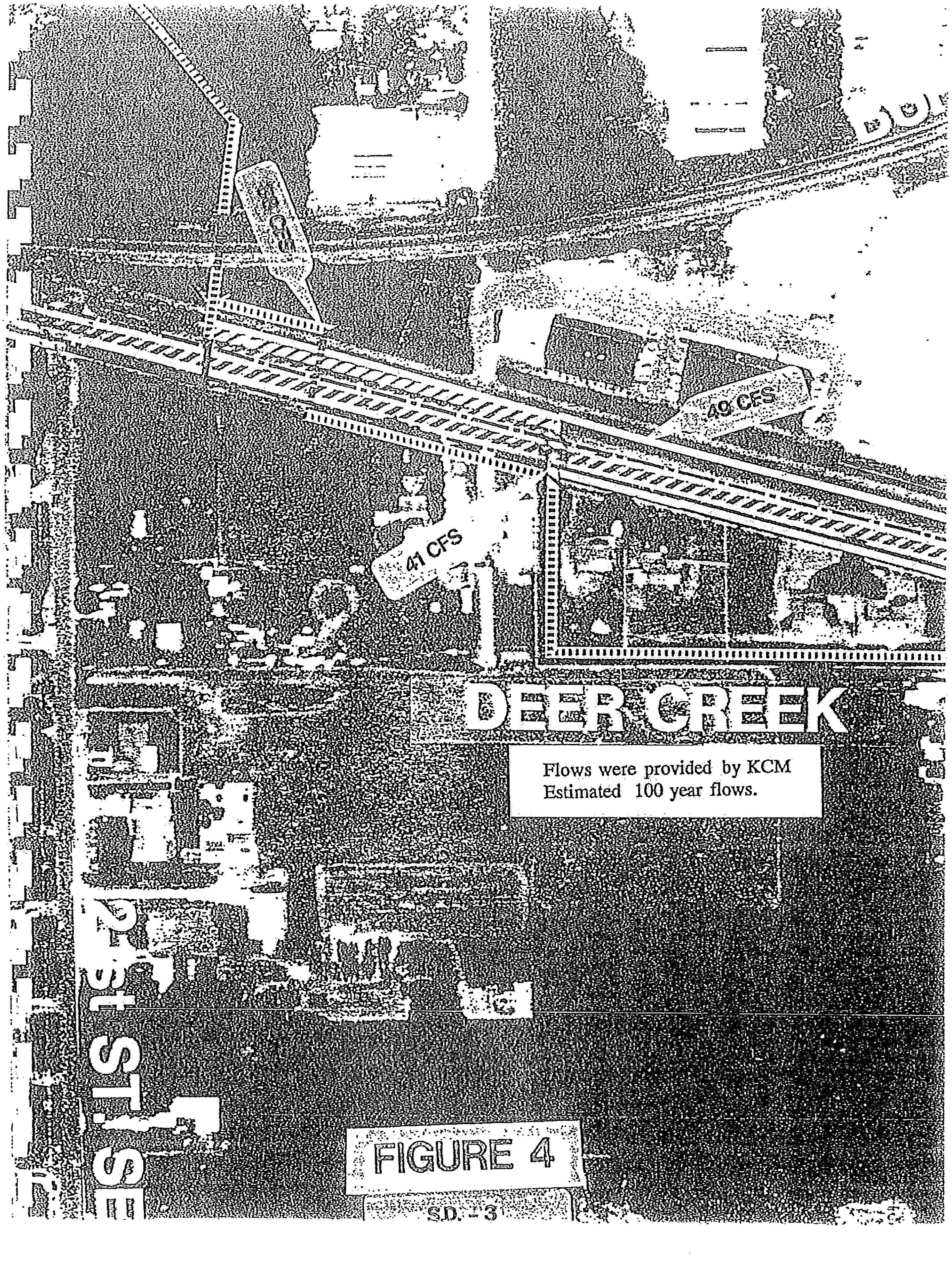
1. Arch CMP 42"x29"; HW = 3.5' (outlet control) 0.20' freeboard available.

OR

2. Concrete bottomless culvert 4'x4'; HW = 2.05' (free flowing) 1.7' from finished roadway grade to depth of flow.

Culvert sized to convey estimated 100 year flow for combined flow of Deer Creek and remainder of ditches (Q = 88 CFS) is:

1. Arch CMP 71"x47"; HW = 3.6' (outlet control) 0.80' freeboard availble.



Flows were provided by KCM
Estimated 100 year flows.

FIGURE 4

DEA DAVID EVANS AND ASSOCIATES, INC.

CLIENT City of Puyallup
JOB DESCRIPTION East Pioneer

JN. CPUP 0001
BY MFF
SHEET 1 OF ____ SHEETS
DATE 10-16-92

Size arch pipe to convey Deer Creek under East Pioneer.

$Q_{100} = 41$ cfs

Finish elev = 58.80'   IE = 54.4 out
IE = 55.1 IN

$L = 70'$ $S = \frac{55.1 - 54.4}{70} = 1\%$

Since slope is relatively flat will need to check inlet & outlet control.

<u>Check inlet control:</u>   (42" x 29"
Span x Rise)

HW/D = 1.4   (with headwall)

$HW = \frac{29''}{12} \times 1.4 = \underline{3.4'}$

Head available = 58.8 - 55.1 = 3.7'

This culvert can convey 100 yr. storm event under inlet control.

<u>Check outlet control:</u>

Assume TW ≤ culvert crown
54.4 + 2.4 = 56.8

$H = 2.2'$

$HW = h_o + H - SL$ $SL = 0.01(70) = 0.70'$

$h_o = \frac{d_c + Dia}{2}$ or TW whichever is greater

$d_c = 1.58$ chart 3-6.1M(3)

DAVID EVANS AND ASSOCIATES, INC.

CLIENT City of Puyallup

JOB DESCRIPTION East Pioneer

JN. CPUP 0001

BY MFF

SHEET 2 OF ______ SHEETS

DATE 10-16-92

$h_o = \frac{1.58 + 2.4}{2} = 1.99'$

$HW = 1.99 + 2.2 - 0.70 = 3.5'$

Outlet control governs - 42"x29" can still convey 100 year storm event with 0.20' of freeboard.

