Exhibit 5

# **11.** Stormwater Technical Information Report

Exhibit 5

# Camas Heights Subdivision

# Preliminary Stormwater Technical Information Report (TIR)

**Date:** October 2021

**Submitted To:**
City of Camas
Community Development
616 NE 4th Avenue
Camas, WA 98607

**Applicant:**
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11807 NE 99th Street, Suite 1170
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**Prepared By:**
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9600 NE 126th Avenue, Suite 2520
Vancouver, WA 98682

**AKS Job Number:** 8468

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## Certificate of the Engineer

**Camas Heights Subdivision**
**Camas, Washington**
**Preliminary Technical Information Report**

This Preliminary 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 Camas Municipal Code (CMC) Chapter 14.02 is included in the proposed stormwater plan and the proposed facilities are feasible.

JOHN M. MEIER
42614

John Meier 10-29-21

Exhibit 5

## Contents

## Tables

## Appendices

## References

Camas Stormwater Design Standards Manual, November 2016, Resolution #1193 – "CSDSM"

2019 Stormwater Management Manual for Western Washington, (Ecology Publication No. 19-10-021, July 2019), Errata released January 22, 2020 – "SWMMWW"

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# Preliminary Stormwater Technical Information Report (TIR)

CAMAS HEIGHTS SUBDIVISION
CAMAS, WASHINGTON

## Section A – Project Overview

This report analyzes the effects the proposed development will have on the existing stormwater conveyance system; documents the criteria, methodology, and informational sources used to design the proposed stormwater system; and presents the results from the preliminary hydraulic analysis.

### Section A.1 – Site Location

The Camas Heights Subdivision project site is located on one parcel of land, totaling approximately 37.27 acres. The Camas Heights Subdivision site address identified for this project is 22630 NE 28th Street, Camas, WA 98607. The project is located within the Northeast ¼ of Section 21, Township 2 North, Range 3 East, Willamette Meridian, Clark County (Parcel Serial Number: 173157-000). The parcel is zoned Single-Family Residential (R10). The site is accessed from NE 28th Street along the southern portion of the project site and will be connected to NE 87th Street on the western boundary.

### Section A.2 – Site Topography and Critical Areas

The existing site has one existing residence, three sheds, and one barn on agricultural land. The site is a mixture of forested and previously forested land, with slopes ranging from under 5 percent grade to maximum slopes of 40 percent in the northern portion of the site. The site slopes to the southwest towards NE 28th Street.

There is one delineated wetland (Wetland A) located on-site and adjacent to the site along the southwestern boundary. The wetland is to be protected by wetland and aquatic system buffers. Any discharge to the wetland shall maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses.

### Section A.3 – Existing On-Site Stormwater System

Currently stormwater infiltrates or sheet flows to the southwest and is collected either in the wetland in Tract A or in an existing ditch which directs stormwater surface flows west along the northern side of NE 28th Street. No other stormwater systems exist on the subject site.

### Section A.4 – Site Parameters That Influence Stormwater Design

The Camas Heights project site consists of varied steep slopes across the entire site. These slopes contribute to challenges associated with site stormwater collection and conveyance design.

### Section A.5 – Adjacent Property Drainage

Properties from the north and east of the site contribute to the drainage area to Wetland A. This off-site area will flow through the project site conveyance system and will be contained within the critical area. All critical areas will be protected by a critical areas buffer. The Camas Heights project will share the outfall discharge location into the wetland in Tract A through the on-site wetpond facility in Tract B.

### Section A.6 – Adjacent Site Areas

The proposed site is bounded by the Green Mountain Estates Subdivision and a private parcel to the east, the Glades Subdivision to the north, the Country View Estates II Subdivision to the west, and NE 28th Street to the south.

Exhibit 5

Basin 1 consists of the on-site area, along with the eastern portion of NE 28th Street for post-developed flows.

Basin 2 contains the off-site area from the Country View Estates II Subdivision.

Basin 3 consists of NE 28th Street. The western portion of NE 28th Street makes up Basin 3 for post-developed flows.

### Section A.7 – General Project Stormwater Description

Proposed site improvements include sidewalks, public streets, open spaces, and 121 single-family residences. The majority of site stormwater will be collected via catch basins or dispersed and routed to conveyance piping and discharged to an on-site wetpond located within Tract B. Discharge from the Tract B wetpond will be released to the wetland in Tract A after being detained at or below pre-developed release rates. All pollution-generating surfaces on-site will be treated by the wetpond in Tract B. See the development plans, Appendix C, and the Stormwater Basin Plan, Appendix D, for stormwater information.

## Section B – Minimum Requirements

### Section B.1 – Determination of Applicable Minimum Requirements

Proposed land disturbances shall include grading and excavation of unsuitable soils for the construction of sidewalks, utilities, streets, and 121 residential lots. Due to the amount of proposed hard surfaces (greater than 5,000 square feet), the project is required to meet Minimum Requirements 1 through 9 per Figures 1.1 & 1.2 of the City of Camas Stormwater Design Manual (CSDSM) (see Appendix B).

The tables in this section provide information pertaining to the stormwater basin within the project area. Basin 1S consists of the on-site area, while Basin 2S and Basin 3S are off-site areas..

**Table B-1: Proposed Hard Surface and Landscaping**

| Basin | Existing Hard Surfaces (acres) | New Hard Surfaces (acres) | Replaced Hard Surfaces (acres) | Native Vegetation Replaced w/ Landscaping (acres) | Total Land Disturbed (acres) |
|---|---|---|---|---|---|
| 1S | 0.347 | 18.639 | 0.347 | 18.627 | 37.613 |
| 2S | 2.773 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3S | 0.099 | 0.154 | 0.099 | 0.000 | 0.253 |

*Note: Areas listed are in acres. Assumes 700-square-foot driveway and 3,300-square-foot roof area per lot.*

Tables B-2 and B-3 show the mitigated site basins, differentiated between pollution- and non-pollution-generating surfaces. It is important to note that any non-pollution-generating areas directly mixing or having the opportunity to mix with stormwater runoff from pollution-generating surface areas are classified as pollution-generating. Therefore, any stormwater collected from a private lot that is not collected from a lateral is considered pollution-generating.

Exhibit 5

**Table B-2: Pollution-Generating Surfaces**

| Basin | Hard Surfaces (acres) | Pervious Surfaces (acres) | Total Surface Area (acres) |
|---|---|---|---|
| 1S | 9.341 | 0.000 | 9.341 |
| 2S | 1.797 | 0.000 | 1.797 |
| 3S | 0.304 | 0.000 | 0.304 |

*Note: Areas listed are in acres. Assume 700-square-foot driveway and 3,300-square-foot roof area per lot.*

**Table B-3: Non-Pollution-Generating Surfaces**

| Basin | Hard Surfaces (acres) | Pervious Surfaces (acres) | Total Surface Area (acres) |
|---|---|---|---|
| 1S | 9.473 | 18.580 | 28.053 |
| 2S | 0.976 | 7.901 | 8.877 |
| 3S | 0.000 | 0.047 | 0.000 |

*Note: Areas listed are in acres. Assume 700-square-foot driveway and 3,300-square-foot roof area per lot.*

Each Basin's effective hard surfaces and their applicability for meeting Minimum Requirements 6 through 8 are summarized in Table B-4 below.

**Table B-4: Effective Hard Surfaces**

| Basin | Hard Surface Area (acres) | MR #6 Required (Y/N) | MR #7 Required (Y/N) | MR #8 Required (Y/N) |
|---|---|---|---|---|
| 1S | 9.341 | Y | Y | Y |
| 2S | 1.797 | N | N | N |
| 3S | 0.304 | Y | Y* | N |

*Note: Areas listed are in acres. Assume 700-square-foot driveway and 3,300-square-foot roof area per lot.*

**New impervious surfaces will be treated utilizing the wetpond facility. Existing impervious surfaces will not be treated.*

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## Section C – Soils Evaluation

### Section C.1 – Soil Suitability for Low Impact Development BMPs

The Camas Heights project is not suitable for stormwater infiltration for flow control, runoff treatment, or LID measures due to the majority of the site consisting of steep slopes. The project geotechnical report, dated March 2021 and within Appendix G, recommends against the use of infiltration systems for stormwater disposal.

### Section C.2 – Water Table Information

Per the project geotechnical report, shallow perched groundwater was observed in test pits during site exploration. Some perched groundwater may be present on-site during the wetter months and periods of heavy rain. Observed groundwater seepage is expected to be reduced during dryer months. Typical dewatering methods may be required on this site. A wetpond facility liner is not recommended due to perched groundwater and generally clayey soils preventing infiltration of stormwater.

### Section C.3 – Soil Parameters

Soil parameters were not used for the design of the site's stormwater system. All site runoff will be collected, detained, and treated in the wetpond facility in Tract B.

### Section C.4 – Infiltration Rate Testing

Infiltration rate testing was not performed as the site is not suitable for infiltration to control stormwater. Infiltration is not recommended due to the presence of a fine-grained soil matrix and steep slopes.

### Section C.5 – Complex Soil Conditions

A preliminary geotechnical report has been prepared and is attached to this report, see Appendix G. Existing soil conditions are summarized, and recommendations are presented in relation to site stormwater design considerations. No complex soil conditions are present on-site with the exception of steep slopes.

## Section D – Source Control

Volume IV of the Stormwater Management Manual for Western Washington (SWMMWW) contains the following applicable source control best management practices (BMPs) for residential development. The source control BMPs and applicable notes to control stormwater runoff impacted by these activities will be included in the Erosion Control Plans and Details and in the Stormwater Pollution Prevention Plan (SWPPP).

- S407: Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots
- S411: BMPs for Landscaping and Lawn/Vegetation Management

## Section E – On-Site Stormwater Management BMPs

Figure I-3.3 of the SWMMWW was used to determine that LIDs are infeasible as infiltration on-site is not recommended because of the presence of a fine-grained soil matrix (see the geotechnical report in Appendix G). Therefore, site runoff from pollution-generating impervious surfaces will be collected and treated by the on-site wetpond. All disturbed areas will meet post-construction soil quality and depth requirements per BMP T5.13.

Exhibit 5

## Section F – Runoff Treatment Analysis and Design

Surface water from pollution-generating surfaces will be treated within the wetpond. Any basin that mixes non-pollution-generating runoff with pollution-generating runoff, the combined runoff is considered to be pollution-generating. A majority of lots will be served by a stormwater lateral to maintain separation from pollution-generating surfaces, see Development Plans in Appendix C for which lots are required to have a service lateral installed. Service laterals will collect lot roof area and lot landscaped area that will not mix with any other stormwater.

## Section G – Flow Control Analysis and Design

The Camas Heights site consists of one on-site basin (Basin 1) and two off-site basins (Basin 2 and Basin 3).

The site will be required to meet flow control standards due to Basin 1 and Basin 2 discharging to a Category IV wetland at the southwestern corner of the site. The project proposes to use a wetpond facility, with a flow control manhole, to meet the site flow control requirements. A berm or free-standing retaining wall will be used to meet length-to-width wetpond requirements. All roof, driveway and incidental landscape runoff within the site is proposed to flow through the site wetpond within Tract B.

## Section H – Wetland Protection

The site contains a category IV wetland associated with the natural drainage on site. The wetland is to be protected by wetland and aquatic system buffers. Water quality of the wetland should not be degraded as treated discharge from the proposed site wetpond facility in Tract B will discharge from a flow control structure to match pre-developed flow rates. No impacts to the wetland are proposed with this development. Hydrophytic vegetation will be maintained or enhanced within the wetland, see the project wetland mitigation plan for more information on site enhancements.

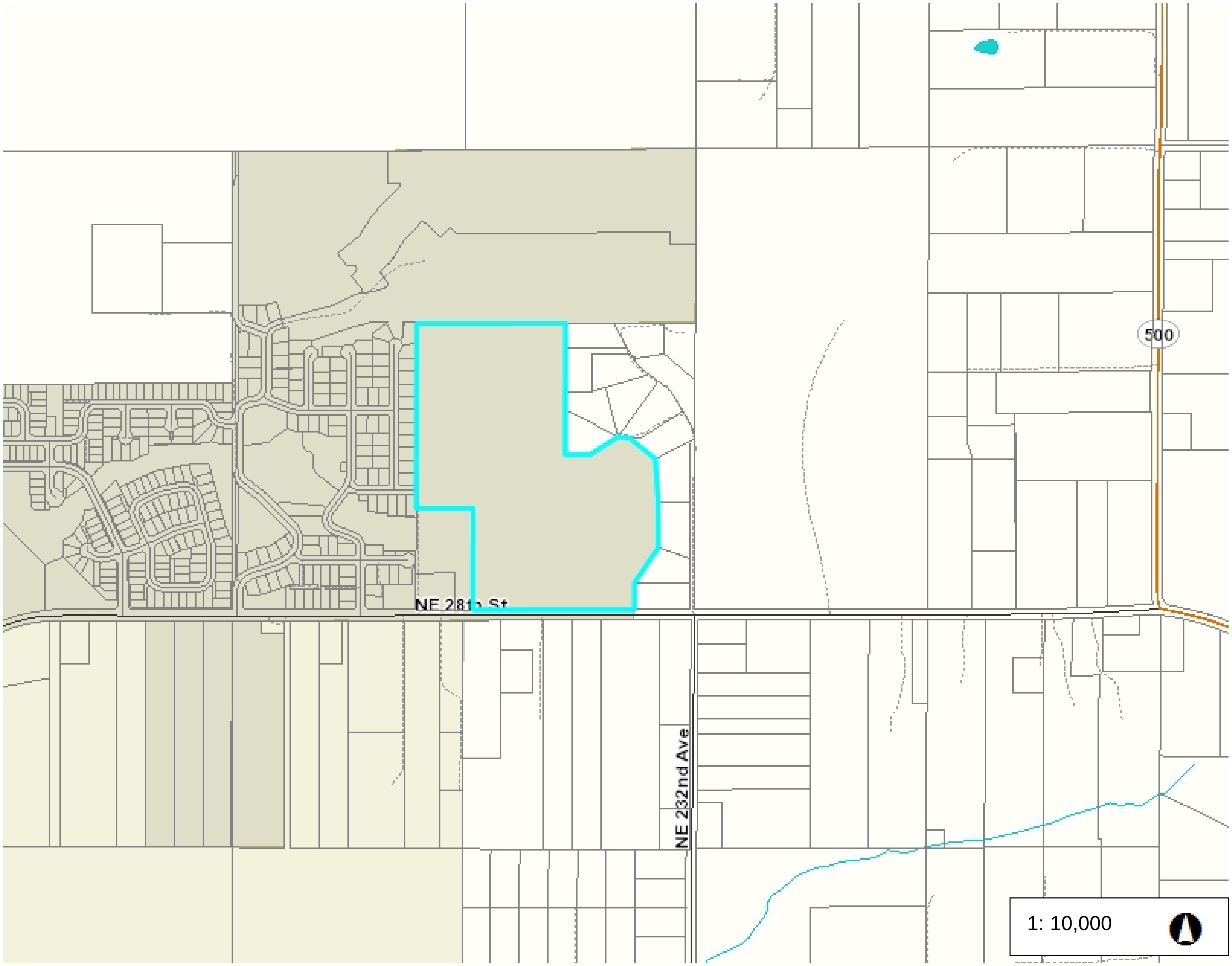
A wetland hydroperiod analysis was not required for this project based on Figure 1-3.5 of the SWMMWW. General protection and protection from pollutants are met with wetland and aquatic system buffers and treatment of stormwater in the wetpond facility. See Appendix B for Figure 1-3.5.

Exhibit 5

# **Appendix A:** Map Submittals

Exhibit 5

# CAMAS HEIGHTS SUBDIVISION



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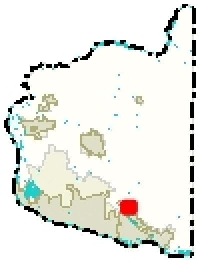


Legend

- ☐ Taxlots
- ▨ Cities Boundaries
- ▨ Urban Growth Boundaries

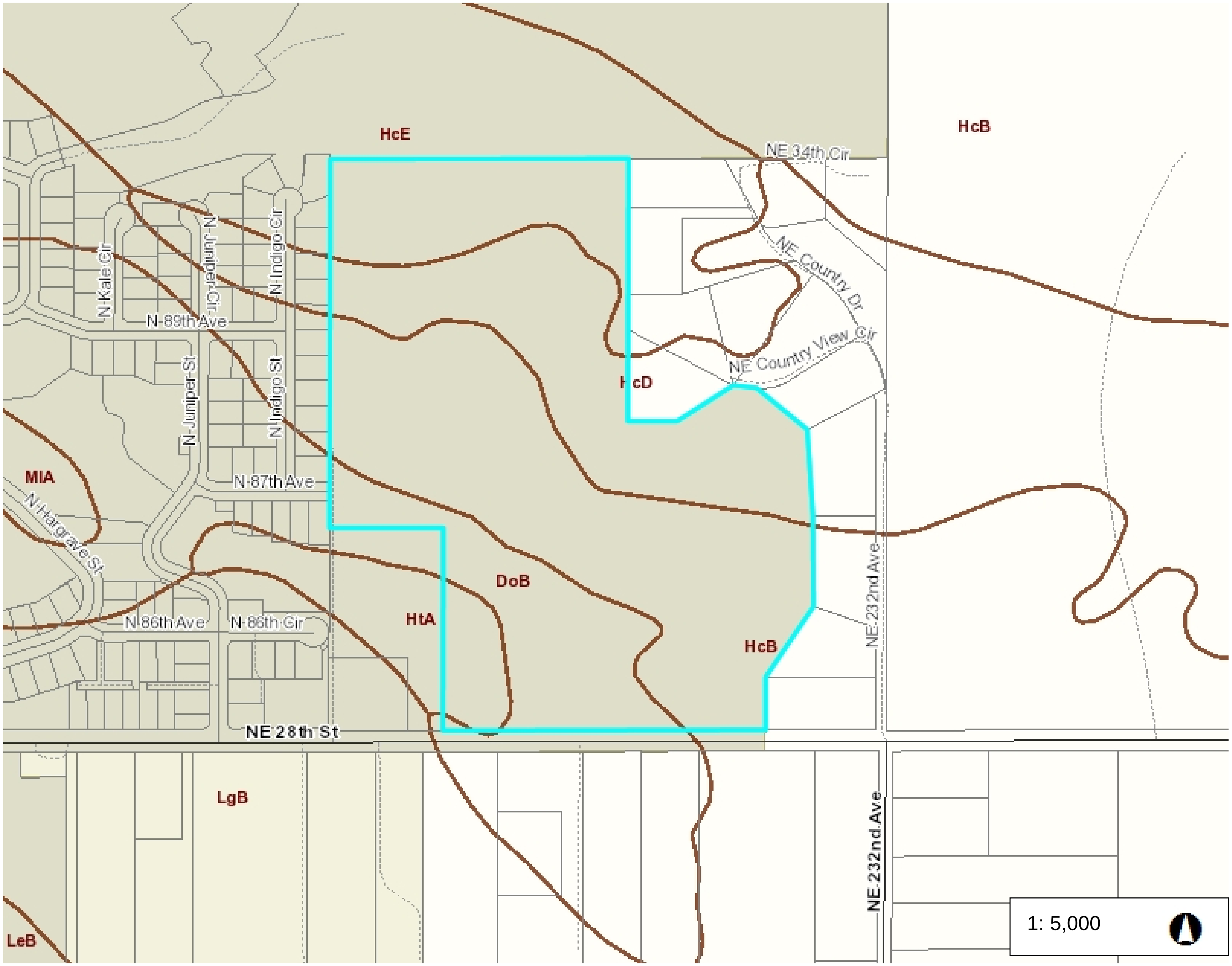
Notes:

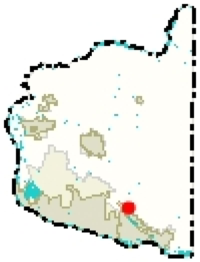
1,666.7 0 833.33 1,666.7 Feet

WGS_1984_Web_Mercator_Auxiliary_Sphere
Clark County, WA. GIS - http://gis.clark.wa.gov

Exhibit 5

# CAMAS HEIGHTS SUBDIVISION SOILS MAP





## Legend

- ☐ Taxlots
- ☐ Soil Type
- All Roads
  - Interstate
  - State Route
  - Arterial
  - Forest Arterial
  - Minor Collector
  - Forest Collector
  - Private or Other
- ▨ Cities Boundaries
- ▨ Urban Growth Boundaries

Notes:

833.3 0 416.67 833.3Feet

WGS_1984_Web_Mercator_Auxiliary_Sphere
Clark County, WA. GIS - http://gis.clark.wa.gov

Exhibit 5

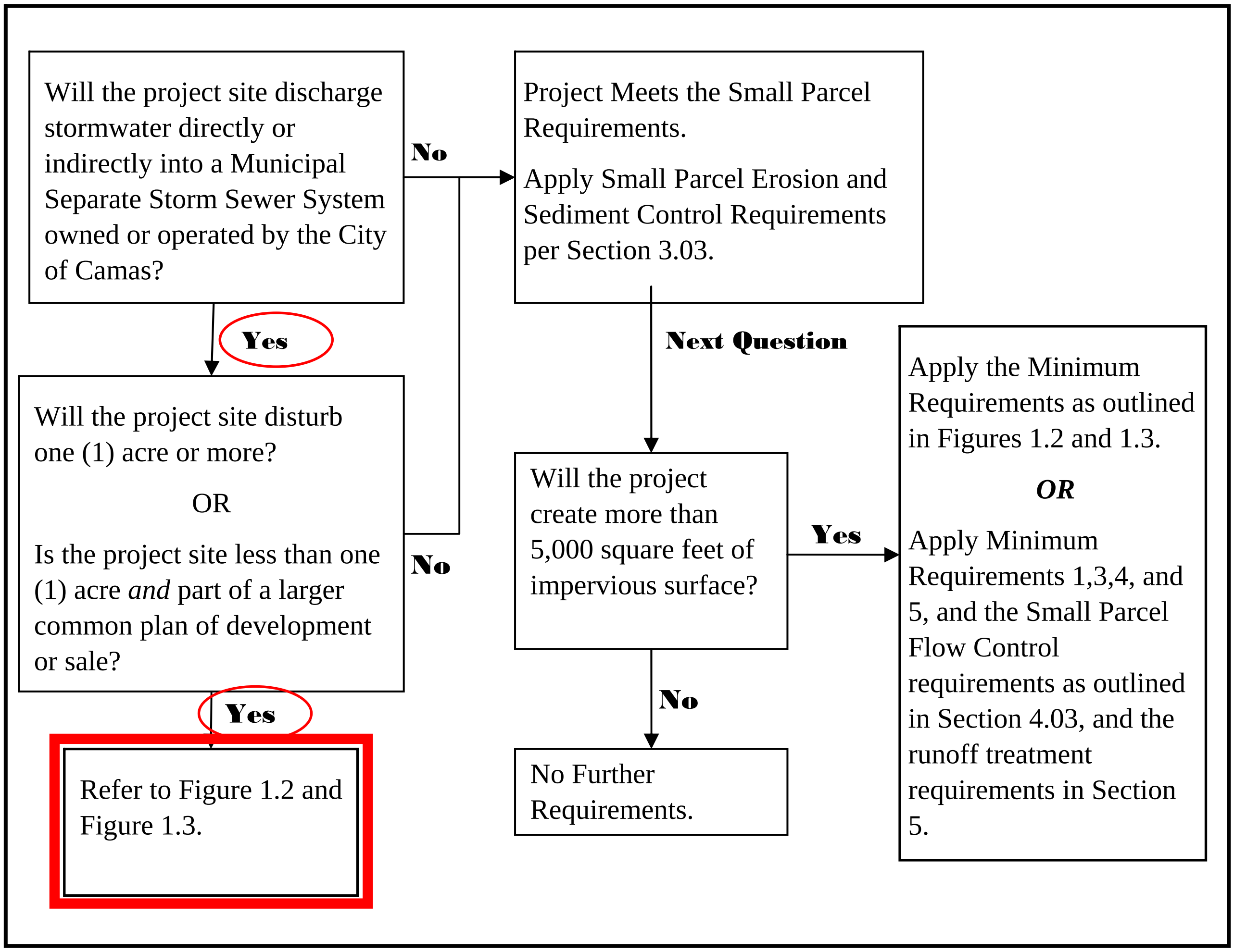
# **Appendix B:** New Development Flow Chart

Exhibit 5

# Chapter 1: General Requirements

Continued

**Figure 1.1: Flow Chart for Determining Stormwater Requirements**



Will the project site discharge stormwater directly or indirectly into a Municipal Separate Storm Sewer System owned or operated by the City of Camas?

Project Meets the Small Parcel Requirements.

Apply Small Parcel Erosion and Sediment Control Requirements per Section 3.03.

Will the project site disturb one (1) acre or more?

OR

Is the project site less than one (1) acre *and* part of a larger common plan of development or sale?

Will the project create more than 5,000 square feet of impervious surface?

Apply the Minimum Requirements as outlined in Figures 1.2 and 1.3.

***OR***

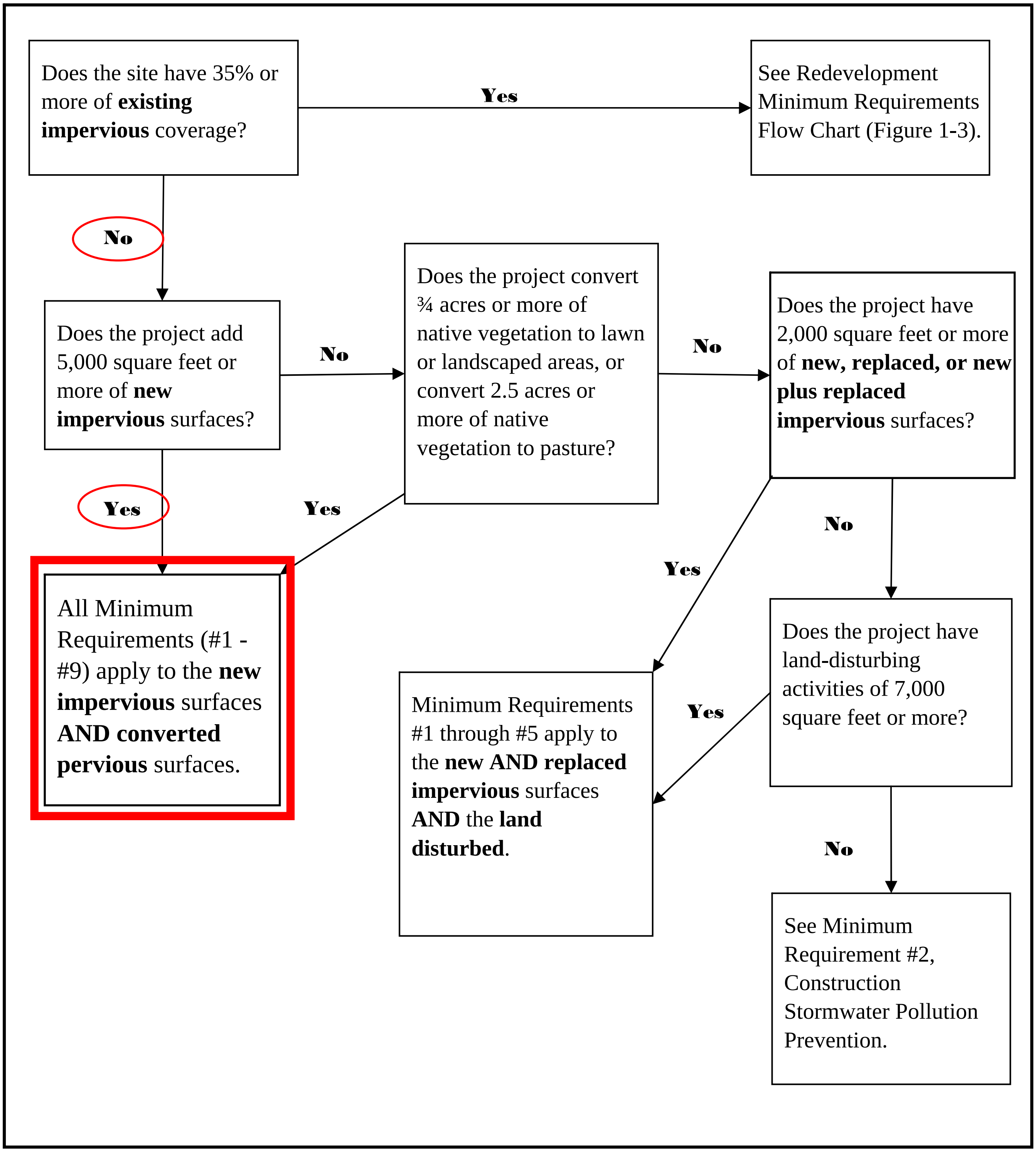
Apply Minimum Requirements 1,3,4, and 5, and the Small Parcel Flow Control requirements as outlined in Section 4.03, and the runoff treatment requirements in Section 5.

Refer to Figure 1.2 and Figure 1.3.

No Further Requirements.

Exhibit 5

**Figure 1.2: New Development Minimum Requirements Flow Chart**



Does the site have 35% or more of **existing impervious** coverage?

See Redevelopment Minimum Requirements Flow Chart (Figure 1-3).

Does the project add 5,000 square feet or more of **new impervious** surfaces?

Does the project convert ¾ acres or more of native vegetation to lawn or landscaped areas, or convert 2.5 acres or more of native vegetation to pasture?

Does the project have 2,000 square feet or more of **new, replaced, or new plus replaced impervious** surfaces?

All Minimum Requirements (#1 - #9) apply to the **new impervious** surfaces **AND converted pervious** surfaces.

Minimum Requirements #1 through #5 apply to the **new AND replaced impervious** surfaces **AND** the **land disturbed**.

Does the project have land-disturbing activities of 7,000 square feet or more?

See Minimum Requirement #2, Construction Stormwater Pollution Prevention.

