HOLLEY PARK SUBDIVISION

PRELIMINARY TECHNICAL INFORMATION REPORT

DATE:	March 2019
SUBMITTED TO:	City of La Center 305 NW Pacific Highway La Center, WA 98629
APPLICANT:	Compass Group, LLC Contact: Kevin Tapani 1904 SE 6th Place Battle Ground, WA 98604 PH: 360-687-1148
CONTACT:	Seth Halling, P.E. PH: (360) 882-0419 SethH@aks-eng.com
PREPARED BY:	AKS Engineering & Forestry, LLC
AKS JOB NO.:	6962

Certificate of the Engineer

Holley Park Subdivision
City of La Center, Washington
Preliminary Technical Information Report

This Technical Information Report and the data contained herein were prepared by the undersigned, whose seal, as a Professional Engineer licensed to practice as such, is affixed below. All information required by the City of La Center Municipal Code (LCMC) Chapter 18.320 Stormwater and Erosion Control is included in the Stormwater Plan. This project complies with Best Management Practices as identified by the State Department of Ecology 1992 Stormwater Management Manual for the Puget Sound Basin.

SETH MICHAEL HALLING
48613

3/14/2019

TABLE OF CONTENTS

TABLES

REFERENCES

1992 Stormwater Management Manual for the Puget Sound Basin – “SMMPSB”

SECTION A. – PROJECT OVERVIEW

The 14.54-acre site is zoned R1-7.5 (single family residential) and P/OS (parks/open space), and is located on parcels 62965242, 209055-000, and 209059-000 in Clark County, WA. The project site is located within the Northwest 1/4 of Section 2, Township 4 North, Range 1 East, Willamette Meridian, Clark County, Washington. More specifically it is bound by NE Ivy Avenue to the west and E 2nd street to the east. See the Vicinity Map for the project location (Appendix A).

The site is characterized by site topography sloping from the northeast to the southwest. The project site is grass field with vegetation around the existing residence and associated buildings. There are 3 streams and steep slopes present on site.

The project proposes to construct sidewalks, public streets, stormwater facilities, and 39 residential lots. Proposed land disturbances will consist of grading and excavation of unsuitable soils for the construction of sidewalks, utilities, streets, stormwater facilities, and landscape features. Due to the amount of proposed impervious surfaces (greater than 5,000 square feet) and the amount of disturbed area (greater than 1 acre), the project is required to meet Minimum Requirements 1-11 per the 1992 Stormwater Management Manual for the Puget Sound Basin (SMMPSB) (See Appendix H). The proposed stormwater wet pond is proposed to be privately owned and maintained.

There are no surface waters, adjacent critical areas (within ¼ mile), or adjacent developments that will be negatively affected by the project. Stormwater runoff from neighboring properties appear to not impact the site.

SECTION B. – APPROVAL CONDITIONS SUMMARY

An approval conditions summary will be provided during final engineering.

SECTION C. – DOWNSTREAM ANALYSIS

Per the LCMC 18.320.220(2)(c) a downstream analysis is not required since the predevelopment runoff calculations assume undisturbed forest.

SECTION D. – QUANTITY CONTROL ANALYSIS AND DESIGN

The project proposes to utilize a stormwater wet pond (BMP RD.05 Wet Pond without Marsh) for meeting flow control requirements. Stormwater runoff from the proposed trail in Basin 2S will sheet flow to the north stream with no flow control. The stormwater wet pond on site will over-detain to offset direct discharge of Basin 2S. See Table 1.2 for proposed hard surface and landscaping areas. See the Preliminary Plans and Development (Basin) Plans for stormwater configuration (Appendix B).

Table 1.1: Existing Hard Surface and Landscaping

Basin	Landscape	Road	Roof	Sidewalk	Total Impervious Area	Total Area
1S	8.73	0.18	0.20	0	0.38	9.11
2S	0.13	0.04	0	0	0.04	0.17

Note: Areas are in acres.

Table 1.2: Proposed Hard Surface and Landscaping						
Basin	**Landscape**	**Road**	**Roof/Driveway**	**Sidewalk**	**Total Impervious Area**	**Total Area**
1S	3.48	1.51	3.78	0.34	5.64	9.11
2S	0	0	0	0.17	0.17	0.17

Note: Areas are in acres.

Tables 1.3 and 1.4 shows the pre-development and post-developed curve numbers that were utilized in the HydroCAD analysis (Appendix E). These curve numbers are for Hydrologic soil group C and D per the USDA Soils Report (Appendix C). See Appendix G for SMMPSB curve number table.

Table 1.3: Pre-Development Curve Numbers			
Area	**Curve Number (CN)**	**Land Use**	**Description**
0.23	92	Grass (Landscaping)	Fair condition (50-75% grass cover) Soil Group D
1.15	90	Grass (Landscaping)	Fair condition (50-75% grass cover) Soil Group C
2.07	89	Pasture	Fair condition (50-75% grass cover) Soil Group D
5.41	85	Pasture	Fair condition (50-75% grass cover) Soil Group C
0.22	98	Road/Driveway	Impervious Surface
0.20	98	Roof	Impervious Surface

Note: Areas are in acres.

Table 1.4: Post-Development Curve Numbers			
Area	**Curve Number (CN)**	**Land Use**	**Description**
0.91	90	Grass (Landscaping)	Good condition (≥75% grass cover) Soil Group D
2.57	86	Grass (Landscaping)	Good condition (≥75% grass cover) Soil Group C
1.51	98	Paved Road	Impervious Surface
3.78	98	Roof	Impervious Surface
0.34	98	Sidewalk	Impervious Surface
0.17	98	Trail to the north in Basin 2S	Impervious Surface

Note: Areas are in acres.

Tables 1.5 and 1.6 show the existing and post-developed runoff volume and discharge that were utilized in the HydroCAD analysis (Appendix E).

Table 1.5: Existing Runoff Volumes/Discharge								
Basin	**2-year Peak Runoff (cfs)**	**2-year Peak Volume (af)**	**10-year Peak Runoff (cfs)**	**10-year Peak Volume (af)**	**25-year Peak Runoff (cfs)**	**25-year Peak Volume (af)**	**100-year Peak Runoff (cfs)**	**100-year Peak Volume (af)**
1S	1.93	0.968	3.49	1.633	4.31	1.980	5.48	2.477

Note: Basin 2S is included in the runoff volume calculations.

Table 1.6: Post Developed Runoff Volumes/Discharge								
Basin	**2-year Peak Runoff (cfs)**	**2-year Peak Volume (af)**	**10-year Peak Runoff (cfs)**	**10-year Peak Volume (af)**	**25-year Peak Runoff (cfs)**	**25-year Peak Volume (af)**	**100-year Peak Runoff (cfs)**	**100-year Peak Volume (af)**
1S	4.19	1.403	6.41	2.134	7.54	2.505	9.12	3.029

Note: Basin 2S is included in the runoff volume calculations.

The detention facility proposed for the development is a surface pond that will be above the wet pool volume. The values in Table 1.7 represent final design values after the volume correction factor has been applied. The volume correction factor is 35% which is based on the sites developed impervious cover. See appendix I for volume correction factor chart. The pond is designed to match developed discharged durations with pre-developed durations for the range of pre-developed discharge rates, 50 percent of the 2-year to the full 100-year peak flow. The pond will also be equipped with a primary overflow designed to bypass the 100-year developed flow and an emergency overflow spillway sized to pass the 100-year flow for protection against breaching of the pond embankment due to high inflows or blockage of the primary overflow. The overflow will be located at or near the outflow control facility and will discharge overflow to the natural, pre-developed flow path of the basin.

Table 1.7: Proposed Detention Facility Performance

Storm Event	Allowable Release Rate (cfs)	Peak Outflow (cfs)	Peak Storage (af)	Peak Elevation (ft)
2yr	1.93	0.95	0.448	2.09
10yr	3.49	3.23	0.534	2.44
25yr	4.31	3.97	0.604	2.72
100yr	5.48	4.77	0.703	3.10

All stormwater quantity facilities for the site have been designed in conformance with the 1992 SMMPSB.

SECTION E. – CONVEYANCE SYSTEMS ANALYSIS AND DESIGN

A basic stormwater layout was designed at this time, without detailed hydraulic analysis of all proposed conveyance systems. Due to site topography sloping down at consistent slopes, this being a standard development in size and land coverage and locating the stormwater facility at the lowest point on site, it was determined that a detailed analysis was not needed to determine feasibility of the project. A detailed hydraulic analysis will be provided during final engineering.

SECTION F. – WATER QUALITY DESIGN

Stormwater treatment for new pervious and impervious pollution generating surfaces in Basin 1S will be provided by a stormwater wet pond per BMP RD.05 Wet Pond without Marsh. To determine the water quality volume requirements of the stormwater wet pond, the basin was modeled in HydroCAD v10.0 using the 6-month, 24-hour storm event of 1.60 inches. Stormwater wet pond usage is approved as a treatment facility by the Washington State Department of Ecology. Water quality design will meet all requirements per LCMC 18.320.210. The bottom of the proposed wet pool is below the ground water. See Appendix J for isopluvial maps and Appendix K for wet pond calculations. A low permeability liner is required on the wet pond per the geotechnical report due to the wet pond being at the top of the steep slope.

Stormwater runoff from the proposed trail in Basin 2S is non-polluting generating; therefore, treatment is not needed.

SECTION G. – SOILS EVALUATION

According to the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) web soil survey (USDA NRCS, 2014 website), on-site soils consist of Gee silt loam and Odne silt loam. The Gee silt loam is hydrologic group C, and the Odne loam is hydrologic group D. Hydrologic group C soils are characterized by slow infiltration rates and moderate runoff potential. Hydrologic group D soils have very slow infiltration rates (Appendix C). The Geotechnical Report contains additional information about site conditions (Appendix D).

SECTION H. – SPECIAL REPORTS AND STUDIES

A critical areas assessment by AKS Engineering and Forestry, LLC assesses the oak mitigation. A geotechnical investigation was conducted by GeoDesign, Inc. GeoDesign, Inc.'s geotechnical report characterizes that the soil properties encountered resemble the Gee silt loam and Odne silt loam. The report mentioned that perched groundwater was encountered in all test pits at depths ranging from 10 - 14 feet (Appendix D). Groundwater levels are often subject to seasonal variance and may rise during extended periods of increased precipitation. Perched groundwater may also be present in localized areas. Seeps and springs may become evident during site grading, primarily along slopes or in areas cut below existing grade. Structures, roads, and drainage design should be planned accordingly.

SECTION I. – OTHER PERMITS

No permits outside of this application are applicable.

SECTION J. – GROUNDWATER MONITORING PROGRAM

Per LCMC 18.320.210 requirements groundwater monitoring is not required for this development.

SECTION K. – MAINTENANCE AND OPERATIONS MANUAL

A Maintenance and Operations Manual will be provided during final engineering.

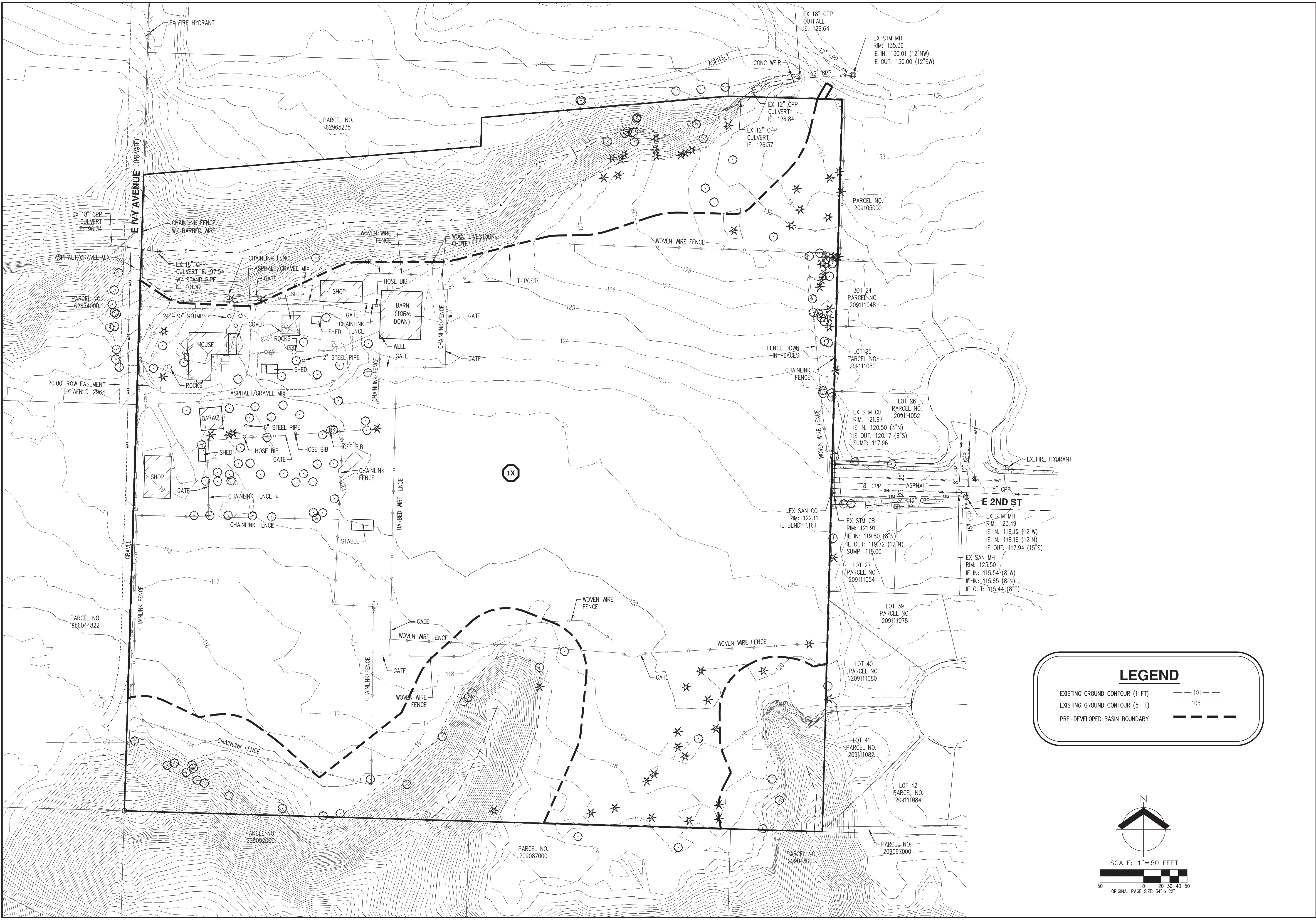
SECTION L. – TECHNICAL APPENDIX

Appendix A - Vicinity Map
Appendix B - Preliminary Plans and Development (Basin) Plans
Appendix C - USDA Soils Report
Appendix D - Geotechnical Report
Appendix E - HydroCAD Analysis
Appendix F - BMP Details
Appendix G - Curve Numbers
Appendix H - New Development Flow Chart
Appendix I - Volume Correction Factor
Appendix J - Isoplouvial Maps
Appendix K - Wet Pond Calculations

APPENDIX A:
MAP SUBMITTALS

VICINITY MAP

APPENDIX B:
PRELIMINARY PLANS AND DEVELOPMENT (BASIN) PLANS



LEGEND

EXISTING GROUND CONTOUR (1 FT)	— 101 —
EXISTING GROUND CONTOUR (5 FT)	— 105 —
PRE-DEVELOPED BASIN BOUNDARY	— — —

AKS DRAWING FILE: 6962 BASIN PLAN.DWG | LAYOUT: EXISTING

AKS ENGINEERING & FORESTRY, LLC
9600 NE 126TH AVE STE 2520
VANCOUVER, WA 98682
P: 360.882.0419
F: 360.882.0426
aks-eng.com

ENGINEERING · SURVEYING · NATURAL RESOURCES
FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

HOLLEY PARK SUBDIVISION

LA CENTER WASHINGTON
PARCEL NO. 209055000, 209059000 AND 62965242
NW 1/4 OF SEC 2 T4N, R1E, W.M.

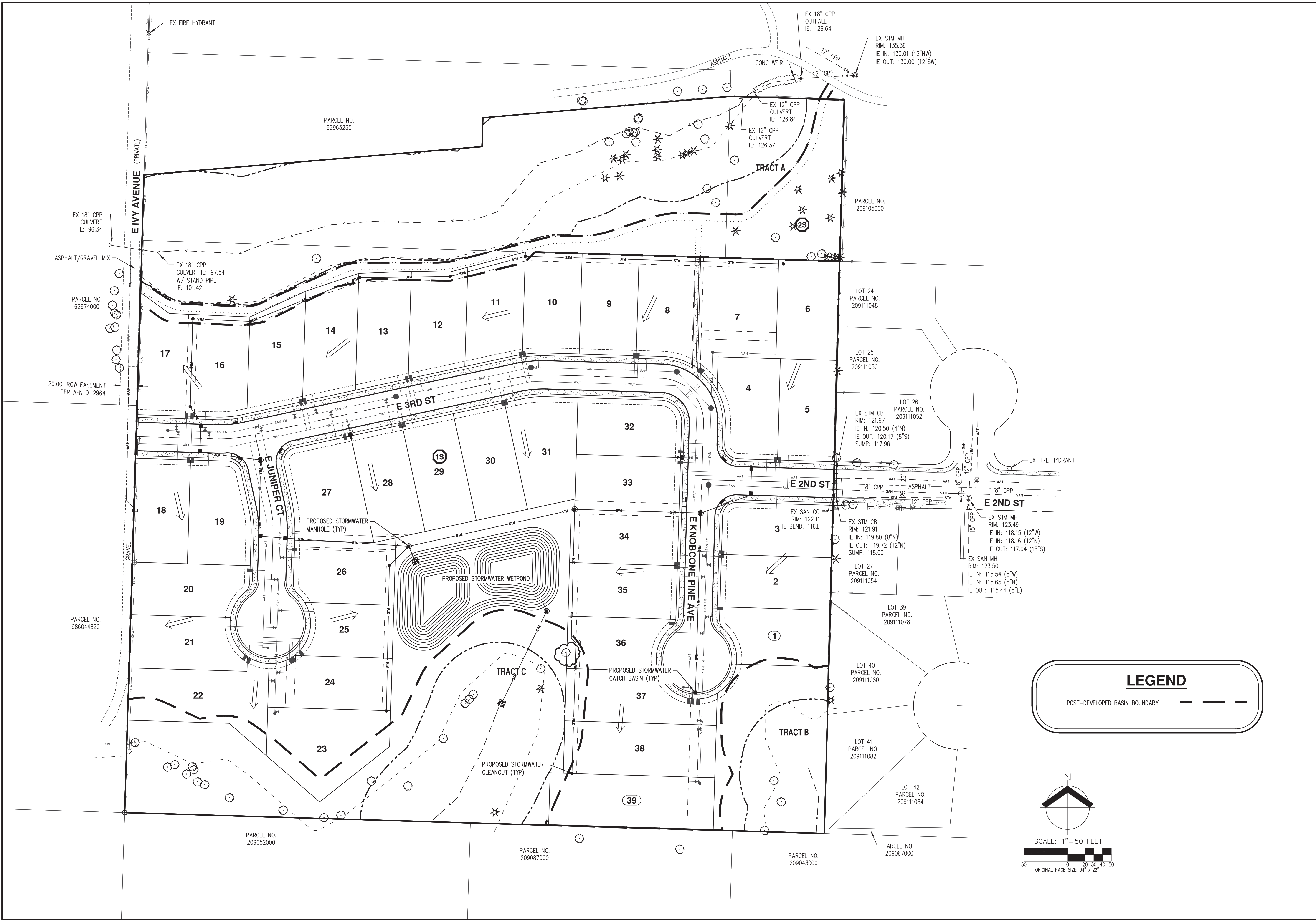
PRE-DEVELOPED BASIN AREAS

DESIGNED BY: JRS
DRAWN BY: MRE
MANAGED BY: SMH
CHECKED BY: JRS
DATE: 3/14/2019

REVISIONS

JOB NUMBER
6962

SHEET
FIG 1



AKS ENGINEERING & FORESTRY, LLC
9600 NE 126TH AVE STE 2520
VANCOUVER, WA 98682
P: 360.882.0419
F: 360.882.0426
aks-eng.com

ENGINEERING · SURVEYING · NATURAL RESOURCES
FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

HOLLEY PARK SUBDIVISION

LA CENTER WASHINGTON
PARCEL NO. 209055000, 209059000 AND 62965242
NW 1/4 OF SEC 2 T4N, R1E, W.M.

POST-DEVELOPED BASIN AREAS

DESIGNED BY: JRS
DRAWN BY: MRE
MANAGED BY: SMH
CHECKED BY: JRS
DATE: 3/14/2019

REVISIONS

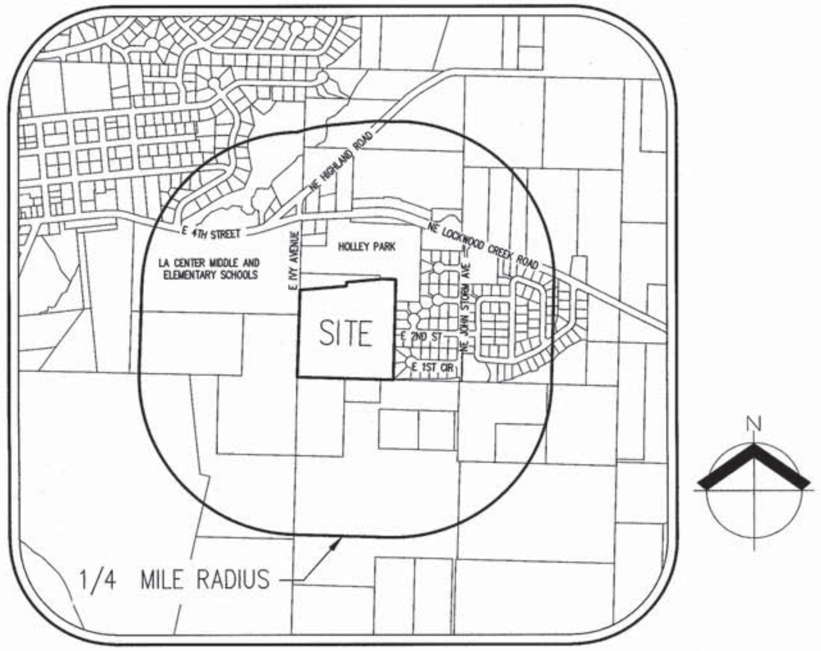
JOB NUMBER
6962

SHEET
FIG 2

AKS DRAWING FILE: 6962 BASIN PLAN.DWG | LAYOUT: PROPOSED

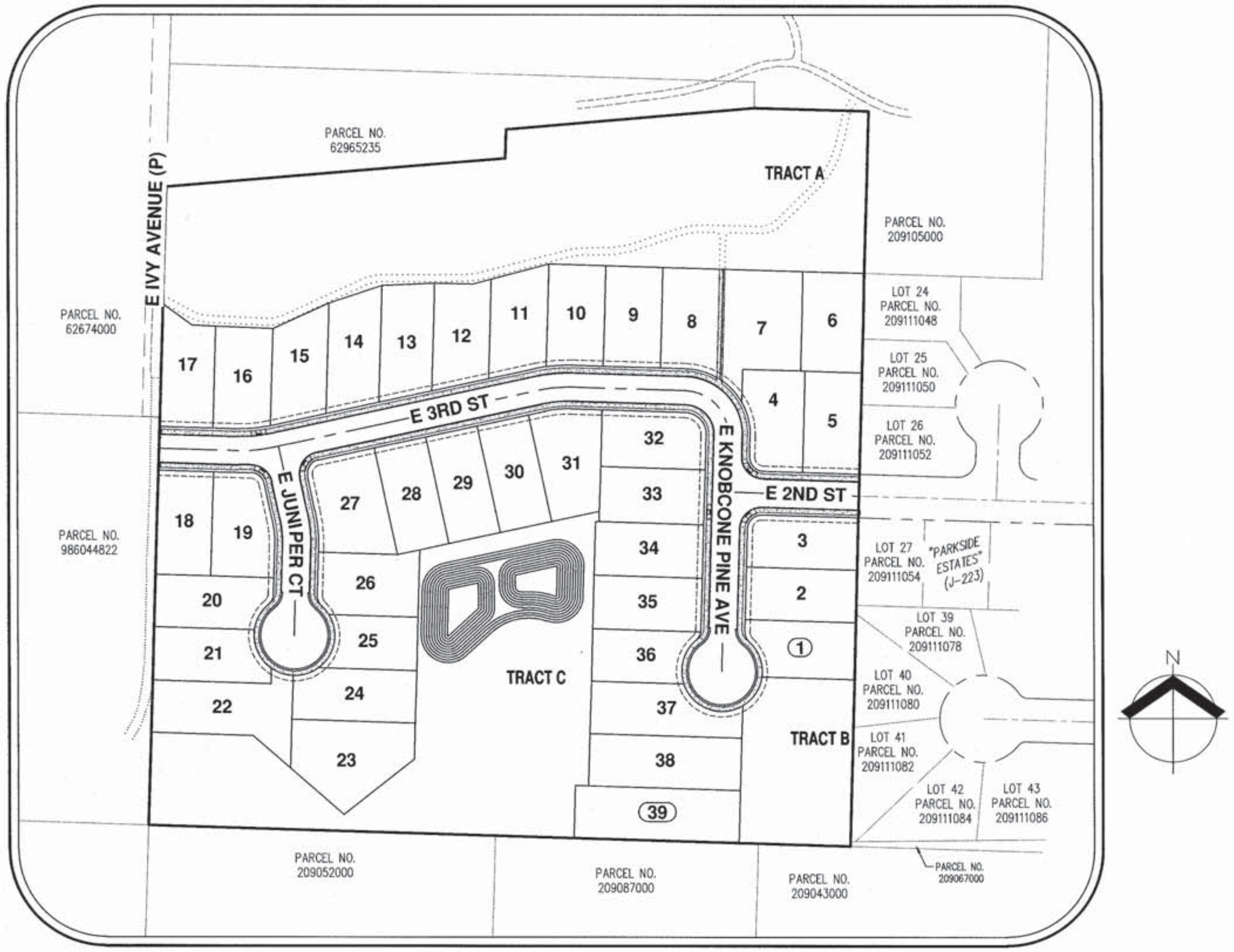
HOLLEY PARK SUBDIVISION

TYPE III SUBDIVISION



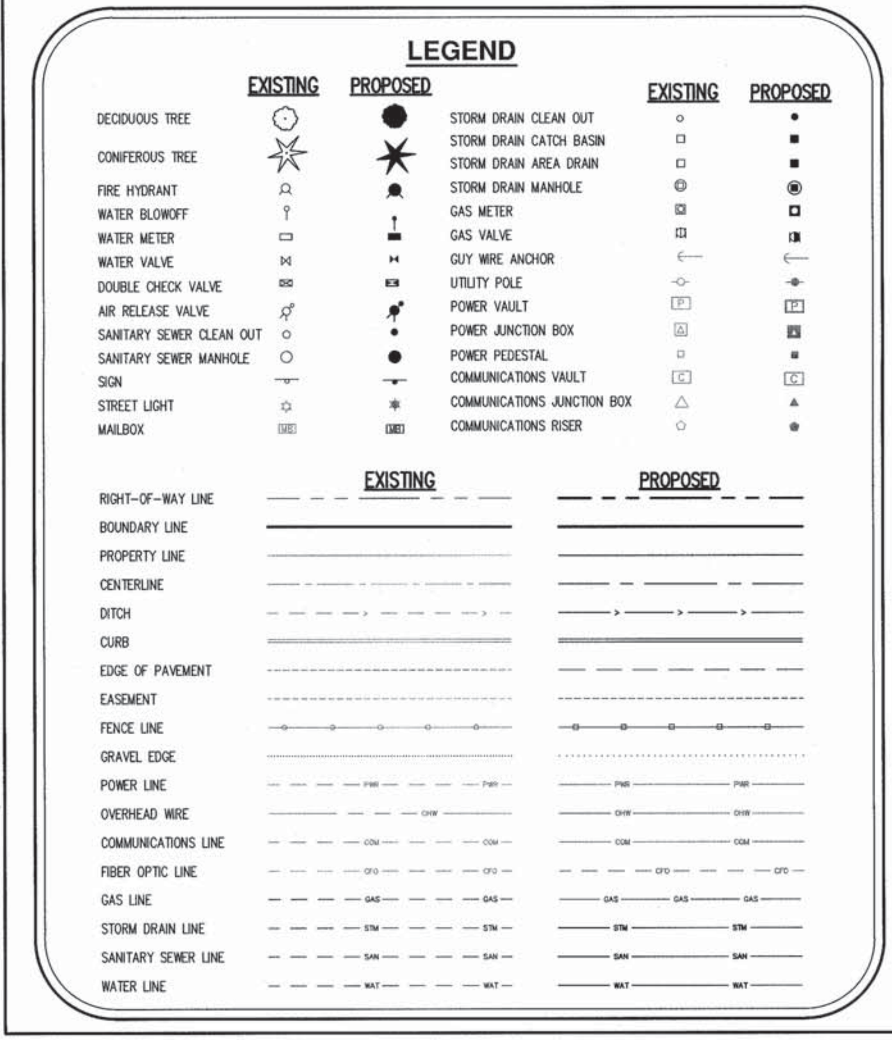
VICINITY MAP

N.T.S.



SITE MAP

N.T.S.



APPLICANT

COMPASS GROUP, LLC.
CONTACT: KEVIN TAPANI
1904 SE 6TH PLACE
BATTLE GROUND, WA 98604
PH: 360-687-1148
E-MAIL: KEVINT@TAPANI.COM

OWNER

MINIHAN ANGELA J & GERALD T III
357 NE IVY AVENUE
LA CENTER, WA 98629

CONTACT

AKS ENGINEERING & FORESTRY, LLC.
CONTACT: SETH HALLING
9600 NE 126TH AVENUE, SUITE 2520
VANCOUVER, WA 98682
PH: 360-882-0419
FAX: 360-882-0426
E-MAIL: SETHH@AKS-ENG.COM

PROPERTY DESCRIPTION

LOCATED IN THE NORTHWEST 1/4 OF SECTION 02, TOWNSHIP 4 NORTH, RANGE 1 EAST, WILLAMETTE MERIDIAN, CLARK COUNTY, WA. PARCEL SERIAL # 209055000, 209059000, AND 62965242.

EXISTING LAND USE

SINGLE FAMILY RESIDENCE WITH AGRICULTURE

PROJECT PURPOSE

39 SINGLE-FAMILY RESIDENTIAL LOTS AND ASSOCIATED ROAD IMPROVEMENTS.

SITE AREA

14.54 AC (633,340 SF)

SHEET INDEX

P1.0 COVER SHEET
P2.0 EXISTING CONDITIONS PLAN
P3.0 PRELIMINARY PLAT AND PROPOSED IMPROVEMENTS PLAN
P4.0 PRELIMINARY SANITARY SEWER AND WATER PLAN
P5.0 PRELIMINARY GRADING AND STORMWATER PLAN
P6.0 PRELIMINARY LANDSCAPE PLAN
P7.0 PRELIMINARY LIGHTING PLAN

AKS DRAWING FILE: 6962 P1.0 COVER.DWG | LAYOUT: P1.0

AKS
AKS ENGINEERING & FORESTRY, LLC
9600 NE 126TH AVE STE 2520
VANCOUVER, WA 98682
P: 360.882.0419
F: 360.882.0426
aks-eng.com
ENGINEERING · SURVEYING · NATURAL RESOURCES
FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

HOLLEY PARK
SUBDIVISION
LA CENTER WASHINGTON
PARCEL NO. 209055000, 209059000 AND 62965242 NW 1/4 OF SEC 2 T4N, R1E, W.M.

COVER SHEET

DESIGNED BY:	JRS
DRAWN BY:	MRE
MANAGED BY:	SMH
CHECKED BY:	JRS

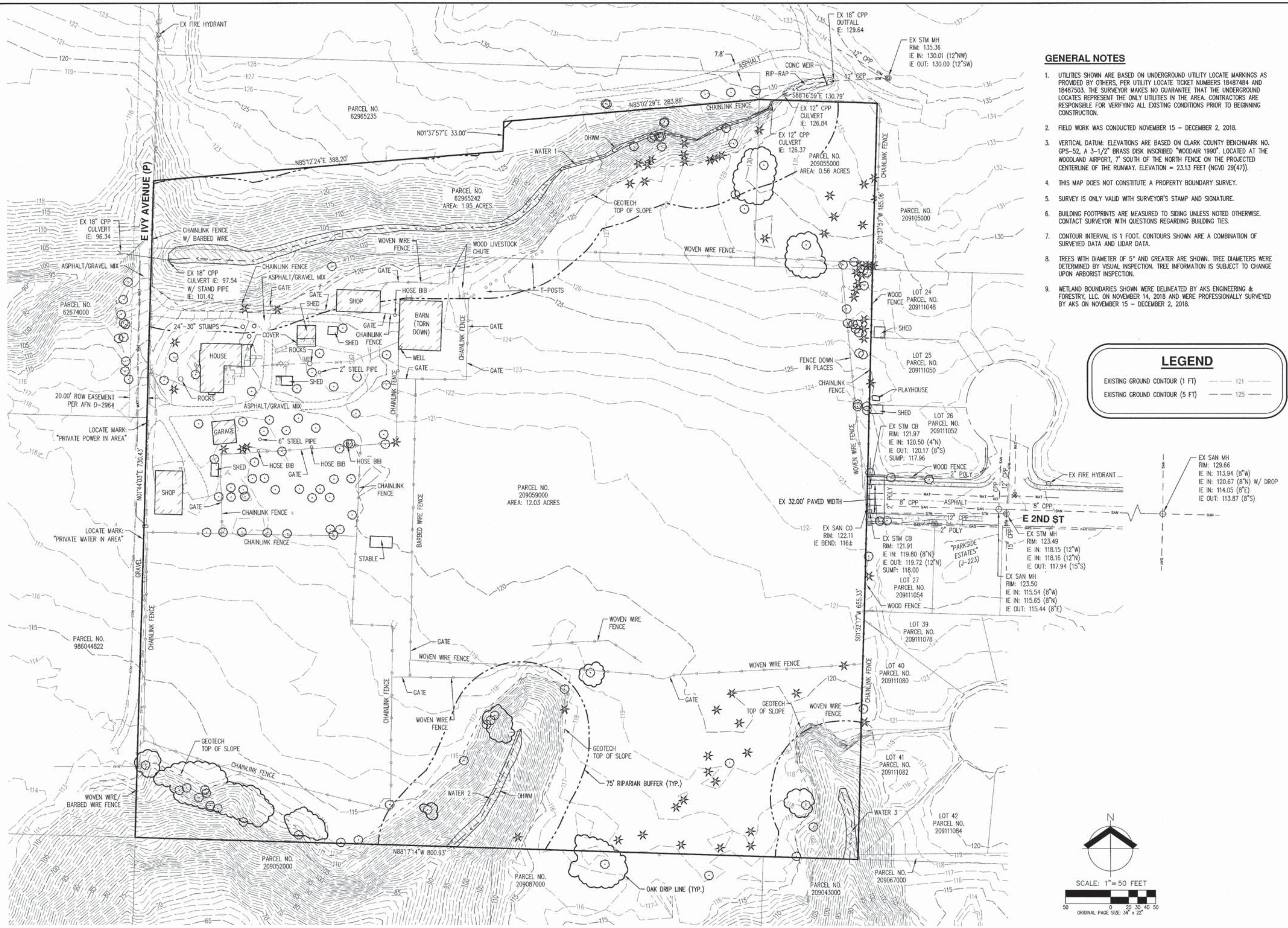
DATE: 3/14/2019

SETH MICHAEL HALLING
PRELIMINARY NOT FOR CONSTRUCTION

REVISIONS

JOB NUMBER
6962

SHEET
P1.0



GENERAL NOTES

1. UTILITIES SHOWN ARE BASED ON UNDERGROUND UTILITY LOCATE MARKINGS AS PROVIDED BY OTHERS, PER UTILITY LOCATE TICKET NUMBERS 18487484 AND 18487503. THE SURVEYOR MAKES NO GUARANTEE THAT THE UNDERGROUND LOCATES REPRESENT THE ONLY UTILITIES IN THE AREA. CONTRACTORS ARE RESPONSIBLE FOR VERIFYING ALL EXISTING CONDITIONS PRIOR TO BEGINNING CONSTRUCTION.
2. FIELD WORK WAS CONDUCTED NOVEMBER 15 – DECEMBER 2, 2018.
3. VERTICAL DATUM: ELEVATIONS ARE BASED ON CLARK COUNTY BENCHMARK NO. GPS-52, A 3-1/2" BRASS DISK INSCRIBED "WOODAIR 1990". LOCATED AT THE WOODLAND AIRPORT, 7' SOUTH OF THE NORTH FENCE ON THE PROJECTED CENTERLINE OF THE RUNWAY. ELEVATION = 23.13 FEET (NGVD 29(47)).
4. THIS MAP DOES NOT CONSTITUTE A PROPERTY BOUNDARY SURVEY.
5. SURVEY IS ONLY VALID WITH SURVEYOR'S STAMP AND SIGNATURE.
6. BUILDING FOOTPRINTS ARE MEASURED TO SIDING UNLESS NOTED OTHERWISE. CONTACT SURVEYOR WITH QUESTIONS REGARDING BUILDING TIES.
7. CONTOUR INTERVAL IS 1 FOOT. CONTOURS SHOWN ARE A COMBINATION OF SURVEYED DATA AND LIDAR DATA.
8. TREES WITH DIAMETER OF 5" AND GREATER ARE SHOWN. TREE DIAMETERS WERE DETERMINED BY VISUAL INSPECTION. TREE INFORMATION IS SUBJECT TO CHANGE UPON ARBORIST INSPECTION.
9. WETLAND BOUNDARIES SHOWN WERE DELINEATED BY AKS ENGINEERING & FORESTRY, LLC. ON NOVEMBER 14, 2018 AND WERE PROFESSIONALLY SURVEYED BY AKS ON NOVEMBER 15 – DECEMBER 2, 2018.

LEGEND

EXISTING GROUND CONTOUR (1 FT)	— 121 —
EXISTING GROUND CONTOUR (5 FT)	— 125 —

AKS ENGINEERING & FORESTRY, LLC
9600 NE 126TH AVE STE 2520
VANCOUVER, WA 98682
P: 360.882.0419
F: 360.882.0426
aks-eng.com

AKS

ENGINEERING · SURVEYING · NATURAL RESOURCES
FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

HOLLEY PARK SUBDIVISION

LA CENTER WASHINGTON

PARCEL NO. 209055000, 209059000 AND 62965242 NW 1/4 OF SEC 2 T4N, R1E, W.M.