Size Culverts to Convey Combined Flow:

Check inlet control: try 64"x43"

$\frac{HW}{D} = 1.1 \quad HW = 1.1 \times \frac{43}{12} = 3.94'$

Head available = 58.8 - 54.4 = 4.4'

Check outlet control:

$L = 350' \quad S = \frac{54.4 - 52.4}{350} = 0.0057$

$H = 4.5' \quad h_o = \frac{d_c + dia}{2} \quad d_c = 2.1$ (Figure 3-6.1M(3))

$h_o = \frac{2.1 + 43/12}{2} = 2.8'$

$HW = h_o + H - SL = 2.8 + 4.5 - 0.0057(350)$

HW = 5.3 not enough head available.

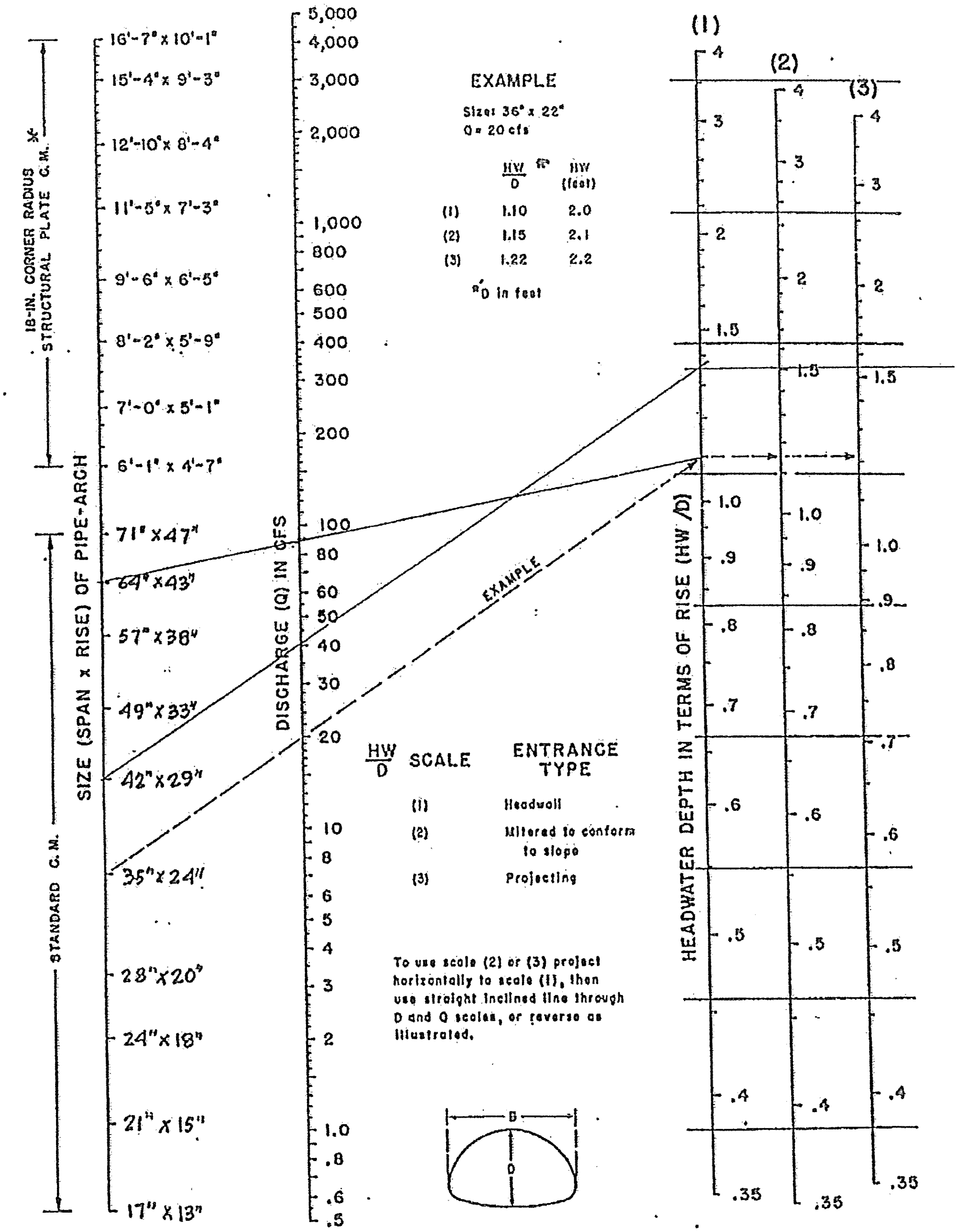
Try 71"x47"

$H = 2.6' \quad h_o = \frac{2.0 + 47/12}{2} = 3.0'$ ($d_c = 2.0$ Figure 3-6.1M(3))

$HW = 3.0 + 2.6 - 0.0057(350) = 3.6'$

0.80' freeboard available.

3-4.3 Corrugated Metal Pipe-Arch (Inlet Control Nomograph) Standard Sizes and 18-Inch Corner Radius