Exhibit 5

**Figure 1.3: Redevelopment Minimum Requirements Flow Chart**

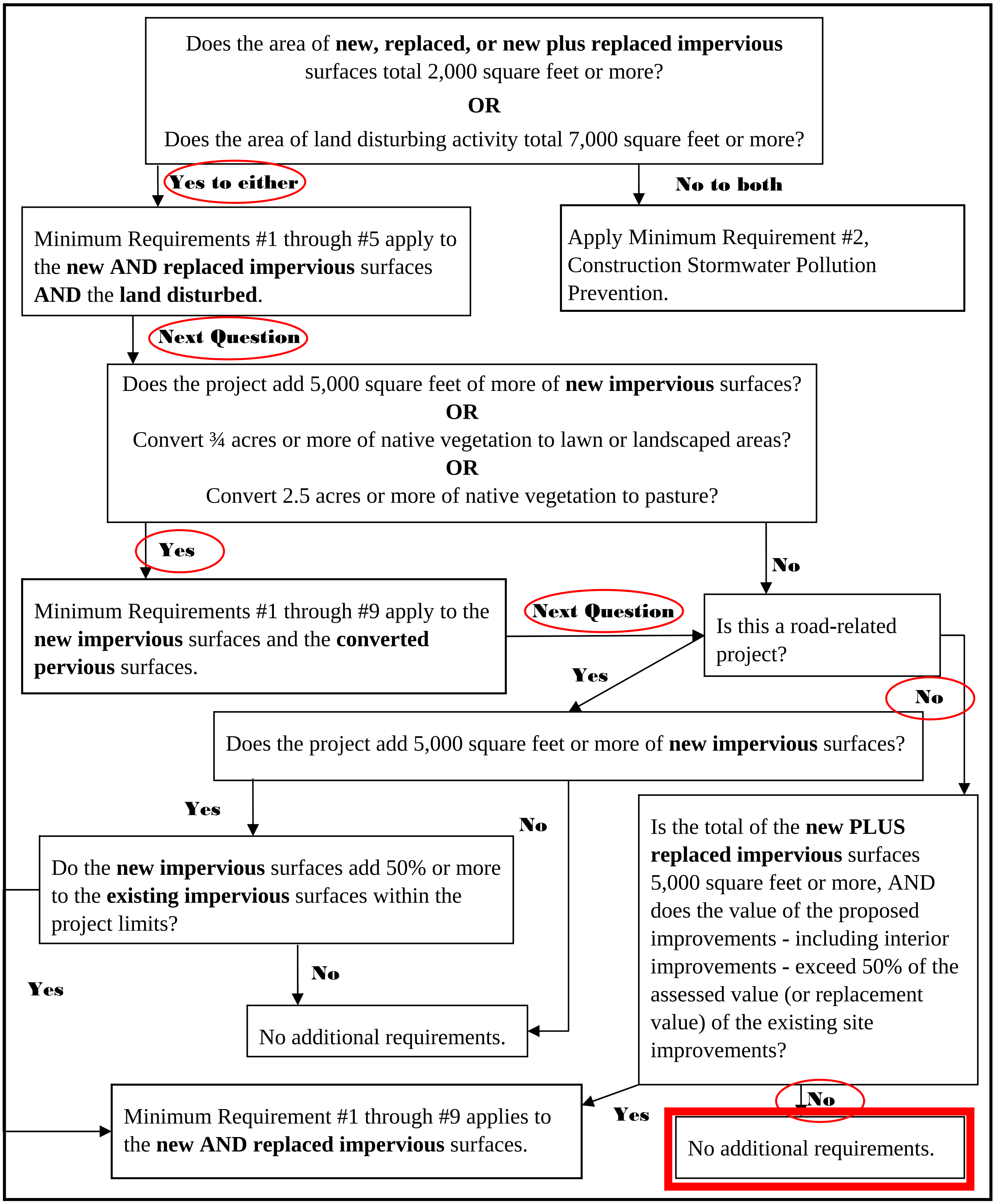
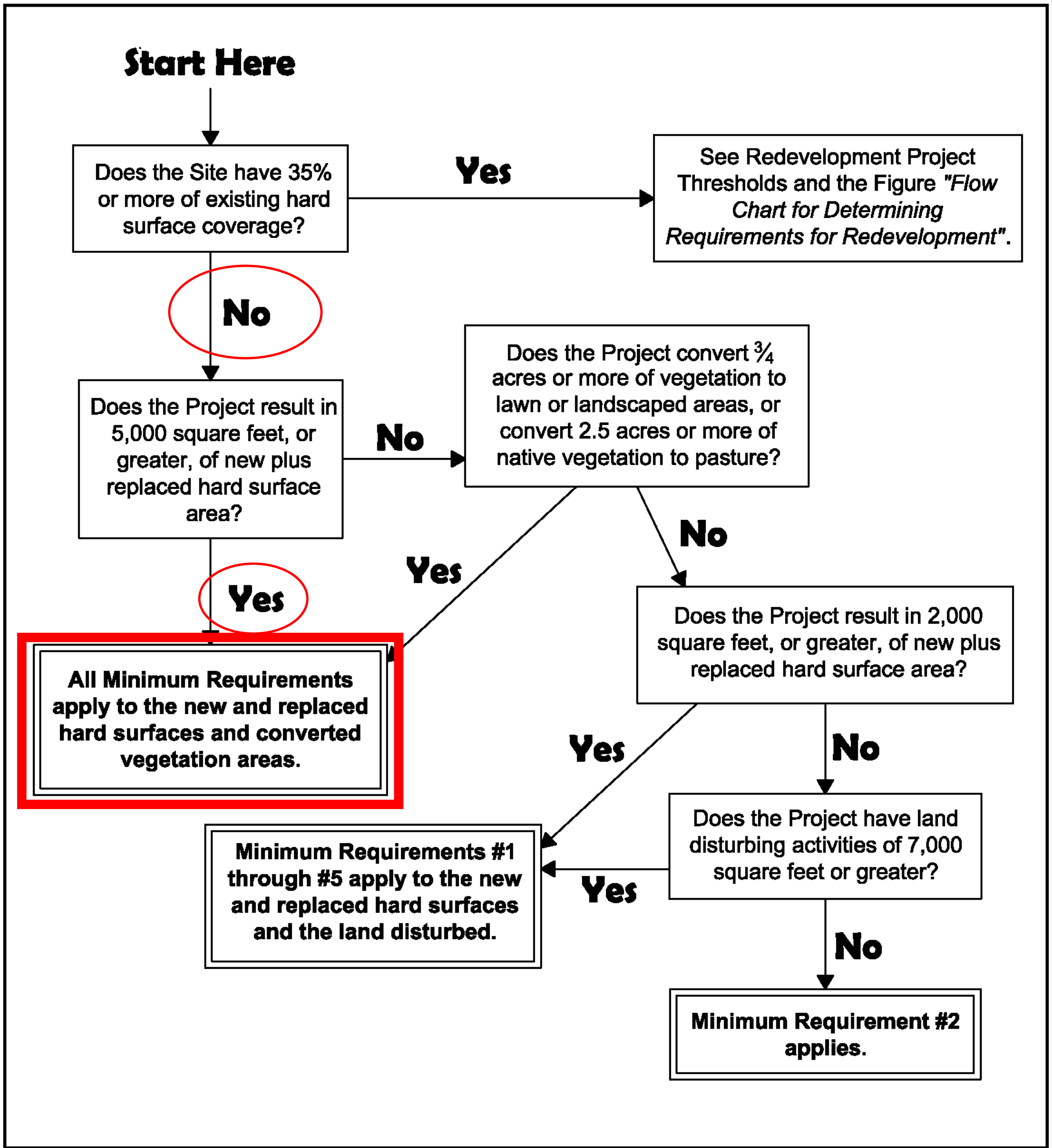


Exhibit 5

**Figure I-3.1: Flow Chart for Determining Requirements for New Development**



DEPARTMENT OF ECOLOGY
State of Washington

Flow Chart for Determining Requirements for New Development

Revised March 2019

Exhibit 5

**Figure I-3.5: Flow Chart for Determining Wetland Protection Level Requirements**

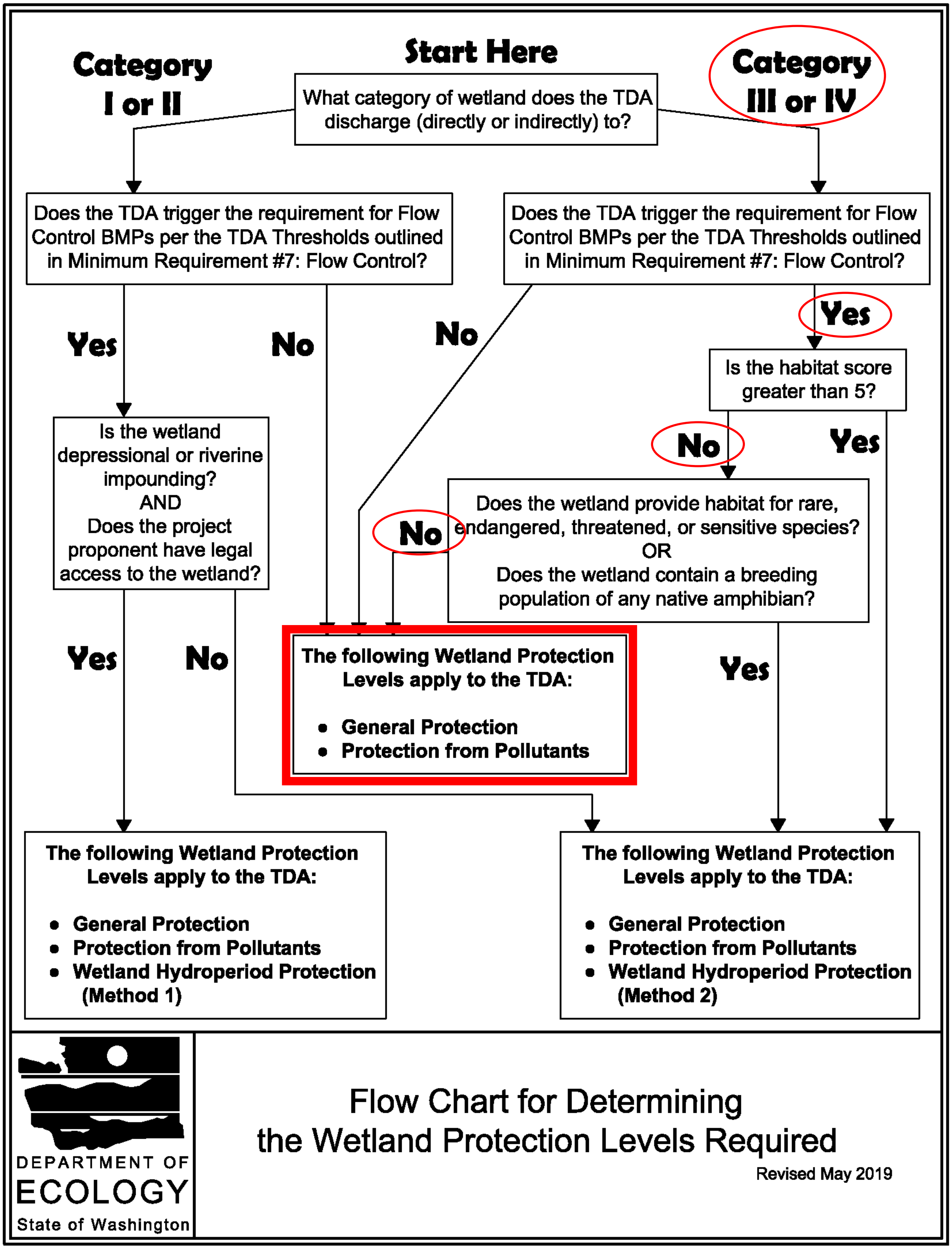


Exhibit 5

# **Appendix C:** Development Plans

Exhibit 5

## LEGEND

| | |
|---|---|
| EXISTING GROUND CONTOUR (2 FT) | — — — — — |
| EXISTING GROUND CONTOUR (10 FT) | — — — 350 — — — |
| FINISHED GRADE CONTOUR (2 FT) | ——————— |
| FINISHED GRADE CONTOUR (10 FT) | ———350——— |
| PHASE BOUNDARY | ▬ ▬ ▬ ▬ |
| STORMWATER FLOW ARROWS | ➡ |

## GENERAL NOTES

1. CONTOUR INTERVAL IS 2 FOOT.
2. TREES ARE NOT SHOWN.
3. STORMWATER DETENTION POND ON TRACT B TO BE OWNED AND MAINTAINED BY THE HOA.
4. ACCORDING TO CLARK COUNTY GIS, THE SITE IS NOT WITHIN OR ADJACENT TO A 100-YEAR FLOODPLAIN.
5. THERE ARE NO KNOWN EXISTING ON-SITE STORMWATER FACILITIES.
6. NATIVE VEGETATION WITHIN TRACT A WILL BE RETAINED AS MUCH AS POSSIBLE AND ENHANCED, AS NEEDED, PER THE WETLAND MITIGATION PLAN.
7. SOME OFF-SITE FLOW OCCURS FROM ADJACENT PARCELS. ANALYSIS OF OFF-SITE FLOW WAS PERFORMED.

AKS DRAWING FILE: 8468 P7.0 STM.DWG | LAYOUT: P7.0

AKS
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FORESTRY · PLANNING · LANDSCAPE ARCHITECTURE

# PRELIMINARY STORMWATER PLAN
# CAMAS HEIGHTS SUBDIVISION
LENNAR NORTHWEST, INC.
CAMAS, WA

PRELIMINARY NOT FOR CONSTRUCTION

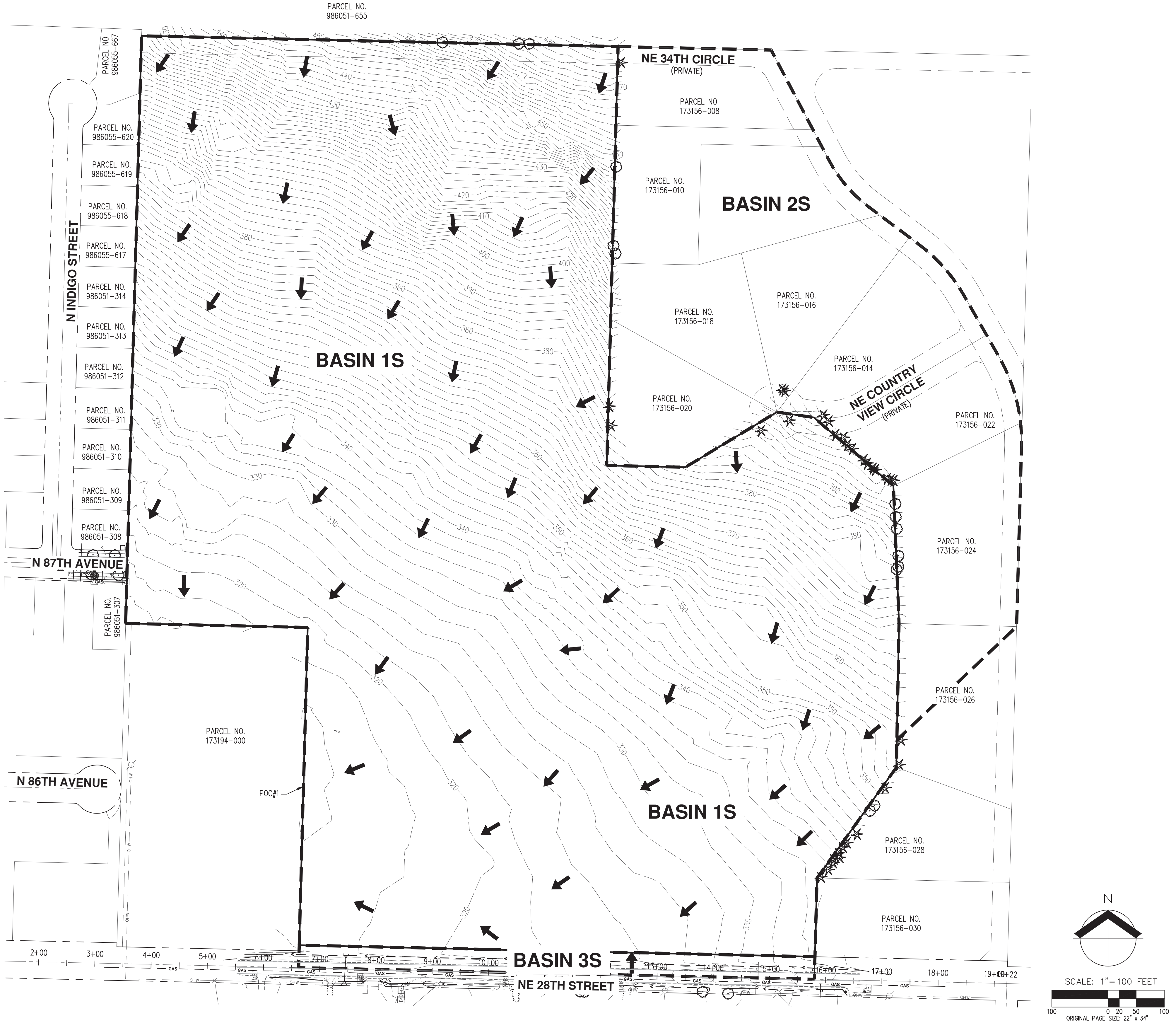
| | |
|---|---|
| JOB NUMBER: | 8468 |
| DATE: | 10/29/2021 |
| DESIGNED BY: | RPM |
| DRAWN BY: | RPM |
| CHECKED BY: | JMM |

P7.0

Exhibit 5

# **Appendix D:** Stormwater Basin Plans

Exhibit 5



**GENERAL NOTES**

1. BASIN 1S AND 2S FLOW THROUGH THE SITE TO POC#1.
2. BASIN 3S DIRECTLY DISCHARGES ALONG NE 28TH STREET.

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# PRE-DEVELOPED BASIN MAP
# CAMAS HEIGHTS SUBDIVISION
LENNAR NORTHWEST, INC.
CAMAS, WA

JOHN M. MEIER
42614
PRELIMINARY
NOT FOR
CONSTRUCTION

| | |
|---|---|
| JOB NUMBER: | 8468 |
| DATE: | 10/29/2021 |
| DESIGNED BY: | RPM |
| DRAWN BY: | RPM |
| CHECKED BY: | JMM |

FIG. 1

AKS DRAWING FILE: 8468 PRE-DEV BASIN MAP.DWG | LAYOUT: PRE-DEV

Exhibit 5

## GENERAL NOTES

1. BASIN 1S AND 2S TO BE DETAINED IN ON-SITE WETPOND LOCATED IN TRACT B.
2. BASIN 3S TO BE DIRECTLY DISCHARGED ALONG NE 28TH STREET.

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# POST-DEVELOPED BASIN MAP
# CAMAS HEIGHTS SUBDIVISION
# LENNAR NORTHWEST, INC.
# CAMAS, WA

JOHN M. MEIER
42014
PRELIMINARY NOT FOR CONSTRUCTION

JOB NUMBER: 8468
DATE: 10/29/2021
DESIGNED BY: RPM
DRAWN BY: RPM
CHECKED BY: JMM

FIG. 2

AKS DRAWING FILE: 8468 POST-DEV BASIN MAP.DWG | LAYOUT: POST-DEV

Exhibit 5

# **Appendix E:** BMP Details

Exhibit 5

## BMP T5.13: Post-Construction Soil Quality and Depth

### Purpose and Description

Naturally occurring (undisturbed) soil and vegetation provide important stormwater functions including: water infiltration; nutrient, sediment, and pollutant adsorption; sediment and pollutant biofiltration; water interflow storage and transmission; and pollutant decomposition. These functions are largely lost when development strips away native soil and vegetation and replaces it with minimal topsoil and sod. Not only are these important stormwater functions lost, but such landscapes themselves become pollution generating pervious surfaces due to increased use of pesticides, fertilizers and other landscaping and household/industrial chemicals, the concentration of pet wastes, and pollutants that accompany roadside litter. Establishing soil quality and depth regains greater stormwater functions in the post development landscape, provides increased treatment of pollutants and sediments that result from development and habitation, and minimizes the need for some landscaping chemicals, thus reducing pollution through prevention.

#### Cross Reference Guide

| | |
|---|---|
| Soils Assessment | NA |
| Meets Minimum Requirements | #5 |
| Related BMPs | None |
| Selection Criteria | Book 1, Sections 2.2 and 2.5.2 |
| Maintenance | Book 4 |

#### Applications, Limitations and Setbacks

Establishing a minimum soil quality and depth is not the same as preservation of naturally occurring soil and vegetation. However, establishing a minimum soil quality and depth will provide improved onsite management of stormwater flow and water quality. Soil organic matter can be attained through addition of numerous materials such as compost, composted woody material, biosolids, and forest product residuals. It is important that the materials used to meet the soil quality and depth BMP be appropriate and beneficial to the plant cover to be established. Likewise, it is important that imported topsoils improve soil conditions and do not have an excessive percent of clay fines. This BMP can be considered infeasible on slopes greater than 33 percent.

Soil and vegetation provide significant benefits, including:

- Water infiltration.
- Absorption of nutrients, sediments and pollutants.

Exhibit 5

- Biofiltration of sediment and pollutants.
- Water interflow storage and transmission.
- Pollutant decomposition.

These functions are largely lost when development strips away native soil and vegetation and replaces it with minimal topsoil and sod. Establishing in-situ soil quality and depth regains greater stormwater functions in the post development landscape and also minimizes the need for some landscaping chemicals, further limiting pollution.

This BMP is mandatory for all projects required to follow Minimum Requirements #1 – #5 or Minimum Requirements #1 – #9.

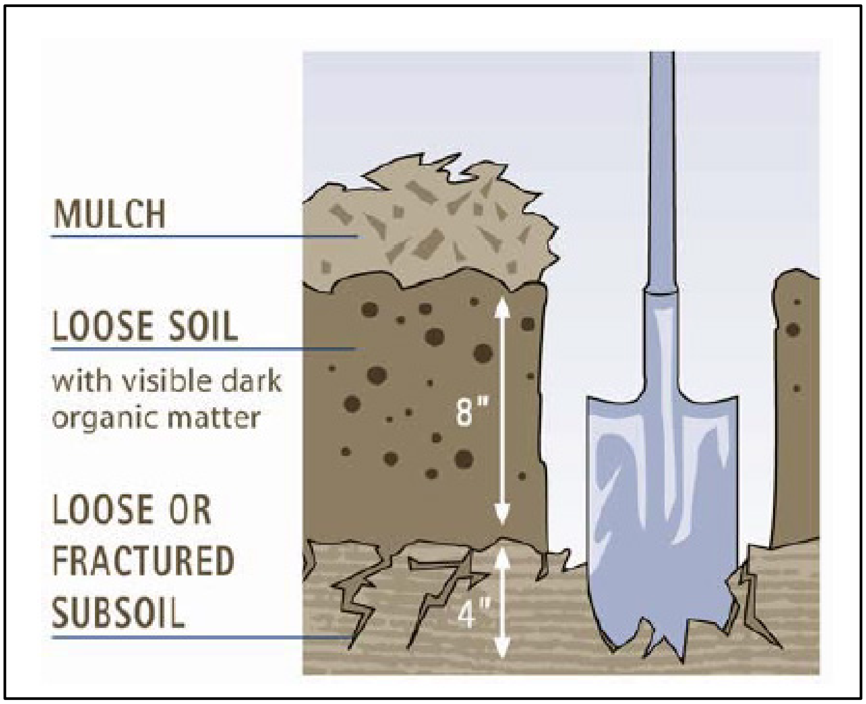

**Figure 2.11: Typical Planting Bed Cross-section**

(Source: Washington Organic Recycling Council graphic in SMMWW)

## Design Criteria

- Retain, in an undisturbed state, the duff layer and native topsoil to the maximum extent practicable. In any areas requiring grading remove and stockpile the duff layer and topsoil on site in a designated, controlled area, not adjacent to public resources and critical areas, to be reapplied to other portions of the site where feasible.
- Areas subject to clearing and grading that have not been covered by hard surfaces, used for a drainage facility, or where the soils have been engineered as structural fill or slope, shall demonstrate the following after completion of the project:

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- A topsoil layer with:
    - A minimum organic matter content of 10% dry weight in planting beds.
    - 5% organic matter content in turf areas.
    - A pH from 6.0 to 8.0 or matching the pH of the undisturbed soil.
    - A minimum topsoil layer depth of 8 inches except where tree roots do not allow this.
- Subsoils below the topsoil layer should be scarified at least 4 inches with some incorporation of the upper material to avoid stratified layers, where feasible.
- Mulch planting beds with 2 inches of organic material.
- Compost and other materials shall meet the following requirements for organic content:
    - The organic content for pre-approved (by Ecology) amendment rates can be met only using compost meeting the compost specification for Bioretention (~~BMP T7.30~~ BMP T5.14B), with the exception that the compost may have up to 35% biosolids or manure. The compost must also have an organic matter content of 40% to 65%,and a carbon to nitrogen ratio below 25:1. The carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Portland/Vancouver region.
    - Calculated amendment rates may be met through use of composted material meeting (a.) above; or other organic materials amended to meet the carbon to nitrogen ratio requirements, and not exceeding the contaminant limits identified in Table 220-B, Testing Parameters, in WAC 173-350-220.
- The resulting soil should be conducive to the type of vegetation to be established.

- Only one of these methods can be used to meet the above criteria for a specific area on the site:
    - Native vegetation and soil should remain undisturbed and protected from compaction during construction.
    - Amend existing topsoil or subsoil either at default "pre-approved" rates, or at custom calculated rates based on soil tests of the soil and amendments.
    - Stockpile existing topsoil during grading and replace it over disturbed areas prior to planting. Stockpiled topsoil must also be amended if needed to meet the organic matter or depth requirements, either at a default "pre-approved" rate or at a custom calculated rate.
    - Import topsoil mix of sufficient organic content and depth to meet the requirements.
    - More than one method may be used on different portions of the same site. Soil that already meets the depth and organic matter quality standards need not be amended.

Exhibit 5

- Scarification of subsoils can be accomplished using mechanical methods such as a rototiller.

## Runoff Modeling Representation

- Areas meeting the design guidelines may be entered into approved runoff models as "Pasture" rather than "Lawn."
- Flow reduction credits can be taken in runoff modeling when BMP T5.13 is used as part of a dispersion design under the conditions described in:
  - BMP T5.10C Downspout Dispersion
  - BMP T5.11 Concentrated Flow Dispersion
  - BMP T5.12 Sheet Flow Dispersion
  - BMP T5.18 Reverse Slope Sidewalks
  - BMP T5.30A Full Dispersion (for public road projects)

ERRATA September 2016

Exhibit 5

# V-2 Site Design BMPs

## V-2.1 Introduction to Site Design BMPs

Site Design BMPs are general practices for site design to minimize the impacts of development on stormwater runoff. They are provided here as an encouragement to project designers. The extent to which these BMPs must be followed depends upon the site development codes, rules, and standards adopted by the local government.

## BMP T5.40: Preserving Native Vegetation

### *Purpose and Definition*

Preserving native vegetation on-site to the maximum extent practicable will minimize the impacts of development on stormwater runoff. Preferably 65 percent or more of the development site should be protected for the purposes of retaining or enhancing existing forest cover and preserving wetlands and stream corridors. Maintain tree canopy on the project site to the greatest extent feasible and in accordance with the requirements of the local jurisdiction.

### *Applications and Limitations*

New development often takes place on tracts of forested land. In fact, building sites are often selected because of the presence of mature trees. However, unless sufficient care is taken and planning done, in the interval between buying the property and completing construction much of this resource is likely to be destroyed. The property owner is ultimately responsible for protecting as many trees as possible, with their understory and groundcover. This responsibility is usually exercised by agents, the planners, designers and contractors. It takes 20 to 30 years for newly planted trees to provide the benefits for which trees are so highly valued.

Forest and native growth areas allow rainwater to naturally percolate into the soil, recharging ground water for summer stream flows and reducing surface water runoff that creates erosion and flooding. Conifers can hold up to about 50 percent of all rain that falls during a storm. Twenty to 30 percent of this rain may never reach the ground but evaporates or is taken up by the tree. Forested and native growth areas also may be effective as stormwater buffers around smaller developments.

Preservation of 65 percent or more of the site in native vegetation will allow the use of full dispersion techniques presented in BMP T5.30: Full Dispersion. Sites that can fully disperse per BMP T5.30: Full Dispersion have met the requirements of I-3.4.5 MR5: On-Site Stormwater Management, I-3.4.6 MR6: Runoff Treatment, and I-3.4.7 MR7: Flow Control.

### *Design Guidelines*

- The preserved area should be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands, and to buffer stream corridors.
- The preserved area should be placed in a separate tract or protected through recorded

Exhibit 5

easements for individual lots.

- If feasible, the preserved area should be located downslope from the building sites, since flow control and runoff treatment are enhanced by flow dispersion through duff, undisturbed soils, and native vegetation.
- The preserved area should be shown on all property maps and should be clearly marked during clearing and construction on the site.

### *Maintenance*

Vegetation and trees should not be removed from the natural growth retention area, except for approved timber harvest activities and the removal of dangerous and diseased trees.

## BMP T5.41: Better Site Design

### *Purpose and Definition*

Fundamental hydrological and stormwater management concepts can be applied at the site design phase that are:

- more integrated with natural topography,
- reinforcing the hydrologic cycle,
- more aesthetically pleasing, and
- often less expensive to build.

A few site planning principles help to:

- locate development on the least sensitive areas of a site;
- accommodate residential land use; and
- mitigate the impact on stormwater quality.

### *Design Guidelines*

- **Define Development Envelope and Protected Areas** - The first step in site planning is to define the development envelope. This is done by identifying protected areas, setbacks, easements and other site features, and by consulting applicable local standards and requirements. Site features to be protected may include important existing trees, steep slopes, erosive soils, riparian areas, or wetlands.

  By keeping the development envelope compact, environmental impacts can be minimized, construction costs can be reduced, and many of the site’s most attractive landscape features can be retained. In some cases, economics or other factors may not allow avoidance of all sensitive areas. In these cases, care can be taken to mitigate the impacts of development through site work and other landscape treatments.

- **Minimize Directly Connected Impervious Areas** - Impervious areas directly connected to

Exhibit 5

the drainage system are the greatest contributors to urban nonpoint source pollution. Any impervious surface that drains into a catch basin or other conveyance structure is a “directly connected impervious surface.” As stormwater runoff flows across parking lots, roadways, and other paved areas, the oil, sediment, metals, and other pollutants are collected and concentrated. If this runoff is collected by a drainage structure and carried directly along impervious gutters or in sealed underground pipes, it has no opportunity for filtering by plant material or infiltration into the soil. It also increases in velocity and amount, causing increased peak-flows in the winter and decreased base-flows in the summer.

A basic site design principle for stormwater management is to minimize these directly connected impervious areas. This can be done by limiting overall impervious land coverage or by infiltrating and/or dispersing runoff within these impervious areas.

- **Maximize Permeability -** Within the development envelope, many opportunities are available to maximize the permeability of new construction. These include minimizing impervious areas, paving with permeable materials, clustering buildings, and reducing the land coverage of buildings by smaller footprints. All of these strategies make more land available for infiltration and dispersion through natural vegetation.

  Clustered driveways, small visitor parking bays and other strategies can also minimize the impact of transportation-related surfaces while still providing adequate access.

  Once site coverage is minimized through clustering and careful planning, pavement surfaces can be selected for permeability. A patio of brick-on-sand, for example, is more permeable than a large concrete slab. Engineered soil/landscape systems are permeable ground covers suitable for a wide variety of uses. Permeable/porous pavements can be used in place of traditional concrete or asphalt pavements in many low traffic applications.

  Maximizing permeability at every possible opportunity requires the integration of many small strategies. These strategies will be reflected at all levels of a project, from site planning to materials selection. In addition to the environmental and aesthetic benefits, a high-permeability site plan may allow the reduction or elimination of expensive underground conveyance systems, Flow Control BMPs, and/or Runoff Treatment BMPs, yielding significant savings in development costs.

- **Build Narrower Streets -** More than any other single element, street design has a powerful impact on stormwater quantity and quality. In residential development, streets and other transportation-related structures typically can comprise between 60 and 70 percent of the total impervious area, and, unlike rooftops, streets are almost always directly connected to the drainage system.

  The combination of large, directly connected impervious areas, together with the pollutants generated by automobiles, makes the street network a principal contributor to stormwater pollution in residential areas.

  Street design is usually mandated by local municipal standards. These standards have been developed to facilitate efficient automobile traffic, maximize parking, and allow for emergency vehicle access. Most require large impervious land coverage. In recent years, new street standards have been gaining acceptance that meet the access requirements of local residential streets while reducing impervious land coverage. These standards generally create a

Exhibit 5

new class of street that is narrower than the current local street standard, called an "access" street. An access street is intended only to provide access to a limited number of residences.

Because street design is the greatest factor in a residential development's impact on stormwater quality, it is important that designers, municipalities and developers employ street standards that reduce impervious land coverage.

- **Maximize Choices for Mobility** - Given the costs of automobile use, both in land area consumed and pollutants generated, maximizing choices for mobility is a basic principle for environmentally responsible site design. By designing residential developments to promote alternatives to automobile use, a primary source of stormwater pollution can be mitigated.

  Bicycle lanes and paths, secure bicycle parking at community centers and shops, direct, safe pedestrian connections, and transit facilities are all site-planning elements that maximize choices for mobility.

- **Use Drainage as a Design Element** - Unlike conveyance drainage systems that hide water beneath the surface and work independently of surface topography, a drainage system for stormwater infiltration or dispersion can work with natural land forms and land uses to become a major design element of a site plan.

  By applying stormwater management techniques early in the site plan development, the drainage system can suggest pathway alignments, optimum locations for parks and play areas, and potential building sites. In this way, the drainage system helps to generate urban form, giving the development an integral, more aesthetically pleasing relationship to the natural features of the site. Not only does the integrated site plan complement the land, it can also save on development costs by minimizing earthwork and expensive drainage features.

Exhibit 5

# V-12 Detention BMPs

## V-12.1 Introduction to Detention BMPs

This section presents guidance for design and analysis of detention BMPs. These BMPs provide Flow Control by providing temporary storage of the increased surface water runoff that results from development. See I-3.4.7 MR7: Flow Control for details on the performance requirements for Flow Control.

The concept of detention is to collect runoff from a developed area and, using a control structure, release it at a slower rate than it enters the collection system (see V-12.2 Control Structure Design). The reduced release rate requires temporary storage of the excess runoff in a pond, tank, or vault, with release occurring over a few hours or days. The volume of temporary storage needed is dependent on:

1. The size of the drainage area.
2. The extent of disturbance of the natural vegetation, topography, and soils and creation of effective impervious surfaces (surfaces that drain to a stormwater collection system).
3. How rapidly the water is allowed to leave the detention pond; i.e., the target release rates.

If runoff from surfaces that require Flow Control is not separated from runoff from other existing surfaces (whether on-site or off-site), refer to the guidance in III-2.4 Flow Bypass and Additional Area Inflow for additional guidance when sizing the detention BMPs.