EXISTING CONDITIONS PLAN

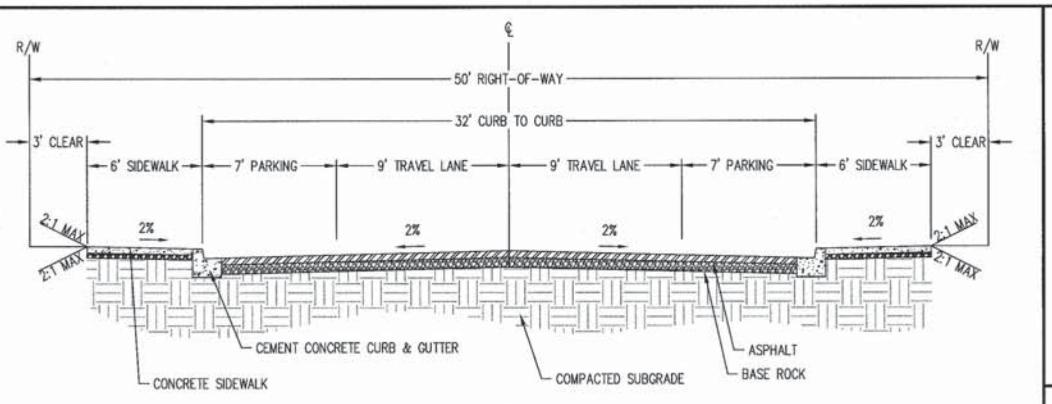
DESIGNED BY:
DRAWN BY: BRE
MANAGED BY: SMH
CHECKED BY: JOH
DATE: 3/14/2019

PRELIMINARY NOT FOR CONSTRUCTION

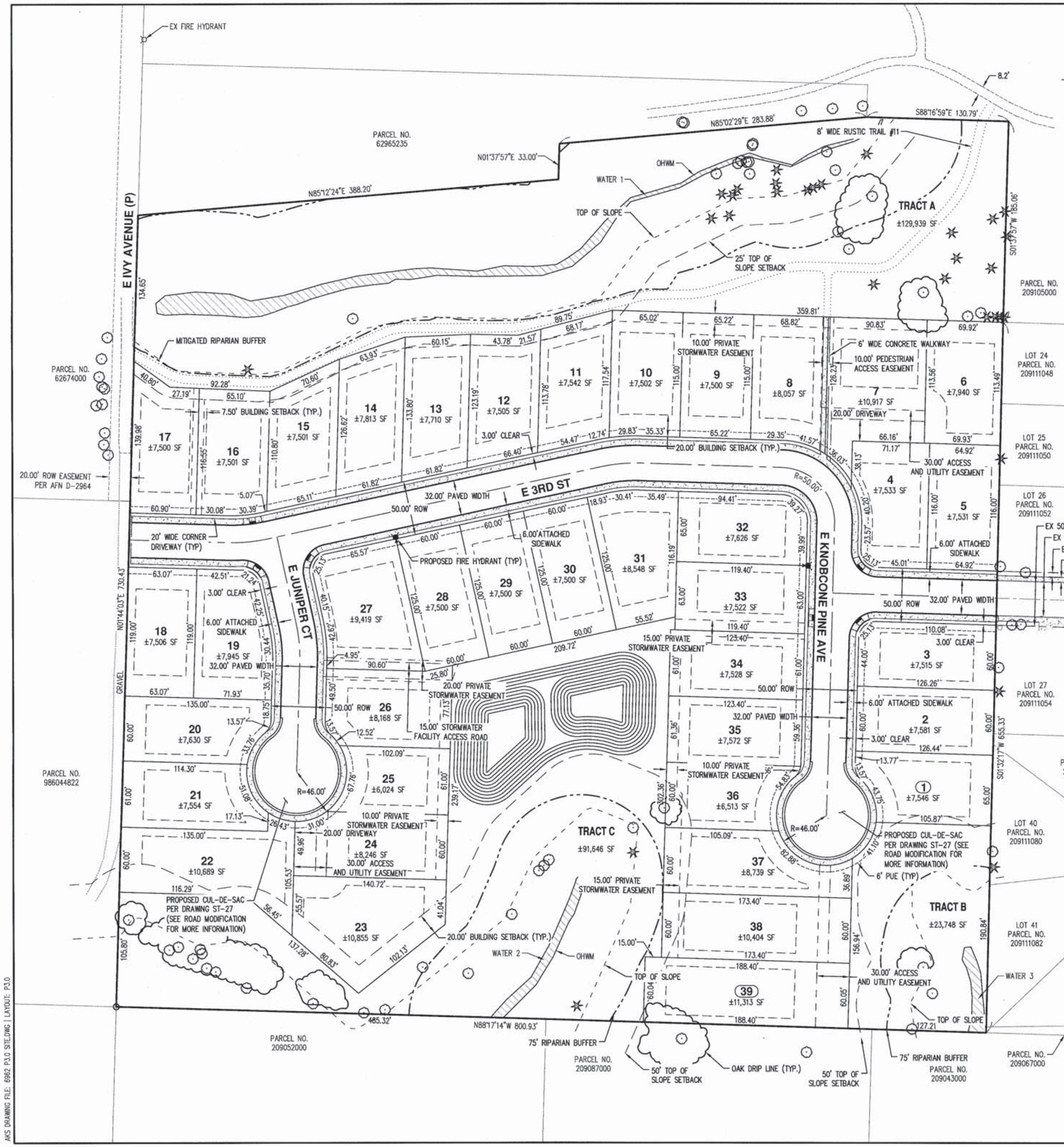
REVISIONS

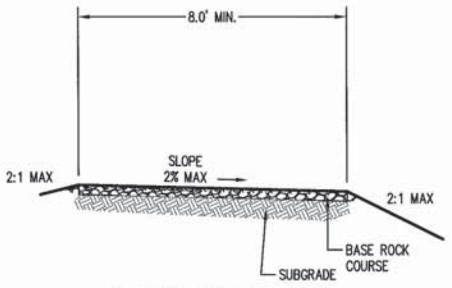
JOB NUMBER
6962

SHEET
P2.0



LOCAL ACCESS
E 2ND STREET, E 3RD STREET, E JUNIPER CT, AND E KNOBCONE PINE AVE
NTS





RUSTIC TRAIL SECTION
NTS

SITE STATISTICS

GROSS AREA:	633,340 SF (14.54 AC)
ROW AREA:	73,010 SF (1.67 AC)
TRACT AREA:	245,333 SF (5.63 AC)
MIN LOT DEPTH:	90FT
MIN LOT WIDTH:	60FT
NUMBER OF PROP LOTS:	39
MIN LOT AREA:	7,500 SF**
MAX LOT AREA:	11,000 SF***
PROP MIN LOT AREA:	6,024 SF
PROP MAX LOT AREA:	11,313 SF

** 10% OF LOTS MAY BE REDUCED TO A MINIMUM LOT AREA OF 6,000 SQUARE FEET.
*** PER LCMC, THE MAXIMUM LOT AREA OF A LOT ABUTTING THE URBAN GROWTH AREA BOUNDARY MAY EXCEED 11,000 SQUARE FEET.

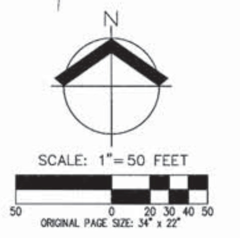
DENSITY STATISTICS

GROSS RESIDENTIAL AREA:	524,206 SF (12.03 AC)
ROW AREA:	73,010 SF (1.67 AC)
CRITICAL AREAS:	79,670 SF (1.83 AC)*
NET SITE AREA:	371,526 SF (8.53 AC)
MIN DENSITY (8.53 X 4):	35
NUMBER OF PROP LOTS:	39

* CRITICAL AREAS INCLUDE STREAM BUFFERS AND STEEP SLOPES.

GENERAL NOTES

1. THE PURPOSE OF THIS PRELIMINARY PLAT IS TO SHOW THE PROPOSED LOT DIMENSIONS FOR PLANNING PURPOSES ONLY. THIS IS NOT AN OFFICIAL PLAT AND IS NOT TO BE USED FOR SURVEY PURPOSES.
2. PROJECT INCLUDES DEVELOPMENT OF 39 SINGLE-FAMILY RESIDENTIAL LOTS.
3. ALL PROPOSED ROADWAYS TO BE PAVED WITH ASPHALT.
4. STORMWATER QUALITY AND QUANTITY REQUIREMENTS WILL BE MET THROUGH THE USE OF A STORMWATER WETPOND FACILITY.
5. PROPOSED DEVELOPMENT TO BE SERVED BY PUBLIC WATER PROVIDED BY CLARK PUBLIC UTILITIES AND SANITARY SEWER PROVIDED BY CITY OF LA CENTER.
8. TWO NEW FIRE HYDRANTS ARE PROPOSED WITH LOCATIONS AS SHOWN.
9. PROPOSED LIGHTING AND LANDSCAPING ARE NOT SHOWN FOR CLARITY. SEE SHEET P6.0 FOR PRELIMINARY LANDSCAPE PLAN AND SHEET P7.0 FOR PRELIMINARY LIGHTING PLAN. FINAL LANDSCAPING AND LIGHTING WILL MEET CITY OF LA CENTER CODE REQUIREMENTS.
10. TRACT A AND B ARE CRITICAL AREAS TRACTS. TRACT C IS A CRITICAL AREAS AND STORMWATER FACILITY TRACT.
11. TRACTS B AND C TO BE PRIVATELY OWNED AND MAINTAINED.
12. TRACT A TO BE TRANSFERRED TO THE CITY OF LA CENTER IN EXCHANGE FOR PARK IMPACT FEE CREDITS.
13. SITE WILL CONTAIN ACCESS, INSPECTION, AND MAINTENANCE EASEMENTS TO THE CITY OF LA CENTER FOR ALL STORMWATER FACILITIES.
14. EROSION CONTROL WILL BE ADDRESSED WITHIN THE FINAL ENGINEERING PLANS AND THE PROJECT SPECIFIC STORMWATER POLLUTION PREVENTION PLAN.
15. ALL FUTURE STRUCTURES WITHIN THIS DEVELOPMENT WILL BE RESIDENTIAL. DESIGN FOR STRUCTURES WILL BE PRESENTED AT TIME OF BUILDING PERMIT APPLICATION. STRUCTURE HEIGHT AND APPEARANCE WILL BE PER CITY OF LA CENTER STANDARDS.



AKS ENGINEERING & FORESTRY, LLC
9600 NE 126TH AVE STE 2520
VANCOUVER, WA 98682
P: 360.882.0419
F: 360.882.0426
aks-eng.com

ENGINEERING · SURVEYING · NATURAL RESOURCES
FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

HOLLEY PARK SUBDIVISION

LA CENTER WASHINGTON
PARCEL NO. 209055000, 209059000 AND 62965242
NW 1/4 OF SEC 2 T4N, R1E, W.M.

PRELIMINARY PLAT AND PROPOSED IMPROVEMENTS PLAN

DESIGNED BY:	JRS
DRAWN BY:	MRE
MANAGED BY:	SMH
CHECKED BY:	JRS

DATE: 3/14/2019

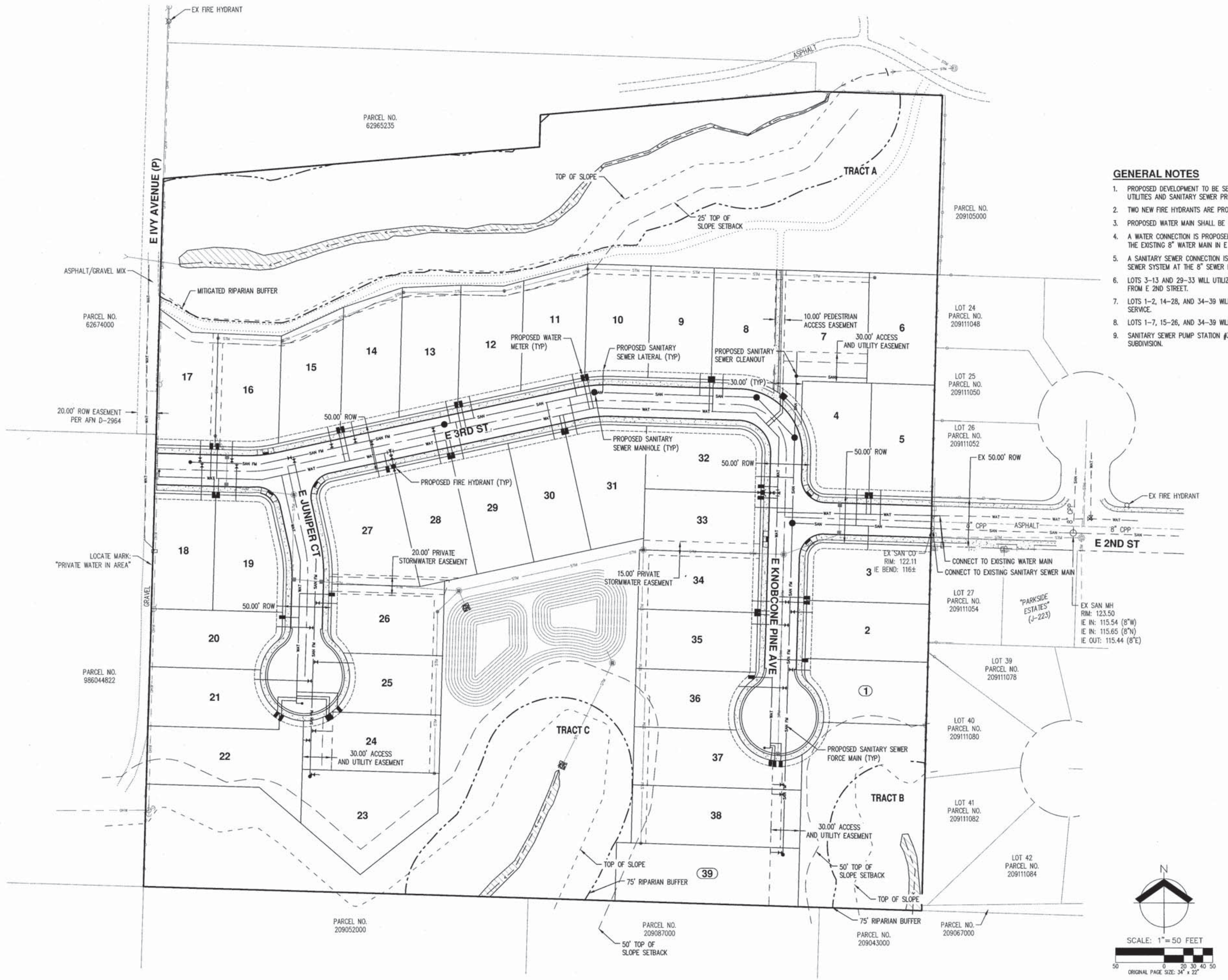
SETH MICHAEL HALL
PRELIMINARY NOT FOR CONSTRUCTION

REVISIONS

JOB NUMBER
6962

SHEET
P3.0

AKS DRAWING FILE: 6962 P3.0 SITE.DWG | LAYOUT: P3.0



GENERAL NOTES

1. PROPOSED DEVELOPMENT TO BE SERVED WITH PUBLIC WATER PROVIDED BY CLARK PUBLIC UTILITIES AND SANITARY SEWER PROVIDED BY THE CITY OF LA CENTER.
2. TWO NEW FIRE HYDRANTS ARE PROPOSED AS SHOWN.
3. PROPOSED WATER MAIN SHALL BE 8" DIAMETER.
4. A WATER CONNECTION IS PROPOSED TO THE CLARK PUBLIC UTILITIES WATER SYSTEM AT THE EXISTING 8" WATER MAIN IN E 2ND STREET.
5. A SANITARY SEWER CONNECTION IS PROPOSED TO THE CITY OF LA CENTER SANITARY SEWER SYSTEM AT THE 8" SEWER MAIN IN E 2ND STREET.
6. LOTS 3-13 AND 29-33 WILL UTILIZE AN EXTENSION OF THE GRAVITY SANITARY SEWER FROM E 2ND STREET.
7. LOTS 1-2, 14-28, AND 34-39 WILL UTILIZE INDIVIDUAL GRINDERS FOR SANITARY SEWER SERVICE.
8. LOTS 1-7, 15-26, AND 34-39 WILL INSTALL FIRE SPRINKLERS WITH HOME CONSTRUCTION.
9. SANITARY SEWER PUMP STATION #3 WILL BE UPGRADED TO ACCOMMODATE THIS SUBDIVISION.

AKS ENGINEERING & FORESTRY, LLC
9600 NE 126TH AVE STE 2520
VANCOUVER, WA 98682
P: 360.882.0419
F: 360.882.0426
aks-eng.com

ENGINEERING · SURVEYING · NATURAL RESOURCES
FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

HOLLEY PARK SUBDIVISION

LA CENTER WASHINGTON
PARCEL NO. 209055000, 209059000 AND 62965242
NW 1/4 OF SEC 2 T4N, R1E, W.M.

PRELIMINARY SANITARY SEWER AND WATER PLAN

DESIGNED BY: JRS
DRAWN BY: MRE
MANAGED BY: SMH
CHECKED BY: JRS
DATE: 3/14/2019

PRELIMINARY
NOT FOR CONSTRUCTION
SETH MICHAEL HALL

REVISIONS

JOB NUMBER
6962

SHEET
P4.0

AKS DRAWING FILE: 6962 P4.0 STR SAN WAT.DWG | LAYOUT: P4.0

GENERAL NOTES

1. STORMWATER QUALITY AND QUANTITY REQUIREMENTS WILL BE MET THROUGH THE USE OF A STORMWATER WETPOND FACILITY.
2. ROOFS, REAR YARDS, STREETS, PLANTER STRIPS, AND FRONT YARDS TO DRAIN TO THE PROPOSED STORMWATER WETPOND FACILITY.
3. EROSION CONTROL WILL BE ADDRESSED IN THE FINAL ENGINEERING PLANS AND THE PROJECT SPECIFIC STORMWATER POLLUTION PREVENTION PLAN.

LEGEND

EXISTING GROUND CONTOUR (1 FT)	— — 351 — —
EXISTING GROUND CONTOUR (5 FT)	— — 350 — —
FINISHED GRADE CONTOUR (1 FT)	——346——
FINISHED GRADE CONTOUR (5 FT)	——345——
FINISHED GRADE FLOW ARROW	⇐

AKS ENGINEERING & FORESTRY, LLC
9600 NE 126TH AVE STE 2520
VANCOUVER, WA 98682
P: 360.882.0419
F: 360.882.0426
aks-eng.com

ENGINEERING · SURVEYING · NATURAL RESOURCES
FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

HOLLEY PARK SUBDIVISION

LA CENTER WASHINGTON
PARCEL NO. 209055000, 209059000 AND 62965242
NW 1/4 OF SEC 2 T4N, R1E, W.M.

PRELIMINARY GRADING AND STORMWATER PLAN

DESIGNED BY: JRS
DRAWN BY: MRE
MANAGED BY: SMH
CHECKED BY: JRS
DATE: 3/14/2019

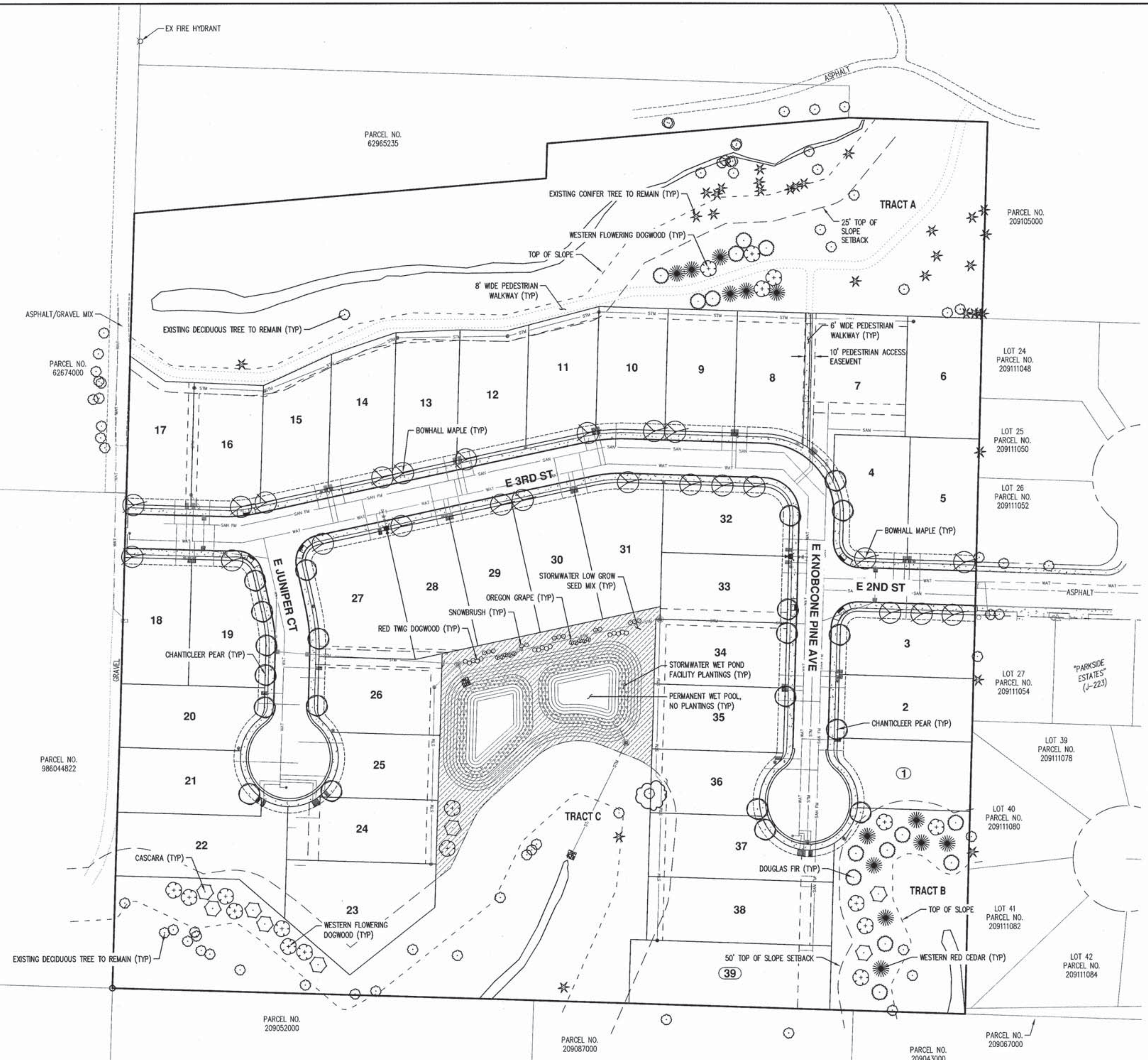
SETH MICHAEL HALL
PRELIMINARY NOT FOR CONSTRUCTION

REVISIONS

JOB NUMBER
6962

SHEET
P5.0

AKS DRAWING FILE: 6962 P5.0 STM.DWG | LAYOUT: P5.0



PRELIMINARY PLANT SCHEDULE

SITE TREES	QTY	BOTANICAL NAME	COMMON NAME	SIZE/CONTAINER	SPACING
⊕	18	CORNUS NUTTALLII	WESTERN FLOWERING DOGWOOD	2" CAL. B&B	AS SHOWN
⊙	14	PSEUDOTSUGA MENZIESII	DOUGLAS FIR	6' HT. B&B	AS SHOWN
⬡	8	RHAMNUS PURSHIANA	CASCARA	2" CAL. B&B	AS SHOWN
✸	13	THUJA PLICATA	WESTERN RED CEDAR	6' HT. B&B	AS SHOWN
STREET TREES	**QTY**	**BOTANICAL NAME**	**COMMON NAME**	**SIZE/CONTAINER**	**SPACING**
⊗	24	ACER RUBRUM 'BOWHALL'	BOWHALL MAPLE	2" CAL. B&B	AS SHOWN
⊙	21	PYRUS CALLERYANA 'CHANTICLEER'	CHANTICLEER PEAR	2" CAL. B&B	AS SHOWN
SHRUBS	**QTY**	**BOTANICAL NAME**	**COMMON NAME**	**SIZE/CONTAINER**	**SPACING**
⊙	13	CEANOTHUS VELUTINUS	SNOWBRUSH	2 GAL CONT.	48" o.c.
○	15	CORNUS SERICEA	RED TWIG DOGWOOD	2 GAL CONT.	48" o.c.
⊕	10	MAHONIA AQUIFOLIUM	OREGON GRAPE	2 GAL CONT.	48" o.c.

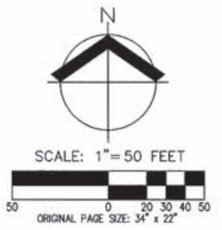
STORMWATER	QTY	DESCRIPTION
▨	APPROX. 17,349 SF	STORMWATER LOW GROW SEED MIX (OR APPROVED EQUAL) - 40% DWARF TALL FESCUE - 30% DWARF PERENNIAL RYE "BARCLAY" - 25% RED FESCUE - 5% COLONIAL BENTGRASS APPLY AT A RATE OF 2 LBS. PER 1,000 SF OR AS RECOMMENDED BY SUPPLIER
▦	APPROX. 4,352 SF	STORMWATER WETPOND FACILITY PLANTINGS (OR APPROVED EQUAL): A MIX OF THE FOLLOWING SHALL BE PLANTED ON THE SIDE SLOPE BELOW THE PERMANENT WATER LEVEL OF THE STORMWATER WETLAND FACILITY:
	251	- CAREX OBNUPTA (SLOUGH SEDGE) INUNDATION 1 TO 3 FEET
	251	- SCIRPUS ACUTUS (HARDSTEM BULRUSH) INUNDATION 1 TO 3 FEET
	251	- JUNCUS EFFUSUS (SOFT RUSH) INUNDATION 1 TO 2 FEET
	251	- SCIRPUS MICROCARPUS (SMALL-FRUITED BULRUSH) INUNDATION 1 TO 2 FEET
	251	- ELEOCHARIS PALUSTRIS (SPIKE RUSH) INUNDATION 1 TO 2 FEET
		ALL PLANTINGS SHALL BE 6" PLUGS, 24" O.C., IN MASS GROUPINGS OF LIKE KIND FOR A NATURAL APPEARANCE. GROUPINGS SHALL HAVE A MINIMUM OF 15 PLANTS PER GROUPING. HATCHED AREAS ARE DIAGRAMMATIC; PLANT FOR FULL COVERAGE OF AREAS SHOWN.

GENERAL LANDSCAPE NOTES

1. LANDSCAPE PLAN IS PRELIMINARY AND INTENDED TO SHOW DESIGN INTENT ONLY. REVISIONS OR SUBSTITUTIONS TO PLANTINGS, INCLUDING CHANGES TO LOCATION, QUANTITIES, SPECIES, SIZES, SPACING, ETC. DUE TO UNFORESEEN SITE CONDITIONS, PLANT AVAILABILITY, ETC. MAY BE MADE WHERE ALLOWED BY CITY OF LA CENTER LANDSCAPE DESIGN STANDARDS, PRIOR TO FINAL APPROVAL.
2. ALL PLANTS AND PLANTINGS SHALL CONFORM TO THE CITY OF LA CENTER DESIGN STANDARDS AND TO AMERICAN NURSERY STANDARDS ANSI Z60.1. PLANT IN ACCORDANCE WITH ACCEPTED BEST PRACTICE INDUSTRY STANDARDS SUCH AS THOSE ADOPTED BY THE WASHINGTON ASSOCIATION OF LANDSCAPE PROFESSIONALS (WALP).
3. KEEP TREE TRUNKS 3' O.C. MINIMUM FROM CURBS, SIDEWALKS, AND OTHER PAVING OR CENTERED IN PLANTER STRIP AS APPLICABLE. ADJUST PLANTINGS AS NECESSARY ON SITE TO AVOID CONFLICT WITH UTILITIES, HYDRANTS, LIGHT POLES, METERS, DRIVEWAYS, ETC.
4. HATCHED AREAS ARE MEANT TO CONVEY GENERAL PLANT LOCATION. PLANT COVERAGE, SPACING, AND LAYOUT SHALL BE CONSISTENT WITH THE SPACING LISTED IN THE PLANT LEGEND FOR FULL COVERAGE.
5. MULCH: APPLY 3" DEEP WELL-AGED MEDIUM GRIND OR SHREDDED DARK HEMLOCK BARK MULCH UNDER AND AROUND ALL TREES IN PLANTER STRIP AREAS. TREES IN OPEN SPACE TRACTS SHALL HAVE A MINIMUM 3" X 3' DIAMETER MULCH RING CENTERED ON TREE FOR MOISTURE RETENTION.
6. TREES SHALL BE WATERED AS NECESSARY, EITHER BY MEANS OF AN IRRIGATION SYSTEM OR BY HAND WATERING, TO ENSURE ESTABLISHMENT SURVIVAL AND GROWTH DURING THE FIRST TWO GROWING SEASONS AFTER PLANTING. IRRIGATION, IF USED, SHALL BE DESIGN-BUILD BY THE LANDSCAPE CONTRACTOR.
7. TREE PROTECTION PLAN WILL BE SUBMITTED WITH FINAL ENGINEERING PLANS.

TREE DATA

TOTAL TREES REMOVED: 98
TOTAL TREES PROPOSED TO BE PLANTED: 98



SCALE: 1"=50 FEET
ORIGINAL PAGE SIZE: 34" x 22"

AKS ENGINEERING & FORESTRY, LLC
9600 NE 126TH AVE STE 2520
VANCOUVER, WA 98682
P: 360.882.0419
F: 360.882.0426
aks-eng.com

AKS

ENGINEERING · SURVEYING · NATURAL RESOURCES
FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

HOLLEY PARK SUBDIVISION

LA CENTER WASHINGTON
PARCEL NO. 209055000, 209059000 AND 62965242
NW 1/4 OF SEC 2 T4N, R1E, W.M.

PRELIMINARY LANDSCAPE PLAN

DESIGNED BY:	TEB
DRAWN BY:	TEB
MANAGED BY:	SMH
CHECKED BY:	KAH

DATE: 3/13/2019

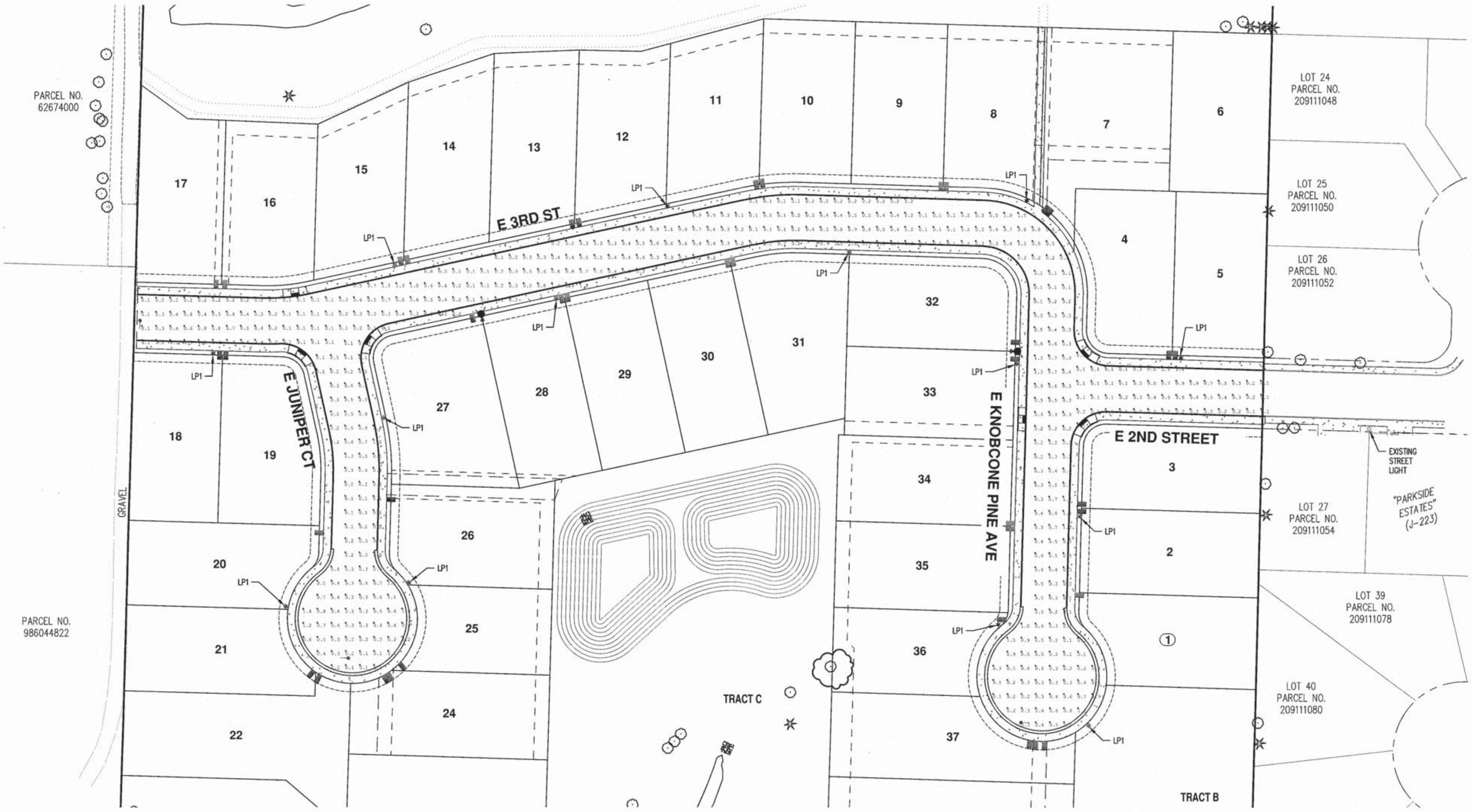
PRELIMINARY NOT FOR CONSTRUCTION

REVISIONS

JOB NUMBER
6962

SHEET
P6.0

AKS DRAWING FILE: 6962 P6.0 LANDSCAPE.DWG | LAYOUT: P6.0



LUMINAIRE AND LIGHT POLE SCHEDULE

SYMBOL	QUANTITY	LABEL	STYLE	LUMINAIRE			
				LAMP	LUMENS	DESCRIPTION	PART NUMBER
✱	14	LP1	PROPOSED	45W LED	4500	HOLOPHANE LUMINAIRE, 14.5' M.H	LUMINAIRE: WFCL2-P20-30K-AS-BK-L3-S PCLL-P7-NL1X1-HSS POLE: BLACK DECORATIVE FIBERGLASS POLE 14.5' DIRECT BURY

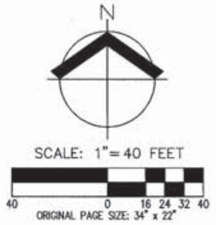
NOTE:
* M.H. IS ABOVE ROAD GRADE

LIGHT LEVEL SUMMARY – CITY OF LA CENTER

ROADWAY	ROADWAY FUNCTIONAL CLASSIFICATION	ILLUMINANCE (fc)	UNIFORMITY RATIO
E 3RD ST	LOCAL	0.39 fc	3.9
E JUNIPER CT	LOCAL	0.39 fc	3.9
E KNOBCONE PINE AVE	LOCAL	0.43 fc	4.3
E 2ND ST	LOCAL	0.31 fc	3.1

NOTES:

1. LIGHTING ANALYSIS WAS PERFORMED WITH AGI32 SOFTWARE.



AKS DRAWING FILE: 6962 P7.0 LIGHTING.DWG | LAYOUT: P7.0

AKS ENGINEERING & FORESTRY, LLC
9600 NE 126TH AVE STE 2520
VANCOUVER, WA 98682
P: 360.882.0419
F: 360.882.0426
aks-eng.com

ENGINEERING · SURVEYING · NATURAL RESOURCES
FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

HOLLEY PARK SUBDIVISION

LA CENTER WASHINGTON
PARCEL NO. 209055000, 209059000 AND 62965242 NW 1/4 OF SEC 2 T4N, R1E, W.M.

PRELIMINARY LIGHTING PLAN

DESIGNED BY: TEB
DRAWN BY: TEB
MANAGED BY: SMH
CHECKED BY: SMH
DATE: 3/13/2019

PRELIMINARY NOT FOR CONSTRUCTION

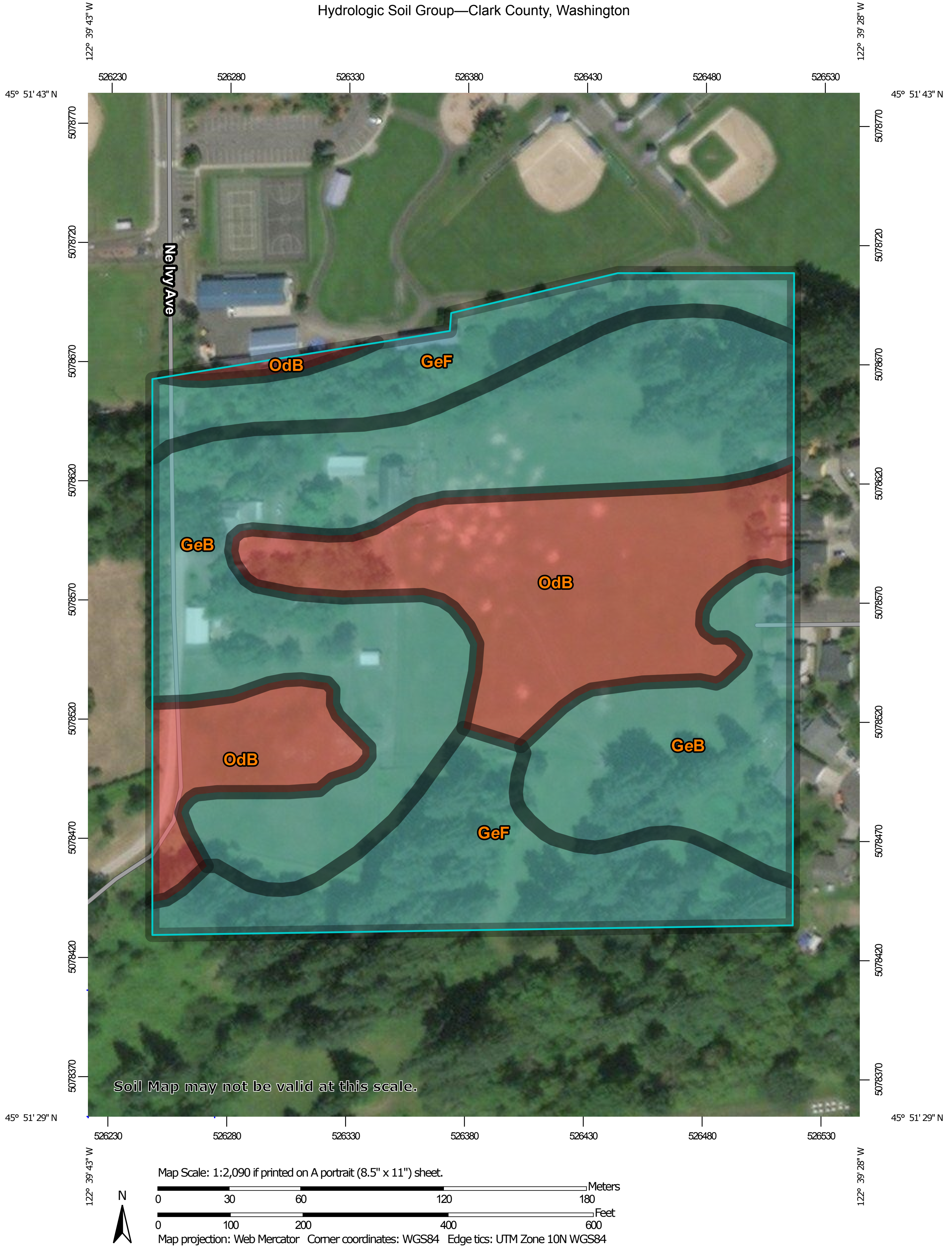
REVISIONS

JOB NUMBER
6962

SHEET
P7.0

APPENDIX C:
USDA SOILS REPORT

Hydrologic Soil Group—Clark County, Washington



Map Scale: 1:2,090 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- ▭ Area of Interest (AOI)

Soils

Soil Rating Polygons

- 🟪 A
- 🟩 A/D
- 🟦 B
- 🟫 B/D
- 🟦 C
- 🟨 C/D
- 🟥 D
- ⬜ Not rated or not available

Soil Rating Lines

- 〰 A
- 〰 A/D
- 〰 B
- 〰 B/D
- 〰 C
- 〰 C/D
- 〰 D
- 〰 Not rated or not available

Soil Rating Points

- ■ A
- ■ A/D
- ■ B
- ■ B/D
- ■ C
- ■ C/D
- ■ D
- □ Not rated or not available

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 1:20,000.

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:
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: Clark County, Washington
Survey Area Data: Version 16, Sep 10, 2018

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

Date(s) aerial images were photographed: Sep 29, 2015—Sep 13, 2016

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.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
GeB	Gee silt loam, 0 to 8 percent slopes	C	8.4	49.0%
GeF	Gee silt loam, 30 to 60 percent slopes	C	4.3	24.7%
OdB	Odne silt loam, 0 to 5 percent slopes	D	4.5	26.3%
Totals for Area of Interest			**17.2**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

APPENDIX D:
GEOTECHNICAL REPORT

GEODESIGN INC

REPORT OF GEOTECHNICAL ENGINEERING SERVICES

Holley Park Subdivision
33105 NE Ivy Avenue
La Center, Washington

For
Compass Group, LLC
January 14, 2019

GeoDesign Project: CompassGrp-1-01

January 14, 2019

Compass Group, LLC
PO Box 1900
Battle Ground, WA 98604

Attention: Kevin Tapani

Report of Geotechnical Engineering Services
Holley Park Subdivision
33105 NE Ivy Avenue
La Center, Washington
GeoDesign Project: CompassGrp-1-01

GeoDesign, Inc. is pleased to submit this report for the proposed Holley Park subdivision located at 33105 NE Ivy Avenue in La Center, Washington. Our services for this project were conducted in accordance with our proposal dated November 6, 2018.

We appreciate the opportunity to be of service to you. Please contact us if you have questions regarding this report.

Sincerely,

GeoDesign, Inc.