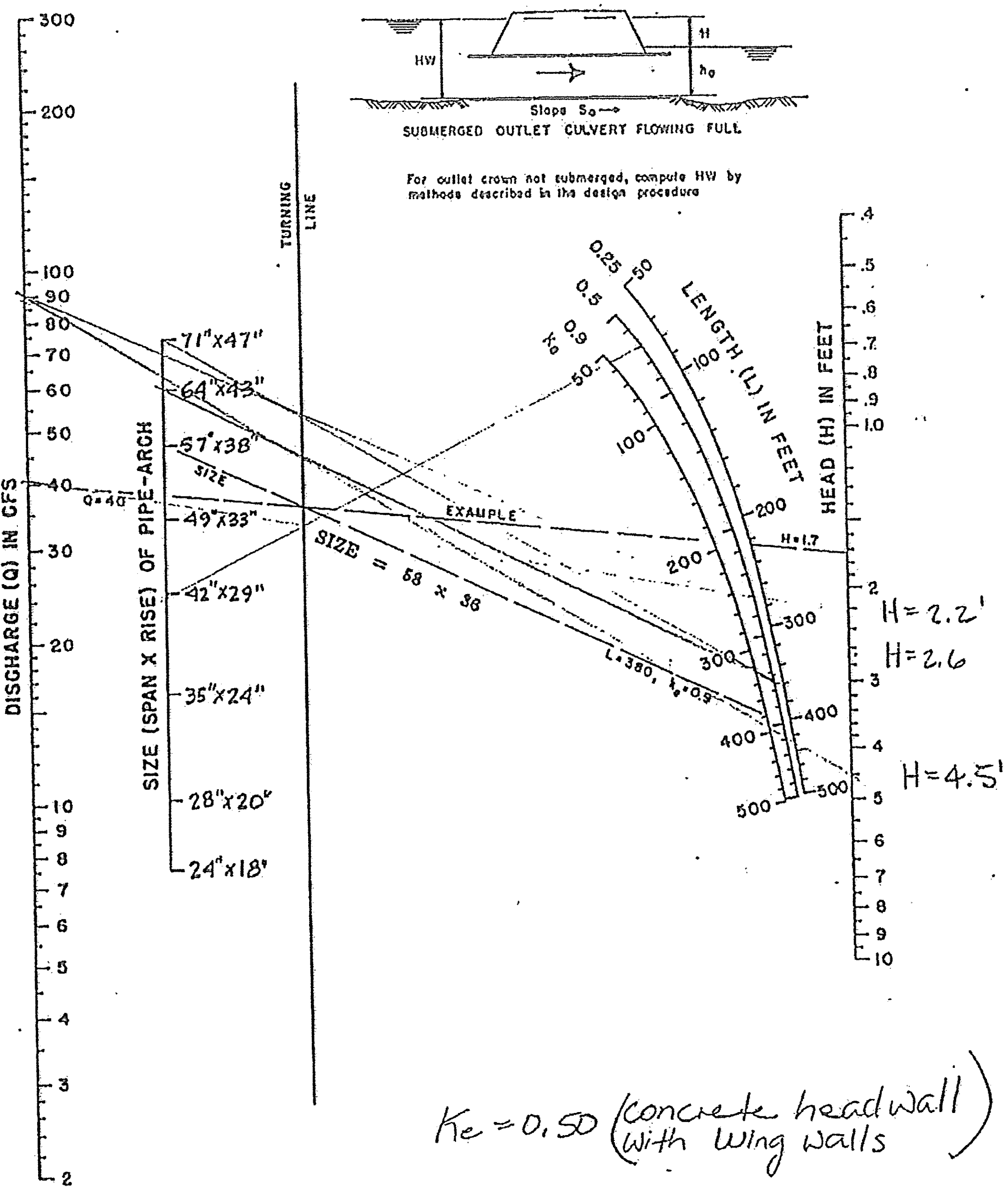


To use scale (2) or (3) project horizontally to scale (1), then use straight inclined line through D and Q scales, or reverse as illustrated.

*ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

BUREAU OF PUBLIC ROADS JAN. 1963

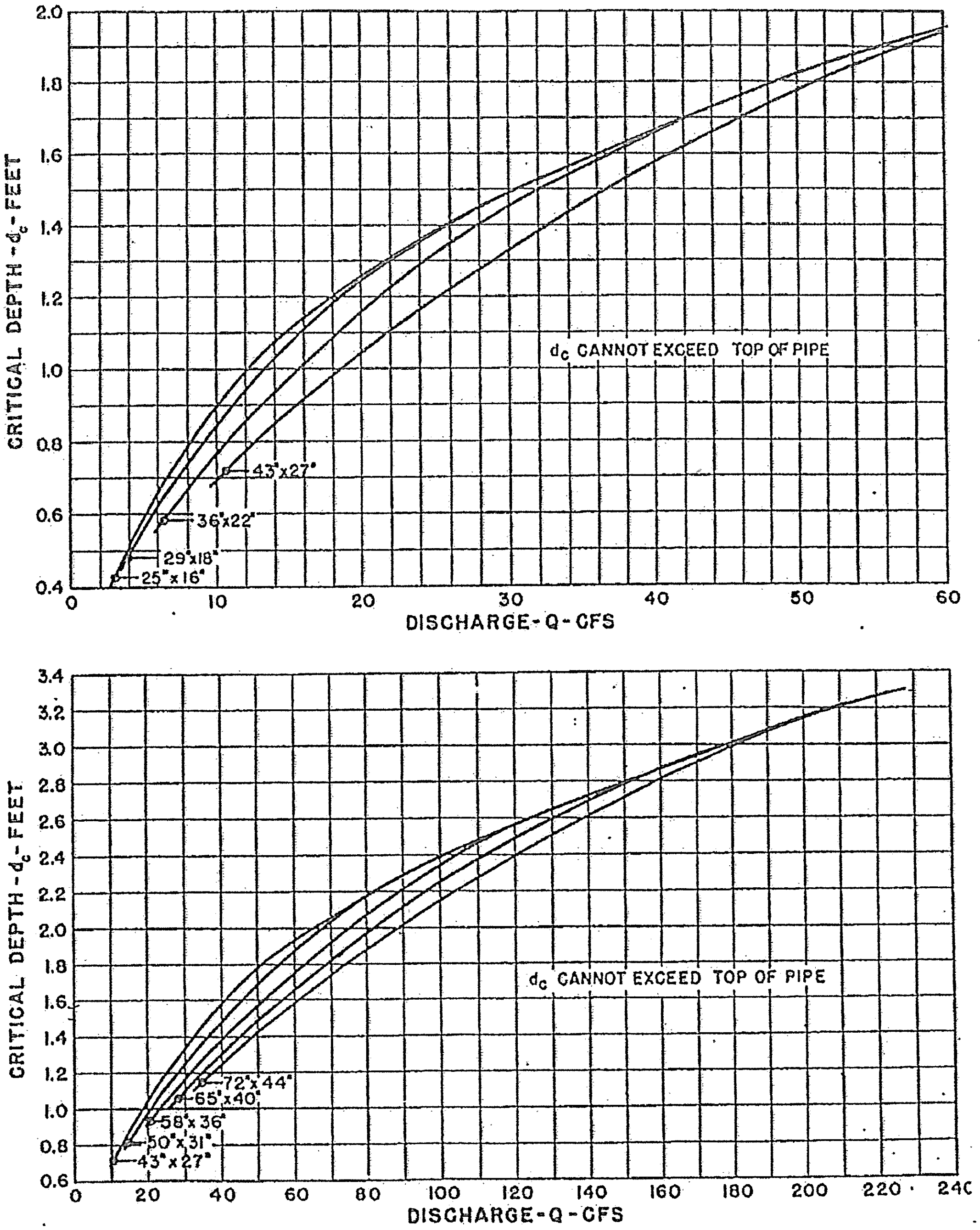
HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL



Ke = 0.50 (concrete headwall with wing walls)

HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n=0.024

BUREAU OF PUBLIC ROADS JAN. 1963



BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

FIGURE 3-6.1M(3)

```
                              MAN-MADE CHANNELS

VARIABLES LIST:
         Y - FLOW DEPTH         B - CHANNEL BOTTOM WIDTH       S - CHANNEL SLOPE
         Q - FLOWRATE           M - CHANNEL SIDE SLOPE         N - CHANNEL ROUGHNESS

VARIABLE TO BE SOLVED (Y,Q,B,M,S OR N) ? Y

Q (CFS)     ? 41                                  RESULTS
B (FT)      ? 4                              =================
M (FT/FT)   ? 0                              Y=        2.05 FT
S (FT/FT)   ? .01                            A=        8.21 SF
N (FT^1/6)  ? .03                            P=        8.10 FT
                                             V=        5.00 FPS
                                             F=        0.61        SUB-CRITICAL FLOW




<Shift> <Prt Sc> print         <Return> repeat         <Space Bar> back to menu
--------------------------------------------------------------------------------
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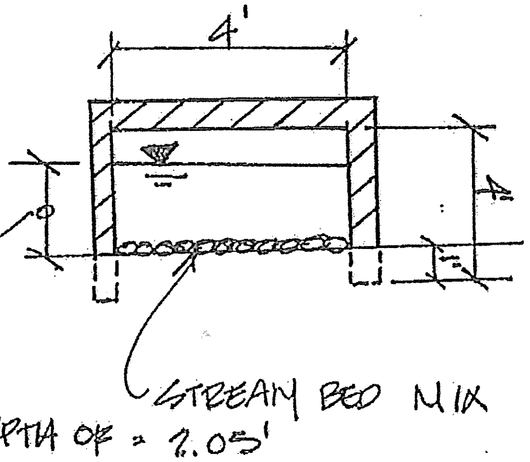
← DEER CREEK FLOW



ESTIMATE DEPTH OF FLOW WITHIN A 4' X 4' BOTTOMLESS CONCRETE CULVERT.

FLOW IS FREE FLOWING & NOT UNDER PRESSURE.

```
                           MAN-MADE CHANNELS

VARIABLES LIST:
         Y - FLOW DEPTH       B - CHANNEL BOTTOM WIDTH      S - CHANNEL SLOPE
         Q - FLOWRATE         M - CHANNEL SIDE SLOPE        N - CHANNEL ROUGHNESS

VARIABLE TO BE SOLVED (Y,Q,B,M,S OR N) ? Y

Q (CFS)      ? 88                            RESULTS
B (FT)       ? 5                       ================
M (FT/FT)    ? .5                      Y=        2.96 FT
S (FT/FT)    ? .006                    A=       19.16 SF
N (FT^1/6)   ? .035                    P=       11.61 FT
                                       V=        4.59 FPS
                                       F=        0.52         SUB-CRITICAL FLOW



<Shift> <Prt Sc> print         <Return> repeat          <Space Bar> back to menu
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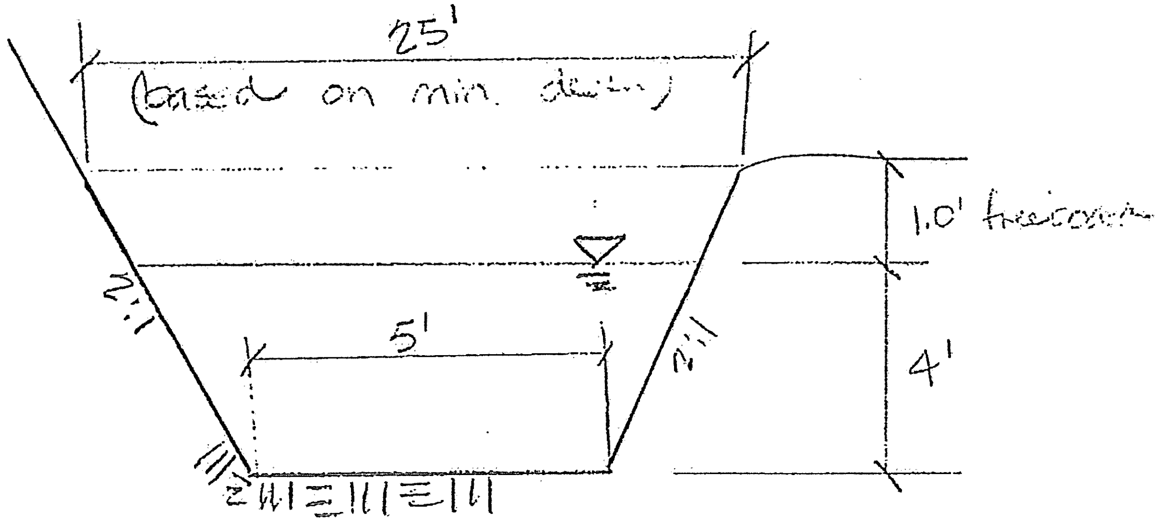

