Exhibit 18

JOB # 791

STERLING DESIGN, INC.
2208 E. Evergreen Blvd., Vancouver, WA 98661
Ph: (360) 759-1794 Fx: (360) 759-4983
Email: Mail@SterlingDesign.biz

**PRELIMINARY TECHNICAL INFORMATION REPORT**

# Green Mountain PRD B1 Pod Subdivision

**October 2018**

Prepared by: Joel G. Stirling, P.E.


# General Location

Account: 986037307, 173178000
Owner: AE GREEN MOUNTAIN LLC
Address: 2551 W 1ST ST
C/S/Z: WASHOUGAL, WA 98671

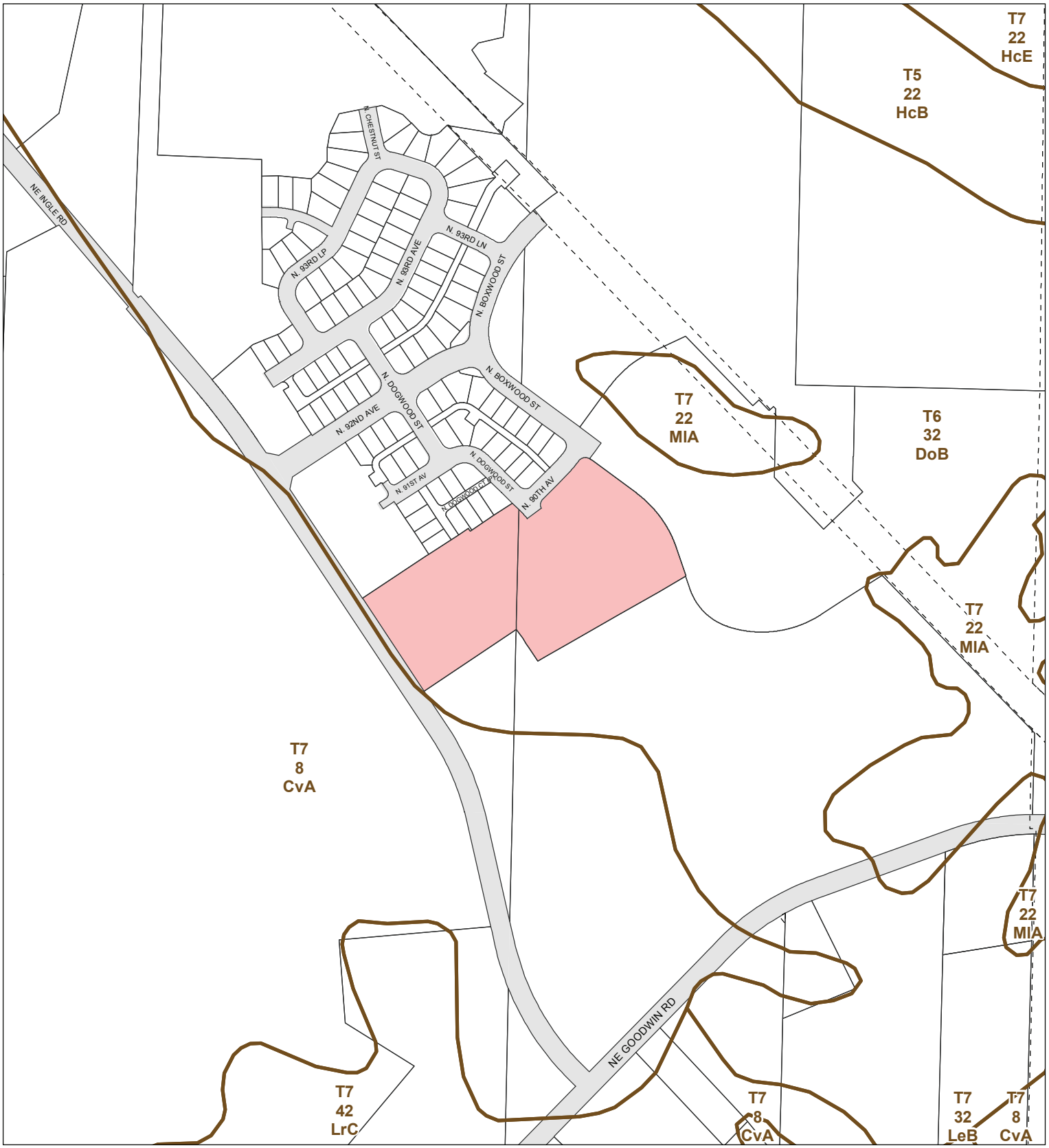
Printed on: July 02, 2018

Location of Subject Property(s)

CLARK COUNTY, WASHINGTON
Geographic Information System

0 1,000 2,000 Feet

*Information shown on this map was collected from several sources. Clark County accepts no responsibility for any inaccuracies that may be present.*




CLARK COUNTY, WASHINGTON

Geographic Information System

0 200 400 Feet

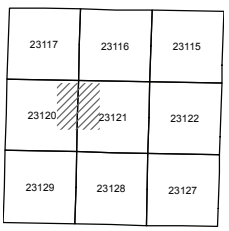
*Information shown on this map was collected from several sources. Clark County accepts no responsibility for any inaccuracies that may be present.*

# Soil Types

Account: 986037307, 173178000
Owner: AE GREEN MOUNTAIN LLC
Address: 2551 W 1ST ST
C/S/Z: WASHOUGAL, WA 98671

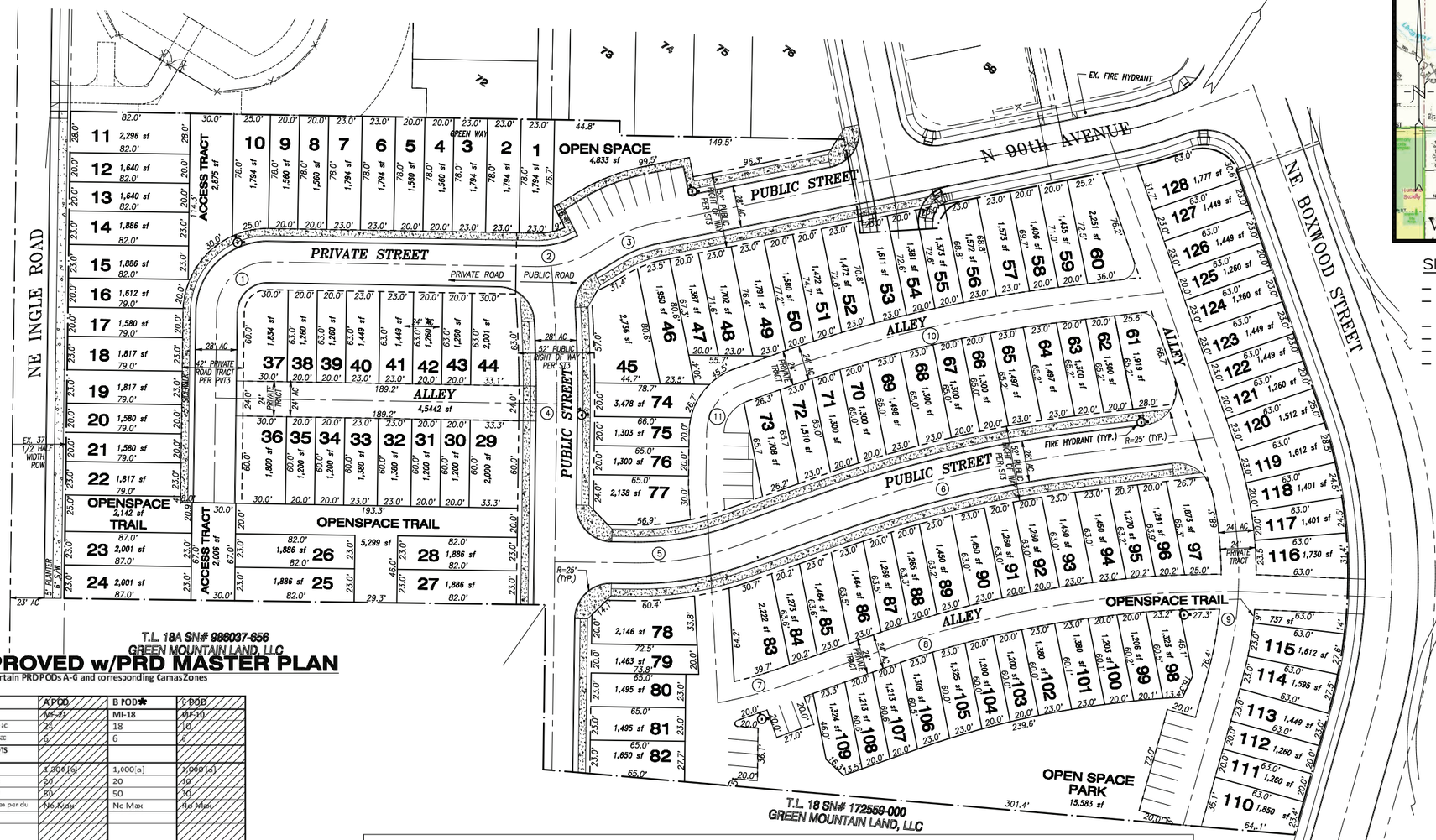
Subject Property(s)
Public Road
Transportation or Major Utility Easement
Soil Type Boundary

Printed on: July 02, 2018



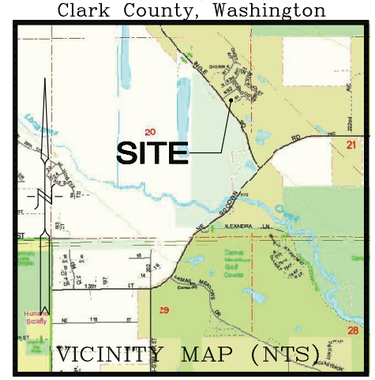
**GREEN MOUNTAIN MASTER PRD NOTE:**
***REFER TO THE APPROVED GREEN MOUNTAIN DEVELOMENT STANDARDS & PHASING PLAN FOR:**
**- OPEN SPACE DEDICATION THAT HAS BEEN COMPLETED AND APPROVED WITH GREEN MOUNTAIN PRD DEVELOPMENT STANDARDS & PHASING PLAN.**
**- DENSITY AND SETBACKS REQUIREMENTS FOR THIS PROJECT HAVE BEEN OUTLINED WITH THE GREEN MOUNTAIN PRD DEVELOPMENT STANDARDS & PHASING PLAN AS DEPICTED ON SHEET 2 OF 8.**

GRAPHIC SCALE
40 0 20 40 80 160
( IN FEET )
1 inch = 40 ft.




# GREEN MOUNTAIN PRD

A Preliminary Plat within
a portion of the NE 1/4 of
Sec. 20, T2N., R3E., W.M.
Clark County, Washington




SITE DATA:

- TAX LOT(S): 22A, 22B & 22
- SERIAL NUMBER(S): 986037-307 & 173178-000
- SITE ADDRESS: NOT SITUATED
- AREA: 7.89 ACRES
- ZONING: MF-18
- COMPREHENSIVE PLAN: MFL

**CENTERLINE CURVE DATA**

| | | |
|---|---|---|
| 1 | R=35.00ft CH=49.60ft A=55.12ft T=35.15ft EX=14.60ft Delta=90 14'16" | R=301.00ft CH=48.51ft A=48.56ft T=24.33ft EX=0.98ft Delta=9 14'38" |
| 2 | R=70.00ft CH=38.97ft A=39.49ft T=20.28ft EX=2.88ft Delta=32 19'17" | R=699.00ft CH=156.76ft A=157.09ft T=78.88ft EX=4.44ft Delta=12 52'34" |
| 3 | R=100.00ft CH=34.95ft A=35.13ft T=17.75ft EX=1.56ft Delta=20 07'40" | R=269.46ft CH=150.64ft A=152.67ft T=78.45ft EX=11.19ft Delta=32 27'48" |
| 4 | R=1000.00ft CH=98.32ft A=98.36ft T=49.22ft EX=1.21ft Delta=5 38'08" | R=903.00ft CH=202.51ft A=202.93ft T=101.90ft EX=5.73ft Delta=12 52'34" |
| 5 | R=200.00ft CH=70.78ft A=71.16ft T=35.96ft EX=3.21ft Delta=20 23'08" | R=35.00ft CH=39.96ft A=42.53ft T=24.33ft EX=7.63ft Delta=69 36'52" |
| 5 | R=200.00ft CH=70.78ft A=71.16ft T=35.96ft EX=3.21ft Delta=20 23'08" | |
| 6 | R=800.00ft CH=179.41ft A=179.79ft T=90.27ft EX=5.08ft Delta=12 52'34" | |

***APPROVED w/PRD MASTER PLAN**
GreenMountain PRDPODs A-G and corresponding CamasZones

| | A POD | B POD* | C POD |
|---|---|---|---|
| DENSITY | MF-24 | MF-18 | MF-10 |
| Max. du/gross ac | 24 | 18 | 10 |
| Min du/gross ac | 6 | 6 | 8 |
| STANDARD LOTS | | | |
| Min lot SF | 1,200 [c] | 1,000 [a] | 1,000 [a] |
| Min lot width | 20 | 20 | 30 |
| Min lot depth | 80 | 50 | 30 |
| Max. Floor Area per du | No Max | No Max | No Max |
| | | | |
| SETBACKS | | | |
| Min front/at garage | None | 6/18@OS,18 | 10/18 |
| Min side | 3 [1] | 3 [1] [d] | 3 [1] [d] |
| Min side Flanking Street | None [a] | 10 [d] | 10 [d] |
| Min rear (garage @alley) | None [a] | 10 [b][c] | 10 [b][c] |
| LOT COVERAGE, Max. | None [c] | Ncne | 35% |
| BUILDING HEIGHT, Max. | 80 | 45 [2] | 35 [2] |

*a. Single Family Detached homes to be permitted. For SFD in A POD apply 3 Pod setbacks.*

*b. 10 foot rear yard for front access garage.*

*c. Minimum rear yard for alley accessed garage is either 4' or 18.*

*d. Minimum side yard at alley is 5'.*

*e. Franchise utilities to be located in front or side yard easements abutting right of way.*

1. The non-attached side of a dwelling unit shall be three feet, otherwise a zero-lot-line is assumed.
2. Maximum building height: three stories and a basement but not to exceed maximum building height.

**PROPOSED PRELIMINARY PLAT SUMMARY:**

| | |
|---|---|
| **Total Lots: 128** | |
| **Total Site Area:** | **35,368, 840 sf (7.89 Acres)** |
| **Minimum Lot Area:** | **1,200 sf.** |
| **Maximum Lot Area:** | **2,736 sf** |
| **Average Lot Area:** | **1,568 sf** |
| **Public Right of Way Dedication:** | **50,435 sf** |
| **Privated Road Dedication:** | **15,080 sf** |
| **Alleys:** | **42,878 sf** |
| **Access Tract:** | **5,471 sf** |
| *** Openspace:** | **28,610 sf** |

*** PROPOSED SITE DENSITY: 16.2 LOTS/ACRE**


PREPARED BY:
STERLING DESIGN, INC.
2208 E.EVERGREEN BLVD
VANCOUVER, WA 98661
PH. (360) 759-1794
FAX (360) 759-4983
Mail@SterlingDesign.biz


STERLING DESIGN INC.

Sheet Description: **PROPOSED DEVELOPMENT PLAN**

Project: **GREEN MOUNTAIN B1 POD**

DANIEL GREGORY SPERANK — EXPIRES 10/31/18 — PROFESSIONAL ENGINEER

10/31/18

Scale: AS SHOWN
Project Number: 791
Design/Drawn JGS/BC
Drawing Date: OCT. 2018
Sheet 4 of 8 Sheet(s)

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**List of Figures:**



**Report:**



**Technical Appendix:**



**List of References:**

Stormwater Management Manual for Western Washington dated 2014.
City of Camas Municipal Code as amended prior to March, 2014

# Green Mountain PRD B1 Pod Subdivision

## Section A – Project Overview

The Green Mountain PRD B1 Pod Subdivision proposal is to subdivide two parcels of land, serial number(s): 986037-307 and 173178-000, located in the NW ¼ quarter of Section(s) 20 & 21, Township 2 North, Range 3 East of the Willamette Meridian, Clark County, Washington, into 128 residential units utilizing the approved Master Plan Development Standards within the MF-18 section of the Green Mountain PRD Development. The site area is approximately 7.9 acres and currently is vacant land that was previously utilized in a portion of the Green Mountain Golf Course. The property topography slopes moderately from the north westerly property corner down to the south easterly property corner and currently contains construction debris from other phases, field grasses, weeds and 2 Oregon White Oak Trees, on it.
The site is zoned MF-18, under the Green Mountain PRD Pods definitions, and the comprehensive plan designation for the site is MFL. The Green Mountain PRD Master Planned Development was submitted and approved in 2014/2015 and is made up of a total of 283 acres of land. The Project Narrative submitted with the Approved PRD Master Planned Development is included here in, following this narrative, and the information contained within this Supplemental Narrative is Site Specific to the B1 Pod portion of the project and how it complies with the approval criterion within the Developer Agreement and Decision for the Green Mountain PRD Master Planned Development. The Green Mountain PRD Master Planned Development provided a broad overview of the proposed development with the understanding that each of the Development "Pods" would clarify how the proposed development configuration met the goals and intents of the Approved Master Plan.

The B1 Pod is located along NE Ingle Road, just to the south and east of the recently constructed Green Mountain Mixed Use PRD Phase 1D Subdivision. The project has Public Roads along the northern and southern boundaries and future phases of the Green Mountain PRD Project to the south and east.

Construction of the Green Mountain PRD B1 Pod Subdivision will consist of grading approximately 7.9 acres of the site for construction of utilities, Alley's, public roads, private roads, building pads, and open spaces. Stormwater facilities will be located to the south and east of the residential development within an acre of land that the project owner has secured for the purposes of constructing stormwater management facilities in a location that maybe combined with facilities from future phases. For the purposes of the Land Use Application and Approvals, the proposed stormwater facilities are depicted using the design and cross sections from the adjacent stormwater 2 celled wet pond that was recently constructed with the D1 Pod. Due to the high groundwater, flat topography and existing soils in the vicinity of the facilities, a 2 celled wet pond is a good fit to be placed along NE Ingle Road. Also, the stormwater facility discharges to the Lacamas Creek Contributing Water Shed which requires enhanced treatment prior to discharge to

the natural flow routes. Wet ponds provide the required level of treatment to meet the water quality and quantity control levels within the Lacamas Creek Contributing Water Shed and final design details for the facility will be provided at the time of Final Construction Plan Preparation since the facility configuration will not impact the proposed development of the B1 Pod.

## Section B – Minimum Requirements

The Green Mountain PRD B1 Pod Subdivision proposal contains only one threshold discharge area (TDA) and is subject to minimum requirements 1 – 9. As required by CMC 14.02, the property is defined as follows: **Pre-developed Condition** - The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement. The pre-developed condition shall be assumed to be a forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.

## Section C – Soils Evaluation

The "Soil Survey of Clark County, Washington" printed by the United States Department of Agriculture Soil Conservation Service (SCS), in cooperation with Washington Agriculture Experiment Station maps the soils on site as Dollar loam (DoB) which is listed within Soils Group (SG) 3 for WWHM calculation purposes and are also categorized as AASHO A-4 soils. Infiltration rates of 0.06-0.20 inches per hour are typical for these soil types. Although infiltration is not being considered for the primary quantity control management system, it is recognized that there is a small amount of natural infiltration that will occur throughout the project which makes the proposed stormwater management system conservative.

## Section D – Source Control

The development activity includes landscaping and lawn/vegetation and maintenance of stormwater drainage and treatment systems. Source control will be the responsibility of each of the new property owners within the subdivision.

## Section E – Onsite Stormwater Management BMPs

There are no specific applicable onsite stormwater management BMPs that apply to the proposed site improvements. All site runoff will be treated as required within an offsite 2

celled wet pond stormwater management facility that is designed to provide water quality control to meet the minimum stormwater quality control requirements of the SWWMM and the City of Camas. All flows from the developed project will be detained to pre-European-development runoff durations, and released to the pre-developed flow paths.

## Section F – Runoff Treatment and Design

Enhance stormwater treatment is required for this project and will be met through the use of a 2 celled wet pond designed in compliance with City of Camas Municipal Code. Initial installation cost and the expenses associated with long-term maintenance are expected to be typical of developments of this size. There are no pollution-generating pervious surfaces (PGPS) on this project

The proposed Stormwater Management Facility will be designed according to the latest Stormwater Management Manual for Western Washington and will be sized as needed to treat at least 91% of all runoff based on the Water Quality flows calculated by the WWHM computer program.

## Section G – Flow Control Analysis and Design

Stormwater flow rates and durations will be controlled using a 2 celled wet pond stormwater management facility that will be constructed just to the south and east of the proposed project within an acre of property that will be designated for the purposes of stormwater management.

## Section H – Flow Control System Plan

See Engineering Plans.

## Section I – Wetlands Protection

There are no wetlands on the property or immediately adjacent to the property.

## Section J – Other Permits

Coverage under the Washington State NPDES Construction Stormwater General Permit will be obtained prior to construction.