## V-12.2 Control Structure Design

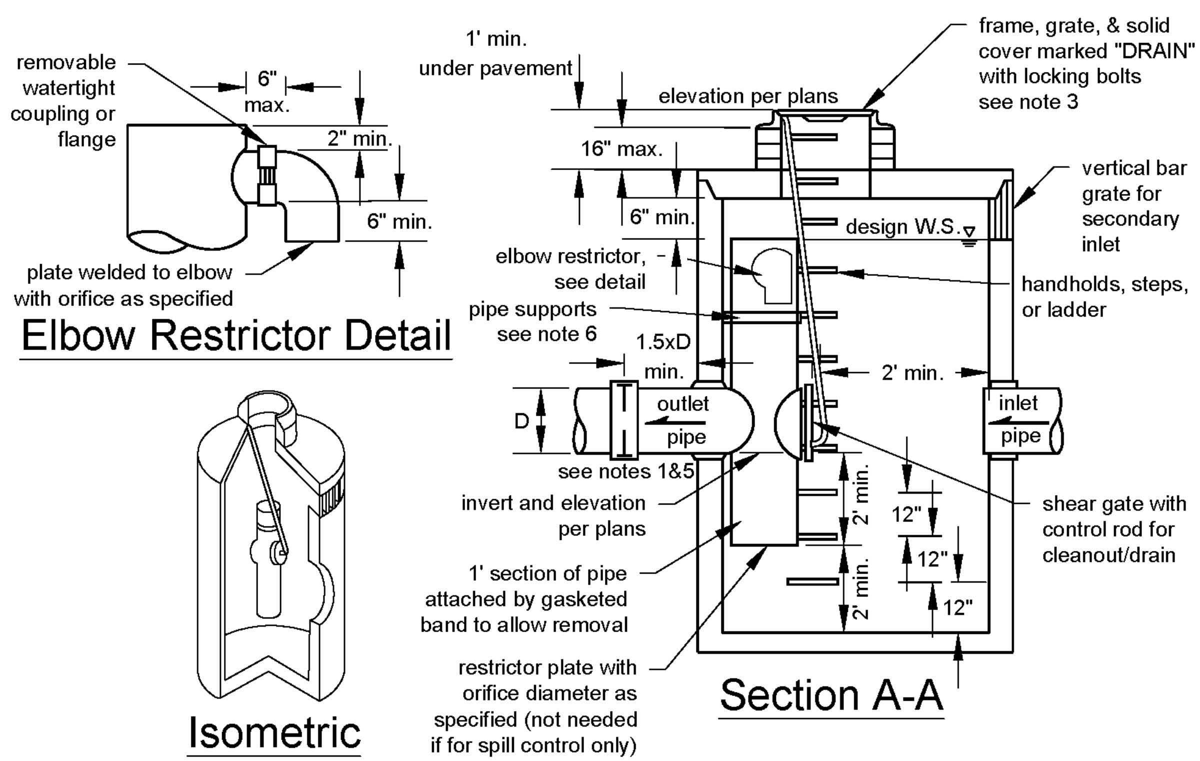
Control structures are catch basins or manholes with a restrictor device for controlling outflow from a detention BMP to meet the desired performance standard. Riser type restrictor devices (“tees” or “FROP Ts”) also provide some incidental oil and water separation to temporarily detain oil or other floatable pollutants in runoff due to accidental spill or illegal dumping.

The restrictor device usually consists of two or more orifices and/or a weir section sized to meet performance requirements.

Standard control structure details are shown in Figure V-12.1: Flow Restrictor (TEE), Figure V-12.2: Flow Restrictor (Baffle), and Figure V-12.3: Flow Restrictor (Weir).

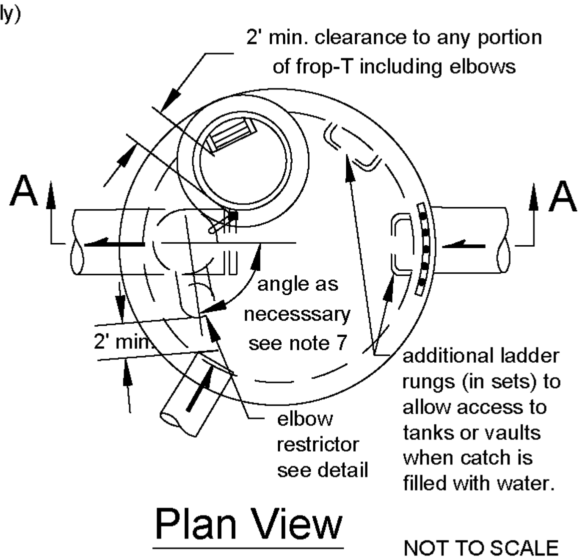
Exhibit 5

## Figure V-12.1: Flow Restrictor (TEE)



Notes:

1. Use a minimum of a 54" diameter type 2 catch basin.
2. Outlet Capacity: 100-yr developed peak flow.
3. Metal Parts: Corrosion resistant. Non-Galvanized parts preferred. Galvanized pipe parts to have asphalt treatment 1.
4. Frame and ladder or steps offset so:
   - A. Cleanout gate is visible from top.
   - B. Climb-down space is clear of riser and cleanout gate.
   - C. Frame is clear of curb.
5. If metal outlet pipe connects to cement concrete pipe: outlet pipe to have smooth O.D. equal to concrete pipe I.D. less ¼".
6. Provide at least one 3" x 0.90 inches support bracket anchored to concrete wall. (maximum 3'-0" vertical spacing)
7. Locate elbow restrictor(s) as necessary to provide minimum clearance as shown.
8. Locate additional ladder rungs in structures used as access to tanks or vaults to allow access when catch basin is filled with water.



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### Flow Restrictor (TEE)

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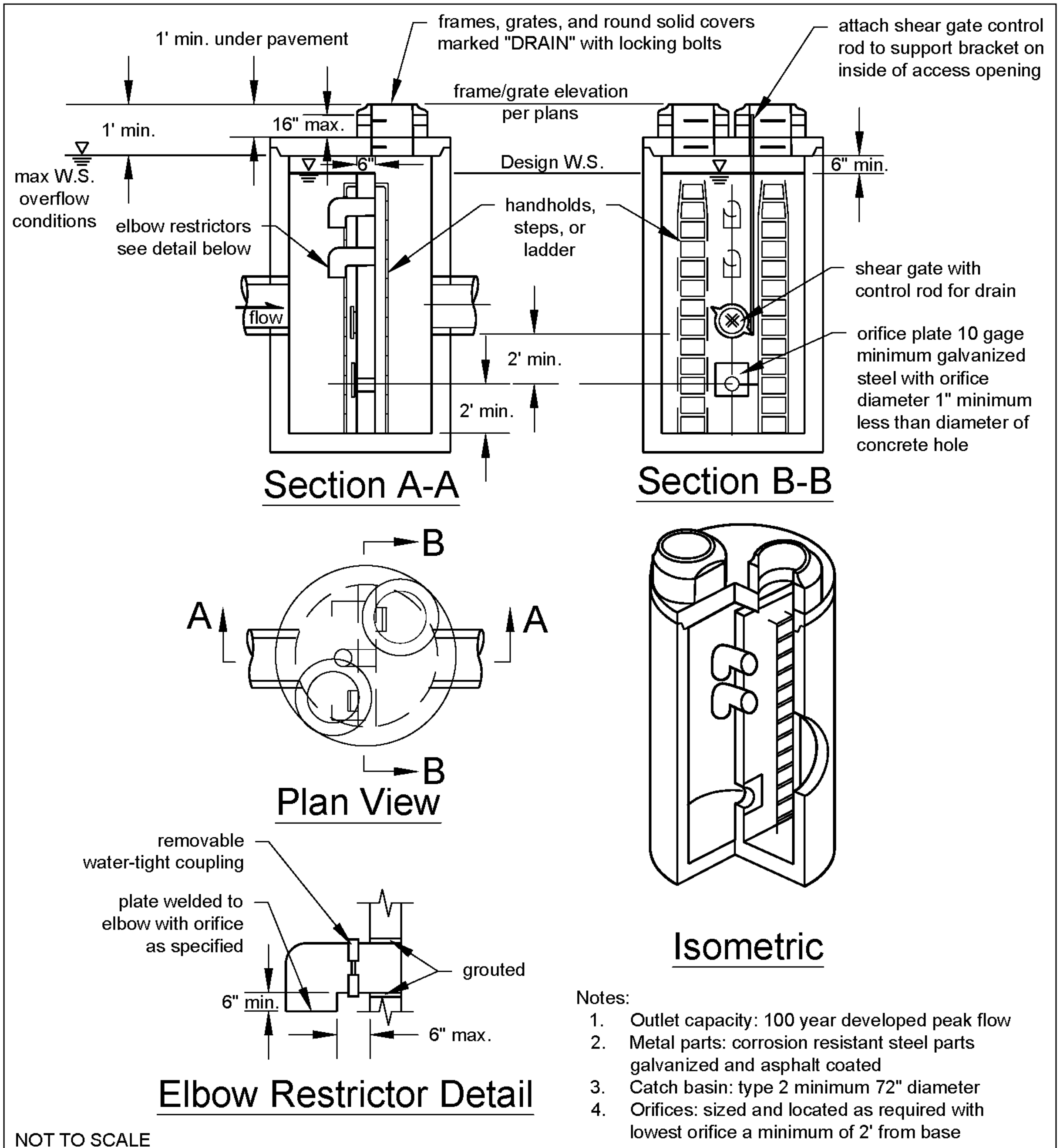
Exhibit 5

## Figure V-12.2: Flow Restrictor (Baffle)



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Notes:

1. Outlet capacity: 100 year developed peak flow
2. Metal parts: corrosion resistant steel parts galvanized and asphalt coated
3. Catch basin: type 2 minimum 72" diameter
4. Orifices: sized and located as required with lowest orifice a minimum of 2' from base

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### Flow Restrictor (Baffle)

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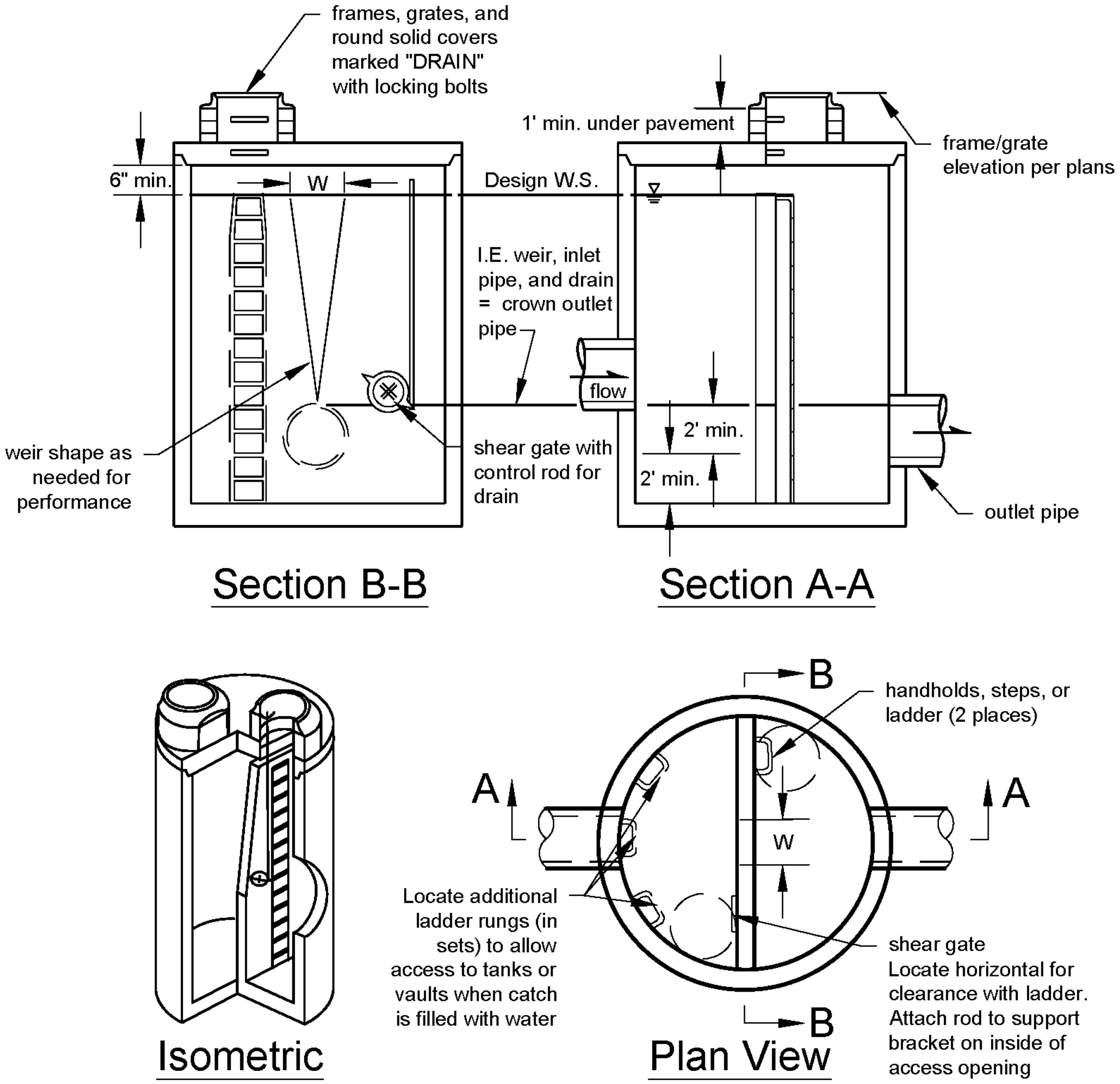
Exhibit 5

**Figure V-12.3: Flow Restrictor (Weir)**



Notes:

1. Outlet Capacity: 100-year developed peak flow.
2. Metal Parts: corrosion resistant steel parts galvanized and asphalt coated.
3. Catch Basin: type 2 min. 72" diameter.
4. Baffle Wall: to be designed with concrete reinforcing as required.
5. Spill containment must be provided to temporarily detain oil or floatable pollutants in runoff due to accidental spill or illegal dumping.

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Flow Restrictor (Weir)

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Exhibit 5

## Design Criteria

### Multiple Orifice Restrictor

In most cases, control structures need only two orifices: one at the bottom and one near the top of the riser, although additional orifices may best utilize the detention storage volume. Several orifices may be located at the same elevation if necessary to meet performance requirements.

1. The minimum orifice diameter is 0.5 inches.

   In some instances, a 0.5 inch bottom orifice will be too large to meet target release rates, even with minimal head. In these cases, the live storage depth need not be reduced to less than 3 feet in an attempt to meet the performance standards. Also, under such circumstances, flow-throttling devices may be a feasible option. These devices will throttle flows while maintaining a plug-resistant opening.

2. Orifices may be constructed on a tee section as shown in Figure V-12.1: Flow Restrictor (TEE) or on a baffle as shown in Figure V-12.2: Flow Restrictor (Baffle).

3. In some cases, performance requirements may require the top orifice/elbow to be located too high on the riser to be physically constructed (e.g., a 13-inch diameter orifice positioned 0.5 feet from the top of the riser). In these cases, a notch weir in the riser pipe may be used to meet performance requirements (see Figure V-12.5: Rectangular, Sharp Crested Weir).

4. Consider the backwater effect of water surface elevations in the downstream conveyance system. High tailwater elevations may affect performance of the restrictor system and reduce live storage volumes.

### Riser and Weir Restrictor

1. Properly designed weirs may be used as flow restrictors (see Figure V-12.3: Flow Restrictor (Weir), Figure V-12.5: Rectangular, Sharp Crested Weir, Figure V-12.6: V-Notch, Sharp-Crested Weir, and Figure V-12.7: Sutro Weir). However, they must be designed to provide for primary overflow of the developed 100-year peak flow discharging to the detention BMP.

2. The combined orifice and riser (or weir) overflow may be used to meet performance requirements; however, the design must still provide for primary overflow of the developed 100 year peak flow assuming all orifices are plugged. Figure V-12.8: Riser Inflow Curves can be used to calculate the head in feet above a riser of given diameter and flow.

### Access

1. Provide an access road to the control structure for inspection and maintenance. Design and construct the access road as specified in BMP D.1: Detention Ponds.

2. Manhole and catch basin lids for control structures must be locking, and rim elevations must match proposed finish grade.

3. Manholes and catch basins must meet the OSHA confined space requirements, which include

clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser, just under the access lid.

### Information Plate

It is recommended that a brass or stainless steel plate be permanently attached inside each control structure with the following information engraved on the plate:

- Name and file number of the project
- Name and organization of (1) project proponent, (2) engineer, and (3) contractor
- Date constructed
- Name and date of manual used for design
- Outflow performance criteria
- Release mechanism size, type, and invert elevation
- List of stage, discharge, and volume at one foot increments
- Elevation of overflow
- Recommended frequency of maintenance.

### Maintenance

Control structures have a history of maintenance-related problems and it is imperative to establish a good maintenance program for them to function properly. Typically, sediment builds up inside the structure, which blocks or restricts flow to the inlet. To prevent this problem, routinely clean out control structures at least twice per year. Conduct regular inspections of control structures to detect the need for non-routine cleanout, especially if construction or land-disturbing activities occur in the contributing drainage area.

Appendix V-A: BMP Maintenance Tables provides maintenance recommendations for control structures.

## Methods of Analysis

This section presents the methods and equations for design of control structure restrictor devices. Included are details for the design of orifices, rectangular sharp crested weirs, v notch weirs, sutro weirs, and overflow risers.

### Orifices

Flow through orifice plates in the standard tee section or turned down elbow may be approximated by the general equation:

$$Q = CA\sqrt{2gh}$$

where

Exhibit 5

Q = flow (cfs)

C = coefficient of discharge (0.62 for plate orifice)

A = area of orifice ($ft^2$)

h = hydraulic head (ft)

g = gravity (32.2 $ft/sec^2$)

Figure V-12.4: Simple Orifice illustrates this simplified application of the orifice equation.

The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}}$$

where

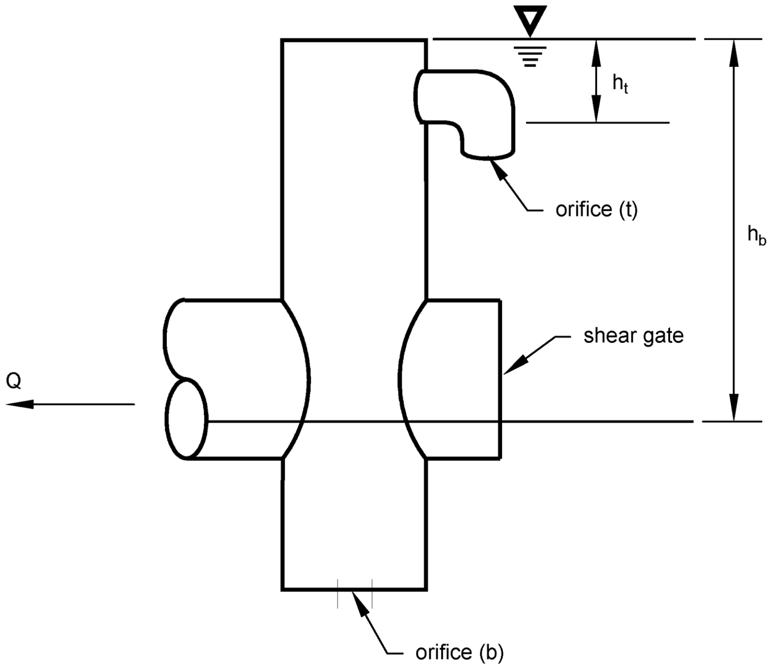
d = orifice diameter (inches)

Q = flow (cfs)

h = hydraulic head (ft)

Exhibit 5

# Figure V-12.4: Simple Orifice



$$Q = CA_b\sqrt{2gh_b} + CA_t\sqrt{2gh_t}$$

$$= C\sqrt{2g}(A_b\sqrt{h_b} + A_t\sqrt{h_t})$$

$h_b$ = distance from hydraulic grade line at the 2 – year flow of the outflow pipe to the overflow elevation

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Simple Orifice

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Exhibit 5

## Rectangular Sharp Crested Weir

The rectangular sharp crested weir design shown in Figure V-12.5: Rectangular, Sharp Crested Weir may be analyzed using standard weir equations for the fully contracted condition.

$$Q=C(L-0.2H)H^{3/2}$$

where

Q = flow (cfs)

C = 3.27 + 0.40 H/P (ft)

H, P are as shown in Figure V-12.5: Rectangular, Sharp Crested Weir

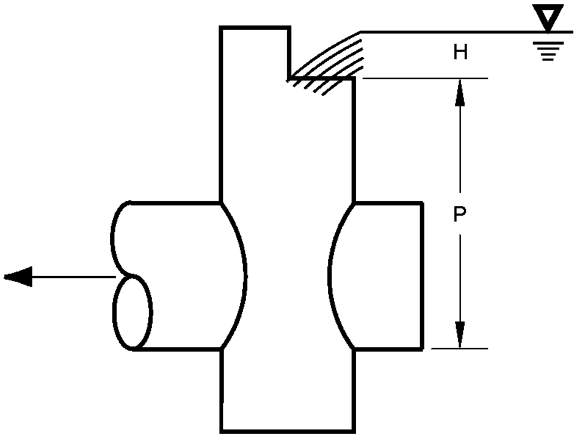
L = length (ft) of the portion of the riser circumference as necessary not to exceed 50 percent of the circumference

D = inside riser diameter (ft)

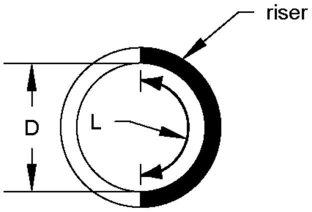
*Note that this equation accounts for side contractions by subtracting 0.1H from L for each side of the notch weir.*

Exhibit 5

## Figure V-12.5: Rectangular, Sharp Crested Weir



Section



Plan

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Rectangular, Sharp-Crested Weir

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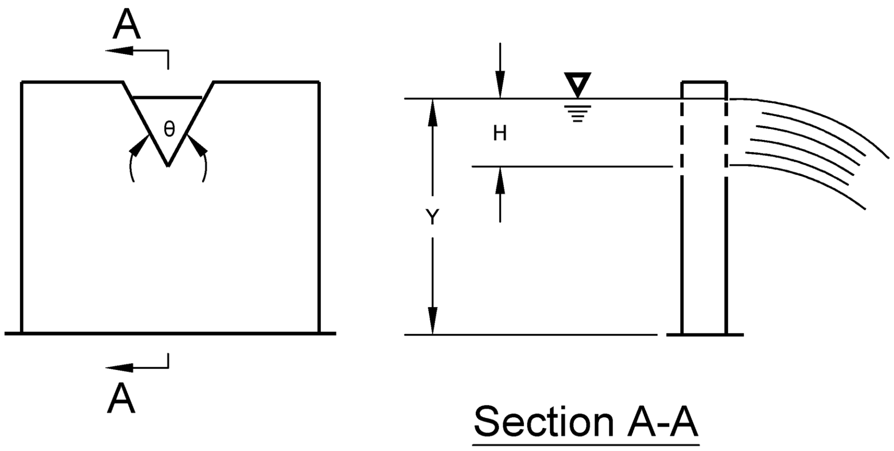
Exhibit 5

### V-Notch Sharp - Crested Weir

V-notch weirs as shown in Figure V-12.6: V-Notch, Sharp-Crested Weir may be analyzed using standard equations for the fully contracted condition.

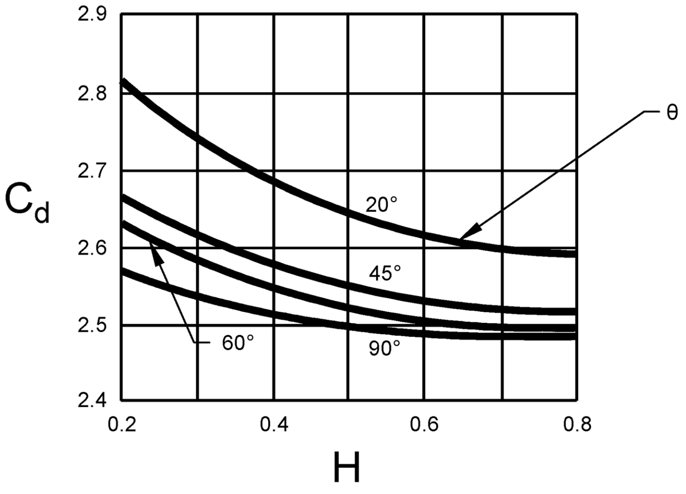
Exhibit 5

### Figure V-12.6: V-Notch, Sharp-Crested Weir



$Q = C_d(\text{Tan}\frac{\theta}{2})H^{\frac{5}{2}}$ in cfs

Where values of $C_d$ may be taken from the following chart :



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## V-Notch, Sharp Crested Weir

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Exhibit 5

## Proportional or Sutro Weir

Sutro weirs are designed so that the discharge is proportional to the total head. This design may be useful in some cases to meet performance requirements.

The sutro weir consists of a rectangular section joined to a curved portion that provides proportionality for all heads above the line A-B (see Figure V-12.7: Sutro Weir). The weir may be symmetrical or non-symmetrical.

For this type of weir, the curved portion is defined by the following equation (calculated in radians):

$$\frac{x}{b} = 1 - \frac{2}{\pi} Tan^{-1} \sqrt{\frac{Z}{a}}$$

where a, b, x and Z are as shown in Figure V-12.7: Sutro Weir.

The head discharge relationship is:

$$Q = (C_d)(b)(\sqrt{2ga})(h_1 - \frac{a}{3})$$

Values of $C_d$ for both symmetrical and non symmetrical sutro weirs are summarized in Table V-12.1: Values of Cd for Sutro Weirs.

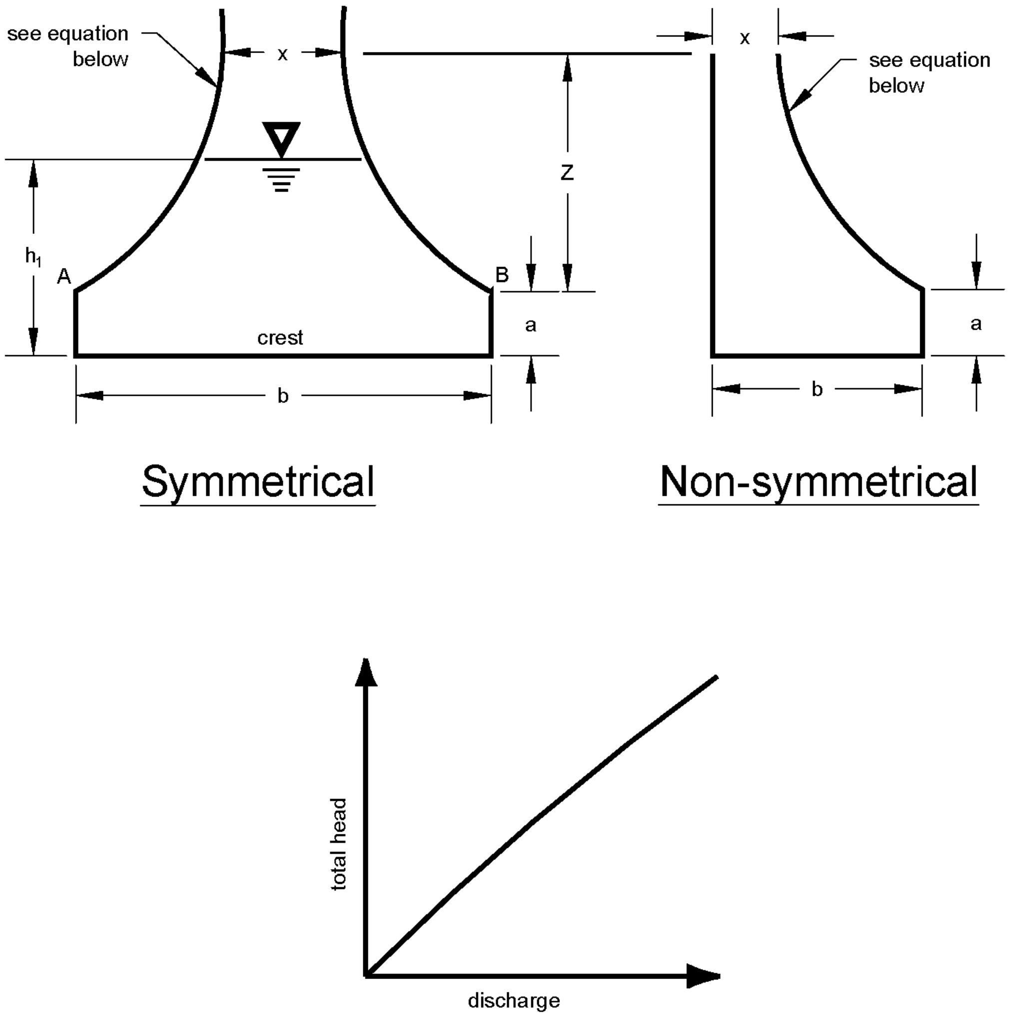
*Note: When b > 1.50 or a > 0.30, use $C_d$=0.6.*

### Table V-12.1: Values of $C_d$ for Sutro Weirs

| $C_d$ Values, Symmetrical | | | | | | $C_d$ Values, Non-Symmetrical | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| b (ft) | | | | | | b (ft) | | | | | |
| a (ft) | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | a (ft) | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 |
| 0.02 | 0.608 | 0.613 | 0.617 | 0.6185 | 0.619 | 0.02 | 0.614 | 0.619 | 0.623 | 0.6245 | 0.625 |
| 0.05 | 0.606 | 0.611 | 0.615 | 0.617 | 0.6175 | 0.05 | 0.612 | 0.617 | 0.621 | 0.623 | 0.6235 |
| 0.10 | 0.603 | 0.608 | 0.612 | 0.6135 | 0.614 | 0.10 | 0.609 | 0.614 | 0.618 | 0.6195 | 0.620 |
| 0.15 | 0.601 | 0.6055 | 0.610 | 0.6115 | 0.612 | 0.15 | 0.607 | 0.6115 | 0.616 | 0.6175 | 0.618 |
| 0.20 | 0.599 | 0.604 | 0.608 | 0.6095 | 0.610 | 0.20 | 0.605 | 0.610 | 0.614 | 0.6155 | 0.616 |
| 0.25 | 0.598 | 0.6025 | 0.6065 | 0.608 | 0.6085 | 0.25 | 0.604 | 0.6085 | 0.6125 | 0.614 | 0.6145 |
| 0.30 | 0.597 | 0.602 | 0.606 | 0.6075 | 0.608 | 0.30 | 0.603 | 0.608 | 0.612 | 0.6135 | 0.614 |

Exhibit 5

**Figure V-12.7: Sutro Weir**



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Sutro Weir

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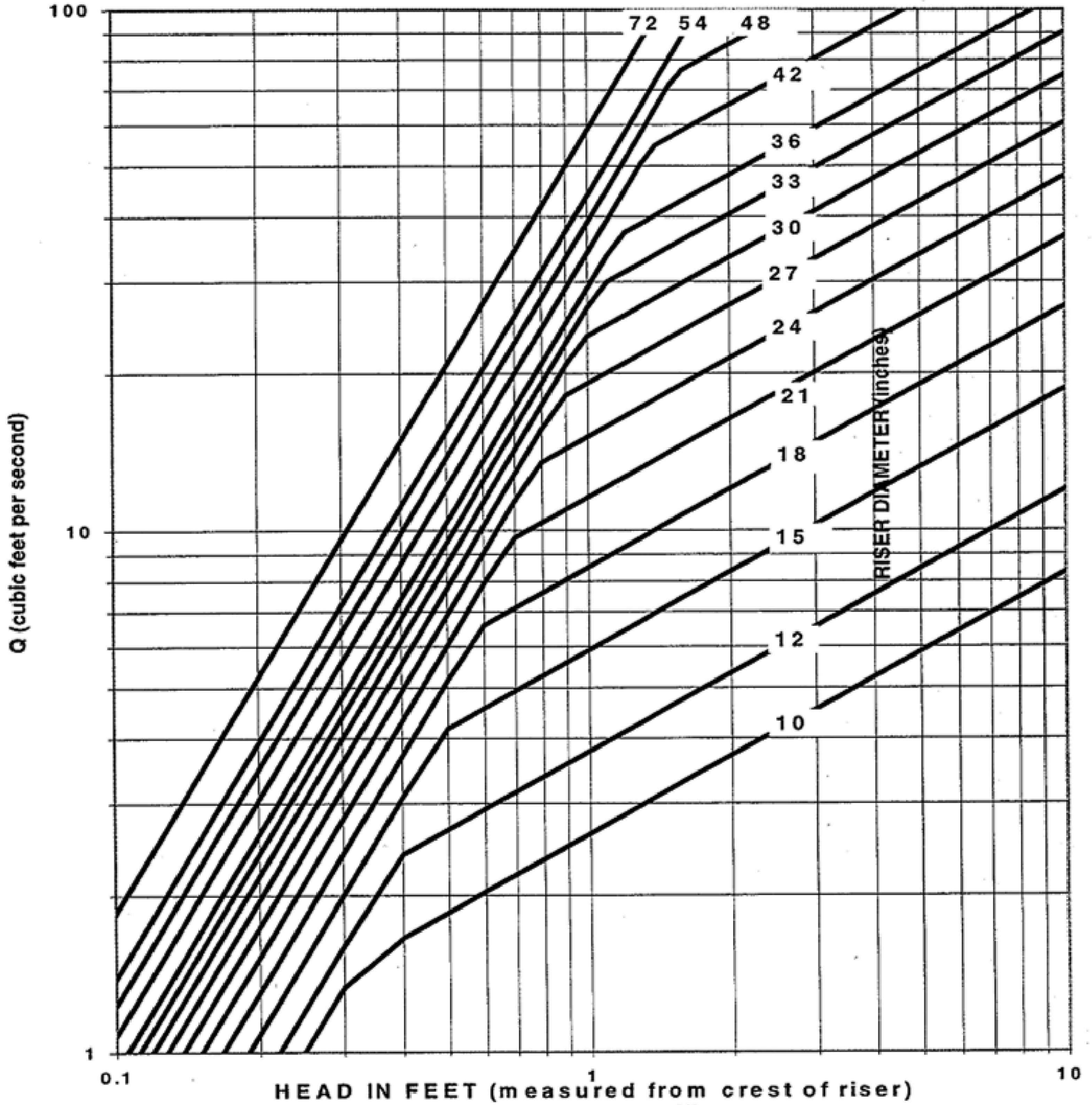
Exhibit 5

**Riser Overflow**

The nomograph in Figure V-12.8: Riser Inflow Curves can be used to determine the head (in feet) above a riser of given diameter and for a given flow (usually the 100 year peak flow for developed conditions).