Nick Paveglio, P.E.
Senior Associate Engineer

Brett A. Shipton, P.E.
Principal Engineer

cc: Seth Halling, AKS Engineering and Forestry (via email only)

NNP:BAS:kt
Attachments
One copy submitted (via email only)
Document ID: CompassGrp-1-01-011419-geor.docx

EXECUTIVE SUMMARY

The primary geotechnical considerations for the project are summarized as follows:

- The proposed buildings can be supported by conventional spread footings bearing on the native soil at the site. Spread footings should not be established on agricultural tilled zones.

- Minimum setback buffers of 25 and 50 feet should be established from the crests of the slopes in the north and south portions of the site, respectively. Buffer zones should remain undisturbed during construction, with the exception of trenches to dispose stormwater, unless additional geotechnical analysis is completed.

- Based on the results of our explorations, the soil at the site is not susceptible to liquefaction or lateral spreading.

- Site explorations encountered a tilled zone in the upper 12 to 30 inches of soil over a majority of the site from past agricultural activities. In general, the tilled zone is unconsolidated and will provide poor support for foundations, fills, floor slabs, and pavements. In roadways and beneath buildings where the tilled zone will not be removed by site cuts, we recommend that the tilled zone be improved by scarifying and re-compacting or cement treating as described in the "Construction" section.

- The near-surface soil is sensitive to disturbance when at a moisture content that is above optimum. This can result in subgrade damage during construction and significant repair costs. We recommend that the project budget include subgrade protection. A discussion of subgrade protection is included in the "Construction" section.

- Perched groundwater was observed within approximately 10 feet of the ground surface. Based on our experience, groundwater could be within 5 feet of the ground surface during the wet season. The presence of shallow groundwater will affect construction of the proposed development. Earthwork contractors should be prepared to dewater excavations at all times of the year.

- Based on the soil and groundwater conditions at the site, on-site infiltration systems are not recommended.

TABLE OF CONTENTS **PAGE NO.**

TABLE OF CONTENTS **PAGE NO.**

APPENDICES (continued)

ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AC	asphalt concrete
ASTM	American Society for Testing and Materials
BGS	below ground surface
g	gravitational acceleration (32.2 feet/second^2)
HMA	hot mix asphalt
H:V	horizontal to vertical
IBC	International Building Code
MCE	maximum considered earthquake
OSHA	Occupational Safety and Health Administration
pcf	pounds per cubic foot
PG	performance grade
psf	pounds per square foot
psi	pounds per square inch
SPT	standard penetration test
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WSS	Washington Standard Specifications for Road, Bridge, and Municipal Construction (2018)

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering evaluation for the proposed Holley Park subdivision at 33105 NE Ivy Street in La Center, Washington. The site is shown relative to surrounding features on Figure 1. Figure 2 shows the locations of our explorations for this study. Acronyms and abbreviations used herein are defined above, immediately following the Table of Contents.

2.0 PROJECT UNDERSTANDING

The project includes construction of a residential subdivision with detached single-family houses. Based on correspondence with AKS Engineering and Forestry (AKS), site cuts and fills are expected to be 5 feet or less. Stormwater generated from the development will be treated and disposed of off site.

3.0 PURPOSE AND SCOPE

The purpose of our services was to provide geotechnical engineering recommendations for design and construction of the proposed development. The specific scope of our services is summarized as follows:

- Reviewed readily available published geologic data and our in-house files for existing information on subsurface conditions in the site vicinity.
- Coordinated and managed the field explorations, including locating utilities and scheduling subcontractors and GeoDesign field staff.
- Drilled three borings to depths between 34.7 and 46.4 feet BGS.
- Excavated 10 test pits to depths between 16.0 and 18.0 feet BGS.
- Collected soil samples for laboratory testing at select depths from the explorations.
- Classified the materials encountered in the explorations.
- Maintained a detailed log of each exploration. Observed groundwater conditions in the explorations.
- Completed a laboratory testing program that included the following:
  - Seventeen moisture content determinations in general accordance with ASTM D2216
  - Fourteen particle-size analyses in general accordance with ASTM C117 or ASTM D1140
  - Three Atterberg limits tests in general accordance with ASTM D4318
- Prepared this geotechnical report summarizing our explorations, laboratory testing, analyses, geotechnical design criteria, and construction recommendations, including information relating to the following:
  - Soil and groundwater conditions
  - Geologic hazards and slope setbacks
  - Earthwork guidelines
  - Seismic design parameters
  - Foundation
  - Pavements

4.0 SITE CONDITIONS

4.1 SURFACE CONDITIONS

The approximately 14.37-acre site is located southeast of downtown La Center, Washington. The site is bound by a small drainage and park to north; a residential subdivision to the east; undeveloped, sloping land to the south; and a large residential property to the west.

The northwest corner of the site is occupied by a residence with multiple barns and outbuildings and the remainder of the site is undeveloped and likely used for agricultural purposes. The majority of the site slopes gently to the south between elevations of approximately 130 and 115 feet, with the exception of slopes along the north and south boundaries. The site slopes are discussed in greater detail in the "Geologic Hazards" section. The site is generally covered with grass and trees are present along the north and south slopes and around the residence.

4.2 SUBSURFACE CONDITIONS

4.2.1 General

Subsurface conditions at the site were evaluated by drilling three borings (B-1 through B-3) to depths between 34.7 and 46.4 feet BGS and excavating 10 test pits (TP-1 through TP-10) to depths between 16.0 and 18.0 feet BGS. The approximate locations of the explorations are shown on Figure 2. Descriptions of the field explorations and laboratory testing programs, logs of the explorations, and results of the laboratory testing are presented in Appendix A.

4.2.2 Root and Agricultural Tilled Zones

An approximately 12– to 30-inch thick tilled zone from agricultural activities is present at the site. The zone consists of very soft to soft, brown silt with variable fractions of sand. A root zone averaging approximately 5 to 6 inches with areas up to 12 inches is present within the tilled zone.

4.2.3 Silt and Sand (Flood Deposits)

Native soil that underlies the tilled zone consists of Quaternary Age flood deposits comprised of soft to medium stiff silt and medium dense, silty sand. The sand content and stiffness of the flood deposits generally increases with depth. The flood deposits extends to depths between 25 and 30 feet BGS at the site. Laboratory testing indicates the silt has low plasticity silt and flood deposits had moisture contents between approximately 32 and 40 percent at the time of explorations.

4.2.4 Clay and Gravel (Conglomerate)

Underlying the flood deposits is Pleistocene Age conglomerate. The conglomerate consists of an approximately 5- to- 10- foot-thick layer of very stiff clay underlain by dense gravel with clay and sand. Based on laboratory testing the moisture content of the conglomerate ranged from 30 to 32 percent at the time of our explorations. The conglomerate extends to the maximum depth explored of 46.4 feet BGS. Geologic mapping indicates the conglomerate is approximately 60 to 120 feet in thickness.

4.2.5 Groundwater

Groundwater was generally encountered in the explorations between depths of 10 and 14 feet BGS. A review of water well logs and groundwater mapping suggests the regional static groundwater table is 50 feet BGS or more and the groundwater encountered during the explorations is perched. Based our experience, the perched groundwater could rise to within 5 feet of the ground surface during the wet season.

4.3 GEOLOGIC HAZARDS

4.3.1 General

Site classes as defined in the IBC range from A to F, with E having the highest relative ground amplification. Site Class F requires a site-specific seismic study. Based on the results of our explorations, a Site Class D is appropriate for the site.

4.3.2 Liquefaction and Lateral Spread (Seismic Hazard Areas)

Liquefaction is caused by a rapid increase in pore water pressure that reduces the effective stress between soil particles to near zero. Granular soil, which relies on interparticle friction for strength, is susceptible to liquefaction until the excess pore pressures can dissipate. In general, loose, saturated sand soil with low silt and clay content is the most susceptible to liquefaction. Silty soil with low plasticity is moderately susceptible to liquefaction under relatively higher levels of ground shaking.

According to the Alternative Liquefaction Susceptibility Map of Clark County by Palmer et al. (2004), the site is described as having very low liquefaction susceptibility. Based on the results of our explorations, liquefaction is expected to be negligible at the site and is not a design consideration.

Lateral spreading is a liquefaction-related seismic hazard and occurs on gently sloping or flat sites underlain by liquefiable sediment adjacent to an open face, such as a riverbank. Liquefied soil adjacent to an open face can flow toward the open face, resulting in lateral ground displacement. There are no major open faces, and the liquefaction potential at the site is low. Accordingly, the potential for lateral spreading at the site is not a design consideration for the project.

4.3.3 Fault Rupture

Based on USGS mapping, the nearest mapped fault to the site is the Lacamas Lake fault, which is located approximately 14 miles to the southeast. As such, fault rupture is not considered a hazard at the site.

4.3.4 Landslides

4.3.4.1 Stability Analysis

According to Chapter 18.300 (Critical Areas) of the La Center Municipal Code, slopes greater than 25 percent are considered “landslide hazard areas.” Based on this criteria, the slopes in the north and south portions of the site are considered landslide hazard areas. Figure 3 shows the slope percentages at the site.

Due to the presence of landslide hazard areas, stability analysis was completed to determine appropriate setbacks in accordance with the La Center Municipal Code. Analysis was completed using Slope/W by Geo-Slope International, Ltd. Slope/W performs two-dimensional limiting equilibrium analysis to compute slope stability. The factor of safety against slope failure is simplistically defined as the ratio of the forces resisting slope movement (e.g., soil strength, soil mass, etc.) to the forces driving slope movement (e.g., soil weight, water pressure). The program predicts the location and geometry of "critical failures planes." Critical failure planes are the zones with the lowest factors of safety. A factor of safety less than 1.0 infers that the model is not in equilibrium and slope movement is likely to occur. Standard of care generally dictates that a minimum factor of safety for static and seismic conditions be 1.5 and 1.1, respectively.

Our analysis included one section (A-A') in the north portion of site and two sections (B-B' and C-C') in the south portion of the site. The locations of the analysis are shown on Figures 2 and 3 and were chosen to represent "worst case" scenarios. The subsurface conditions were based on the results of our explorations, laboratory testing, and experience with similar soil.

A conservative surcharge load of 2,000 psf was used for the entire footprint of residences and a maximum of 5 feet of fill was assumed per AKS. This is conservative where roadways are above slopes because the surcharge loading associated with the roadways would be 250 psf. A seismic coefficient of 0.135 g (one-half the site peak ground acceleration of 0.27 g) was used for the seismic condition. The configurations, soil parameters, and results of the analysis are presented in Appendix B.

4.3.4.2 Buffer Recommendation

Minimum setback buffers of 25 and 50 feet should be established from the crests of the slopes in the north and south portions of the site, respectively. Buffer zones should remain undisturbed during construction, with the exception of trenches to dispose stormwater, unless additional geotechnical analysis is completed. The locations of the buffers should be clearly shown on the project plans.

Provided design and construction of the development near the slopes are completed conformance with the recommendations of this report, it is our opinion that the proposed development will not adversely affect the short- or long-term stability of the slopes nor pose a significant risk to public safety.

4.3.4.3 Stormwater System Recommendations on Steep Slopes

Surface water should not be allowed to sheet flow onto steep slope faces. Stormwater should be collected and transferred to the base of all steep slopes in solid pipes, and angular rock should be installed at the base of the outfall pipes to dissipate energy generated from the gradient.

Granular backfill for pipes on steep slopes will create preferential flow paths for water that can generate moderate velocities within the trenches and a potential for piping. Where stormwater pipes are installed in slopes that exceed 15 percent, we recommend the trench backfill consist of fine-grained soil. If trenches are installed in the wet season and compaction of fine-grained soil is not possible, granular backfill can be used provided cutoff trenches, consisting of low-strength concrete or high-plasticity clay, are installed every 25 feet to reduce subsurface water velocities with the pipe backfill.

Stormwater infiltration systems are not recommended for the project. We recommend that stormwater detention ponds located within 200 feet of the crest of any slope be lined with an impermeable membrane or bentonite to prevent water from infiltrating into the subsurface soil.

4.3.5 Erosion Hazard

The USDA Web Soil Survey indicates that the surficial soil at the site consists of Gee, Hillsboro, and Odne silt loam. The survey describes these soils as having very low to low permeability and slight to very severe erosion hazard when the soil is left bare, depending on slope gradient. Based on our experience with similar soils, the erosion hazard is moderate to very severe when the soil is left bare and where slope gradients are steeper than 15 percent. Where slope gradients are less than 15 percent, erosion hazard is low to moderate

Currently, the ground surface at the site is covered with grass, brush, and trees. We consider the site (in its current state) to have a low to moderate erosion hazard. The proposed development of the site will remove much of the existing vegetation in the development area. This will temporarily increase the erosion hazard to moderate to severe. It is our understand that disturbance to slopes steeper than 25 percent will not occur during construction; therefore, very severe erosion hazards should not be present. During construction of the proposed development, erosion control measures as discussed in this report and as recommended by the project civil engineer shall be employed.

With a properly implemented erosion control plan, the impact of erosion on the site during construction should be minimal and easily mitigated as part of finished grading. If suitable erosion control measures are implemented and maintained throughout construction until a new vegetative cover is established, there should be little or no adverse impact to the overall stability of the site or to neighboring sites.

Upon completion of the proposed development, the majority of the development area will either be covered with pavement, sidewalks, or homes or will be landscaped with conventional residential ornamental shrubs and ground cover. We anticipate the open space areas will remain covered with native vegetation. Surface run-off will be greatly decreased due to the collection of surface water from the streets and roof tops. The collected run-off will then be directed to the stormwater detention pond in the southwest corner of the site. In our opinion, these final “built-out” conditions will result in a low future erosion hazard.

5.0 DESIGN

5.1 FOUNDATION SUPPORT

5.1.1 Bearing Capacity

The proposed buildings can be supported on conventional spread footings bearing on undisturbed native soil or structural fill overlying undisturbed native soil. Foundation elements should not be supported on agricultural till. If present, the agricultural till should be removed and replaced with structural fill.

5.1.2 Bearing Capacity

Continuous wall and isolated spread footings should be at least 18 and 24 inches wide, respectively. The bottom of exterior footings should be at least 18 inches below the lowest adjacent exterior grade. The bottom of interior footings should be established at least 12 inches below the base of the slab. Footings should be embedded so that a minimum of 10 feet of horizontal clearance exists between the toe of the footing and any adjacent slopes.

Footings bearing on native silt or new structural fill on native soil should be designed assuming an allowable bearing pressure of 2,000 psf. This is a net bearing pressure; the weight of the footing and overlying backfill can be ignored in calculating footing sizes. Also, the allowable bearing pressures apply to the total of dead plus long-term live loads and can be increased by one-half for short-term loads, such as those resulting from wind or seismic forces.

Total post-construction foundation settlement should be less than 1 inch, with differential settlement between similarly loaded foundations of less than ½ inch.

5.1.3 Resistance to Sliding

Lateral loads on footings can be resisted by passive earth pressure on the sides of the structure and by friction on the base of the footings. An unfactored passive earth pressure of 350 pcf can be used for footings confined by firm native soil. Adjacent floor slabs, pavement, or the upper 12-inch depth of adjacent unpaved areas should not be considered when calculating passive resistance. In order to rely on passive resistance, a minimum of 10 feet of horizontal clearance must exist between the face of the footings and adjacent downslopes.

For footings in contact with the native soil, a coefficient of friction equal to 0.35 may be used when calculating resistance to sliding.

5.1.4 Subgrade Observation

All footing and floor subgrades should be evaluated by qualified personnel to evaluate the bearing conditions. Observations should also confirm that all loose or soft material, organics, unsuitable fill, prior topsoil zones, and softened subgrades (if present) have been removed. Localized deepening of footing excavations may be required to penetrate any deleterious material.

5.1.5 Construction Considerations

If footing excavations are conducted during wet weather conditions, we recommend that a minimum of 3 inches of granular material be placed and compacted until well keyed at the base of the footing excavations. The granular material reduces water softening of silt-rich subgrade soil, reduces subgrade disturbance during placement of forms and reinforcement, and provides clean conditions for the reinforcing steel.

5.2 SEISMIC DESIGN CRITERIA

Table 1 provides seismic design parameters in accordance with IBC 2015. We selected a Site Class D based the results of explorations and testing.

Table 1. IBC 2015 Seismic Design Parameters

Parameter	Short Period (T_s = 0.2 second)	1 Second Period (T_1 = 1.0 second)
MCE Spectral Acceleration, S	S_s = 0.890 g	S_1 = 0.397 g
Site Class	D	
Site Coefficient, F	F_a = 1.144	F_v = 1.606
Adjusted Spectral Acceleration, S_M	S_{MS} = 1.018 g	S_{M1} = 0.638 g
Design Spectral Response Acceleration Parameters, S_D	S_{DS} = 0.679 g	S_{D1} = 0.425 g

5.3 FLOOR SLABS

Satisfactory subgrade support for building floor slabs supporting up to 100 psf area loading can be obtained provided the building pad is prepared as described in the "Construction" section. The floor slab be supported on at least 6 inches of imported granular material to aid as a capillary break and to provide uniform support. The imported granular material should be placed and compacted as described in the "Structural Fill" section.

Exterior slabs, such as those for patios, walkways, driveways, and garages, should be structurally independent from the building foundations. Expansion joints should be provided between floor slabs and foundations. This will allow minor movement of the slabs to occur as a result of vehicular loading, tree root growth, seasonal soil shifting, and other factors, while reducing the potential for slab cracking around the perimeter. Interior slabs may be tied to the building's foundation system. Slabs should be reinforced according to their proposed use and per the structural engineer's recommendations.

5.4 RETAINING STRUCTURES

5.4.1 Assumptions

Our retaining wall design recommendations are based on the following assumptions: (1) the walls consist of conventional, cantilevered retaining walls, (2) the walls are less than 8 feet in height, (3) the backfill is drained and consists of imported granular material, and (4) the backfill has a slope flatter than 4H:1V. Re-evaluation of our recommendations will be required if the retaining wall design criteria for the project varies from these assumptions.

5.4.2 Wall Design Parameters

Permanent retaining structures free to rotate slightly around the base should be designed for active earth pressures using an equivalent fluid unit pressure of 35 pcf. If retaining walls are restrained against rotation during backfilling, they should be designed for an at-rest earth pressure of 55 pcf.

Seismic lateral forces can be calculated using a dynamic force equal to $7H^2$ pounds per linear foot of wall, where H is the wall height. The seismic force should be applied as a distributed load with the centroid located at 0.6H from the wall base. Footings for retaining walls should be designed as recommended for shallow foundations.

If surcharges (i.e., slopes steeper than 2H:1V, foundations, vehicles, etc.) are located within a horizontal distance of twice the height of the wall from the back of the wall, additional pressures will need to be accounted for in the wall design. Our office should be contacted for appropriate wall surcharges based on the actual magnitude and configuration of the applied loads.

5.4.3 Wall Drainage and Backfill

The above design parameters have been provided assuming drains will be installed behind walls to prevent buildup of hydrostatic pressures behind all walls. If a drainage system is not installed, our office should be contacted for revised design forces.

Backfill material placed behind the walls and extending a horizontal distance of ½H, where H is the height of the retaining wall, should consist of retaining wall select backfill placed and compacted in conformance with the "Structural Fill" section.

A minimum 6-inch-diameter, perforated collector pipe should be placed at the base of the walls. The pipe should be embedded in a minimum 2-foot-wide zone of angular drain rock that is wrapped in a drainage geotextile fabric and extends up the back of the wall to within 1 foot of the finished grade. The drain rock and drainage geotextile fabric should meet specifications provided in the "Materials" section. The perforated collector pipes should discharge at an appropriate location away from the base of the wall. The discharge pipe(s) should not be tied directly into stormwater drain systems, unless measures are taken to prevent backflow into the drainage system of the wall.

Settlement of up to 1 percent of the wall height commonly occurs immediately adjacent to the wall as the wall rotates and develops active lateral earth pressures. Consequently, we recommend that construction of flatwork adjacent to retaining walls be postponed at least four weeks after backfilling of the wall, unless survey data indicates that settlement is complete prior to that time.

5.5 DRAINAGE

5.5.1 Temporary

During work at the site, the contractor should be made responsible for temporary drainage of surface water as necessary to prevent standing water and/or erosion at the working surface. During rough and finished grading of the site, the contractor should keep all pads and subgrade free of ponding water.

5.5.2 Surface

The ground surface at finished pads should be sloped away from their edges at a minimum 2 percent gradient for a distance of at least 5 feet. Roof drainage from the buildings should be directed into solid, smooth-walled drainage pipes that carry the collected water to the storm drain system. Trapped planter areas should not be created adjacent to roadways and structures without providing means for positive drainage (e.g., swales or catch basins).

5.5.3 Subsurface

Based on the soil and groundwater conditions, it is prudent to install perimeter drains around the buildings. Drains should consist of a filter fabric-wrapped, drain rock-filled trench that extends at least 12 inches below the lowest adjacent grade (i.e., slab subgrade elevation). A perforated pipe should be placed at the base to collect water that gathers in the drain rock. The drain rock and filter fabric should meet specifications outlined in the "Materials" section. Discharge for the footing drain should not be tied directly into the stormwater drainage system, unless mechanisms are installed to prevent backflow.

5.5.4 Stormwater Infiltration

Based on the subsurface and groundwater conditions at the site, on-site infiltration systems are not recommended for the development.

5.6 PERMANENT SLOPES

All cut and fill slopes should be located outside the slope buffer zone and should not exceed 2H:1V. Upslope roads and pavements should be located at least 5 feet from the top of cut and fill slopes. The setback should be increased to 10 feet for buildings. The slopes should be planted with appropriate vegetation to provide protection against erosion as soon as possible after grading. Surface water runoff should be collected and directed away from slopes to prevent water from running down the face of the slope.

5.7 PAVEMENTS

Pavements for new roadways will be installed as part of the development. Pavements should be installed on improved agricultural till, firm native soil, structural fill, or cement-treated subgrade prepared in conformance with the "Site Preparation" and "Materials" sections.

The pavement section will be in conformation with City of La Center standard detail ST-14. Based on explorations and testing, the AASHTO soil classification at the site is A-5, resulting in a section of 0.35 foot of AC over 0.90 foot of aggregate base. If the roadway is constructed during the wet season and the subgrade is cement treated, a reduction in aggregate base may be suitable. GeoDesign should be contacted to provide recommendations if cement treated. AC and aggregate base should meet the requirements in the "Materials" section.

The material thicknesses are intended to be minimum acceptable values for the final condition. The aggregate base thickness does not account for construction traffic, and haul roads and staging areas should be used as described in the "Construction" section.

6.0 CONSTRUCTION

6.1 SITE PREPARATION

The existing topsoil zone should be stripped and removed from all fill areas. Based on our explorations, the average depth of stripping will be approximately 5 to 6 inches, although greater stripping depths will be required to remove localized zones of loose or organic soil. Greater stripping depths (approaching 12 inches) are anticipated in areas with thicker vegetation and shrubs, in all forested areas, and along the base of draws. The actual stripping depth should be based on field observations at the time of construction. Stripped material should be transported off site for disposal or used in landscaped areas.

Trees and shrubs should be removed from fill areas. In addition, root balls should be grubbed out to the depth of the roots, which could exceed 3 feet BGS. Depending on the methods used to remove the root balls, considerable disturbance and loosening of the subgrade could occur during site grubbing. We recommend that soil disturbed during grubbing operations be removed to expose firm, undisturbed subgrade. The resulting excavations should be backfilled with structural fill.

6.1.1 Tilled Zone

An approximately 12- to 36-inch-thick agricultural tilled zone was observed directly beneath the ground surface in our explorations over a majority of the site. We recommend that the tilled zone be improved during site preparation in areas where cuts do not remove the tilled zone. Prior to fill placement and construction, the tilled zone should be improved by removing and replacing with structural fill or scarifying and compacting as structural fill.

The native soil can be sensitive to small changes in moisture content and will be difficult, if not impossible, to compact adequately during wet weather. While scarification and compaction of the subgrade is the best option for subgrade improvement, it will likely only be possible during extended dry periods and following moisture conditioning of the soil. As discussed further on in this report, cement amendment is an option for conditioning the soil for use as structural fill during periods of wet weather or when drying the soil is not an option.

6.1.2 Subgrade Evaluation

Upon completion of stripping and prior to the placement of any structural fill or pavement, the exposed subgrade should be evaluated by proof rolling to identify soft, loose, or unsuitable areas. Proof rolling should be conducted with a fully loaded dump truck or similar heavy, rubber tire construction equipment. Qualified personnel should observe proof rolling to evaluate yielding of the ground surface. The subgrade should be evaluated by probing with a foundation probe when the subgrade is too wet. If soft or yielding subgrade is identified, the subgrade should be excavated and replaced with structural fill.

6.2 CONSTRUCTION CONSIDERATIONS

The fine-grained soil present on this site is easily disturbed. If not carefully executed, site preparation, utility trench work, and roadway excavation can create extensive soft areas and significant repair costs can result. Earthwork planning, regardless of the time of year, should include considerations for minimizing subgrade disturbance.

If construction occurs during or extends into the wet season, or if the moisture content of the surficial soil is more than a couple percentage points above optimum, site stripping and cutting may need to be accomplished using track-mounted equipment. Likewise, the use of granular haul roads and staging areas will be necessary for support of construction traffic during the rainy season or when the moisture content of the surficial soil is more than a few percentage points above optimum. The amount of staging and haul road areas, as well as the required thickness of granular material, will vary with the contractor's sequencing of a project and type/frequency of construction equipment. Based on our experience, between 12 and 18 inches of imported granular material is generally required in staging areas and between 18 and 24 inches in haul roads areas. Stabilization material may be used as a substitute provided the top 4 inches of material consists of imported granular material. The actual thickness will depend on the contractor's means and methods and should be the contractor's responsibility. In addition, a geotextile fabric should be considered to assist in developing a barrier between the subgrade and imported granular material in areas of repeated construction traffic. The imported granular material, stabilization material, and geotextile fabric should meet the specifications in the "Materials" section.

As an alternative to thickened crushed rock sections, haul roads and utility work zones may be constructed using cement-amended subgrades overlain by a crushed rock wearing surface. If this approach is used, the thickness of granular material in staging areas and along haul roads can typically be reduced to between 6 and 9 inches. This recommendation is based on an assumed minimum unconfined compressive strength of 100 psi for subgrade amended to a depth of 12 to 16 inches. The actual thickness of the amended material and imported granular material will depend on the contractor's means and methods and should be the contractor's responsibility. Cement amendment is discussed in the "Materials" section.

6.3 TEMPORARY SLOPES

Temporary slopes less than 10 feet high should be no steeper than 1½H:1V, provided groundwater seepage does not occur. If slopes greater than 10 feet high are required, GeoDesign should be contacted to make additional recommendations. We recommend a minimum horizontal distance of 5 feet from the edge of the existing improvements to the top of the temporary slope. All cut slopes should be protected from erosion by covering them during wet weather. If sloughing or instability is observed, the slope should be flattened or supported by shoring. Excavations should not undermine adjacent utilities, foundations, walkways, streets, or other hardscapes unless special shoring or underpinned support is provided.

6.4 EROSION CONTROL

The on-site soil is susceptible to erosion. Consequently, we recommend that slopes be covered with an appropriate erosion control product if construction occurs during periods of wet weather. We recommend that all slope surfaces be planted as soon as practical to minimize erosion. Surface water runoff should be collected and directed away from slopes to prevent water from running down the slope face. Erosion control measures, such as straw bales, sediment fences, and temporary detention and settling basins, should be used in accordance with local and state ordinances.

6.5 EXCAVATION

6.5.1 General

Perched groundwater was generally observed between depths of 10 and 14 feet BGS in the explorations. Based on our experience in the area, perched groundwater could be present within approximately few feet of the ground surface during the wet season. Cuts in the near-surface soil should be readily completed with conventional excavation equipment. Temporary excavation sidewalls should stand vertical to a depth of approximately 4 feet, provided groundwater seepage is not observed in the sidewalls. Open excavation techniques may be used to excavate trenches with depths between 4 and 8 feet, provided the walls of the excavation are cut at a slope of 1H:1V and groundwater seepage is not present. Excavations should be flattened to 1½H:1V or 2H:1V if excessive sloughing or raveling occurs. If groundwater is present, caving and raveling could occur. In lieu of large and open cuts, approved temporary shoring may be used for excavation support. A wide variety of shoring and dewatering systems are available. Consequently, we recommend that the contractor be responsible for selecting the appropriate shoring and dewatering systems.

If box shoring is used, it should be understood that box shoring is a safety feature used to protect workers and does not prevent caving. If the excavations are left open for extended periods of time, caving of the sidewalls may occur. The presence of caved material will limit the ability to properly backfill and compact the trenches. The contractor should be prepared to fill voids between the box shoring and the sidewalls of the trenches with sand or gravel before caving occurs.

If shoring is used, we recommend that the type and design of the shoring system be the responsibility of the contractor, who is in the best position to choose a system that fits the overall plan of operation. All excavations should be made in accordance with applicable OSHA and state regulations.

6.5.2 Dewatering

Dewatering may be required for excavations at the site, particularly during the wet season. If encountered, pumping from a sump located within the trench may be effective in dewatering localized sections of trench. However, this method is unlikely to prove effective in dewatering long sections of trench or large excavations. In addition, the sidewalls of trench excavations will need to be flattened or shored if seepage is encountered.

Where groundwater seepage into shored excavations occurs, we recommend placing at least 1 foot to 2 feet of stabilization material at the base of the excavations. Trench stabilization material should meet the requirements provided in the "Structural Fill" section.

We note that these recommendations are for guidance only. Dewatering of excavations is the sole responsibility of the contractor, as the contractor is in the best position to select these systems based on their means and methods.

6.6 MATERIALS

6.6.1 Structural Fill

Fills should only be placed over subgrade that has been prepared in conformance with the "Site Preparation" section. A variety of material may be used as structural fill at the site. However, all material used as structural fill should be free of organic matter or other unsuitable material and should meet the specifications provided in WSS 9-03 – Aggregates, depending on the application. A brief characterization of some of the acceptable materials and our recommendations for their use as structural fill are provided below.

6.6.2 On-Site Soil

The on-site soil is suitable for structural fill provided it is free of organic matter and unsuitable materials. Based on laboratory testing results, the moisture content of the on-site soil is above the optimum required for compaction at the time of our explorations and moisture conditioning, including drying and mixing, will be required to use the on-site soil for structural fill. Accordingly, extended dry weather and sufficient area to dry the soil will be required to adequately condition the soil for use as structural fill. The on-site fine-grained soil should not be used as structural fill during the wet season.

When used as structural fill, the on-site fine-grained soil should be placed in lifts with a maximum uncompacted thickness of 8 inches and compacted to not less than 92 percent of the maximum dry density, as determined by ASTM D1557.

6.6.3 Imported Granular Material

Imported granular material used during periods of wet weather, for building pad subgrades, and for staging areas should be pit- or quarry-run rock, crushed rock, or crushed gravel and sand and should meet the specifications provided in WSS 9-03.9(1) – Ballast, WSS 9-03.14(1) – Gravel Borrow, or WSS 9-03.14(2) – Select Borrow. The imported granular material should be fairly well graded between coarse and fine material, have less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve, and have a minimum of two mechanically fractured faces.

Imported granular material should be placed in lifts with a maximum uncompacted thickness of 8 to 12 inches and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557. During the wet season or when wet subgrade conditions exist, the initial lift should be approximately 18 inches in uncompacted thickness and should be compacted with a smooth-drum roller without using vibratory action.

Where imported granular material is placed over wet or soft soil subgrades, we recommend a geotextile be placed as a barrier between the subgrade and imported granular material. Depending on site conditions, the geotextile should meet the specifications provided in WSS 9-33.2(1) – Geotextile Properties (Table 3) for soil separation or stabilization. The geotextile should be installed in conformance with WSS 2-12 – Construction Geosynthetic.

6.6.4 Stabilization Material

Stabilization material used to create haul roads for construction traffic or at the base of unstable trenches should consist of pit- or quarry-run rock or crushed rock. The material should have a maximum particle size of 6 inches and less than 5 percent by dry weight passing the

U.S. Standard No. 4 sieve, have at least two mechanically fractured faces, and be free of organic matter and other deleterious material. Material meeting the specifications provided in WSS 9-27.3(6) – Stone is generally acceptable for use. Stabilization material should be placed in lifts between 12 and 18 inches thick and compacted to a firm condition with a smooth-drum roller without using vibratory action.

Where the stabilization material is used to stabilize soft subgrade beneath pavements or construction haul roads, a geotextile should be placed as a barrier between the soil subgrade and the imported granular material. Geotextile is not required where stabilization material is used at the base of utility trenches.

6.6.5 Trench Backfill

Trench backfill placed beneath, adjacent to, and for at least 2 feet above utility lines (i.e., the pipe zone) should consist of well-graded, granular material with a maximum particle size of 1½ inches and less than 7 percent by dry weight passing the U.S. Standard No. 200 sieve and should meet the specifications provided in WSS 9-03.12(3) – Gravel Backfill for Pipe Zone Bedding. The pipe zone backfill should be compacted to at least 90 percent of the maximum dry density, as determined by ASTM D1557, or as required by the pipe manufacturer or local building department.

Within roadway alignments or beneath proposed or future building pads, the remainder of the trench backfill should consist of well-graded, granular material with a maximum particle size of 2½ inches and less than 7 percent by dry weight passing the U.S. Standard No. 200 sieve and should meet the specifications provided in WSS 9-03.19 – Bank Run Gravel for Trench Backfill. This material should be compacted to at least 92 percent of the maximum dry density, as determined by ASTM D1557, or as required by the pipe manufacturer or local building department. The upper 2 feet of the trench backfill should be compacted to at least 95 percent of the maximum dry density, as determined by ASTM D1557. Outside of structural improvement areas (e.g., roadway alignments or building pads), trench backfill placed above the pipe zone may consist of general fill material that is free of organics and material over 6 inches in size and meets the specifications provided in WSS 9-03.14(3) – Common Borrow and WSS 9-03.15 – Native Material for Trench Backfill. This general trench backfill should be compacted to at least 90 percent of the maximum dry density, as determined by ASTM D1557, or as required by the pipe manufacturer or local building department.

Refer to the “Geologic Hazards” section for a discussion of trench backfill on slopes.

6.6.6 Aggregate Base Rock

Imported granular material placed beneath pavements and floor slabs should be clean crushed rock or crushed gravel and sand that are fairly well graded between coarse and fine. The granular material should not contain deleterious material, should have a maximum particle size of 1½ inches, should meet the specifications provided in WSS 9-03.9(3) – Crushed Surfacing and WSS 9-03.10 – Aggregate for Gravel Base, should have less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve, and should have a minimum of two mechanically fractured faces. The imported granular material should be placed in one lift and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

6.6.7 Retaining Wall Select Backfill

Backfill material placed behind retaining walls and extending a horizontal distance of ½H, where H is the height of the retaining wall, should consist of select granular material that meets the requirements provided in WSS 9-03.12(2) – Gravel Backfill for Walls. We recommend the select granular wall backfill be separated from general fill, native soil, and/or topsoil using a geotextile fabric that meets the specifications provided below for drainage geotextiles.

The wall backfill should be compacted to a minimum of 95 percent of the maximum dry density, as determined by ASTM D1557. However, backfill located within a horizontal distance of 3 feet from a retaining wall should only be compacted to approximately 90 percent of the maximum dry density, as determined by ASTM D1557. Backfill placed within 3 feet of the walls should be compacted in lifts less than 6 inches thick using hand-operated tamping equipment (such as a jumping jack or vibratory plate compactor). If flatwork (sidewalks or pavements) will be placed atop the wall backfill, we recommend that the upper 2 feet of material be compacted to 95 percent of the maximum dry density, as determined by ASTM D1557.

6.6.8 Geotextile Separation Fabric

A geotextile separation fabric will be required at the interface of the existing soil and imported granular material beneath the proposed walls. In addition, geotextile fabric may be required where soft subgrade is encountered. The separation fabric should meet the specifications provided in WSS 9-33.2(1) – Geotextile Properties (Table 3) for soil separation. The geotextile should be installed in conformance the specifications provided in WSS 2-12 – Construction Geosynthetic.

6.6.9 AC

6.6.9.1 General

The AC pavement should conform to WSS 5-04 - Hot Mix Asphalt. AC should consist of ½-inch HMA. The asphalt cement binder should be PG 64-22 Performance Grade Asphalt Cement conforming to WSS 9-02.1(4) – Performance Graded Asphalt Binder. The layer thickness should be 2.0 to 3.5 inches. The job mix formula should meet the requirements for non-statistical ½-inch HMA (WSS 5-04 – Hot Mix Asphalt and WSS 9-03.8 – Aggregates for Hot Mix Asphalt) and be compacted to 91 percent of the maximum specific gravity or as required by the local jurisdiction in public right-of-way areas.

6.6.9.2 Cold Weather Paving Considerations

In general, AC paving is not recommended during cold weather (temperatures less than 40 degrees Fahrenheit). Compacting under these conditions can result in low compaction and premature pavement distress. Each AC mix design has a recommended compaction temperature range that is specific for the particular AC binder used. In colder temperatures, it is more difficult to maintain the temperature of the AC mix as it can lose heat while stored in the delivery truck, as it is placed, and in the time between placement and compaction. The AC surface temperature during paving should be at least 40 degrees Fahrenheit for lift thickness greater than 2.5 inches and at least 50 degrees Fahrenheit for lift thickness between 2.0 and 2.5 inches.

If paving activities must take place during cold-weather construction as defined above, the project team should be consulted and a site meeting should be held to discuss ways to lessen low compaction risks.

6.4.9 Soil Amendment with Cement

6.4.9.1 General

As an alternative to the use of imported granular material or as an alternative to scarification and compaction during wet periods, an experienced contractor may be able to amend the on-site fine-grained soil with portland cement to obtain suitable support properties. It is generally less costly to amend on-site soil than to remove and replace soft soil with granular material. Based on the moisture contents, soil types, and processing speed, cement amendment would be more suitable at this site than lime amendment. The amount of cement used during treatment should be based on an assumed soil dry unit weight of 100 pcf.

6.4.9.2 Subbase Stabilization

Specific recommendations based on exposed site conditions for soil amending can be provided if necessary. However, for preliminary design purposes, we recommend a target strength for cement-amended subgrade for building and pavement subbase (below aggregate base) soil of 100 psi. The amount of cement used to achieve this target generally varies with moisture content and soil type. It is difficult to predict field performance of soil to cement amendment due to variability in soil response, and we recommend laboratory testing to confirm expectations. Generally, 6 percent cement by weight of dry soil can be used when the soil moisture content does not exceed approximately 20 percent. If the soil moisture content is in the range of 25 to 35 percent, 7 to 9 percent by weight of dry soil is recommended. The amount of cement added to the soil may need to be adjusted based on field observations and performance. Moreover, depending on the time of year and moisture content levels during amendment, water may need to be applied during tilling to appropriately condition the soil moisture content.

For pavement subbase, we recommend assuming a minimum cement ratio of 6 percent (by dry weight). If the soil moistures are in excess of 30 percent, a cement ratio of 7 to 8 percent will likely be needed. Due to the higher organic content and moisture, we recommend using a cement ratio of 8 percent when stabilizing topsoil (tilled) zone material for building and pavement subbase and anticipate that the cement will need to be applied in two 4 percent applications followed by multiple tilling passes with each application.

We recommend cement-spreading equipment be equipped with balloon tires to reduce rutting and disturbance of the fine-grained soil. A static sheepsfoot or segmented pad roller with a minimum static weight of 40,000 pounds should be used for initial compaction of the fine-grained soil. A smooth-drum roller with a minimum applied linear force of 700 pounds per inch should be used for final compaction. The amended soil should be compacted to at least 92 percent of the achievable dry density at the moisture content of the material, as defined in ASTM D1557.

A minimum curing time of four days is required between treatment and construction traffic access. Construction traffic should not be allowed on unprotected, cement-amended subgrade. To protect the cement-treated surfaces from abrasion or damage, the finished surface should be covered with 4 to 6 inches of imported granular material.

Treatment depths for building/pavement, haul roads, and staging areas are typically on the order of 12, 16, and 12 inches, respectively. The crushed rock typically becomes contaminated with soil during construction. Contaminated base rock should be removed and replaced with clean rock in pavement areas. The actual thickness of the amended material and imported granular material for haul roads and staging areas will depend on the anticipated traffic, as well as the contractor's means and methods and should be the contractor's responsibility.

Cement amending should not be attempted when air temperature is below 40 degrees Fahrenheit or during moderate to heavy precipitation. Cement should not be placed when the ground surface is saturated or standing water exists.