Q = 88 cfs   combined flow
north side

Preliminary Ditch Sizing

```
                              MAN-MADE CHANNELS

VARIABLES LIST:
        Y - FLOW DEPTH       B - CHANNEL BOTTOM WIDTH      S - CHANNEL SLOPE
        Q - FLOWRATE         M - CHANNEL SIDE SLOPE        N - CHANNEL ROUGHNESS

VARIABLE TO BE SOLVED (Y,Q,B,M,S OR N) ? Y


Q (CFS)      ? 49                             RESULTS
B (FT)       ? 5                          =================
M (FT/FT)    ? .5                         Y=       2.56 FT
S (FT/FT)    ? .003                       A=      16.09 SF
N (FT^1/6)   ? .035                       P=      10.73 FT
                                          V=       3.05 FPS
                                          F=       0.37      SUB-CRITICAL FLOW




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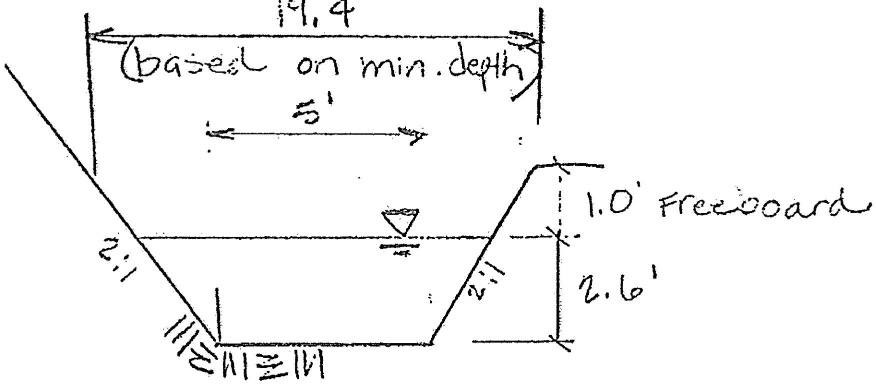


Q = 49 cfs - north side from 25th Street to combined flow from south side.

Preliminary Ditch Sizing

Memo **Kramer, Chin & Mayo, Inc.**

Date: October 14, 1992

To: Marlene Ford, David Evans & Assoc.

From: Lorna Taylor, P.E. LT

Proj. Number: 3045-06

Subject: Pioneer Avenue Flood Flows

Copies: Dave Carlton, Greg Gaasland, Tom Heinecke (Puyallup)

RECEIVED
PUYALLUP
OCT 15 1992

In response to your request, attached is a sketch showing flows, velocities and water surface elevations for the area near the intersection of 25th Street SE and Pioneer Avenue East as predicted by our recent computer modeling. Several factors must be considered if these data are to be used for design purposes:

- The model is predicting extensive flooding upstream along 25th Street SE. If drainage improvements are ever constructed to reduce this flooding, the flows along Pioneer Avenue East may be substantially increased. This is the reason for the extremely small difference between the 25 and 100 year storm at this location. Excess flows are flooding into storage upstream.
- While the elevation of the area is above the 100 year flood elevation predicted for the Puyallup River, substantial backwater conditions may still occur upstream of the wetland north of the railroad tracks.
- The SWMM model is a dynamic model, therefore peak flows predicted occur at varying times during the simulation.
- The model was calibrated using a fairly small storm without much overall volume. It would be better to obtain flow data for a major rainfall event and recalibrate the model prior to using it for design purposes.

If you have any further questions, please feel free to call.

Map provided by KCM on October 14, 1992

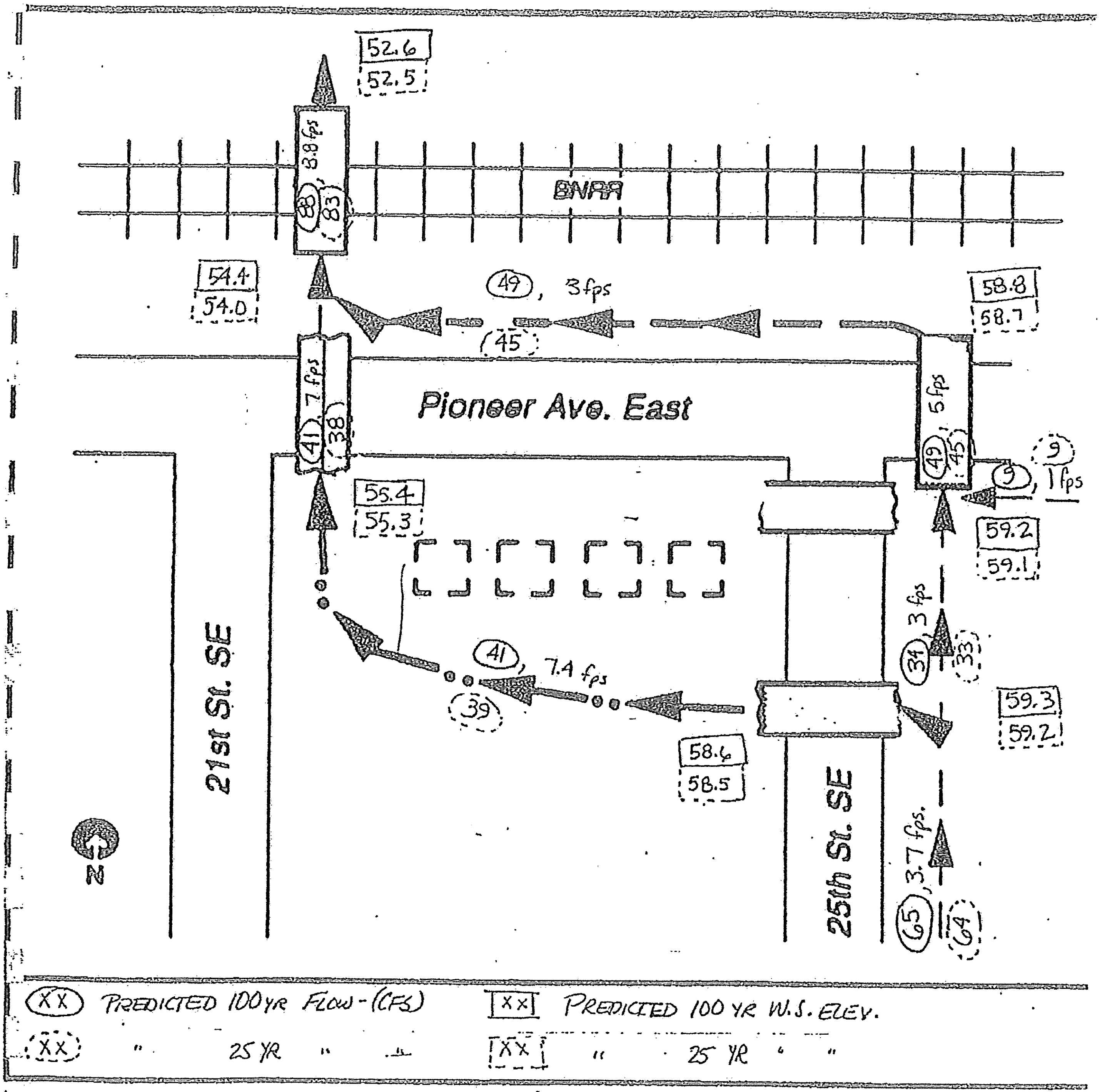
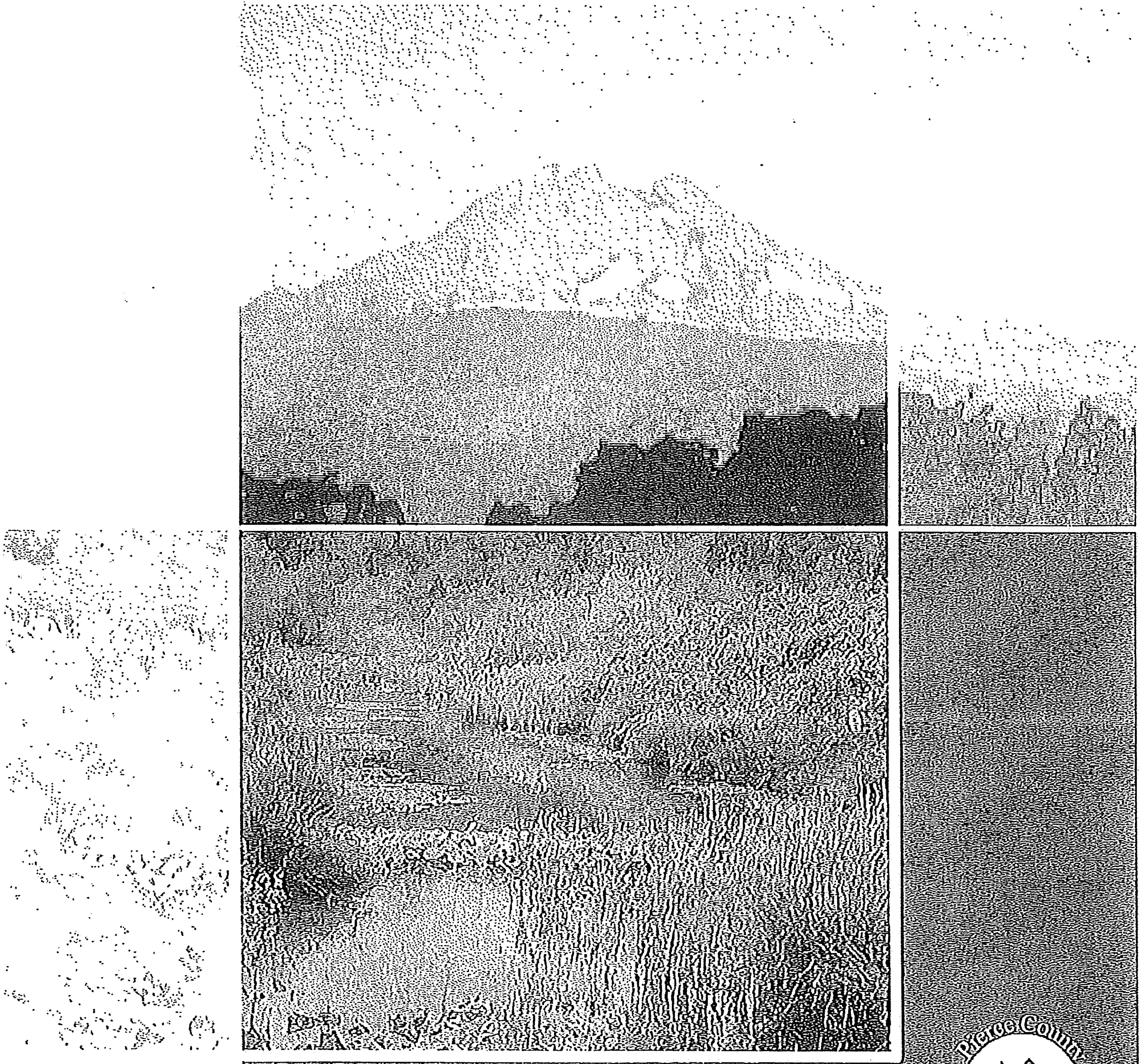


FIGURE 8
STORMWATER MAINTENANCE MANUAL

Pierce County
Stormwater Maintenance Manual for Private Facilities



Pierce County

2.0 STORMWATER MANAGEMENT FACILITIES

To help understand stormwater facility maintenance requirements, it is useful to have a general knowledge of how they function. Some maintenance needs are common to all types of facilities, while others depend on the specific facility.

The three major components of stormwater management include stormwater collection/conveyance, stormwater quantity control (detention/retention) and stormwater quality control (treatment). This section describes general stormwater management theories and goals. Specific stormwater facility descriptions and maintenance requirements are provided in Section 3.0.

2.1 Collection and Conveyance Systems

Collection and conveyance systems intercept and transport stormwater and typically consist of inlets that collect water and pipes and/or open channels (ditches). Stormwater conveyance systems are designed to provide capacity for a specific maximum flow rate. Typical failures include reduced capacity due to clogged surface grates and pipes. Plugging commonly occurs due to sediment and large debris washed from adjacent surfaces. Reduced conveyance system capacity results in localized flooding and possible property damage.

2.2 Stormwater Quantity Control (Detention/Retention)

The intent of stormwater quantity control facilities is to slow down stormwater flow discharged to the environment from developed sites. Impervious surfaces, such as roads, roofs, and lawns, quicken the rate of stormwater runoff into natural streams which can create flooding. Stormwater quantity control facilities mitigate the increased runoff by providing temporary storage and controlling the release rate from the site to prevent flooding and erosion. Detention and retention facilities may be designed as ponds or underground facilities.