Exhibit 5

## Figure V-12.8: Riser Inflow Curves



$Q_{weir} = 9.739\ DH^{3/2}$

$Q_{orifice} = 3.782\ D^2H^{1/2}$

Q in cfs, D and H in feet

Slope change occurs at weir-orifice transition

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Riser Inflow Curves

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Exhibit 5

# **Appendix F:** WWHM Analysis

Exhibit 5

# WWHM2012

# PROJECT REPORT

Exhibit 5

# *General Model Information*

| | |
|---|---|
| Project Name: | PRELIM POND SIZING 20211018 |
| Site Name: | |
| Site Address: | |
| City: | |
| Report Date: | 10/27/2021 |
| Gage: | Lacamas |
| Data Start: | 1948/10/01 |
| Data End: | 2008/09/30 |
| Timestep: | 15 Minute |
| Precip Scale: | 1.300 |
| Version Date: | 2018/07/12 |
| Version: | 4.2.15 |

## *POC Thresholds*

| | |
|---|---|
| Low Flow Threshold for POC1: | 50 Percent of the 2 Year |
| High Flow Threshold for POC1: | 50 Year |

Exhibit 5

# *Landuse Basin Data*

## *Predeveloped Land Use*

### Basin 1

| | |
|---|---|
| Bypass: | No |
| GroundWater: | No |
| Pervious Land Use | acre |
| SG4, Forest, Steep | 37.27 |
| Pervious Total | 37.27 |
| Impervious Land Use | acre |
| Impervious Total | 0 |
| Basin Total | 37.27 |

Element Flows To:

| Surface | Interflow | Groundwater |
|---|---|---|

Exhibit 5

## Offsite Basin

| | |
|---|---|
| Bypass: | No |
| GroundWater: | No |
| Pervious Land Use | acre |
| SG4, Forest, Steep | 7.9 |
| Pervious Total | 7.9 |
| Impervious Land Use | acre |
| ROADS MOD | 0.82 |
| ROOF TOPS FLAT | 0.98 |
| DRIVEWAYS MOD | 0.98 |
| Impervious Total | 2.78 |
| Basin Total | 10.68 |

Element Flows To:

| Surface | Interflow | Groundwater |
|---|---|---|

Exhibit 5

## Basin 3

| | |
|---|---|
| Bypass: | No |
| GroundWater: | No |
| Pervious Land Use | acre |
| Pervious Total | 0 |
| Impervious Land Use | acre |
| ROADS MOD | 0.6 |
| Impervious Total | 0.6 |
| Basin Total | 0.6 |

Element Flows To:

| Surface | Interflow | Groundwater |
|---|---|---|

Exhibit 5

## *Mitigated Land Use*

### Basin 1

| | |
|---|---|
| Bypass: | No |
| GroundWater: | No |
| Pervious Land Use | acre |
| SG4, Field, Mod | 18.63 |
| Pervious Total | 18.63 |
| Impervious Land Use | acre |
| ROADS MOD | 6.34 |
| ROOF TOPS FLAT | 9.17 |
| DRIVEWAYS MOD | 1.99 |
| SIDEWALKS MOD | 1.49 |
| Impervious Total | 18.99 |
| Basin Total | 37.62 |

Element Flows To:

| Surface | Interflow | Groundwater |
|---|---|---|
| Trapezoidal Pond 1 | Trapezoidal Pond 1 | |

Exhibit 5

## Offsite Basin

| | |
|---|---|
| Bypass: | No |
| GroundWater: | No |
| Pervious Land Use | acre |
| SG4, Forest, Steep | 7.9 |
| Pervious Total | 7.9 |
| Impervious Land Use | acre |
| ROADS MOD | 0.82 |
| ROOF TOPS FLAT | 0.98 |
| DRIVEWAYS MOD | 0.98 |
| Impervious Total | 2.78 |
| Basin Total | 10.68 |

Element Flows To:

| Surface | Interflow | Groundwater |
|---|---|---|
| Trapezoidal Pond 1 | Trapezoidal Pond 1 | |

Exhibit 5

## Basin 3

| | |
|---|---|
| Bypass: | Yes |
| GroundWater: | No |
| Pervious Land Use | acre |
| Pervious Total | 0 |
| Impervious Land Use | acre |
| ROADS MOD | 0.25 |
| Impervious Total | 0.25 |
| Basin Total | 0.25 |

Element Flows To:

| Surface | Interflow | Groundwater |
|---|---|---|

Exhibit 5

# *Routing Elements*

## *Predeveloped Routing*

Exhibit 5

## *Mitigated Routing*

## Trapezoidal Pond 1

| | |
|---|---|
| Bottom Length: | 140.10 ft. |
| Bottom Width: | 140.10 ft. |
| Depth: | 6 ft. |
| Volume at riser head: | 2.7699 acre-feet. |
| Side slope 1: | 3 To 1 |
| Side slope 2: | 3 To 1 |
| Side slope 3: | 3 To 1 |
| Side slope 4: | 3 To 1 |
| Discharge Structure | |
| Riser Height: | 5 ft. |
| Riser Diameter: | 18 in. |
| Notch Type: | Rectangular |
| Notch Width: | 1.193 ft. |
| Notch Height: | 1.452 ft. |
| Orifice 1 Diameter: | 10.45 in. Elevation:0 ft. |
| Element Flows To: | |
| Outlet 1 | Outlet 2 |

Pond Hydraulic Table

| **Stage(feet)** | **Area(ac.)** | **Volume(ac-ft.)** | **Discharge(cfs)** | **Infilt(cfs)** |
|---|---|---|---|---|
| 0.0000 | 0.450 | 0.000 | 0.000 | 0.000 |
| 0.0667 | 0.453 | 0.030 | 0.765 | 0.000 |
| 0.1333 | 0.455 | 0.060 | 1.082 | 0.000 |
| 0.2000 | 0.458 | 0.090 | 1.325 | 0.000 |
| 0.2667 | 0.461 | 0.121 | 1.530 | 0.000 |
| 0.3333 | 0.463 | 0.152 | 1.710 | 0.000 |
| 0.4000 | 0.466 | 0.183 | 1.874 | 0.000 |
| 0.4667 | 0.468 | 0.214 | 2.024 | 0.000 |
| 0.5333 | 0.471 | 0.245 | 2.164 | 0.000 |
| 0.6000 | 0.474 | 0.277 | 2.295 | 0.000 |
| 0.6667 | 0.476 | 0.309 | 2.419 | 0.000 |
| 0.7333 | 0.479 | 0.340 | 2.537 | 0.000 |
| 0.8000 | 0.482 | 0.373 | 2.650 | 0.000 |
| 0.8667 | 0.484 | 0.405 | 2.758 | 0.000 |
| 0.9333 | 0.487 | 0.437 | 2.862 | 0.000 |
| 1.0000 | 0.490 | 0.470 | 2.963 | 0.000 |
| 1.0667 | 0.492 | 0.502 | 3.060 | 0.000 |
| 1.1333 | 0.495 | 0.535 | 3.154 | 0.000 |
| 1.2000 | 0.498 | 0.569 | 3.246 | 0.000 |
| 1.2667 | 0.500 | 0.602 | 3.335 | 0.000 |
| 1.3333 | 0.503 | 0.635 | 3.421 | 0.000 |
| 1.4000 | 0.506 | 0.669 | 3.506 | 0.000 |
| 1.4667 | 0.509 | 0.703 | 3.588 | 0.000 |
| 1.5333 | 0.511 | 0.737 | 3.669 | 0.000 |
| 1.6000 | 0.514 | 0.771 | 3.748 | 0.000 |
| 1.6667 | 0.517 | 0.805 | 3.825 | 0.000 |
| 1.7333 | 0.520 | 0.840 | 3.901 | 0.000 |
| 1.8000 | 0.522 | 0.875 | 3.975 | 0.000 |
| 1.8667 | 0.525 | 0.910 | 4.048 | 0.000 |
| 1.9333 | 0.528 | 0.945 | 4.120 | 0.000 |
| 2.0000 | 0.531 | 0.980 | 4.190 | 0.000 |
| 2.0667 | 0.533 | 1.016 | 4.260 | 0.000 |

Exhibit 5

| | | | | |
|---|---|---|---|---|
| 2.1333 | 0.536 | 1.051 | 4.328 | 0.000 |
| 2.2000 | 0.539 | 1.087 | 4.395 | 0.000 |
| 2.2667 | 0.542 | 1.123 | 4.461 | 0.000 |
| 2.3333 | 0.545 | 1.160 | 4.526 | 0.000 |
| 2.4000 | 0.548 | 1.196 | 4.590 | 0.000 |
| 2.4667 | 0.550 | 1.233 | 4.654 | 0.000 |
| 2.5333 | 0.553 | 1.269 | 4.716 | 0.000 |
| 2.6000 | 0.556 | 1.306 | 4.778 | 0.000 |
| 2.6667 | 0.559 | 1.344 | 4.839 | 0.000 |
| 2.7333 | 0.562 | 1.381 | 4.899 | 0.000 |
| 2.8000 | 0.565 | 1.419 | 4.958 | 0.000 |
| 2.8667 | 0.568 | 1.456 | 5.017 | 0.000 |
| 2.9333 | 0.570 | 1.494 | 5.075 | 0.000 |
| 3.0000 | 0.573 | 1.532 | 5.132 | 0.000 |
| 3.0667 | 0.576 | 1.571 | 5.189 | 0.000 |
| 3.1333 | 0.579 | 1.609 | 5.245 | 0.000 |
| 3.2000 | 0.582 | 1.648 | 5.301 | 0.000 |
| 3.2667 | 0.585 | 1.687 | 5.356 | 0.000 |
| 3.3333 | 0.588 | 1.726 | 5.410 | 0.000 |
| 3.4000 | 0.591 | 1.766 | 5.464 | 0.000 |
| 3.4667 | 0.594 | 1.805 | 5.517 | 0.000 |
| 3.5333 | 0.597 | 1.845 | 5.570 | 0.000 |
| 3.6000 | 0.600 | 1.885 | 5.670 | 0.000 |
| 3.6667 | 0.603 | 1.925 | 5.837 | 0.000 |
| 3.7333 | 0.606 | 1.965 | 6.044 | 0.000 |
| 3.8000 | 0.609 | 2.006 | 6.280 | 0.000 |
| 3.8667 | 0.612 | 2.046 | 6.543 | 0.000 |
| 3.9333 | 0.615 | 2.087 | 6.829 | 0.000 |
| 4.0000 | 0.618 | 2.128 | 7.136 | 0.000 |
| 4.0667 | 0.621 | 2.170 | 7.462 | 0.000 |
| 4.1333 | 0.624 | 2.211 | 7.806 | 0.000 |
| 4.2000 | 0.627 | 2.253 | 8.167 | 0.000 |
| 4.2667 | 0.630 | 2.295 | 8.544 | 0.000 |
| 4.3333 | 0.633 | 2.337 | 8.936 | 0.000 |
| 4.4000 | 0.636 | 2.379 | 9.343 | 0.000 |
| 4.4667 | 0.639 | 2.422 | 9.764 | 0.000 |
| 4.5333 | 0.642 | 2.465 | 10.19 | 0.000 |
| 4.6000 | 0.645 | 2.507 | 10.64 | 0.000 |
| 4.6667 | 0.648 | 2.551 | 11.10 | 0.000 |
| 4.7333 | 0.651 | 2.594 | 11.57 | 0.000 |
| 4.8000 | 0.654 | 2.638 | 12.06 | 0.000 |
| 4.8667 | 0.658 | 2.681 | 12.55 | 0.000 |
| 4.9333 | 0.661 | 2.725 | 13.06 | 0.000 |
| 5.0000 | 0.664 | 2.769 | 13.58 | 0.000 |
| 5.0667 | 0.667 | 2.814 | 13.90 | 0.000 |
| 5.1333 | 0.670 | 2.858 | 14.44 | 0.000 |
| 5.2000 | 0.673 | 2.903 | 15.11 | 0.000 |
| 5.2667 | 0.676 | 2.948 | 15.88 | 0.000 |
| 5.3333 | 0.680 | 2.993 | 16.68 | 0.000 |
| 5.4000 | 0.683 | 3.039 | 17.47 | 0.000 |
| 5.4667 | 0.686 | 3.085 | 18.21 | 0.000 |
| 5.5333 | 0.689 | 3.130 | 18.85 | 0.000 |
| 5.6000 | 0.692 | 3.177 | 19.37 | 0.000 |
| 5.6667 | 0.695 | 3.223 | 19.76 | 0.000 |
| 5.7333 | 0.699 | 3.269 | 20.06 | 0.000 |
| 5.8000 | 0.702 | 3.316 | 20.43 | 0.000 |
| 5.8667 | 0.705 | 3.363 | 20.73 | 0.000 |
| 5.9333 | 0.708 | 3.410 | 21.02 | 0.000 |

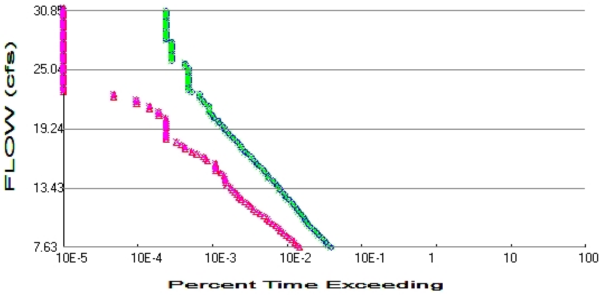
Exhibit 5

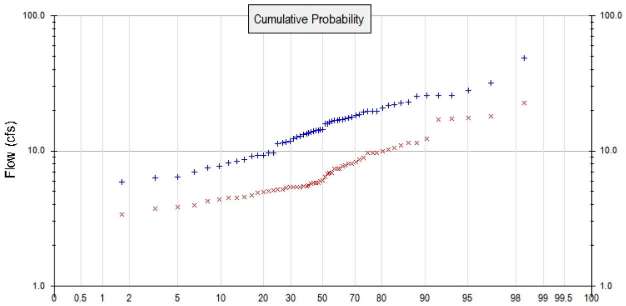
| | | | | |
|---|---|---|---|---|
| 6.0000 | 0.711 | 3.457 | 21.30 | 0.000 |
| 6.0667 | 0.715 | 3.505 | 21.57 | 0.000 |

Exhibit 5

# *Analysis Results*

## *POC 1*





+ Predeveloped    x Mitigated

| | |
|---|---|
| Predeveloped Landuse Totals for POC #1 | |
| Total Pervious Area: | 45.17 |
| Total Impervious Area: | 3.38 |

| | |
|---|---|
| Mitigated Landuse Totals for POC #1 | |
| Total Pervious Area: | 26.53 |
| Total Impervious Area: | 22.02 |

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

| **Return Period** | **Flow(cfs)** |
|---|---|
| 2 year | 15.250578 |
| 5 year | 21.963799 |
| 10 year | 25.427034 |
| 25 year | 28.852121 |
| 50 year | 30.84717 |
| 100 year | 32.46739 |

Flow Frequency Return Periods for Mitigated. POC #1

| **Return Period** | **Flow(cfs)** |
|---|---|
| 2 year | 6.633016 |
| 5 year | 9.807369 |
| 10 year | 12.292749 |
| 25 year | 15.904798 |
| 50 year | 18.961267 |
| 100 year | 22.351245 |

## Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

| **Year** | **Predeveloped** | **Mitigated** |
|---|---|---|
| 1949 | 11.424 | 7.739 |
| 1950 | 13.852 | 6.744 |
| 1951 | 19.570 | 5.589 |
| 1952 | 12.638 | 6.861 |
| 1953 | 15.785 | 5.502 |
| 1954 | 25.730 | 5.723 |
| 1955 | 12.216 | 5.168 |
| 1956 | 22.113 | 18.077 |
| 1957 | 20.808 | 7.415 |
| 1958 | 17.161 | 10.214 |

Exhibit 5

| | | |
|---|---|---|
| 1959 | 9.714 | 3.843 |
| 1960 | 9.105 | 4.522 |
| 1961 | 19.623 | 7.344 |
| 1962 | 14.367 | 5.828 |
| 1963 | 15.865 | 5.364 |
| 1964 | 14.402 | 6.078 |
| 1965 | 13.121 | 8.577 |
| 1966 | 17.681 | 7.378 |
| 1967 | 16.537 | 5.292 |
| 1968 | 18.589 | 5.768 |
| 1969 | 19.734 | 8.268 |
| 1970 | 48.644 | 22.779 |
| 1971 | 8.345 | 4.685 |
| 1972 | 12.849 | 5.994 |
| 1973 | 13.645 | 8.044 |
| 1974 | 19.315 | 17.604 |
| 1975 | 11.342 | 5.372 |
| 1976 | 17.575 | 7.776 |
| 1977 | 1.368 | 3.349 |
| 1978 | 25.859 | 12.337 |
| 1979 | 17.049 | 9.601 |
| 1980 | 9.624 | 5.111 |
| 1981 | 22.735 | 11.387 |
| 1982 | 16.271 | 11.427 |
| 1983 | 28.009 | 10.453 |
| 1984 | 9.273 | 4.870 |
| 1985 | 6.396 | 5.043 |
| 1986 | 8.634 | 4.518 |
| 1987 | 14.170 | 7.987 |
| 1988 | 8.144 | 3.932 |
| 1989 | 9.312 | 4.380 |
| 1990 | 6.979 | 4.235 |
| 1991 | 16.938 | 5.426 |
| 1992 | 16.817 | 4.986 |
| 1993 | 21.689 | 10.912 |
| 1994 | 14.195 | 9.612 |
| 1995 | 11.784 | 8.811 |
| 1996 | 25.234 | 17.016 |
| 1997 | 31.599 | 17.162 |
| 1998 | 25.861 | 5.477 |
| 1999 | 16.840 | 9.612 |
| 2000 | 11.568 | 3.731 |
| 2001 | 6.337 | 3.393 |
| 2002 | 22.909 | 6.827 |
| 2003 | 18.248 | 9.926 |
| 2004 | 5.875 | 4.484 |
| 2005 | 7.442 | 5.147 |
| 2006 | 13.440 | 5.831 |
| 2007 | 7.695 | 6.403 |
| 2008 | 13.899 | 5.397 |

## Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated.  POC #1

| Rank | Predeveloped | Mitigated |
|---|---|---|
| 1 | 48.6436 | 22.7793 |
| 2 | 31.5989 | 18.0772 |
| 3 | 28.0090 | 17.6038 |
| 4 | 25.8607 | 17.1620 |

Exhibit 5

| | | |
|---|---|---|
| 5 | 25.8593 | 17.0160 |
| 6 | 25.7298 | 12.3374 |
| 7 | 25.2336 | 11.4273 |
| 8 | 22.9088 | 11.3874 |
| 9 | 22.7349 | 10.9122 |
| 10 | 22.1128 | 10.4533 |
| 11 | 21.6887 | 10.2140 |
| 12 | 20.8083 | 9.9256 |
| 13 | 19.7342 | 9.6124 |
| 14 | 19.6228 | 9.6118 |
| 15 | 19.5698 | 9.6008 |
| 16 | 19.3153 | 8.8114 |
| 17 | 18.5892 | 8.5765 |
| 18 | 18.2483 | 8.2683 |
| 19 | 17.6807 | 8.0441 |
| 20 | 17.5751 | 7.9873 |
| 21 | 17.1613 | 7.7757 |
| 22 | 17.0485 | 7.7389 |
| 23 | 16.9379 | 7.4149 |
| 24 | 16.8397 | 7.3775 |
| 25 | 16.8174 | 7.3436 |
| 26 | 16.5367 | 6.8610 |
| 27 | 16.2712 | 6.8274 |
| 28 | 15.8651 | 6.7444 |
| 29 | 15.7845 | 6.4034 |
| 30 | 14.4017 | 6.0779 |
| 31 | 14.3671 | 5.9944 |
| 32 | 14.1949 | 5.8314 |
| 33 | 14.1698 | 5.8281 |
| 34 | 13.8990 | 5.7679 |
| 35 | 13.8518 | 5.7228 |
| 36 | 13.6449 | 5.5886 |
| 37 | 13.4402 | 5.5016 |
| 38 | 13.1212 | 5.4773 |
| 39 | 12.8489 | 5.4263 |
| 40 | 12.6380 | 5.3967 |
| 41 | 12.2155 | 5.3721 |
| 42 | 11.7837 | 5.3636 |
| 43 | 11.5682 | 5.2920 |
| 44 | 11.4238 | 5.1683 |
| 45 | 11.3423 | 5.1474 |
| 46 | 9.7143 | 5.1107 |
| 47 | 9.6245 | 5.0427 |
| 48 | 9.3123 | 4.9856 |
| 49 | 9.2729 | 4.8705 |
| 50 | 9.1054 | 4.6848 |
| 51 | 8.6337 | 4.5221 |
| 52 | 8.3447 | 4.5176 |
| 53 | 8.1444 | 4.4837 |
| 54 | 7.6951 | 4.3797 |
| 55 | 7.4422 | 4.2346 |
| 56 | 6.9789 | 3.9322 |
| 57 | 6.3960 | 3.8427 |
| 58 | 6.3368 | 3.7308 |
| 59 | 5.8753 | 3.3935 |
| 60 | 1.3680 | 3.3494 |

Exhibit 5

Exhibit 5

## Duration Flows

The Facility PASSED

| Flow(cfs) | Predev | Mit | Percentage | Pass/Fail |
|---|---|---|---|---|
| 7.6253 | 820 | 309 | 37 | Pass |
| 7.8599 | 751 | 283 | 37 | Pass |
| 8.0944 | 701 | 266 | 37 | Pass |
| 8.3290 | 654 | 244 | 37 | Pass |
| 8.5635 | 609 | 222 | 36 | Pass |
| 8.7981 | 557 | 203 | 36 | Pass |
| 9.0327 | 527 | 188 | 35 | Pass |
| 9.2672 | 494 | 170 | 34 | Pass |
| 9.5018 | 450 | 161 | 35 | Pass |
| 9.7364 | 422 | 147 | 34 | Pass |
| 9.9709 | 398 | 133 | 33 | Pass |
| 10.2055 | 379 | 120 | 31 | Pass |
| 10.4401 | 358 | 114 | 31 | Pass |
| 10.6746 | 338 | 103 | 30 | Pass |
| 10.9092 | 323 | 91 | 28 | Pass |
| 11.1438 | 302 | 81 | 26 | Pass |
| 11.3783 | 287 | 74 | 25 | Pass |
| 11.6129 | 267 | 67 | 25 | Pass |
| 11.8474 | 254 | 63 | 24 | Pass |
| 12.0820 | 238 | 57 | 23 | Pass |
| 12.3166 | 220 | 51 | 23 | Pass |
| 12.5511 | 203 | 47 | 23 | Pass |
| 12.7857 | 197 | 45 | 22 | Pass |
| 13.0203 | 182 | 42 | 23 | Pass |
| 13.2548 | 168 | 39 | 23 | Pass |
| 13.4894 | 163 | 37 | 22 | Pass |
| 13.7240 | 153 | 33 | 21 | Pass |
| 13.9585 | 144 | 32 | 22 | Pass |
| 14.1931 | 136 | 31 | 22 | Pass |
| 14.4277 | 118 | 31 | 26 | Pass |
| 14.6622 | 117 | 30 | 25 | Pass |
| 14.8968 | 109 | 27 | 24 | Pass |
| 15.1314 | 103 | 23 | 22 | Pass |
| 15.3659 | 97 | 23 | 23 | Pass |
| 15.6005 | 88 | 23 | 26 | Pass |
| 15.8350 | 82 | 23 | 28 | Pass |
| 16.0696 | 76 | 18 | 23 | Pass |
| 16.3042 | 72 | 17 | 23 | Pass |
| 16.5387 | 69 | 16 | 23 | Pass |
| 16.7733 | 63 | 13 | 20 | Pass |
| 17.0079 | 57 | 11 | 19 | Pass |
| 17.2424 | 52 | 9 | 17 | Pass |
| 17.4770 | 51 | 9 | 17 | Pass |
| 17.7116 | 49 | 8 | 16 | Pass |
| 17.9461 | 46 | 7 | 15 | Pass |
| 18.1807 | 41 | 5 | 12 | Pass |
| 18.4153 | 39 | 5 | 12 | Pass |
| 18.6498 | 36 | 5 | 13 | Pass |
| 18.8844 | 34 | 5 | 14 | Pass |
| 19.1189 | 31 | 5 | 16 | Pass |
| 19.3535 | 30 | 5 | 16 | Pass |
| 19.5881 | 28 | 5 | 17 | Pass |
| 19.8226 | 26 | 5 | 19 | Pass |

| | | | | |
|---|---|---|---|---|
| 20.0572 | 25 | 5 | 20 | Pass |
| 20.2918 | 22 | 5 | 22 | Pass |
| 20.5263 | 21 | 4 | 19 | Pass |
| 20.7609 | 20 | 4 | 20 | Pass |
| 20.9955 | 19 | 4 | 21 | Pass |
| 21.2300 | 19 | 3 | 15 | Pass |
| 21.4646 | 19 | 3 | 15 | Pass |
| 21.6992 | 17 | 2 | 11 | Pass |
| 21.9337 | 16 | 2 | 12 | Pass |
| 22.1683 | 15 | 2 | 13 | Pass |
| 22.4028 | 14 | 1 | 7 | Pass |
| 22.6374 | 14 | 1 | 7 | Pass |
| 22.8720 | 11 | 0 | 0 | Pass |
| 23.1065 | 10 | 0 | 0 | Pass |
| 23.3411 | 10 | 0 | 0 | Pass |
| 23.5757 | 10 | 0 | 0 | Pass |
| 23.8102 | 10 | 0 | 0 | Pass |
| 24.0448 | 10 | 0 | 0 | Pass |
| 24.2794 | 10 | 0 | 0 | Pass |
| 24.5139 | 10 | 0 | 0 | Pass |
| 24.7485 | 10 | 0 | 0 | Pass |
| 24.9831 | 10 | 0 | 0 | Pass |
| 25.2176 | 10 | 0 | 0 | Pass |
| 25.4522 | 9 | 0 | 0 | Pass |
| 25.6868 | 9 | 0 | 0 | Pass |
| 25.9213 | 6 | 0 | 0 | Pass |
| 26.1559 | 6 | 0 | 0 | Pass |
| 26.3904 | 6 | 0 | 0 | Pass |
| 26.6250 | 6 | 0 | 0 | Pass |
| 26.8596 | 6 | 0 | 0 | Pass |
| 27.0941 | 6 | 0 | 0 | Pass |
| 27.3287 | 6 | 0 | 0 | Pass |
| 27.5633 | 6 | 0 | 0 | Pass |
| 27.7978 | 6 | 0 | 0 | Pass |
| 28.0324 | 5 | 0 | 0 | Pass |
| 28.2670 | 5 | 0 | 0 | Pass |
| 28.5015 | 5 | 0 | 0 | Pass |
| 28.7361 | 5 | 0 | 0 | Pass |
| 28.9707 | 5 | 0 | 0 | Pass |
| 29.2052 | 5 | 0 | 0 | Pass |
| 29.4398 | 5 | 0 | 0 | Pass |
| 29.6743 | 5 | 0 | 0 | Pass |
| 29.9089 | 5 | 0 | 0 | Pass |
| 30.1435 | 5 | 0 | 0 | Pass |
| 30.3780 | 5 | 0 | 0 | Pass |
| 30.6126 | 5 | 0 | 0 | Pass |
| 30.8472 | 5 | 0 | 0 | Pass |

Exhibit 5

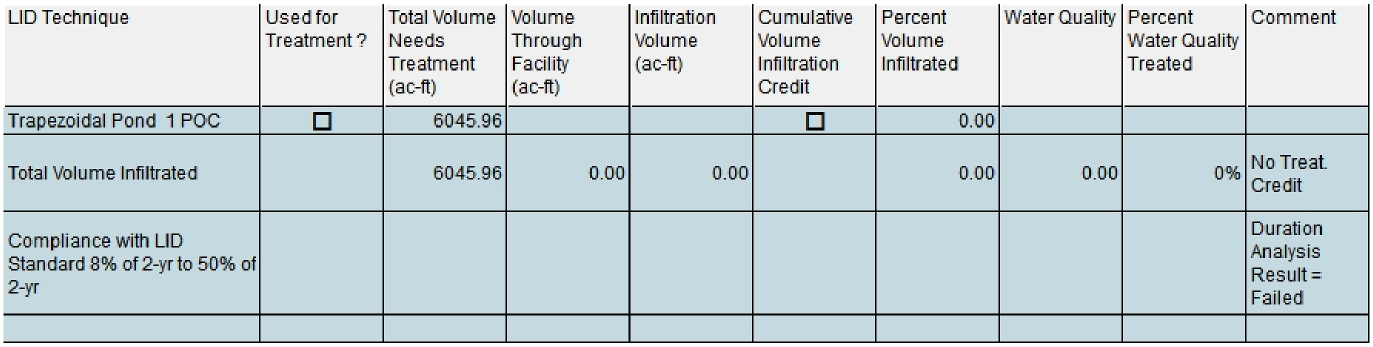
## Water Quality

Water Quality BMP Flow and Volume for POC #1

| | |
|---|---|
| On-line facility volume: | 5.1471 acre-feet |
| On-line facility target flow: | 3.8493 cfs. |
| Adjusted for 15 min: | 3.8493 cfs. |
| Off-line facility target flow: | 2.2506 cfs. |
| Adjusted for 15 min: | 2.2506 cfs. |

Exhibit 5

## LID Report



| LID Technique | Used for Treatment ? | Total Volume Needs Treatment (ac-ft) | Volume Through Facility (ac-ft) | Infiltration Volume (ac-ft) | Cumulative Volume Infiltration Credit | Percent Volume Infiltrated | Water Quality | Percent Water Quality Treated | Comment |
|---|---|---|---|---|---|---|---|---|---|
| Trapezoidal Pond 1 POC | ☐ | 6045.96 | | | ☐ | 0.00 | | | |
| Total Volume Infiltrated | | 6045.96 | 0.00 | 0.00 | | 0.00 | 0.00 | 0% | No Treat. Credit |
| Compliance with LID Standard 8% of 2-yr to 50% of 2-yr | | | | | | | | | Duration Analysis Result = Failed |
| | | | | | | | | | |

Exhibit 5

# *Model Default Modifications*

Total of 0 changes have been made.

## *PERLND Changes*

No PERLND changes have been made.

## *IMPLND Changes*

No IMPLND changes have been made.