6.4.9.3 Cement-Amended Structural Fill

On-site soil that would not otherwise be suitable for structural fill may be amended and placed as fill over a subgrade prepared in conformance with the "Site Preparation" section. The cement ratio for general cement-amended fill can generally be reduced by 1 percent (by dry weight). Typically, a minimum curing of four days is required between treatment and construction traffic access. Consecutive lifts of fill may be treated immediately after the previous lift has been amended and compacted (e.g., the four-day wait period does not apply). However, where the final lift of fill is a building or roadway subgrade, the four-day wait period is in effect for the final lift of cement-amended soil.

6.4.9.4 Other Considerations

Portland cement-amended soil is hard and has low permeability. This soil does not drain well and it is not suitable for planting. Future planted areas should not be cement amended, if practical, or accommodations should be made for drainage and planting. Moreover, cement amending soil within building areas must be done carefully to avoid trapping water under floor slabs. We should be contacted if this approach is considered. Cement amendment should not be used if runoff during construction cannot be directed away from adjacent wetlands (if any).

7.0 OBSERVATION OF CONSTRUCTION

Satisfactory earthwork and foundation performance depends to a large degree on the quality of construction. Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions often requires experience; therefore, qualified personnel should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated. In addition, sufficient observation of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications.

8.0 LIMITATIONS

We have prepared this report for use by Compass Group, LLC and members of the design and construction teams for the proposed development. The data and report can be used for estimating purposes, but our report, conclusions, and interpretations should not be construed as a warranty of the subsurface conditions and are not applicable to other sites.

Soil explorations indicate soil conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect soil strata or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, re-evaluation will be necessary.

The site development plans and design details were not finalized at the time this report was prepared. When the design has been finalized and if there are changes in the site grades or location, configuration, design loads, or type of construction, the conclusions and recommendations presented may not be applicable. If design changes are made, we should be retained to review our conclusions and recommendations and to provide a written evaluation or modification.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

◆ ◆ ◆

We appreciate the opportunity to be of service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

GeoDesign, Inc.

Nick Paveglio, P.E.
Senior Associate Engineer

Brett A. Shipton, P.E.
Principal Engineer

NICHOLAS N. PAVEGLIO
STATE OF WASHINGTON
45872
REGISTERED
PROFESSIONAL ENGINEER

Signed 01/14/2019

REFERENCES

Clark County GIS, 2018. Website: http://gis.clark.wa.gov/imf/imf.jsp?site=digitalatlas.

International Building Code, 2015.

Palmer et al., 2004. Liquefaction Susceptibility of Clark County. Washington Division of Geology and Earth Resources Open File Report, 2004-20. September 2004.

Washington State Department of Transportation, 2018. Standard Specifications for Road, Bridge, and Municipal Construction, M41-10.

FIGURES

VICINITY MAP BASED ON AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO®

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

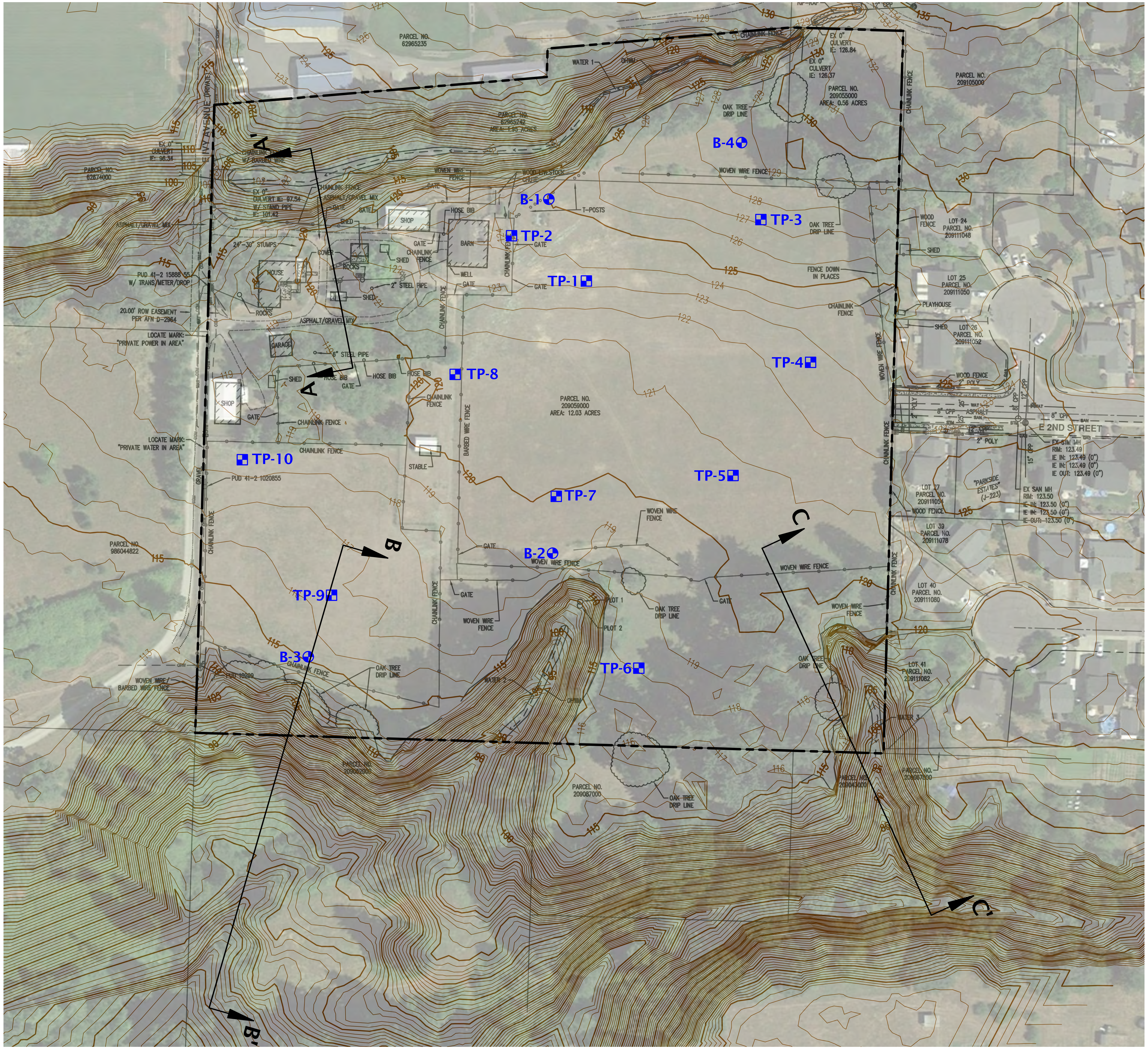
JANUARY 2019

VICINITY MAP

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE 1

Printed By: mmiller | Print Date: 1/9/2019 11:07:59 AM
File Name: J:\A-D\CompassGrp\CompassGrp-1\CompassGrp-1-01\Figures\CAD\CompassGrp-1-01-VM01.dwg | Layout: FIGURE 1



LEGEND:

▬ ▬ - ▬	SITE BOUNDARY
B-1◕	BORING
TP-1▚	TEST PIT
125	EXISTING TOPOGRAPHY (1-FOOT INTERVALS; 5-FOOT INDEX CONTOURS)
A A'	CROSS SECTION

N

0 120 240

(SCALE IN FEET)

NOTES:

1. SITE PLAN BASED ON DRAWING FROM AKS ENGINEERING & FORESTRY, LLC JANUARY 3, 2019.
2. AERIAL IMAGE OBTAINED FROM GOOGLE EARTH PRO JANUARY 7, 2019.

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

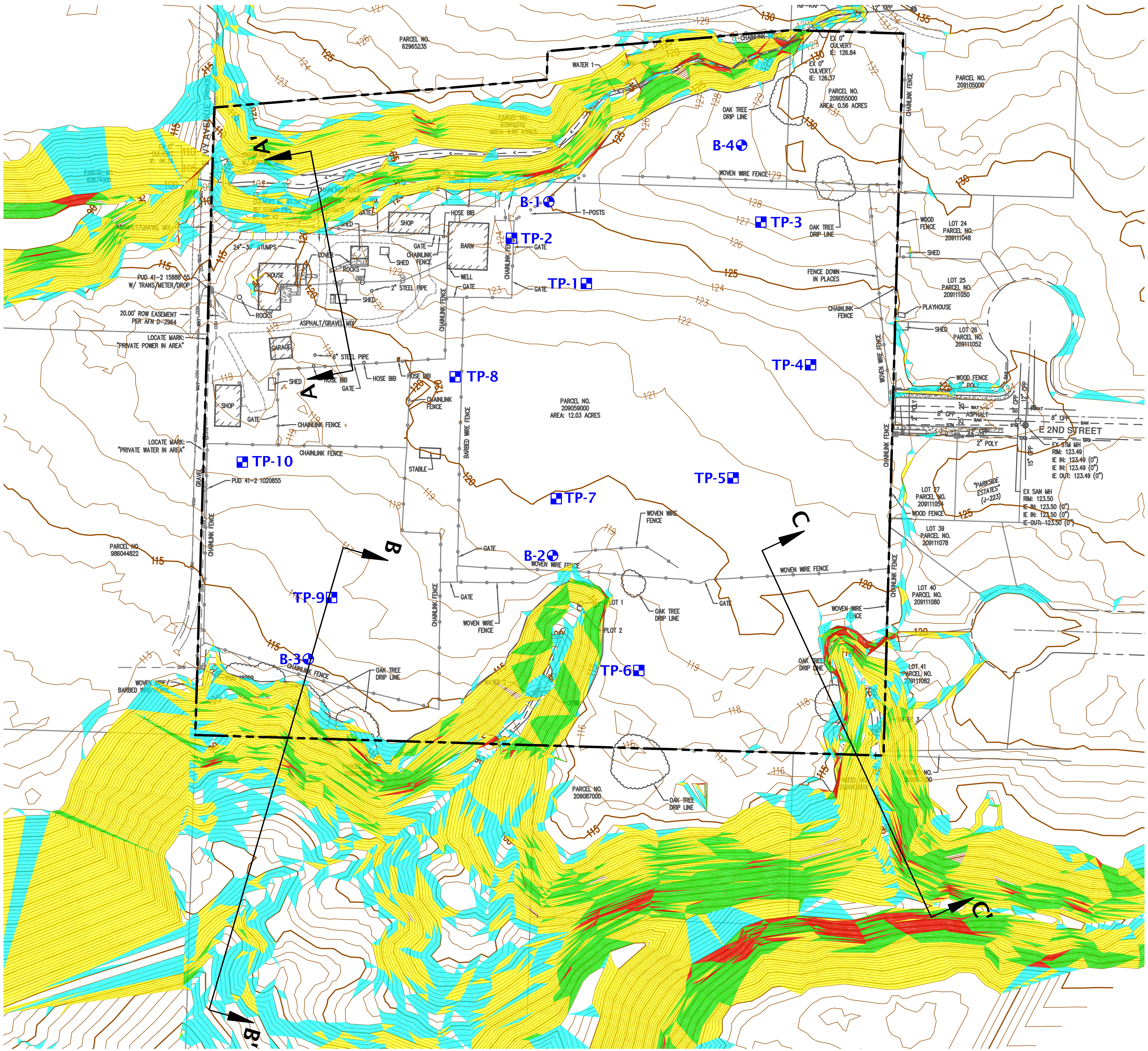
JANUARY 2019

SITE PLAN

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE 2

Printed By: aday | Print Date: 1/11/2019 2:46:05 PM
File Name: J:\A-D\CompassGrp\CompassGrp-1\CompassGrp-1-01\Figures\CAD\CompassGrp-1-01-SP01.dwg | Layout: FIGURE 2



LEGEND:

SITE BOUNDARY

B-1 ◐ BORING

TP-1 ▨ TEST PIT

125 EXISTING TOPOGRAPHY (1-FOOT INTERVALS; 5-FOOT INDEX CONTOURS)

A A' CROSS SECTION

SLOPES TABLE		
COLOR	MINIMUM SLOPE	MAXIMUM SLOPE
🟦	15%	24.9%
🟨	25%	49.9%
🟩	50%	74.9%
🟥	75%	>75%

N

0 120 240

(SCALE IN FEET)

NOTE:

1. SITE PLAN BASED ON DRAWING FROM AKS ENGINEERING & FORESTRY, LLC JANUARY 3, 2019.

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

SITE PLAN - SLOPE PERCENTAGE

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE 3

Printed By: aday | Print Date: 1/11/2019 4:17:50 PM
File Name: J:\A-D\CompassGrp\CompassGrp-1\CompassGrp-1-01\Figures\CAD\CompassGrp-1-01-SP01.dwg | Layout: FIGURE 3

APPENDIX A

APPENDIX A

FIELD EXPLORATIONS

We explored subsurface conditions at the site by drilling three borings (B-1 through B-3) and excavating 10 test pits (TP-1 through TP-10). The borings were drilled to depths between 34.7 and 46.4 feet BGS, and the test pits were excavated to depths between 16.0 and 18.0 feet BGS. Drilling services were provided by Dan Fisher Excavating, Inc. of Forest Grove, Oregon. Excavation services were provided by Tapani Underground, Inc. of Battle Ground, Washington. The exploration logs are presented in this appendix.

The locations of the explorations are shown on Figure 2. Locations were determined in the field by pacing and taping from existing site features. This information should be considered accurate only to the degree implied by the methods used.

A member of our geotechnical staff observed the explorations. We collected representative samples of the various soils encountered in the explorations for geotechnical laboratory testing.

SOIL SAMPLING

Samples were collected from the borings using 1½-inch-diameter split-spoon SPT samplers in general accordance with ASTM D1586. The samplers were driven into the soil with a 140-pound automatic trip hammer free-falling 30 inches. The sampler was driven a total distance of 18 inches. The number of blows required to drive the sampler the final 12 inches is recorded on the exploration logs, unless otherwise noted. Disturbed samples of the soil observed in the test pits were collected from the walls or base of the test pits using the excavator bucket. Sampling methods and intervals are shown on the exploration logs.

SOIL CLASSIFICATION

The soil samples were classified in accordance with the “Exploration Key” (Table A-1) and “Soil Classification System” (Table A-2), which are presented in this appendix. The exploration logs indicate the depths at which the soils or their characteristics change, although the change actually could be gradual. If the change occurred between sample locations, the depth was interpreted. Classifications are shown on the exploration logs.

LABORATORY TESTING

CLASSIFICATION

The soil samples were classified in the laboratory to confirm field classifications. The laboratory classifications are included on the exploration logs if those classifications differed from the field classifications.

MOISTURE CONTENT

We tested the natural moisture content of select soil samples in general accordance with ASTM D2216. The test results are presented in this appendix.

PARTICLE-SIZE ANALYSIS

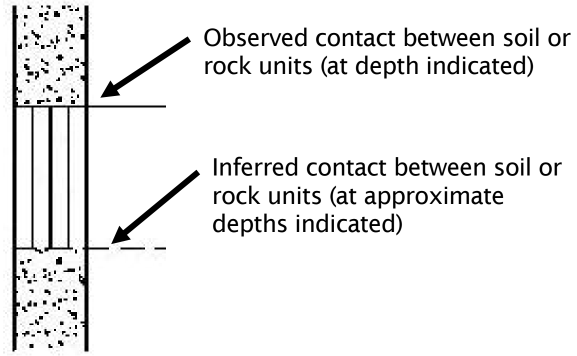
We completed particle-size analysis on select soil samples in order to determine the distribution of soil particle sizes. The testing consisted percent fines determination (percent passing the U.S. Standard No. 200 sieve) analyses completed in general accordance with ASTM C117 or ASTM D1140.

ATTERBERG LIMITS

The plastic limit and liquid limit (Atterberg limits) of select soil samples were determined in accordance with ASTM D4318. The Atterberg limits and the plasticity index were completed to aid in the classification of the soil. The test results are presented in this appendix.

SYMBOL	SAMPLING DESCRIPTION
◧	Location of sample obtained in general accordance with ASTM D 1586 Standard Penetration Test with recovery
◧	Location of sample obtained using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D 1587 with recovery
◧	Location of sample obtained using Dames & Moore sampler and 300-pound hammer or pushed with recovery
◧	Location of sample obtained using Dames & Moore and 140-pound hammer or pushed with recovery
◧	Location of sample obtained using 3-inch-O.D. California split-spoon sampler and 140-pound hammer
☒	Location of grab sample
▮	Rock coring interval
▽	Water level during drilling
▼	Water level taken on date shown

Graphic Log of Soil and Rock Types



Observed contact between soil or rock units (at depth indicated)

Inferred contact between soil or rock units (at approximate depths indicated)

GEOTECHNICAL TESTING EXPLANATIONS

ATT	Atterberg Limits	P	Pushed Sample
CBR	California Bearing Ratio	PP	Pocket Penetrometer
CON	Consolidation	P200	Percent Passing U.S. Standard No. 200 Sieve
DD	Dry Density		
DS	Direct Shear	RES	Resilient Modulus
HYD	Hydrometer Gradation	SIEV	Sieve Gradation
MC	Moisture Content	TOR	Torvane
MD	Moisture-Density Relationship	UC	Unconfined Compressive Strength
NP	Nonplastic	VS	Vane Shear
OC	Organic Content	kPa	Kilopascal

ENVIRONMENTAL TESTING EXPLANATIONS

CA	Sample Submitted for Chemical Analysis	ND	Not Detected
P	Pushed Sample	NS	No Visible Sheen
PID	Photoionization Detector Headspace Analysis	SS	Slight Sheen
		MS	Moderate Sheen
ppm	Parts per Million	HS	Heavy Sheen

EXPLORATION KEY

TABLE A-1

RELATIVE DENSITY - COARSE-GRAINED SOIL

Relative Density	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)
Very Loose	0 – 4	0 - 11	0 - 4
Loose	4 – 10	11 - 26	4 - 10
Medium Dense	10 – 30	26 - 74	10 - 30
Dense	30 – 50	74 - 120	30 - 47
Very Dense	More than 50	More than 120	More than 47

CONSISTENCY - FINE-GRAINED SOIL

Consistency	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)	Unconfined Compressive Strength (tsf)
Very Soft	Less than 2	Less than 3	Less than 2	Less than 0.25
Soft	2 - 4	3 – 6	2 - 5	0.25 - 0.50
Medium Stiff	4 - 8	6 – 12	5 - 9	0.50 - 1.0
Stiff	8 - 15	12 – 25	9 - 19	1.0 - 2.0
Very Stiff	15 - 30	25 – 65	19 – 31	2.0 - 4.0
Hard	More than 30	More than 65	More than 31	More than 4.0

PRIMARY SOIL DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOIL (more than 50% retained on No. 200 sieve)	GRAVEL (more than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (< 5% fines)	GW or GP	GRAVEL
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)	GW-GM or GP-GM	GRAVEL with silt
			GW-GC or GP-GC	GRAVEL with clay
		GRAVEL WITH FINES (> 12% fines)	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SAND (<5% fines)	SW or SP	SAND
		SAND WITH FINES (≥ 5% and ≤ 12% fines)	SW-SM or SP-SM	SAND with silt
			SW-SC or SP-SC	SAND with clay
		SAND WITH FINES (> 12% fines)	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOIL (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50	ML	SILT
			CL	CLAY
			CL-ML	silty CLAY
			OL	ORGANIC SILT or ORGANIC CLAY
		Liquid limit 50 or greater	MH	SILT
			CH	CLAY
			OH	ORGANIC SILT or ORGANIC CLAY
HIGHLY ORGANIC SOIL			PT	PEAT

MOISTURE CLASSIFICATION

Term	Field Test
dry	very low moisture, dry to touch
moist	damp, without visible moisture
wet	visible free water, usually saturated

ADDITIONAL CONSTITUENTS

Secondary granular components or other materials such as organics, man-made debris, etc.					
Percent	Silt and Clay In:		Percent	Sand and Gravel In:	
	Fine-Grained Soil	Coarse-Grained Soil		Fine-Grained Soil	Coarse-Grained Soil
< 5	trace	trace	< 5	trace	trace
5 – 12	minor	with	5 – 15	minor	minor
> 12	some	silty/clayey	15 – 30	with	with
			> 30	sandy/gravelly	Indicate %

SOIL CLASSIFICATION SYSTEM

TABLE A-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	▲ BLOW COUNT	● MOISTURE CONTENT %	INSTALLATION AND COMMENTS
0.0	Medium stiff, brown SILT with sand (ML); moist.					
2.5				7		
5.0	stiff at 5.0 feet		ATT	14	●	LL = 45% PL = 26%
7.5	medium stiff at 7.5 feet			6		
10.0	Stiff, brown with gray mottled CLAY (CL), minor sand; moist.	10.0		3		
12.5						
15.0	Medium stiff, brown with orange mottled, sandy SILT (ML); moist.	15.0		5		
17.5						
20.0			P200	7	●	P200 = 68%
22.5						
25.0	Very stiff, dark gray CLAY (CL), minor sand; moist.	25.0		24		
27.5						
30.0						

▥ RQD% ▨ CORE REC%

0 50 100

DRILLED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/12/18

BORING METHOD: solid-stem auger (see document text)

BORING BIT DIAMETER: 4 inches

GEODESIGN INC

703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

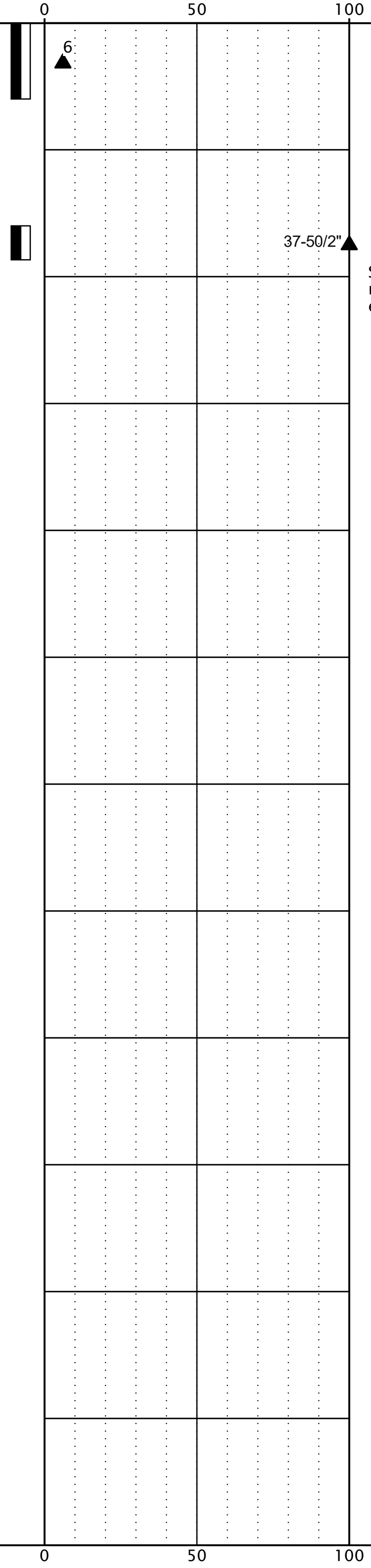
BORING B-1

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-1

BORING LOG COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % ▥ RQD% ▨ CORE REC%	INSTALLATION AND COMMENTS
30.0		medium stiff at 30.0 feet				6	
32.5							
		Very dense, gray with yellow mottled, clayey GRAVEL with sand (GC); moist to wet.	33.0			37-50/2"	
		Exploration terminated at a depth of 34.7 feet due to auger refusal. Hammer efficiency factor is unknown. SPT completed using two wraps with a cathead.	34.7				Surface elevation was not measured at the time of exploration.
35.0							
37.5							
40.0							
42.5							
45.0							
47.5							
50.0							
52.5							
55.0							
57.5							
60.0							



DRILLED BY: Dan J. Fischer Excavating, Inc.
LOGGED BY: Z. Rogers
COMPLETED: 12/12/18

BORING METHOD: solid-stem auger (see document text)
BORING BIT DIAMETER: 4 inches

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

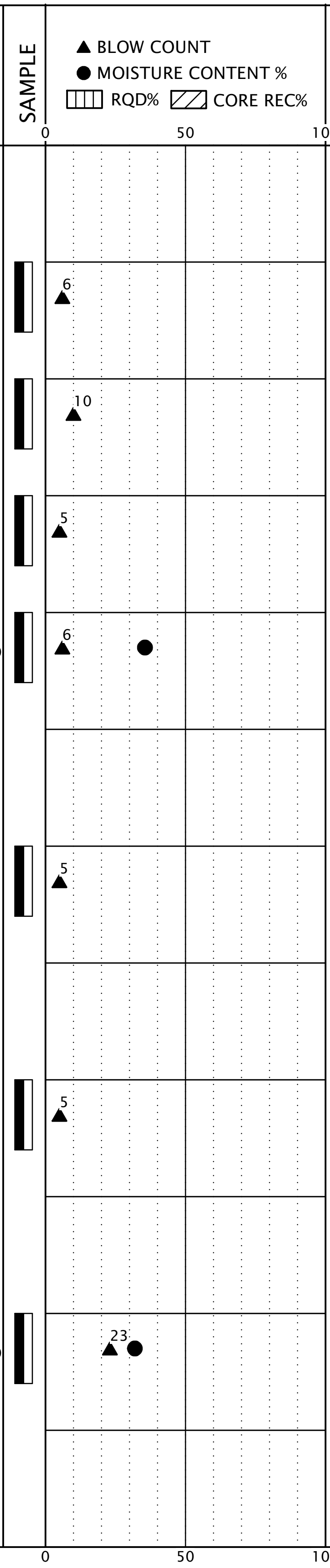
JANUARY 2019

BORING B-1
(continued)

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-1

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	▲ BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Medium stiff, brown with gray mottled SILT with sand (ML); moist.				
2.5				6	
5.0	Loose to medium dense, brown with gray-black mottled SAND with silt (SP-SM); moist.	5.0		10	
7.5	Medium stiff, brown with gray mottled, sandy SILT (ML); moist.	7.5		5	
10.0	brown with orange mottles at 10.0 feet		P200	6	P200 = 71%
12.5					
15.0				5	
17.5					
20.0				5	
22.5					
25.0	Medium dense, dark gray, silty SAND (SM); wet.	25.0	P200	23	P200 = 42%
27.5					
30.0					



DRILLED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/12/18

BORING METHOD: solid-stem auger (see document text)

BORING BIT DIAMETER: 4 inches

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

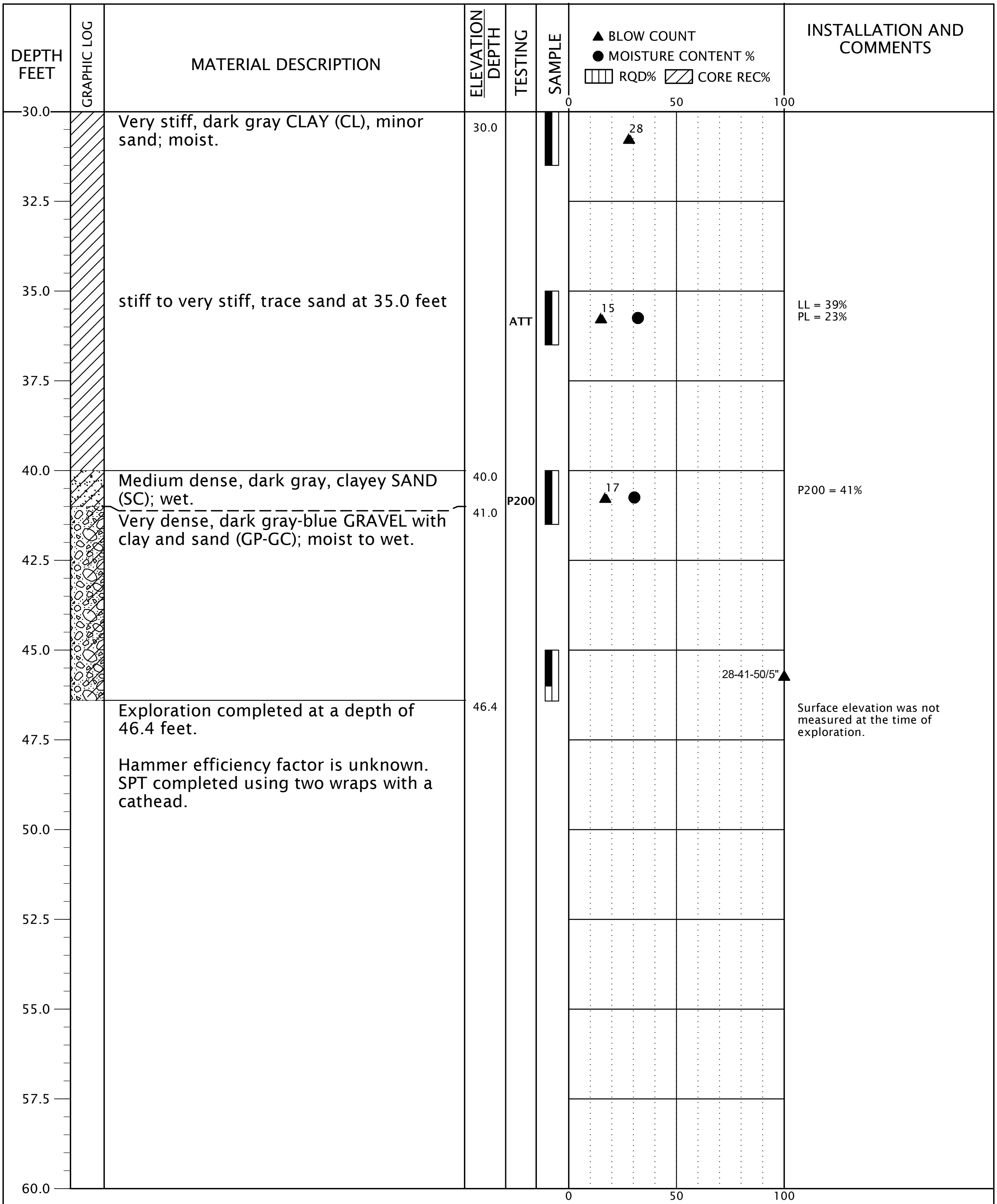
JANUARY 2019

BORING B-2

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-2

BORING LOG COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT



DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	▲ BLOW COUNT	INSTALLATION AND COMMENTS
30.0	Very stiff, dark gray CLAY (CL), minor sand; moist.	30.0		28	
35.0	stiff to very stiff, trace sand at 35.0 feet		ATT	15	LL = 39% PL = 23%
40.0	Medium dense, dark gray, clayey SAND (SC); wet.	40.0	P200	17	P200 = 41%
	Very dense, dark gray-blue GRAVEL with clay and sand (GP-GC); moist to wet.	41.0			
45.0				28-41-50/5"	
	Exploration completed at a depth of 46.4 feet. Hammer efficiency factor is unknown. SPT completed using two wraps with a cathead.	46.4			Surface elevation was not measured at the time of exploration.

DRILLED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: Z. Rogers COMPLETED: 12/12/18

BORING METHOD: solid-stem auger (see document text) BORING BIT DIAMETER: 4 inches

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

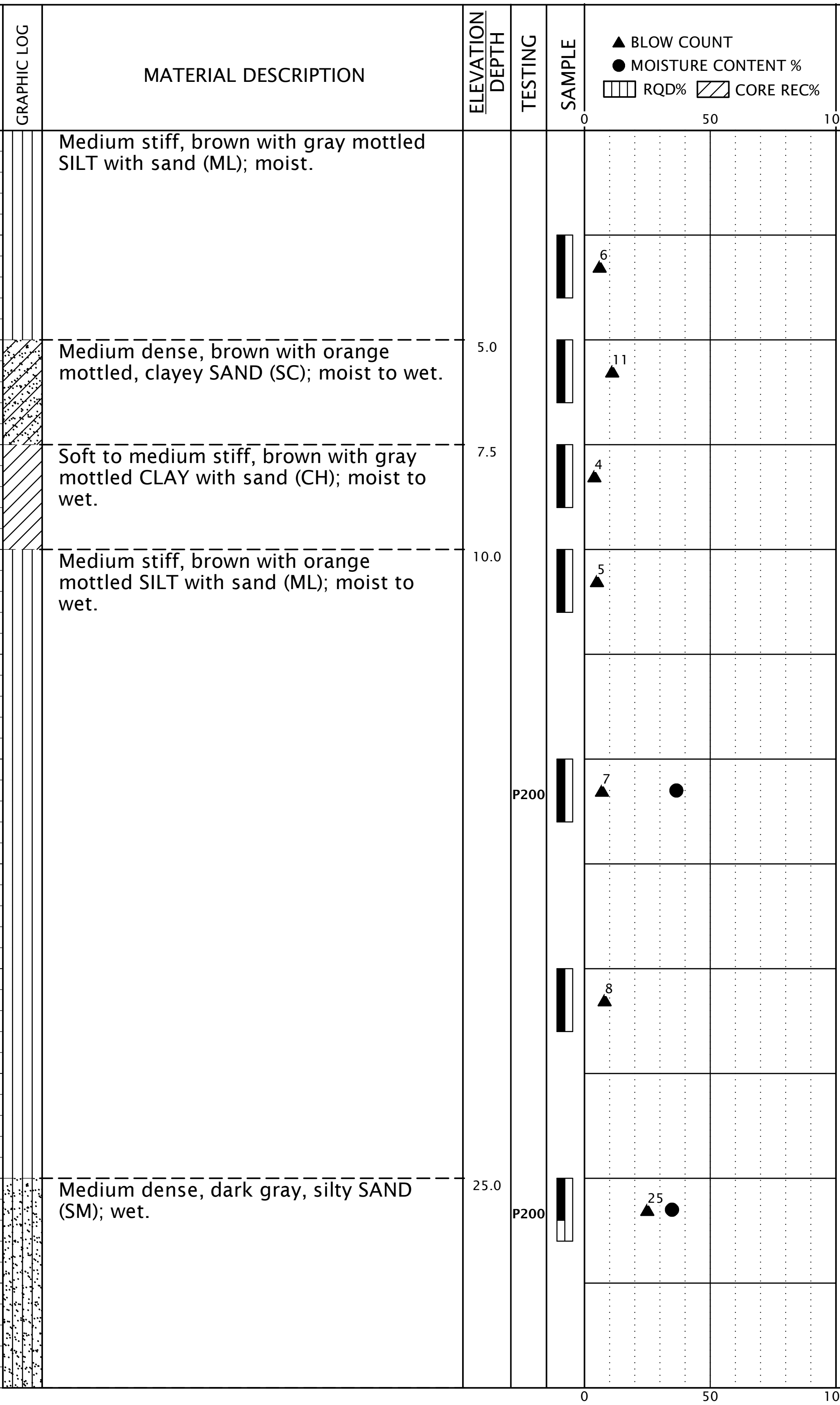
BORING B-2
(continued)

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-2

BORING LOG COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	INSTALLATION AND COMMENTS
0.0	Medium stiff, brown with gray mottled SILT with sand (ML); moist.			
5.0	Medium dense, brown with orange mottled, clayey SAND (SC); moist to wet.	5.0		
7.5	Soft to medium stiff, brown with gray mottled CLAY with sand (CH); moist to wet.	7.5		
10.0	Medium stiff, brown with orange mottled SILT with sand (ML); moist to wet.	10.0		
15.0			P200	P200 = 73%
25.0	Medium dense, dark gray, silty SAND (SM); wet.	25.0	P200	P200 = 40%
30.0				



DRILLED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/12/18

BORING METHOD: solid-stem auger (see document text)

BORING BIT DIAMETER: 4 inches

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

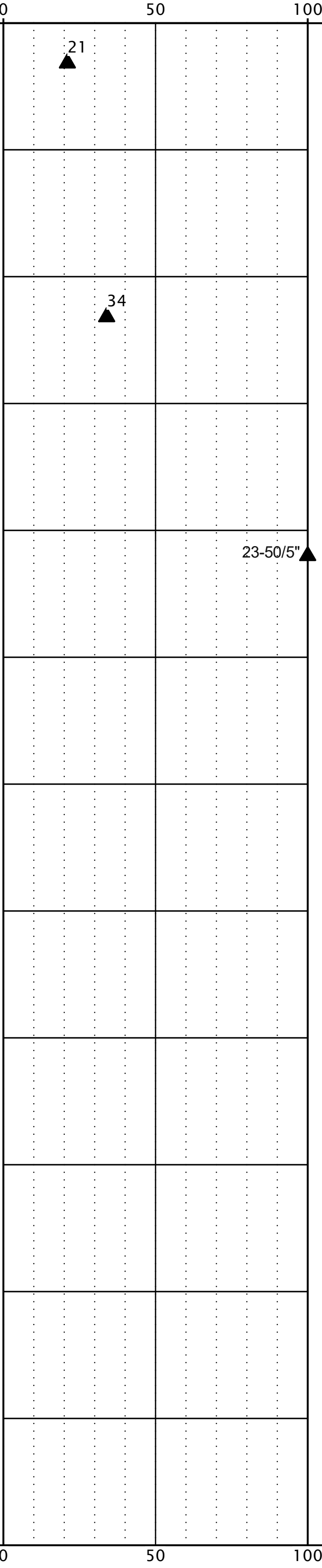
BORING B-3

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-3

BORING LOG COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % ▥ RQD% ▨ CORE REC%	INSTALLATION AND COMMENTS
30.0	Very stiff, gray CLAY with sand (CL); moist.	30.0		▮	21	
35.0	hard, dark gray at 35.0 feet			▮	34	
40.0	Very dense, dark gray GRAVEL with sand and silt (GP-GM); wet.	40.0		▮	23-50/5"	Surface elevation was not measured at the time of exploration.
	Exploration completed at a depth of 40.9 feet. Hammer efficiency factor is unknown. SPT completed using two wraps with a cathead.	40.9				



DEPTH FEET: 30.0, 32.5, 35.0, 37.5, 40.0, 42.5, 45.0, 47.5, 50.0, 52.5, 55.0, 57.5, 60.0

DRILLED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: Z. Rogers COMPLETED: 12/12/18

BORING METHOD: solid-stem auger (see document text) BORING BIT DIAMETER: 4 inches

GEODESIGN INC 703 Broadway Street - Suite 650 Vancouver WA 98660 360.693.8416 www.geodesigninc.com	COMPASSGRP-1-01	**BORING B-3** (continued)	
	JANUARY 2019	HOLLEY PARK SUBDIVISION LA CENTER, WA	**FIGURE A-3**

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % 0 50 100	COMMENTS
0.0		Soft, brown SILT (ML), minor sand and organics; moist (24-inch-thick tilled zone, 5-inch-thick root zone).		PP			PP = 0.25 tsf
2.5		without organics at 2.0 feet		P200	☒	●	P200 = 91%
				PP			PP = 0.25 tsf
5.0							
7.5							
		medium stiff, brown with orange and gray mottles, sandy at 8.0 feet		PP	☒		PP = 0.75 tsf
10.0							
12.5							
		Medium dense, brown with orange mottled, silty SAND (SM); moist.	13.0				
					☒		Slow groundwater seepage observed at 14.0 feet.
15.0					☒		
		Exploration completed at a depth of 17.0 feet.	17.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
17.5							
20.0							
22.5							
25.0							
27.5							
30.0						0 50 100	

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

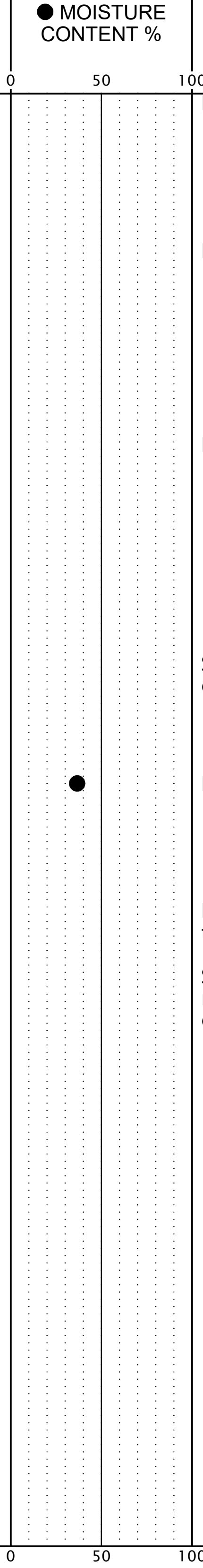
COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-1

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-4



DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	COMMENTS
0.0	Soft, brown SILT (ML), minor sand and organics; moist, sand is fine (12-inch-thick tilled zone, 6-inch-thick root zone).		PP		PP = 0.25 tsf
2.5	very stiff, brown with gray mottles, without organics at 2.5 feet		PP	☒	PP = 3.0 tsf
7.0	soft, sandy at 7.0 feet		PP	☒	PP = 0.5 tsf
12.0					Slow groundwater seepage observed at 12.0 feet.
14.0	Medium dense, brown with orange mottled, silty SAND (SM); moist.	14.0	P200	☒	P200 = 40%
17.0	Exploration completed at a depth of 17.0 feet.	17.0			No groundwater seepage observed to the depth explored. Surface elevation was not measured at the time of exploration.