Detention facilities function by providing temporary storage of stormwater runoff to be released at a controlled rate. The intent of the detention facility is to match the pre-developed runoff rates for several specific storm events in the developed condition.

Retention facilities are typically located in areas where water soaks easily into the ground. Retention facilities provided temporary storage while allowing the water to soak into the ground, mimicking natural conditions. There is typically no release of stormwater to other pipes or water bodies.

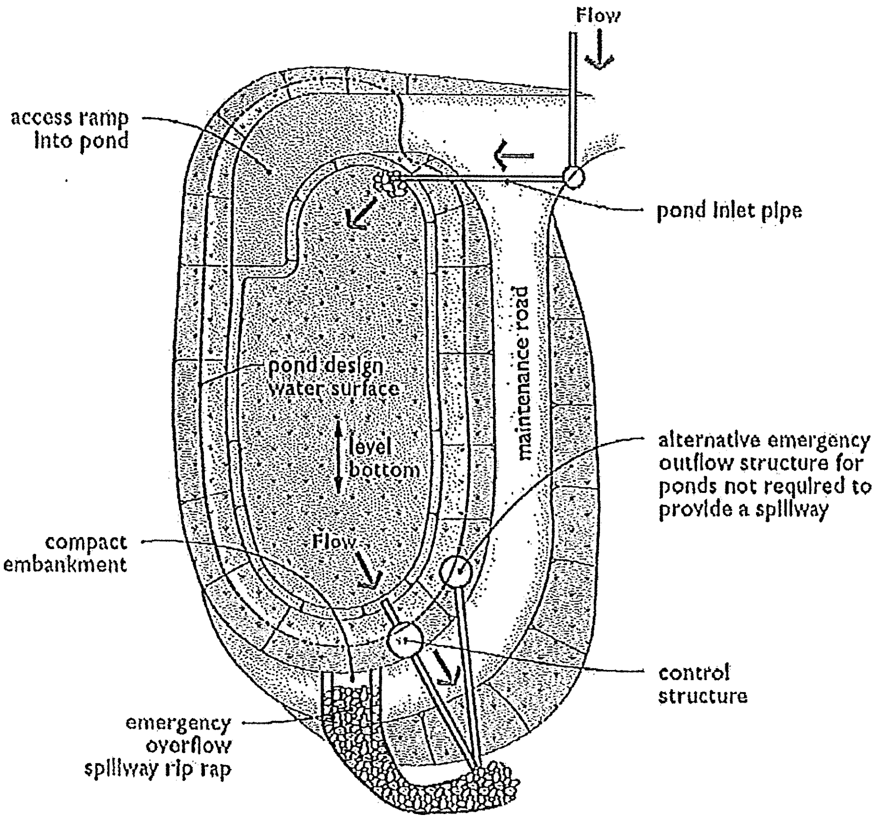
2.3 Stormwater Quality Control (Treatment)

There are a several Best Management Practices (BMPs) utilized for stormwater quality control. These systems provide stormwater treatment through a combination of filtration, sediment settling, plant nutrient uptake, and physical separation. The most common treatment systems include biofiltration swales, filter strips, wetponds, and sandfilters. There are also some proprietary structural treatment systems including Stormfilters®, oil/water separators, and Vortech® treatment units. The intent of all stormwater treatment facilities is to remove oils, chemicals, metals, and sediment from stormwater runoff prior to being discharged from the property.

Stormwater treatment facilities have a limited pollutant removal capability and are not intended to replace proper site management. The most effective technique for reducing pollutant discharge from the site is to provide good housekeeping through source control Best Management Practices (BMPs) as provided in the Stormwater Pollution Prevention Manual located at http://www.co.pierce.wa.us/PC/services/home/environ/water/swm/sppman/.

3.1 Detention Ponds

Stormwater detention ponds are open basins built by excavating below existing ground or by constructing above-ground berms (embankments). The detention pond temporarily stores stormwater runoff during rain events and slowly releases it through an outlet (control structure). Detention ponds are typically designed to completely drain within 24 hours after the completion of a storm event. Components that are typically associated with a detention pond include the following: control structure/flow restrictor, debris barrier (e.g. trash rack), energy dissipaters, access road, and fence.



Detention Ponds Checklist

Frequency	Drainage System Feature	Date				Problem	Conditions to Check For	Conditions That Should Exist
		✓	✓	✓	✓			
M,S	General					Trash & Debris	Any trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size garbage can). In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
A	General					Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local weed board) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required
M,S	General					Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants	No contaminants or pollutants present. (Coordinate removal/cleanup with local water quality response agency).
M	General					Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
M	General					Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies)
A	General					Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies.
A	General					Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood).

Detention Ponds Checklist (Continued)

		Date						
Frequency	Drainage System Feature	✓	✓	✓	✓	Problem	Conditions to Check For	Conditions That Should Exist
							trees are not interfering with access or maintenance, do not remove	
A	General						If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	Remove hazard Trees
M	Side Slopes of Pond					Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
M,S	Side Slopes of Pond						Any erosion observed on a compacted berm embankment.	If erosion is occurring on compacted berms a licensed civil engineer should be consulted to resolve source of erosion.
M	Storage Area					Sediment	Accumulated sediment that exceeds 10% (typically 6"-to 12") of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
M	Storage Area					Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.
A	Pond Berms (Dikes)					Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
A	Pond Berms (Dikes)					Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goetechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.

Detention Ponds Checklist (Continued)

		Date						
Frequency	Drainage System Feature	✓	✓	✓	✓	Problem	Conditions to Check For	Conditions That Should Exist