## Section K – Conveyance System Analysis and Design

See Engineering Plans for entire conveyance system design. The project is located on a property with considerable slope therefore all conveyance systems will convey the predicted 100 year flows to the proposed stormwater management facilities.

## Section L – Offsite Analysis

As required by Camas Municipal Code, a representative of STERLING DESIGN, INC. visited the site and followed the downstream flow route to a point in the receiving water more than ¼ of a mile from the site in order to analyze existing conditions and potential impacts of this development activity. This analysis looked for indications of excessive sedimentation, stream bank erosion, polluted discharges to ground water contributing to recharge zones, violations of water quality standards, and spills and discharges of priority pollutants as well as for potential impacts to public health and safety and private or public facilities downstream. All storm water from the site will connect to a public stormwater system that was recently installed within NE Ingle Road. The existing conveyance conveys all stormwater to a discharge point that is on the west side of NE Ingle Road. From the discharge point the stormwater flows in a south westerly flow path to a tributary that flows into Lacamas Lake. Stormwater flows from the proposed Green Mountain PRD B1 Pod Subdivision will continue to follow historical flow routes and will not be rerouted to another drainage basin. The designed stormwater system mimics the pre-developed condition by managing developed stormwater flow rates and discharging to the pre-development flow path. This project will not have a significant adverse impact on the downstream and/or upstream drainage system.

## Section M – Groundwater Monitoring Program

Ground water monitoring is not a requirement for single family residential developments and it is unlikely that there is any threat to ground water from the proposed Green Mountain PRD B1 Pod project.

## Section N – Maintenance and Operations Manual

Stormwater facilities will be privately owned and maintained per City of Camas Stormwater code CMC 14.02 and pages 7-24 and 7-25 of 2014 Stormwater Management Manual for Western Washington, Volume V.

**Appendix I: Option Agreement to purchase up to 1 acre offsite for stormwater management facilities**

# OPTION AGREEMENT

This Option Agreement (this "**Agreement**") is entered into as of this ____ day of _____, 2018 (the "**Effective Date**"), between Green Mountain Land LLC, a Washington limited liability company ("**GML**"), and AE Green Mountain, LLC, a Washington limited liability company ("**AE**").

## Recitals

A. AE is the owner of that certain real property described on Exhibit A attached hereto (the "**AE Property**").

B. GML is the owner of that certain real property described on Exhibit B attached hereto (the "**GML Property**").

C. AE wishes to acquire an option to either purchase, or obtain an easement to use, a portion of the GML Property for the purpose of constructing and operating a stormwater detention facility on such property for the benefit of the AE Property. GML is willing to grant such an option pursuant to the terms and conditions set forth below.

## Agreement

Now, therefore, for the sum of $10 paid by AE to GML, and for certain other valuable consideration, the receipt and sufficiency of which are hereby acknowledged by GML and AE, GML and AE hereby agree as follows:

1. AE's Notice. On or before May 1, 2019, AE may provide written notice to GML ("**AE's Notice**") that it desires to acquire fee title to, or an easement to use, a certain portion of that portion of the GML Property that is depicted on the drawing attached as Exhibit C hereto, not to exceed one acre in size, for the purpose of constructing and operating a stormwater detention facility (the "**Facility**") on such property. AE's Notice shall identify the property that AE intends to be the subject of the purchase and sale agreement or easement agreement; such property shall hereinafter be referred to as the "Designated Property." AE's Notice shall (a) specify the precise location and configuration of the Designated Property and (b) indicate whether AE intends to acquire fee title to the Designated Property or to obtain an easement to use the Designated Property. If AE's Notice is not given to GML on or before May 1, 2019, AE shall have no further right to acquire fee title to or an easement with respect to any portion of the GML Property, and AE's rights under this Agreement shall terminate.

2. Designated Property. The precise location and configuration of the Designated Property are subject to the written approval of GML, and such approval shall not be unreasonably withheld. It shall be deemed reasonable for GML to withhold such approval if fewer than two hundred (200) feet of the Designated Property abut Ingle Road or if the length of the Designated Property that abuts Ingle Road is less than one and one-half (1.5) times the length of either the northern or southern boundary line of the Designated Property. (The foregoing sentence is not intended to include an exclusive list of reasons for which GML may reasonably withhold its approval of the location and configuration of the Designated Property.) GML shall

notify AE within fourteen (14) days after GML's receipt of AE's Notice if GML approves of the Designated Property.

3. Purchase and Sale Agreement/Easement Agreement. If GML notifies AE, within fourteen (14) days after GML's receipt of AE's Notice, that GML approves of the Designated Property, GML and AE shall use commercially reasonable efforts to enter into a purchase and sale agreement (if AE's Notice states that AE desires to acquire fee title to the Designated Property) or easement agreement (if AE's Notice states that AE desires to acquire an easement to use the Designated Property) with respect to the Designated Property. Among other things, such purchase and sale agreement or easement agreement shall:

(a) Obligate AE to pay to GML, upon the closing of the sale of the Designated Property to AE or at the time of the parties' execution of the easement agreement, the sum of $5.17 per square foot ($225,205 per acre) for the Designated Property. The closing of the sale or the execution of the easement agreement shall occur thirty (30) days after the date on which AE has given notice to GML that AE has received final engineering approval for the Facility.

(b) Require GML to reasonably cooperate with AE, at no out-of-pocket cost or expense to GML, in connection with AE's efforts to seek appropriate governmental permits and approvals for the construction and operation of the Facility, which reasonable cooperation may include the execution of commercially reasonable applications.

(c) Provide that the Facility shall not in any manner materially interfere with vehicular or pedestrian access from Ingle Road to the GML Property or with vehicular or pedestrian access from the GML Property to Ingle Road.

(d) If an easement agreement is entered into, (i) require AE to reimburse GML for AE's share of all real property taxes and assessments imposed or assessed against the Designated Property and/or the Facility, as such share is reasonably determined by GML; (ii) allow GML to terminate the easement and AE's rights with respect to the Designated Property in the event of AE's breach of the easement agreement, following written notice to AE of the breach and a reasonable opportunity to cure such breach; and (iii) give GML the right at any time to convey the Designated Property to AE by bargain and sale deed and obligate AE to accept such conveyance, provided that if the Designated Property is not then a legal lot or parcel that may be lawfully conveyed to AE, GML shall be responsible for the creation of such legal lot or parcel and for all costs and expenses associated therewith, and AE shall reasonably cooperate with GML in connection with the creation of such legal lot or parcel.

(e) If a purchase and sale agreement is entered into, provide that (i) GML shall have no obligation to provide any title insurance to AE with respect to the Designated Property; (ii) such property shall be conveyed by GML to AE by bargain and sale deed; and (iii) in the event the Designated Property is not then a legal lot or parcel that may be lawfully conveyed separately to AE, GML and AE shall reasonably cooperate with each other to create, a separate, legal lot or parcel for the Designated Property that may be lawfully conveyed to AE; provided, however, that (A) AE shall pay all costs and expenses relating to the creation of such legal lot or parcel and promptly reimburse GML for any such costs or expenses incurred by

GML, and (B) in no event shall GML be obligated to take any action or otherwise cooperate if GML reasonably believes that the creation of such new lot or parcel will have a material adverse effect on the development of the remainder of the GML Property or any portion thereof.

(f) Obligate AE to indemnify GML for, hold GML harmless from, and defend GML against (with counsel reasonably acceptable to GML) any and all claims, losses, actions or causes of action, liabilities, judgments, damages, and costs and expenses arising or resulting from the construction and/or operation or use of the Facility and any acts or omissions of AE or any of AE's employees, agents, contractors, subcontractors, or tenants in connection with the Designated Property or the Facility.

(g) Provide that the Facility shall be constructed and operated at AE's sole cost and expense.

(h) Allow GML to relocate the Facility to another location on the GML Property that is reasonably acceptable to AE in order to accommodate the development of the GML Property, provided that the relocated Facility's capacity and function shall not be materially diminished as the result of such relocation and further provided that all costs and expenses relating to such relocation shall be borne by GML.

(i) Provide that AE shall use its reasonable best efforts to design the Facility such that it may be expanded to accommodate stormwater from the GML Property and that, upon GML's request, the Facility shall be expanded to accommodate stormwater from the GML Property, provided that GML pays all costs and expenses in connection with such expansion.

(j) State that the agreement shall bind and inure to the benefit of all future owners of the GML Property and the AE Property (subject to the restrictions set forth in Section 4 below) to the same extent that GML and AE are bound and benefited thereunder.

If a purchase and sale agreement or easement agreement that is acceptable to GML and AE has not been entered into between GML and AE within sixty (60) days after GML's receipt of AE's Notice, AE shall have no further right or option to purchase or obtain an easement with respect to any portion of the GML Property, and AE's rights under this Agreement shall terminate.

4. Assignment. AE may not assign this Agreement or its rights hereunder without GML's prior written consent, which may be withheld in GML's sole discretion unless the proposed assignee is an entity that (a) acquires the AE Property from AE and (b) is owned and controlled by M. Allan Evridge, in which event GML's consent to the assignment shall not be unreasonably withheld. It shall be deemed reasonable for GML to withhold its consent to any proposed assignment if the assignee does not assume AE's duties and obligations under this Agreement pursuant to an assignment and assumption agreement that is acceptable to GML.

5. Notices. All notices or other communications required or permitted under this Agreement shall be in writing and shall be (a) personally delivered (including by means of professional messenger service), which notices and communications shall be deemed given on the date of their receipt at the office of the addressee; (b) sent by registered or certified mail, postage prepaid, return receipt requested, which notices and communications shall be deemed given two (2) business days after the date of their deposit in the United States mail; or (c) sent by

overnight delivery using a nationally recognized overnight courier service, which notices and communications shall be deemed given one business day after the date of their deposit with such courier. Notices shall be sent to the following addresses:

| | |
|---|---|
| To GML: | Green Mountain Land LLC<br>Attention: John O'Neil<br>17933 N.W. Evergreen Parkway, Suite 300<br>Beaverton, Oregon 97006 |
| With a copy to: | Schwabe, Williamson & Wyatt, P.C.<br>Attention: James F. Dulcich<br>1211 S.W. Fifth Avenue, Suite 1900<br>Portland, Oregon 97204 |
| To AE: | AE Green Mountain, LLC<br>Attention: Allan Evridge<br>2551 W. 1st Street<br>Washougal, Washington 98671 |

Notice of change of address shall be given by written notice in the manner detailed in this Section 5. Notices may be given by a party or a party's attorney or agent.

6. Successors and Assigns. Subject to the limitations on assignment set forth in Section 4 above, this Agreement shall be binding on and shall inure to the benefit of the successors and assigns of GML and AE.

7. Attorney Fees. In the event that either party to this Agreement institutes a suit, action, arbitration, or other legal proceeding of any nature whatsoever, relating to this Agreement or to the rights or obligations of the parties with respect thereto, the prevailing party shall be entitled to recover from the losing party the prevailing party's reasonable attorney, paralegal, accountant, expert witness (whether or not called to testify at trial or other proceeding) and other professional fees and all other fees, costs, and expenses actually incurred and reasonably necessary in connection therewith, including but not limited to deposition transcript and court reporter costs, as determined by the judge or arbitrator at trial or other proceeding, and including such fees, costs and expenses incurred in any appellate or review proceeding, or in collecting any judgment or award, or in enforcing any decree rendered with respect thereto, in addition to all other amounts provided for by law. This cost and attorney fees provision shall apply with respect to any litigation or other proceedings in bankruptcy court, including litigation or proceedings related to issues unique to bankruptcy law.

8. Entire Agreement. This Agreement (including any exhibits attached to it) is the final expression of, and contains the entire agreement between the parties with respect to the subject matter of the Agreement and supersedes all prior letters of intent and understandings with respect to the subject matter of the Agreement. This Agreement may not be modified, changed, supplemented, or terminated, nor may any obligations under it be waived, except by written instrument signed by the party to be charged or by its agent duly authorized in writing or as

otherwise expressly permitted herein. The parties do not intend to confer any benefit on any person, firm, or corporation other than the parties hereto.

9. Counterparts. This Agreement may be executed in counterparts, each of which will be considered an original and all of which together will constitute one and the same agreement.

10. Time. GML and AE hereby acknowledge and agree that time is strictly of the essence with respect to each and every term, condition, obligation, and provision of this Agreement. Unless otherwise specified, in computing any period of time described in this Agreement, the day of the act or event after which the designated period of time begins to run is not to be included and the last day of the period so computed is to be included, unless the last day is a Saturday, Sunday, or legal holiday, in which event the period shall run until the end of the next day that is not a Saturday, Sunday, or legal holiday.

This Agreement is deemed effective as of the Effective Date set forth above.

GREEN MOUNTAIN LAND LLC, a Washington limited liability company

By:_____
John O'Neil, Manager

By: TERRELL GROUP MANAGEMENT, LLC, an Oregon limited liability company
Its: Manager

By:_____
Patrick Terrell, Managing Member

AE GREEN MOUNTAIN, LLC, a Washington limited liability company

By: M Allen Enbridge

Name: M. Allen Enbridge

Title: Member

# EXHIBIT A
# TO
# OPTION AGREEMENT

**(Legal description of the AE Property)**

OLSON ENGINEERING INC.

*LAND SURVEYORS*
*ENGINEERS*
*(360) 695-1385*
*222 E. Evergreen Blvd.*
*Vancouver, WA*
*98660*

LEGAL DESCRIPTION FOR GREEN MOUNTAIN LAND LLC
ADJUSTED PARCEL 1 WEST

July 27, 2017

A parcel of land in the Thomas J. Fletcher Donation Land Claim No. 51 and the East half of Section 20, and the West half of Section 21 all in Township 2 North, Range 3 East of the Willamette Meridian in the City of Camas, Clark County, Washington, being a portion of that parcel of land described under Exhibit C as "Parcel 1", recorded under Auditor's File No. 5237696 BLA, recorded December 4, 2015, records of said county, described as follows:

COMMENCING at the Northwest corner of said Section 21;

THENCE South 88° 40' 59" East, along the North line of the Northwest quarter of said Section 21, a distance of 830.93 feet to the East line of the Thomas J. Fletcher Donation Land Claim No. 51;

THENCE South 01° 13' 25" West, along said East line, a distance of 1315.09 feet to the North line of the South half of said Northwest quarter;

THENCE South 88° 42' 01" East, along said North line, a distance of 180.00 feet to the most Easterly, Northwest corner of said "Parcel 1";

THENCE along the Westerly lines of said "Parcel 1" the following courses:

THENCE South 01° 17' 59" West, a distance of 214.50 feet;

THENCE South 43° 42' 01" East, a distance of 97.00 feet;

THENCE South 46° 17' 59" West, a distance of 217.43 feet;

THENCE North 43° 42' 01" West, a distance of 217.20 feet;

THENCE North 01° 17' 59" East, a distance of 209.50 feet;

THENCE North 44° 04' 38" West, a distance of 10.00 feet;

THENCE South 45° 55' 22" West, a distance of 18.00 feet;

THENCE North 44° 04' 38" West, a distance of 45.00 feet;

THENCE South 45° 55' 22" West, a distance of 25.00 feet;

THENCE North 44° 04' 38" West, a distance of 293.00 feet;

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THENCE South 64° 48' 03" West, a distance of 119.90 feet to a point on a 325.00 foot radius curve to the left;

THENCE along said 325.00 foot radius curve to the left (the long chord of which bears South 50° 35' 01" West, a distance of 159.64 feet), an arc distance of 161.29 feet;

THENCE South 36° 21' 59" West, a distance of 152.00 feet;

THENCE South 53° 38' 01" East, a distance of 82.00 feet;

THENCE South 36° 21' 59" West, a distance of 60.08 feet to a point on a non-tangent 25.00 foot radius curve to the right and the TRUE POINT OF BEGINNING;

THENCE leaving said Westerly lines, and along said 25.00 foot radius curve to the right (the long chord of which bears South 55° 55' 31" East, a distance of 2.00 feet), an arc distance of 2.00 feet;

THENCE South 53° 38' 01" East, a distance of 171.47 feet to a point on a 345.00 foot radius curve to the right;

THENCE along said 345.00 foot radius curve to the right (the long chord of which bears South 36° 10' 39" East, a distance of 206.98 feet), an arc distance of 210.22 feet;

THENCE South 18° 43' 16" East, a distance of 89.02 feet to a point on the South line of said "Parcel 1";

THENCE along the Southerly lines of said "Parcel 1" the following courses:

THENCE South 60° 11' 05" West, a distance of 517.11 feet;

THENCE North 33° 35' 50" West, a distance of 116.84 feet;

THENCE South 56° 24' 10" West, a distance of 337.32 feet to a point on the Northeasterly right-of-way line of Northeast Ingle Road as conveyed to Clark County by deed recorded under Auditor's File Number 4217481 D, said point being 30.00 feet from, when measured perpendicular to, the centerline of said Road;

THENCE North 33° 35' 50" West, along said right-of-way line, a distance of 334.36 feet to a point on the Westerly line of said "Parcel 1";

THENCE along the Westerly lines of said "Parcel 1" the following courses:

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THENCE North 56° 38' 34" East, leaving said Northeasterly right-of-way line, a distance of 384.01 feet;

THENCE South 33° 21' 26" East, a distance of 10.00 feet;

THENCE North 56° 38' 34" East, a distance of 154.02 feet;

THENCE South 45° 33' 03" East, a distance of 41.94 feet to a point on a 174.00 foot radius curve to the right;

THENCE along said 174.00 foot radius curve to the right (the long chord of which bears South 41° 41' 00" East, a distance of 23.47 feet), an arc distance of 23.49 feet;

THENCE North 52° 11' 03" East, a distance of 52.78 feet to a point on a non-tangent 25.00 foot radius curve to the right;

THENCE along said 25.00 foot radius curve to the right (the long chord of which bears North 10° 50' 12" East, a distance of 27.68 feet), an arc distance of 29.33 feet;

THENCE North 44° 26' 57" East, a distance of 116.20 feet to a point on a 226.00 foot radius curve to the left;

THENCE along said 226.00 foot radius curve to the left (the long chord of which bears North 40° 24' 28" East, a distance of 31.86 feet), an arc distance of 31.88 feet;

THENCE North 36° 21' 59" East, a distance of 10.37 feet to a point on a 25.00 foot radius curve to the right, said point bears South 79° 04' 29" West, from the TRUE POINT OF BEGINNING;

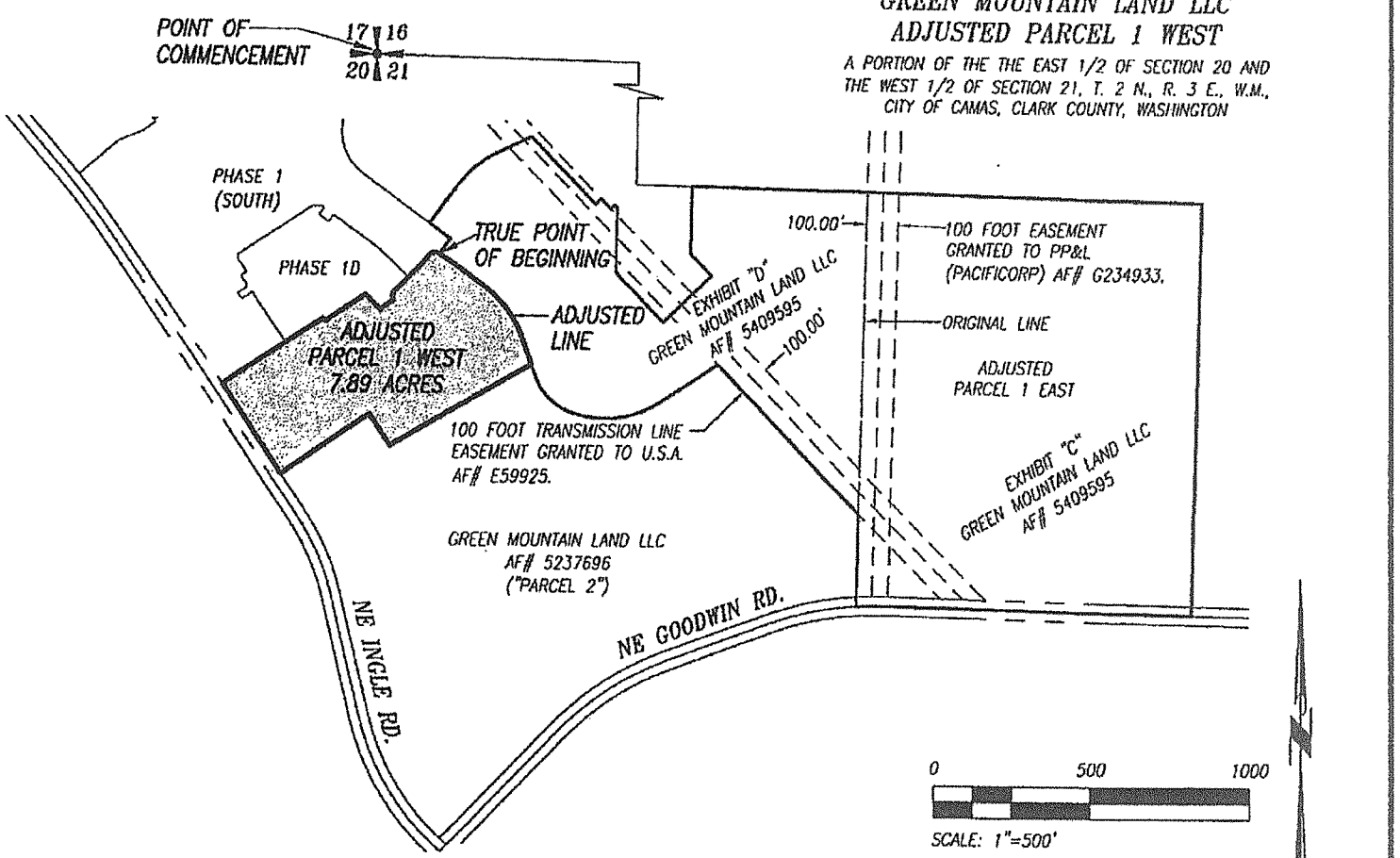
THENCE along said 25.00 foot radius curve (the long chord of which bears North 79° 04' 29" East, a distance of 33.91 feet), an arc distance of 37.27 feet to the TRUE POINT OF BEGINNING.