EXCAVATED BY: Tapani, Inc.
LOGGED BY: Z. Rogers
COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-2

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-5

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0	Soft, brown SILT (ML), minor sand and organics; moist (30-inch-thick tilled zone, 12-inch-thick root zone).		PP			PP = 0.25 tsf
			PP	☒		PP = 0.25 tsf
2.5	very stiff, brown with gray-orange mottles, without organics at 2.5 feet		PP	☒		PP = 3.5 tsf
5.0						
7.5						
10.0						
12.5	sandy at 12.0 feet		P200	☒	●	P200 = 68% Slow groundwater seepage observed at 13.0 feet.
	Medium dense, brown-orange, silty SAND (SM); moist.	13.5		☒		
15.0	brown-dark gray at 15.0 feet					
17.5	Exploration completed at a depth of 17.0 feet.	17.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
20.0						
22.5						
25.0						
27.5						
30.0					0 50 100	

EXCAVATED BY: Tapani, Inc. LOGGED BY: Z. Rogers COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-3

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-6

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Very soft, brown SILT with sand and organics (ML); moist (12-inch-thick tilled zone, 6-inch-thick root zone).		PP			PP = 0.25 tsf
		medium stiff to stiff, gray with orange mottles, without organics at 1.0 foot		PP	☒		PP = 1.0 tsf
12.0		Medium dense, brown with orange mottled, silty SAND (SM); moist.	12.0		☒		Slow groundwater seepage observed at 12.0 feet.
15.0		dark gray at 15.0 feet			☒		
18.0		Exploration completed at a depth of 18.0 feet.	18.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

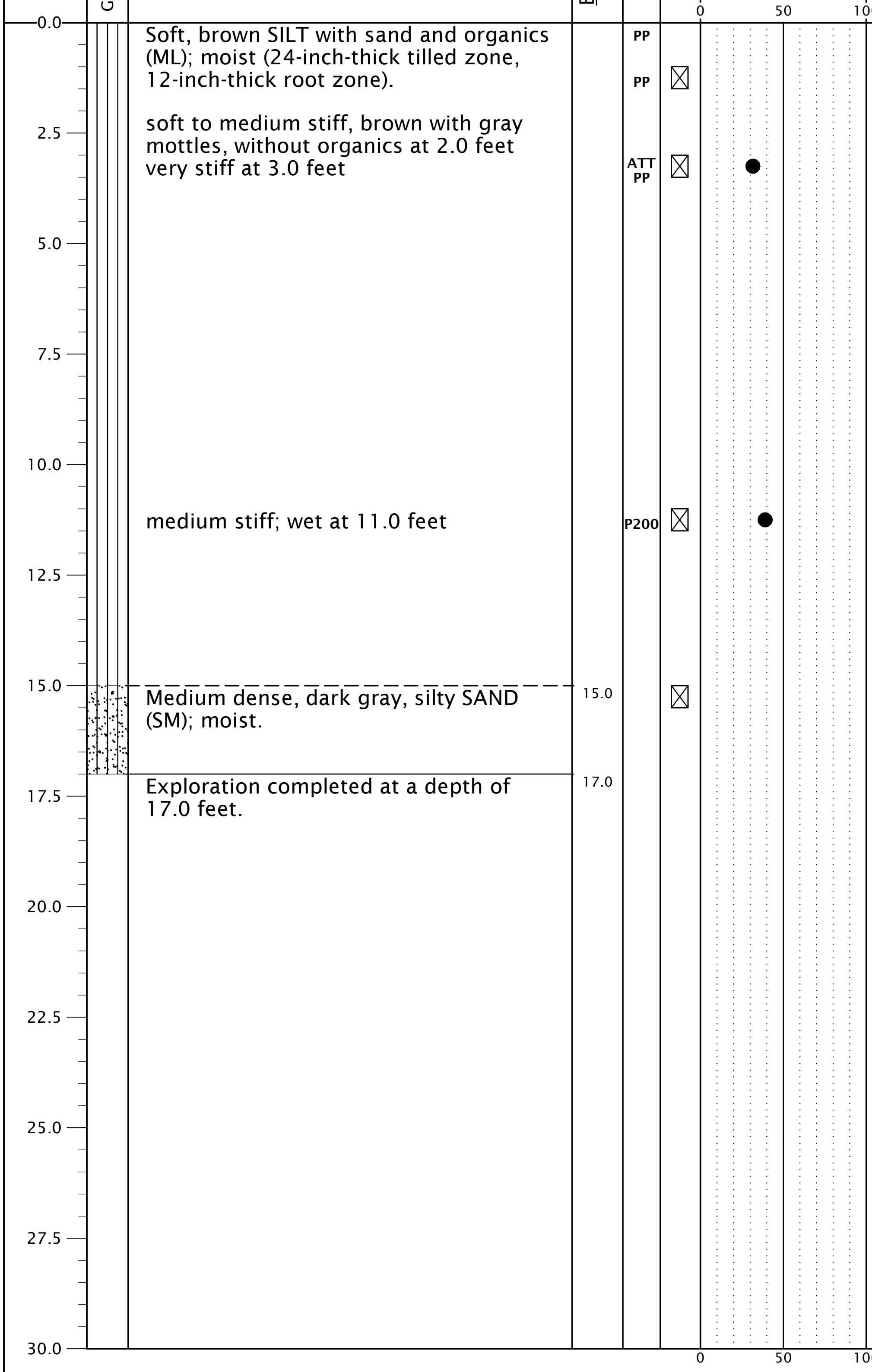
JANUARY 2019

TEST PIT TP-4

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-7

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT %	COMMENTS
0.0		Soft, brown SILT with sand and organics (ML); moist (24-inch-thick tilled zone, 12-inch-thick root zone).		PP			PP = 0.25 tsf
				PP	☒		PP = 1.0 tsf
2.5		soft to medium stiff, brown with gray mottles, without organics at 2.0 feet very stiff at 3.0 feet		ATT PP	☒	●	PP = 2.75 tsf LL = 49% PL = 25%
		medium stiff; wet at 11.0 feet		P200	☒	●	Groundwater seepage observed at 11.0 feet. P200 = 54%
15.0		Medium dense, dark gray, silty SAND (SM); moist.	15.0		☒		
17.5		Exploration completed at a depth of 17.0 feet.	17.0				No caving was observed to the depth explored. Surface elevation was not measured at the time of exploration.



EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-5

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-8

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0	Soft, brown SILT with sand and organics (ML); moist, sand is fine (12-inch-thick tilled zone, 6-inch-thick root zone). brown with gray mottles, without organics at 1.0 foot		PP			PP = 0.25 tsf
2.5			PP	☒		PP = 0.25 tsf
						Slow groundwater seepage observed at 4.0 feet. Minor caving observed at 4.0 feet.
5.0	medium stiff at 5.0 feet					
10.0			P200	☒	●	P200 = 94%
15.0				☒		
17.5	Exploration completed at a depth of 17.0 feet.	17.0				Surface elevation was not measured at the time of exploration.

EXCAVATED BY: Tapani, Inc.　LOGGED BY: Z. Rogers　COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-6

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-9

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % 0 50 100	COMMENTS
0.0		Very soft, brown SILT with sand and organics (ML); moist (12-inch-thick tilled zone, 6-inch-thick root zone). medium stiff to stiff, brown with gray-orange mottles, without organics at 1.0 foot					
2.5				PP	☒		PP = 1.0 tsf
5.0							
7.5					☒		
10.0				PP	☒		PP = 0.75 tsf
12.5							
		Medium dense, light brown, silty SAND (SM); moist. orange at 14.0 feet	13.0		☒		Slow groundwater seepage observed at 13.0 feet.
15.0							
17.5							
		Exploration completed at a depth of 18.0 feet.	18.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
20.0							
22.5							
25.0							
27.5							
30.0						0 50 100	

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

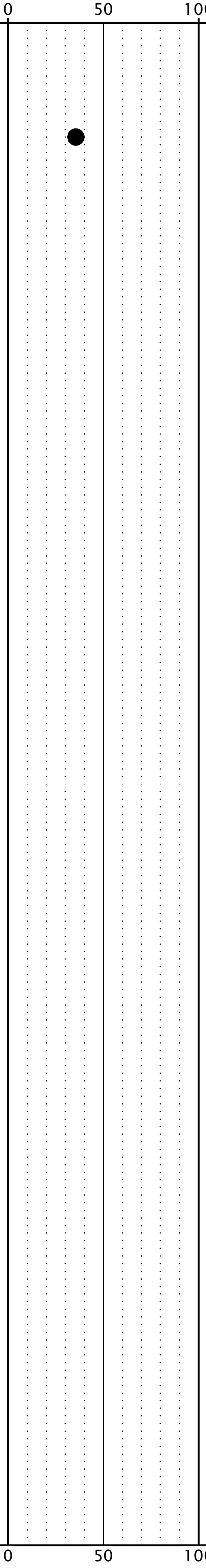
TEST PIT TP-7

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-10

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Soft, brown SILT with sand and organics (ML); moist, sand is fine (24-inch-thick tilled zone, 12-inch-thick root zone).		PP			PP = 0.25 tsf
2.5		without organics at 2.0 feet		P200 PP	☒	●	P200 = 85% PP = 2.0 tsf
5.0							
7.5							
10.0							
					☒		Slow groundwater seepage observed at 11.0 feet.
12.5							
		Medium dense, light brown-gray SAND with silt (SP-SM); moist.	14.0		☒		
15.0							
17.5							
		Exploration completed at a depth of 18.0 feet.	18.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
20.0							
22.5							
25.0							
27.5							
30.0							



EXCAVATED BY: Tapani, Inc. LOGGED BY: Z. Rogers COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-8

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-11

TEST PIT LOG - 1 PER PAGE COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KM:KT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0	Very soft, brown SILT with sand and organics (ML); moist, sand is fine (24-inch-thick tilled zone, 12-inch-thick root zone).		PP			PP = 0.25 tsf
2.5	soft to medium stiff, gray with orange mottles, without organics at 2.0 feet		PP	☒		PP = 6.5 tsf
	brown, sandy at 9.0 feet			☒		
10.0			P200	☒	●	Slow groundwater seepage observed at 10.0 feet. P200 = 62%
15.0	Medium dense, brown with orange mottled, silty SAND (SM); moist.	15.0		☒		
	Exploration completed at a depth of 16.0 feet.	16.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

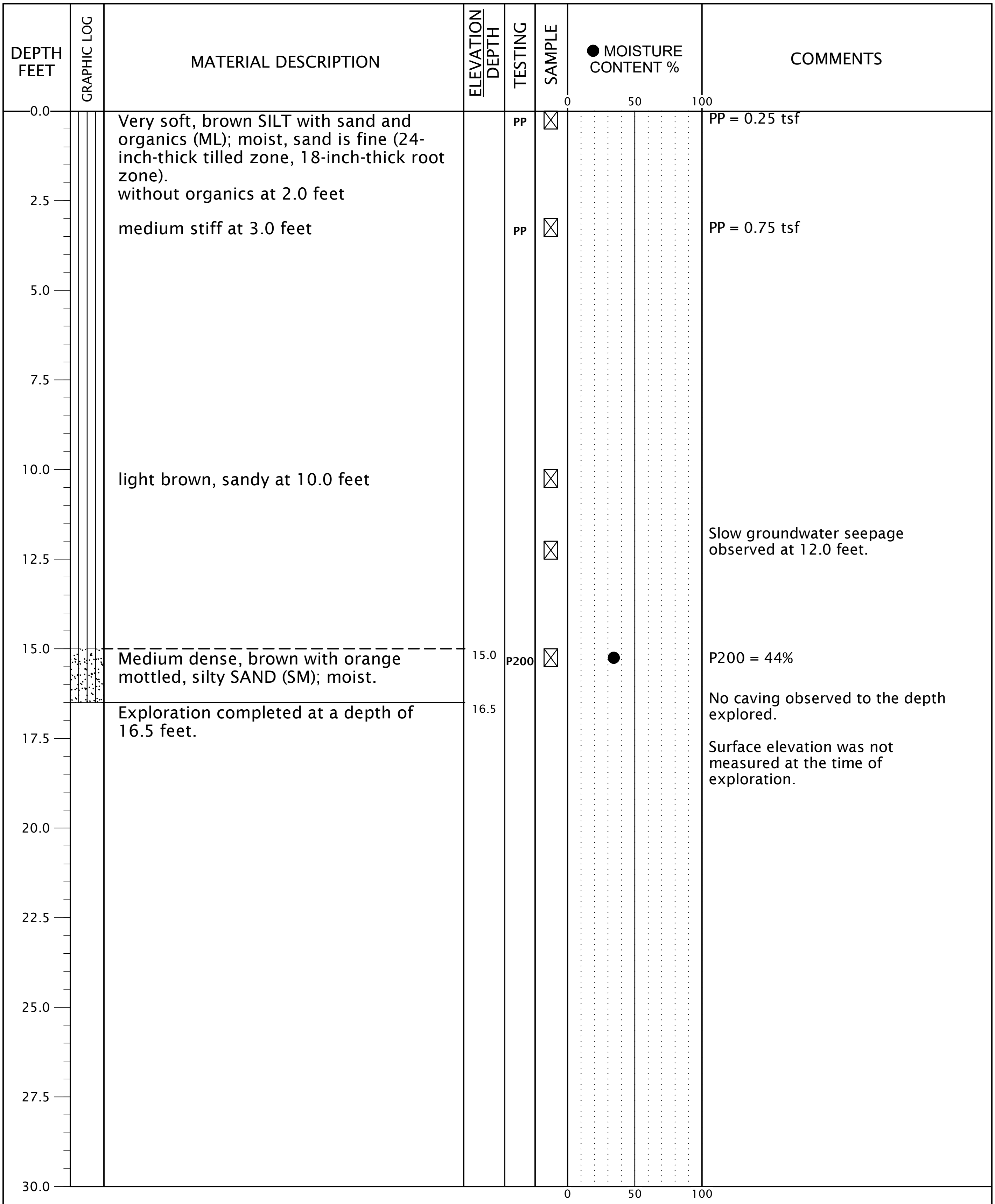
COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-9

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-12



DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0–100)	COMMENTS
0.0	Very soft, brown SILT with sand and organics (ML); moist, sand is fine (24-inch-thick tilled zone, 18-inch-thick root zone).		PP	☒		PP = 0.25 tsf
	without organics at 2.0 feet					
	medium stiff at 3.0 feet		PP	☒		PP = 0.75 tsf
10.0	light brown, sandy at 10.0 feet			☒		
12.5				☒		Slow groundwater seepage observed at 12.0 feet.
15.0	Medium dense, brown with orange mottled, silty SAND (SM); moist.	15.0	P200	☒	●	P200 = 44%
	Exploration completed at a depth of 16.5 feet.	16.5				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.

EXCAVATED BY: Tapani, Inc.

LOGGED BY: Z. Rogers

COMPLETED: 12/13/18

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

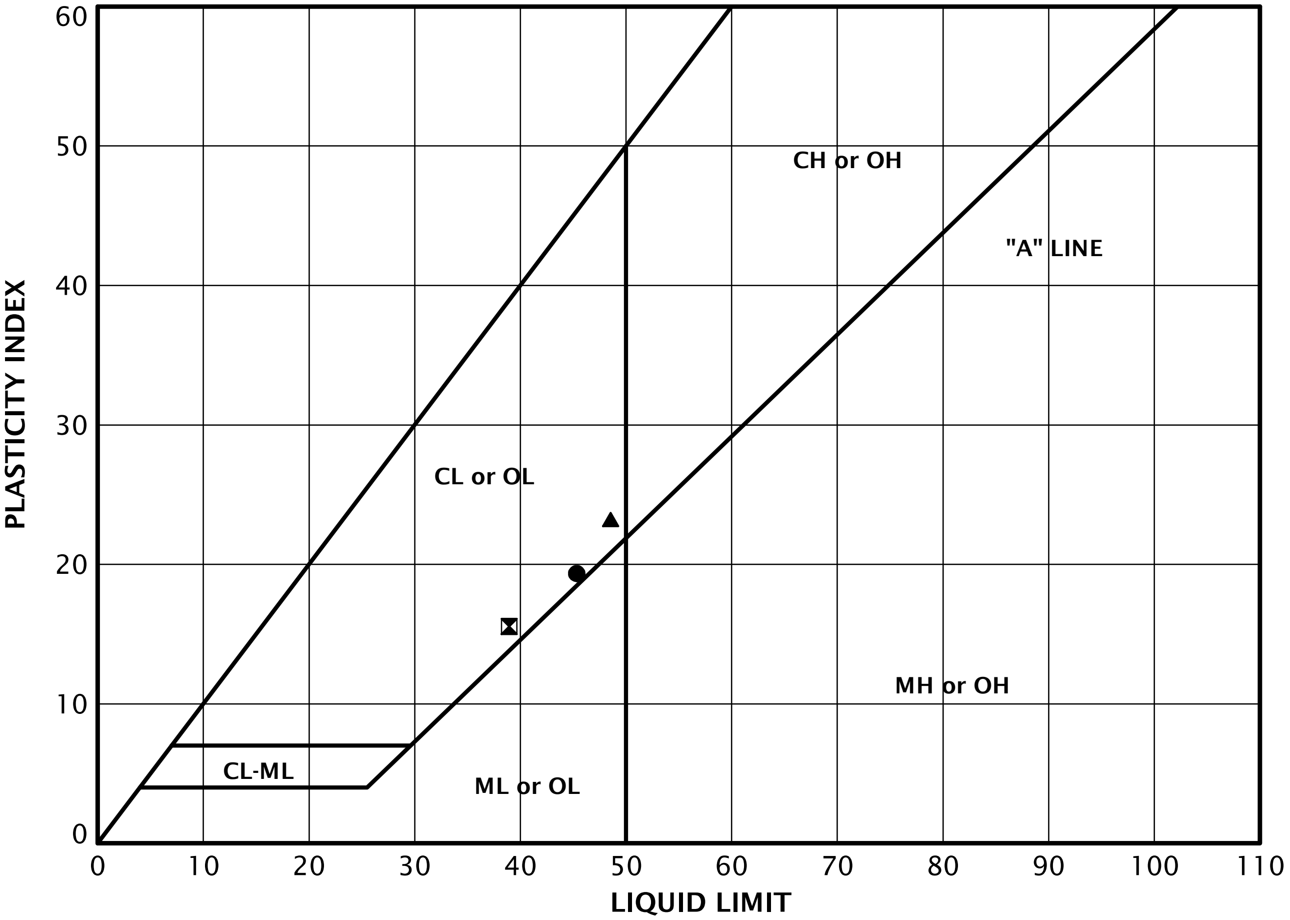
COMPASSGRP-1-01

JANUARY 2019

TEST PIT TP-10

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-13



KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
●	B-1	5.0	32	45	26	19
☒	B-2	35.0	32	39	23	16
▲	TP-5	3.0	32	49	25	24

GEODESIGN INC

703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

ATTERBERG LIMITS TEST RESULTS

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-14

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
B-1	5.0		32					45	26	19
B-1	20.0		33				68			
B-2	10.0		36				71			
B-2	25.0		32				42			
B-2	35.0		32					39	23	16
B-2	40.0		30				41			
B-3	15.0		37				73			
B-3	25.0		35				40			
TP-1	2.0		39				91			
TP-2	14.0		37				40			
TP-3	12.0		40				68			
TP-5	3.0		32					49	25	24
TP-5	11.0		39				54			
TP-6	10.0		40				94			
TP-8	2.0		36				85			
TP-9	10.0		34				62			
TP-10	15.0		34				44			

LAB SUMMARY COMPASSGRP-1-01-B1_3-TP1_10.GPJ GEODESIGN.GDT PRINT DATE: 1/11/19:KT

GEODESIGN INC
703 Broadway Street - Suite 650
Vancouver WA 98660
360.693.8416 www.geodesigninc.com

COMPASSGRP-1-01

JANUARY 2019

SUMMARY OF LABORATORY DATA

HOLLEY PARK SUBDIVISION
LA CENTER, WA

FIGURE A-15

APPENDIX B

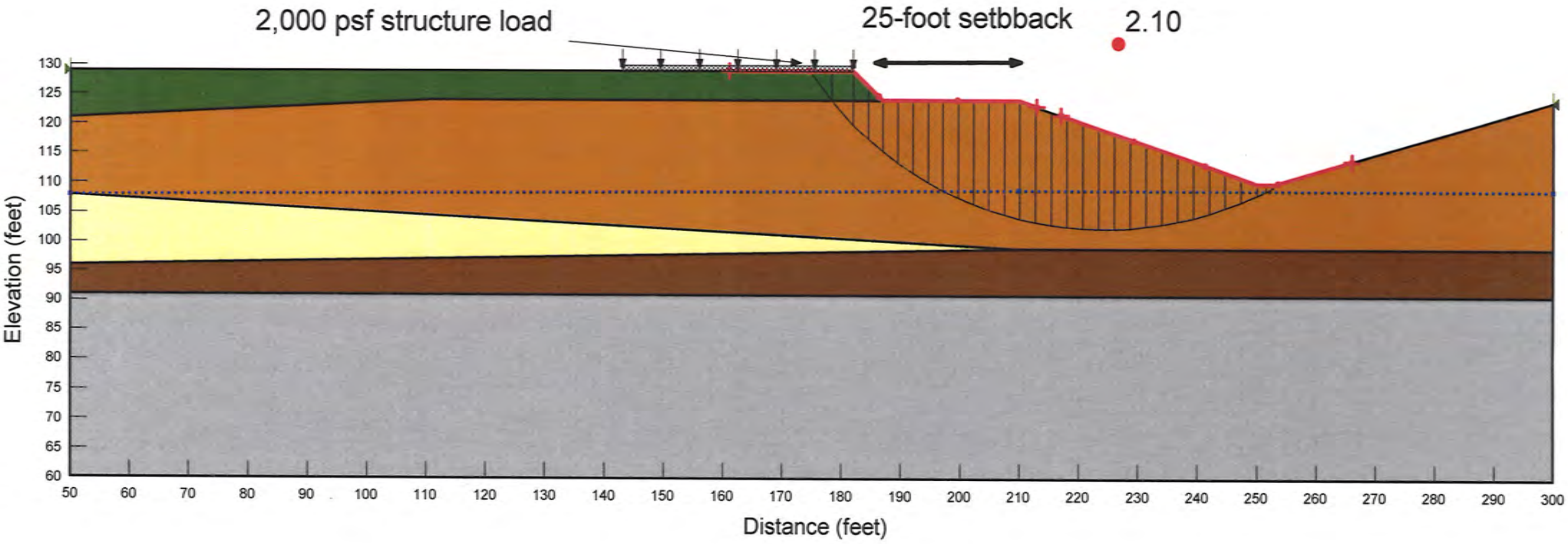
APPENDIX B

SLOPE STABILITY ANALYSIS

This appendix contains the outputs of the slope stability analysis from the software program Slope/W by GeoStudio. The locations of the analyzed sections are shown on Figures 2 and 3 and a discussion of the results is present in the main report.

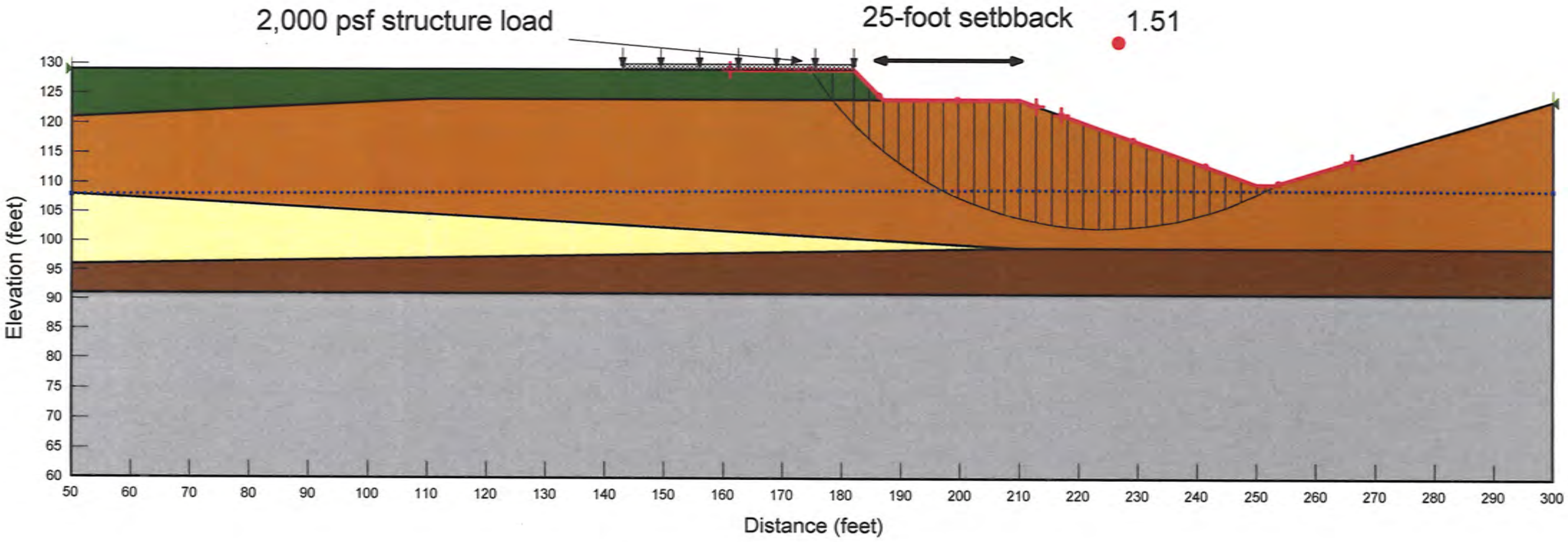
Holley Park
North Slope Stability Analysis - Section A-A'
Static Condition
Horz Seismic Coef.: 0

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬜	Dense Gravel	Mohr-Coulomb	125	0	37
🟨	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
🟧	Medium Stiff Silt	Mohr-Coulomb	110	50	30
🟫	Stiff Clay	Mohr-Coulomb	115	100	32
🟩	Structural Fill	Mohr-Coulomb	120	0	32



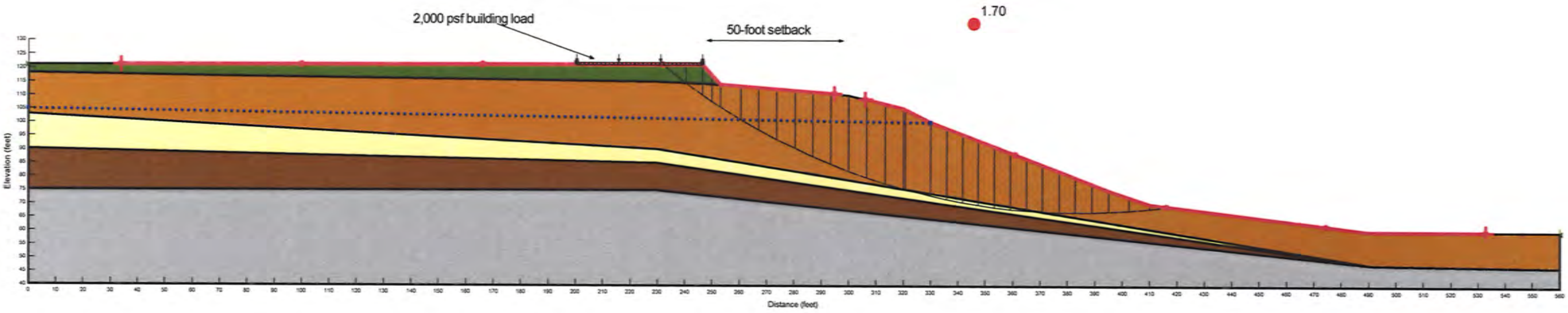
Holley Park
North Slope Stability Analysis - Section A-A'
Seismic Condition
Horz Seismic Coef.: 0.135

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬜	Dense Gravel	Mohr-Coulomb	125	0	37
🟨	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
🟧	Medium Stiff Silt	Mohr-Coulomb	110	50	30
🟫	Stiff Clay	Mohr-Coulomb	115	100	32
🟩	Structural Fill	Mohr-Coulomb	120	0	32



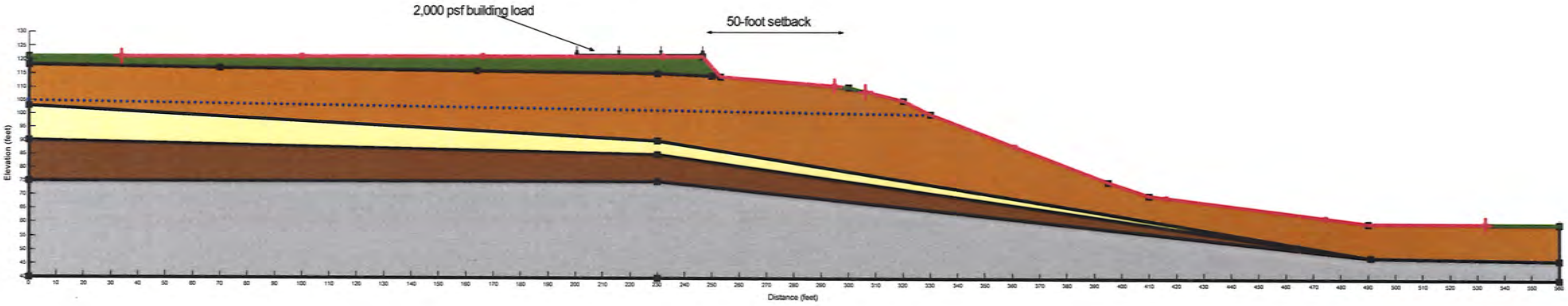
Holley Park
Slope Stability Analysis - Section B-B'
Static Condition
Horz Seismic Coef.: 0

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬜	Dense Gravel	Mohr-Coulomb	125	0	37
🟨	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
🟧	Soft to Medium Stiff Silt	Mohr-Coulomb	110	50	30
🟫	Stiff Clay	Mohr-Coulomb	115	100	32
🟩	Structural Fill	Mohr-Coulomb	120	0	32



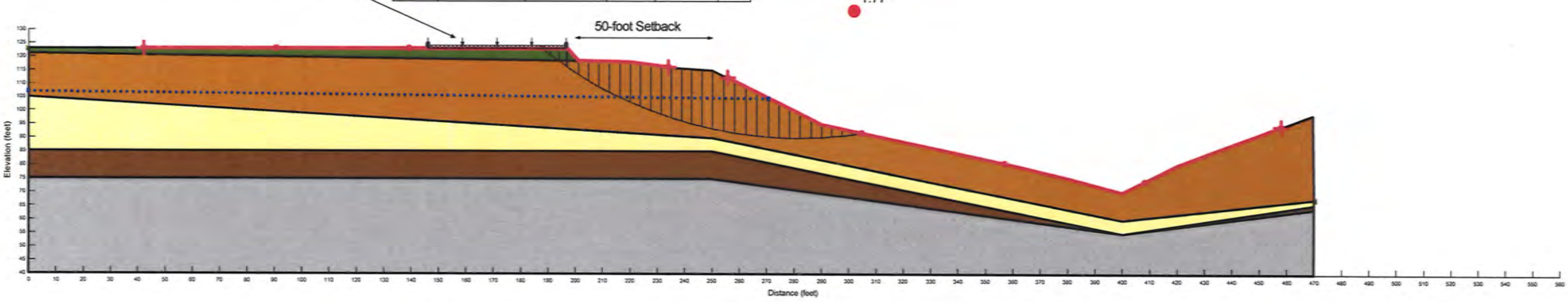
Holley Park
Slope Stability Analysis - Section B-B'
Seismic Condition
Horz Seismic Coef.: 0.135

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬜	Dense Gravel	Mohr-Coulomb	125	0	37
🟨	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
🟧	Soft to Medium Stiff Silt	Mohr-Coulomb	110	50	30
🟫	Stiff Clay	Mohr-Coulomb	115	100	32
🟩	Structural Fill	Mohr-Coulomb	120	0	32



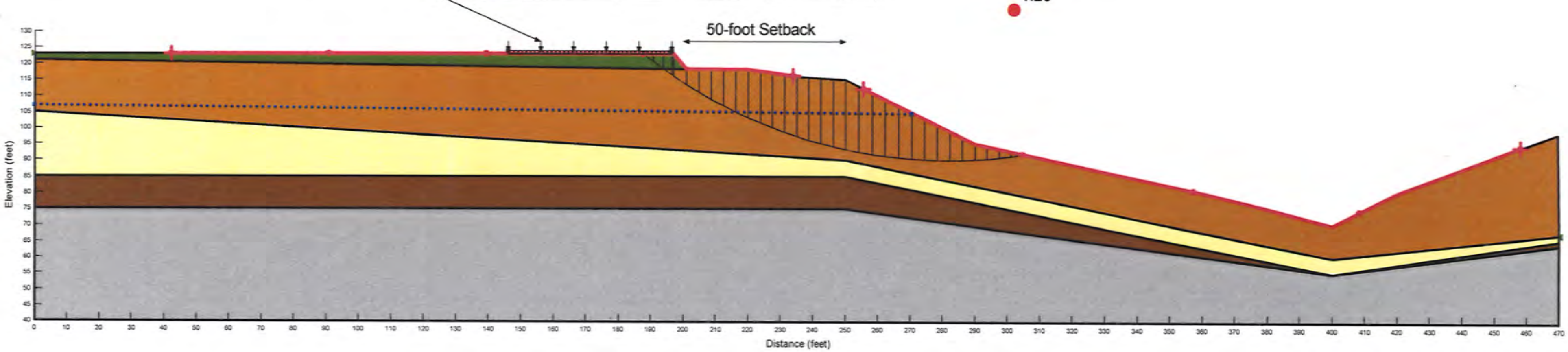
Holley Park
Slope Stability Analysis - Section C-C'
Static Condition
Horz Seismic Coef.: 0

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬜	Dense Gravel	Mohr-Coulomb	125	0	37
🟨	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
🟧	Soft to Medium Stiff Silt	Mohr-Coulomb	110	50	30
🟫	Stiff Clay	Mohr-Coulomb	115	100	32
🟩	Structural Fill	Mohr-Coulomb	120	0	32



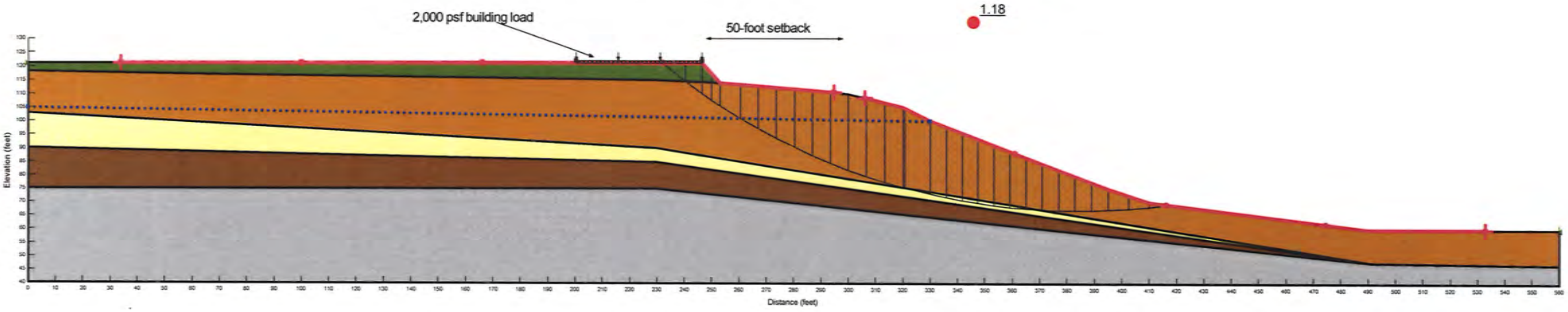
Holley Park
Slope Stability Analysis - Section C-C'
Seismic Condition
Horz Seismic Coef.: 0.135

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬜	Dense Gravel	Mohr-Coulomb	125	0	37
🟨	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
🟧	Soft to Medium Stiff Silt	Mohr-Coulomb	110	50	30
🟫	Stiff Clay	Mohr-Coulomb	115	100	32
🟩	Structural Fill	Mohr-Coulomb	120	0	32



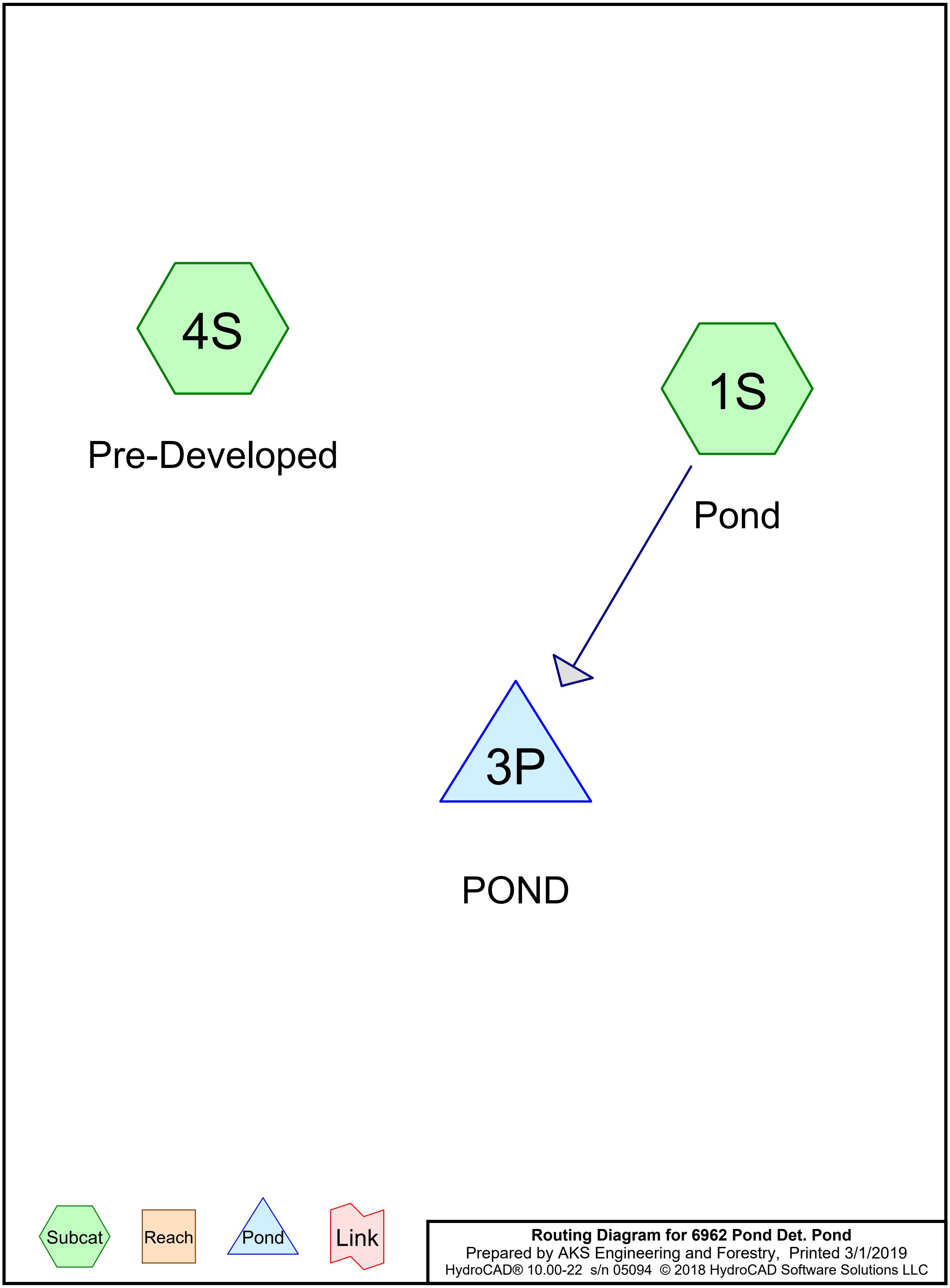
Holley Park
Slope Stability Analysis - Section B-B'
Seismic Condition
Horz Seismic Coef.: 0.135