Exhibit 5

# Appendix

## Predeveloped Schematic

Exhibit 5

## *Mitigated Schematic*

Exhibit 5

## Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2008 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   PRELIM POND SIZING 20211018.wdm
MESSU      25   PrePRELIM POND SIZING 20211018.MES
           27   PrePRELIM POND SIZING 20211018.L61
           28   PrePRELIM POND SIZING 20211018.L62
           30   POCPRELIM POND SIZING 202110181.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      30
      IMPLND       2
      IMPLND       4
      IMPLND       6
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                    MAX                      1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                           in  out             ***
   30     SG4, Forest, Steep      1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   30         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
```

Exhibit 5

```
   30         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   30         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   30              0         6      0.04       400      0.15         0      0.96
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   30              0         0         3         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   30            0.2       0.4      0.35         2       0.4       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   30              0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                      in  out           ***
    2      ROADS/MOD              1    1    1   27    0
    4      ROOF TOPS/FLAT         1    1    1   27    0
    6      DRIVEWAYS/MOD          1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    2         0    0    1    0    0    0
    4         0    0    1    0    0    0
    6         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    2         0    0    4    0    0    0    1    9
    4         0    0    4    0    0    0    1    9
    6         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    2         0    0    0    0    0
    4         0    0    0    0    0
    6         0    0    0    0    0
  END IWAT-PARM1
```

Exhibit 5

```
  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    2            400      0.05       0.1      0.08
    4            400      0.01       0.1       0.1
    6            400      0.05       0.1      0.08
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    2              0         0
    4              0         0
    6              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    2              0         0
    4              0         0
    6              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  30                       37.27     COPY   501     12
PERLND  30                       37.27     COPY   501     13
Offsite Basin***
PERLND  30                         7.9     COPY   501     12
PERLND  30                         7.9     COPY   501     13
IMPLND   2                        0.82     COPY   501     15
IMPLND   4                        0.98     COPY   501     15
IMPLND   6                        0.98     COPY   501     15
Basin  3***
IMPLND   2                         0.6     COPY   501     15

******Routing******
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                           in  out                           ***
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
```

Exhibit 5

```
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.3            PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.3            IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.8            PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.8            IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    501 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       15
IMPLND     IWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   15


END MASS-LINK

END RUN
```

Exhibit 5

## *Mitigated UCI File*

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2008 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   PRELIM POND SIZING 20211018.wdm
MESSU      25   MitPRELIM POND SIZING 20211018.MES
           27   MitPRELIM POND SIZING 20211018.L61
           28   MitPRELIM POND SIZING 20211018.L62
           30   POCPRELIM POND SIZING 202110181.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      32
      IMPLND       2
      IMPLND       4
      IMPLND       6
      IMPLND       9
      PERLND      30
      RCHRES       1
      COPY         1
      COPY       501
      COPY       601
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Trapezoidal Pond  1         MAX                    1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1        1    1
  501        1    1
  601        1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out           ***
   32     SG4, Field, Mod        1    1    1    1   27    0
   30     SG4, Forest, Steep     1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
```

Exhibit 5

```
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   32         0    0    1    0    0    0    0    0    0    0    0    0
   30         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   32         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   30         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   32         0    0    0    0    0    0    0    0    0    0    0
   30         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   32              0         6      0.03       400       0.1         0      0.96
   30              0         6      0.04       400      0.15         0      0.96
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   32              0         0         3         2         0         0         0
   30              0         0         3         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   32           0.15       0.4       0.3         2       0.4       0.4
   30            0.2       0.4      0.35         2       0.4       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   32              0         0         0         0       2.5         1         0
   30              0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                      in  out           ***
    2      ROADS/MOD              1    1    1   27    0
    4      ROOF TOPS/FLAT         1    1    1   27    0
    6      DRIVEWAYS/MOD          1    1    1   27    0
    9      SIDEWALKS/MOD          1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    2         0    0    1    0    0    0
    4         0    0    1    0    0    0
    6         0    0    1    0    0    0
    9         0    0    1    0    0    0
  END ACTIVITY
```

```
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    2         0    0    4    0    0    0    1    9
    4         0    0    4    0    0    0    1    9
    6         0    0    4    0    0    0    1    9
    9         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    2         0    0    0    0    0
    4         0    0    0    0    0
    6         0    0    0    0    0
    9         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    2            400      0.05       0.1      0.08
    4            400      0.01       0.1       0.1
    6            400      0.05       0.1      0.08
    9            400      0.05       0.1      0.08
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    2              0         0
    4              0         0
    6              0         0
    9              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    2              0         0
    4              0         0
    6              0         0
    9              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  32                       18.63     RCHRES   1      2
PERLND  32                       18.63     RCHRES   1      3
IMPLND   2                        6.34     RCHRES   1      5
IMPLND   4                        9.17     RCHRES   1      5
IMPLND   6                        1.99     RCHRES   1      5
IMPLND   9                        1.49     RCHRES   1      5
Offsite Basin***
PERLND  30                         7.9     RCHRES   1      2
PERLND  30                         7.9     RCHRES   1      3
IMPLND   2                        0.82     RCHRES   1      5
IMPLND   4                        0.98     RCHRES   1      5
IMPLND   6                        0.98     RCHRES   1      5
Basin  3***
IMPLND   2                        0.25     COPY   501     15
IMPLND   2                        0.25     COPY   601     15

******Routing******
PERLND  32                       18.63     COPY     1     12
IMPLND   2                        6.34     COPY     1     15
```

Exhibit 5

```
IMPLND   4                        9.17     COPY     1     15
IMPLND   6                        1.99     COPY     1     15
IMPLND   9                        1.49     COPY     1     15
PERLND  32                       18.63     COPY     1     13
PERLND  30                         7.9     COPY     1     12
IMPLND   2                        0.82     COPY     1     15
IMPLND   4                        0.98     COPY     1     15
IMPLND   6                        0.98     COPY     1     15
PERLND  30                         7.9     COPY     1     13
RCHRES   1                           1     COPY   501     16
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                          in  out                            ***
    1     Trapezoidal Pond-005    1    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *        ***
    1        0  1  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1             1      0.03       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1            0         4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      1
```

Exhibit 5

```
 91    4
   Depth      Area    Volume  Outflow1 Velocity  Travel Time***
    (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
0.000000  0.450606  0.000000  0.000000
0.066667  0.453183  0.030126  0.765148
0.133333  0.455767  0.060425  1.082083
0.200000  0.458358  0.090895  1.325276
0.266667  0.460957  0.121539  1.530297
0.333333  0.463563  0.152357  1.710924
0.400000  0.466177  0.183348  1.874223
0.466667  0.468797  0.214514  2.024392
0.533333  0.471425  0.245855  2.164166
0.600000  0.474061  0.277371  2.295445
0.666667  0.476704  0.309063  2.419612
0.733333  0.479354  0.340931  2.537710
0.800000  0.482011  0.372977  2.650552
0.866667  0.484676  0.405200  2.758782
0.933333  0.487348  0.437601  2.862923
1.000000  0.490028  0.470180  2.963407
1.066667  0.492715  0.502938  3.060594
1.133333  0.495409  0.535876  3.154788
1.200000  0.498111  0.568993  3.246250
1.266667  0.500820  0.602291  3.335205
1.333333  0.503536  0.635769  3.421848
1.400000  0.506260  0.669429  3.506350
1.466667  0.508991  0.703271  3.588864
1.533333  0.511729  0.737295  3.669523
1.600000  0.514475  0.771501  3.748446
1.666667  0.517228  0.805891  3.825742
1.733333  0.519988  0.840465  3.901507
1.800000  0.522756  0.875223  3.975828
1.866667  0.525531  0.910166  4.048785
1.933333  0.528313  0.945294  4.120450
2.000000  0.531103  0.980608  4.190890
2.066667  0.533900  1.016108  4.260166
2.133333  0.536704  1.051795  4.328333
2.200000  0.539516  1.087669  4.395443
2.266667  0.542335  1.123731  4.461544
2.333333  0.545162  1.159981  4.526679
2.400000  0.547995  1.196419  4.590890
2.466667  0.550837  1.233047  4.654216
2.533333  0.553685  1.269864  4.716692
2.600000  0.556541  1.306872  4.778350
2.666667  0.559404  1.344070  4.839223
2.733333  0.562275  1.381459  4.899340
2.800000  0.565153  1.419040  4.958728
2.866667  0.568038  1.456813  5.017414
2.933333  0.570931  1.494779  5.075420
3.000000  0.573830  1.532938  5.132772
3.066667  0.576738  1.571290  5.189489
3.133333  0.579652  1.609836  5.245593
3.200000  0.582574  1.648577  5.301104
3.266667  0.585504  1.687513  5.356039
3.333333  0.588440  1.726645  5.410416
3.400000  0.591384  1.765972  5.464253
3.466667  0.594336  1.805496  5.517564
3.533333  0.597294  1.845217  5.570364
3.600000  0.600260  1.885136  5.670376
3.666667  0.603234  1.925252  5.837823
3.733333  0.606215  1.965567  6.044019
3.800000  0.609203  2.006081  6.280751
3.866667  0.612198  2.046794  6.543521
3.933333  0.615201  2.087708  6.829373
4.000000  0.618211  2.128821  7.136171
4.066667  0.621228  2.170136  7.462278
4.133333  0.624253  2.211652  7.806389
4.200000  0.627285  2.253370  8.167430
4.266667  0.630325  2.295290  8.544499
4.333333  0.633372  2.337414  8.936825
4.400000  0.636426  2.379740  9.343736
```

Exhibit 5

```
  4.466667  0.639488  2.422271  9.764643
  4.533333  0.642556  2.465005  10.19902
  4.600000  0.645633  2.507945  10.64641
  4.666667  0.648716  2.551090  11.10638
  4.733333  0.651807  2.594441  11.57854
  4.800000  0.654906  2.637998  12.06255
  4.866667  0.658011  2.681762  12.55809
  4.933333  0.661124  2.725733  13.06486
  5.000000  0.664244  2.769912  13.58258
  5.066667  0.667372  2.814299  13.90031
  5.133333  0.670507  2.858895  14.44182
  5.200000  0.673649  2.903700  15.11827
  5.266667  0.676799  2.948715  15.88081
  5.333333  0.679956  2.993940  16.68242
  5.400000  0.683121  3.039376  17.47474
  5.466667  0.686292  3.085023  18.21094
  5.533333  0.689471  3.130882  18.85123
  5.600000  0.692658  3.176953  19.37012
  5.666667  0.695852  3.223237  19.76502
  5.733333  0.699053  3.269734  20.06589
  5.800000  0.702261  3.316444  20.43154
  5.866667  0.705477  3.363369  20.73126
  5.933333  0.708700  3.410508  21.02097
  6.000000  0.711931  3.457862  21.30170
  END FTABLE  1
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.3            PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.3            IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.8            PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.8            IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC     ENGL    1.3            RCHRES   1     EXTNL  PREC
WDM      1 EVAP     ENGL    0.8            RCHRES   1     EXTNL  POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   1 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1001 STAG     ENGL      REPL
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
COPY   601 OUTPUT MEAN   1 1     48.4      WDM    901 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        2
PERLND     PWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
PERLND     PWATER IFWO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    3

  MASS-LINK        5
IMPLND     IWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    5

  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
```

```
  END MASS-LINK   13

  MASS-LINK       15
IMPLND     IWATER SURO        0.083333       COPY           INPUT  MEAN
  END MASS-LINK   15

  MASS-LINK       16
RCHRES     ROFLOW                            COPY           INPUT  MEAN
  END MASS-LINK   16


END MASS-LINK

END RUN
```

Exhibit 5

## *Predeveloped HSPF Message File*

Exhibit 5

## *Mitigated HSPF Message File*

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1970/ 1/22 17: 0

RCHRES:     1

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
91 1.4856E+05 1.5062E+05 1.6041E+05
```

---

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1970/ 1/22 17: 0

RCHRES:     1

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
1.4074E+02 6.1742E+04 -3.555E+05    5.6845  5.6845E+00      3
```

---

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1970/ 1/22 17:15

RCHRES:     1

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
91 1.4856E+05 1.5062E+05 1.6096E+05
```

---

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1970/ 1/22 17:15

RCHRES:     1

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
1.4074E+02 6.1742E+04 -3.720E+05    5.9443  5.9443E+00      3
```

---

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1970/ 1/22 17:30

RCHRES:     1
```

Exhibit 5

```
The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
91 1.4856E+05 1.5062E+05 1.5374E+05
```

---

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1970/ 1/22 17:30

RCHRES:     1

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
1.4074E+02 6.1742E+04 -1.553E+05    2.5018  2.5018E+00      3
```

---

Exhibit 5

# Disclaimer

## Legal Notice

Clear Creek Solutions, Inc.
6200 Capitol Blvd.  Ste F
Olympia, WA.  98501
Toll Free 1(866)943-0304
Local (360)943-0304

www.clearcreeksolutions.com

Exhibit 5

## Summary for Subcatchment 1S: 1S

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

Runoff = 14.69 cfs @ 7.95 hrs, Volume= 5.157 af, Depth> 1.28"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr WQ-Event Rainfall=2.09"

| Area (ac) | CN | Description |
|---|---|---|
| 21.770 | 98 | Paved parking, HSG D |
| 26.530 | 84 | 50-75% Grass cover, Fair, HSG D |
| 48.300 | 90 | Weighted Average |
| 26.530 | 84 | 54.93% Pervious Area |
| 21.770 | 98 | 45.07% Impervious Area |

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

## Subcatchment 1S: 1S

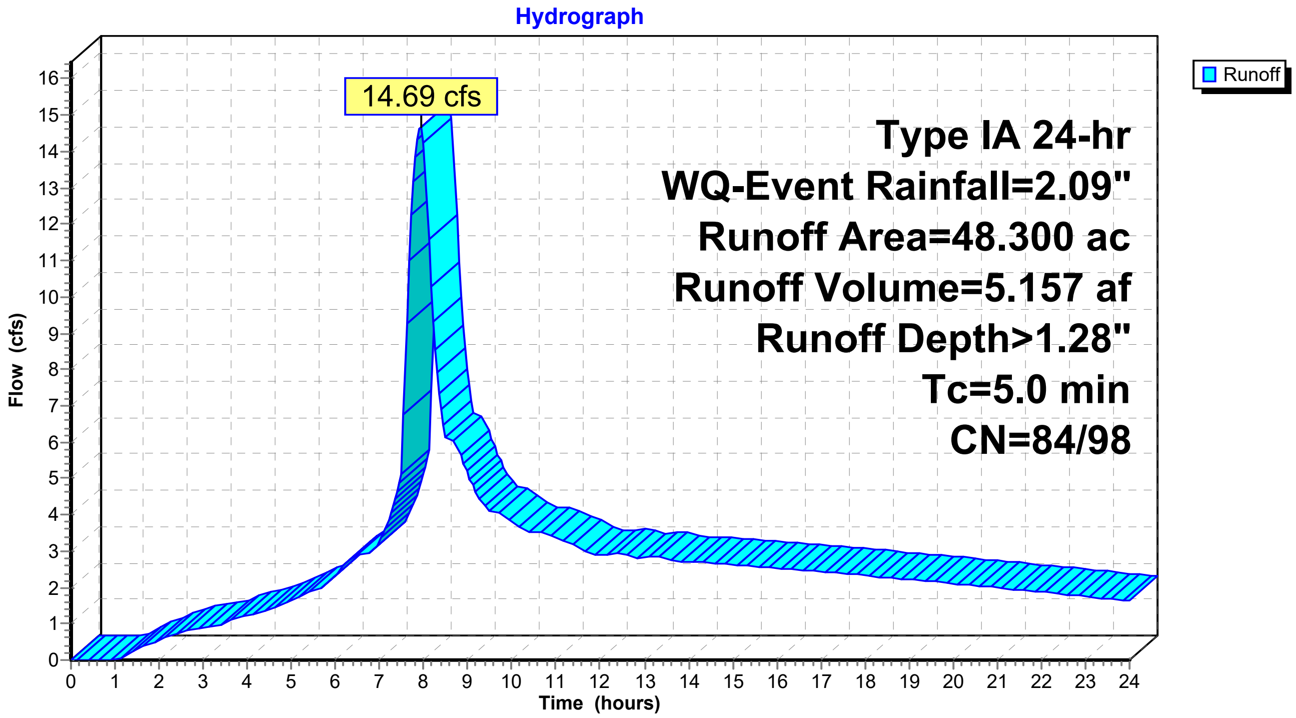


Exhibit 5

# **Appendix G:** Geotechnical Reports

Exhibit 5

**Real-World Geotechnical Solutions**
**Investigation • Design • Construction Support**

# Preliminary Geotechnical Engineering Report

**Project Information:**
Camas Valley Estates
GeoPacific Project No. 21-5741
March 8, 2021

**Site Location:**
22630 NE 28th Street
Camas, Washington 98607
Clark County Property No. 173157000

**Client:**
Lennar Northwest
11807 NE 99th Street, Suite 1179
Vancouver, Washington 98682
Phone: (360) 258-7889

Exhibit 5

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## 1.0 PROJECT INFORMATION

This report presents the results of a geotechnical engineering study conducted by GeoPacific Engineering, Inc. (GeoPacific) for the above-referenced project. The purpose of our investigation was to evaluate subsurface conditions at the site, assess potential geologic hazards at the property, and to provide geotechnical recommendations for site development. This geotechnical study was performed in accordance with GeoPacific Proposal No. P-7651, dated February 19, 2021, and your subsequent authorization of our proposal and *General Conditions for Geotechnical Services*.

## 2.0 SITE AND PROJECT DESCRIPTION

As indicated on Figures 1 through 3 the subject site is located at 22630 NE 28th Street in Camas, Washington, and consists of Clark County Property No. 173157000. The property is approximately 38.23-acres in size. The site is bordered by NE 28th Street to the south, by Green Mountain to the north, and by existing residential properties to the east, and west. The site latitude and longitude are 45.645846, -122.438997, and the legal description is the NE ¼ of Section 21, T2N, R3E, Willamette Meridian. Topography at the site is relatively level to moderately sloping to the south with site elevations ranging from approximately 318 to 484 feet above mean sea level (amsl). Site gradients range from approximately 0 to 25 percent with the steepest areas being located in the northern portion of the property. An existing home with detached barns and sheds is present in the western-central portion of the property, accessed via a gravel drive located along the western margin of the site extending from NE 28th Street. Vegetation at the site ranges from open grassy areas to areas overgrown with blackberries, and some trees around the margins of the site. The site has been regularly mowed and may have been used for agricultural purposes in the past.

As shown on Figure 3, GeoPacific understands that development at the site will consist of a 116-Lot residential subdivision supporting construction of single-family homes, construction of new public streets, stormwater facilities, and installation of new underground utilities. We anticipate that the homes will be constructed with typical spread foundations and wood framing, with maximum structural loading on column footings and continuous strip footings on the order of 10 to 35 kips, and 2 to 4 kips respectively. We anticipate maximum cuts and fills will be on the order of ten feet.

## 3.0 REGIONAL GEOLOGIC SETTING AND LANDSLIDE MAPPING

Regionally, the subject site lies within the Willamette Valley/Puget Sound lowland, a broad structural depression situated between the Coast Range on the west and the Cascade Range on the east. A series of discontinuous faults subdivide the Willamette Valley into a mosaic of fault-bounded, structural blocks (Yeats et al., 1996). Uplifted structural blocks form bedrock highlands, while down-warped structural blocks form sedimentary basins. The *Geologic Map of the Lacamas Creek Quadrangle, Clark County, Washington, (*U.S. Department of the Interior, U.S. Geological Survey, 1998, Russell C. Evarts, 2006*)*, indicates that the northern portion of the site located on Green Mountain is underlain by late Miocene to earth Pliocene-aged massive to crudely stratified, pebbly and cobbly conglomerate with sparse to abundant lenses of friable to lithified, arkosic to basaltic sandstone, typically referred to as the Troutdale Formation (Ttfc). The geologic map indicates that the southern portion of the site is underlain by early Pleistocene-aged unconsolidated to semi-consolidated, thick-bedded, pebble to boulder conglomerate with matrix of volcanic lithic to micaceous, quartzo-feldspathic sand (QTc). Clasts are largely comprised of volcanic rocks eroded from the western Cascade Range and the Columbia River Basalt group.

Exhibit 5

## 4.0 REGIONAL SEISMIC SETTING

At least four major fault zones capable of generating damaging earthquakes are thought to exist in the vicinity of the subject site. These include the Lacamas Creek/Sandy River Fault Zone, the Portland Hills Fault Zone, the Gales Creek-Newberg-Mt. Angel Structural Zone, and the Cascadia Subduction Zone.

### 4.1 Lacamas Creek / Sandy River Fault Zone

The Lacamas Creek Fault intersects the northeast trending Sandy River Fault north of Camas, Washington at Lacamas Lake, approximately 1 mile south of the subject site. The fault trace lies approximately 0.25 miles west of the site. The Lacamas Creek Fault extends northwest to southeast, intersecting the northeast, southwest trending Sandy River Fault. According to the USGS Earthquake Hazards Program the fault has been mapped as a normal fault with down-to-the-southwest displacement and has also been described as a steeply northeast or southwest-dipping, oblique, right-lateral, slip-fault. The trace of the Lacamas Lake fault is marked by the very linear lower reach of Lacamas Creek. No fault scarps on Quaternary surficial deposits have been described. The Lacamas Lake fault offsets Pliocene-aged sedimentary conglomerates generally identified as the Troutdale formation, and Pliocene to Pleistocene aged basalts generally identified as the Boring Lava formation. Recent seismic reflection data across the probable trace of the fault under the Columbia River yielded no unequivocal evidence of displacement underlying the Missoula flood deposits, however, recorded mild seismic activity during the recent past indicates this area may be potentially seismogenic.

### 4.2 Portland Hills Fault Zone

The Portland Hills Fault Zone is a series of NW-trending faults that include the central Portland Hills Fault, the western Oatfield Fault, and the eastern East Bank Fault. These faults occur in a northwest-trending zone that varies in width between 3.5 and 5.0 miles. The combined three faults reportedly vertically displace the Columbia River Basalt by 1,130 feet and appear to control thickness changes in late Pleistocene (approx. 780,000 years) sediment (Madin, 1990). The Portland Hills Fault occurs along the Willamette River at the base of the Portland Hills, and is located approximately 15 miles southwest of the site. The Oatfield Fault occurs along the western side of the Portland Hills, and is located approximately 17 miles southwest of the site. The East Bank Fault occurs along the eastern margin of the Willamette River, and is located approximately 12. miles southwest of the site. The accuracy of the fault mapping is stated to be within 500 meters (Wong, et al., 2000).

According to the USGS Earthquake Hazards Program, the fault was originally mapped as a down-to-the-northeast normal fault, but has also been mapped as part of a regional-scale zone of right-lateral, oblique slip faults, and as a steep escarpment caused by asymmetrical folding above a south-west dipping, blind thrust fault. The Portland Hills fault offsets Miocene Columbia River Basalts, and Miocene to Pliocene sedimentary rocks of the Troutdale Formation. No fault scarps on surficial Quaternary deposits have been described along the fault trace, and the fault is mapped as buried by the Pleistocene aged Missoula flood deposits. No historical seismicity is correlated with the mapped portion of the Portland Hills Fault Zone, but in 1991 a M3.5 earthquake occurred on a NW-trending shear plane located 1.3 miles east of the fault (Yelin, 1992). Although there is no definitive evidence of recent activity, the Portland Hills Fault Zone is assumed to be potentially active (Geomatrix Consultants, 1995).

Exhibit 5

### 4.3 Gales Creek-Newberg-Mt. Angel Structural Zone

The Gales Creek-Newberg-Mt. Angel Structural Zone is a 50-mile-long zone of discontinuous, NW-trending faults that lies about 35 miles southwest of the subject site. These faults are recognized in the subsurface by vertical separation of the Columbia River Basalt and offset seismic reflectors in the overlying basin sediment (Yeats et al., 1996; Werner et al., 1992). A geologic reconnaissance and photogeologic analysis study conducted for the Scoggins Dam site in the Tualatin Basin revealed no evidence of deformed geomorphic surfaces along the structural zone (Unruh et al., 1994). No seismicity has been recorded on the Gales Creek Fault or Newberg Fault (the fault closest to the subject site); however, these faults are considered to be potentially active because they may connect with the seismically active Mount Angel Fault and the rupture plane of the 1993 M5.6 Scotts Mills earthquake (Werner et al. 1992; Geomatrix Consultants, 1995).

According to the USGS Earthquake Hazards Program, the Mount Angel fault is mapped as a high-angle, reverse-oblique fault, which offsets Miocene rocks of the Columbia River Basalts, and Miocene and Pliocene sedimentary rocks. The fault appears to have controlled emplacement of the Frenchman Spring Member of the Wanapum Basalts, and thus must have a history that predates the Miocene age of these rocks. No unequivocal evidence of deformation of Quaternary deposits has been described, but a thick sequence of sediments deposited by the Missoula floods covers much of the southern part of the fault trace.

### 4.4 Cascadia Subduction Zone

The Cascadia Subduction Zone is a 680-mile-long zone of active tectonic convergence where oceanic crust of the Juan de Fuca Plate is subducting beneath the North American continent at a rate of 4 cm per year (Goldfinger et al., 1996). A growing body of geologic evidence suggests that prehistoric subduction zone earthquakes have occurred (Atwater, 1992; Carver, 1992; Peterson et al., 1993; Geomatrix Consultants, 1995). This evidence includes: (1) buried tidal marshes recording episodic, sudden subsidence along the coast of northern California, Oregon, and Washington, (2) burial of subsided tidal marshes by tsunami wave deposits, (3) paleoliquefaction features, and (4) geodetic uplift patterns on the Oregon coast. Radiocarbon dates on buried tidal marshes indicate a recurrence interval for major subduction zone earthquakes of 250 to 650 years with the last event occurring 300 years ago (Atwater, 1992; Carver, 1992; Peterson et al., 1993; Geomatrix Consultants, 1995). The inferred seismogenic portion of the plate interface lies approximately along the Oregon Coast at depths of between 20 and 40 kilometers below the surface.

## 5.0 FIELD EXPLORATION AND SUBSURFACE CONDITIONS

Our subsurface explorations for this report were conducted on March 2, 2021. A total of ten test pits (TP-1 through TP-10) were excavated at the site using a New Holland 11-88, rubber-tracked excavator to a maximum depth of 13 feet bgs. Explorations were conducted under the full-time observation of a GeoPacific geologist. During the explorations pertinent information including soil sample depths, stratigraphy, soil engineering characteristics, and groundwater occurrence was recorded. Soils were classified in accordance with the Unified Soil Classification System (USCS). Soil samples obtained from the explorations were placed in relatively air-tight plastic bags. At the completion of each test, the test pits were loosely backfilled with onsite soils. The approximate locations of the explorations are indicated on Figures 2 and 3.

Exhibit 5

It should be noted that exploration locations were located in the field by pacing or taping distances from apparent property corners and other site features shown on the plans provided. As such, the locations of the explorations should be considered approximate. Summary exploration logs are attached. The stratigraphic contacts shown on the individual test pit logs represent the approximate boundaries between soil types. The actual transitions may be more gradual. The soil and groundwater conditions depicted are only for the specific dates and locations reported, and therefore, are not necessarily representative of other locations and times. Soil and groundwater conditions encountered in the explorations are summarized below.

### 5.1 Soil Descriptions

***Topsoil***: Vegetation at the site typically consists of grassy vegetation and blackberry growth. Sparse trees are present along the property margins. The topsoil horizon typically ranged from approximately 6 to 8 inches in grassy areas, and up to 14 inches where blackberries are present, consisting of dark brown or red brown, organic, Lean CLAY (OL-CL), containing fine roots. The depth of organic soils will increase where trees are present.

***Lean CLAY (CL)***: Below the topsoil within our test pits, soils typically consisted of light brown, brown, or red brown, medium stiff to stiff, very moist to wet, low to moderately plastic, Lean CLAY (CL) containing varying degrees of subrounded gravel to cobble-sized rock. The soil type was found to be present in varying thicknesses and extending to varying depths across the site.

***Clayey SAND (SC)***: At the locations of test pits TP-1 and TP-2, brown, orange, gray, and light gray, medium dense, very moist to wet, low plasticity, Clayey SAND layers were encountered below the Lean CLAY soil type at depths ranging from approximately 4.5 to 7 feet and extending to approximate depths of 9 to 10 feet bgs.

***Clayey GRAVEL (GC)***: At the locations of test pits TP-4, and TP-5, brown to gray, medium dense, very moist to wet, low plasticity, Clayey GRAVEL containing subrounded gravel to cobble-sized rock was encountered below the Lean CLAY soil type at depths ranging from approximately 4 to 7 feet and extending to the maximum depth of exploration.

### 5.2 Shrink-Swell Potential

Low to moderately plasticity fine-grained and coarse-grained soils were encountered near the ground surface within subsurface explorations conducted at the site. Based upon the results of our soils laboratory testing and our local experience with the soil layers in the vicinity of the subject site, the plasticity of the soils is low, and the shrink-swell potential of the soil types is considered to be low. Special design measures are not considered necessary to minimize the risk of uncontrolled damage of foundations as a result of potential soil expansion at this site.

### 5.3 Groundwater and Soil Moisture

On March 2, 2021 observed soil moisture conditions were generally very moist to wet. Shallow perched groundwater seepage was observed within test pits TP-1, TP-2, TP-4, TP-5, TP-7, and TP-10 at depths ranging from approximately 5 to 10 feet below the existing ground surface. Moderately flowing static groundwater seepage was observed at a depth of approximately 7 feet within test pit TP-9. It is anticipated that groundwater conditions will vary depending on the season,

Exhibit 5

local subsurface conditions, changes in site utilization, and other factors. Perched groundwater may be encountered in localized areas. Seeps and springs may exist in areas not explored and may become evident during site grading.

## 6.0 PRELIMINARY STEEP SLOPE ASSESSMENT

We reviewed available topographic data, LiDAR imagery, and geologic mapping, and Clark County Hazard mapping regarding potential geologic hazards associated with steep slope areas at the site. Based on our review we understand that Clark County geologic hazard mapping indicates that the site contains gradients ranging from level to maximum of 25 percent. The steepest portions of the site are located in the northern portion of the property. Gradients decrease rapidly to the south, with the approximate southern half of the property being relatively level or under 5 percent grade.

For the purpose of conducting a preliminary assessment of potential geologic hazards associated with development on or near a steep slope area GeoPacific (1) reviewed of available literature and published geologic mapping; (2) reviewed available LiDAR and landslide inventory mapping; (3) conducted field reconnaissance and slope measurements, and (4) conducted shallow subsurface exploration at the property consisting of excavator test pits. Quantitative slope stability modelling, detailed landslide investigation is beyond the scope of this preliminary study. Based on our review of the available public literature, no landslides have been identified to be present within or adjacent to the property boundaries.

### 6.1 LiDAR Review

Published regional geologic mapping and the Washington State Department of Natural Resources online LiDAR database show no mapped landslides at the subject site. We reviewed available LiDAR imagery of the site which indicates relatively smooth, topography for the majority of the subject site. The imagery does not indicate hummocky terrain or other typical features generally associated with the presence of a landslide. The subject site is located within the yellow square in the LiDAR imagery shown below.

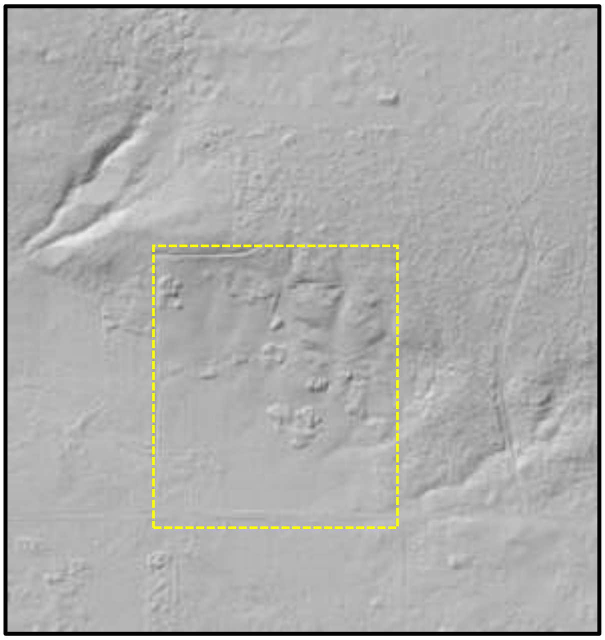

Exhibit 5

### 6.2 Field Reconnaissance Subsurface Exploration

A GeoPacific engineering geologist conducted field reconnaissance during our site investigation to observe geomorphic features and surficial soil conditions, and to assess the development area for evidence of potential slope instability. We did not observe geomorphic evidence of recent slope instability such as exposed terrace scarps, or areas of recent erosion. No tension cracks, slumping, or areas of recent landsliding were observed. Vegetation appeared to be native and undisturbed on the slope. The trees were observed to be large and growing with straight trunks. In general, the site displayed relatively smooth, even topography consistent with stable slope conditions.

We conducted subsurface exploration at the site consisting of ten excavator test pits. See Figures 2 and 3 for the approximate subsurface exploration locations, and the attached test pit logs for detail. Native soils encountered within our subsurface explorations consisted of stiff clayey soil types, or medium dense clayey gravels. Geologic mapping indicates the presence of conglomeritic bedrock at depth. No evidence of slip planes or bedding planes was detected or observed during subsurface exploration. Light groundwater seepage observed within some of our subsurface explorations which extended to a maximum depth of 13 feet bgs. In general, the results of our field reconnaissance and subsurface exploration indicated stable soil conditions within the proposed development area.

## 7.0 PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

Our site investigation indicates that the proposed construction appears to be geotechnically feasible, provided that the recommendations of this report are incorporated into the design and construction phases of the project. The primary geotechnical concerns associated with site development are:

- A grading plan review should be conducted by GeoPacific when site planning is completed, and the findings and conclusions presented in this report should be updated to reflect the proposed final grades.
- Shallow perched groundwater was observed in some of the test pits and may be encountered in subsurface explorations during the wet season. Based on our observations we anticipate the observed groundwater seepage to be reduced during dry summer months, however the contractor should be prepared to utilize typical dewatering methods in trenches.
- Keyways, keying, and benching will be required for engineered fill placed in portions of the site where slopes exceed 15 percent. At this time a grading plan is not available. The earthworks contractor should work closely with GeoPacific during construction to properly locate and construct keyways for engineered fill slopes.

### 7.1 Site Preparation Recommendations

Areas of proposed construction and areas to receive fill should be cleared of any organic and inorganic debris, and loose stockpiled soils. Inorganic debris and organic materials from clearing should be removed from the site. Organic-rich soils and root zones should then be stripped from construction areas of the site or where engineered fill is to be placed. Depth of stripping of existing organic topsoil is estimated to be approximately 8 to 14 inches at the site and will be deepest where trees are present. Following removal of topsoil and undocumented fill soils, the existing ground surface should be aerated, scarified and recompacted in areas proposed for placement of engineered fill and structures.

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The final depth of soil removal should be determined by the geotechnical engineer or designated representative during site inspection while stripping/excavation is being performed. Stripped topsoil should be removed from areas proposed for placement of engineered fill and structures. Any remaining topsoil should be stockpiled only in designated areas and stripping operations should be observed and documented by the geotechnical engineer or his representative.

Where encountered, undocumented fills and any subsurface structures (dry wells, basements, driveway and landscaping fill, old utility lines, septic leach fields, etc.) should be completely removed and the excavations backfilled with engineered fill. Some of the undocumented fill soil may be suitable for re-use as engineered fill.

Site earthwork may be impacted by wet weather conditions. Stabilization of subgrade soils may require aeration and re-compaction. If subgrade soils are found to be difficult to stabilize, over-excavation, placement of granular soils, or cement treatment of subgrade soils may be feasible options. GeoPacific should be onsite to observe preparation of subgrade soil conditions prior to placement of engineered fill.