Containing 7.89 acres, more or less.


07/28/17

# SKETCH TO ACCOMPANY LEGAL DESCRIPTION FOR GREEN MOUNTAIN LAND LLC ADJUSTED PARCEL 1 WEST

A PORTION OF THE THE EAST 1/2 OF SECTION 20 AND THE WEST 1/2 OF SECTION 21, T. 2 N., R. 3 E., W.M., CITY OF CAMAS, CLARK COUNTY, WASHINGTON





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LEGAL DESCRIPTION FOR GREEN MOUNTAIN LAND LLC
PARCEL 2

June 21, 2016

A parcel of land in the Thomas J. Fletcher Donation Land Claim No. 51, the Northeast quarter of Section 20, and the Southeast quarter of Section 17 all in Township 2 North, Range 3 East of the Willamette Meridian in Clark County, Washington, described as follows:

COMMENCING at the Southeast corner of said Section 17;

THENCE North 01° 45' 46" East, along the East line of said Southeast quarter, 293.65 feet to the North line of Parcel 1 as described in Exhibit C of that Lot Segregation recorded under Auditor's File Number 5244964 BLA, records of Clark County, Washington and the TRUE POINT OF BEGINNING;

THENCE North 89° 08' 23" West, along said North line, 633.51 feet;

THENCE South 01° 45' 46" West, along said North line, 180.54 feet;

THENCE South 61° 08' 05" West, along said North line, 149.41 feet;

THENCE North 89° 08' 23" West, along said North line and the Westerly projection thereof, 406.50 feet to a point on the Northerly projection of the East line of that parcel of land conveyed to Ronald D. Warman and Rhonda Warman, husband and wife, by deed recorded under Auditor's File No. 9004270087, records of Clark County, Washington and the TRUE POINT OF BEGINNING;

THENCE South 89° 08' 23" East, along the Westerly projection of said North line, 60.01 feet to the most Westerly Northwest corner of said Parcel 1;

THENCE South 02° 04' 33" West, along the West line of said Parcel 1, a distance of 693.82 feet to the most Westerly Southwest corner thereof;

THENCE South 87° 55' 27" East, along the South line of said Parcel 1, a distance of 315.67 feet to an angle point;

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THENCE South 00° 12' 48" East, along the West line of said Parcel 1, a distance of 50.91 feet to an angle point on the Northwesterly line of New Tax Lot 12 as described in Exhibit D of that Lot Segregation recorded under Auditor's File No. 5229224 BLA, records of Clark County, Washington;

THENCE along the Northwesterly line of said Exhibit D parcel the following courses;

THENCE South 00° 12' 48" East, 326.26 feet;

THENCE South 72° 58' 30" East, 52.44 feet to a point on a 101.00 foot radius non-tangent curve the left;

THENCE along said 101.00 foot radius non-tangent curve to the left (the long chord of which bears South 13° 07' 19" East, 69.87 feet), an arc distance of 71.34 feet;

THENCE South 33° 21' 26" East, 48.91 feet;

THENCE South 55° 00' 30" West, 48.70 feet;

THENCE South 68° 07' 19" West, 86.89 feet;

THENCE South 49° 42' 41" West, 162.78 feet to a point on a 2030.00 foot radius non-tangent curve to the left, said point being on the Northeasterly right-of-way line of Northeast Ingle Road as conveyed to Clark County by deed recorded under Auditor's File No. 4217481 D, said point being 30.00 feet from, when measured perpendicular to, the centerline of said Northeast Ingle Road;

THENCE leaving said Northwesterly line, along said right-of-way line and said 2030.00 foot radius non-tangent curve to the left (the long chord of which bears North 40° 12' 15" West, 15.52 feet), an arc distance of 15.52 feet;

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THENCE North 40° 25' 24" West, along said right-of-way line, 353.90 feet to the East line of said Warman parcel;

THENCE North 02° 04' 33" East, along the East line of said Warman parcel and the Northerly projection thereof, a distance of 1092.13 feet to the TRUE POINT OF BEGINNING;

Contains 6.17 acres, more or less.


6/22/18

# SKETCH TO ACCOMPANY LEGAL DESCRIPTIONS FOR GREEN MOUNTAIN LAND LLC PARCELS 1 & 2

SE1/4 SECTION 17 & NE1/4 SECTION 20, T. 2 N., R. 3 E., W.M.,
CITY OF CAMAS, CLARK COUNTY, WASHINGTON

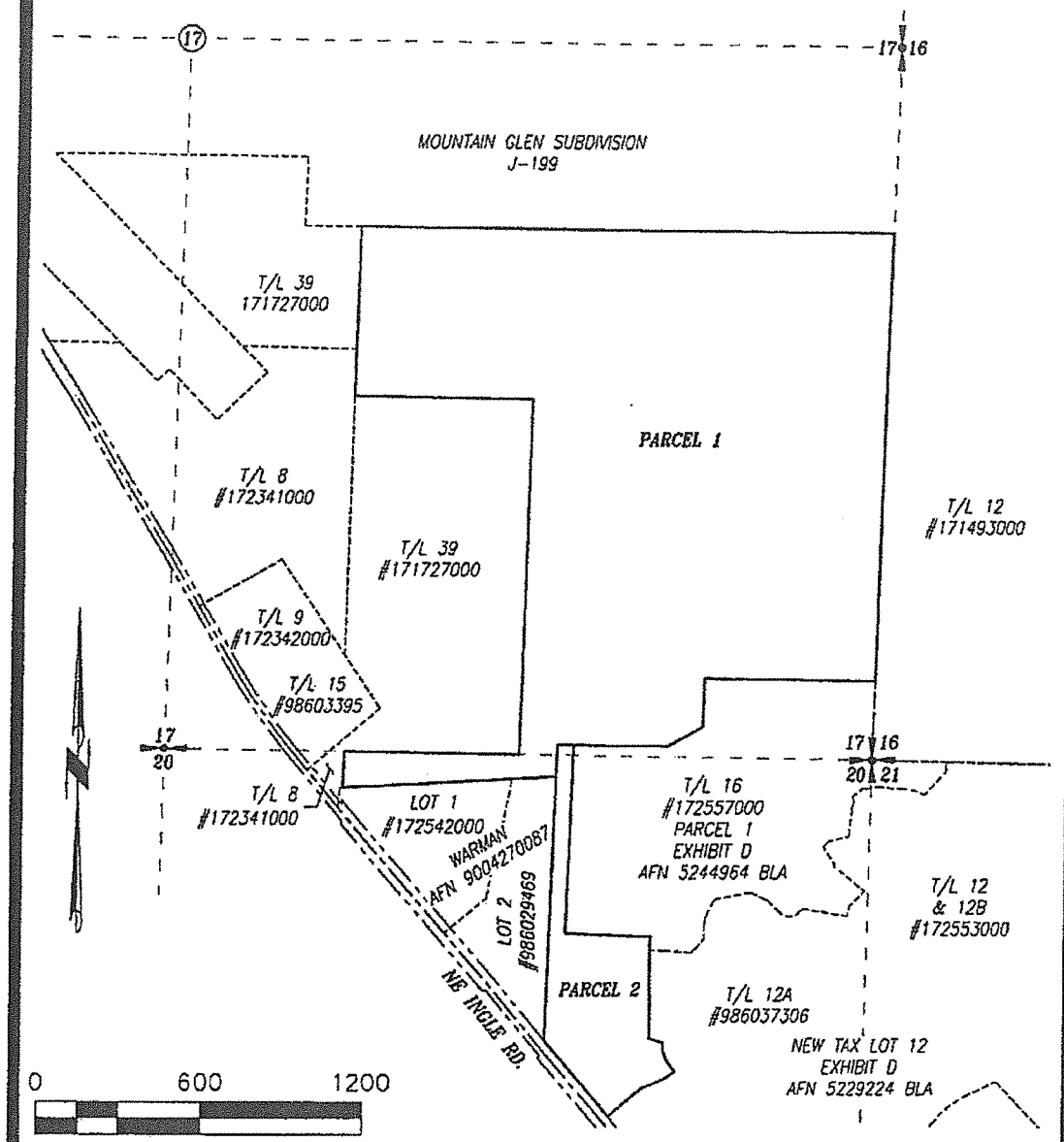



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EXHIBIT B
TO
OPTION AGREEMENT

(Legal description of the GML Property)

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# EXHIBIT B

## LEGAL DESCRIPTION FOR GREEN MOUNTAIN LAND LLC

December 10, 2015

A parcel of land in the Thomas J. Fletcher Donation Land Claim No. 51 and the East half of Section 20, and the West half of Section 21 all in Township 2 North, Range 3 East of the Willamette Meridian in Clark County, Washington, described as follows:

COMMENCING at the Northwest corner of said Section 21;

THENCE South 88° 40' 59" East, along the North line of the Northwest quarter of said Section 21, a distance of 830.93 feet to the East line of the Thomas J. Fletcher Donation Land Claim No. 51;

THENCE South 01° 13' 25" West, along said East line, a distance of 1315.09 feet to the North line of the South half of said Northwest quarter;

THENCE South 88° 42' 01" East, along said North line, a distance of 180.00 feet;

THENCE South 01° 17' 59" West, leaving said North line, a distance of 214.50 feet;

THENCE South 43° 42' 01" East, a distance of 97.00 feet;

THENCE South 46° 17' 59" West, a distance of 217.43 feet;

THENCE North 43° 42' 01" West, a distance of 217.20 feet;

THENCE North 01° 17' 59" East, a distance of 209.50 feet;

THENCE North 44° 04' 38" West, a distance of 10.00 feet;

THENCE South 45° 55' 22" West, a distance of 18.00 feet;

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THENCE North 44° 04' 38" West, a distance of 45.00 feet;

THENCE South 45° 55' 22" West, a distance of 25.00 feet;

THENCE North 44° 04' 38" West, a distance of 293.00 feet;

THENCE South 64° 48' 03" West, a distance of 119.90 feet to a point of a 325.00 foot radius curve to the left;

THENCE along said 325.00 foot radius curve to the left (the long chord of which bears South 50° 35' 01" West, a distance of 159.64 feet), an arc distance of 161.29 feet;

THENCE South 36° 21' 59" West, a distance of 152.00 feet;

THENCE South 53° 38' 01" East, a distance of 82.00 feet;

THENCE South 36° 21' 59" West, a distance of 60.08 feet to a point on a 25.00 foot radius non-tangent curve to the left;

THENCE along said 25.00 foot radius non-tangent curve to the left (the long chord of which bears South 79° 04' 29" West, a distance of 33.91 feet), an arc distance of 37.27 feet;

THENCE South 36° 21' 59" West, a distance of 10.37 feet to a point on a 226.00 foot radius curve to the right;

THENCE along said 226.00 foot radius curve to the right (the long chord of which bears South 40° 24' 28" West, a distance of 31.86 feet), an arc distance of 31.88 feet;

THENCE South 44° 26' 57" West, a distance of 116.20 feet to a point on a 25.00 foot radius curve to the left;

THENCE along said 25.00 radius curve to the left (the long chord of which bears South 10° 50' 12" West, a distance of 27.68 feet), an arc distance of 29.33 feet;

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THENCE South 52° 11' 03" West, a distance of 52.78 feet to a point on a 174.00 foot radius non-tangent curve to the left;

THENCE along said 174.00 foot radius non-tangent curve to the left (the long chord of which bears North 41° 41' 00" West, a distance of 23.47 feet), an arc distance of 23.49 feet;

THENCE North 45° 33' 03" West, a distance of 41.94 feet;

THENCE South 56° 38' 34" West, a distance of 154.02 feet;

THENCE North 33° 21' 26" West, a distance of 10.00 feet;

THENCE South 56° 38' 34" West, a distance of 384.01 feet to the Northeasterly right-of-way line of Northeast Ingle Road as conveyed to Clark County by deed recorded under Auditor's File Number 4217481 D, said point being 30.00 from, when measured perpendicular to, the centerline of said Road;

THENCE South 33° 35' 50" East, along said right-of-way line, a distance of 334.36 feet to the TRUE POINT OF BEGINNING;

THENCE North 56° 24' 10" East, leaving said right-of-way line, a distance of 337.32 feet;

THENCE South 33° 35' 50" East, a distance of 116.84 feet;

THENCE North 60° 11' 05" East, a distance of 517.11 feet;

THENCE South 18° 43' 16" East, a distance of 40.08 feet to a point on a 180.00 foot radius curve to the left;

THENCE along said 180.00 foot radius curve to the left (the long chord of which bears South 44° 53' 37" East, a distance of 158.79 feet), an arc distance of 164.45 feet to a point of compound curvature with a 330.00 foot radius curve to the left;

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THENCE along said 330.00 foot radius curve to the left (the long chord of which bears North 83° 01' 06" East, a distance of 288.45 feet), an arc distance of 298.52 feet;

THENCE North 57° 06' 11" East, a distance of 219.78 feet;

THENCE South 44° 04' 38" East, a distance of 645.44 feet;

THENCE South 01° 37' 56" West, a distance of 296.43 feet to a point on the centerline of Northeast Goodwin Road, said point being a point on a 955.00 foot radius non-tangent curve to the left;

THENCE along said centerline, and along said 955.00 foot radius non-tangent curve to the left (the long chord of which bears South 78° 15' 35" West, a distance of 277.41 feet), an arc distance of 278.40 feet;

THENCE South 69° 54' 30" West, along said centerline, a distance of 354.84 feet to a point on a 955.00 foot radius curve to the left;

THENCE along said centerline, and along said 955.00 foot radius curve to the left ( the long chord of which bears South 56° 56' 15" West, a distance of 428.71 feet), an arc distance of 432.40 feet;

THENCE South 43° 58' 00" West, along said centerline, a distance of 494.48 feet to a point of intersection with the Southerly projection of the Northeasterly right-of- way line of said Northeast Ingle Road, said point being 30.00 from, when measured perpendicular to, the centerline of said Road;

THENCE North 46° 15' 59" West, along said Northeasterly right-of-way line and the Southerly projection thereof, a distance of 39.01 feet to a point on a 770.00 foot radius curve to the right;

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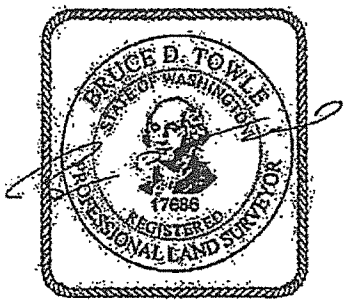
THENCE along said right-of-way line, and along said 770.00 foot radius curve to the right (the long chord of which bears North 29° 32' 51" West, a distance of 443.01 feet), an arc distance of 449.36 feet;

THENCE North 12° 49' 45" West, along said right-of-way line, a distance of 392.70 feet to a point on an 830.00 foot radius curve to the left;

THENCE along said right-of-way line, and along said 830.00 foot radius curve to the left (the long chord of which bears North 23° 12' 47" West, a distance of 299.21 feet), an arc distance of 300.85 feet;

THENCE North 33° 35' 50" West, along said right-of-way line, a distance of 129.00 feet to the TRUE POINT OF BEGINNING.

Contains 35.38 Acres, more or less.



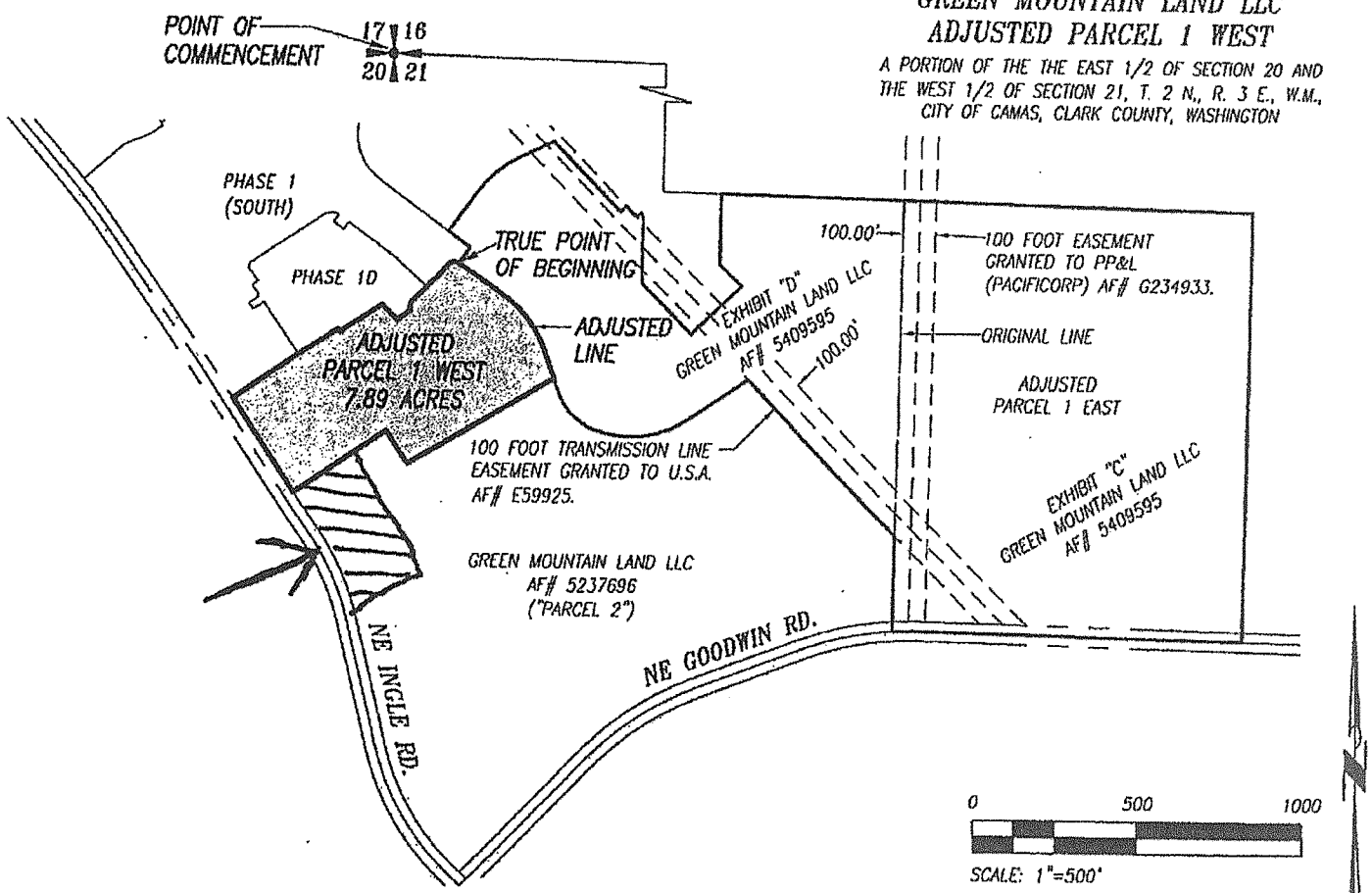

12/10/15

**EXHIBIT C**
**TO**
**OPTION AGREEMENT**

**(Depiction of the portion of the GML Property from which the Designated Property may be specified by AE)**

# SKETCH TO ACCOMPANY LEGAL DESCRIPTION FOR GREEN MOUNTAIN LAND LLC ADJUSTED PARCEL 1 WEST

A PORTION OF THE THE EAST 1/2 OF SECTION 20 AND THE WEST 1/2 OF SECTION 21, T. 2 N., R. 3 E., W.M., CITY OF CAMAS, CLARK COUNTY, WASHINGTON





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# Appendix II: Wet Pond Stormwater Management Design Information

## BMP T10.40 Combined Detention and Wetpool Facilities

### *Purpose and Definition*

Combined detention and WQ wetpool facilities have the appearance of a detention facility but contain a permanent pool of water as well. The following design procedures, requirements, and recommendations cover differences in the design of the stand-alone WQ facility when combined with detention storage. The following combined facilities are addressed:

- Detention/wetpond (basic and large)
- Detention/wetvault
- Detention/stormwater wetland.

There are two sizes of the combined wetpond, a basic and a large, but only a basic size for the combined wetvault and combined stormwater wetland. The facility sizes (basic and large) are related to the pollutant removal goals. See Chapter 3 for more information about treatment performance goals.