A	Emergency Overflow/ Spillway					Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm/spillway restoration.
A	Emergency Overflow/ Spillway					Emergency Overflow/ Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.

If you are unsure whether a problem exists, please contact a Professional Engineer.

Comments:

<u>Key</u>:

(M) Monthly from November through April.
(A) Once in late summer (preferably September)
(S) After any major storm (use 1-inch in 24 hours as a guideline).

4.0 Developing a Maintenance Program

A stormwater maintenance program is essential to ensure that the facilities continue to function as designed to prevent possible flooding and property damage. The maintenance program consists of inspections and repairs as detailed in the maintenance checklists provided in Section 3.0.

Stormwater management facilities are not intended to replace good housekeeping procedures. Good housekeeping includes educating facility users of proper storage and disposal of chemicals and potential pollutants, procedures for spill cleanup, proper use of fertilizers and other lawn care products, and maintenance of equipment to prevent release of pollutants to the stormwater system. Guidelines for establishing good housekeeping procedures (Source Control BMPs) and developing a training program to educate facility users can be found in the Pierce County Stormwater Pollution Prevention Manual located at:

http://www.co.pierce.wa.us/PC/services/home/environ/water/swm/sppman/.

4.1 Who Should Perform Maintenance Duties?

Private stormwater facility owners are responsible for ensuring that the facilities are maintained and continue to function as designed. Some activities such as litter removal and mowing can be effectively undertaken by facility owners, however, it is usually worth the cost to have a professional do the more difficult tasks. Filling eroded areas and soil disturbing activities, such as reseeding or re-planting vegetation are tasks that a professional landscaping firm should manage. If these tasks are not performed properly, erosion may occur resulting in accelerated sedimentation of stormwater facilities. Grading and sediment removal are tasks that are best left to professional contractors with the equipment and experience to safely perform the task and who are also able to identify potential problems early when it is most cost effective to make repairs or alterations.

4.2 Working with Maintenance Contractors

Selecting and working with a maintenance contractor can be an intimidating process for many private facility owners. The following is a guideline for researching and choosing a qualified contractor to meet your maintenance needs.

Start your search for a contractor the right way - be informed. The information provided below will help you in your search for the right contractor for your job.

- Landscape maintenance contractors are typically capable of providing most routine maintenance for stormwater facilities. Special, non-routine maintenance may require an earthwork contractor or vactor company. Recently, several contractors have started specializing in stormwater facility maintenance. Private owners can choose to hire contractors when individual maintenance needs arise or enter into annual maintenance agreements where the contractor monitors and provides routine maintenance throughout the year as needed.
- Develop a list of potential contractors. Look in the Yellow Pages and/or ask friends, neighbors, relatives, and coworkers who they have used. Find out if their experiences were good or bad and why. Ask if they would use the contractor again.
- Ask contractors for references. Call your potential contractors and ask for a list of their customers or locations of completed jobs. Call references and ask whether they were satisfied with the job done, if the contractor kept to the agreed upon schedule, and whether they would hire the same contractor again.
- Ask to which trade associations the contractor belongs. Membership in a professional association is one sign the contractor recognizes the responsibilities of being a professional.
- Make sure to obtain and evaluate bids. Ask for a free written estimate of the work you want done. Be sure everyone is bidding on the same exact scope of work and including the exact materials you want. Be sure all quotes include everything you want and that there is a clear understanding of work to be performed by owner and work to be performed by contractor.