### 7.2 Keyways, Benching, and Subdrains for Fill Slopes

Keying and benching will be required on this project where engineered fills are proposed on hillsides. Engineered fill placed on existing sloped areas inclining at, or steeper than an approximately fifteen percent grade should be constructed on a keyway and benches in accordance with the typical designs shown in the attached Fill Slope Detail (Figure 4). Keyways should have a minimum depth of three feet on the downhill size, and a minimum width of ten feet. Keyways should be excavated at the toe of the fill slope and extend perpendicular to the downslope direction. Additional removal of weakened or soft soils may be required depending on the conditions observed during construction. Benches and keyways should be roughly horizontal in the down slope direction, by may slope up to a 10 percent grade along a topographic contour. Keyways sloping more than a fifteen percent grade along a topographic contour should be benched or configured as approved by the geotechnical engineer or his designated representative. Actual determination and dimensions of keyways should be decided once final planning is complete, and under the direction of the geotechnical engineer.

If groundwater seepage is observed during excavation, keyways should include a subdrain consisting of a minimum 4-inch-diameter, ADS Heavy Duty Grade (or equivalent), perforated plastic pipe enveloped in a minimum of 4 cubic feet per lineal foot of 2”- ½”, open-graded gravel drain rock wrapped with geotextile filter fabric (Mirafi 140N or equivalent). A minimum 0.5 percent gradient should be maintained throughout all subdrain pipes and outlets. GeoPacific should inspect keyways, subdrains and benching prior to fill placement. Subdrains may be eliminated at the discretion of the geotechnical engineer.

### 7.3 Engineered Fill

We understand that cuts and fills are proposed on the order of 10 feet maximum, however a site grading plan has not yet been prepared for this project. Where incorporated into the project, all grading for the proposed construction should be performed as engineered grading in accordance with the applicable building code at the time of construction with the exceptions and additions noted herein. Site grading should be conducted in accordance with the requirements outlined in the 2018

Exhibit 5

International Building Code (IBC), and Chapter 18 and Appendix J. Areas proposed for fill placement should be prepared as described in Section 6.1, *Site Preparation Recommendations,* and Section 6.2, *Keyways, Benching, and Subdrains for Fill Slopes*. Surface soils should be aerated, scarified and recompacted prior to placement of structural fill. Site preparation, soil stripping, and grading activities should be observed and documented by a geotechnical engineer or his representative. Proper test frequency and earthwork documentation usually requires daily observation and testing during stripping, rough grading, and placement of engineered fill.

Onsite native soils appear to be suitable for use as engineered fill. Soils containing greater than 5 percent organic content should not be used as structural fill. Imported fill material must be approved by the geotechnical engineer prior to being imported to the site. Oversize material greater than 6 inches in size should not be used within 3 feet of foundation footings, and material greater than 12 inches in diameter should not be used in engineered fill.

Engineered fill should be compacted in horizontal lifts not exceeding 12 inches using standard compaction equipment. We recommend that engineered fill be compacted to at least 95 percent of the maximum dry density determined by ASTM D698 (Standard Proctor) or equivalent. Soils should be moisture conditioned to within two percent of optimum moisture. Field density testing should conform to ASTM D2922 and D3017, or D1556. All engineered fill should be observed and tested by the project geotechnical engineer or his representative. Typically, one density test is performed for at least every 2 vertical feet of fill placed or every 500 $yd^3$, whichever requires more testing. Because testing is performed on an on-call basis, we recommend that the earthwork contractor be held contractually responsible for test scheduling and frequency.

Site earthwork may be impacted by shallow groundwater, soil moisture and wet weather conditions. Earthwork in wet weather would likely require extensive use of additional crushed aggregate, cement or lime treatment, or other special measures, at considerable additional cost compared to earthwork performed under dry-weather conditions.

## 7.4 Excavating Conditions and Utility Trench Backfill

We anticipate that onsite soils can generally be excavated using conventional heavy equipment. Bedrock was not encountered within subsurface explorations which extended to a maximum depth of approximately 13 feet bgs. Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the contractor. Actual slope inclinations at the time of construction should be determined based on safety requirements and actual soil and groundwater conditions. All temporary cuts in excess of 4 feet in height should be sloped in accordance with U.S. Occupational Safety and Health Administration (OSHA) regulations (29 CFR Part 1926) or be shored. The existing native soils to a depth of approximately 13 feet bgs classify as Type B Soil and temporary excavation side slope inclinations as steep as 1H:1V may be assumed for planning purposes. These cut slope inclinations are applicable to excavations above the water table only.

Shallow, perched groundwater may be encountered at the site and should be anticipated in excavations and utility trenches. Vibrations created by traffic and construction equipment may cause some caving and raveling of excavation walls. In such an event, lateral support for the excavation walls should be provided by the contractor to prevent loss of ground support and possible distress to existing or previously constructed structural improvements.

Exhibit 5

Underground utility pipes should be installed in accordance with the procedures specified in ASTM D2321 and City of Camas standards. We recommend that structural trench backfill be compacted to at least 95 percent of the maximum dry density obtained by the Modified Proctor (ASTM D1557, AASHTO T-180) or equivalent. Initial backfill lift thicknesses for a ¾”-0 crushed aggregate base may need to be as great as 4 feet to reduce the risk of flattening underlying flexible pipe. Subsequent lift thickness should not exceed 1 foot. If imported granular fill material is used, then the lifts for large vibrating plate-compaction equipment (e.g. hoe compactor attachments) may be up to 2 feet, provided that proper compaction is being achieved and each lift is tested. Use of large vibrating compaction equipment should be carefully monitored near existing structures and improvements due to the potential for vibration-induced damage.

Adequate density testing should be performed during construction to verify that the recommended relative compaction is achieved. Typically, at least one density test is taken for every 4 vertical feet of backfill on each 100-lineal-foot section of trench.

### 7.5 Erosion Control Considerations

During our field exploration program, we did not observe soil and topographic conditions which are considered highly susceptible to erosion. In our opinion, the primary concern regarding erosion potential will occur during construction in areas that have been stripped of vegetation. Erosion at the site during construction can be minimized by implementing the project erosion control plan, which should include judicious use of straw waddles, fiber rolls, and silt fences. If used, these erosion control devices should remain in place throughout site preparation and construction.

Erosion and sedimentation of exposed soils can also be minimized by quickly re-vegetating exposed areas of soil, and by staging construction such that large areas of the project site are not denuded and exposed at the same time. Areas of exposed soil requiring immediate and/or temporary protection against exposure should be covered with either mulch or erosion control netting/blankets. Areas of exposed soil requiring permanent stabilization should be seeded with an approved grass seed mixture, or hydroseeded with an approved seed-mulch-fertilizer mixture.

### 7.6 Wet Weather Earthwork

Soils underlying the site are likely to be moisture sensitive and will be difficult to handle or traverse with construction equipment during periods of wet weather. Earthwork is typically most economical when performed under dry weather conditions. Earthwork performed during the wet-weather season will require expensive measures such as cement treatment or imported granular material to compact areas where fill may be proposed to the recommended engineering specifications. If earthwork is to be performed or fill is to be placed in wet weather or under wet conditions when soil moisture content is difficult to control, the following recommendations should be incorporated into the contract specifications.

- Earthwork should be performed in small areas to minimize exposure to wet weather. Excavation or the removal of unsuitable soils should be followed promptly by the placement and compaction of clean engineered fill. The size and type of construction equipment used may have to be limited to prevent soil disturbance. Under some circumstances, it may be necessary to excavate soils with a backhoe to minimize subgrade disturbance caused by equipment traffic;

Exhibit 5

- The ground surface within the construction area should be graded to promote run-off of surface water and to prevent the ponding of water;
- Material used as engineered fill should consist of clean, granular soil containing less than 5 percent passing the No. 200 sieve. The fines should be non-plastic. Alternatively, cement treatment of on-site soils may be performed to facilitate wet weather placement;
- The ground surface within the construction area should be sealed by a smooth drum vibratory roller, or equivalent, and under no circumstances should be left uncompacted and exposed to moisture. Soils which become too wet for compaction should be removed and replaced with clean granular materials;
- Excavation and placement of fill should be observed by the geotechnical engineer to verify that all unsuitable materials are removed and suitable compaction and site drainage is achieved; and
- Geotextile silt fences, straw waddles, and fiber rolls should be strategically located to control erosion.

If cement or lime treatment is used to facilitate wet weather construction, GeoPacific should be contacted to provide additional recommendations and field monitoring.

## 7.7 Spread Foundations

As shown on Figure 3, GeoPacific understands that development at the site will consist of a 116-Lot residential subdivision supporting construction of single-family homes. We anticipate that the homes will be constructed with typical spread foundations and wood framing, with maximum structural loading on column footings and continuous strip footings on the order of 10 to 35 kips, and 2 to 4 kips respectively. We anticipate maximum cuts and fills will be on the order of ten feet.

The proposed structures may be supported on shallow foundations bearing on stiff, native soils and/or engineered fill, appropriately designed and constructed as recommended in this report. Foundation design, construction, and setback requirements should conform to the applicable building code at the time of construction. For maximization of bearing strength and protection against frost heave, spread footings should be embedded at a minimum depth of 12 inches below exterior grade. If soft soil conditions are encountered at footing subgrade elevation, they should be removed and replaced with compacted crushed aggregate.

The anticipated allowable soil bearing pressure is 1,500 lbs/ft$^2$ for footings bearing on competent, native soil and/or engineered fill. The recommended maximum allowable bearing pressure may be increased by 1/3 for short-term transient conditions such as wind and seismic loading. For loads heavier than 35 kips, the geotechnical engineer should be consulted. If heavier loads than described above are proposed, it may be necessary to over-excavate point load areas and replace with additional compacted crushed aggregate to achieve a higher allowable bearing capacity. The coefficient of friction between on-site soil and poured-in-place concrete may be taken as 0.42, which includes no factor of safety. The maximum anticipated total and differential footing movements (generally from soil expansion and/or settlement) are 1 inch and ¾ inch over a span of 20 feet, respectively. We anticipate that the majority of the estimated settlement will occur during construction, as loads are applied. Excavations near structural footings should not extend within a 1H:1V plane projected downward from the bottom edge of footings.

Exhibit 5

Footing excavations should penetrate through topsoil and any disturbed soil to competent subgrade that is suitable for bearing support. All footing excavations should be trimmed neat, and all loose or softened soil should be removed from the excavation bottom prior to placing reinforcing steel bars. Due to the moisture sensitivity of on-site native soils, foundations constructed during the wet weather season may require over-excavation of footings and backfill with compacted, crushed aggregate.

Our recommendations are for residential construction incorporating raised wood floors and conventional spread footing foundations. After site development, a Final Soil Engineer's Report should either confirm or modify the above recommendations.

### 7.8 Concrete Slabs-on-Grade

Preparation of areas beneath concrete slab-on-grade floors should be performed as described in Section 6.1, *Site Preparation Recommendations* and Section 6.7, *Spread Foundations*. Care should be taken during excavation for foundations and floor slabs, to avoid disturbing subgrade soils. If subgrade soils have been adversely impacted by wet weather or otherwise disturbed, the surficial soils should be scarified to a minimum depth of 8 inches, moisture conditioned to within about 3 percent of optimum moisture content and compacted to engineered fill specifications. Alternatively, disturbed soils may be removed and the removal zone backfilled with additional crushed rock.

For evaluation of the concrete slab-on-grade floors using the beam on elastic foundation method, a modulus of subgrade reaction of 150 kcf (87 pci) should be assumed for the stiff, fine -grained soils anticipated to be present at foundation subgrade elevation following adequate site preparation as described above. This value assumes the concrete slab system is designed and constructed as recommended herein, with a minimum thickness of 8 inches of 1½"-0 crushed aggregate beneath the slab. The total thickness of crushed aggregate will be dependent on the subgrade conditions at the time of construction and should be verified visually by proof-rolling. Under-slab aggregate should be compacted to at least 95 percent of its maximum dry density as determined by ASTM D1557 (Modified Proctor) or equivalent.

In areas where moisture will be detrimental to floor coverings or equipment inside the proposed structure, appropriate vapor barrier and damp-proofing measures should be implemented. A commonly applied vapor barrier system consists of a 10-mil polyethylene vapor barrier placed directly over the capillary break material. Other damp/vapor barrier systems may also be feasible. Appropriate design professionals should be consulted regarding vapor barrier and damp proofing systems, ventilation, building material selection and mold prevention issues, which are outside GeoPacific's area of expertise.

### 7.9 Footing and Roof Drains

Construction should include typical measures for controlling subsurface water beneath the structure, including positive crawlspace drainage to an adequate low-point drain exiting the foundation, visqueen covering the expose ground in the crawlspace, and crawlspace ventilation (foundation vents). The client should be informed and educated that some slow flowing water in the crawlspaces is considered normal and not necessarily detrimental to the home given these other design elements incorporated into its construction. Appropriate design professionals should be consulting regarding

Exhibit 5

crawlspace ventilation, building material selection and mold prevention issues, which are outside GeoPacific's area of expertise.

Down spouts and roof drains should collect roof water in a system separate from the footing drains to reduce the potential for clogging. Roof drain water should be directed to an appropriate discharge point and storm system well away from structural foundations. Grades should be sloped downward and away from buildings to reduce the potential for ponded water near structures. If the proposed structure will have a raised floor, and no concrete slab-on-grade floors are used, perimeter footing drains may be eliminated at the discretion of the geotechnical engineer based on soil conditions encountered at the site and experience with standard local construction practices. Where it is desired to reduce the potential for moist crawl spaces, footing drains may be installed.

If concrete slab-on-grade floors are used in living spaces, perimeter footing drains should be installed as recommended below. Concrete slab-on-grade garage floors are not considered living spaces and would not require perimeter footing drains unless the geotechnical engineer or builder deems it necessary.

Where necessary, perimeter footing drains should consist of 3 or 4-inch diameter, perforated plastic pipe embedded in a minimum of 1 $ft^3$ per lineal foot of clean, free-draining drain rock. The drain pipe and surrounding drain rock should be wrapped in non-woven geotextile (Mirafi 140N, or approved equivalent) to minimize the potential for clogging and/or ground loss due to piping. A minimum 0.5 percent fall should be maintained throughout the drain and non-perforated pipe outlet. Figure 5 presents a typical perimeter footing drain detail. In our opinion, footing drains may outlet at the curb, or on the back sides of lots where sufficient fall is not available to allow drainage to meet the street.

### 7.10 Permanent Below-Grade Walls

Lateral earth pressures against below-grade retaining walls will depend upon the inclination of any adjacent slopes, type of backfill, degree of wall restraint, method of backfill placement, degree of backfill compaction, drainage provisions, and magnitude and location of any adjacent surcharge loads. At-rest soil pressure is exerted on a retaining wall when it is restrained against rotation. In contrast, active soil pressure will be exerted on a wall if its top is allowed to rotate or yield a distance of roughly 0.001 times its height or greater.

If the subject retaining walls will be free to rotate at the top, they should be designed for an active earth pressure equivalent to that generated by a fluid weighing 35 pcf for level backfill against the wall. For restrained wall, an at-rest equivalent fluid pressure of 52 pcf should be used in design, again assuming level backfill against the wall. These values assume that the recommended drainage provisions are incorporated, and hydrostatic pressures are not allowed to develop against the wall.

During a seismic event, lateral earth pressures acting on below-grade structural walls will increase by an incremental amount that corresponds to the earthquake loading. Based on the Mononobe-Okabe equation and peak horizontal accelerations appropriate for the site location, seismic loading should be modeled using the active or at-rest earth pressures recommended above, plus an incremental rectangular-shaped seismic load of magnitude 6.5H, where H is the total height of the wall.

Exhibit 5

We assume relatively level ground surface below the base of the walls. As such, we recommend a passive earth pressure of 320 pcf for use in design, assuming wall footings are cast against competent native soils or engineered fill. If the ground surface slopes down and away from the base of any of the walls, a lower passive earth pressure should be used and GeoPacific should be contacted for additional recommendations.

A coefficient of friction of 0.42 may be assumed along the interface between the base of the wall footing and subgrade soils. The recommended coefficient of friction and passive earth pressure values do not include a safety factor, and an appropriate safety factor should be included in design. The upper 12 inches of soil should be neglected in passive pressure computations unless it is protected by pavement or slabs on grade.

The above recommendations for lateral earth pressures assume that the backfill behind the subsurface walls will consist of properly compacted structural fill, and no adjacent surcharge loading. If the walls will be subjected to the influence of surcharge loading within a horizontal distance equal to or less than the height of the wall, the walls should be designed for the additional horizontal pressure. For uniform surcharge pressures, a uniformly distributed lateral pressure of 0.3 times the surcharge pressure should be added. Traffic surcharges may be estimated using an additional vertical load of 250 psf (2 feet of additional fill), in accordance with local practice.

The recommended equivalent fluid densities assume a free-draining condition behind the walls so that hydrostatic pressures do not build-up. This can be accomplished by placing a 12 to 18-inch wide zone of sand and gravel containing less than 5 percent passing the No. 200 sieve against the walls. A 3-inch minimum diameter perforated, plastic drain-pipe should be installed at the base of the walls and connected to a suitable discharge point to remove water in this zone of sand and gravel. The drain-pipe should be wrapped in filter fabric (Mirafi 140N or other as approved by the geotechnical engineer) to minimize clogging.

Wall drains are recommended to prevent detrimental effects of surface water runoff on foundations – not to dewater groundwater. Drains should not be expected to eliminate all potential sources of water entering a basement or beneath a slab-on-grade. An adequate grade to a low point outlet drain in the crawlspace is required by code. Underslab drains are sometimes added beneath the slab when placed over soils of low permeability and shallow, perched groundwater.

Water collected from the wall drains should be directed into the local storm drain system or other suitable outlet. A minimum 0.5 percent fall should be maintained throughout the drain and non-perforated pipe outlet. Down spouts and roof drains should not be connected to the wall drains in order to reduce the potential for clogging. The drains should include clean-outs to allow periodic maintenance and inspection. Grades around the proposed structure should be sloped such that surface water drains away from the building.

GeoPacific should be contacted during construction to verify subgrade strength in wall keyway excavations, to verify that backslope soils are in accordance with our assumptions, and to take density tests on the wall backfill materials.

Exhibit 5

Structures should be located a horizontal distance of at least 1.5H away from the back of the retaining wall, where H is the total height of the wall. GeoPacific should be contacted for additional foundation recommendations where structures are located closer than 1.5H to the top of any wall.

## 8.0 SEISMIC DESIGN

Available geologic data indicates that the site is in an area where *very strong* ground shaking is anticipated during an earthquake. Structures should be designed to resist earthquake loading in accordance with the methodology described in the 2015 International Building Code (IBC) with applicable State of Washington Building Code revisions (current 2015). We recommend Site Class C be used for design as defined in ASCE 7-16, Chapter 20, and Table 20.3-1. Design values determined for the site using the ATC Hazards by Location 2021 Seismic Design Maps Summary Report are summarized in Table 1 and are based upon observed existing soil conditions.

**Table 1: Recommended Earthquake Ground Motion Parameters (ASCE-7-16)**

| Parameter | Value |
|---|---|
| Location (Lat, Long), degrees | 45.645, -122.439 |
| Probabilistic Ground Motion Values,<br>2% Probability of Exceedance in 50 yrs | |
| Peak Ground Acceleration $PGA_M$ | 0.423 g |
| Short Period, $S_s$ | 0.787 g |
| 1.0 Sec Period, $S_1$ | 0.348 g |
| Soil Factors for Site Class C: | |
| $F_a$ | 1.2 |
| $F_v$ | 1.5 |
| $SD_s = 2/3 \times F_a \times S_s$ | 0.63 g |
| $SD_1 = 2/3 \times F_v \times S_1$ | 0.348 g |
| Seismic Design Category | D |

### 8.1 Soil Liquefaction

Soil liquefaction is a phenomenon wherein saturated soil deposits temporarily lose strength and behave as a liquid in response to ground shaking caused by strong earthquakes. Soil liquefaction is generally limited to loose, sands and granular soils located below the water table, and fine-grained soils with a plasticity index less than 15. According to *Clark County Maps Online*, the site is mapped as *very low* susceptibility for liquefaction. Based upon the results of our study, it is our opinion that the risk of soil liquefaction during a seismic event at the subject site should be considered to be low.

Exhibit 5

## 9.0 UNCERTAINTIES AND LIMITATIONS

We have prepared this report for the owner and their consultants for use in design of this project only. This report should be provided in its entirety to prospective contractors for bidding and estimating purposes; however, the conclusions and interpretations presented in this report should not be construed as a warranty of the subsurface conditions. Experience has shown that soil and groundwater conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations that may not be detected by a geotechnical study. If, during future site operations, subsurface conditions are encountered which vary appreciably from those described herein, GeoPacific should be notified for review of the recommendations of this report, and revision of such if necessary.

Sufficient geotechnical monitoring, testing and consultation should be provided during construction to confirm that the conditions encountered are consistent with those indicated by explorations. The checklist attached to this report outlines recommended geotechnical observations and testing for the project. Recommendations for design changes will be provided should conditions revealed during construction differ from those anticipated, and to verify that the geotechnical aspects of construction comply with the contract plans and specifications.

Within the limitations of scope, schedule and budget, GeoPacific attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology at the time the report was prepared. No warranty, expressed or implied, is made. The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous or toxic substances in the soil, surface water, or groundwater at this site.

We appreciate this opportunity to be of service.

Sincerely,

**GEOPACIFIC ENGINEERING, INC.**

2978
3/5/2021
BENJAMIN L COOK

JAMES D. IMBRIE
27177
Exp. 3-31-22

Benjamin L. Cook, L.G.
Associate Geologist

James D. Imbrie, P.E.
Principal Geotechnical Engineer

Exhibit 5

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## CHECKLIST OF RECOMMENDED GEOTECHNICAL TESTING AND OBSERVATION

| Item No. | Procedure | Timing | By Whom | Done |
|---|---|---|---|---|
| 1 | Preconstruction meeting | Prior to beginning site work | Contractor, Developer, Civil and Geotechnical Engineers | |
| 2 | Fill removal from site or sorting and stockpiling | Prior to mass stripping | Soil Technician/ Geotechnical Engineer | |
| 3 | Stripping, aeration, and root-picking operations | During stripping | Soil Technician | |
| 4 | Compaction testing of engineered fill (95% of Standard Proctor) | During filling, tested every 2 vertical feet | Soil Technician | |
| 5 | Foundation Subgrade Compaction (95% of Modified Proctor) | During Foundation Preparation, Prior to Placement of Reinforcing Steel | Soil Technician/ Geotechnical Engineer | |
| 6 | Compaction testing of trench backfill (95% of Modified Proctor) | During backfilling, tested every 4 vertical feet for every 200 linear feet | Soil Technician | |
| 7 | Street Subgrade Inspection (95% of Standard Proctor) | Prior to placing base course | Soil Technician | |
| 8 | Base course compaction (95% of Modified Proctor) | Prior to paving, tested every 200 linear feet | Soil Technician | |
| 9 | Asphalt Compaction (92% Rice Value) | During paving, tested every 100 linear feet | Soil Technician | |
| 10 | Final Geotechnical Engineer's Report | Completion of project | Geotechnical Engineer | |

Exhibit 5

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# FIGURES

Exhibit 5

**GeoPacific**
**Engineering, Inc.**

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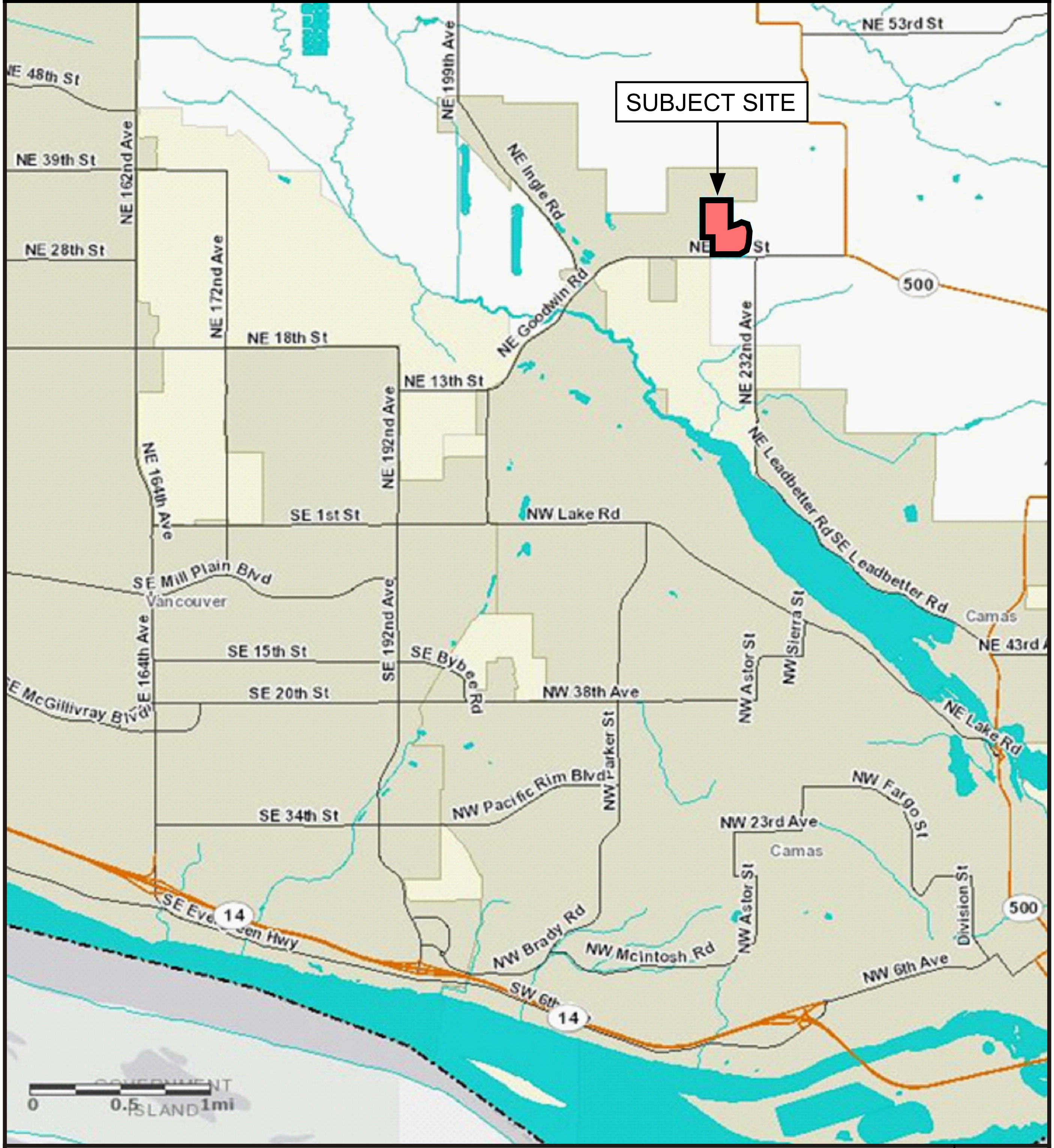
Portland, Oregon 97224
Tel: (503) 598-8445 Fax: (503) 941-9281

# SITE VICINITY MAP



Base Map: Clark Count Maps Online, 2021
Date: 3/4/2021
Drawn by: BLC

North

Project: Camas Valley Estates
22630 NE 28th Street
Camas, Washington 98607

Project No. 21-5741

FIGURE 1

Exhibit 5

**GeoPacific Engineering, Inc.**

14835 SW 72nd Avenue
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# SITE AERIAL AND EXPLORATION LOCATIONS

Legend: Base Map Obtained From Google Earth 2021

TP-1
▦ Test Pit Exploration Designation and Approximate Location

APPROXIMATE SCALE
(FEET)
150 0 150 300

Drawn by: BLC
Date: 3/4/2021

↑ North

Project: Camas Valley Estates
22630 NE 28th Street
Camas, Washington 98607

Project No. 21-5741

FIGURE 2

Exhibit 5

GeoPacific Engineering, Inc.

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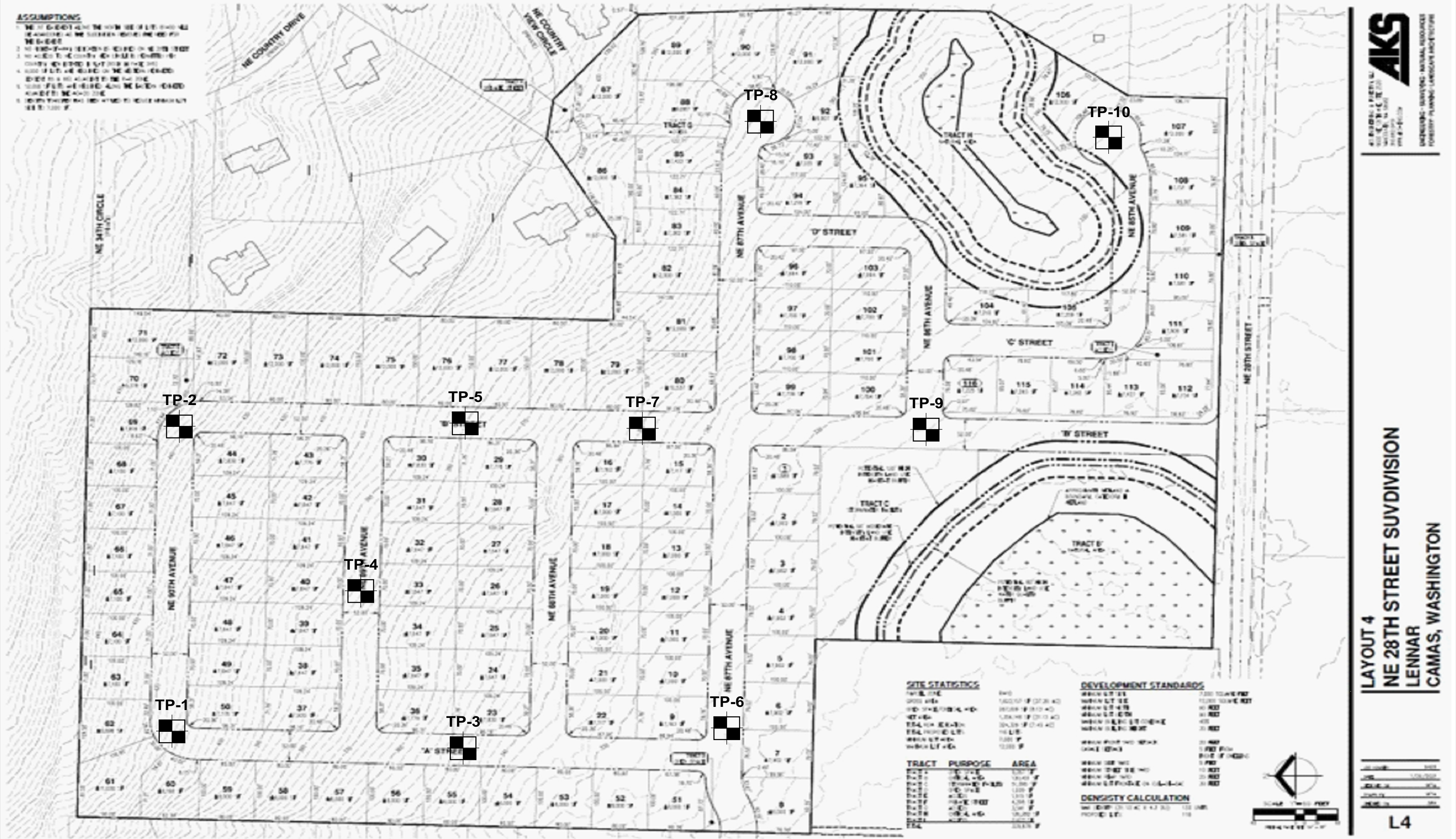
# SITE PLAN AND EXPLORATION LOCATIONS



Legend:

**TP-1**

▨ Test Pit Exploration Designation and Approximate Location

Base Map: Layout 4, NE 28th Street Subdivision, AKS Engineering, Sheet L4

**APPROXIMATE SCALE (AS NOTED)**

Drawn by: BLC

Date: 3/4/2021

← **North**

| | | |
|---|---|---|
| Project: Camas Valley Estates<br>22630 NE 28th Street<br>Camas, Washington 98607 | Project No. 21-5741 | FIGURE 3 |

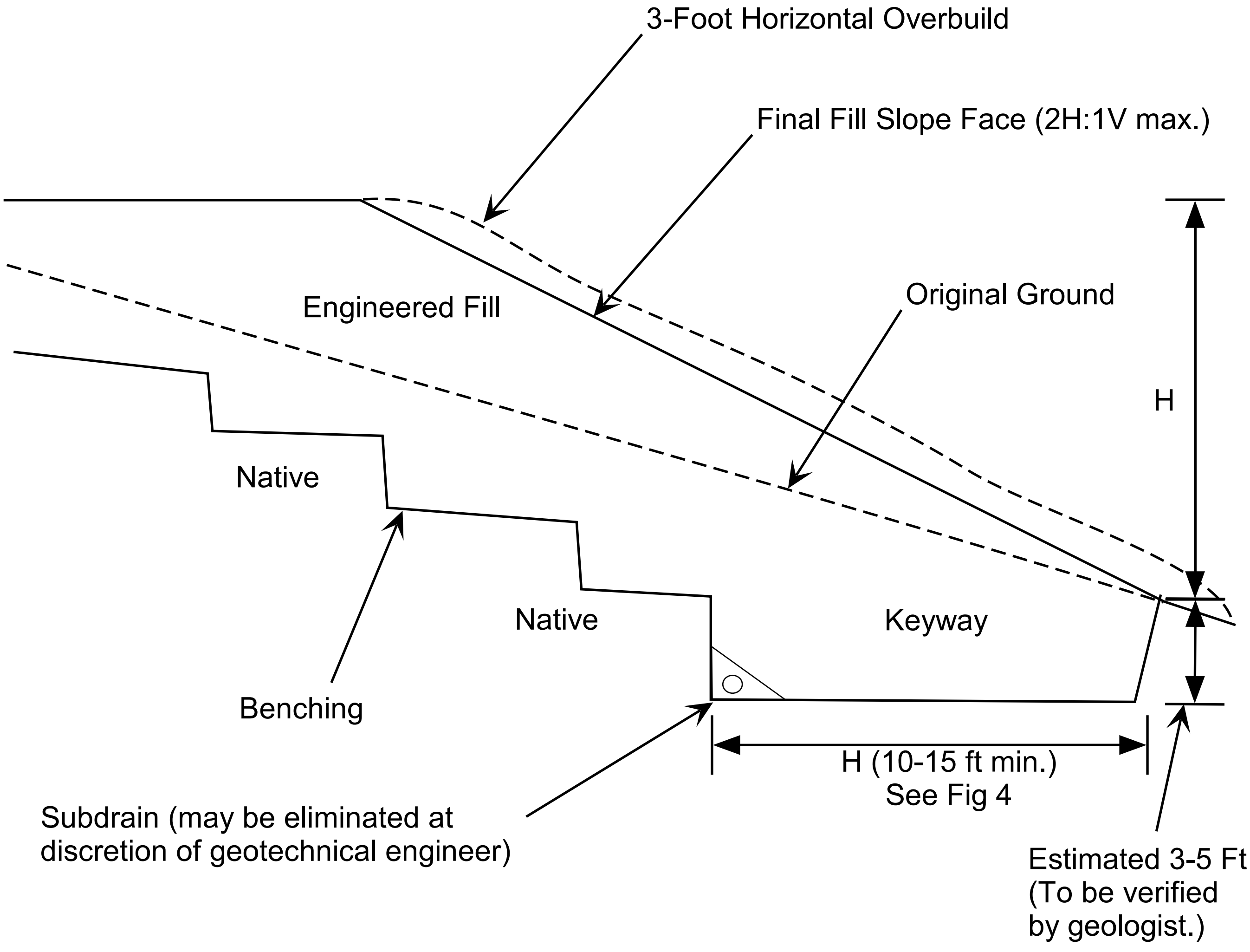
Exhibit 5

GeoPacific Engineering, Inc.