### *Applications and Limitations*

Combined detention and water quality facilities are very efficient for sites that also have detention requirements. The water quality facility may often be placed beneath the detention facility without increasing the facility surface area. However, the fluctuating water surface of the live storage will create unique challenges for plant growth and for aesthetics alike.

The basis for pollutant removal in combined facilities is the same as in the stand-alone WQ facilities. However, in the combined facility, the detention function creates fluctuating water levels and added turbulence. For simplicity, the positive effect of the extra live storage volume and the negative effect of increased turbulence are assumed to balance, and are thus ignored when sizing the wetpool volume. For the combined detention/stormwater wetland, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

Unlike the wetpool volume, the live storage component of the facility should be provided above the seasonal high water table.

### *Combined Detention and Wetpond (Basic and Large)*

Typical design details and concepts for a combined detention and wetpond are shown in Figures 10.9 and 10.10. The detention portion of the facility shall meet the design criteria and sizing procedures set forth in Volume 3.

**Sizing Procedure**

The sizing procedure for combined detention and wetponds are identical to those outlined for wetponds and for detention facilities. The wetpool volume for a combined facility shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91$^{st}$ percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used to size the wetpool. Follow the standard procedure specified in Volume III to size the detention portion of the pond.

**Detention and Wetpool Geometry**

- The wetpool and sediment storage volumes shall not be included in the required detention volume.
- The "Wetpool Geometry" criteria for wetponds (see BMP T10.10) shall apply with the following modifications/clarifications:

Criterion 1: The permanent pool may be made shallower to take up most of the pond bottom, or deeper and positioned to take up only a limited portion of the bottom. Note, however, that having the first wetpool cell at the inlet allows for more efficient sediment management than if the cell is moved away from the inlet. Wetpond criteria governing water depth must, however, still be met. See Figure 10.11 for two possibilities for wetpool cell placement.

Intent: This flexibility in positioning cells is provided to allow for multiple use options, such as volleyball courts in live storage areas in the drier months.

Criterion 2: The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with the detention sediment storage requirement.

**Berms, Baffles, and Slopes**

Same as for wetponds (see BMP T10.10).

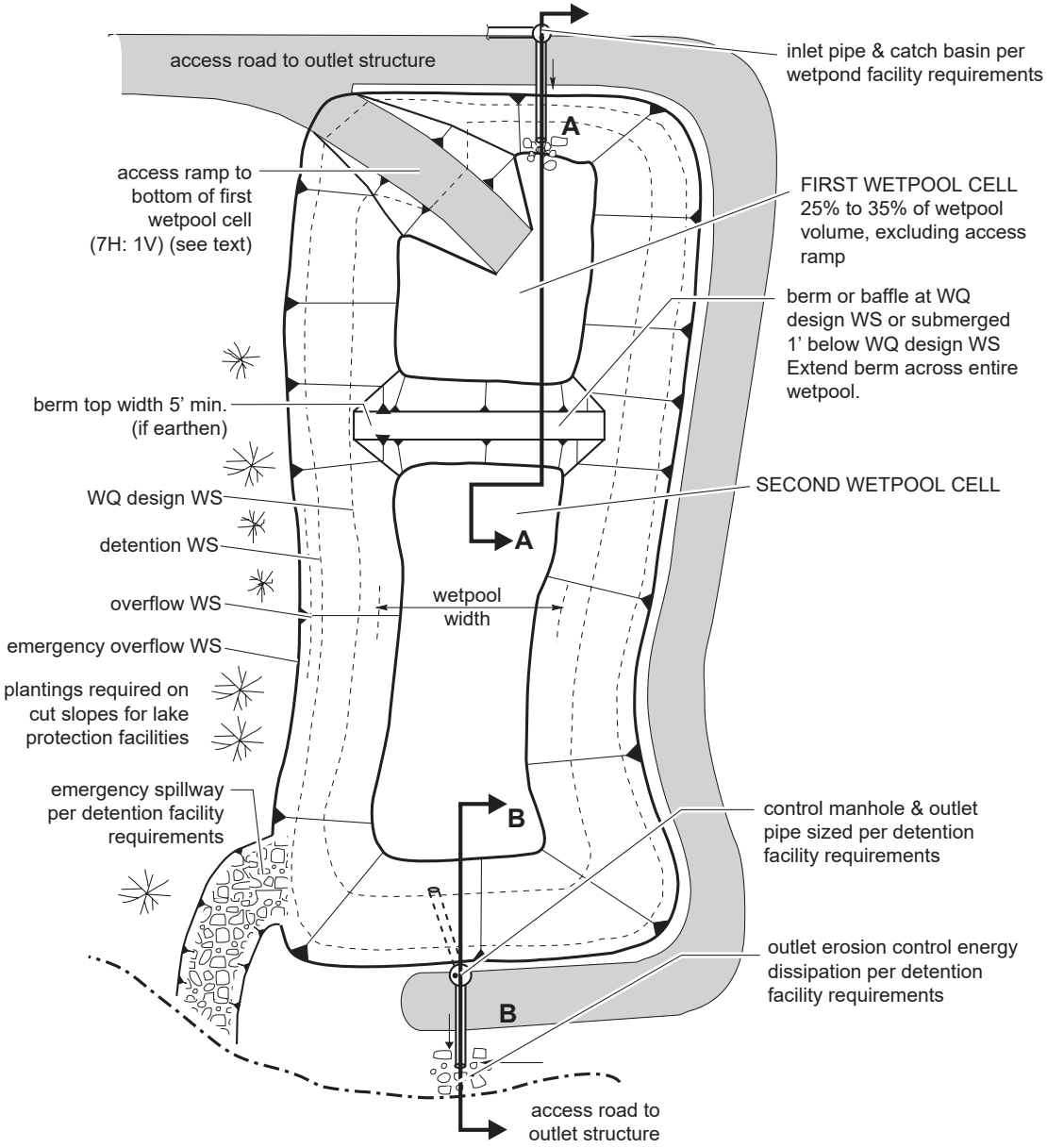
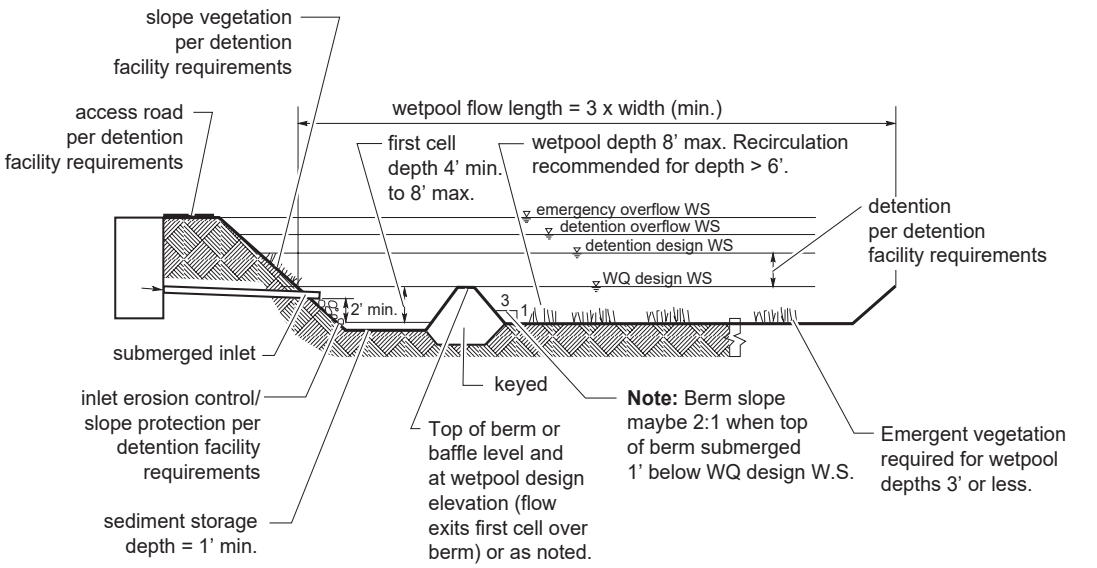
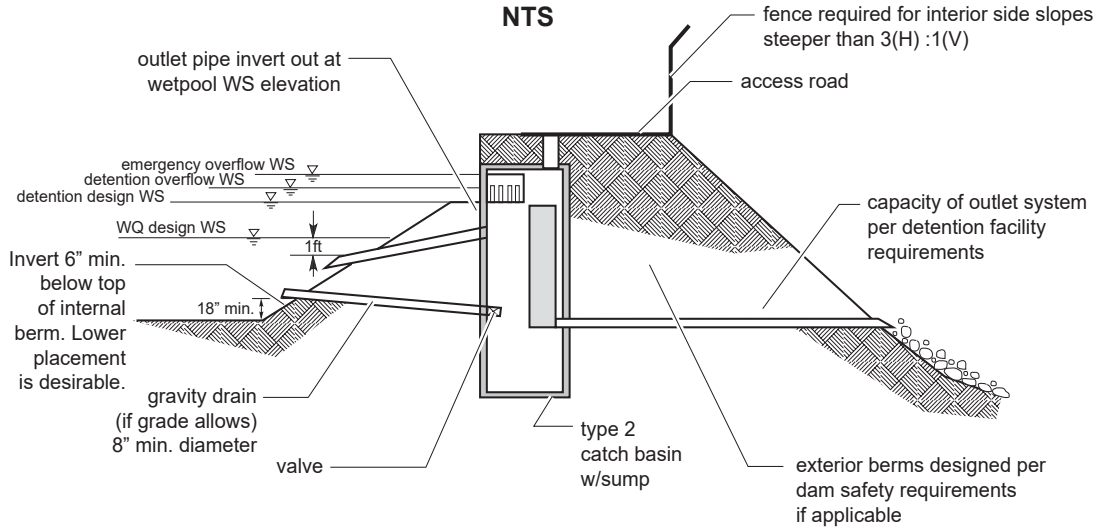



**Figure 10.9 – Combined Detention and Wetpond**



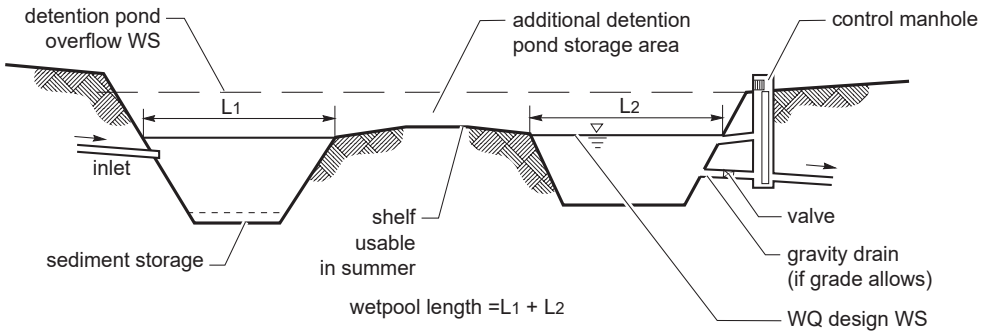

**SECTION A-A**
**NTS**



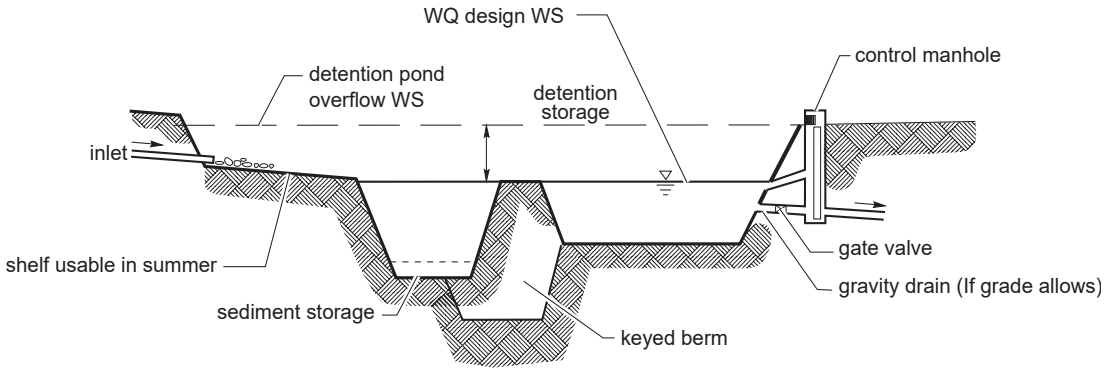

**Note:** See detention facility requirements for location, interior & exterior sideslopes, and setback requirements.

**SECTION B-B**
**NTS**

**Figure 10.10 – Combined Detention and Wetpond (Continued)**




**SECTION VIEW**
**NTS**




**SECTION VIEW**
**NTS**

**Note:** These examples show how the combined detention/wetpool can be configured to allow for "shelves" for joint use opportunities in dry weather. Other options may also be acceptable.

**Figure 10.11 – Alternative Configurations of Detention and Wetpool Areas**

**Inlet and Outlet**

The "Inlet and Outlet" criteria for wetponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined ponds.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Volume III).

**Access and Setbacks**

Same as for wetponds.

**Planting Requirements**

Same as for wetponds.

**Combined Detention and Wetvault**

The sizing procedure for combined detention and wetvaults is identical to those outlined for wetvaults and for detention facilities. The wetvault volume for a combined facility shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91$^{st}$ percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used to size the wetpool portion of vault. Follow the standard procedure specified in Volume 3 to size the detention portion of the vault.

The design criteria for detention vaults and wetvaults must both be met, except for the following modifications or clarifications:

- The minimum sediment storage depth in the first cell shall average 1-foot. The 6 inches of sediment storage required for detention vaults does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.
- The oil retaining baffle shall extend a minimum of 2 feet below the WQ design water surface.

Intent: The greater depth of the baffle in relation to the WQ design water surface compensates for the greater water level fluctuations experienced in the combined vault. The greater depth is deemed prudent to better ensure that separated oils remain within the vault, even during storm events.

*Note:* If a vault is used for detention as well as water quality control, the facility may not be modified to function as a baffle oil/water separator as allowed for wetvaults in BMP T10.20. This is because the added pool fluctuation in the combined vault does not allow for the quiescent conditions needed for oil separation.

**Combined Detention and Stormwater Wetland**

The sizing procedure for combined detention and stormwater wetlands is identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure specified in BMP T10.30 to determine the

stormwater wetland size. Follow the standard procedure specified in Volume III to size the detention portion of the wetland.

The design criteria for detention ponds and stormwater wetlands must both be met, except for the following modifications or clarifications:

- The "Wetland Geometry" criteria for stormwater wetlands (see BMP T10.30) are modified as follows:
- The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, nor does the 6 inches of sediment storage in the second cell of detention ponds need to be added.

Intent: Since emergent plants are limited to shallower water depths, the deeper water created before sediments accumulate is considered detrimental to robust emergent growth. Therefore, sediment storage is confined to the first cell which functions as a presettling cell.

The "Inlet and Outlet" criteria for wetponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined facilities.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Volume III).

  The "Planting Requirements" for stormwater wetlands are modified to use the following plants which are better adapted to water level fluctuations:

  | | |
  |---|---|
  | Scirpus acutus (hardstem bulrush) | 2 - 6' depth |
  | Scirpus microcarpus (small-fruited bulrush) | 1 - 2.5' depth |
  | Sparganium emersum (burreed) | 1 - 2' depth |
  | Sparganium eurycarpum (burreed) | 1 - 2' depth |
  | Veronica sp. (marsh speedwell) | 0 - 1' depth |

  In addition, the shrub Spirea douglasii (Douglas spirea) may be used in combined facilities.

  Water Level Fluctuation Restrictions: The difference between the WQ design water surface and the maximum water surface associated with the 2-year runoff shall not be greater than 3 feet. If this restriction cannot be met, the size of the stormwater wetland must be increased. The additional area may be placed in the first cell, second cell, or both. If placed in the second cell, the additional area need not be planted with wetland vegetation or counted in calculating the average depth.

Intent: This criterion is designed to dampen the most extreme water level fluctuations expected in combined facilities to better ensure that fluctuation-tolerant wetland plants will be able to survive in the facility. It is not intended to protect native wetland plant communities and is not to be applied to natural wetlands.

## BMP T10.40 Combined Detention and Wetpool Facilities

### *Purpose and Definition*

Combined detention and WQ wetpool facilities have the appearance of a detention facility but contain a permanent pool of water as well. The following design procedures, requirements, and recommendations cover differences in the design of the stand-alone WQ facility when combined with detention storage. The following combined facilities are addressed:

- Detention/wetpond (basic and large)
- Detention/wetvault
- Detention/stormwater wetland.

There are two sizes of the combined wetpond, a basic and a large, but only a basic size for the combined wetvault and combined stormwater wetland. The facility sizes (basic and large) are related to the pollutant removal goals. See Chapter 3 for more information about treatment performance goals.

### *Applications and Limitations*

Combined detention and water quality facilities are very efficient for sites that also have detention requirements. The water quality facility may often be placed beneath the detention facility without increasing the facility surface area. However, the fluctuating water surface of the live storage will create unique challenges for plant growth and for aesthetics alike.

The basis for pollutant removal in combined facilities is the same as in the stand-alone WQ facilities. However, in the combined facility, the detention function creates fluctuating water levels and added turbulence. For simplicity, the positive effect of the extra live storage volume and the negative effect of increased turbulence are assumed to balance, and are thus ignored when sizing the wetpool volume. For the combined detention/stormwater wetland, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

Unlike the wetpool volume, the live storage component of the facility should be provided above the seasonal high water table.

### *Combined Detention and Wetpond (Basic and Large)*

Typical design details and concepts for a combined detention and wetpond are shown in Figures 10.9 and 10.10. The detention portion of the facility shall meet the design criteria and sizing procedures set forth in Volume 3.

**Sizing Procedure**

The sizing procedure for combined detention and wetponds are identical to those outlined for wetponds and for detention facilities. The wetpool volume for a combined facility shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91$^{st}$ percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used to size the wetpool. Follow the standard procedure specified in Volume III to size the detention portion of the pond.

**Detention and Wetpool Geometry**

- The wetpool and sediment storage volumes shall not be included in the required detention volume.
- The "Wetpool Geometry" criteria for wetponds (see BMP T10.10) shall apply with the following modifications/clarifications:

Criterion 1: The permanent pool may be made shallower to take up most of the pond bottom, or deeper and positioned to take up only a limited portion of the bottom. Note, however, that having the first wetpool cell at the inlet allows for more efficient sediment management than if the cell is moved away from the inlet. Wetpond criteria governing water depth must, however, still be met. See Figure 10.11 for two possibilities for wetpool cell placement.

Intent: This flexibility in positioning cells is provided to allow for multiple use options, such as volleyball courts in live storage areas in the drier months.

Criterion 2: The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with the detention sediment storage requirement.

**Berms, Baffles, and Slopes**

Same as for wetponds (see BMP T10.10).