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
⬜	Dense Gravel	Mohr-Coulomb	125	0	37
🟨	Medium Dense Silty Sand	Mohr-Coulomb	110	0	32
🟧	Soft to Medium Stiff Silt	Mohr-Coulomb	110	50	30
🟫	Stiff Clay	Mohr-Coulomb	115	100	32
🟩	Structural Fill	Mohr-Coulomb	120	0	32



www.geodesigninc.com

Appendix E:
HydroCAD Analysis



Routing Diagram for 6962 Pond Det. Pond
Prepared by AKS Engineering and Forestry, Printed 3/1/2019
HydroCAD® 10.00-22 s/n 05094 © 2018 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.910	90	grass (1S)
2.570	86	grass (1S)
2.260	92	pasture (4S)
6.430	90	pasture (4S)
1.510	98	road (1S)
4.200	98	roof and driveway (1S, 4S)
0.340	98	sidewalk (1S)
0.170	98	trail (1S)
18.390	**92**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
18.390	Other	1S, 4S
18.390		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	3.480	3.480	grass	1S
0.000	0.000	0.000	0.000	8.690	8.690	pasture	4S
0.000	0.000	0.000	0.000	1.510	1.510	road	1S
0.000	0.000	0.000	0.000	4.200	4.200	roof and driveway	1S, 4S
0.000	0.000	0.000	0.000	0.340	0.340	sidewalk	1S
0.000	0.000	0.000	0.000	0.170	0.170	trail	1S
0.000	**0.000**	**0.000**	**0.000**	**18.390**	**18.390**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	3P	0.00	-19.50	130.0	0.1500	0.010	12.0	0.0	0.0

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Pond Runoff Area=9.280 ac 62.50% Impervious Runoff Depth>1.81"
Tc=5.0 min CN=87/98 Runoff=4.19 cfs 1.403 af

Subcatchment 4S: Pre-Developed Runoff Area=9.110 ac 4.61% Impervious Runoff Depth>1.53"
Flow Length=650' Tc=29.9 min CN=91/98 Runoff=2.50 cfs 1.160 af

Pond 3P: POND Peak Elev=2.19' Storage=0.472 af Inflow=4.19 cfs 1.403 af
Outflow=1.20 cfs 0.967 af

Total Runoff Area = 18.390 ac Runoff Volume = 2.563 af Average Runoff Depth = 1.67"
66.18% Pervious = 12.170 ac 33.82% Impervious = 6.220 ac

Summary for Subcatchment 1S: Pond

[49] Hint: Tc<2dt may require smaller dt

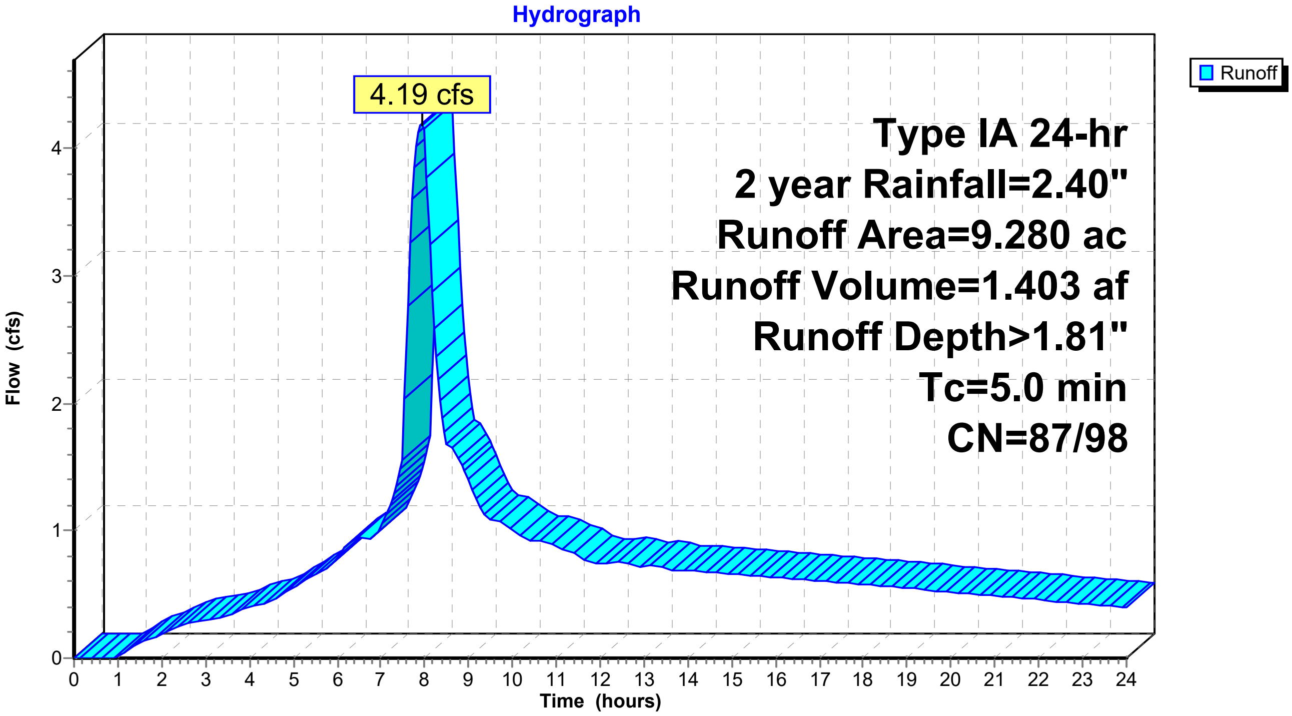
Runoff = 4.19 cfs @ 7.92 hrs, Volume= 1.403 af, Depth> 1.81"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 2 year Rainfall=2.40"

	Area (ac)	CN	Description
*	1.510	98	road
*	3.780	98	roof and driveway
*	0.340	98	sidewalk
*	0.910	90	grass
*	2.570	86	grass
*	0.170	98	trail
	9.280	94	Weighted Average
	3.480	87	37.50% Pervious Area
	5.800	98	62.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 1S: Pond



Summary for Subcatchment 4S: Pre-Developed

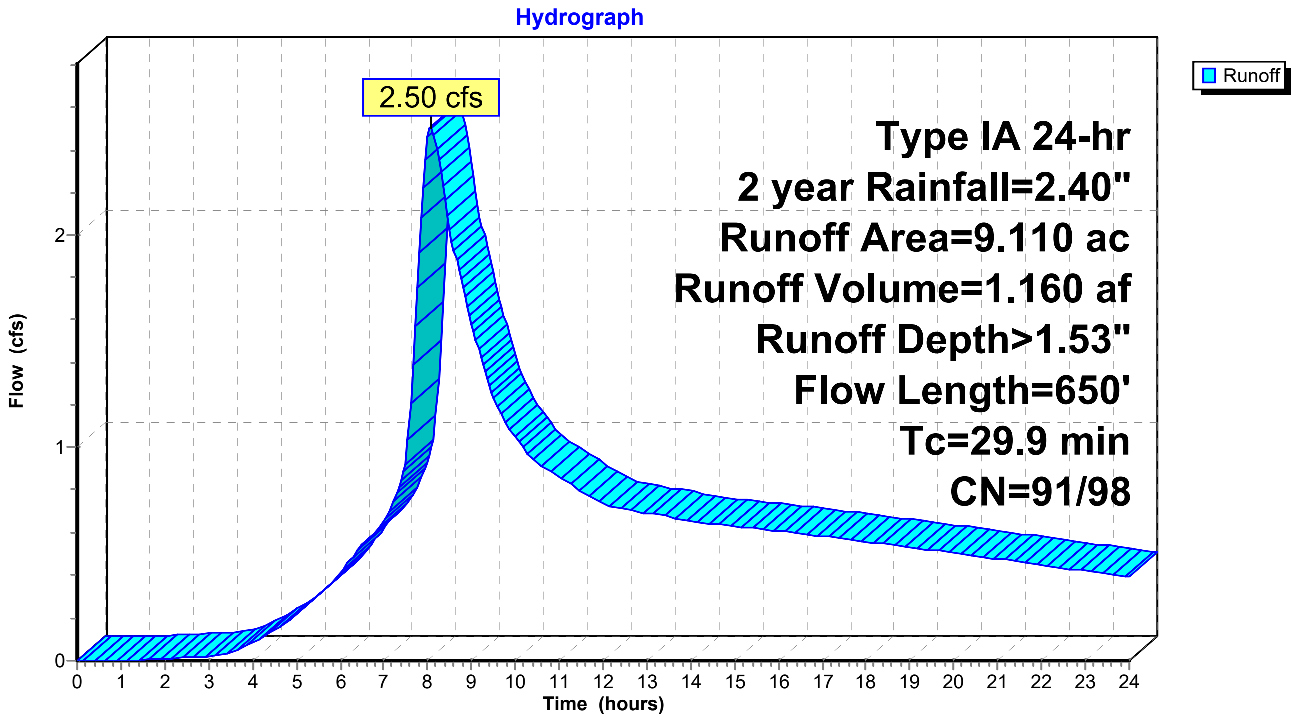
Runoff = 2.50 cfs @ 8.06 hrs, Volume= 1.160 af, Depth> 1.53"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 2 year Rainfall=2.40"

	Area (ac)	CN	Description
*	0.420	98	roof and driveway
*	2.260	92	pasture
*	6.430	90	pasture
	9.110	91	Weighted Average
	8.690	91	95.39% Pervious Area
	0.420	98	4.61% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.0	300	0.0275	0.21		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.40"
5.9	350	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
29.9	650	Total			

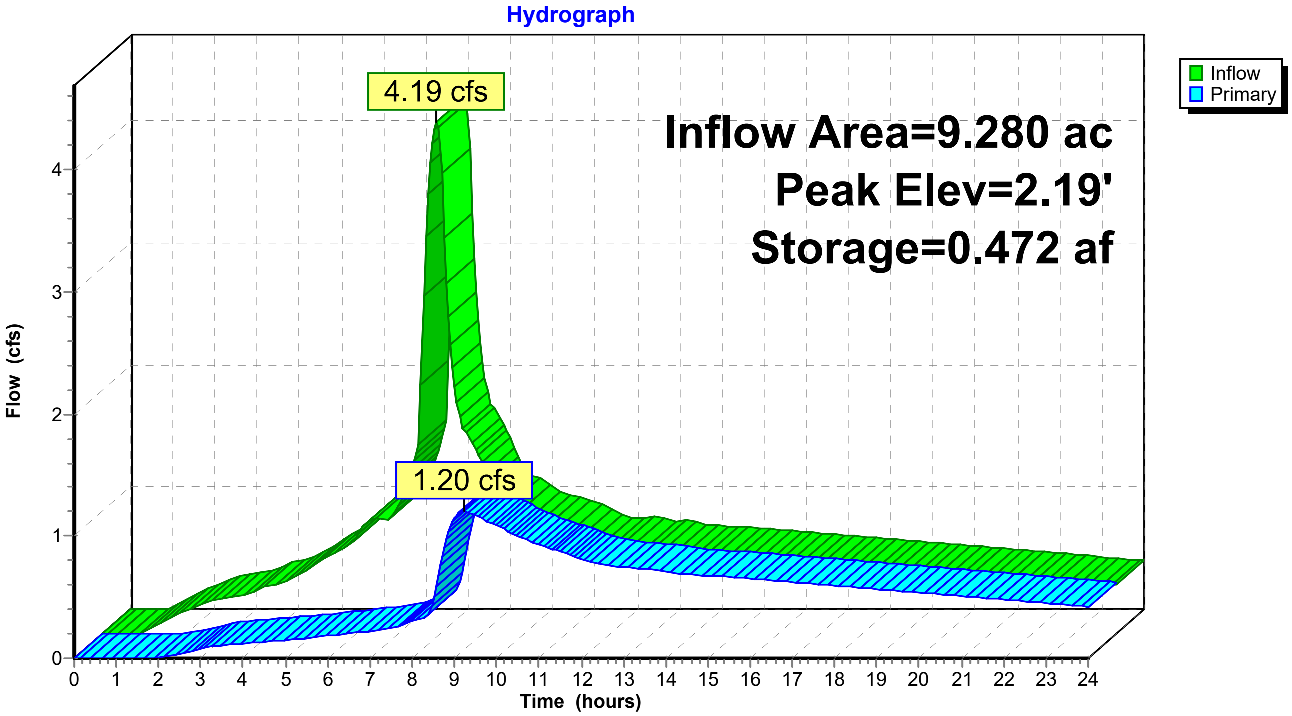
Subcatchment 4S: Pre-Developed



Summary for Pond 3P: POND

```
[44] Hint: Outlet device #2 is below defined storage

Inflow Area =      9.280 ac,  62.50% Impervious,  Inflow Depth >   1.81"    for  2 year event
Inflow      =      4.19 cfs @    7.92 hrs,  Volume=          1.403 af
Outflow     =      1.20 cfs @    9.24 hrs,  Volume=          0.967 af,  Atten= 71%,  Lag= 79.3 min
Primary     =      1.20 cfs @    9.24 hrs,  Volume=          0.967 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 2.19' @ 9.24 hrs   Surf.Area= 0.243 ac   Storage= 0.472 af

Plug-Flow detention time= 339.1 min calculated for 0.965 af (69% of inflow)
Center-of-Mass det. time= 150.8 min ( 855.7 - 704.9 )

Volume      Invert   Avail.Storage   Storage Description
  #1         0.00'        0.956 af   Custom Stage Data (Irregular)Listed below (Recalc)  x 0.74

Elevation     Surf.Area     Perim.       Inc.Store       Cum.Store      Wet.Area
   (feet)       (acres)     (feet)     (acre-feet)     (acre-feet)       (acres)
     0.00         0.255      470.4           0.000           0.000         0.255
     1.00         0.288      489.2           0.271           0.271         0.290
     2.00         0.322      508.1           0.305           0.576         0.326
     3.00         0.358      526.9           0.340           0.916         0.364
     4.00         0.395      545.8           0.376           1.292         0.403

Device   Routing          Invert   Outlet Devices
  #1     Primary           0.00'   12.0"  Round Culvert
                                   L= 130.0'   CMP, projecting, no headwall,  Ke= 0.900
                                   Inlet / Outlet Invert= 0.00' / -19.50'   S= 0.1500 '/'   Cc= 0.900
                                   n= 0.010  PVC, smooth interior,  Flow Area= 0.79 sf
  #2     Device 1         -2.00'   3.0" Horiz. Orifice/Grate   C= 0.600
                                   Limited to weir flow at low heads
  #3     Primary           2.00'   12.0" Horiz. Orifice/Grate   C= 0.600
                                   Limited to weir flow at low heads

Primary OutFlow  Max=1.20 cfs @ 9.24 hrs  HW=2.19'   (Free Discharge)
↑─1=Culvert  (Passes 0.35 cfs of 3.88 cfs potential flow)
│  ↑─2=Orifice/Grate  (Orifice Controls 0.35 cfs @ 7.13 fps)
└─3=Orifice/Grate  (Weir Controls 0.85 cfs @ 1.43 fps)
```

Pond 3P: POND


Hydrograph
4.19 cfs
1.20 cfs
Inflow Area=9.280 ac
Peak Elev=2.19'
Storage=0.472 af
Inflow
Primary
Flow (cfs)
0
1
2
3
4
Time (hours)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Pond Runoff Area=9.280 ac 62.50% Impervious Runoff Depth>2.76"
Tc=5.0 min CN=87/98 Runoff=6.41 cfs 2.134 af

Subcatchment 4S: Pre-Developed Runoff Area=9.110 ac 4.61% Impervious Runoff Depth>2.45"
Flow Length=650' Tc=29.9 min CN=91/98 Runoff=4.15 cfs 1.859 af

Pond 3P: POND Peak Elev=2.61' Storage=0.576 af Inflow=6.41 cfs 2.134 af
Outflow=3.33 cfs 1.686 af

Total Runoff Area = 18.390 ac Runoff Volume = 3.992 af Average Runoff Depth = 2.61"
66.18% Pervious = 12.170 ac 33.82% Impervious = 6.220 ac

Summary for Subcatchment 1S: Pond

[49] Hint: Tc<2dt may require smaller dt

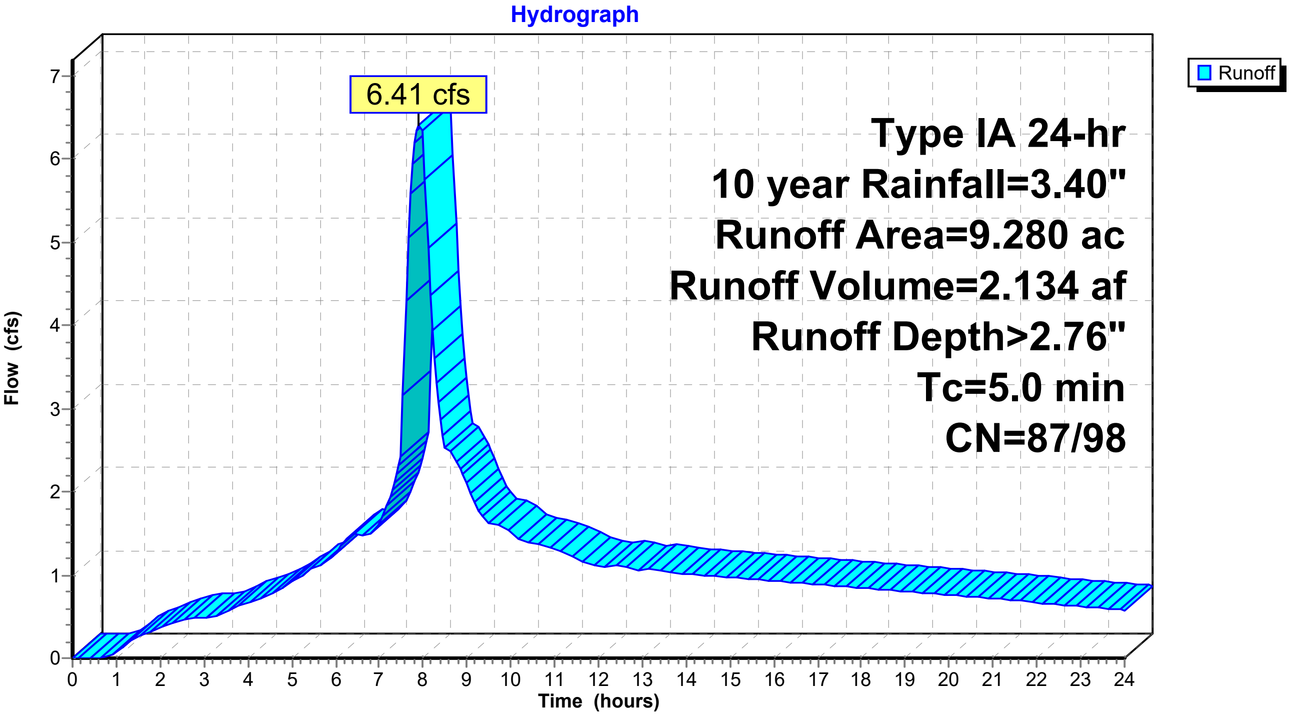
Runoff = 6.41 cfs @ 7.92 hrs, Volume= 2.134 af, Depth> 2.76"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 10 year Rainfall=3.40"

	Area (ac)	CN	Description
*	1.510	98	road
*	3.780	98	roof and driveway
*	0.340	98	sidewalk
*	0.910	90	grass
*	2.570	86	grass
*	0.170	98	trail
	9.280	94	Weighted Average
	3.480	87	37.50% Pervious Area
	5.800	98	62.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 1S: Pond



Summary for Subcatchment 4S: Pre-Developed

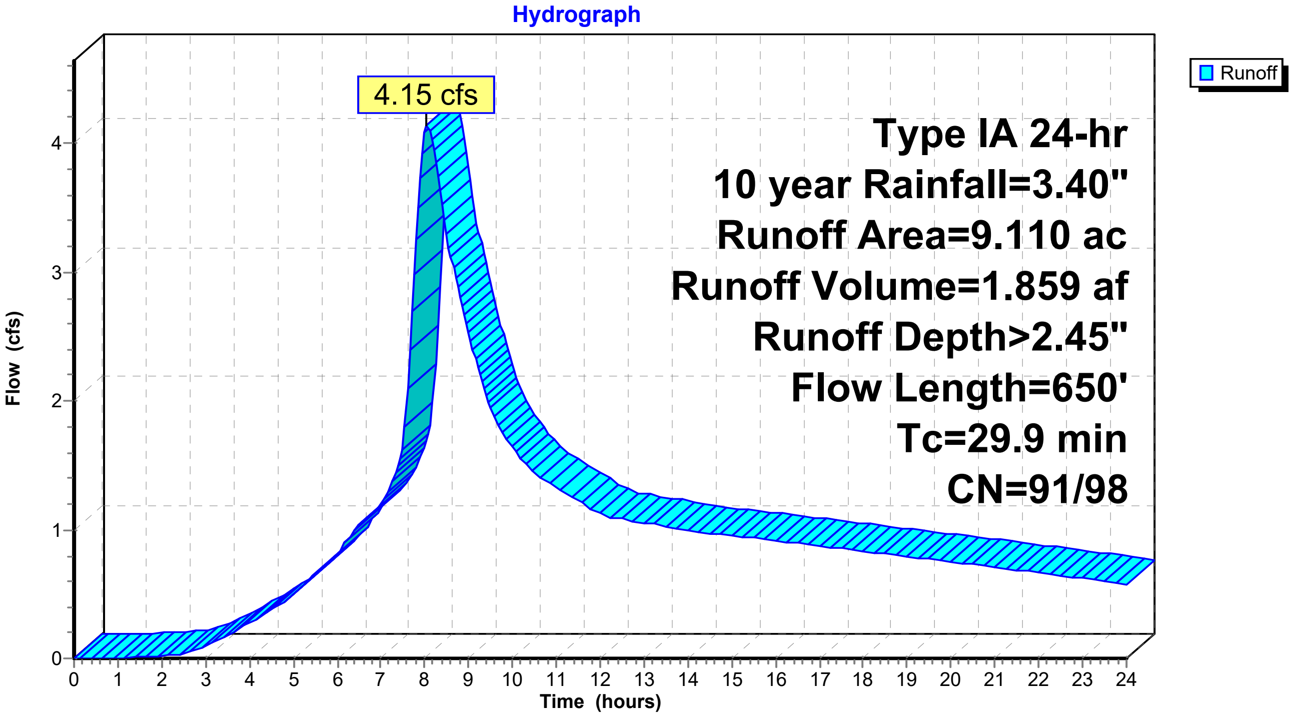
Runoff = 4.15 cfs @ 8.05 hrs, Volume= 1.859 af, Depth> 2.45"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 10 year Rainfall=3.40"

	Area (ac)	CN	Description
*	0.420	98	roof and driveway
*	2.260	92	pasture
*	6.430	90	pasture
	9.110	91	Weighted Average
	8.690	91	95.39% Pervious Area
	0.420	98	4.61% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.0	300	0.0275	0.21		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.40"
5.9	350	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
29.9	650	Total			

Subcatchment 4S: Pre-Developed



Summary for Pond 3P: POND

[44] Hint: Outlet device #2 is below defined storage

Inflow Area = 9.280 ac, 62.50% Impervious, Inflow Depth > 2.76" for 10 year event
Inflow = 6.41 cfs @ 7.92 hrs, Volume= 2.134 af
Outflow = 3.33 cfs @ 8.30 hrs, Volume= 1.686 af, Atten= 48%, Lag= 23.0 min
Primary = 3.33 cfs @ 8.30 hrs, Volume= 1.686 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 2.61' @ 8.30 hrs Surf.Area= 0.254 ac Storage= 0.576 af

Plug-Flow detention time= 242.5 min calculated for 1.683 af (79% of inflow)
Center-of-Mass det. time= 106.6 min (799.0 - 692.3)

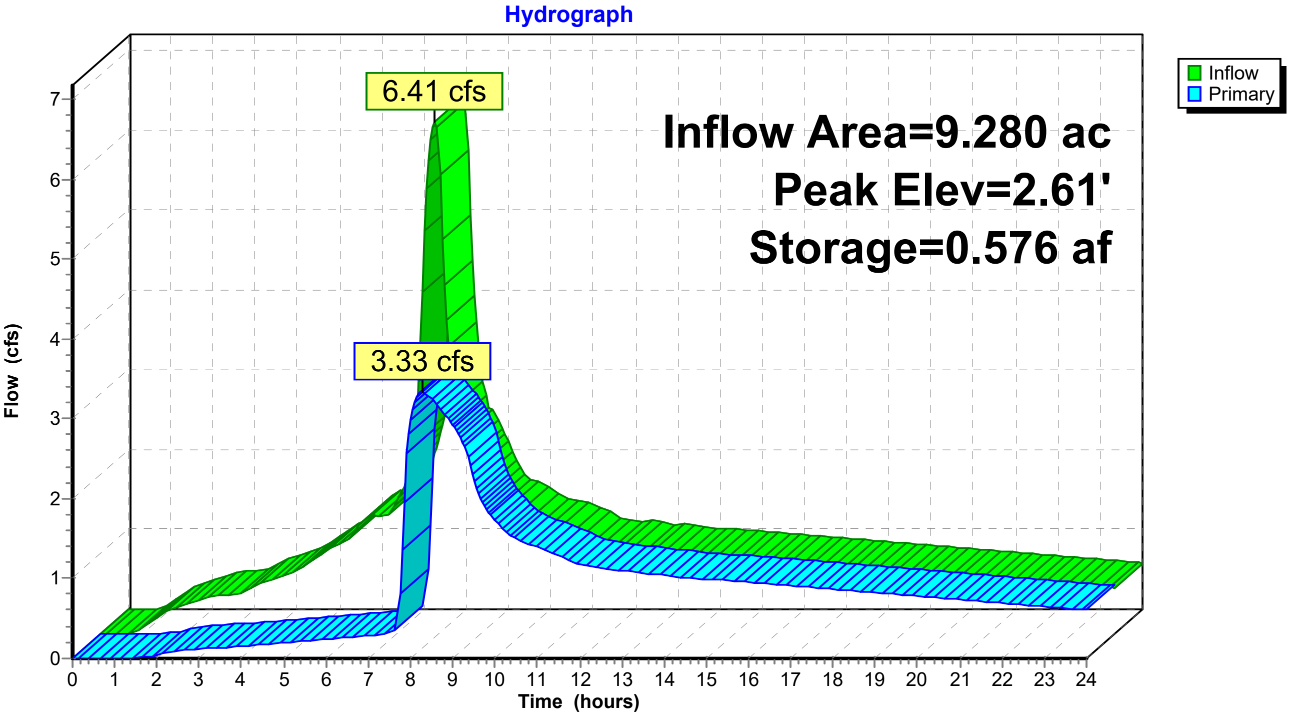
Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	0.956 af	**Custom Stage Data (Irregular)**Listed below (Recalc) x 0.74

Elevation (feet)	Surf.Area (acres)	Perim. (feet)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
0.00	0.255	470.4	0.000	0.000	0.255
1.00	0.288	489.2	0.271	0.271	0.290
2.00	0.322	508.1	0.305	0.576	0.326
3.00	0.358	526.9	0.340	0.916	0.364
4.00	0.395	545.8	0.376	1.292	0.403

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	**12.0" Round Culvert** L= 130.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 0.00' / -19.50' S= 0.1500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.79 sf
#2	Device 1	-2.00'	**3.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	2.00'	**12.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=3.33 cfs @ 8.30 hrs HW=2.61' (Free Discharge)
└─**1=Culvert** (Passes 0.38 cfs of 4.33 cfs potential flow)
  └─**2=Orifice/Grate** (Orifice Controls 0.38 cfs @ 7.78 fps)
└─**3=Orifice/Grate** (Orifice Controls 2.95 cfs @ 3.75 fps)

Pond 3P: POND


Hydrograph
6.41 cfs
3.33 cfs
Inflow Area=9.280 ac
Peak Elev=2.61'
Storage=0.576 af
Inflow
Primary
Flow (cfs)
0
1
2
3
4
5
6
7
Time (hours)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Pond	Runoff Area=9.280 ac 62.50% Impervious Runoff Depth>3.24" Tc=5.0 min CN=87/98 Runoff=7.54 cfs 2.505 af
Subcatchment 4S: Pre-Developed	Runoff Area=9.110 ac 4.61% Impervious Runoff Depth>2.92" Flow Length=650' Tc=29.9 min CN=91/98 Runoff=4.98 cfs 2.216 af
Pond 3P: POND	Peak Elev=2.89' Storage=0.650 af Inflow=7.54 cfs 2.505 af Outflow=3.98 cfs 2.053 af

Total Runoff Area = 18.390 ac Runoff Volume = 4.722 af Average Runoff Depth = 3.08"
66.18% Pervious = 12.170 ac 33.82% Impervious = 6.220 ac

Summary for Subcatchment 1S: Pond

[49] Hint: Tc<2dt may require smaller dt

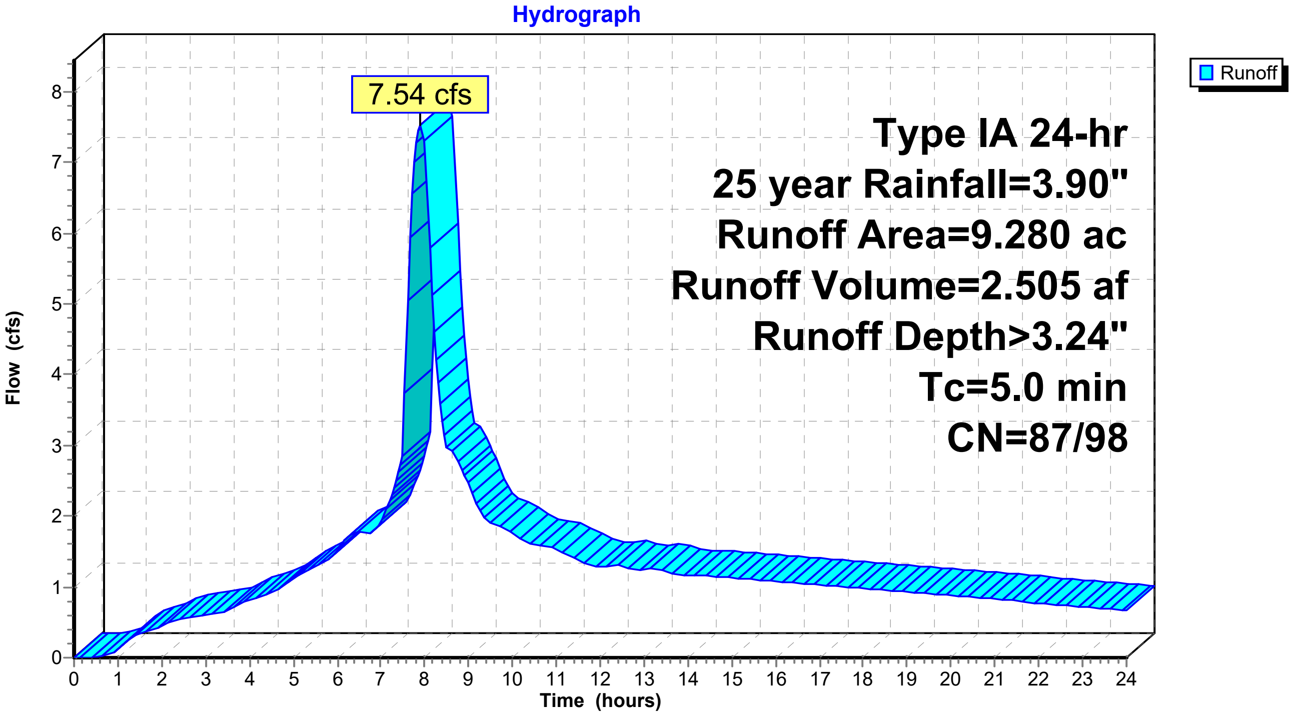
```
Runoff      =        7.54 cfs @    7.91 hrs,  Volume=          2.505 af,  Depth>  3.24"
```

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25 year Rainfall=3.90"

	Area (ac)	CN	Description
*	1.510	98	road
*	3.780	98	roof and driveway
*	0.340	98	sidewalk
*	0.910	90	grass
*	2.570	86	grass
*	0.170	98	trail
	9.280	94	Weighted Average
	3.480	87	37.50% Pervious Area
	5.800	98	62.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 1S: Pond



Summary for Subcatchment 4S: Pre-Developed

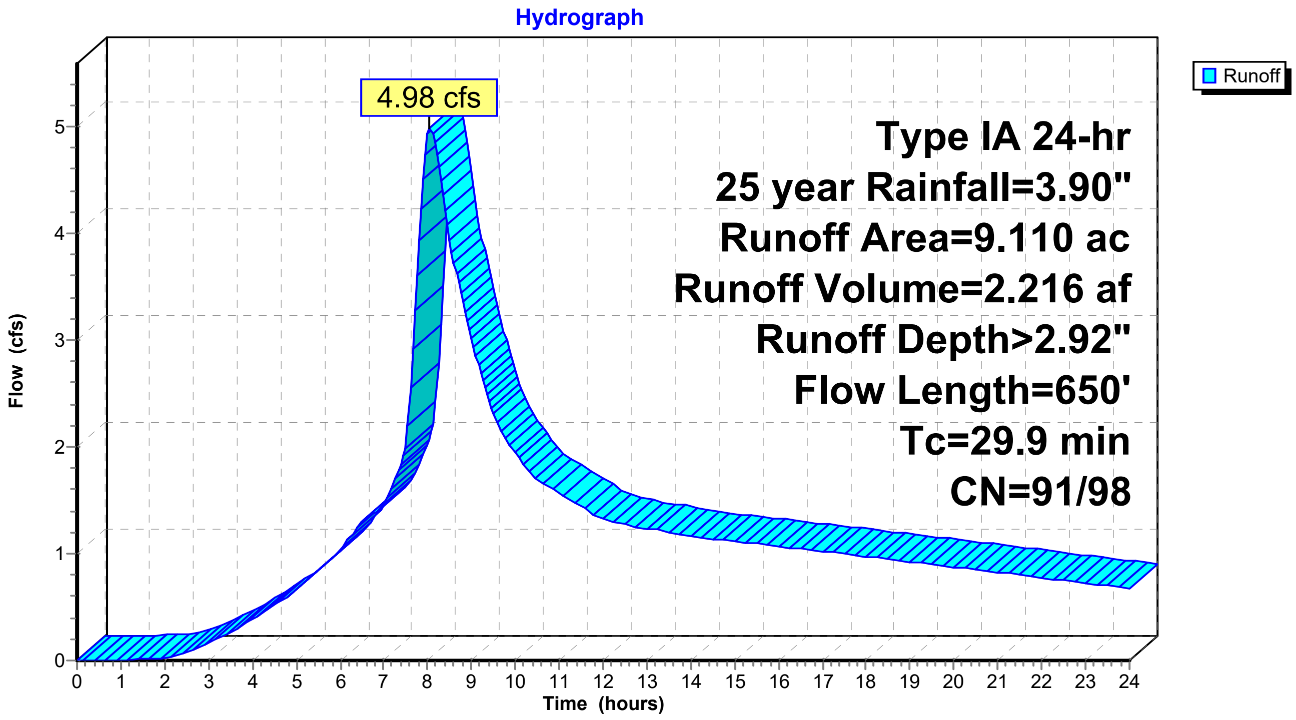
Runoff = 4.98 cfs @ 8.05 hrs, Volume= 2.216 af, Depth> 2.92"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25 year Rainfall=3.90"

	Area (ac)	CN	Description
*	0.420	98	roof and driveway
*	2.260	92	pasture
*	6.430	90	pasture
	9.110	91	Weighted Average
	8.690	91	95.39% Pervious Area
	0.420	98	4.61% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.0	300	0.0275	0.21		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.40"
5.9	350	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
29.9	650	Total			

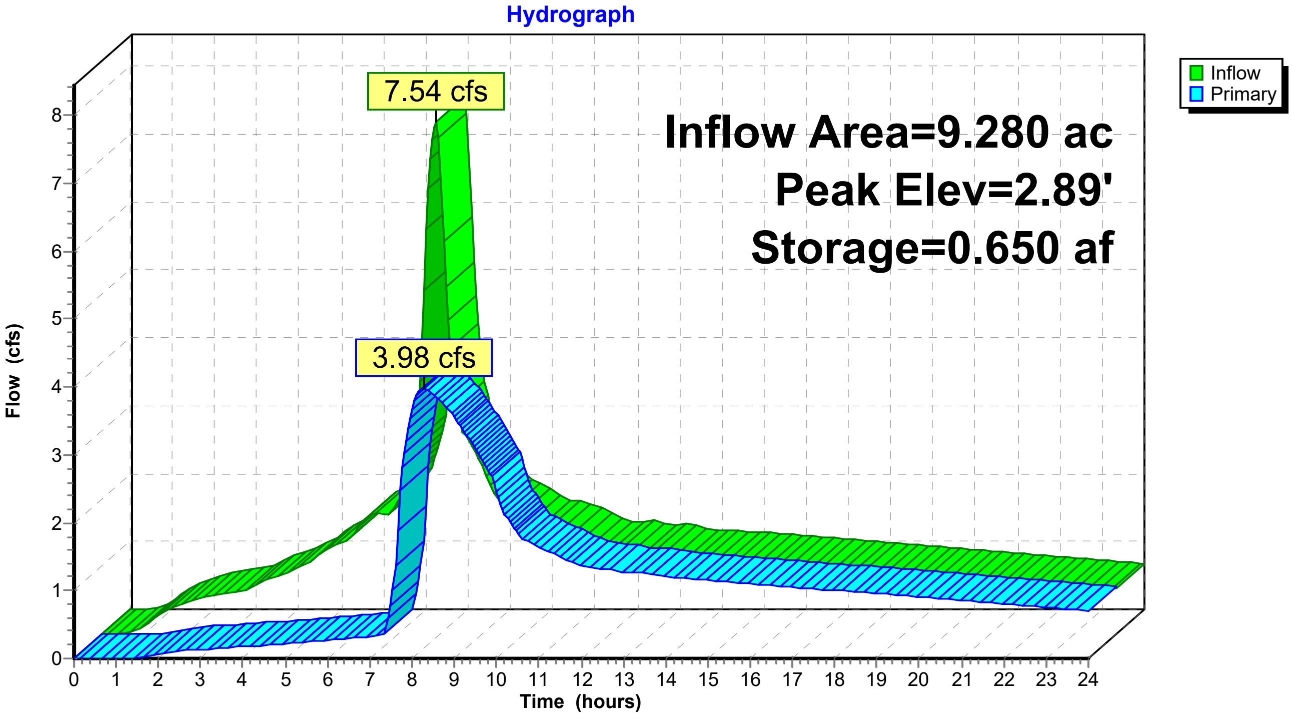
Subcatchment 4S: Pre-Developed



Summary for Pond 3P: POND

```
[44] Hint: Outlet device #2 is below defined storage

Inflow Area =       9.280 ac, 62.50% Impervious, Inflow Depth >  3.24"   for 25 year event
Inflow      =      7.54 cfs @   7.91 hrs, Volume=         2.505 af
Outflow     =      3.98 cfs @   8.29 hrs, Volume=         2.053 af, Atten= 47%, Lag= 22.4 min
Primary     =      3.98 cfs @   8.29 hrs, Volume=         2.053 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 2.89' @ 8.29 hrs   Surf.Area= 0.262 ac   Storage= 0.650 af

Plug-Flow detention time= 217.4 min calculated for 2.053 af (82% of inflow)
Center-of-Mass det. time= 97.6 min ( 785.3 - 687.7 )

Volume     Invert   Avail.Storage  Storage Description
  #1        0.00'        0.956 af  Custom Stage Data (Irregular)Listed below (Recalc) x 0.74

Elevation    Surf.Area    Perim.      Inc.Store      Cum.Store      Wet.Area
  (feet)      (acres)     (feet)    (acre-feet)    (acre-feet)       (acres)
    0.00        0.255      470.4          0.000          0.000         0.255
    1.00        0.288      489.2          0.271          0.271         0.290
    2.00        0.322      508.1          0.305          0.576         0.326
    3.00        0.358      526.9          0.340          0.916         0.364
    4.00        0.395      545.8          0.376          1.292         0.403

Device  Routing          Invert  Outlet Devices
  #1    Primary           0.00'  12.0"  Round Culvert
                                 L= 130.0'  CMP, projecting, no headwall,  Ke= 0.900
                                 Inlet / Outlet Invert= 0.00' / -19.50'  S= 0.1500 '/'  Cc= 0.900
                                 n= 0.010  PVC, smooth interior,  Flow Area= 0.79 sf
  #2    Device 1         -2.00'  3.0" Horiz. Orifice/Grate   C= 0.600
                                 Limited to weir flow at low heads
  #3    Primary           2.00'  12.0" Horiz. Orifice/Grate   C= 0.600
                                 Limited to weir flow at low heads

Primary OutFlow  Max=3.97 cfs @ 8.29 hrs  HW=2.89'  (Free Discharge)
 ├─1=Culvert  (Passes 0.40 cfs of 4.62 cfs potential flow)
 │  └─2=Orifice/Grate  (Orifice Controls 0.40 cfs @ 8.19 fps)
 └─3=Orifice/Grate  (Orifice Controls 3.57 cfs @ 4.55 fps)
```