14835 SW 72nd Avenue
Portland, Oregon 97224
Tel: (503) 598-8445 Fax: (503) 941-9281

# FILL SLOPE DETAIL

## TYPICAL KEYWAY, BENCHING & FILL SLOPE DETAIL



Recommended subdrain is minimum 3-inch-diameter ADS Heavy Duty grade (or equivalent), perforated plastic pipe enveloped in a minimum of 3 cubic feet per lineal foot of 2" to 1/2" open-graded gravel drain rock wrapped with geotextile filter fabric (Mirafi 140N or equivalent).

| | | |
|---|---|---|
| Project: Camas Valley Estates<br>22630 NE 28th Street<br>Camas, Washington 98607 | Project No. 21-5741 | FIGURE 4 |

Exhibit 5

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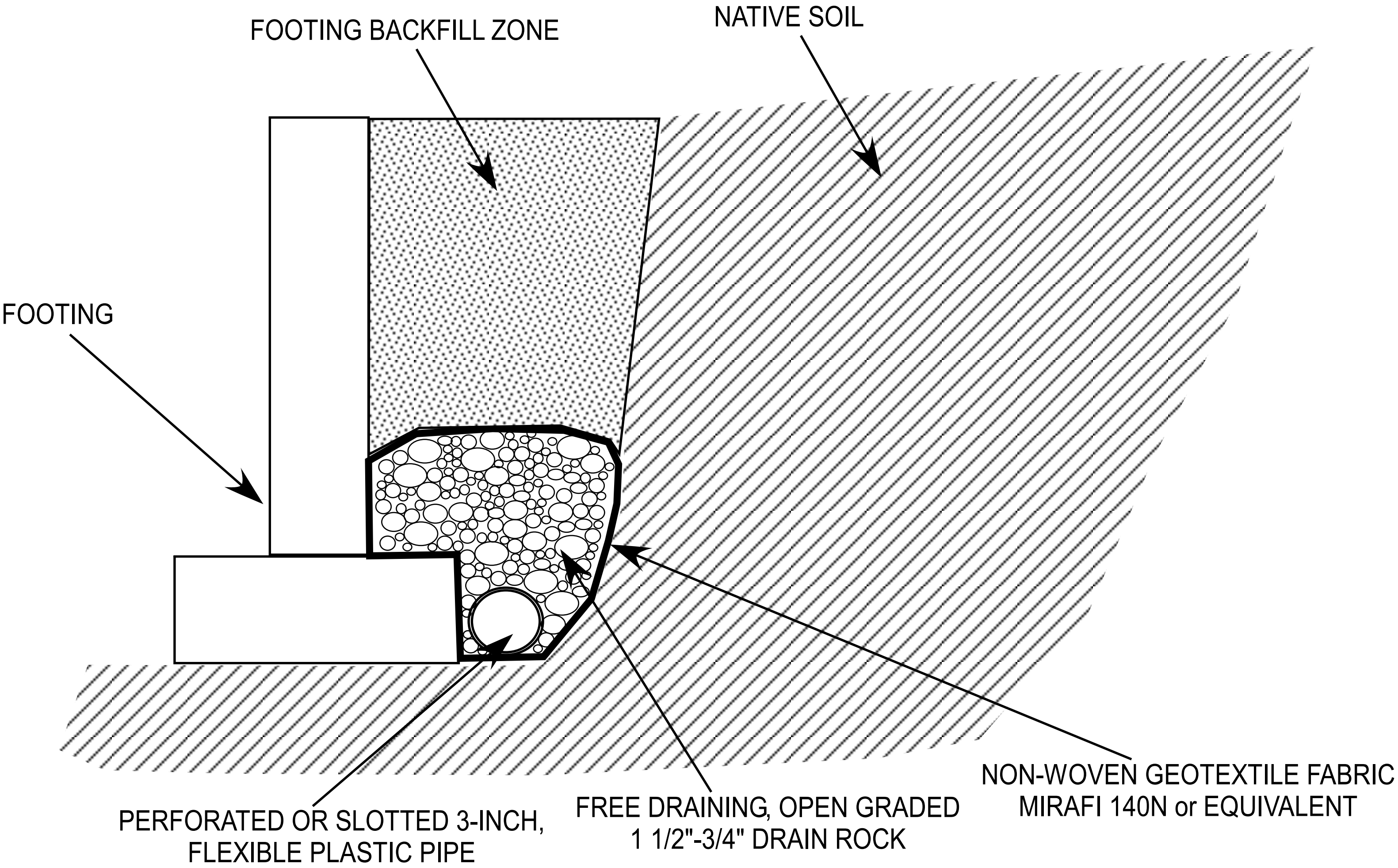
# TYPICAL PERIMETER FOOTING DRAIN DETAIL



Notes:
1) Drain rock should contain no more than 5 percent fines passing the U.S. No. 200 Sieve.
2) Trench bottom and drain pipe should be sloped to drain to approved discharge location.

Date:3/4/2021
**Drawn by: BLC**

Project: Camas Valley Estates
22630 NE 28th Street
Camas, Washington 98607

Project No. 21-5741

FIGURE 5

Exhibit 5

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Real-World Geotechnical Solutions
Investigation • Design • Construction Support

# EXPLORATION LOGS

Exhibit 5

**GeoPacific Engineering, Inc.**

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# TEST PIT LOG

Project: Camas Valley Estates
Camas, Washington

Project No. 21-5741

Test Pit No. **TP-1**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Torvane Shear (tons/ft²) | Sample Type | % Passing No. 200 Sieve | Moisture Content (%) | Water Bearing Zone | **Material Description** |
|---|---|---|---|---|---|---|---|
| 1 | 1.5 | | | | | | TOPSOIL. Blackberry growth. Dark brown, organic, Lean CLAY, with roots extending to approximately 14 inches bgs. |
| 2 | 2.5 | | | | | | Lean CLAY (CL), brown, medium stiff, very moist, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 3 | 3.0 | | 100 to 1,000 g | | | | |
| 4 | 3.0 | | | | | | |
| 5 | | | | | | | Clayey SAND (SC), brown/orange/gray, with light gray seams, medium dense, very moist, containing fine to medium-sized sand, and displaying minor lamination, low to moderate plasticity. |
| 6 | | | 100 to 1,000 g | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |
| 9 | | | 100 to 1,000 g | | | | Lean CLAY (CL), brown, stiff, wet, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 10 | | | | | | 10 ▼<br>▨ | |
| 11 | | | | | | | Test pit terminated at 10.5 feet bgs.<br>Light groundwater seepage observed at 10 feet bgs.<br>Excavator: New Holland 11-88 Tracked Excavator |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | | | | | | | |

LEGEND

| 100 to 1,000 g | 5 Gal. Bucket | ▯ | 💧 | ▨ | ▽ |
|---|---|---|---|---|---|
| Bag Sample | Bucket Sample | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment |

Date Excavated: 3/2/2021
Logged By: B. Cook
Surface Elevation: 410 Feet

Exhibit 5

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# TEST PIT LOG

Project: Camas Valley Estates
Camas, Washington

Project No. 21-5741

Test Pit No. **TP-2**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Torvane Shear (tons/ft²) | Sample Type | % Passing No. 200 Sieve | Moisture Content (%) | Water Bearing Zone | **Material Description** |
|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL. Blackberry growth. Dark brown, organic, Lean CLAY, with roots extending to approximately 14 inches bgs. |
| 1 | 1.5 | | | | | | |
| 2 | 2.5 | | | | | | Lean CLAY (CL), brown, medium stiff, very moist to wet, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 3 | 2.5 | | 100 to 1,000 g | | | | |
| 4 | 2.5 | | | | | | |
| 5 | | | | | | 5 ▼<br>▨ | Light perched groundwater seeps observed piping on sides of test pit |
| 6 | | | 100 to 1,000 g | | | ▨ | |
| 7 | | | | | | ▨ | Clayey SAND (SC), brown/orange/gray, with light gray seams, medium dense, very moist to wet, containing fine to medium-sized sand, and displaying minor lamination, low to moderate plasticity. |
| 8 | | | | | | ▨ | |
| 9 | | | 100 to 1,000 g | | | ▨ | |
| 10 | | | | | | ▨ | Lean CLAY (CL), brown, stiff, very moist to wet, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 11 | | | | | | ▨ | |
| 12 | | | | | | ▨ | |
| 13 | | | | | | | Test pit terminated at 13 feet bgs.<br>Light groundwater seepage observed at 5 feet bgs.<br>Excavator: New Holland 11-88 Tracked Excavator |
| 14 | | | | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | | | | | | | |

LEGEND

- 100 to 1,000 g — Bag Sample
- 5 Gal. Bucket — Bucket Sample
- Shelby Tube Sample
- Seepage
- ▨ Water Bearing Zone
- Water Level at Abandonment

Date Excavated: 3/2/2021
Logged By: B. Cook
Surface Elevation: 444 Feet

Exhibit 5

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# TEST PIT LOG

Project: Camas Valley Estates
Camas, Washington

Project No. 21-5741

Test Pit No. **TP-3**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Torvane Shear (tons/ft²) | Sample Type | % Passing No. 200 Sieve | Moisture Content (%) | Water Bearing Zone | **Material Description** |
|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL. Grassy area growth. Red brown, organic, Lean CLAY, with roots extending to approximately 8 inches bgs. |
| 1 | 1.5 | | | | | | Lean CLAY (CL), reddish brown, medium stiff, very moist, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 2 | 1.5 | | | | | | |
| 3 | 2.0 | | 100 to 1,000 g | | | | Lean CLAY (CL), light brown, medium stiff to stiff, very moist, low to moderate plasticity. |
| 4 | 2.5 | | | | | | |
| 5 | | | | | | | |
| 6 | | | 100 to 1,000 g | | | | |
| 7 | | | | | | | Sandy Lean CLAY (CL), gray brown, stiff, very moist, low to moderate plasticity. |
| 8 | | | | | | | |
| 9 | | | 100 to 1,000 g | | | | |
| 10 | | | | | | | Lean CLAY (CL), brown, stiff, very moist, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 11 | | | | | | | Test pit terminated at 11 feet bgs.<br>No groundwater seepage observed.<br>Excavator: New Holland 11-88 Tracked Excavator |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | | | | | | | |

LEGEND

- 100 to 1,000 g — Bag Sample
- 5 Gal. Bucket — Bucket Sample
- Shelby Tube Sample
- Seepage
- ▨ Water Bearing Zone
- Water Level at Abandonment

Date Excavated: 3/2/2021
Logged By: B. Cook
Surface Elevation: 351 Feet

Exhibit 5

**GeoPacific Engineering, Inc.**

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**Portland, Oregon 97224**
**Tel: (503) 598-8445 Fax: (503) 941-9281**

# TEST PIT LOG

Project: Camas Valley Estates
Camas, Washington

Project No. 21-5741

Test Pit No. **TP-4**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Torvane Shear (tons/ft²) | Sample Type | % Passing No. 200 Sieve | Moisture Content (%) | Water Bearing Zone | **Material Description** |
|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL. Grassy area growth. Red brown, organic, Lean CLAY, with roots extending to approximately 8 inches bgs. |
| 1 | 1.5 | | | | | | Lean CLAY (CL), red brown, medium stiff, very moist to wet, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 2 | 2.5 | | | | | | |
| 3 | 2.5 | | | | | | Lean CLAY (CL), light brown to gray, medium stiff to stiff, very moist to wet, low to moderate plasticity. |
| 4 | 2.5 | | | | | 5 ▼ | |
| 5 | | | | | | ▨ | Light perched groundwater seeps observed piping on sides of test pit |
| 6 | | | | | | ▨ | |
| 7 | | | | | | ▨ | Clayey GRAVEL (GC), brown/gray, medium dense, very moist to wet, containing subrounded gravel to cobble-sized rock, low plasticity. |
| 8 | | | | | | ▨ | |
| 9 | | | | | | ▨ | |
| 10 | | | | | | ▨ | |
| 11 | | | | | | ▨ | |
| 12 | | | | | | | Test pit terminated at 12 feet bgs.<br>Light groundwater seepage observed at 5 feet bgs.<br>Excavator: New Holland 11-88 Tracked Excavator |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | | | | | | | |

LEGEND

| | | | | | |
|---|---|---|---|---|---|
| 100 to 1,000 g | 5 Gal. Bucket | ▯ | 💧 | ▨ | ▼ |
| Bag Sample | Bucket Sample | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment |

Date Excavated: 3/2/2021
Logged By: B. Cook
Surface Elevation: 382 Feet

Exhibit 5

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# TEST PIT LOG

Project: Camas Valley Estates
Camas, Washington

Project No. 21-5741

Test Pit No. **TP-5**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Torvane Shear (tons/ft²) | Sample Type | % Passing No. 200 Sieve | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | TOPSOIL. Grassy area growth. Red brown, organic, Lean CLAY, with roots extending to approximately 8 inches bgs. |
| 1 | 1.5 |  |  |  |  |  | Lean CLAY (CL), red brown, medium stiff, very moist to wet, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 2 | 2.5 |  |  |  |  |  |  |
| 3 | 2.5 |  |  |  |  |  |  |
| 4 | 2.5 |  |  |  |  |  | Clayey GRAVEL (GC), brown/gray, medium dense, very moist to wet, containing subrounded gravel to cobble-sized rock, low plasticity.<br>Light perched groundwater seeps observed piping on sides of test pit |
| 5 |  |  |  |  |  | 5 ▼ ▨ |  |
| 6 |  |  |  |  |  | ▨ |  |
| 7 |  |  |  |  |  | ▨ |  |
| 8 |  |  |  |  |  | ▨ |  |
| 9 |  |  |  |  |  | ▨ |  |
| 10 |  |  |  |  |  |  | Test pit terminated at 10 feet bgs.<br>Light groundwater seepage observed at 5 feet bgs.<br>Excavator: New Holland 11-88 Tracked Excavator |
| 11 |  |  |  |  |  |  |  |
| 12 |  |  |  |  |  |  |  |
| 13 |  |  |  |  |  |  |  |
| 14 |  |  |  |  |  |  |  |
| 15 |  |  |  |  |  |  |  |
| 16 |  |  |  |  |  |  |  |
| 17 |  |  |  |  |  |  |  |

LEGEND

- 100 to 1,000 g — Bag Sample
- 5 Gal. Bucket — Bucket Sample
- Shelby Tube Sample
- Seepage
- ▨ Water Bearing Zone
- Water Level at Abandonment

Date Excavated: 3/2/2021
Logged By: B. Cook
Surface Elevation: 386 Feet

Exhibit 5

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# TEST PIT LOG

Project: Camas Valley Estates
Camas, Washington

Project No. 21-5741

Test Pit No. **TP-6**

| Depth (ft) | Pocket Penetrometer (tons/ft$^2$) | Torvane Shear (tons/ft$^2$) | Sample Type | % Passing No. 200 Sieve | Moisture Content (%) | Water Bearing Zone | **Material Description** |
|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL. Grassy area growth. Red brown, organic, Lean CLAY, with roots extending to approximately 8 inches bgs. |
| 1 | 1.5 | | | | | | Lean CLAY (CL), red brown, medium stiff to stiff, very moist, low to moderate plasticity. |
| 2 | 3.5 | | | | | | |
| 3 | 3.5 | | | | | | |
| 4 | 3.5 | | | | | | |
| 5 | | | | | | | Lean CLAY (CL), brown, medium stiff to stiff, very moist, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 6 | | | | | | | |
| 7 | | | | | | | Lean CLAY (CL), light brown to gray, stiff, very moist to wet, low to moderate plasticity. |
| 8 | | | | | | | |
| 9 | | | 100 to 1,000 g | | | | |
| 10 | | | | | | | |
| 11 | | | | | | | Test pit terminated at 11 feet bgs.<br>No groundwater seepage observed.<br>Excavator: New Holland 11-88 Tracked Excavator |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | | | | | | | |

LEGEND

| 100 to 1,000 g | 5 Gal. Bucket | ▯ | 💧 | ▨ | ▽ |
|---|---|---|---|---|---|
| Bag Sample | Bucket Sample | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment |

Date Excavated: 3/2/2021
Logged By: B. Cook
Surface Elevation: 322 Feet

Exhibit 5

**GeoPacific**
**Engineering, Inc.**

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# TEST PIT LOG

Project: Camas Valley Estates
Camas, Washington

Project No. 21-5741

Test Pit No. **TP-7**

| Depth (ft) | Pocket Penetrometer (tons/ft$^2$) | Torvane Shear (tons/ft$^2$) | Sample Type | % Passing No. 200 Sieve | Moisture Content (%) | Water Bearing Zone | **Material Description** |
|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | TOPSOIL. Grassy area growth. Red brown, organic, Lean CLAY, with roots extending to approximately 8 inches bgs. |
| 1 | 1.5 |  |  |  |  |  | Lean CLAY (CL), red brown, medium stiff to stiff, very moist, low to moderate plasticity. |
| 2 | 2.5 |  |  |  |  |  |  |
| 3 | 3.0 |  |  |  |  |  |  |
| 4 | 3.5 |  |  |  |  |  |  |
|  |  |  |  |  |  | 5 ▼ | Lean CLAY (CL), brown, medium stiff to stiff, very moist, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 5 |  |  |  |  |  | ▨ |  |
| 6 |  |  |  |  |  | ▨ |  |
| 7 |  |  |  |  |  | ▨ |  |
| 8 |  |  |  |  |  | ▨ |  |
| 9 |  |  |  |  |  | ▨ |  |
| 10 |  |  |  |  |  |  | Test pit terminated at 10 feet bgs.<br>Light groundwater seepage observed at 5 feet bgs.<br>Excavator: New Holland 11-88 Tracked Excavator |
| 11 |  |  |  |  |  |  |  |
| 12 |  |  |  |  |  |  |  |
| 13 |  |  |  |  |  |  |  |
| 14 |  |  |  |  |  |  |  |
| 15 |  |  |  |  |  |  |  |
| 16 |  |  |  |  |  |  |  |
| 17 |  |  |  |  |  |  |  |

LEGEND

- 100 to 1,000 g — Bag Sample
- 5 Gal. Bucket — Bucket Sample
- Shelby Tube Sample
- Seepage
- ▨ Water Bearing Zone
- Water Level at Abandonment

Date Excavated: 3/2/2021
Logged By: B. Cook
Surface Elevation: 350 Feet

Exhibit 5

GeoPacific Engineering, Inc.

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# TEST PIT LOG

| Project: Camas Valley Estates<br>Camas, Washington | Project No. 21-5741 | Test Pit No. **TP-8** |
|---|---|---|

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Torvane Shear (tons/ft²) | Sample Type | % Passing No. 200 Sieve | Moisture Content (%) | Water Bearing Zone | **Material Description** |
|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL. Grassy area growth. Red brown, organic, Lean CLAY, with roots extending to approximately 8 inches bgs. |
| 1 | 1.5 | | | | | | Lean CLAY (CL), red brown, medium stiff, very moist, low to moderate plasticity. |
| 2 | 1.5 | | | | | | |
| 3 | 2.0 | | | | | | |
| 4 | 3.0 | | | | | | Lean CLAY (CL), gray, stiff, very moist, low to moderate plasticity. |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | Lean CLAY (CL), tan, stiff, very moist, low to moderate plasticity. |
| 8 | | | | | | | |
| 9 | | | | | | | |
| 10 | | | | | | | Test pit terminated at 10 feet bgs.<br>No groundwater seepage observed.<br>Excavator: New Holland 11-88 Tracked Excavator |
| 11 | | | | | | | |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | | | | | | | |

LEGEND

| | | | | | |
|---|---|---|---|---|---|
| 100 to 1,000 g | 5 Gal. Bucket | ▯ | 💧 | ▨ | ▽ |
| Bag Sample | Bucket Sample | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment |

Date Excavated: 3/2/2021
Logged By: B. Cook
Surface Elevation: 369 Feet

Exhibit 5

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# TEST PIT LOG

Project: Camas Valley Estates
Camas, Washington

Project No. 21-5741

Test Pit No. **TP-9**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Torvane Shear (tons/ft²) | Sample Type | % Passing No. 200 Sieve | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL. Grassy area growth. Red brown, organic, Lean CLAY, with roots extending to approximately 8 inches bgs. |
| | | | | | | | Lean CLAY (CL), red brown, medium stiff to stiff, very moist, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 1 | 2.0 | | | | | | |
| 2 | 2.0 | | | | | | |
| 3 | 2.5 | | | | | | |
| 4 | 3.0 | | | | | | |
| | | | | | | | Lean CLAY (CL), light brown, medium stiff to stiff, very moist, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | 7<br>▼<br>▨ | Moderate groundwater seepage observed, filling bottom of test pit. |
| 8 | | | | | | ▨ | |
| 9 | | | | | | ▨ | |
| 10 | | | | | | | Test pit terminated at 10 feet bgs.<br>Moderate groundwater seepage observed at 7 feet bgs.<br>Excavator: New Holland 11-88 Tracked Excavator |
| 11 | | | | | | | |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | | | | | | | |

LEGEND

- 100 to 1,000 g — Bag Sample
- 5 Gal. Bucket — Bucket Sample
- Shelby Tube Sample
- Seepage
- ▨ Water Bearing Zone
- ▽ Water Level at Abandonment

Date Excavated: 3/2/2021
Logged By: B. Cook
Surface Elevation: 326 Feet

Exhibit 5

**GeoPacific Engineering, Inc.**

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**Portland, Oregon 97224**
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# TEST PIT LOG

Project: Camas Valley Estates
Camas, Washington

Project No. 21-5741

Test Pit No. **TP-10**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Torvane Shear (tons/ft²) | Sample Type | % Passing No. 200 Sieve | Moisture Content (%) | Water Bearing Zone | **Material Description** |
|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL. Grassy area growth. Red brown, organic, Lean CLAY, with roots extending to approximately 8 inches bgs. |
| 1 | 2.0 | | | | | | Lean CLAY (CL), brown, medium stiff, very moist, low to moderate plasticity. |
| 2 | 2.5 | | | | | | |
| 3 | 2.5 | | 100 to 1,000 g | | | | |
| 4 | 2.5 | | | | | | Lean CLAY (CL), light brown, medium stiff to stiff, very moist, low to moderate plasticity. |
| 5 | | | | | | 5 ▼<br>▨ | Light perched groundwater seeps observed piping on sides of test pit |
| 6 | | | 100 to 1,000 g | | | ▨ | Lean CLAY (CL), light brown, medium stiff to stiff, very moist to wet, containing minor amounts of subrounded gravel to cobble-sized rock, low to moderate plasticity. |
| 7 | | | | | | ▨ | |
| 8 | | | | | | ▨ | |
| 9 | | | 100 to 1,000 g | | | ▨ | |
| 10 | | | | | | ▨ | |
| 11 | | | | | | | Test pit terminated at 10.5 feet bgs.<br>Light groundwater seepage observed at 5 feet bgs.<br>Excavator: New Holland 11-88 Tracked Excavator |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | | | | | | | |

LEGEND

| | | | | | |
|---|---|---|---|---|---|
| 100 to 1,000 g | 5 Gal. Bucket | ▯ | 💧 | ▨ | ▽ |
| Bag Sample | Bucket Sample | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment |

Date Excavated: 3/2/2021
Logged By: B. Cook
Surface Elevation: 334 Feet

Exhibit 5

# UNIFIED SOIL CLASSIFICATION SYSTEM

## UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOILS
(more than 50% of material is larger than No. 200 sieve size.)

| | | | |
|---|---|---|---|
| **GRAVELS**<br>More than 50% of coarse fraction larger than No. 4 sieve size | Clean Gravels (Less than 5% fines) | | |
| | ▨ | GW | Well-graded gravels, gravel-sand mixtures, little or no fines |
| | ▨ | GP | Poorly-graded gravels, gravel-sand mixtures, little or no fines |
| | Gravels with fines (More than 12% fines) | | |
| | ▨ | GM | Silty gravels, gravel-sand-silt mixtures |
| | ▨ | GC | Clayey gravels, gravel-sand-clay mixtures |
| **SANDS**<br>50% or more of coarse fraction smaller than No. 4 sieve size | Clean Sands (Less than 5% fines) | | |
| | ▨ | SW | Well-graded sands, gravelly sands, little or no fines |
| | ▨ | SP | Poorly graded sands, gravelly sands, little or no fines |
| | Sands with fines (More than 12% fines) | | |
| | ▨ | SM | Silty sands, sand-silt mixtures |
| | ▨ | SC | Clayey sands, sand-clay mixtures |

FINE-GRAINED SOILS
(50% or more of material is smaller than No. 200 sieve size.)

| | | | |
|---|---|---|---|
| **SILTS AND CLAYS**<br>Liquid limit less than 50% | ▨ | ML | Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity |
| | ▨ | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays |
| | ▨ | OL | Organic silts and organic silty clays of low plasticity |
| **SILTS AND CLAYS**<br>Liquid limit 50% or greater | ▨ | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts |
| | ▨ | CH | Inorganic clays of high plasticity, fat clays |
| | ▨ | OH | Organic clays of medium to high plasticity, organic silts |
| **HIGHLY ORGANIC SOILS** | ▨ | PT | Peat and other highly organic soils |

## LABORATORY CLASSIFICATION CRITERIA

| | | |
|---|---|---|
| GW | $C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3 | |
| GP | Not meeting all gradation requirements for GW | |
| GM | Atterberg limits below "A" line or P.I. less than 4 | Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols |
| GC | Atterberg limits above "A" line with P.I. greater than 7 | |
| SW | $C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3 | |
| SP | Not meeting all gradation requirements for GW | |
| SM | Atterberg limits below "A" line or P.I. less than 4 | Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols. |
| SC | Atterberg limits above "A" line with P.I. greater than 7 | |

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent .................................... GW, GP, SW, SP
More than 12 percent .................................. GM, GC, SM, SC
5 to 12 percent ................... Borderline cases requiring dual symbols

## PLASTICITY CHART

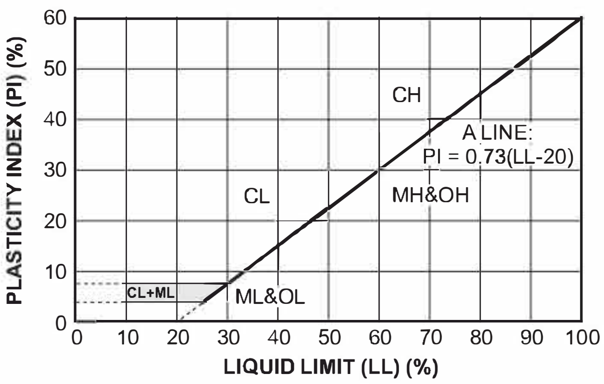


Exhibit 5

# SOIL DESCRIPTION AND CLASSIFICATION GUIDELINES

## Particle-Size Classification

| COMPONENT | ASTM/USCS | | AASHTO | |
|---|---|---|---|---|
| | size range | sieve size range | size range | sieve size range |
| Cobbles | > 75 mm | greater than 3 inches | > 75 mm | greater than 3 inches |
| Gravel | 75 mm – 4.75 mm | 3 inches to No. 4 sieve | 75 mm – 2.00 mm | 3 inches to No. 10 sieve |
| Coarse | 75 mm – 19.0 mm | 3 inches to 3/4-inch sieve | - | - |
| Fine | 19.0 mm – 4.75 mm | 3/4-inch to No. 4 sieve | - | - |
| Sand | 4.75 mm – 0.075 mm | No. 4 to No. 200 sieve | 2.00 mm – 0.075 mm | No. 10 to No. 200 sieve |
| Coarse | 4.75 mm – 2.00 mm | No. 4 to No. 10 sieve | 2.00 mm – 0.425 mm | No. 10 to No. 40 sieve |
| Medium | 2.00 mm – 0.425 mm | No. 10 to No. 40 sieve | - | - |
| Fine | 0.425 mm – 0.075 mm | No. 40 to No. 200 sieve | 0.425 mm – 0.075 mm | No. 40 to No. 200 sieve |
| Fines (Silt and Clay) | < 0.075 mm | Passing No. 200 sieve | < 0.075 mm | Passing No. 200 sieve |

## Consistency for Cohesive Soil

| CONSISTENCY | SPT N-VALUE (BLOWS PER FOOT) | POCKET PENETROMETER (UNCONFINED COMPRESSIVE STRENGTH, tsf) |
|---|---|---|
| Very Soft | 2 | less than 0.25 |
| Soft | 2 to 4 | 0.25 to 0.50 |
| Medium Stiff | 4 to 8 | 0.50 to 1.0 |
| Stiff | 8 to 15 | 1.0 to 2.0 |
| Very Stiff | 15 to 30 | 2.0 to 4.0 |
| Hard | 30 to 60 | greater than 4.0 |
| Very Hard | greater than 60 | - |

## Relative Density for Granular Soil

| RELATIVE DENSITY | SPT N-VALUE (BLOWS PER FOOT) |
|---|---|
| Very Loose | 0 to 4 |
| Loose | 4 to 10 |
| Medium Dense | 10 to 30 |
| Dense | 30 to 50 |
| Very Dense | more than 50 |

## Moisture Designations

| TERM | FIELD IDENTIFICATION |
|---|---|
| Dry | No moisture. Dusty or dry. |
| Damp | Some moisture. Cohesive soils are usually below plastic limit and are moldable. |
| Moist | Grains appear darkened, but no visible water is present. Cohesive soils will clump. Sand will bulk. Soils are often at or near plastic limit. |
| Wet | Visible water on larger grains. Sand and silt exhibit dilatancy. Cohesive soil can be readily remolded. Soil leaves wetness on the hand when squeezed. Soil is much wetter than optimum moisture content and is above plastic limit. |

Exhibit 5

# AASHTO SOIL CLASSIFICATION SYSTEM

**TABLE 1. Classification of Soils and Soil-Aggregate Mixtures**

| General Classification | Granular Materials (35 Percent or Less Passing .075 mm) | | | Silt-Clay Materials (More than 35 Percent Passing 0.075) | | | |
|---|---|---|---|---|---|---|---|
| Group Classification | A-1 | A-3 | A-2 | A-4 | A-5 | A-6 | A-7 |
| Sieve analysis, percent passing: | | | | | | | |
| 2.00 mm (No. 10) | - | - | - | | | | |
| 0.425 mm (No. 40) | 50 max | 51 min | - | - | - | - | - |
| 0.075 mm (No. 200) | 25 max | 10 max | 35 max | 36 min | 36 min | 36 min | 36 min |
| Characteristics of fraction passing 0.425 mm (No. 40) | | | | | | | |
| Liquid limit | | | | 40 max | 41 min | 40 max | 41 min |
| Plasticity index | 6 max | N.P. | | 10 max | 10 max | 11 min | 11 min |
| General rating as subgrade | Excellent to good | | | Fair to poor | | | |