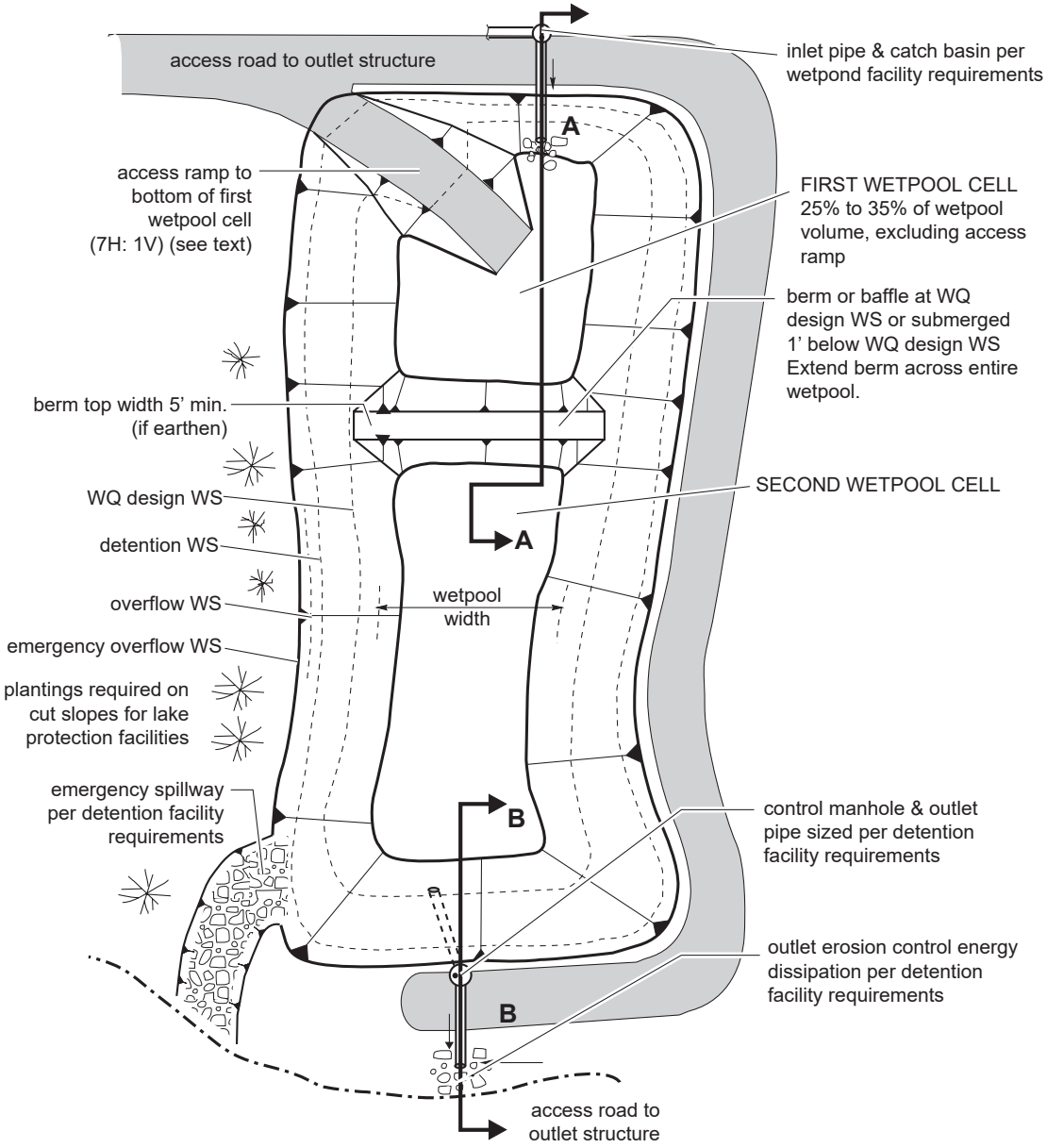



**Figure 10.9 – Combined Detention and Wetpond**

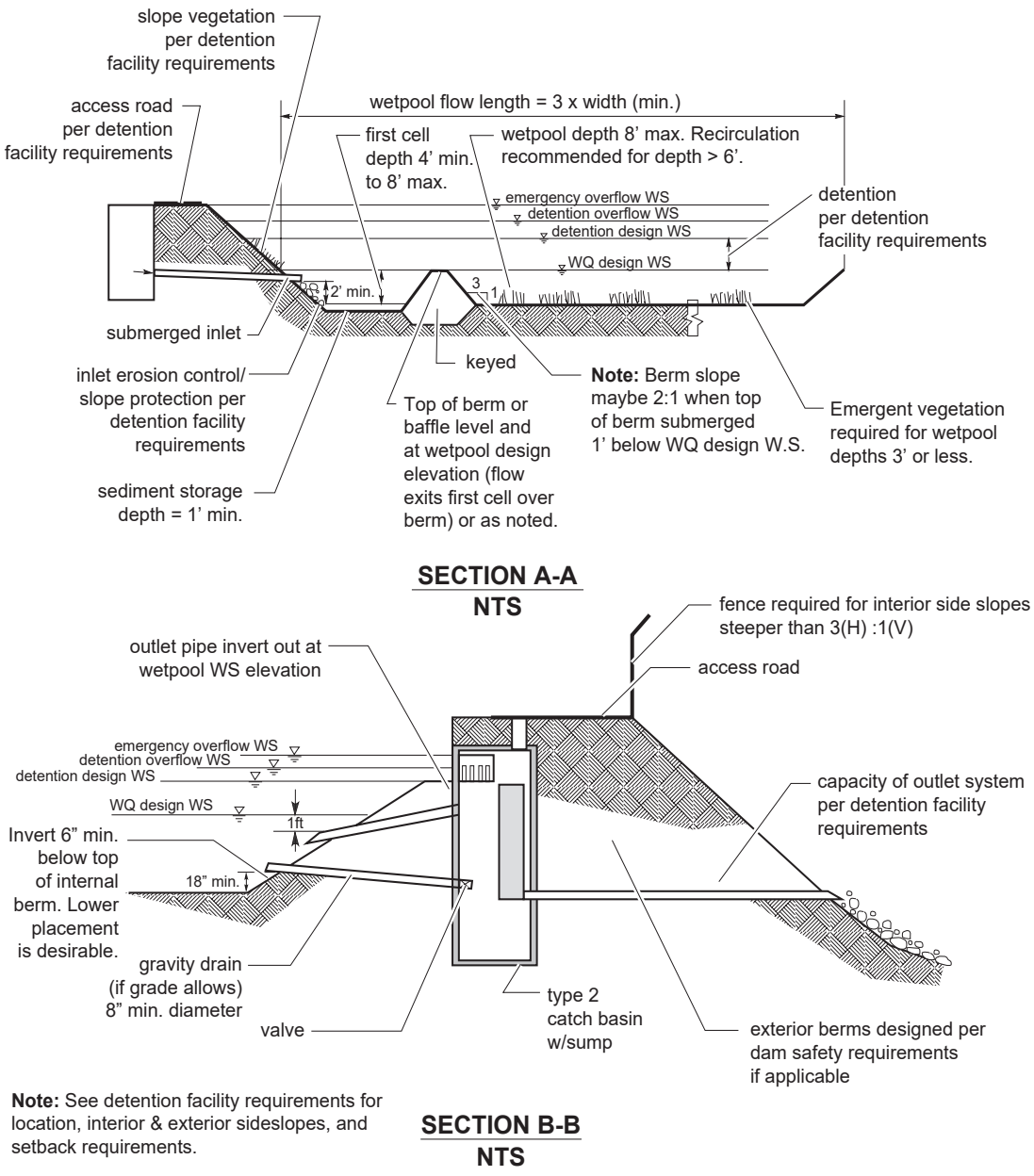
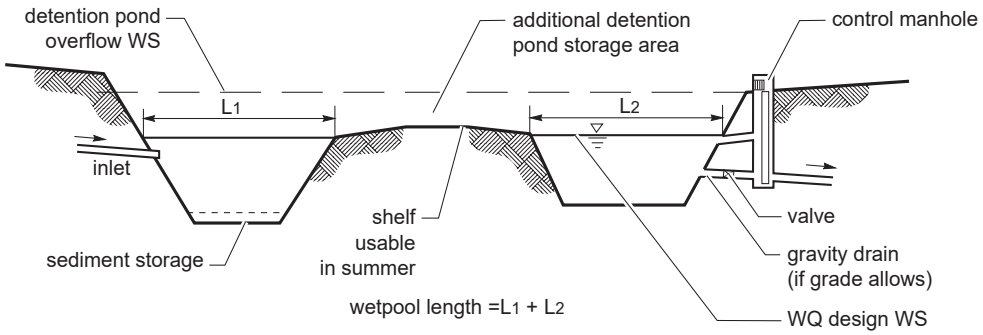
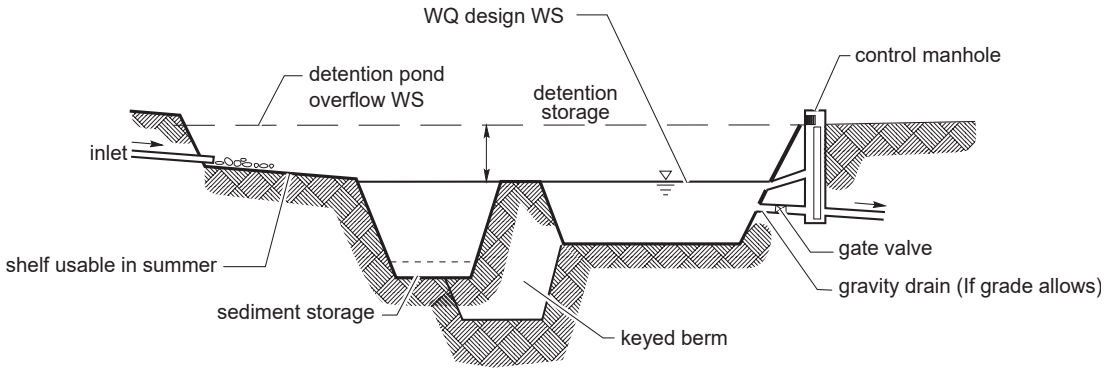



**Figure 10.10 – Combined Detention and Wetpond (Continued)**




**SECTION VIEW**
**NTS**




**SECTION VIEW**
**NTS**

**Note:** These examples show how the combined detention/wetpool can be configured to allow for "shelves" for joint use opportunities in dry weather. Other options may also be acceptable.

**Figure 10.11 – Alternative Configurations of Detention and Wetpool Areas**

**Inlet and Outlet**

The "Inlet and Outlet" criteria for wetponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined ponds.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Volume III).

**Access and Setbacks**

Same as for wetponds.

**Planting Requirements**

Same as for wetponds.

**Combined Detention and Wetvault**

The sizing procedure for combined detention and wetvaults is identical to those outlined for wetvaults and for detention facilities. The wetvault volume for a combined facility shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, the 91$^{st}$ percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used to size the wetpool portion of vault. Follow the standard procedure specified in Volume 3 to size the detention portion of the vault.

The design criteria for detention vaults and wetvaults must both be met, except for the following modifications or clarifications:

- The minimum sediment storage depth in the first cell shall average 1-foot. The 6 inches of sediment storage required for detention vaults does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.
- The oil retaining baffle shall extend a minimum of 2 feet below the WQ design water surface.

Intent: The greater depth of the baffle in relation to the WQ design water surface compensates for the greater water level fluctuations experienced in the combined vault. The greater depth is deemed prudent to better ensure that separated oils remain within the vault, even during storm events.

*Note:* If a vault is used for detention as well as water quality control, the facility may not be modified to function as a baffle oil/water separator as allowed for wetvaults in BMP T10.20. This is because the added pool fluctuation in the combined vault does not allow for the quiescent conditions needed for oil separation.

**Combined Detention and Stormwater Wetland**

The sizing procedure for combined detention and stormwater wetlands is identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure specified in BMP T10.30 to determine the

stormwater wetland size. Follow the standard procedure specified in Volume III to size the detention portion of the wetland.

The design criteria for detention ponds and stormwater wetlands must both be met, except for the following modifications or clarifications:

- The "Wetland Geometry" criteria for stormwater wetlands (see BMP T10.30) are modified as follows:
- The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, nor does the 6 inches of sediment storage in the second cell of detention ponds need to be added.

Intent: Since emergent plants are limited to shallower water depths, the deeper water created before sediments accumulate is considered detrimental to robust emergent growth. Therefore, sediment storage is confined to the first cell which functions as a presettling cell.

The "Inlet and Outlet" criteria for wetponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined facilities.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Volume III).

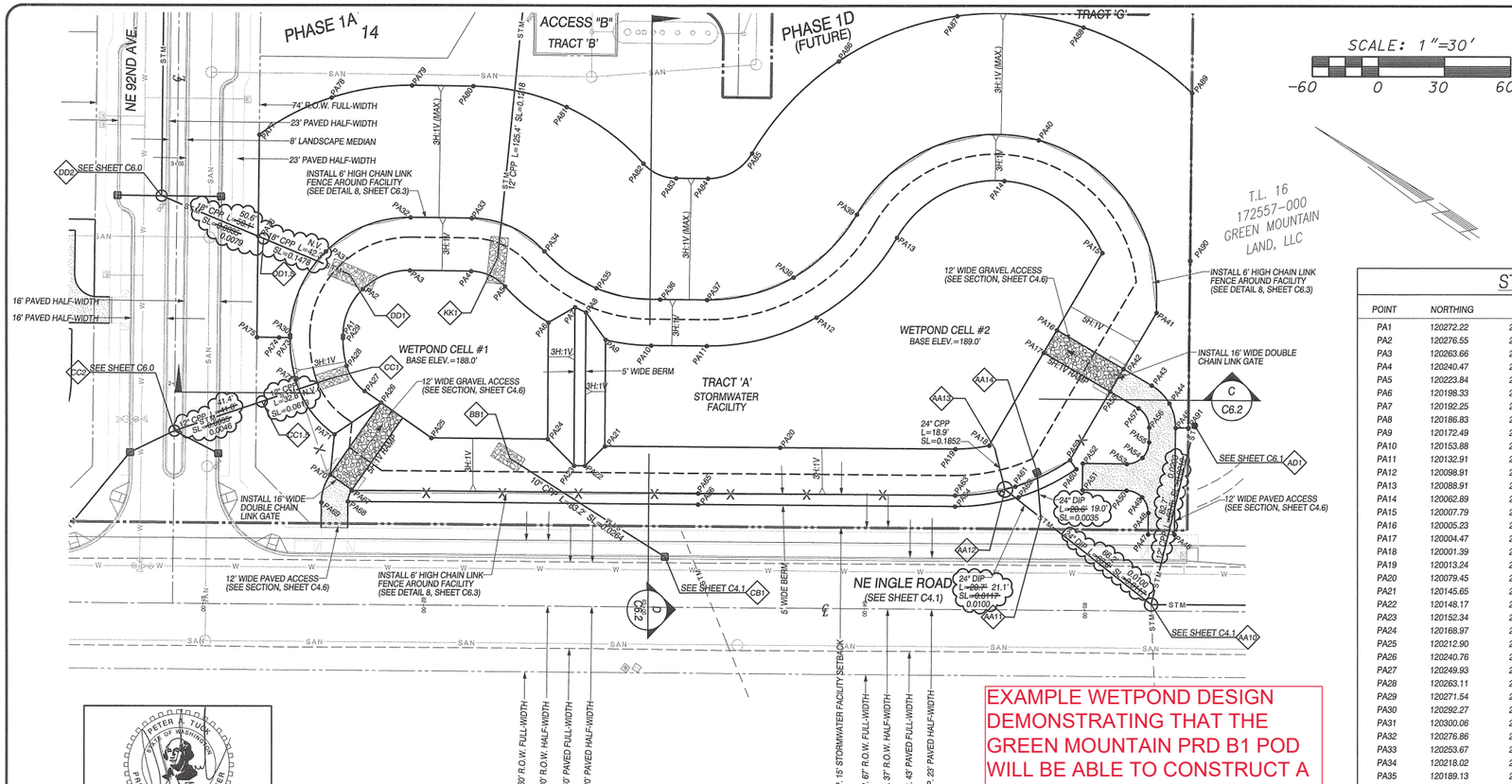
  The "Planting Requirements" for stormwater wetlands are modified to use the following plants which are better adapted to water level fluctuations:

  | | |
  |---|---|
  | Scirpus acutus (hardstem bulrush) | 2 - 6' depth |
  | Scirpus microcarpus (small-fruited bulrush) | 1 - 2.5' depth |
  | Sparganium emersum (burreed) | 1 - 2' depth |
  | Sparganium eurycarpum (burreed) | 1 - 2' depth |
  | Veronica sp. (marsh speedwell) | 0 - 1' depth |

  In addition, the shrub Spirea douglasii (Douglas spirea) may be used in combined facilities.

  Water Level Fluctuation Restrictions: The difference between the WQ design water surface and the maximum water surface associated with the 2-year runoff shall not be greater than 3 feet. If this restriction cannot be met, the size of the stormwater wetland must be increased. The additional area may be placed in the first cell, second cell, or both. If placed in the second cell, the additional area need not be planted with wetland vegetation or counted in calculating the average depth.

Intent: This criterion is designed to dampen the most extreme water level fluctuations expected in combined facilities to better ensure that fluctuation-tolerant wetland plants will be able to survive in the facility. It is not intended to protect native wetland plant communities and is not to be applied to natural wetlands.




SCALE: 1"=30'

-60 0 30 60

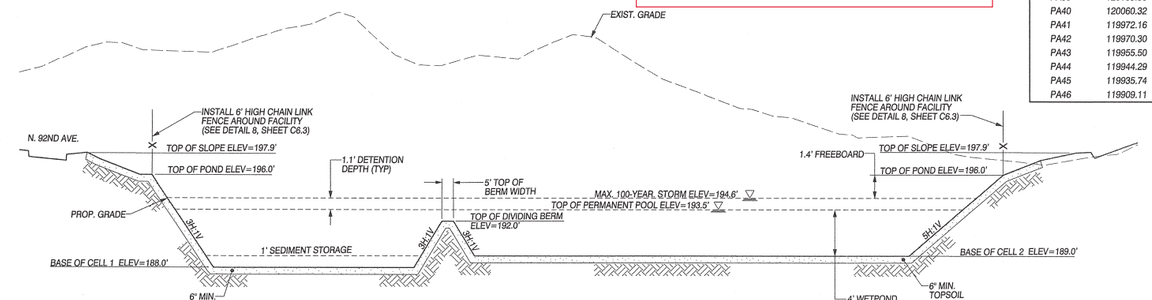
EXAMPLE WETPOND DESIGN DEMONSTRATING THAT THE GREEN MOUNTAIN PRD B1 POD WILL BE ABLE TO CONSTRUCT A SIMILAR FACILITY WITHIN 1-ACRE OF OFF-SITE PROPERTY

*STORMWATER FACILITY CONSTRUCTION NOTES:*

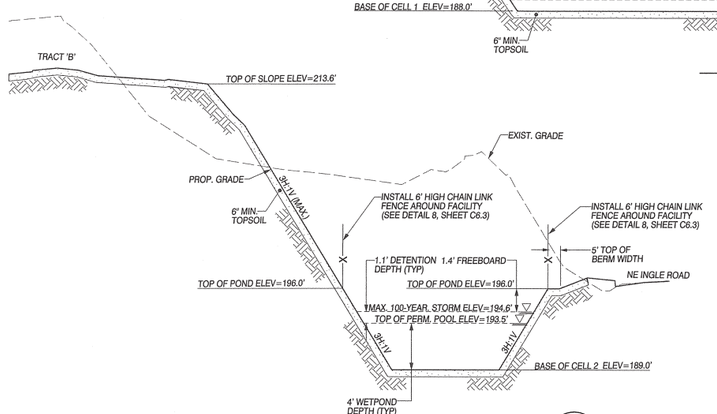
1) *THE STORMWATER DRAINAGE FACILITY SHALL BE OWNED AND MAINTAINED BY THE H.O.A. WITH AN EASEMENT DEDICATED TO THE CITY OF CAMAS FOR ACCESS AND INSPECTION.*
2) *THE CONTRACTOR SHALL ENSURE THAT ALL EROSION CONTROL MEASURES ARE IN PLACE AND IN WORKING CONDITION PRIOR TO COMMENCEMENT OF DRAINAGE FACILITY CONSTRUCTION.*
3) *POND GRADING AND SEEDING SHALL OCCUR AS SOON AS POSSIBLE. ONCE SEEDED THE AREA SHALL BE WATERED AS REQUIRED TO GERMINATE AND MAINTAIN A HEALTHY GROWTH OF GRASS.*
4) *VEGETATION FOR THE FACILITY SHOULD BE A SEED MIX CONSISTING OF:*
   *30% CHATEAU KENTUCKY BLUEGRASS*
   *40% COCHISE TURF, TALL FESCUE TYPE*
   *30% DELAWARE DWARF PERENNIAL RYEGRASS*
   *PREPARE GROUND, SEEDING RATE, FERTILIZER, AND MULCHING AS PER THE MANUFACTURER'S RECOMMENDATIONS.*
5) *A 6 FOOT HIGH BLACK VINYL-COATED CYCLONE FENCE OR APPROVED EQUAL SHALL BE INSTALLED AROUND THE PERIMETER OF THE DRAINAGE FACILITY AND A STANDARD 16 FOOT WIDE GATE SHALL BE INSTALLED FOR POND ACCESS.*