Pond 3P: POND


Hydrograph
7.54 cfs
3.98 cfs
Inflow Area=9.280 ac
Peak Elev=2.89'
Storage=0.650 af
🟩 Inflow
🟦 Primary
Flow (cfs)
0
1
2
3
4
5
6
7
8
Time (hours)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

```
                 Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
                  Runoff by SBUH method, Split Pervious/Imperv.
     Reach routing by Dyn-Stor-Ind method  -  Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Pond               Runoff Area=9.280 ac  62.50% Impervious  Runoff Depth>3.92"
                                                   Tc=5.0 min  CN=87/98  Runoff=9.12 cfs  3.029 af

Subcatchment 4S: Pre-Developed       Runoff Area=9.110 ac  4.61% Impervious  Runoff Depth>3.59"
                                 Flow Length=650'  Tc=29.9 min  CN=91/98  Runoff=6.16 cfs  2.723 af

Pond 3P: POND                        Peak Elev=3.22'  Storage=0.737 af  Inflow=9.12 cfs  3.029 af
                                                                     Outflow=4.60 cfs  2.572 af

      Total Runoff Area = 18.390 ac  Runoff Volume = 5.752 af  Average Runoff Depth = 3.75"
                                     66.18% Pervious = 12.170 ac   33.82% Impervious = 6.220 ac
```

Summary for Subcatchment 1S: Pond

[49] Hint: Tc<2dt may require smaller dt

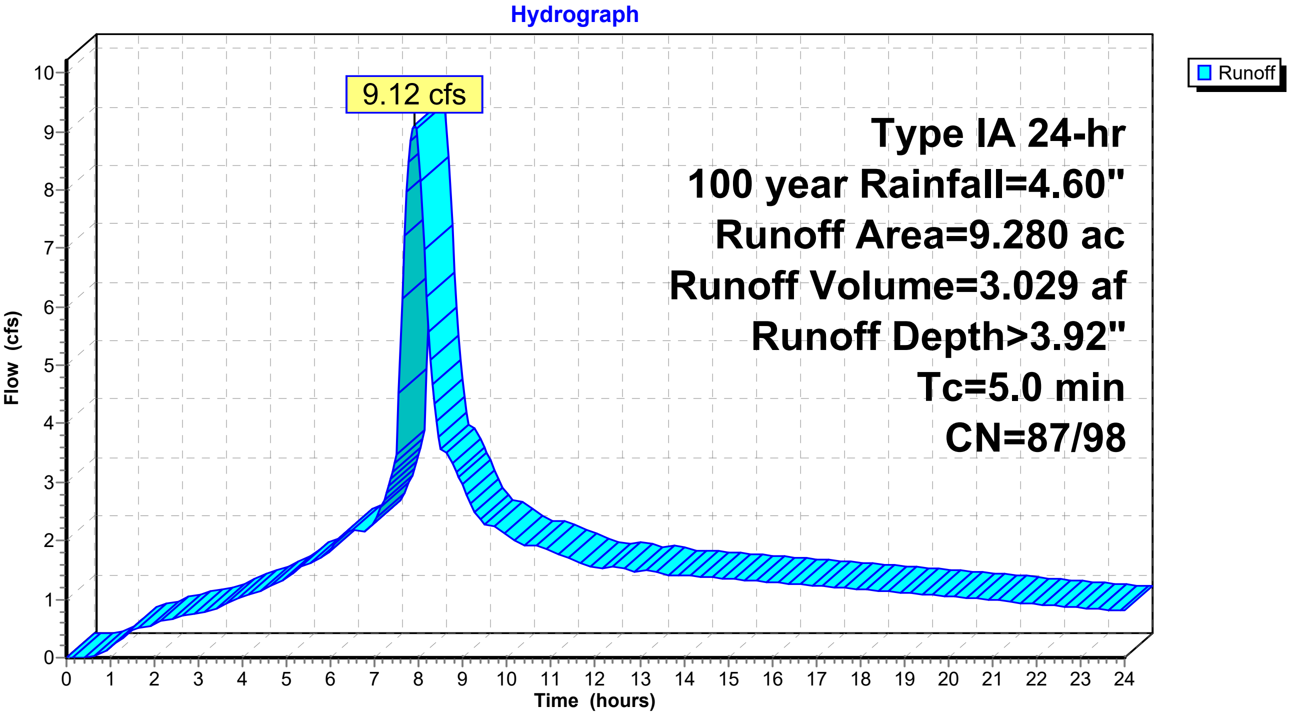
Runoff = 9.12 cfs @ 7.91 hrs, Volume= 3.029 af, Depth> 3.92"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 100 year Rainfall=4.60"

	Area (ac)	CN	Description
*	1.510	98	road
*	3.780	98	roof and driveway
*	0.340	98	sidewalk
*	0.910	90	grass
*	2.570	86	grass
*	0.170	98	trail
	9.280	94	Weighted Average
	3.480	87	37.50% Pervious Area
	5.800	98	62.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 1S: Pond



Summary for Subcatchment 4S: Pre-Developed

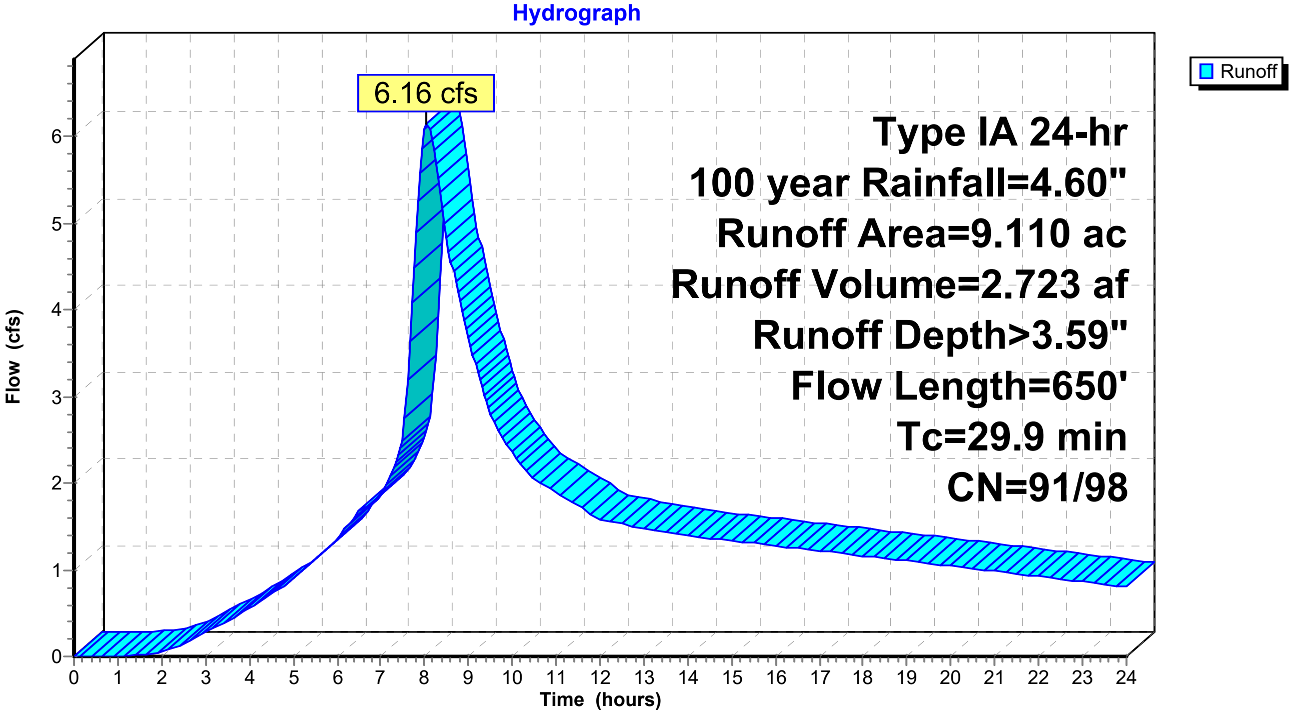
Runoff = 6.16 cfs @ 8.05 hrs, Volume= 2.723 af, Depth> 3.59"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 100 year Rainfall=4.60"

	Area (ac)	CN	Description
*	0.420	98	roof and driveway
*	2.260	92	pasture
*	6.430	90	pasture
	9.110	91	Weighted Average
	8.690	91	95.39% Pervious Area
	0.420	98	4.61% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.0	300	0.0275	0.21		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.40"
5.9	350	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
29.9	650	Total			

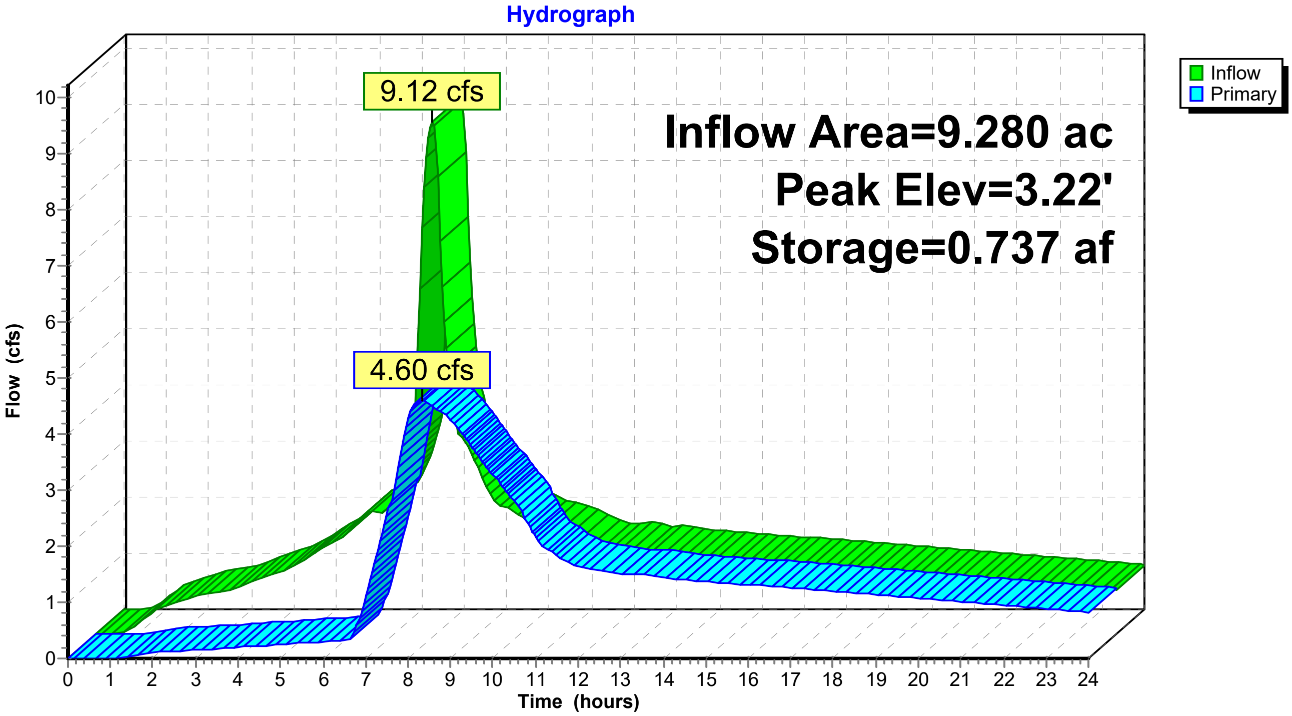
Subcatchment 4S: Pre-Developed



Summary for Pond 3P: POND

```
[44] Hint: Outlet device #2 is below defined storage

Inflow Area =        9.280 ac, 62.50% Impervious,  Inflow Depth >  3.92"   for 100 year event
Inflow      =        9.12 cfs @   7.91 hrs,  Volume=          3.029 af
Outflow     =        4.60 cfs @   8.31 hrs,  Volume=          2.572 af,  Atten= 50%,  Lag= 24.1 min
Primary     =        4.60 cfs @   8.31 hrs,  Volume=          2.572 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 3.22' @ 8.31 hrs   Surf.Area= 0.271 ac   Storage= 0.737 af

Plug-Flow detention time= 191.6 min calculated for 2.567 af (85% of inflow)
Center-of-Mass det. time= 89.2 min ( 771.6 - 682.4 )

Volume        Invert    Avail.Storage   Storage Description
   #1          0.00'         0.956 af   Custom Stage Data (Irregular)Listed below (Recalc)  x 0.74

 Elevation     Surf.Area     Perim.        Inc.Store        Cum.Store      Wet.Area
    (feet)       (acres)     (feet)      (acre-feet)      (acre-feet)       (acres)
      0.00         0.255      470.4            0.000            0.000         0.255
      1.00         0.288      489.2            0.271            0.271         0.290
      2.00         0.322      508.1            0.305            0.576         0.326
      3.00         0.358      526.9            0.340            0.916         0.364
      4.00         0.395      545.8            0.376            1.292         0.403

Device   Routing          Invert   Outlet Devices
   #1    Primary           0.00'   12.0"  Round Culvert
                                   L= 130.0'   CMP, projecting, no headwall,  Ke= 0.900
                                   Inlet / Outlet Invert= 0.00' / -19.50'   S= 0.1500 '/'   Cc= 0.900
                                   n= 0.010  PVC, smooth interior,  Flow Area= 0.79 sf
   #2    Device 1         -2.00'   3.0" Horiz. Orifice/Grate   C= 0.600
                                   Limited to weir flow at low heads
   #3    Primary           2.00'   12.0" Horiz. Orifice/Grate   C= 0.600
                                   Limited to weir flow at low heads

Primary OutFlow  Max=4.60 cfs @ 8.31 hrs  HW=3.22'   (Free Discharge)
↑—1=Culvert  (Passes 0.42 cfs of 4.92 cfs potential flow)
│  ↑—2=Orifice/Grate  (Orifice Controls 0.42 cfs @ 8.64 fps)
└—3=Orifice/Grate  (Orifice Controls 4.18 cfs @ 5.32 fps)
```

Pond 3P: POND


Hydrograph
9.12 cfs
4.60 cfs
Inflow Area=9.280 ac
Peak Elev=3.22'
Storage=0.737 af
🟩 Inflow
🟦 Primary
Flow (cfs)
0
1
2
3
4
5
6
7
8
9
10
Time (hours)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

APPENDIX F:
BMP DETAILS

III-4.4 STANDARDS AND SPECIFICATIONS FOR DETENTION PONDS

III-4.4.1 BMP RD.05 Wet Pond (Conventional Pollutants)

Purpose and Definition

This BMP is designed to provide runoff treatment for conventional pollutants but not nutrients. It may also be designed to provide streambank erosion control. A wet pond is an open pond which treats runoff using a permanent pool of water ("dead storage"). As an option, a shallow marsh area can be created within the permanent pool volume to provide additional treatment (see BMP RD.06, Wet Pond for Nutrient Control). Streambank erosion control is provided in the "live storage" area above the permanent pool. Figure III-4.1 illustrates a typical wet pond BMP.

Planning Considerations

Wet ponds require careful planning in order to function correctly. Throughout the design process the designer should be committed to considering the potential impacts of the completed facility. Such impacts can be positive or negative and can be as broadly classified as social, economic, political, and environmental. Designers can often influence the positive or negative aspects of these impacts by their careful evaluation of decisions made in the design process. Generally speaking, the completed facility must provide for safety to people as well as protection of real property, water quality, and wildlife habitats.

Multiple Uses

Multi-purpose use of the facility and aesthetic enhancement of the general area should also be major considerations. Above all, the facility should function in such a manner as to be compatible with overall stormwater systems both upstream and downstream to promote a watershed approach to providing stormwater management as well as local flood control and erosion protection.

If the facility is planned as an artificial lake to enhance property values and promote the aesthetic value of the land, pretreatment in the form of landscape retention areas or perimeter swales should be incorporated into the stormwater management facility. If possible, catchbasins should be located in grassed areas. By incorporating this "treatment train" concept into the overall collection and conveyance system, the engineer can prolong the utility of these permanently wet installations and improve their appearance. Any amount of runoff waters, regardless how small, that is filtered or percolated along its way to the final detention area can remove oil and grease, metals, and sediment. In addition, this will reduce the annual nutrient load to prevent the wet detention lake from eutrophying.

Detention system site selection should consider both the natural topography of the area and property boundaries. Aesthetic and water quality considerations may also dictate locations. For example, ponds with wetland vegetation are more aesthetically pleasing than ponds without vegetation. Ponds containing wetland vegetation also provide better conditions for pollutant capture and treatment.

A storage facility is an integral part of the environment and therefore should serve as an aesthetic improvement to the area if possible. Use of good landscaping principles is encouraged. The planting and preservation of desirable trees and other vegetation should be an integral part of the storage facility design.

Water Quality Considerations

In planning new detention facilities, it should be kept in mind that the goal of improved water quality downstream may conflict with certain desired uses of the facility. It is only logical that if the basin is used to remove pollutants, the *water quality within the basin itself will be lowered, thus reducing the applicability for uses such as water supply, recreation, and aesthetics. In planning the facility the engineer or planner should have a good knowledge of site-specific runoff constituents and an understanding of the possible effects on the quality of the stored water.*

Basin Planning

The design of urban detention facilities should be coordinated with a basin plan for managing stormwater runoff. In a localized situation, an individual property owner can, of course, by his or her actions alone, provide effective assistance to the next owner downstream if no other areas contribute to that owner's problems. However, uncontrolled proliferation of impoundments within a watershed can severely alter natural flow conditions, causing compounded flow peaks or increased flow duration which can contribute to downstream degradation. In addition, upstream impacts due to future land use changes should be considered when designing the structure. Land use planning and regulation may be necessary to preserve the intended function of the impoundment. See Minimum Requirement #9 (Basin Planning) and the appendix in Volume I for a further discussion of basin planning.

Sediment and Debris

More often than not, detention ponds serve primarily as sedimentation basins during construction when erosion rates are particularly high. In and of itself, this situation does not present a problem. Unfortunately, these facilities are often installed without the benefit of the designer having evaluated the capacity of either the initial or the final (post-construction) design configuration to perform this type of function.

If a facility is to be used as the principal means to avoid having excessive levels of turbidity discharged from the site during construction, the engineer should evaluate the pond geometry in conjunction with the rate of outflow and grain size distribution of the soils and design the temporary sediment basin according to BMPs E3.35 or E3.40 in Volume II.

Heavy Metal Contamination

Studies have shown high accumulation rates of lead, zinc, and copper on and near heavily traveled highways and streets. Runoff from highways and streets can be expected to carry significant concentrations of these heavy metals. If a significant portion of the drainage area into a pond consists of highways, streets, or parking areas or other known sources of heavy metal contamination, there is a potential environmental health hazard. In such cases the multiple use functions of the pond should be limited and accessibility should be restricted. Additionally, liners may be required in order to prevent these types of pollutants from migrating into the underlying soil and ground water system.

This may require that sediment dredged out of the basins during maintenance cleaning be treated as a Dangerous Waste. Investigations of sediments removed from detention ponds to date have found that many pollutants are tightly bound with only a slight possibility of leaching. To be safe, sediments to be removed should be analyzed and elutriate tests performed to verify that the sediment can be safely disposed of by conventional methods (see Volume IV, Catchbasin Sediment Disposal Policy (to be written) which deals with disposal procedures).

Overflows

Detention facility design must take into consideration overflows and secondary overflow. Overflows include all facilities designed to bypass flows over or around the restrictor system. Overflow may result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage *due to sediment buildup in the facility.*

Secondary overflow occurs when the capacities of all conveyance facilities, and all overflow facilities are exceeded or are not functioning. In such instances, stormwater will often exit the conveyance system through catchbasin grates and flow down the corridor of least resistance. Careful consideration must be given to the impact of secondary overflows on public health, safety and welfare, property, and wildlife habitat. When secondary overflow occurs, design of secondary drainage facilities following careful analysis and planning can significantly reduce impacts. Street alignments and grades are the key components in developing secondary drainage design, and consideration should be given early in the planning stages to their use as secondary overflow facilities.

Site Constraints and Setbacks

Site constraints are any manmade restrictions such as property lines, easements, structures, etc. that impose constraints on development. Constraints may also be imposed from <u>*natural*</u> *features such as requirements of the local government's Sensitive Areas Ordinance and Rules (if adopted). These should also be reviewed for specific application to the proposed development.*

All facilities shall be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government, and 100 feet from any septic tank/drainfield (except wet vaults shall be a minimum of 20 feet).

All facilities shall be a minimum of 50 feet from any steep (greater than 15%) slope. A geotechnical report must address the potential impact of a wet pond on a steep slope.

Dam Safety

In urban or urbanizing areas, failure of an impoundment structure can cause significant property damage and even loss of life. Such structures should be designed only by professional engineers registered in the State of Washington who are qualified and experienced in impoundment design. Wherever they exist, local safety standards for impoundment design shall be followed. Where no such criteria exist, widely recognized design criteria such as those used by the USDA Soil Conservation Service, Ecology Dam Safety Standards, or U.S. Army Corps of Engineers are recommended.

Safety, Signage and Fencing

Ponds which are readily accessible to populated areas should incorporate all possible safety precautions. Steep side slopes (steeper than 3H:1V) at the perimeter shall be avoided and dangerous outlet facilities shall be protected by enclosure. Warning signs for deep water and potential health risks shall be used wherever appropriate. Signs should be placed so that at least one is clearly visible and legible from all adjacent streets, sidewalks or paths. A notice should be posted warning residents of potential waterborne disease that may be associated with body contact recreation such as swimming in these facilities.

If the pond surface exceeds 20,000 sq. feet, include a safety bench around the basin with a width of 5 feet, and with a depth not exceeding 1 foot during non-storm periods. Emergent vegetation such as cattails should be placed on the bench to inhibit entry by unauthorized people.

A fence is required at the maximum water surface elevation, or higher, when a pond slope is a wall. Local governments and Homeowners Associations may also require appropriate fencing as an additional safety requirement in any event.

Design Criteria

Sizing Wet Ponds

Wet ponds designed for treatment of conventional pollutants utilize a permanent pool of water to provide treatment and are to be designed using the hydrologic analysis methods presented in Chapter III-1.

Permanent Pool Volume

The permanent pool volume shall be equal to the runoff volume of the 6-month, 24-hour design storm. It is not necessary to vegetate the permanent pool, but establishment of a shallow marsh system can provide additional pollutant removal capabilities.

Surface Area-Pool Depth Relationships

The pond surface area is found by dividing the permanent pool volume by the depth, with a maximum depth of six (6) feet recommended. A minimum depth of three (3) feet is recommended so that resuspension of trapped pollutants is inhibited. Permanent pools deeper than six (6) feet could potentially contaminate ground water (should they intersect the existing ground water level). Also, deeper ponds can stratify and create anaerobic condition that can cause pollutants which are normally bound in the sediment (e.g., metals and phosphorus) to resolubilize; their release back to the water column can seriously affect the effectiveness of the BMP and also create nuisance conditions.

See Table III-4.2 for the surface area-pool depth relationship. Table III-4.3 illustrates typical surface area-to-drainage area ratios for this and other detention BMPs.

If the wet pond is also designed to provide streambank erosion control, then additional surface area and depth will be required for the "live storage" volume located above the permanent pool. There is no specific surface area-pool depth relationship for the "live storage" volume.

Ponds designed to provide streambank erosion control may be deeper than six feet as long as the permanent pool volume provided for runoff treatment does not exceed six feet.

Outlet Structure

The outlet structure must be designed to accomplish an extended detention time so that runoff can be released at the flow rates established by Minimum Requirement #5, Streambank Erosion Control (see Chapter I-2). Figure III-4.3 illustrates methods for extending detention time in wet ponds.

Pond Configuration and Geometry

Wet ponds shall be multi-celled with a least two cells, and preferably three. The cells should be approximately equal in size. The first cell should be three feet deep in order to effectively trap coarser sediments and reduce turbulence which can resuspend sediments. It should be easily accessible for maintenance purposes.

Long, narrow, and irregularly shaped ponds are preferred, as these configurations are less prone to short-circuiting and tend to maximize available treatment area. The length-to-width ratio should be at least 3:1 and preferably 5:1. Irregularly shaped ponds may perform more effectively and will have a more natural appearance.

The inlet and outlet should be at opposite ends of the pond where feasible. If this is not possible, then baffles can be installed to increase the flow path and water residence time (see BMP RD.10, Presettling Basin, for details).

Interior side slopes up to the maximum water surface shall be no steeper than 3H:1V. Exterior side slopes shall be no steeper than 2H:1V.

The pond bottom shall be level to facilitate sedimentation.

Pond walls may be retaining walls, provided that the design is prepared and stamped by a structural engineer registered in the State of Washington, that they are constructed of reinforced concrete per Section III-4.6.1, that a fence is provided along the top of the wall, and that at least 25 percent of the pond perimeter will be a vegetated soil slope of not greater than 3H:1V.

Other Design Considerations

Liner to Prevent Infiltration

Detention BMPs should have negligible infiltration rates through the bottom of the pond. Infiltration will impair the proper functioning of detention BMPs and can contaminate ground water. If infiltration is anticipated, then a detention facility must either **not** be used and an infiltration BMP used instead (see Chapter III-3) or a liner should be installed to prevent infiltration. If a liner is used, the specifications provided in Section III-3.7 (Filtration BMPs) can be used. When using a liner the following are recommended:

- A layer of (track) compacted top soil (minimum 18" thick shall be placed over the liner prior to seeding with an appropriate seed mixture (see BMP E1.35 in Chapter II-5).
- Other liners may be used provided the design engineer can supply support documentation that the material will provide the required performance.

Overflow and Emergency Spillway

If streambank erosion control is not required, a pond overflow system must provide controlled discharge of the 100-year, 24-hour design storm event for developed site conditions without overtopping any part of the pond embankment or exceeding the capacity of the emergency spillway. The design must provide controlled discharge directly into the downstream conveyance system. This assumes the pond will be full due to plugged control structure inflow pipe and/or plugged restrictor/orifices conditions.

Open Type 2 catchbasins can function as weirs when used as pond overflow structures to control overtopping. The overflow structure, as shown in Figure III-4.5, may be required in some circumstances to protect embankments from overtopping.

In addition to the above overflow requirements, an emergency overflow spillway (secondary overflow) must be provided to safely pass the 100-year, 24-hour design storm event (for developed site conditions and assuming the pond is full to the crest of the spillway) over the pond embankment in the event of control structure failure or for storm/runoff events exceeding design. The spillway must be located to direct overflows safely towards the downstream conveyance system and shall be located in existing soil wherever feasible. The emergency overflow spill shall be armored with riprap in conformance with Table III-2.4 and shall extend to the toe of each face of the berm embankment.

- Design of emergency overflow spillways requires the analysis of a broad-crested trapezoidal weir. The following weir section is required for the emergency overflow spillway, as per Figure III-4.4.

Figure III-4.2 Methods for Extending Detention Time in Wet Ponds

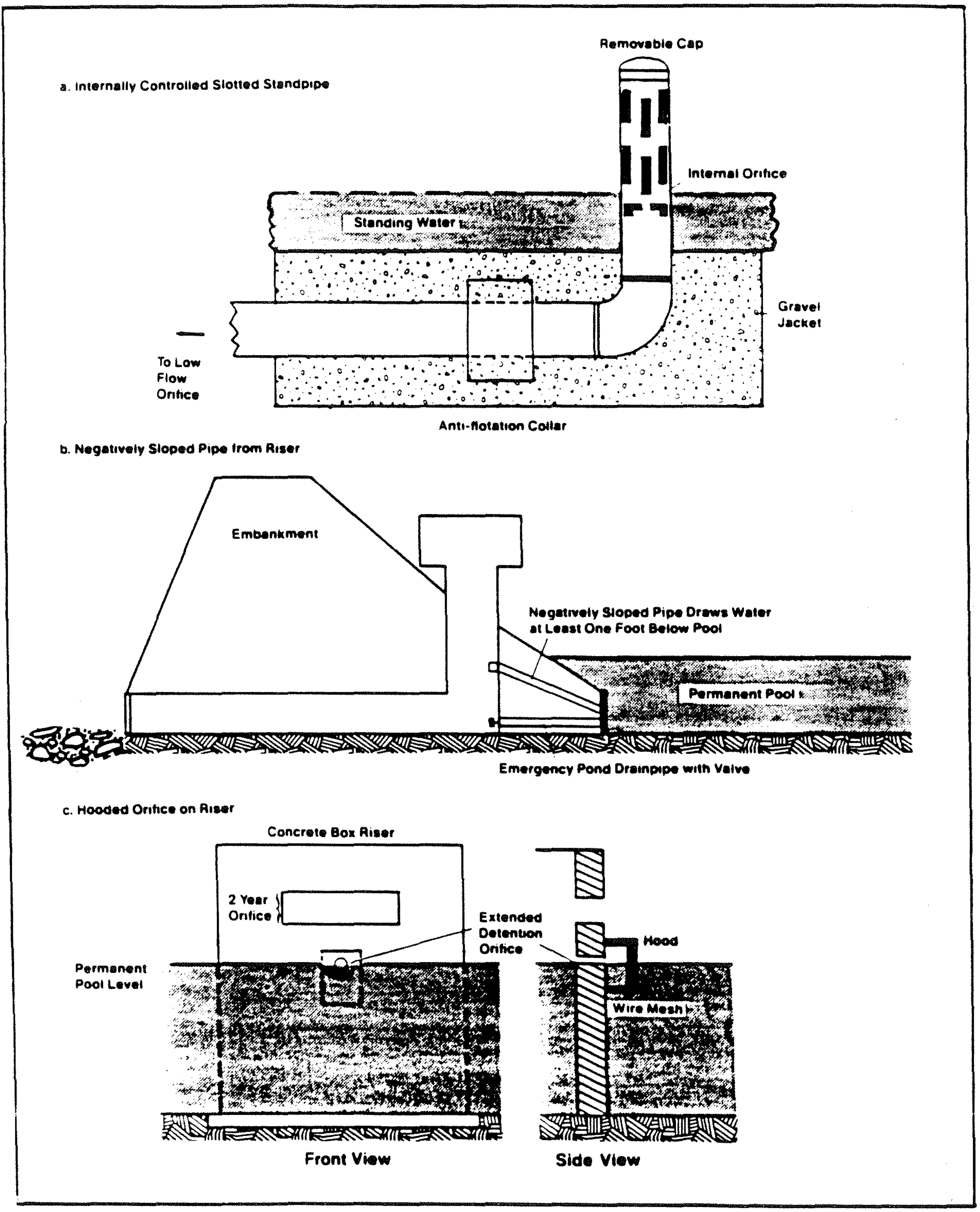
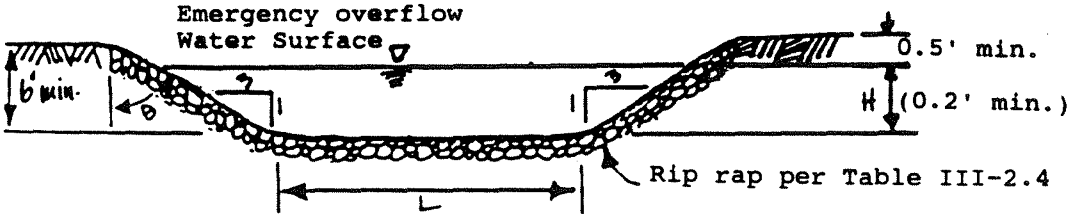


Figure III-4.3 Weir Section for Emergency Overflow Spillway



- The emergency overflow spillway weir section can be designed to pass the 100-year, 24-hour design storm event for developed conditions as follows:

  For this weir, $Q_{100} = C\ (2g)^{1/2}[(2/3)LH^{3/2} + 8/15 \text{ Tan } \Theta\ H^{5/2}]$

  using:
  $C = 0.6$ (discharge coefficient);
  $\text{Tan } \Theta = 3$ (for 3:1 slopes);
  $\Theta = 72°$;

  The equation becomes: $Q_{100} = 3.21\ (LH^{3/2} + 2.4H^{5/2})$

  To find width L, the equation is rearranged to use the computed Q_{100} (peak flow for the 100-year, 24-hour design storm) and trial values of H (0.2 feet minimum).

  $L = (Q_{100}/(3.21H^{3/2})) - (2.4H^2);$
  $= 6$ feet minimum

Berm Embankment/Slope Stabilization

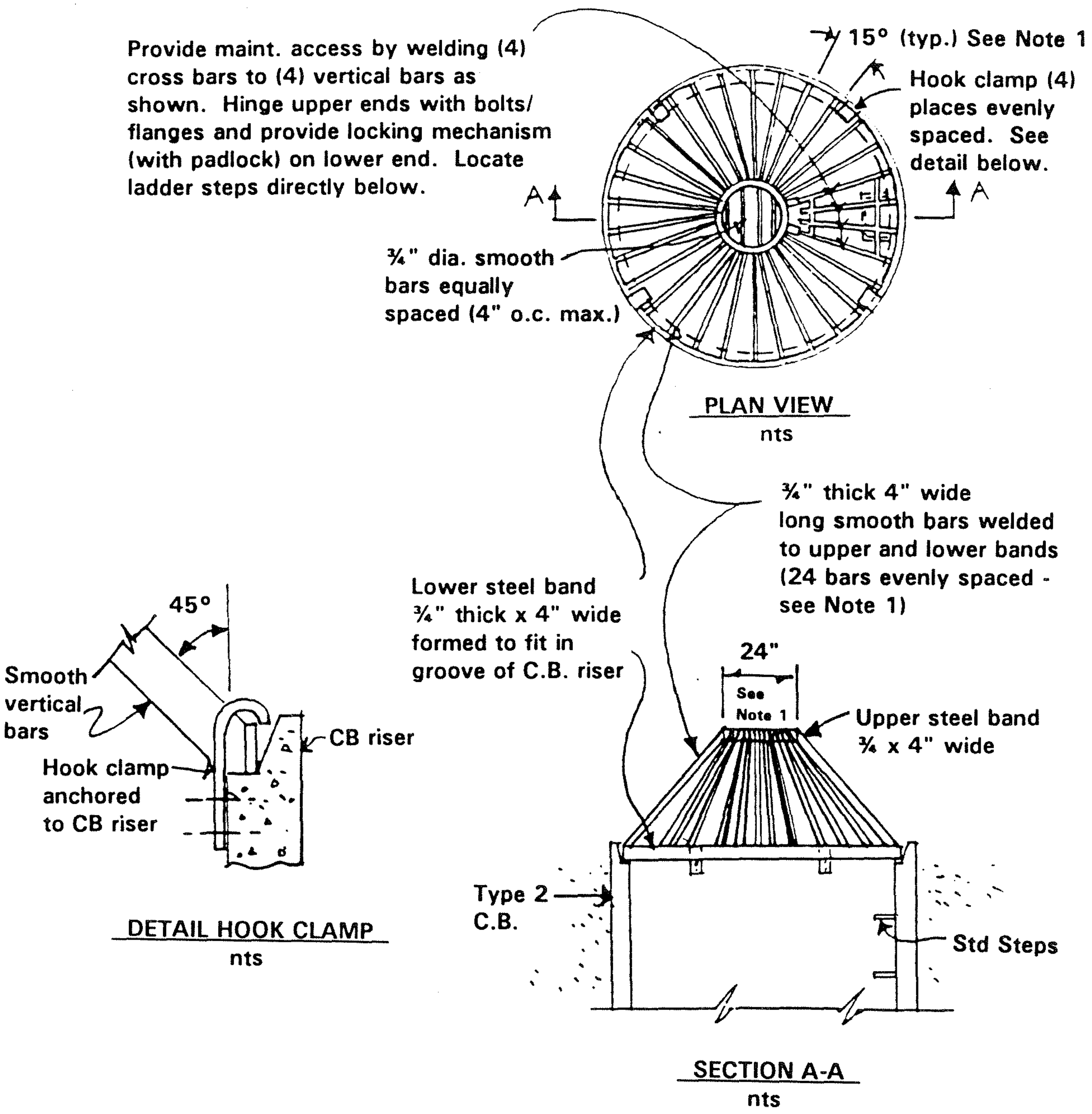
Pond embankments higher than 6 feet shall require design by a geotechnical-civil engineer licensed in the State of Washington. The embankment shall have a minimum 15 foot top width where necessary for maintenance access; otherwise, top width may vary as recommended by the geotechnical-civil engineer.

The berm dividing the pond into cells shall have a 5 foot minimum top width, a top elevation set one foot lower than the design water surface, maximum 3:1 side slopes, and a quarry spall and gravel filter "window" between the cells (see Figure III-4.5).

For berm embankments of 6 feet or less than (including 1 foot freeboard), the minimum top width shall be 6 feet or as recommended by the geotechnical-civil engineer.

The toe of the exterior slope of pond berm embankment must be no closer than 5 feet from the tract or easement property line.

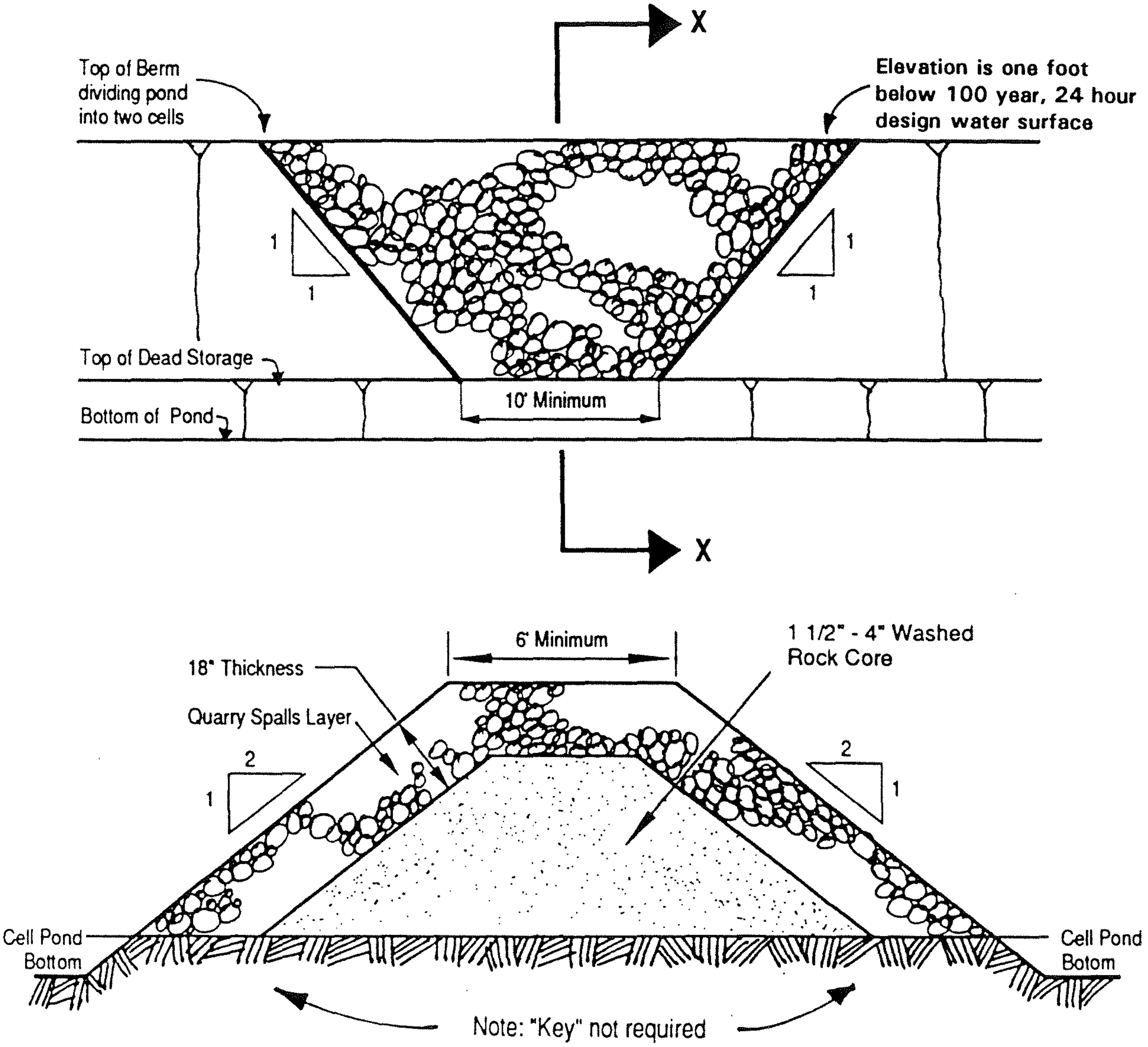
Figure III-4.4 Detention Pond Overflow Structure



Notes:

1. Dimensions are for installation on 54" dia. C.B. For different dia.C.B.'s adjust dimensions to maintain 45° angle on "vertical" bars and 7" O.C. max. spacing of bars around lower steel band.
2. Metal parts: corrosion resistant.
3. This debris barrier is also recommended for use on the inlet to roadway cross-culverts with high potential for debris collection (except on Class 2 streams).