Note: The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

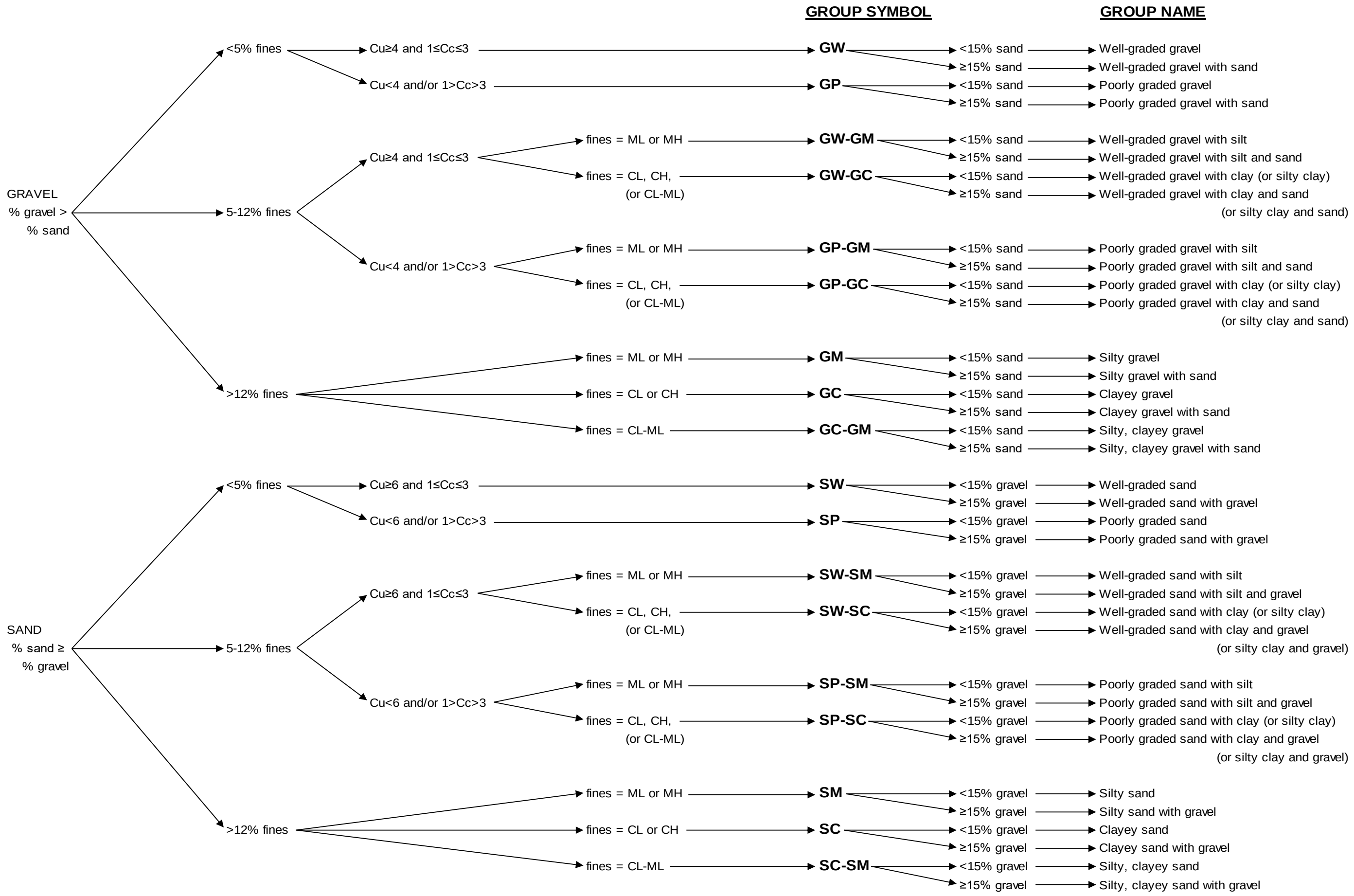
**TABLE 2. Classification of Soils and Soil-Aggregate Mixtures**

| General Classification | Granular Materials (35 Percent or Less Passing 0.075 mm) | | | | | | | Silt-Clay Materials (More than 35 Percent Passing 0.075 mm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | A-1 | | | A-2 | | | | | | | A-7 |
| Group Classification | A-1-a | A-1-b | A-3 | A-2-4 | A-2-5 | A-2-6 | A-2-7 | A-4 | A-5 | A-6 | A-7-5,<br>A-7-6 |
| Sieve analysis, percent passing: | | | | | | | | | | | |
| 2.00 mm (No. 10) | 50 max | - | - | - | - | - | - | - | - | - | - |
| 0.425 mm (No. 40) | 30 max | 50 max | 51 min | - | - | - | - | - | - | - | - |
| 0.075 mm (No. 200) | 15 max | 25 max | 10 max | 35 max | 35 max | 35 max | 35 max | 36 min | 36 min | 36 min | 36 min |
| Characteristics of fraction passing 0.425 mm (No. 40) | | | | | | | | | | | |
| Liquid limit | | | | 40 max | 41 min | 40 max | 41 min | 40 max | 41 min | 40 max | 41 min |
| Plasticity index | 6 max | | N.P. | 10 max | 10 max | 11 min | 11 min | 10 max | 10 max | 11 min | 11min |
| Usual types of significant constituent materials | Stone fragments, gravel and sand | | Fine sand | Silty or clayey gravel and sand | | | | Silty soils | | Clayey soils | |
| General ratings as subgrade | Excellent to Good | | | | | | | Fair to poor | | | |

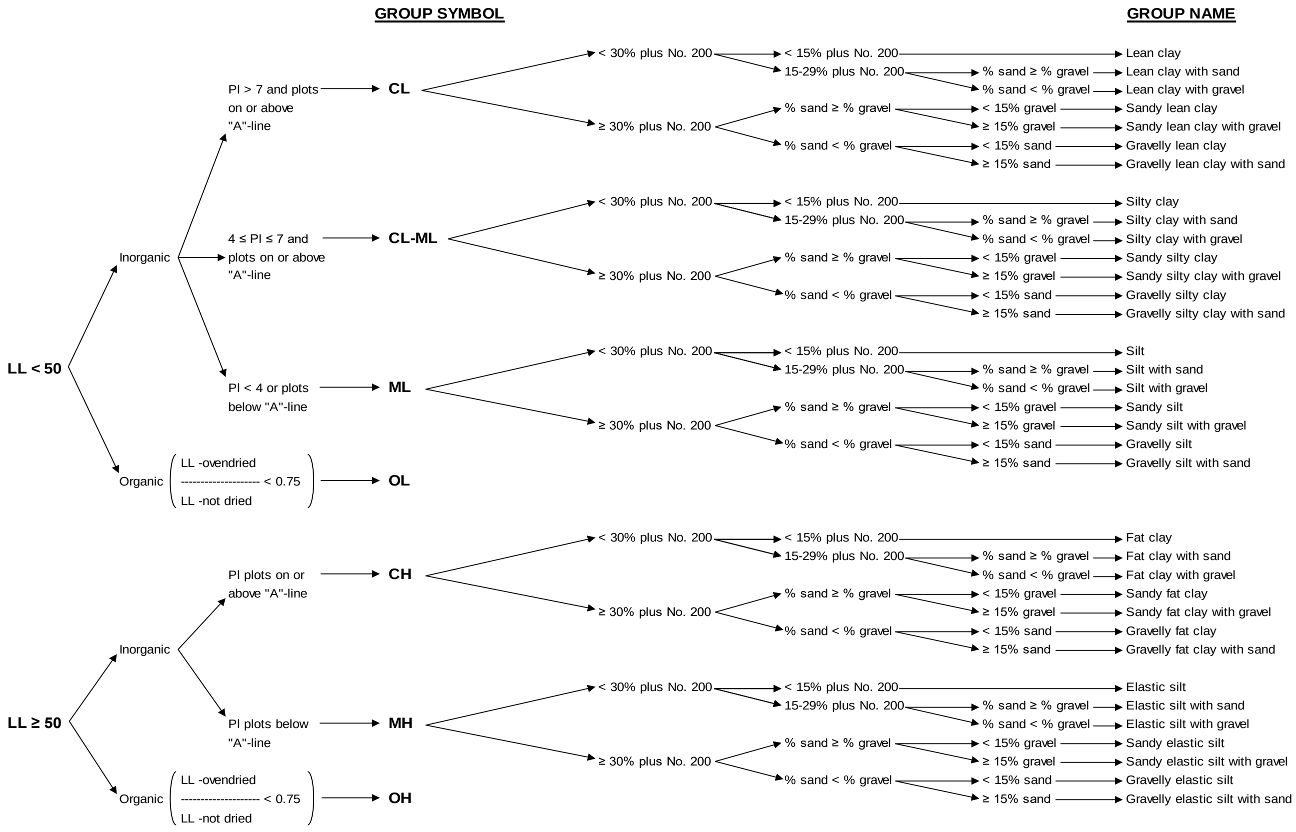
Note: Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30 (see Figure 2).

AASHTO = American Association of State Highway and Transportation Officials

Exhibit 5



Flow Chart for Classifying Coarse-Grained Soils (More Than 50% Retained on No. 200 Sieve)



Flow Chart for Classifying Fine-Grained Soil (50% or More Passes No. 200 Sieve)

Exhibit 5

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# SITE RESEARCH

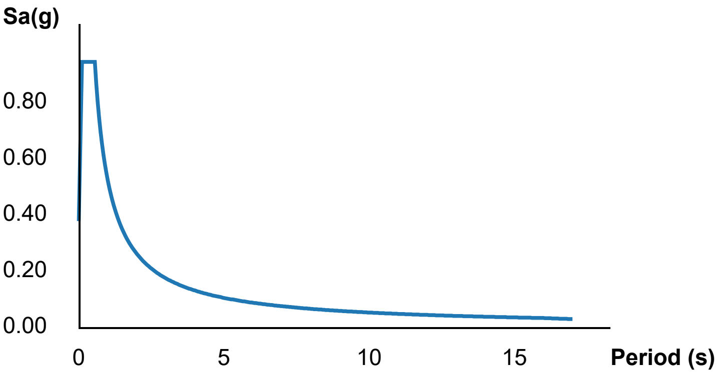
Exhibit 5

# ATC Hazards by Location

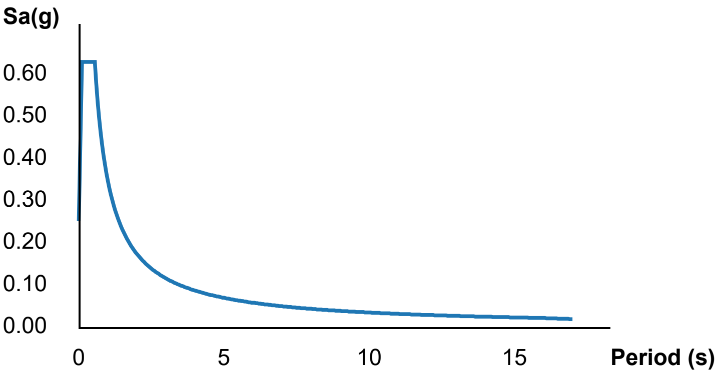
## Search Information

| | |
|---|---|
| **Coordinates:** | 45.645516, -122.439154 |
| **Elevation:** | 337 ft |
| **Timestamp:** | 2021-03-05T19:11:00.505Z |
| **Hazard Type:** | Seismic |
| **Reference Document:** | ASCE7-16 |
| **Risk Category:** | II |
| **Site Class:** | C |

## MCER Horizontal Response Spectrum



## Design Horizontal Response Spectrum



## Basic Parameters

| Name | Value | Description |
|---|---|---|
| $S_S$ | 0.787 | $MCE_R$ ground motion (period=0.2s) |
| $S_1$ | 0.348 | $MCE_R$ ground motion (period=1.0s) |
| $S_{MS}$ | 0.945 | Site-modified spectral acceleration value |
| $S_{M1}$ | 0.522 | Site-modified spectral acceleration value |
| $S_{DS}$ | 0.63 | Numeric seismic design value at 0.2s SA |
| $S_{D1}$ | 0.348 | Numeric seismic design value at 1.0s SA |

## ▾Additional Information

| Name | Value | Description |
|---|---|---|
| SDC | D | Seismic design category |
| $F_a$ | 1.2 | Site amplification factor at 0.2s |
| $F_v$ | 1.5 | Site amplification factor at 1.0s |
| $CR_S$ | 0.89 | Coefficient of risk (0.2s) |

Exhibit 5

| | | |
|---|---|---|
| $CR_1$ | 0.868 | Coefficient of risk (1.0s) |
| PGA | 0.352 | $MCE_G$ peak ground acceleration |
| $F_{PGA}$ | 1.2 | Site amplification factor at PGA |
| $PGA_M$ | 0.423 | Site modified peak ground acceleration |
| $T_L$ | 16 | Long-period transition period (s) |
| SsRT | 0.787 | Probabilistic risk-targeted ground motion (0.2s) |
| SsUH | 0.885 | Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years) |
| SsD | 1.5 | Factored deterministic acceleration value (0.2s) |
| S1RT | 0.348 | Probabilistic risk-targeted ground motion (1.0s) |
| S1UH | 0.401 | Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years) |
| S1D | 0.6 | Factored deterministic acceleration value (1.0s) |
| PGAd | 0.5 | Factored deterministic acceleration value (PGA) |

*The results indicated here DO NOT reflect any state or local amendments to the values or any delineation lines made during the building code adoption process. Users should confirm any output obtained from this tool with the local Authority Having Jurisdiction before proceeding with design.*

## Disclaimer

Hazard loads are provided by the U.S. Geological Survey Seismic Design Web Services.

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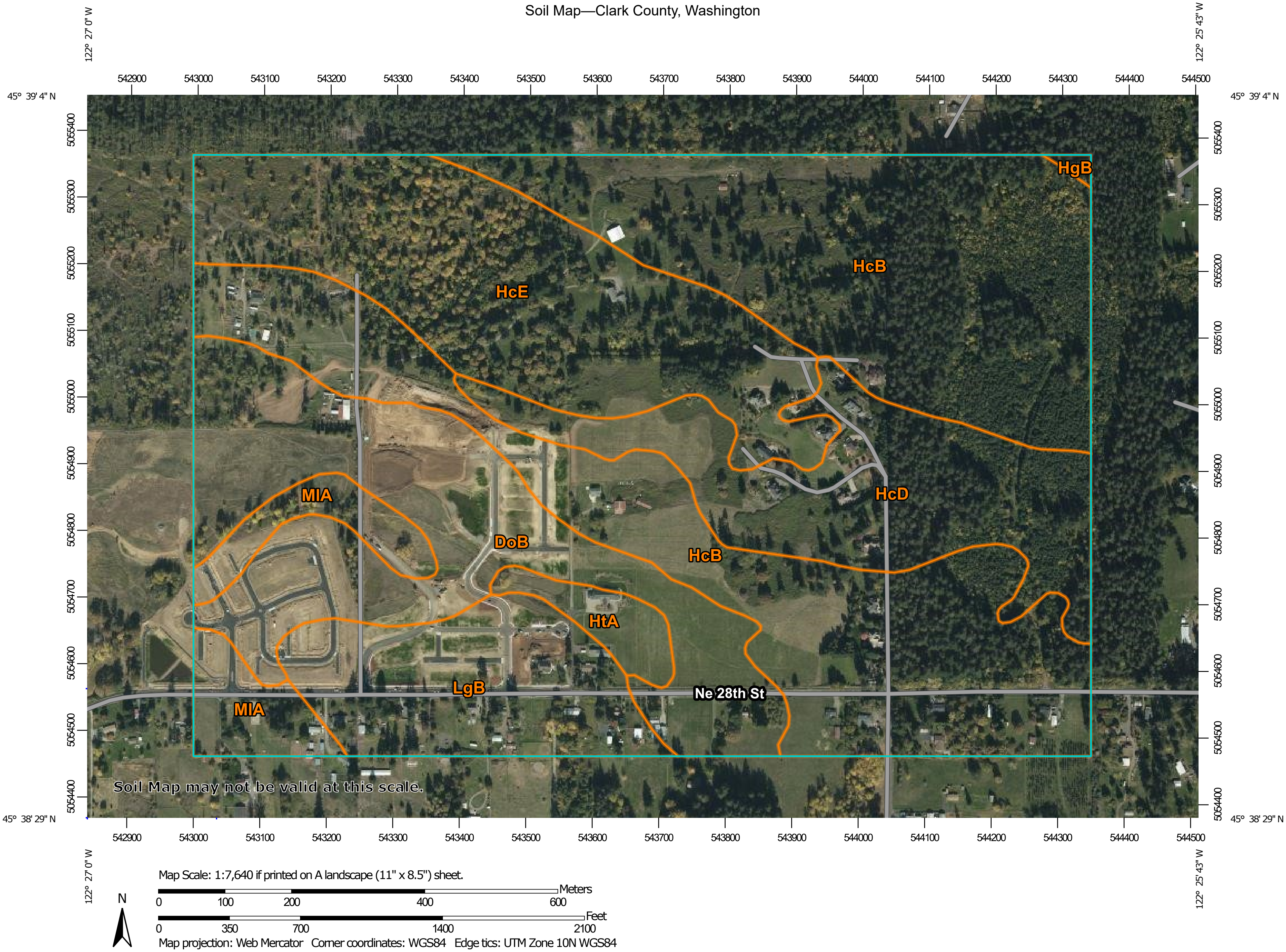
Exhibit 5

# Soil Map—Clark County, Washington



Map Scale: 1:7,640 if printed on A landscape (11" x 8.5") sheet.

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

Exhibit 5

## MAP LEGEND

**Area of Interest (AOI)**
- Area of Interest (AOI)

**Soils**
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

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

**Water Features**
- Streams and Canals

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

**Background**
- Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

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 18, Jun 4, 2020

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

Date(s) aerial images were photographed: Oct 15, 2018—Oct 18, 2018

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.

Exhibit 5

# Map Unit Legend

| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|---|---|---|---|
| DoB | Dollar loam, 0 to 5 percent slopes | 50.7 | 16.8% |
| HcB | Hesson clay loam, 0 to 8 percent slopes | 118.7 | 39.3% |
| HcD | Hesson clay loam, 8 to 20 percent slopes | 36.1 | 12.0% |
| HcE | Hesson clay loam, 20 to 30 percent slopes | 52.8 | 17.5% |
| HgB | Hesson gravelly clay loam, 0 to 8 percent slopes | 0.4 | 0.1% |
| HtA | Hockinson loam, 0 to 3 percent slopes | 4.8 | 1.6% |
| LgB | Lauren gravelly loam, 0 to 8 percent slopes | 25.8 | 8.5% |
| MlA | McBee silt loam, coarse variant, 0 to 3 percent slopes | 12.7 | 4.2% |
| **Totals for Area of Interest** | | **302.1** | **100.0%** |

Exhibit 5

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# PHOTOGRAPHIC LOG

Exhibit 5

# CAMAS VALLEY ESTATES
# GEOTECHNICAL INVESTIGATION
# PHOTOGRAPHIC LOG

**Site Facing Southwest**

**Site Facing Northeast**

Exhibit 5

# CAMAS VALLEY ESTATES GEOTECHNICAL INVESTIGATION PHOTOGRAPHIC LOG

**Southern Half of Site, Facing East**

**Northern Portion of Site Facing South, Moderately Sloping Area**

Exhibit 5

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# CAMAS VALLEY ESTATES
# GEOTECHNICAL INVESTIGATION
# PHOTOGRAPHIC LOG

**Excavator Test Pits**

**Test Pit TP-1**

Exhibit 5

# CAMAS VALLEY ESTATES
# GEOTECHNICAL INVESTIGATION
# PHOTOGRAPHIC LOG

**Test Pit TP-3**

**Test Pit TP-3**

Exhibit 5

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# CAMAS VALLEY ESTATES GEOTECHNICAL INVESTIGATION PHOTOGRAPHIC LOG

**Test Pit TP-4**

**Test Pit TP-4**

Exhibit 5

# CAMAS VALLEY ESTATES
# GEOTECHNICAL INVESTIGATION
# PHOTOGRAPHIC LOG

**Test Pit TP-7**

**Test Pit TP-7**

Exhibit 5

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# CAMAS VALLEY ESTATES
# GEOTECHNICAL INVESTIGATION
# PHOTOGRAPHIC LOG

**Test Pit TP-8**

**Test Pit TP-8**

Exhibit 5

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# CAMAS VALLEY ESTATES
# GEOTECHNICAL INVESTIGATION
# PHOTOGRAPHIC LOG

Test Pit TP-9

Test Pit TP-9

Exhibit 5

# **Appendix H:** Maintenance & Operations

Exhibit 5

# Appendix V-A: BMP Maintenance Tables

Ecology intends the facility-specific maintenance standards contained in this section to be conditions for determining if maintenance actions are required as identified through inspection. Recognizing that Permittees have limited maintenance funds and time, Ecology does not require that a Permittee perform all these maintenance activities on all their stormwater BMPs. We leave the determination of importance of each maintenance activity and its priority within the stormwater program to the Permittee. We do expect, however, that sufficient maintenance will occur to ensure that the BMPs continue to operate as designed to protect ground and surface waters.

Ecology doesn't intend that these measures identify the facility's required condition at all times between inspections. In other words, exceedance of these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, based upon inspection observations, the Permittee shall adjust inspection and maintenance schedules to minimize the length of time that a facility is in a condition that requires a maintenance action.

### Table V-A.1: Maintenance Standards - Detention Ponds

| Maintenance Component | Defect | Conditions When Maintenance Is Needed | Results Expected When Maintenance Is Performed |
|---|---|---|---|
| General | Trash & Debris | Any trash and debris which exceed 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping.<br>If less than threshold all trash and debris will be removed as part of next scheduled maintenance. | Trash and debris cleared from site |
| | Poisonous Vegetation and noxious weeds | Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public.<br>Any evidence of noxious weeds as defined by State or local regulations.<br>(Apply requirements of adopted IPM policies for the use of herbicides). | No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department)<br>Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required |
| | Contaminants and Pollution | Any evidence of oil, gasoline, contaminants or other pollutants<br>(Coordinate removal/cleanup with local water quality response agency). | No contaminants or pollutants present. |
| | Rodent Holes | Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes. | Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.) |
| | Beaver Dams | Dam results in change or function of the facility. | Facility is returned to design function.<br>(Coordinate trapping of beavers and removal of dams with appropriate permitting agencies) |
| | Insects | When insects such as wasps and hornets interfere with maintenance activities. | Insects destroyed or removed from site.<br>Apply insecticides in compliance with adopted IPM policies |
| | Tree Growth and Hazard Trees | Tree growth does not allow maintenance and inspection access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove<br>If dead, diseased, or dying trees are identified<br>(Use a certified Arborist to determine health of tree or removal requirements) | Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood).<br>Remove hazard Trees |
| Side Slopes of Pond | Erosion | Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.<br>Any erosion observed on a compacted berm embankment. | Slopes should be stabilized using appropriate erosion control measure(s); e.g.,rock reinforcement, planting of grass, compaction.<br>If erosion is occurring on compacted berms a licensed engineer in the state of Washington should be consulted to resolve source of erosion. |
| Storage Area | Sediment | Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility. | Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion. |

Exhibit 5

## Table V-A.1: Maintenance Standards - Detention Ponds (continued)

| Maintenance Component | Defect | Conditions When Maintenance Is Needed | Results Expected When Maintenance Is Performed |
|---|---|---|---|
| | Liner (if Applicable) | Liner is visible and has more than three 1/4-inch holes in it. | Liner repaired or replaced. Liner is fully covered. |
| Ponds Berms (Dikes) | Settlements | Any part of berm which has settled 4 inches lower than the design elevation<br>If settlement is apparent, measure berm to determine amount of settlement<br>Settling can be an indication of more severe problems with the berm or outlet works. A licensed engineer in the state of Washington should be consulted to determine the source of the settlement. | Dike is built back to the design elevation. |
| | Piping | Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue.<br>(Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition. | Piping eliminated. Erosion potential resolved. |
| Emergency Overflow/ Spillway and Berms over 4 feet in height | Tree Growth | Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.<br>Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm. | Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed engineer in the state of Washington should be consulted for proper berm/spillway restoration. |
| | Piping | Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue.<br>(Recommend a Geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition. | Piping eliminated. Erosion potential resolved. |
| Emergency Overflow/Spillway | Emergency Overflow/Spillway | Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway.<br>(Rip-rap on inside slopes need not be replaced.) | Rocks and pad depth are restored to design standards. |
| | Erosion | See "Side Slopes of Pond" | |

## Table V-A.2: Maintenance Standards - Infiltration

| Maintenance Component | Defect | Conditions When Maintenance Is Needed | Results Expected When Maintenance Is Performed |
|---|---|---|---|
| General | Trash & Debris | See Table V-A.1: Maintenance Standards - Detention Ponds | See Table V-A.1: Maintenance Standards - Detention Ponds |
| | Poisonous/Noxious Vegetation | See Table V-A.1: Maintenance Standards - Detention Ponds | See Table V-A.1: Maintenance Standards - Detention Ponds |
| | Contaminants and Pollution | See Table V-A.1: Maintenance Standards - Detention Ponds | See Table V-A.1: Maintenance Standards - Detention Ponds |
| | Rodent Holes | See Table V-A.1: Maintenance Standards - Detention Ponds | See Table V-A.1: Maintenance Standards - Detention Ponds |
| Storage Area | Sediment | Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. Treatment basins should infiltrate Water Quality Design Storm Volume within 48 hours, and empty within 24 hours after cessation of most rain events. | Sediment is removed and/or facility is cleaned so that infiltration system works according to design. |

Exhibit 5

## Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults) (continued)

| Maintenance Component | Defect | Conditions When Maintenance is Needed | Results Expected When Maintenance is Performed |
|---|---|---|---|
| Manhole | Cover Not in Place | Cover is missing or only partially in place. Any open manhole requires maintenance. | Manhole is closed. |
| | Locking Mechanism Not Working | Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids). | Mechanism opens with proper tools. |
| | Cover Difficult to Remove | One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance. | Cover can be removed and reinstalled by one maintenance person. |
| | Ladder Rungs Unsafe | Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks. | Ladder meets design standards. Allows maintenance person safe access. |
| Catch Basins | See Table V-A.5: Maintenance Standards - Catch Basins | See Table V-A.5: Maintenance Standards - Catch Basins | See Table V-A.5: Maintenance Standards - Catch Basins |

## Table V-A.4: Maintenance Standards - Control Structure/Flow Restrictor

| Maintenance Component | Defect | Condition When Maintenance is Needed | Results Expected When Maintenance is Performed |
|---|---|---|---|
| General | Trash and Debris (Includes Sediment) | Material exceeds 25% of sump depth or 1 foot below orifice plate. | Control structure orifice is not blocked. All trash and debris removed. |
| | Structural Damage | Structure is not securely attached to manhole wall.<br>Structure is not in upright position (allow up to 10% from plumb).<br>Connections to outlet pipe are not watertight and show signs of rust.<br>Any holes - other than designed holes - in the structure. | Structure securely attached to wall and outlet pipe.<br>Structure in correct position.<br>Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.<br>Structure has no holes other than designed holes. |
| Cleanout Gate | Damaged or Missing | Cleanout gate is not watertight or is missing.<br>Gate cannot be moved up and down by one maintenance person.<br>Chain/rod leading to gate is missing or damaged.<br>Gate is rusted over 50% of its surface area. | Gate is watertight and works as designed.<br>Gate moves up and down easily and is watertight.<br>Chain is in place and works as designed.<br>Gate is repaired or replaced to meet design standards. |
| Orifice Plate | Damaged or Missing | Control device is not working properly due to missing, out of place, or bent orifice plate. | Plate is in place and works as designed. |
| | Obstructions | Any trash, debris, sediment, or vegetation blocking the plate. | Plate is free of all obstructions and works as designed. |
| Overflow Pipe | Obstructions | Any trash or debris blocking (or having the potential of blocking) the overflow pipe. | Pipe is free of all obstructions and works as designed. |
| Manhole | See Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults) | See Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults) | See Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults) |
| Catch Basin | See Table V-A.5: Maintenance Standards - Catch Basins | See Table V-A.5: Maintenance Standards - Catch Basins | See Table V-A.5: Maintenance Standards - Catch Basins |

Exhibit 5

## Table V-A.5: Maintenance Standards - Catch Basins

| Maintenance Component | Defect | Conditions When Maintenance is Needed | Results Expected When Maintenance is performed |
|---|---|---|---|
| General | Trash & Debris | Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.<br>Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.<br>Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.<br>Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane). | No Trash or debris located immediately in front of catch basin or on grate opening.<br>No trash or debris in the catch basin.<br>Inlet and outlet pipes free of trash or debris.<br>No dead animals or vegetation present within the catch basin. |
| | Sediment | Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe. | No sediment in the catch basin |
| | Structure Damage to Frame and/or Top Slab | Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch. (Intent is to make sure no material is running into basin).<br>Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached | Top slab is free of holes and cracks.<br>Frame is sitting flush on the riser rings or top slab and firmly attached. |
| | Fractures or Cracks in Basin Walls/ Bottom | Maintenance person judges that structure is unsound.<br>Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks. | Basin replaced or repaired to design standards.<br>Pipe is regrouted and secure at basin wall. |
| | Settlement/ Mis-alignment | If failure of basin has created a safety, function, or design problem. | Basin replaced or repaired to design standards. |
| | Vegetation | Vegetation growing across and blocking more than 10% of the basin opening.<br>Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart. | No vegetation blocking opening to basin.<br>No vegetation or root growth present. |
| | Contamination and Pollution | See Table V-A.1: Maintenance Standards - Detention Ponds | No pollution present. |
| Catch Basin Cover | Cover Not in Place | Cover is missing or only partially in place. Any open catch basin requires maintenance. | Cover/grate is in place, meets design standards, and is secured |
| | Locking Mechanism Not Working | Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread. | Mechanism opens with proper tools. |
| | Cover Difficult to Remove | One maintenance person cannot remove lid after applying normal lifting pressure.<br>(Intent is keep cover from sealing off access to maintenance.) | Cover can be removed by one maintenance person. |
| Ladder | Ladder Rungs Unsafe | Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges. | Ladder meets design standards and allows maintenance person safe access. |
| Metal Grates (If Applicable) | Grate opening Unsafe | Grate with opening wider than 7/8 inch. | Grate opening meets design standards. |
| | Trash and Debris | Trash and debris that is blocking more than 20% of grate surface inletting capacity. | Grate free of trash and debris. |
| | Damaged or Missing. | Grate missing or broken member(s) of the grate. | Grate is in place, meets the design standards, and is installed and aligned with the flow path. |

Exhibit 5

## Table V-A.6: Maintenance Standards - Debris Barriers (e.g., Trash Racks)

| Maintenance Components | Defect | Condition When Maintenance is Needed | Results Expected When Maintenance is Performed |
|---|---|---|---|
| General | Trash and Debris | Trash or debris that is plugging more than 20% of the openings in the barrier. | Barrier cleared to design flow capacity. |
| Metal | Damaged/ Missing Bars. | Bars are bent out of shape more than 3 inches.<br>Bars are missing or entire barrier missing.<br>Bars are loose and rust is causing 50% deterioration to any part of barrier. | Bars in place with no bends more than 3/4 inch.<br>Bars in place according to design.<br>Barrier replaced or repaired to design standards. |
| | Inlet/Outlet Pipe | Debris barrier missing or not attached to pipe | Barrier firmly attached to pipe |

## Table V-A.7: Maintenance Standards - Energy Dissipators

| Maintenance Components | Defect | Conditions When Maintenance is Needed | Results Expected When Maintenance is Performed |
|---|---|---|---|
| External: | | | |
| Rock Pad | Missing or Moved Rock | Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil. | Rock pad replaced to design standards. |
| | Erosion | Soil erosion in or adjacent to rock pad. | Rock pad replaced to design standards. |
| Dispersion Trench | Pipe Plugged with Sediment | Accumulated sediment that exceeds 20% of the design depth. | Pipe cleaned/flushed so that it matches design. |
| | Not Discharging Water Properly | Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage. | Trench redesigned or rebuilt to standards. |
| | Perforations Plugged. | Over 1/2 of perforations in pipe are plugged with debris and sediment. | Perforated pipe cleaned or replaced. |
| | Water Flows Out Top of "Distributor" Catch Basin. | Maintenance person observes or receives credible report of water flowing out during any storm less than the design storm or its causing or appears likely to cause damage. | Facility rebuilt or redesigned to standards. |
| | Receiving Area Over-Saturated | Water in receiving area is causing or has potential of causing landslide problems. | No danger of landslides. |
| Internal: | | | |
| Manhole/Chamber | Worn or Damaged Post, Baffles, Side of Chamber | Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding one square foot which would make structure unsound. | Structure replaced to design standards. |
| | Other Defects | See Table V-A.5: Maintenance Standards - Catch Basins | See Table V-A.5: Maintenance Standards - Catch Basins |

## Table V-A.8: Maintenance Standards - Typical Biofiltration Swale

| Maintenance Component | Defect or Problem | Condition When Maintenance is Needed | Recommended Maintenance to Correct Problem |
|---|---|---|---|
| General | Sediment Accumulation on Grass | Sediment depth exceeds 2 inches. | Remove sediment deposits on grass treatment area of the bio-swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased. |
| | Standing Water | When water stands in the swale between storms and does not drain freely. | Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale. |
| | Flow spreader | Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width. | Level the spreader and clean so that flows are spread evenly over entire swale width. |