## STORMWATER FACILITY STAKING TABLE

| POINT | NORTHING | EASTING | ELEV. | POINT | NORTHING | EASTING | ELEV. |
|---|---|---|---|---|---|---|---|
| PA1 | 120272.22 | 2499619.49 | 188.02 | PA47 | 119919.10 | 2499749.11 | 197.86 |
| PA2 | 120276.55 | 2499642.04 | 188.00 | PA48 | 119924.49 | 2499757.30 | 197.86 |
| PA3 | 120263.66 | 2499661.04 | 188.00 | PA49 | 119930.83 | 2499761.60 | 197.73 |
| PA4 | 120240.47 | 2499676.31 | 188.00 | PA50 | 119938.34 | 2499760.15 | 197.41 |
| PA5 | 120223.84 | 2499679.14 | 188.00 | PA51 | 119955.05 | 2499749.16 | 196.50 |
| PA6 | 120198.33 | 2499676.53 | 188.00 | PA52 | 119961.65 | 2499759.18 | 196.50 |
| PA7 | 120192.25 | 2499689.07 | 192.00 | PA53 | 119944.94 | 2499770.18 | 197.41 |
| PA8 | 120186.83 | 2499689.95 | 192.00 | PA54 | 119940.65 | 2499776.51 | 197.65 |
| PA9 | 120172.49 | 2499684.62 | 189.00 | PA55 | 119942.09 | 2499784.03 | 197.86 |
| PA10 | 120153.88 | 2499693.99 | 189.00 | PA56 | 119945.76 | 2499789.60 | 197.86 |
| PA11 | 120132.91 | 2499707.92 | 189.00 | PA57 | 119954.74 | 2499794.09 | 197.34 |
| PA12 | 120098.91 | 2499746.56 | 189.00 | PA58 | 119969.54 | 2499793.15 | 196.00 |
| PA13 | 120088.91 | 2499797.04 | 189.00 | PA59 | 119967.28 | 2499757.22 | 196.00 |
| PA14 | 120062.89 | 2499845.65 | 189.00 | PA60 | 119962.62 | 2499755.39 | 196.00 |
| PA15 | 120007.79 | 2499843.53 | 189.00 | PA61 | 119981.18 | 2499733.32 | 196.00 |
| PA16 | 120005.23 | 2499802.93 | 189.00 | PA62 | 119977.29 | 2499730.18 | 196.00 |
| PA17 | 120004.47 | 2499790.95 | 189.00 | PA63 | 120001.62 | 2499714.70 | 196.00 |
| PA18 | 120001.39 | 2499742.11 | 189.00 | PA64 | 119998.85 | 2499710.54 | 196.00 |
| PA19 | 120013.24 | 2499732.19 | 189.00 | PA65 | 120098.70 | 2499650.21 | 196.00 |
| PA20 | 120079.45 | 2499688.21 | 189.00 | PA66 | 120095.93 | 2499646.05 | 196.00 |
| PA21 | 120145.65 | 2499644.23 | 189.00 | PA67 | 120229.59 | 2499563.26 | 196.00 |
| PA22 | 120148.17 | 2499631.75 | 192.00 | PA68 | 120228.19 | 2499558.18 | 196.00 |
| PA23 | 120152.34 | 2499628.98 | 192.00 | PA69 | 120237.91 | 2499551.11 | 196.00 |
| PA24 | 120168.97 | 2499632.34 | 188.00 | PA70 | 120241.58 | 2499663.73 | 196.00 |
| PA25 | 120212.90 | 2499603.16 | 188.00 | PA71 | 120250.42 | 2499579.92 | 196.00 |
| PA26 | 120240.76 | 2499603.73 | 188.00 | PA72 | 120278.65 | 2499590.63 | 196.00 |
| PA27 | 120249.93 | 2499603.91 | 188.00 | PA73 | 120291.59 | 2499605.25 | 196.00 |
| PA28 | 120263.11 | 2499608.91 | 188.00 | PA74 | 120295.76 | 2499602.50 | 196.00 |
| PA29 | 120271.54 | 2499618.45 | 188.00 | PA75 | 120304.12 | 2499597.01 | 197.65 |
| PA30 | 120292.27 | 2499606.29 | 196.00 | PA76 | 120329.41 | 2499635.42 | 201.52 |
| PA31 | 120300.06 | 2499646.88 | 196.00 | PA77 | 120354.70 | 2499673.84 | 206.58 |
| PA32 | 120276.86 | 2499681.09 | 196.00 | PA78 | 120336.98 | 2499706.20 | 210.29 |
| PA33 | 120253.67 | 2499696.35 | 196.00 | PA79 | 120309.85 | 2499731.20 | 213.11 |
| PA34 | 120218.02 | 2499702.42 | 196.00 | PA80 | 120286.66 | 2499746.47 | 215.03 |
| PA35 | 120189.13 | 2499701.73 | 196.00 | PA81 | 120246.31 | 2499782.32 | 215.06 |
| PA36 | 120162.71 | 2499713.44 | 196.00 | PA82 | 120202.99 | 2499760.51 | 213.95 |
| PA37 | 120144.53 | 2499725.41 | 196.00 | PA83 | 120186.99 | 2499763.23 | 212.46 |
| PA38 | 120117.75 | 2499755.86 | 196.00 | PA84 | 120174.96 | 2499771.23 | 211.90 |
| PA39 | 120109.86 | 2499795.63 | 196.00 | PA85 | 120164.74 | 2499791.93 | 211.86 |
| PA40 | 120060.32 | 2499869.72 | 196.00 | PA86 | 120155.60 | 2499848.75 | 212.34 |
| PA41 | 119972.16 | 2499834.77 | 196.02 | PA87 | 120122.49 | 2499895.82 | 213.57 |
| PA42 | 119970.30 | 2499805.13 | 196.00 | PA88 | 120072.11 | 2499923.63 | 213.12 |
| PA43 | 119955.50 | 2499806.06 | 197.03 | PA89 | 120014.64 | 2499926.56 | 209.51 |
| PA44 | 119944.29 | 2499803.79 | 197.91 | PA90 | 119972.77 | 2499862.97 | 198.78 |
| PA45 | 119935.74 | 2499796.20 | 197.92 | PA91 | 119930.91 | 2499799.38 | 197.97 |
| PA46 | 119909.11 | 2499755.75 | 197.92 | | | | |




TRACT "A" WETPOND SECTION — NTS — C6.2




TRACT "A" WETPOND SECTION — NTS — D C6.2

*NOTE:*
*THE ENGINEER HAS PERFORMED AN AS-BUILT INSPECTION OF THE FACILITIES AND VERIFIED THAT, AS CONSTRUCTED, THE FACILITIES MEET THE DESIGN CRITERIA PER THE STORM WATER REPORT FOR STORM WATER TREATMENT AND DETENTION REQUIREMENTS OF THE SITE*

*NOTE:*
*ALL STREET NAME DIRECTIONAL DESIGNATIONS INCLUDED IN THIS PLAN SET ARE TO BE N. RATHER THAN N.E.*

## STORM SEWER NOTES

- AA10 — *SEE SHEET C4.1*
- AA11 — *STA 64+79.54 (42.15' LT-NE INGLE ROAD) INSTALL: (1) 18" - 45° WYE IE=193.30*
- AA12 — *STA 64+63.17 (54.87' LT-NE INGLE ROAD) INSTALL 72" STORM SEWER FLOW CONTROL MH. (SEE DETAIL 3, SHEET C6.3)*
- AA13 — *STA 64+58.45 (73.21' LT-NE INGLE ROAD) INSTALL 24" PIPE OUTLET WITH DEBRIS BARRIER. IE=190.00 (SEE DETAIL 6, SHEET C6.3)*
- AA14 — *STA 64+77.71 (62.64' LT-NE INGLE ROAD) INSTALL EMERGENCY OVERFLOW DITCH INLET RIM=195.00 IE=193.38 (SEE DETAIL SD6, SHEET C9.8)*
- BB1 — *STA 62+38.45 (67.00' LT-NE INGLE RD) INSTALL 10" OUTFALL W/ HAND-PLACED RIP RAP. (SEE DETAIL 5, SHEET C6.3)*
- CC1 — *STA 2+02.92 (70.43' RT-NE 92ND AVE.) INSTALL 12" OUTFALL W/ HAND-PLACED RIP RAP. (SEE DETAIL 5, SHEET C6.3)*
- CC1.5 — *STA 1+92.16 (39.50' RT-NE 92ND AVE.) INSTALL STD. STORM SEWER MH.*
- DD1 — *STA 2+50.61 (78.71' RT-NE 92ND AVE.) INSTALL 18" OUTFALL W/ HAND-PLACED RIP RAP. (SEE DETAIL 5, SHEET C6.3)*
- DD1.5 — *STA 2+66.44 (39.50' RT-N 92ND AVE) INSTALL STD. STORM SEWER MH.*
- KK1 — *STA 1+74.86 (125.33' LT-NE 92ND AVE.) INSTALL 12" OUTFALL W/ HAND-PLACED RIP RAP. (SEE DETAIL 5, SHEET C6.3)*

THIS STAMP APPLIES TO THE HORIZONTAL AND VERTICAL ASBUILT INFORMATION SHOWN ON THIS SHEET ONLY BY ( ) FOR:

A N/A

- [X] GRADING
- [X] STORM SEWER
- [X] SANITARY SEWER
- [X] WATER

[X] LOCATIONS FOR WATER VALVES, SERVICES AND FIRE HYDRANTS CONFIRMED BY VISUAL INSPECTION

PETER A. TUCK — STATE OF WASHINGTON — 19917 — REGISTERED PROFESSIONAL ENGINEER

3/16/16

J:\data\8000\8900\8930\8938\Engineering\Final\Phases 1A & 1B\Sheets\ASBUILTS\8938.e.ASBUILT.C6.2.storm facility A.dgn
M:\Microstation V8\pen tables\OCE table setup\OCE stormpond.tbl

ASBUILTS

CLIENT:
GREEN MOUNTAIN LAND, LLC
17933 NW EVERGREEN PARKWAY, SUITE 300
BEAVERTON, OR 97006
ATTN: JOHN O'NEIL
PH: (503) 597-7100
FAX: (503) 597-7149
EMAIL: johno@metlandgroup.com

TRACT "A" STORMWATER FACILITY PLAN AND SECTIONS FOR:
GREEN MOUNTAIN MIXED USE P.R.D.
PHASES 1A & 1B

OLSON ENGINEERING INC. — LAND SURVEYORS — ENGINEERS — 222 E. EVERGREEN BLVD., VANCOUVER, WA 98660 — 360-695-1385 — 503-339-9936

PETER A. TUCK — STATE OF WASHINGTON — 19917 — REGISTERED PROFESSIONAL ENGINEER

3/16/16

CHANGES / REVISIONS

| DESCRIPTION: | DATE: |
|---|---|
| STREET NAMES | 6/17/16 |
| STORM SEWER DEPTH | 7/22/16 |
| FENCE HEIGHT | 8/16/16 |

DESIGNED: RWP
DRAWN: RWP
CHECKED: PAT
DATE: MARCH 2016
SCALE: H: 1"=30' V:

GREEN MOUNTAIN MIXED USE P.R.D. PHASES 1A & 1B
8938.01.02

SHEET
C6.2

**Appendix III: Geotechnical Report**

Real-World Geotechnical Solutions
Investigation • Design • Construction Support

Revised December 3, 2014
Project No. 13-3186

**John O'Neil**
**Metropolitan Land Group, LLC**
17933 NW Evergreen Parkway, Suite 300
Beaverton, Oregon 97006

**SUBJECT: PRELIMINARY GEOTECHNICAL ENGINEERING REPORT**
**GREEN MOUNTAIN - PHASE 1**
**NE INGLE ROAD & NE 28TH STREET**
**CAMAS, WASHINGTON**

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 and to provide geotechnical recommendations for site development. This geotechnical study was performed in accordance with GeoPacific Proposal No. P-4836, dated April 30, 2014, and your subsequent authorization of our proposal and *General Conditions for Geotechnical Services*. This report is considered Preliminary because a final grading plan has not been developed.

## SITE DESCRIPTION AND PROPOSED DEVELOPMENT

The Green Mountain site is located on the north side of NE Goodwin Road and east of NE Ingle Road in the City of Camas, Clark County, Washington. The property includes several tax lots that total approximately 281.6 acres. Topography on the southern portion of the site is flat to gently sloping with grades of about 5 to 10 percent. Steeper slopes (up to 35 percent grade) are present on Green Mountain, which is a basalt cinder cone, located in the northern portion of the site. Near vertical slopes are present at the base of Green Mountain where basalt bedrock is exposed.

Phase 1 is approximately 51 acres and located in the southern portion of the site, which is part of the Green Mountain Golf Course. Topography is flat to gently sloping with grades generally about 5 to 20 percent. Improvements include several structures, parking areas and driveways, cart tracks, manmade ponds, and fairways. Vegetation consists of short grasses and sparse trees.

It is our understanding that the proposed development will consist of a subdivision for single family homes, new streets, and associated underground utilities. A grading plan has not been provided for our review; however, we anticipate maximum cuts and fills will be on the order of about 12 feet due to the sloping topography and filling of existing ponds.

## REGIONAL AND LOCAL GEOLOGIC SETTING

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 low-lying portion of the site is underlain by the Quaternary aged (last 1.6 million years) Willamette Formation, a catastrophic flood deposits associated with repeated glacial outburst flooding of the Willamette Valley (Trimble, 1963; Yeats et al., 1996; Phillips, 1987). The last of these outburst floods occurred about 10,000 years ago. These deposits typically consist of horizontally layered, micaceous, silty sand with gravel that is underlain by medium dense to dense gravel.

The Willamette Formation is underlain by a gravel conglomerate interbedded with siltstone and sandstone. Evarts (2006) indicates the age of the conglomerate is poorly constrained but is likely Pliocene to Pleistocene in age (10,000 to 5.3 million years ago). The conglomerate is partially cemented with the upper portion moderately weathered.

The northern portion of the Green Mountain site is underlain by Basaltic Andesite of Green Mountain (Evarts, 2006). The gray basaltic andesite lava flows erupted from a cinder cone on Green Mountain during the Pleistocene (2.6 to 5.3 million years ago). The basalt contains weathered ash, trace quartzite pebbles, and fine grained xenoliths (Evarts, 2006).

A portion of the site is underlain by Miocene to Pleistocene age (16 to 0.5 million years ago) terrigenous sedimentary rocks belonging to the Troutdale Formation (Evarts, 2006). The Troutdale Formation is informally divided into an upper and lower member. Lithologies in the upper member include lenticular layers of volcaniclastic (vitric) sand, quartzite-bearing gravel, fine-grained sand, silt and clay, micaceous quartz-rich sand, and conglomerate with a cumulative average thickness of 100 to 150 feet. The lower member consists primarily of laminated silty clay and sand with reported thicknesses in water well logs of up to 800 feet. These sediments vary from weakly-consolidated to well-indurated.

## REGIONAL SEISMIC SETTING

At least four potential source zones capable of generating damaging earthquakes are thought to exist in the region. These include the Lacamas Creek-Sandy River Fault, Portland Hills Fault Zone, Gales Creek-Newberg-Mt. Angel Structural Zone, and the Cascadia Subduction Zone, as discussed below.

### Lacamas Creek-Sandy River Fault

The Lacamas Creek Fault is recognized based on a fault shear contact between Oligocene (30 million years old) volcanic rocks and the Troutdale Formation, and a series of prominent geomorphic lineaments with a cumulative length of 24 miles (Mundorff, 1964; Beeson et al., 1989). The Sandy River Fault, interpreted from gravity and borehole data, forms a possible right stepping, 7-mile-long extension of the Lacamas Creek Fault that vertically displaces the Columbia River Basalt by 1,300 feet (Beeson et al., 1989; Geomatrix Consultants, 1995). A 1989, M3.9 earthquake in the vicinity may have occurred on the Lacamas Creek Fault. A comprehensive seismic hazard study commissioned by the Oregon Department of Transportation concluded that

the Lacamas Creek-Sandy River Fault Zone is potentially active with a possible rupture length of greater than 25 miles. The Lacamas Creek Fault is mapped as being ½ mile southwest of the subject site (Figure 1).

**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 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 about 13 miles southwest of the site. The Oatfield Fault occurs along the western side of the Portland Hills, and is about 16 miles southwest of the site. The accuracy of the fault mapping is stated to be within 500 meters (Wong, et al., 2000). 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).

**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 36 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; 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).

**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 50 miles west of the Portland Basin at depths of between 20 and 40 kilometers below the surface.

## FIELD EXPLORATION

Our site-specific exploration for Phase 1 was conducted on May 23rd, 2014. A total of 13 exploratory test pits were excavated with a medium sized trackhoe to depths ranging between 5 and 9 feet at the approximate locations shown on Figure 2. Test pits TP-1 and TP-12 are outside of the Phase 1 boundary due to a reconfiguration of the layout and are not presented. The previous investigation for the entire Green Mountain site consisted of 25 exploratory test pits excavated November 5th through 7th, 2013. Five test pits from the previous investigation are located within Phase 1 – test pits TP-1, TP-10, TP-13, TP-15, and TP-16. Test pits from the 2013 investigation for the entire Green Mountain site will be referred to as TP-1 (2013), TP-10 (2013), TP-13 (2013), TP-15 (2013), and TP-16 (2013). 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.

A GeoPacific geologist continuously monitored the field exploration program and logged the borings. Soils observed in the explorations were classified in general accordance with the Unified Soil Classification System. During exploration, our geologist also noted geotechnical conditions such as soil consistency, moisture and groundwater conditions. Logs of test pits are attached to this report. The following report sections are based on the exploration program and summarize subsurface conditions encountered at the site.

**Undocumented Fill** – Undocumented fill was encountered directly at the ground surface in test pits TP-2, TP-3, TP-4, TP-7, TP-8, TP-10, TP-11, and TP-13. The fill generally consisted of brown, medium stiff to stiff, silt (ML) with gravel, clay, and sand and medium dense, silty sand (SM). The fill extended to a depth of 1.5 to 3.5 feet. It is likely that other areas of undocumented fill exist in the vicinity of the existing structures, driveways, and the throughout the golf course.

**Topsoil Horizon** – The ground surface in test pits TP-5, TP-6, TP-9, TP-1 (2013), TP-10 (2013), TP-13 (2013), TP-15 (2013), and TP-16 (2013) was directly underlain by a low to highly organic topsoil horizon. The dark brown silt (OL-ML) contained trace amounts of sand and contained fine roots throughout. The topsoil horizon was loose and extended to a depth of 6 to 18 inches.

**Colluvial Soil** – Colluvial soil, formed by downward migration of material under gravitational forces, was encountered beneath the topsoil horizon in test pit TP-15. These soils generally consisted of stiff to very stiff, silty clay (CL) to clayey silt (ML) with weathered basalt that displayed strong orange and gray mottling. In explorations, the colluvial soil extended to a depth of 3 feet in test pit TP-15.

**Buried Topsoil Horizon** – A low organic, buried topsoil horizon was encountered beneath the fill in test pit TP-8. The buried topsoil horizon was on the order of 6 inches in thickness - extending to a depth of 3 feet.

**Fine Grained Catastrophic Flood Deposits (Willamette Formation)** – Underlying the topsoil horizon in test pits TP-5, TP-6, TP-9, TP-1 (2013), TP-10 (2013), and TP-13 (2013); the buried topsoil horizon in test pit TP-8; and the fill in test pits TP-2, TP-4, TP-7, TP-10, and TP-13 was fine grained catastrophic flood deposits. These soils generally consisted of stiff to very stiff, light brown, clayey silt (ML) with trace sand that displayed subtle to strong orange and gray mottling. Where encountered, the flood deposits generally extended to a depth of 3 to 7 feet and beyond the maximum depth of exploration in test pits TP-4, TP-7, TP-8, and TP-1 (2013) excavated to a maximum depth of 8.5 feet.

**Conglomerate** – Underlying the topsoil horizon in test pits TP-15 (2013) and TP-16 (2013); the fill in test pit TP-3, and the fine grained catastrophic flood deposits in test pits TP-2, TP-5, TP-6, TP-9, TP-10, TP-13, TP-10 (2013), and TP-13 (2013) was dense to very dense subrounded gravel (GM) with sandy, clayey silt matrix; dense, silty sand (SM); and stiff silt (ML) with subrounded gravel. The conglomerate was partially cemented and extended beyond the maximum depth of exploration (6 to 10.5 feet).

### Soil Moisture and Groundwater

On May 23, 2014 and November 5 through 7, 2013, soils encountered in test pits were moist to wet. Groundwater seepage was encountered in test pits TP-2, TP-5 through TP-9, TP-13, TP-1 (2013), TP-13 (2013), TP-15 (2013) and TP-16 (2013) at depths of 2 to 8.5 feet. Discharge was visually estimated at ¼ to 2 gallons per minute. In test pit TP-1 (2013), the static groundwater level rose to a depth of 2 feet after the test pit had been left open for a time period of several hours. Experience has shown that temporary perched storm-related groundwater conditions often occur within the surface soils over fine-grained native deposits such as those beneath the site, particularly during the wet season. It is anticipated that groundwater conditions will vary depending on the season, local subsurface conditions, changes in site utilization, and other factors.

## SLOPE STABILITY

For the purpose of evaluating slope stability, we: (1) reviewed regional 1:24,000 scale topography by the U.S. Geological Survey and published geologic mapping, (2) reviewed 1:150 scale topographic survey mapping of the site by Olson Engineering, Inc., (3) performed a geological reconnaissance of the site, and (4) evaluated subsurface soil conditions in exploratory test pits. Regional slope stability mapping of Clark County, Washington published by the Washington Department of Natural Resources Division of Geology identifies an area of potential instability on the southwest side of Green Mountain (Fiksdal, 1975). This area roughly correlates with the near vertical rock exposures at the base of Green Mountain that is north of the Phase 1 area. No mapped landslides are indicated in the Phase 1 study area on more recent geologic mapping conducted by Evarts (2006).

Based on the data review, field reconnaissance and site exploration, the slope instability hazard for the Phase 1 portion of the Green Mountain property is considered to be low. Slopes in the Phase 1 area are on the order of 5 to 20 percent. Slope geomorphology at the site is generally smooth and uniform - consistent with relative stability. Subsurface explorations indicate the site is generally underlain by stiff to very-stiff, clayey silt (ML) loess underlain by dense to very dense, silty gravel (GM). These materials are generally characterized by moderate to high shear strength and a relatively high resistance to slope instability on gentle slopes. The Phase 1 area is considered generally suitable for development.

## PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

Our investigation indicates that the proposed development is geotechnically feasible, provided that the recommendations of this report are incorporated into the design and construction phases of the project. The primary geotechnical constraint to development is the presence of fill throughout the site. Up to 5 feet of fill was encountered in the exploratory test pits. It is anticipated that fill is prevalent throughout the fairway areas of the golf course where sand traps, ponds, and sculpted topography have been created.