Figure III-4.5 Quarry Spall and Gravel Filter "Window"



Pond berm embankments must be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical report) free of loose surface soil materials, roots and other organic debris.

Pond berm embankments must be constructed by excavating a "key" equal to 50 percent of the berm embankment cross-sectional height and width (except on highly compacted till soils where the "key" minimum depth can be reduced to 1 foot of excavation into the till).

The berm embankment shall be constructed on compacted soil (95 percent minimum dry density, standard proctor method per ASTM D1557), placed in 6-inch lifts, with the following soil characteristics per the United States Department of Agriculture's Textural Triangle: a minimum of 30 percent clay, a maximum of 60 percent sand, a maximum of 60 percent silt, with nominal gravel and cable content (Note, in general, excavated glacial till will be well-suited for berm embankment material).

Anti-seepage collars must be placed on outflow pipes in berm embankments impounding water greater than 8 feet in depth at the design water surface.

Exposed earth on the pond bottom and side slopes shall be sodded or seeded with the appropriate seed mixture as soon as is practicable (see Erosion and Sediment Control BMP E1.35 in Volume II). Establishment of protective vegetative cover shall be ensured with jute mesh or other protection and reseeded as necessary (see Erosion and Sediment Control BMPs E1.15 and E1.35 in Volume II).

Gravity Drain

A gravity drain for maintenance shall provide an outlet invert of one foot above the bottom of the facility and shall be sized to drain the facility in four hours or less.

Erosion and Sediment

Bank erosion is often a significant problem during the initial stages of development. Stabilization with sod down to the permanent pool and preventing undue sediment deposition is required for the planting to survive.

Erosion and sediment control BMPs must be used to retain sediment on-site during construction (see Erosion and Sediment Control in Volume II). BMPs must be shown on the design plans and the engineer must provide instructions for proper O&M. Permanently stabilize all areas above the normal water level of ponds to prevent erosion and sedimentation of plantings (see Chapter II-5).

Littoral Zone Planting

For treating conventional pollutants a wet pond does not require the establishment of vegetation in its shallow areas, or "littoral zones." However, a shallow marsh system can provide additional treatment of runoff and be aesthetically pleasing (see BMP RD.06, Wet Pond for Nutrient Control, for details). If littoral zone vegetation is planned it shall be planted according to the advice of a wetlands specialist. Nursery sources are recommended wherever possible. Small (2-4 inch) containers are encouraged to avoid transporting large amounts of potting soil to the pond. White roots and active basal budding indicate a healthy stock.

Most wetlands specialists prefer to have someone on-site during the construction phase to ensure that the littoral shelf is located and graded properly. Knowing exactly where the normal water level of the facility will reside after construction is absolutely essential to the success of this element of the system.

Construction and Maintenance Criteria

Construction

Widely acceptable construction standards and specifications such as those developed by the USDA - Soil Conservation Service or the U.S. Army Corps of Engineers for embankment ponds and reservoirs should be followed to build the impoundment.

Chapter 17 of the SCS Engineering Field Manual provides guidance on construction methods for the various elements of a pond or reservoir. Specifications for the work should conform to methods and procedures for installing earthwork, concrete, reinforcing steel, pipe, water gates, metal work, woodwork, and masonry, that are applicable to the site and the purpose of the structure, and satisfy all requirements of the local government.

Maintenance

General

Maintenance is of primary importance if detention ponds are to continue to function as originally designed. A local government, a designated group such as a homeowners' association, or some individual shall accept the responsibility for maintaining the structures and the impoundment area. A specific maintenance plan shall be formulated outlining the schedule and scope of maintenance operations. Debris removal in detention basins can be achieved through the use of trash racks or other screening devices.

Design with maintenance in mind. Good maintenance will be crucial to successful use of the impoundment. Hence, provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Table III-4.4 for specific maintenance requirements.

Any standing water removed during the maintenance operation must be disposed of to a sanitary sewer at an approved discharge location. Residuals must be disposed in accordance with current health department requirements of the local government.

Vegetation

If a shallow marsh is established, then periodic removal of dead vegetation will be necessary. The frequency of removal has not been established and Ecology requests comments on this issue. Since decomposing vegetation can release pollutants captured in the wet pond, especially nutrients, it may be necessary to harvest dead vegetation annually prior to the winter wet season. Otherwise the decaying vegetation can export pollutants out of the pond and also can cause nuisance conditions to occur. If harvesting is to be done in the wetland, a written harvesting procedure shall be prepared by a wetland scientist and will be submitted with the drainage design to the local government.

Sediment

Maintenance of sediment forebays and attention to sediment accumulation within the pond is extremely important. Sediment deposition should be continually monitored in the basin. Owners, operators, and maintenance authorities should be aware that significant concentrations of heavy metals (e.g., lead, zinc, and cadmium) as well as some organics such as pesticides, may be expected to accumulate at the bottom of these treatment facilities. Testing of sediment, especially near points of inflow, should be conducted regularly to determine the leaching potential and level of accumulation of hazardous material before disposal. For disposal procedures, refer to Volume IV - disposal requirements for catchbasin and pond sediments (to be written).

Access

Pond access tracts and roads are required when ponds do not abut public right-of-way. Road(s) shall provide access to the control structure and along side(s) of the pond as necessary for vehicular maintenance. For ponds with bottom widths of 15 feet or more, the access road shall extend to the pond bottom and an access pad provided to facilitate cleaning. For ponds less than 15 feet in width, an access road must extend along one side.

Roads and pads shall meet the following criteria:

- Maximum Grade: 15 percent to control structure, 20 percent into pond.
- Provide 40 foot minimum outside radius on the access road to the control structure and the turn around to the pond bottom.
- Fence gates shall be provided for access roads at "straight" sections of road.
- Access roads shall be 15 feet in width.
- Access pads shall be 15 feet in width and 25 feet in length.
- Manhole and catchbasin lids must be at either edge of an access road or pad and be at least 3 feet from a property line.

Access shall be limited by a double-posted gate if a fence is required or by bollards. Bollards shall consist of two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards.

Access roads and pads shall be constructed by utilizing one of the following techniques:

- Construct an asphalt surface meeting the same standard as residential minor access streets, as required by the local government.
- Construct a gravel surface road by removing all unsuitable material, laying a geotextile fabric over the native soil, placing quarry spalls (2"-4") six inches thick then providing a two-inch thick crushed gravel surface.
- Construct a landscape block (24"x24"x 6") surface by removing all unsuitable material, laying a geotextile fabric over the native soil, placing landscape blocks, filling the honeycombs with soil particles, and planting grass.

Nuisance Conditions

The presence of wet ponds and marshes in established urban areas is perceived by many people to be undesirable. They are often thought of as mud holes where mosquitoes and other insects breed. If the wet pond has a shallow marsh established (more likely in the cases of BMP RD.06 and BMP RD.09), the pond can become a welcomed addition to an urban community. Constructed fresh water marshes can provide miniature wildlife refuges, and while insect populations are increased, insect predators also increase, often reducing the problem to a tolerable level. Advice from the University of Washington (Rick Sugg, personal communication) suggests that in the Puget Sound lowlands, the extra breeding habitat provided by any wetponds would not be significant. Nevertheless, local governments and homeowners associations may wish to temporarily drain wet ponds during late spring (May) and summer if there is sufficient concern. **However, it is imperative that vegetation in shallow marsh areas not die off during draindown periods. Otherwise, the pollutant removal effectiveness of the wet pond can be severely impacted. In addition, the decaying vegetation can create nuisance conditions.**

Table III-4.4 Specific Maintenance Requirements for Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
I. Ponds - General	Trash and debris	Any trash or debris which exceeds 1 $ft^3/1000\ ft^2$ (equal to the volume of a standard size office garbage can). In general, there should be no evidence of dumping.	Trash and debris cleared from site.
	Poisonous vegetation	Any poisonous vegetation which may constitute a hazard to maintenance personnel or the public, e.g. tansy, poison oak, stinging nettles, devils club.	No danger of poisonous vegetation where maintenance personnel or the public might normally be. Coordinate with the local county health dept.
	Pollution	1 gallon or more of oil, gas or other contaminants or any amount found that could: 1) cause damage to plant, animal or marine life, 2) constitute a fire hazard, 3) be flushed downstream during storms or 4) contaminate ground water.	No contaminants present other than a surface film. Coordinate with the local county health dept.
	Unmowed grass/ground cover	In residential areas, mowing is needed when the cover exceeds 18 inches in height. Otherwise, match facility cover with adjacent ground cover and terrain as long as there is no decrease in facility function.	When mowing is needed, grass or ground cover should be mowed down to 2 inches. A dense grass cover must be maintained on slopes, and in dry ponds on the bottom as well.
	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 the local county health dept.
	Insects	When insects such as wasps or hornets interfere with maintenance activities.	Insects destroyed or removed from site. Coordinate with people who remove wasps for anti-venom production.
	Tree growth	Tree growth does not allow maintenance access or interferes with maintenance activity. If trees are not interfering with access, leave trees alone.	Trees do not hinder maintenance activities. Selectively cultivate trees such as alders for firewood.
Side Slopes of Pond	Erosion	Eroded damage >2 inches deep where cause of damage is still present or where there is potential for continued erosion.	Slopes should be stabilized with appropriate erosion control BMPs e.g. seeding, plastic covers, riprap.
Storage Area, Forebay	Sediment	Accumulated sediment that exceeds 10% of the designed forebay depth, or every three years.	Sediment cleaned out to designed pond shape and depth; reseeded if necessary to control erosion.
Pond Dikes	Settling	Any part of dike which has settled 4 inches lower than the design elevation.	Dike should be built back to the design elevation.
Emergency Overflow, Spillway	Rock missing	Only 1 layer of rock above native soil in an area ≥ 5 ft^2 or any exposure of native soil.	Replace rock to design standards.
II. Debris Barriers - General	Trash and debris	Trash or debris that is plugging ≥20% of the openings in the barrier.	Barrier clear to receive capacity flow.

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Metal	Damaged/missing bars	Bars are bent out of shape ≥ 3 inches.	Bars in place with no bend ≥ 3/4".
		Bars or entire barrier is missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of the barrier.	Repair or replace barrier to standards.
III. Fencing - General	Missing or broken parts	Any defect in the fence that permits easy entrance to the facility.	Parts in place to provide adequate security.
		Parts broken or missing.	Broken or missing parts replaced.
	Erosion	Erosion ≥ 4 inches deep and 12 - 18 inches wide permitting an opening under the fence.	No opening under the fence ≥ 4 inches in depth.
Wire Fences	Damaged parts	Posts out of plumb more than 6 inches.	Posts plumb within 1½ inches.
		Top rails bent more than 6 inches.	Top rail free of bends ≥ 1 inch.
		Any part of fence (including posts, top rails and fabric) ≥ 1 foot out of design alignment.	Fence is aligned and meets design standards.
		Missing or loose tension wire.	Tension wire in place & holding fabric.
		Missing or loose barbed wire sagging more than 2½ inches between posts.	Barbed wire in place with < 3/4 inch sag between posts.
		Extension arm missing, broken or bent out of shape more than 1½ inches.	Extension arm in place with no bends larger than 3/4 inch.
	Deteriorated paint or protective coating	Part(s) that have a rusting or scaling condition which has affected structural adequacy.	Structurally adequate posts or parts with a uniform protective coating.
	Openings in fabric	Openings in fabric are such that an 8 inch diameter ball could fit through.	No openings in fence.
IV. Gates - General	Damaged or missing members	Missing gate or locking device.	Gates and locking devices in place.
		Broken or missing hinges such that gate cannot be easily opened and closed by maintenance personnel.	Hinges intact & lubed, gate working freely.
		Gate is out of plumb ≥ 6 inches and ≥ 1 foot out of design alignment.	Gate is aligned & vertical.
		Missing stretcher bar, stretcher bands and ties.	Stretcher bar, bands & ties in place.
		See "Fencing" standard, above.	See "Fencing" standard, above.
V. Access Roads, Easements - General	Trash and debris	Exceeds 1 $ft^3/1000\ ft^2$ or the amount that would fill a standard size garbage can.	Trash & debris cleared from site.
	Blocked roadway	Debris which could damage vehicle tires.	Roadway free of such debris.
		Obstructions which reduce clearance above road surface to < 14 feet.	Roadway overhead clear to 14 feet high.

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
V. Access Roads, Easements, continued	Blocked roadway, continued	Any obstructions restricting access to a 10 - 12 foot width for a distance of $\geq$ 12 feet or any point restricting access to a $<$ 10 foot width.	Obstruction moved to allow at least a 12 foot access route.
	Settlement, potholes, mushy spots, ruts	When any surface exceeds 6 inches in depth and 6 ft^2 in area. In general, any surface defect which prevents or hinders maintenance access.	Road surface uniformly smooth with no evidence of potholes, settlement, mushy spots or ruts.
	Vegetation in surface	Weeds growing in the road surface that are $\geq$ 6 inches tall and $<$ 6 inches apart within a 400 ft^2 area.	Road surface free of weeds taller than 2 inches.
	Erosion damage	Erosion within 1 foot of the roadway $\geq$ 8 inches wide & 6 inches deep.	Shoulder free of erosion & matching the surrounding road.
	Weeds and brush	Weeds and brush exceed 18 inches in height or hinder maintenance access.	Weeds and brush cut to 2 inches in height or cleared in such a way as to allow maintenance access.

APPENDIX G:
CURVE NUMBERS

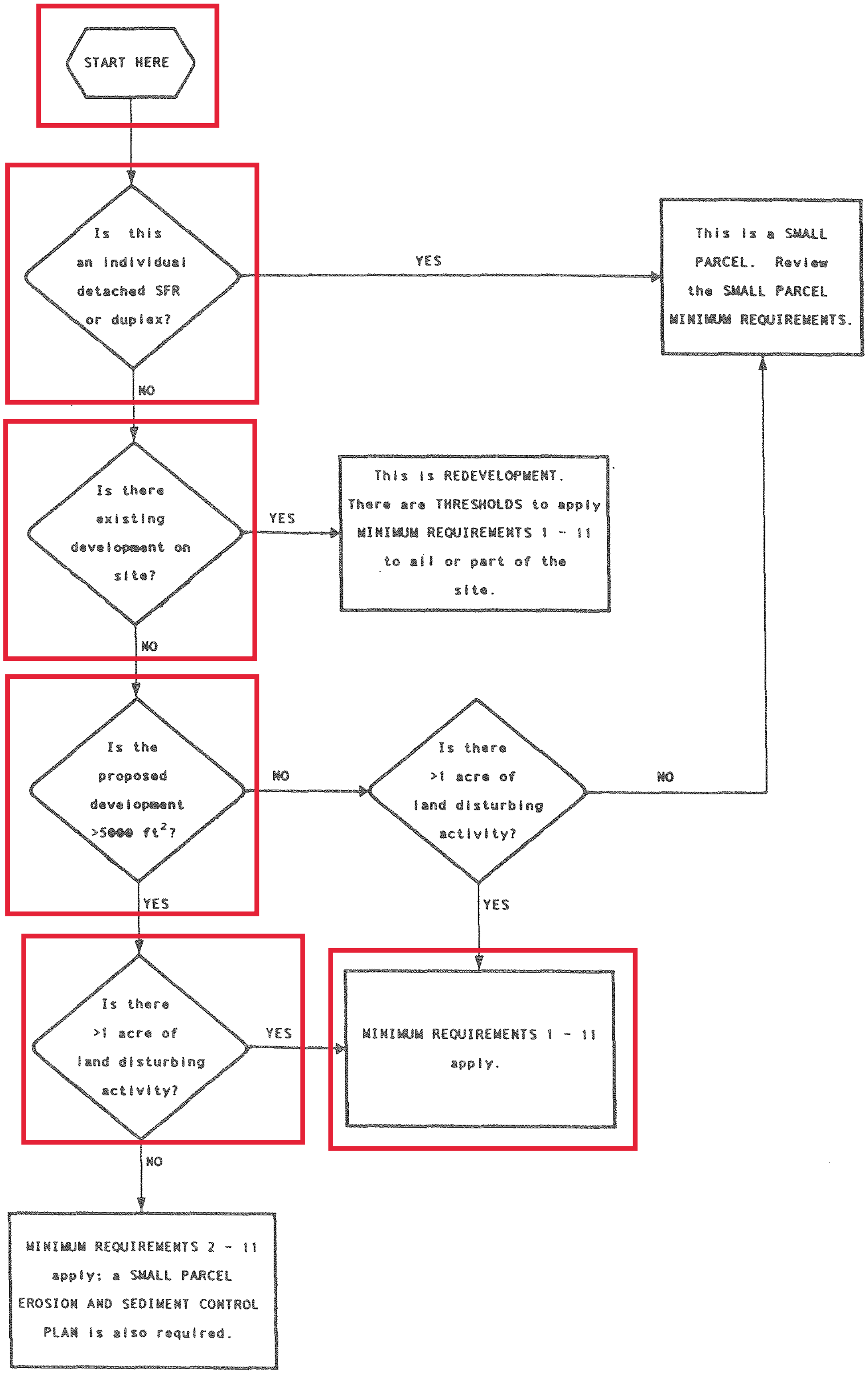
Table III-1.3 SCS Western Washington Runoff Curve Numbers
(Published by SCS in 1982) Runoff curve numbers for selected agricultural, suburban and urban land use for Type 1A rainfall distribution, 24-hour storm duration.

LAND USE DESCRIPTION		CURVE NUMBERS BY HYDROLOGIC SOIL GROUP			
		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):		Separate curve number shall be selected for pervious & impervious portions of the site or basin			
Dwelling Unit/Gross Acre	%Impervious(3)				
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.

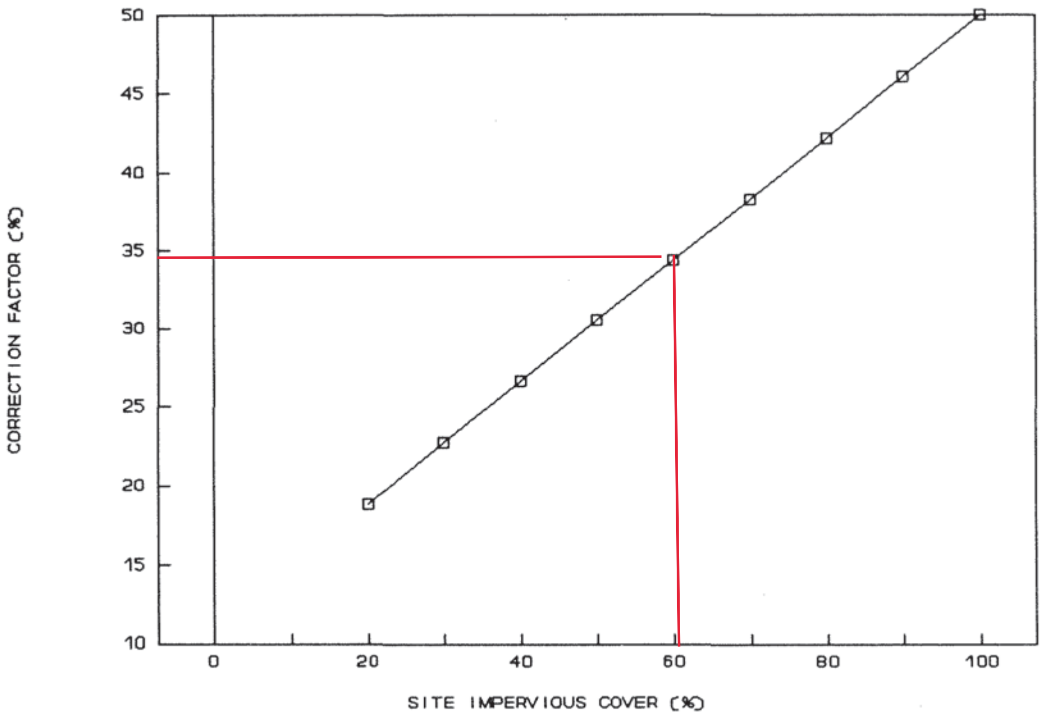
APPENDIX H:
NEW DEVELOPMENT FLOW CHART

Figure I-2.1 Flowchart Demonstrating Minimum Requirements



APPENDIX I:
VOLUME CORRECTION FACTOR

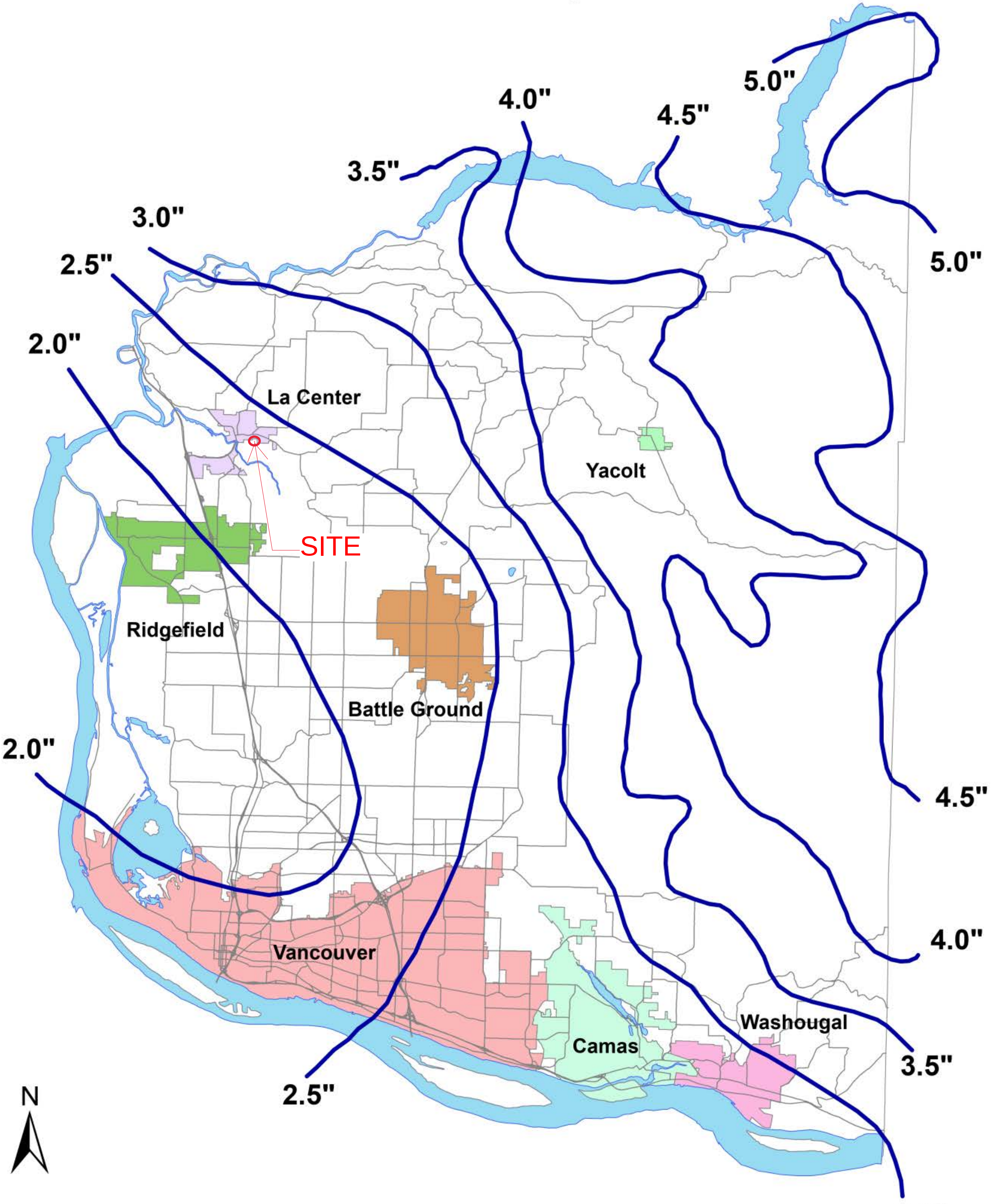
FIGURE III-1.1
Volume Correction Factor to be Applied to
Streambank Erosion Control BMPs
Based on Site Impervious Cover



APPENDIX J:
ISOPLUVIAL MAPS

Isopluvial Map for Clark County

2-Year, 24-Hour Design Storm

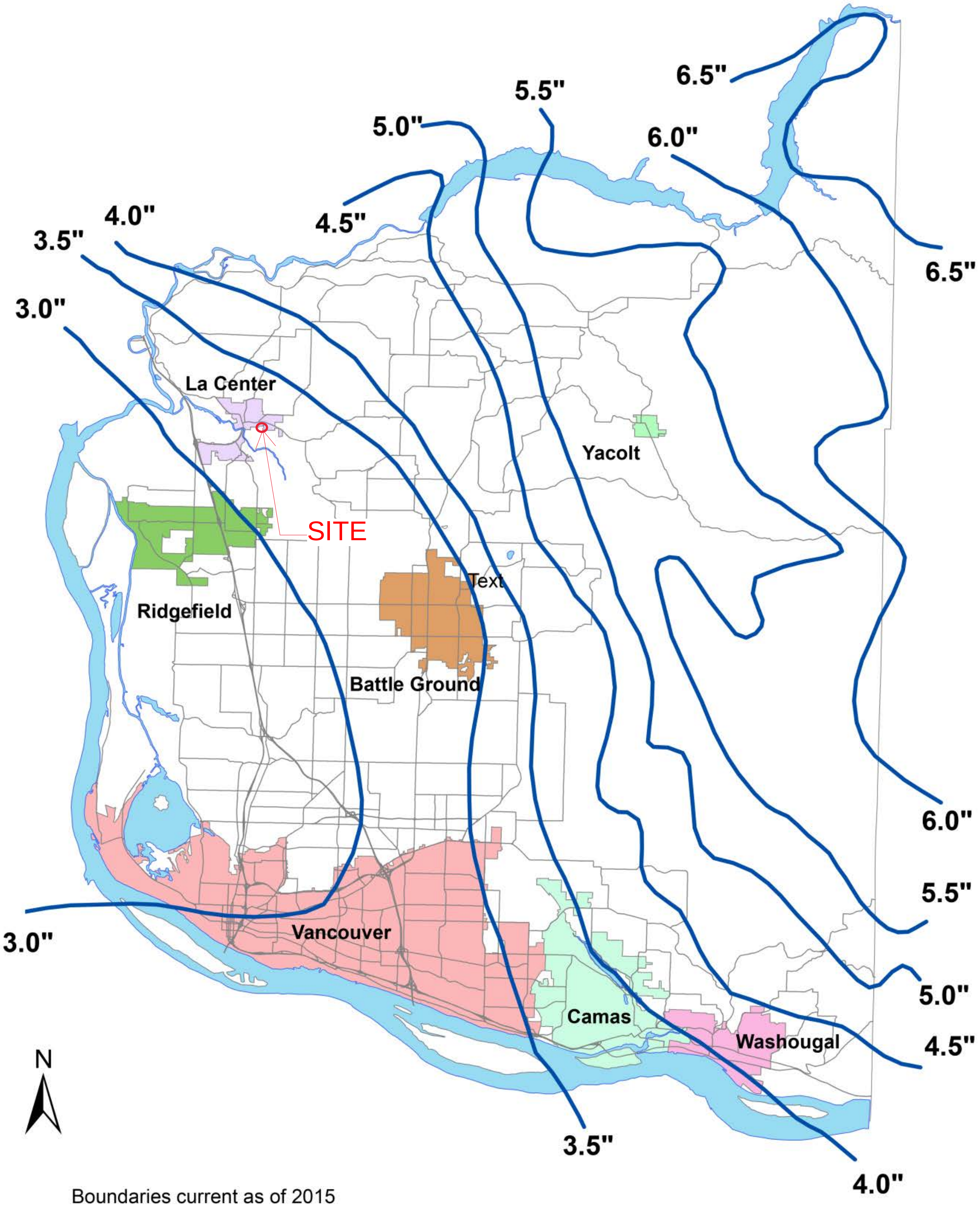


Boundaries current as of 2015

ERRATA September 2016

Isopluvial Map for Clark County

10-Year, 24-Hour Design Storm

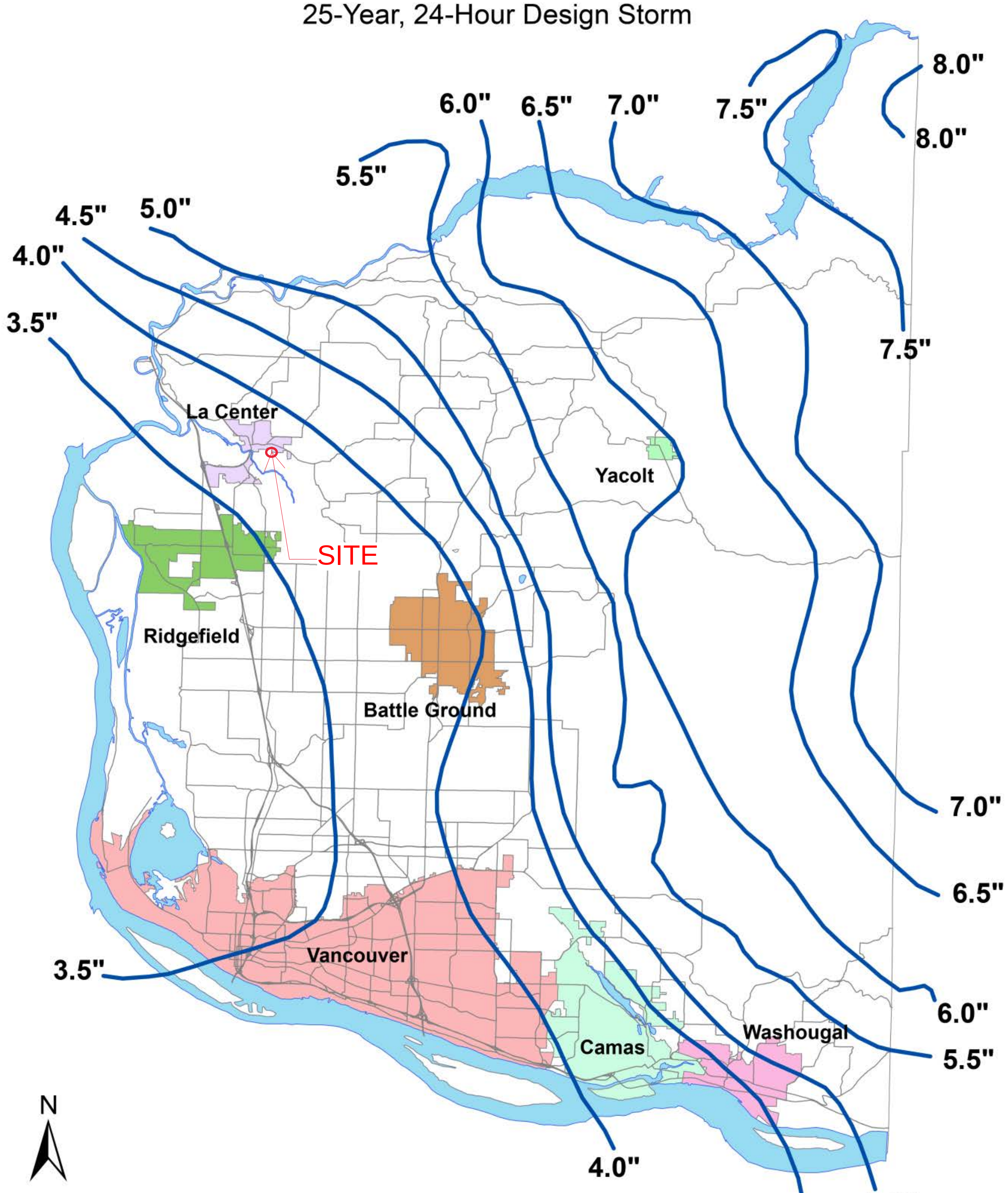


Boundaries current as of 2015

ERRATA September 2016

Isopluvial Map for Clark County

25-Year, 24-Hour Design Storm

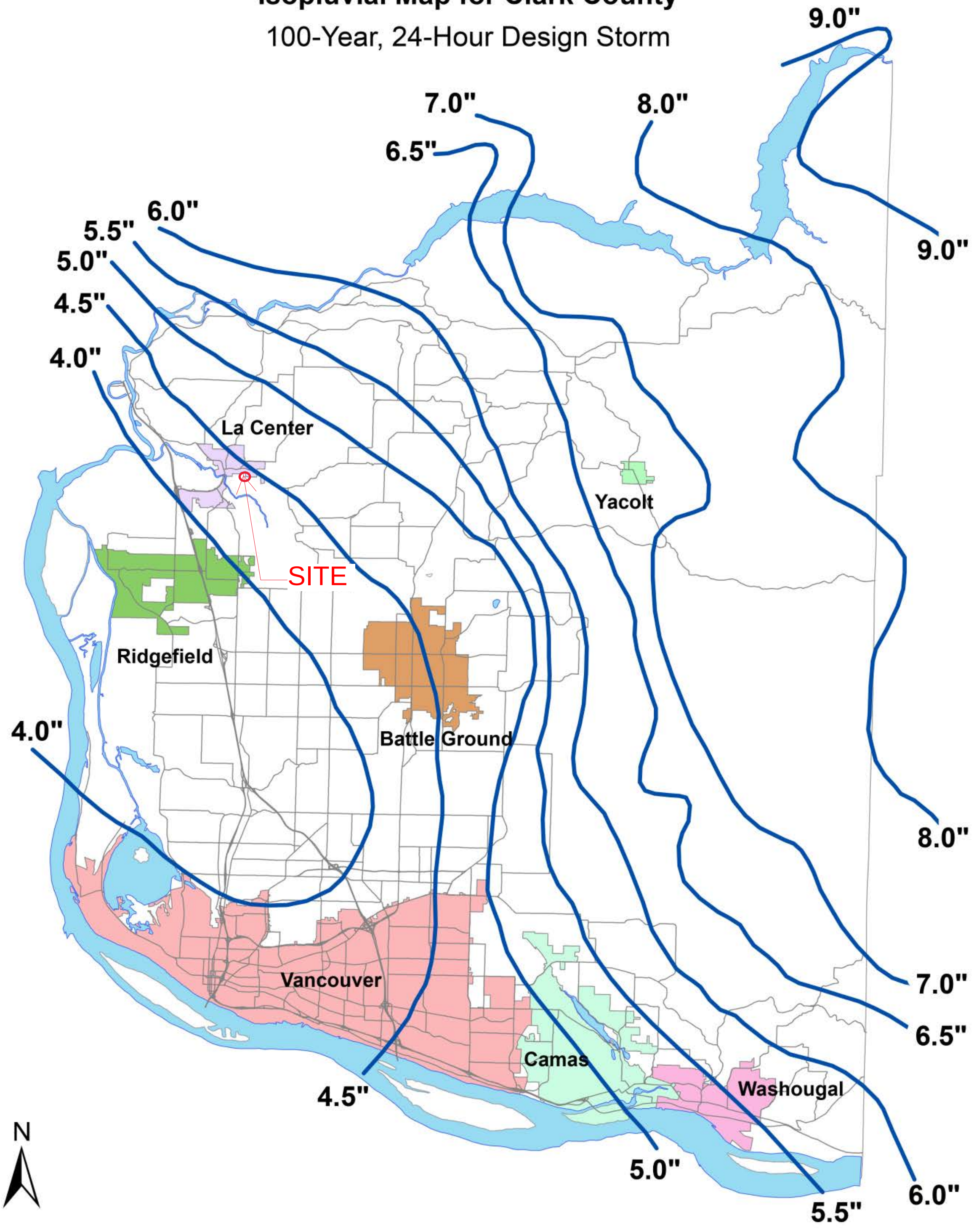


Boundaries current as of 2015.

ERRATA September 2016

Isopluvial Map for Clark County

100-Year, 24-Hour Design Storm



Boundaries current as of 2015.

ERRATA September 2016

APPENDIX K:
WET POND CALCULATIONS

AKS
ENGINEERING & FORESTRY

Stormwater Wetpond Calculations

Volume of Water Quality Storm Event V= 0.884 ac-ft from HydroCAD

Wetpond Volume V= 38507.04 cubic feet

First cell volume V_s= 20655.42 cubic feet
Second cell volume V_s= 18442.17 cubic feet
Actual Wetpond Volume V_s= 39097.59 cubic feet

SA=Surface Area (as percent of total surface area)

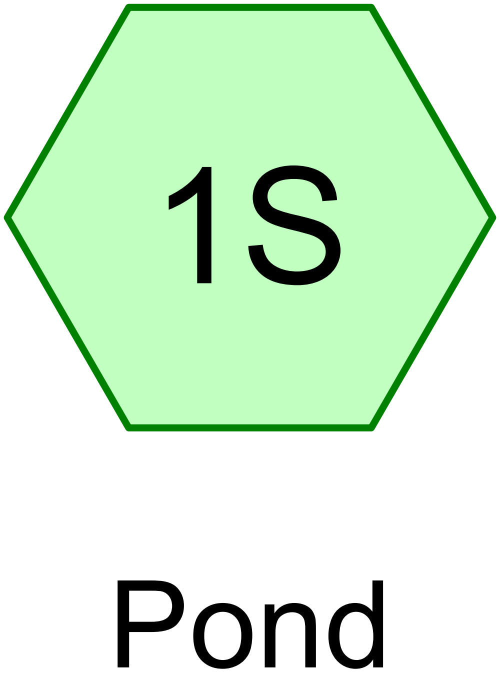
Actual Wetpond Surface Area (0'-2' Pool Depth) A_s= 4782.71 square feet 46.17

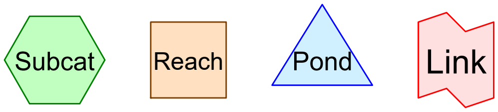
Actual Wetpond Surface Area (2'-6' Pool Depth) A_s= 5577.07 square feet 53.83

Total surface Area= 10359.78 square feet
Average depth = SA*2' pool depth + SA*6' pool depth

Average depth = 4.15 feet

Maximum average depth= 4.8 feet





Routing Diagram for 6962 Pond WQ sizing
Prepared by AKS Engineering and Forestry, Printed 3/1/2019

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
2.566	90	grass C (1S)
0.901	92	grass D (1S)
1.509	98	road (1S)
3.781	98	roof and driveway (1S)
0.349	98	sidewalk (1S)
9.106	**95**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
9.106	Other	1S
9.106		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	2.566	2.566	grass C	1S
0.000	0.000	0.000	0.000	0.901	0.901	grass D	1S
0.000	0.000	0.000	0.000	1.509	1.509	road	1S
0.000	0.000	0.000	0.000	3.781	3.781	roof and driveway	1S
0.000	0.000	0.000	0.000	0.349	0.349	sidewalk	1S
0.000	**0.000**	**0.000**	**0.000**	**9.106**	**9.106**	**TOTAL AREA**	

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Pond Runoff Area=9.106 ac 61.93% Impervious Runoff Depth>1.16"
Tc=5.0 min CN=91/98 Runoff=2.66 cfs 0.884 af

Total Runoff Area = 9.106 ac Runoff Volume = 0.884 af Average Runoff Depth = 1.16"
38.07% Pervious = 3.467 ac 61.93% Impervious = 5.639 ac

Summary for Subcatchment 1S: Pond

[49] Hint: Tc<2dt may require smaller dt

Runoff = 2.66 cfs @ 7.93 hrs, Volume= 0.884 af, Depth> 1.16"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 6 mon Rainfall=1.60"

	Area (ac)	CN	Description
*	1.509	98	road
*	3.781	98	roof and driveway
*	0.349	98	sidewalk
*	0.901	92	grass D
*	2.566	90	grass C
	9.106	95	Weighted Average
	3.467	91	38.07% Pervious Area
	5.639	98	61.93% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 1S: Pond