- Remember *"you get what you pay for."* A higher bid may be worth the price for better workmanship and contractor reliability.
- Make sure you understand the different types of bids you may receive. Be careful about hiring a contractor on an hourly time-and-materials, or cost-plus basis. Although the price may seem high at first, a fixed-price bid may give you the best protection and price. Also beware of "special deals," "demonstration projects," or *"a great deal from a friend of a friend."* Completely review and understand the contract prior to authorizing work.

Questions to Ask Before Hiring a Contractor

- What experience, expertise and/or certification do you have? Do you specialize?
- Who will be doing the actual work: you personally, your employees, or subcontractors?
- Who will oversee the day-to-day job? (You may really like the contractor, but that person may not be the one performing or supervising the work.)
- How many other jobs will you be working on at the same time as mine? (If there are several, yours may not get the attention you want. On the other hand, the contractor's business may be large and he may be able to handle several jobs.)
- How long will the job take? What kind of mess, noise, and inconvenience should I expect? What problems may come up? (Asking questions before the job starts helps prevent surprises later.)
- Where will you dispose of material removed from storm drainage facilities? Is there an extra fee for contaminated materials?
- Does hiring this contractor feel right? (Use intuition - if you do not feel comfortable, find someone else.)
- Do I have rapport with this contractor? Am I confident in his expertise and ideas? Does he care about my concerns? Will he be reliable, keep his appointments, and return my telephone calls?
- Can I communicate with this person? Does he seem honest and forthright? (The contractor may be top-notch at the trade, but if the final product is not what you expected, you will not be happy.)
- Am I willing to be reasonable about unexpected costs that arise and to let my contractor make a profit?
- Am I ready for the unexpected, such as digging into solid rock, major replacement, etc.?
- Can I be flexible when the job takes longer than expected?
- Are my expectations so high that I will never be satisfied with my contractor?

4.3 How much will it Cost to Maintain a Stormwater Management System?

Specific maintenance costs depend on the characteristics of the facility, the site, and the area that contributes runoff to the facility. The general rule of thumb is that annual maintenance costs will be 5 to 10% of the facility's total capital cost. Routine, scheduled maintenance can help keep overall costs down by addressing problems before they require major attention.

Most of the routine maintenance measures recommended in the checklists (excluding major repair and replacement) are estimated to have an annual cost of $200 to $600 per acre of facility, above current landscape maintenance costs. Costs can vary depending on the types and level of maintenance practices used.

The cost and intensity of maintenance activities are usually higher during the two-year plant establishment period than after the facility has "settled in" after those first two years.

You need to determine how you will finance your maintenance needs. A healthy reserve should be put into place for both capital maintenance procedures (e.g., facility replacement and non-routine maintenance such as sediment removal, facility component repair or replacement, major replanting, or safety structure construction) and operating maintenance procedures (routine activities such as facility inspection, debris removal, and vegetation management).

The best recommendation is to establish a facility maintenance fund. For homeowner associations, this could be a portion of homeowner fees or a specific assessment. The fund should include:

° Ten percent of the facility's capital cost for annual routine maintenance per year.

° A percentage of the non-routine maintenance costs per year (i.e. for sediment removal, vegetation replacement) based on the frequency of removal. For example, if the facility needs mechanical sediment removal every 10 years, 10 percent of the total cost should be put aside each year.

° An additional 3 to 5% of the facility's capital cost per year for eventual facility replacement, based on the facility's life expectancy. Most of these facilities have a life expectancy of 25 to 50 years.