## Stormwater Disposal

Soil conditions at the site generally consist of fine grained flood deposits (consisting of clayey silt with sand) underlain by coarse grained, partially cemented conglomerate consisting of subrounded gravel with a clayey silt matrix and trace sand. Orange and gray mottling was observed in near surface soils in all explorations. Soil moisture conditions were moist to wet and perched groundwater seepage was encountered in test pits TP-2, TP-5 through TP-9, TP-13, TP-1 (2013), TP-13 (2013), TP-15 (2013) and TP-16 (2013) at depths of 2 to 8.5 feet. Static groundwater was measured at a depth of 2 feet below the ground surface in test pit TP-1 (2013). Soil mottling, the presence of clay soils, and the prevalent groundwater seepage indicates the soils will likely accept little runoff – if any. Soils with moderate permeability are already saturated with perched groundwater. We would expect soil conditions to behave more as Soil Group 4 soils than Soil Group 3 soils outlined in the Western Washington Continuous Simulation Hydrology Model.

## Site Preparation

Due to the presence of fill through the site, areas of proposed construction and areas to receive fill should be cleared of vegetation and existing fill soils should then be removed to stiff or dense native soils. Organic soils are likely present at the bottom of the ponds and should be removed to stiff, native soils. Inorganic debris and organic materials from clearing should be removed from the site. It is likely that the existing fill may be reused as engineered fill provided that they are properly moisture conditioned and free of organic or inorganic debris. Organic-rich root zones should then be stripped from construction areas of the site or where engineered fill is to be placed. Depth of stripping is estimated to average 8+ inches. The final depth of soil removal will be determined on the basis of a site inspection after the stripping/ excavation has been performed. Stripped topsoil should preferably be removed from the site. 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.

Remaining undocumented fills and any subsurface structures (dry wells, basements, driveway and landscaping fill, old utility lines, septic leach fields, etc.) should be removed and the excavations backfilled with engineered fill. Fill in excess of 5 feet was encountered directly at the ground surface in test pits for this investigation. Sculpted topography in the vicinity of the fairways indicates the presence of fill. We anticipate that other areas of fill may exist in the vicinity of the existing structures, parking lots, and driveways.

## Engineered Fill

All grading for the proposed construction should be performed as engineered grading in accordance with the applicable building code at time of construction with the exceptions and additions noted herein. Proper test frequency and earthwork documentation usually requires daily observation and testing during stripping, rough grading, and placement of engineered 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 8 inches using standard compaction equipment. We recommend that engineered fill be compacted to at least 90% of the maximum dry density determined by ASTM D1557 (Modified Proctor) or equivalent. 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 will be impacted by soil moisture and shallow groundwater conditions. Earthwork in wet weather would likely require extensive use of cement or lime treatment, or other special measures, at considerable additional cost compared to earthwork performed under dry-weather conditions.

## Excavating Conditions and Utility Trenches

We anticipate that on-site soils can be excavated using conventional heavy equipment such as trackhoes to a depth of 9 feet. 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 soil is classified as Type B Soil and temporary excavation side slope inclinations as steep as 1H:1V may be assumed for planning purposes. This cut slope inclination is applicable to excavations above the water table only. 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.

Soft, saturated soils and groundwater may be encountered in utility trenches, particularly during the wet season. We anticipate that dewatering systems consisting of ditches, sumps and pumps would be adequate for control of perched groundwater. Regardless of the dewatering system used, it should be installed and operated such that in-place soils are prevented from being removed along with the groundwater. Trench bottom stabilization, such as one to two feet of compacted crushed aggregate base, may be necessary in deeper 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.

PVC pipe should be installed in accordance with the procedures specified in ASTM D2321. We recommend that trench backfill be compacted to at least 95% of the maximum dry density obtained by Modified Proctor ASTM D1557 or equivalent. Initial backfill lift thickness 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, one density test is taken for every 4 vertical feet of backfill on each 200-lineal-foot section of trench.

## Erosion Control Considerations

During our field exploration program, we did not observe soil types that would be considered highly susceptible to erosion, except in areas of steeply sloping topography. 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 bales and silt fences. If used, these erosion control devices should be in place and 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.

**Wet Weather Earthwork**

Soils underlying the site are likely to be moisture sensitive and may 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 probably require expensive measures such as cement treatment or imported granular material to compact fill 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;
- 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 fines. 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
- Bales of straw and/or geotextile silt fences 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.

**Anticipated Foundations**

The proposed residential structures may be supported on shallow foundations bearing on competent undisturbed, 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 18 inches below exterior grade. The recommended minimum widths for continuous footings supporting wood-framed walls without masonry are 12 inches for single-story, 15 inches for two-story, and 18 inches for three-story structures. Minimum foundation reinforcement should consist of a No. 4 bar at the top of the stem walls, and a No. 4 bar at the bottom of the footings. Concrete slab-on-grade reinforcement should consist of No. 4 bars placed on 24-inch centers in a grid pattern.

The anticipated allowable soil bearing pressure is 1,500 lbs/ft$^2$ for footings bearing on competent, native soil and/or engineered fill. A maximum chimney and column load of 30 kips is recommended for the site. The recommended maximum allowable bearing pressure may be increased by 1/3 for short-term transient conditions such as wind and seismic loading. For heavier loads, the geotechnical engineer should be consulted. The coefficient of friction between on-site soil and poured-in-place concrete may be taken as 0.40, 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.

Footing excavations should penetrate through topsoil and any loose 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 overexcavation of footings and backfill with compacted, crushed aggregate.

Our recommendations are for house construction incorporating raised wood floors and conventional spread footing foundations. If living space of the structures will incorporate basements, a geotechnical engineer should be consulted to make additional recommendations for retaining walls, water-proofing, underslab drainage and wall subdrains. After site development, a Final Soil Engineer's Report should either confirm or modify the above recommendations.

## Pavement Design

For design purposes, we used an estimated resilient modulus of 9,000 for compacted native soil. Table 1 presents our recommended minimum pavement section for dry weather construction.

**Table 1. Recommended Minimum Dry-Weather Pavement Section**

| Material Layer | Light-duty Public Streets | Compaction Standard |
|---|---|---|
| Asphaltic Concrete (AC) | 3 in. | 92%/ 92% of Rice Density AASHTO T-209 |
| Crushed Aggregate Base ¾"-0 (leveling course) | 2 in. | 95% of Modified Proctor AASHTO T-180 |
| Crushed Aggregate Base 1½"-0 | 8 in. | 95% of Modified Proctor AASHTO T-180 |
| Subgrade | 12 in. | 95% of Modified Proctor AASHTO T-180 or equivalent |

Any pockets of organic debris or loose fill encountered during ripping or tilling should be removed and replaced with engineered fill (see *Site Preparation* Section). In order to verify subgrade strength, we recommend proof-rolling directly on subgrade with a loaded dump truck during dry weather and on top of base course in wet weather. Soft areas that pump, rut, or weave should be stabilized prior to paving. If pavement areas are to be constructed during wet weather, the subgrade and construction plan should be reviewed by the project geotechnical engineer at the time of construction so that condition specific recommendations can be provided. The moisture sensitive subgrade soils make the site a difficult wet weather construction project.

During placement of pavement section materials, density testing should be performed to verify compliance with project specifications. Generally, one subgrade, one base course, and one asphalt compaction test is performed for every 100 to 200 linear feet of paving.

## Seismic Design

Structures should be designed to resist earthquake loading in accordance with the methodology described in the 2010 ASCE-7 Standard. We recommend Site Class D be used for design. Design values determined for the site using the USGS (United States Geological Survey) *U.S. Seismic Design Maps* tool (Version 3.1.0) are summarized in Table 2, presented on the following page.

**Table 2. Recommended Earthquake Ground Motion Parameters (2010 ASCE-7)**

| Parameter | Value |
|---|---|
| Location (Lat, Long), degrees | 45.646, -122.457 |
| Mapped Spectral Acceleration Values (MCE): | |
| Peak Ground Acceleration | 0.374 |
| Short Period, $S_s$ | 0.880 g |
| 1.0 Sec Period, $S_1$ | 0.375 g |
| Soil Factors for Site Class D: | |
| $F_a$ | 1.148 |
| $F_v$ | 1.650 |
| Residential Site Value = 2/3 x $F_a$ x $S_s$ | 0.673 g |
| Residential Seismic Design Category | $D_0$ |

Soil liquefaction is a phenomenon wherein saturated soil deposits temporarily lose strength and behave as a liquid in response to earthquake shaking. Soil liquefaction is generally limited to loose, granular soils located below the water table. Following development, on-site soils will consist predominantly of engineered fill or native fine-grained soils above the water table, which are not considered susceptible to liquefaction. Therefore, it is our opinion that special design or construction measures are not required to mitigate the effects of liquefaction.

## Drainage

The upslope side of retaining walls and perimeter footings should be provided with a drainage system consisting of 3-inch diameter, slotted, flexible plastic pipe embedded in a minimum of 1 $ft^3$ per lineal foot of clean, free-draining gravel or 1 1/2" - 3/4" 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. Water collected from the footing 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 foundation drains in order to reduce the potential for clogging. The footing 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. Footing drains are recommended to prevent detrimental effects of groundwater on foundations, and should not be expected to eliminate all potential sources of water entering a crawlspace or beneath a slab-on-grade. An adequate grade to a low point outlet drain in any crawlspace areas is required by code. Underslab drains are sometimes added beneath the slab when placed over soils of low permeability and shallow, perched groundwater.

## 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.**


Beth K. Rapp
Senior Geotechnical Staff

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

Attachments: References
Figure 1 – Vicinity Map
Figure 2 – Site and Exploration Plan
Test Pit Logs – TP-2 through TP-11, & TP-13
Test Pit Logs from Previous Study – TP-1 (2013), TP-10 (2013), TP-13 (2013), TP-15 (2013) & TP-16 (2013)

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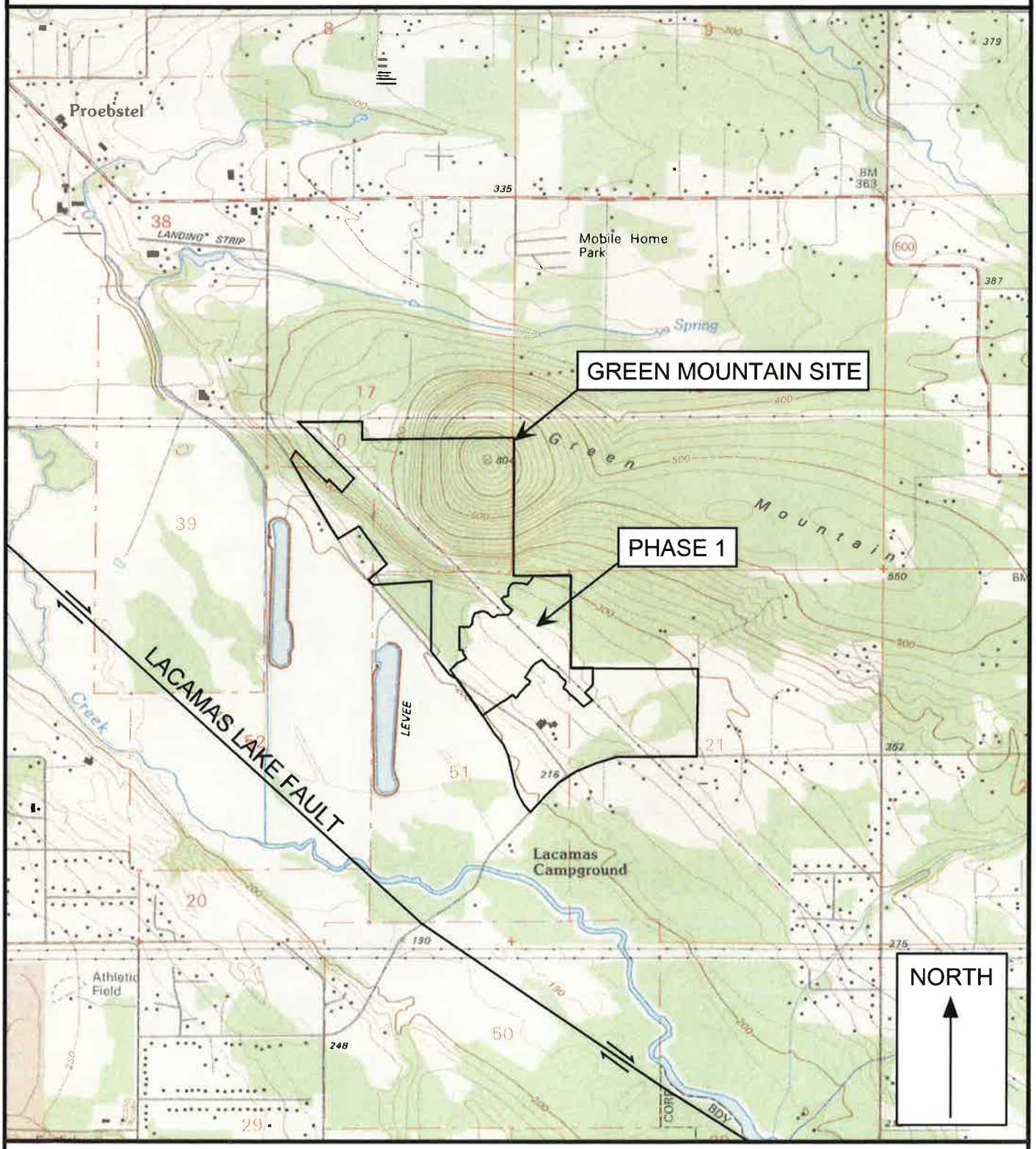
# VICINITY MAP




Legend

Approximate Scale 1 in = 2,000 ft

Date: 11/25/2014
Drawn by: EKR

Base map: U.S. Geological Survey 7.5 minute Topographic Map Series, Lacamas Creek, Washington Quadrangle, 1990.

| Project: Green Mountain Phase 1<br>Camas, Washington | Project No. 13-3186 | FIGURE 1 |
|---|---|---|

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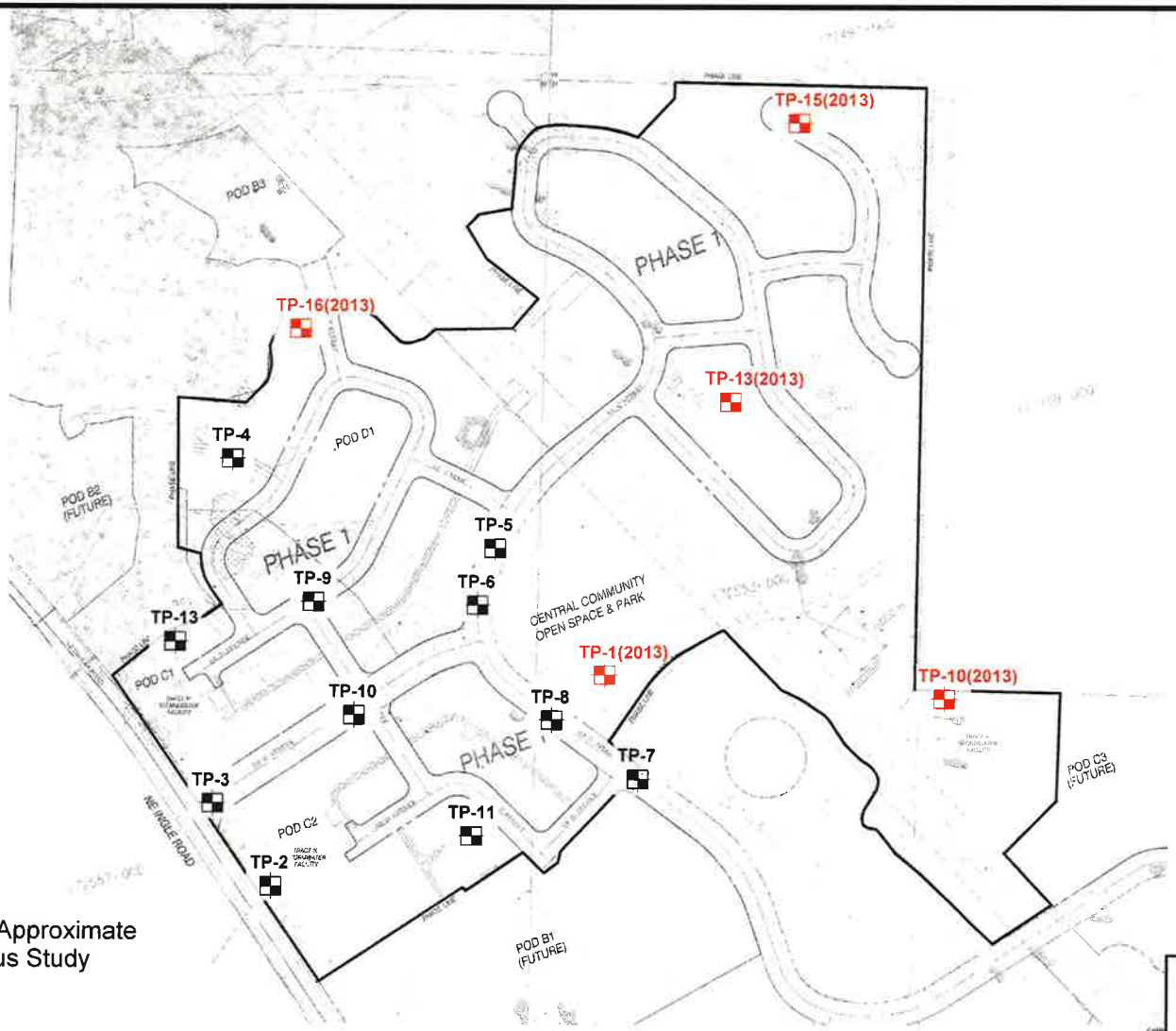
# SITE PLAN AND EXPLORATION LOCATIONS




## Legend

**TP-2** Test Pit Designation and Approximate Location

**TP-16(2013)** Test Pit Designation and Approximate Location-from Previous Study

0 400'

APPROXIMATE SCALE 1"=400'

Base map provided by Olson Engineering Dated November 2014.

| Project: Green Mountain Phase 1<br>Camas, Washington | Project No. 13-3186 | Date: 10/2/2014<br>Drawn by: EKR | FIGURE 2 |
|---|---|---|---|

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# TEST PIT LOG

Project: Green Mountain Phase 1
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-2**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 3.0 | | | | | Stiff to very stiff, SILT (ML), trace sand, brown, moderately organic, trace roots throughout, 6 inch topsoil developed at surface, strong orange and gray mottling, trace black staining, moist (Fill) |
| 2 | 1.5 | | | | | Stiff to very stiff, clayey SILT (ML), trace sand, brown, micaceous, subtle orange and gray mottling, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 3 | 4.5 | | | | | |
| 4 | 3.5 | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | 💧 | Dense, subrounded GRAVEL (GM), trace clayey silt matrix, trace sand, brown to gray, trace black staining, partially cemented, strong orange and gray mottling, gravel is up to 9 inches in diameter, well graded, moist to wet (Conglomerate) |
| 8 | | | | | 💧 | |
| 9 | | | | | | Test Pit Terminated at 8.5 Feet. |
| 10 | | | | | | Note: Groundwater seepage encountered at 7 - 8 feet. Discharge visually estimated at 1/2 gallon per minute. |
| 11 | | | | | | |
| 12 | | | | | | |

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: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

Project: Green Mountain Phase 1
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-3**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 4.5 | | | | | Stiff to very stiff, SILT (ML), trace subrounded gravel, brown, with inorganic debris (asphalt), trace roots throughout, 6 inch thick topsoil developed at surface, strong orange and gray mottling, trace black staining, moist (Fill) |
| 2 | 4.5 | | | | | |
| 3 | 4.5 | | | | | |
| 4 | 3.5 | | | | | Stiff to very stiff, sandy SILT (ML), trace subrounded gravel, brown, micaceous, subtle to strong orange and gray mottling, trace black staining, moist (Conglomerate) |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | Dense, subrounded GRAVEL (GM), trace clayey silt matrix, trace sand, brown to gray, trace black staining, partially cemented, strong orange and gray mottling, gravel is up to 9 inches in diameter, well graded, moist to wet (Conglomerate) |
| 8 | | | | | | |
| 9 | | | | | | Test Pit Terminated at 8.5 Feet. |
| 10 | | | | | | Note: No seepage or groundwater encountered. |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND


Bag Sample | Bucket Sample | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment

Date Excavated: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

Project: Green Mountain Phase 1
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-4**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 4.5 | | | | | Stiff to very stiff, sandy SILT (ML), trace subrounded gravel, gray, trace organic debris, trace roots throughout, 6 inch thick topsoil developed at surface, subtle to strong orange and gray mottling, trace black staining, moist (Fill) |
| 2 | 4.0 | | | | | |
| 3 | 3.5 | | | | | Stiff to very stiff, sandy SILT (ML), light brown, micaceous, strong orange and gray mottling, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 4 | 3.0 | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | Test Pit Terminated at 8 Feet. |
| 9 | | | | | | |
| 10 | | | | | | Note: No seepage or groundwater encountered. |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample

Bucket Sample


Shelby Tube Sample


Seepage


Water Bearing Zone


Water Level at Abandonment

Date Excavated: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

Project: Green Mountain Phase 1
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-5**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 4.5 | | | | | Low to moderately organic, SILT (OL-ML), dark brown, fine roots throughout, loose, moist (Topsoil) |
| 2 | 2.0 | | | | | Stiff to very stiff, sandy SILT (ML), light brown, micaceous, subtle to strong orange and gray mottling, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 3 | 2.5 | | | | | |
| 4 | 2.5 | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | Medium dense to dense, silty SAND (SM), brown to blue gray below 8.5 feet, subtle to strong orange and gray mottling, sand is fine to medium grained, partially lithified, trace black staining, moist (Conglomerate) |
| 8 | | | | | | |
| 9 | | | | | | Test Pit Terminated at 9 Feet. |
| 10 | | | | | | Note: Groundwater seepage encountered at 7.5 feet. Discharge visually estimated at 1/4 gallon per minute. |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample (100 to 1,000 g) | Bucket Sample (5 Gal. Bucket) | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment

Date Excavated: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

Project: Green Mountain Phase 1
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-6**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 2.5 | | | | | Low organic, SILT (OL-ML), dark brown, roots throughout, loose, moist (Topsoil) |
| 2 | 4.5 | | | | | Stiff to very stiff, sandy SILT (ML), light brown, micaceous, subtle to strong orange and gray mottling, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 3 | 3.5 | | | | | |
| 4 | 4.0 | | | | | |
| 5 | | | | | | |
| 6 | | | | | | Medium dense to dense, silty SAND (SM), trace subrounded gravel, brown, strong orange and gray mottling, sand is fine to medium grained, partially lithified, trace black staining, moist (Conglomerate) |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | Test Pit Terminated at 8.5 Feet. |
| 10 | | | | | | Note: Groundwater seepage encountered at 4.5 feet. Discharge visually estimated at 1/4 gallon per minute. |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample

Bucket Sample


Shelby Tube Sample


Seepage


Water Bearing Zone


Water Level at Abandonment

Date Excavated: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

Project: Green Mountain Phase 1
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-7**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 4.0 | | | | | Stiff to very stiff, sandy SILT (ML), trace subrounded gravel, light brown, trace roots throughout, 6 inch thick topsoil developed at surface, strong orange and gray mottling, trace black staining, moist (Fill) |
| 2 | 4.0 | | | | | |
| 3 | 2.0 | | | | | |
| 4 | 2.5 | | | | | Stiff to very stiff, sandy SILT (ML), light brown, micaceous, strong orange and gray mottling, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | Test Pit Terminated at 8.5 Feet. |
| 10 | | | | | | Note: Groundwater seepage encountered at 5.5 - 6.5 feet. Discharge visually estimated at 1/4 gallon per minute. |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample (100 to 1,000 g) | Bucket Sample (5 Gal. Bucket) | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment

Date Excavated: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

Project: Green Mountain Phase 1
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-8**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 2.0 | | | | | Stiff to very stiff, sandy SILT (ML), light brown, trace roots throughout, 6 inch thick topsoil developed at surface, strong orange and gray mottling, moist (Fill) |
| 2 | 2.5 | | | | | Low organic, SILT (OL-ML), gray, trace fine roots throughout, loose, moist (Buried Topsoil) |
| 3 | 2.0 | | | | | |
| 4 | 1.5 | | | | | Stiff to very stiff, sandy SILT (ML), light brown, micaceous, strong orange and gray mottling, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | Test Pit Terminated at 8.5 Feet. |
| 10 | | | | | | Note: Groundwater seepage encountered at 5.5 - 7.5 feet. Discharge visually estimated at 1/2 gallon per minute. |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample (100 to 1,000 g) | Bucket Sample (5 Gal Bucket) | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment

Date Excavated: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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Portland, Oregon 97224
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# TEST PIT LOG

Project: Green Mountain Phase 1
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-9**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 4.0 | | | | | Moderately organic, SILT (OL-ML), trace gravel fill, dark brown, fine roots throughout, loose, moist (Topsoil) |
| 2 | 3.5 | | | | | Stiff to very stiff, clayey SILT (ML), trace sand, brown, micaceous, subtle orange and gray mottling, trace roots to 3 feet, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 3 | 4.5 | | | | | |
| 4 | 4.5 | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | Dense, subrounded GRAVEL (GM), trace clayey silt matrix, trace sand, brown to gray, trace black staining, partially cemented, strong orange and gray mottling, moist to wet (Conglomerate) |
| 9 | | | | | | Test Pit Terminated at 8.5 Feet. |
| 10 | | | | | | Note: Groundwater seepage encountered at 7.5 feet. Discharge visually estimated at 1/4 gallon per minute. |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample (100 to 1,000 g) | Bucket Sample (5 Gal Bucket) | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment

Date Excavated: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

Project: Green Mountain Phase 1
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-10**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 4.0 | | | | | Stiff to very stiff, SILT (ML), trace sand, brown, trace inorganic debris, trace roots throughout, 6 inch topsoil developed at surface, strong orange and gray mottling, moist (Fill) |
| 2 | 4.0 | | | | | |
| 3 | 4.5 | | | | | Stiff to very stiff, sandy SILT (ML), trace clay, light brown, micaceous, subtle to strong orange and gray mottling, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 4 | 4.5 | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | Dense to very dense, subrounded GRAVEL (GM), trace clayey silt matrix, trace sand, brown to gray, trace black staining, partially cemented, strong orange and gray mottling, gravel is up to 6 inches in diameter, well graded, moist (Conglomerate) |
| 8 | | | | | | |
| 9 | | | | | | Test Pit Terminated at 8.5 Feet. |
| 10 | | | | | | Note: No seepage or groundwater encountered. |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample

Bucket Sample


Shelby Tube Sample


Seepage


Water Bearing Zone


Water Level at Abandonment

Date Excavated: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

Project: Green Mountain Phase 1
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-11**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 2.5 | | | | | Stiff to very stiff, sandy SILT (ML), trace gravel, light brown, trace fine roots throughout, 6 inch thick topsoil developed at surface, moist (Fill) |
| 2 | 4.5 | | | | | Low to moderately organic, SILT (OL-ML), brown, trace fine roots throughout, moist (Buried Topsoil) |
| 3 | 3.5 | | | | | Stiff to very stiff, sandy SILT (ML), light brown, subtle to strong orange and gray mottling, moist (Fill) |
| 4 | 3.0 | | | | | |
| 5 | | | | | | Test Pit Terminated at 5 Feet due to Buried Water Line Tape. |
| 6 | | | | | | Note: No groundwater or seepage encountered. |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND


Bag Sample | Bucket Sample | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment

Date Excavated: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

| Project: Green Mountain Phase 1<br>Camas, Washington | Project No. 13-3186 | Test Pit No. **TP-13** |
|---|---|---|

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 1.5 | | | | | Stiff, sandy SILT (ML), trace clay, light brown, trace roots throughout, 6 inch thick topsoil developed at surface, strong orange and gray mottling, moist (Fill) |
| 2 | 2.0 | | | | | |
| 3 | 2.5 | | | | | Stiff to very stiff, sandy SILT (ML), light brown, micaceous, strong orange and gray mottling, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 4 | 4.0 | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | Dense to very dense, subrounded GRAVEL (GM), trace silty sand matrix, brown to gray, trace black staining, strong orange and gray mottling, gravel is up to 12 inches in diameter, moist (Conglomerate) |
| 8 | | | | | | |
| 9 | | | | | | Test Pit Terminated at 8.5 Feet. |
| 10 | | | | | | Note: Groundwater seepage encountered at 8.5 feet. Discharge visually estimated at 1/4 gallon per minute. |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample (100 to 1,000 g) | Bucket Sample (5 Gal. Bucket) | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment

Date Excavated: 5/23/2014
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

Project: Green Mountain
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-1 (2013)**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 0.5 | | | | | Moderately organic, sandy SILT (OL-ML), dark brown, roots throughout, loose, moist (Topsoil) |
| 2 | 1.0 | | | | ▽ | Medium stiff, sandy SILT (ML), brown, micaceous, strong orange and gray mottling, moist to wet (Fine Grained Catastrophic Flood Deposits) |
| 3 | 1.0 | | | | 💧 | |
| 4 | 0.5 | | | | | Test Pit Terminated at 4 Feet for Infiltration Testing. |
| 5 | | | | | | Note: Groundwater seepage encountered at 3 feet. Discharge visually estimated at less than 1 gallon per minute. Static groundwater at 2 Feet at Completion of Infiltration Testing. |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample (100 to 1,000 g) | Bucket Sample (5 Gal Bucket) | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment

Date Excavated: 11/5-7/2013
Logged By: B. Rapp
Surface Elevation:

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# TEST PIT LOG

| Project: Green Mountain<br>Camas, Washington | Project No. 13-3186 | Test Pit No. **TP-10 (2013)** |
|---|---|---|

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 2.0 | | | | | Moderately organic, SILT (OL-ML), dark brown, fine roots throughout, loose, moist (Topsoil) |
| 2 | 2.0 | | | | | Stiff to very stiff, sandy SILT (ML), trace clay, light brown, micaceous, strong orange and gray mottling, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 3 | 1.5 | | | | | |
| 4 | 3.5 | | | | | Dense, subrounded GRAVEL (GM), trace sandy silt matrix, light brown to gray, trace black staining, strong orange and gray mottling, micaceous, moist (Conglomerate) |
| 5 | | | | | | |
| 6 | | | | | | Test Pit Terminated at 6 Feet. |
| 7 | | | | | | Note: No seepage or groundwater encountered. |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample

Bucket Sample


Shelby Tube Sample


Seepage


Water Bearing Zone


Water Level at Abandonment

Date Excavated: 11/5-7/2013
Logged By: B. Rapp
Surface Elevation:

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

# TEST PIT LOG

| Project: Green Mountain Phase 1<br>Camas, Washington | Project No. 13-3186 | Test Pit No. TP-13 (2013) |
|---|---|---|

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | | | | | | Moderately organic, SILT (OL-ML), brown, fine roots throughout, loose, moist (Topsoil) |
| 2 | 1.5 | | | | | Medium stiff to very stiff, sandy SILT (ML), trace clay, light brown, micaceous, strong orange and gray mottling, trace black staining, moist (Fine Grained Catastrophic Flood Deposits) |
| 3 | 3.0 | | | | | |
| 4 | | | | | | |
| 5 | | | | | | Dense, subrounded GRAVEL (GM), trace sandy silt matrix, trace clay, light brown to gray, trace black staining, well graded, strong orange and gray mottling, micaceous, moist (Conglomerate) |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | Test Pit Terminated at 9 Feet. |
| 10 | | | | | | Note: Groundwater seepage encountered at 8 feet. Discharge visually estimated at 1 gallon per minute. |
| 11 | | | | | | |
| 12 | | | | | | |

LEGEND

Bag Sample

Bucket Sample


Shelby Tube Sample


Seepage


Water Bearing Zone


Water Level at Abandonment

Date Excavated: 11/5-7/2013
Logged By: B. Rapp
Surface Elevation:

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

# TEST PIT LOG

| Project: Green Mountain Phase 1<br>Camas, Washington | Project No. 13-3186 | Test Pit No. TP-15 (2013) |
|---|---|---|

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 1.5 | | | | | Moderately organic, SILT (OL-ML), with basalt fragments, dark brown, fine roots throughout, loose, moist (Topsoil) |
| 2 | 3.5 | | | | ~ | Stiff to very stiff, silty CLAY (CL) to clayey SILT (ML), with gray weathered basalt, light reddish-brown, trace fine roots throughout, strong orange and gray mottling, black staining, moist (Colluvial Soil) |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | Medium dense, silty SAND (SM) with interbeds of stiff, sandy SILT (ML), light brown, micaceous, sand is fine to medium grained, strong orange and gray mottling, trace black staining, moist (Conglomerate) |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | Test Pit Terminated at 10.5 Feet. |
| 12 | | | | | | Note: Groundwater seepage encountered at 2 feet. Discharge visually estimated at 1 gallon per minute. |

LEGEND

Bag Sample (100 to 1,000 g) | Bucket Sample (5 Gal. Bucket) | Shelby Tube Sample | Seepage | Water Bearing Zone | Water Level at Abandonment

Date Excavated: 11/5-7/2013
Logged By: B. Rapp
Surface Elevation:

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

# TEST PIT LOG

Project: Green Mountain
Camas, Washington

Project No. 13-3186

Test Pit No. **TP-16 (2013)**

| Depth (ft) | Pocket Penetrometer (tons/ft²) | Sample Type | In-Situ Dry Density (lb/ft³) | Moisture Content (%) | Water Bearing Zone | Material Description |
|---|---|---|---|---|---|---|
| 1 | 0.5 | | | | | Moderately organic, SILT (OL-ML), dark brown, fine roots throughout, loose, moist (Topsoil) |
| 2 | 2.0 | | | | | |
| 3 | 3.5 | | | | | Medium dense, silty SAND (SM) with interbeds of stiff, sandy SILT (ML), light brown to gray, micaceous, sand is coarse to medium grained, strong orange and gray mottling, trace black staining, moist to wet (Conglomerate) |
| 4 | 2.0 | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | Test Pit Terminated at 9 Feet. |
| 10 | | | | | | |
| 11 | | | | | | Note: Groundwater seepage encountered at 3.5 to 6.5 feet. Discharge visually estimated at 2 gallons per minute. |
| 12 | | | | | | |

LEGEND

Bag Sample

Bucket Sample


Shelby Tube Sample


Seepage


Water Bearing Zone


Water Level at Abandonment

Date Excavated: 11/5-7/2013
Logged By: B. Rapp
Surface Elevation:

# Appendix IV: Maintenance Manual


City of Camas

# Storm Sewer Systems

# Operation & Maintenance Manual

## Public & Private Systems

September 2009

City of Camas

# Storm Sewer Systems

# Operation & Maintenance Manual

## Public & Private Systems

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# TABLE OF CONTENTS

# Operation & Maintenance Manual

# Introduction

## Public & Private Systems

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**Background**
Everything, whether it be public or privately owned, roads, parking lots, residential developments, commercial or industrial developments, or school facilities have various components that make up a storm sewer system. These components consist of conveyance pipes, catch basins, manholes, roadside ditches, stormwater facilities (such as drywells, bioswales, detention ponds, wet ponds, oil/water separators), landscaping (both hardscape and softscape), and any other structure that collects, conveys, controls, and/or treats stormwater. Regardless of the component, all storm sewer systems eventually discharge into 'waters of the state' which are our streams, rivers, lakes, wetlands, and groundwater.

Under the Federal Clean Water Act (FCWA) and in compliance with the Department of Ecology's NPDES Phase II Permit 'waters of the state' are to be protected from contamination. This in turn protects threatened and endangered species under the Federal Endangered Species Act (FESA).

One way to protect 'waters of the state' is to provide the proper maintenance of all storm sewer system components. It is the responsibility of the City of Camas to ensure that all components of the storm sewer system are properly maintained and operated. The City is responsible for those components that are located within the City's right-of-way, such as the conveyance pipes, manholes, catch basins, and roadside ditches. There are also a few specific stormwater ponds that are the responsibility of the City. However, the majority of the storm facilities are owned and maintained by the property owners as private facilities. These property owners include, but are not limited to, Homeowners Associations (HOA's), property manager companies, school districts, and commercial/industrial site owners.

**Purpose of the Manual**
This manual is intended to help, both public and private operators, meet the requirements for proper maintenance and operation of the various storm sewer system components. Proper maintenance will help to assure that:

- Storm sewer facilities operate as they were designed;
- Storm sewer systems are cleaned of the pollutants that they trap, such as sediment and oils, so that storm sewer systems are not overwhelmed and in so doing become pollutant sources;
- Pollutant sources are removed, or minimized, prior to entering the storm sewer system.

Along with keeping a site from flooding, properly maintained storm sewers can help reduce surface water and groundwater pollution. Most sites have some type of stormwater control component designed to limit the environmental and flooding damage caused by stormwater runoff. These components require more labor intensive maintenance than a system of pipes and catch basins.

It is the intent of the City to conduct yearly inspections of storm sewer facilities, preferably late spring/early summer to allow maintenance to occur late summer, prior to the fall rainy season. See Appendix A for an example of a *Storm Sewer System Maintenance Notification* form.

**Manual Layout**
The manual breaks out the various storm sewer system components and the general maintenance activities required for said component. For each component or activity this manual will:

- Briefly describe the component type, e.g. facility or activity.
- List the water quality and non-water quality result of each facility or activity.
- List the *Best Management Practices (BMP's)* needed to meet the water quality and general maintenance requirements.

Additional information may be found in other manuals, such as the Washington Department of Ecology's *2005 Stormwater Management Manual for Western Washington, Vols. IV and V*, or site specific Operation and Maintenance (O&M) Manuals.

Maintenance is performed as a means to obtain specific results. The maintenance results, as listed below, are specified for each drainage feature or activity. They include maintaining performance and appearance of the facility, and the need to prevent maintenance work itself from becoming a pollutant source or damaging habitat.

**Maintenance Results (R1-R10)**
Water Quality Results:
R1 Avoid or minimize sediment and pollutant discharges from the work area.
R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
R3 Avoid or minimize vegetation removal.
R4 Preserve native vegetation.

Infrastructure Maintenance Results:
R5 Protect public safety and health.
R6 Prevent catastrophique infrastructure failures.
R7 Maintain and/or restore the intended infrastructure function.
R8 Prevent and/or reduce flooding.
R9 Protect infrastructure.
R10 Meet public expectations for aesthetics.

Storm sewer facility refers to specific drainage features, such as catch basins, pipes, ditches, ponds, biofiltration swales, and infiltration systems. Activities refer to maintenance tasks associated with operating and maintaining stormwater facilities such as vegetation management and small repair projects. Depending on the extent of the maintenance, some property owners may be able to handle storm sewer maintenance themselves. Often, however, depending on the type of maintenance, the property owners will contract out the work. Landscapers are often employed to maintain vegetated facilities, such as swales and pond areas.

Heavier work, like cleaning catch basins, ditch inlets, outlet structures, or drywells often requires special equipment, such as trucks that can vacuum out sediment. When located within the city right-of-way, maintenance is typically the responsibility of the City. For those located on private

property a contractor would need to be contacted to perform this work. Check phone book listings, such as sewer and cleaning contractors, tank cleaning, and environmental and ecological services. Check with the contractor to ensure that all materials are disposed of according to solid waste and hazardous materials regulations. *Ultimately, the generator of the waste or hazardous material is responsible for proper disposal.*

**Special Facilities:**
Manufactured storm sewer facilities, such as leaf compost filters and oil/water separators often have maintenance requirements and manuals specified or written by the manufacturer. Also, larger or more complex storm sewer facilities may include specifications for maintenance and vegetation management that provide specific detail above and beyond this manual. Where the *Public Works Director* determines that these manuals or plans provide an equal or greater level of maintenance and water quality protection, then these procedures shall be followed by the owner. The Public Works Director must approve these individual maintenance plans, specifications, or manuals.

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# Operation & Maintenance Procedures

# Vegetated Facilities

# Public & Private Systems

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## Biofiltration Swales

Biofiltration swales use grass or other dense vegetation to filter sediment and oily materials out of stormwater. Usually they look like flat-bottomed channels with grass growing in them. Swales are stormwater treatment devices that must be properly maintained to sustain pollutant removal capacity.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the surrounding area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R7 Maintain or restore the intended infrastructure function.
- R10 Meet public expectations for aesthetics.

**Procedures**

*Inspection*

Swales are easy to inspect and need to be well maintained to treat stormwater. Make frequent visual inspections, at least once every 6 months and after storm events of >0.50 inch rainfall/24 hours, for problems such as channeling flow, rills, bare ground, sediment accumulation, oily material, and debris. Maintain adequate grass growth and eliminate bare spots.

Identify and remove pollutant sources that are discharging to the swale.

Maintain access to inlet and outlet structures for pollutant removal, and to grass swale for mowing and noxious weed removal.

*Cleaning*

Remove leaves, litter, sediment, oily materials, and grass cuttings when mowing or at any time that it is observed in the swale as this can cause blockage of inlets and outlets.

Clear inlets, outlets, curb cuts, and level spreaders of debris to prevent blockage of stormwater flow.

Use a rake and shovel to remove, by hand, sediment accumulations greater than 2-inches thick that cover grass areas; avoid vegetation removal. Reseed bare areas.

*Vegetation Management*

Mow to keep grass at the maximum height (9-inches). Mow to no less then 4-inches in height and a minimum of four cuttings per year. Remove clippings from the swale.

If a swale has an underdrain system, vehicular traffic (other then grass mowing equipment) on the swale bottom is to be avoided to prevent damage to the underdrain pipes.

Preserve healthy vegetation or reestablish vegetation where needed. Seed bare spots.

Blackberry removal is required and should be done 2-3 times a year. Pesticide use is **not** allowed. After cutting down of blackberries, vines are to be bagged and removed from the area.

Use appropriate BMP's to cover bare soils. BMP's include hydroseeding or mulches.

Trees and shrubbery are not allowed to grow within the biofiltration swale as they interfere with the facility's function and maintenance activities. Any cut trees should be salvaged for habitat enhancement or converted to mulch or firewood.

Storm sewer facilities are, in effect, water body buffers where pesticides and fertilizers are not to be used. See Vegetation Management in Storm Sewer Systems for more information.

*Repairs*

Often swales have problems due to flooding or erosion. Where possible, correct the underlying problem before trying to repair the symptom.

Level spreaders must be in proper working order for swales to function properly. Where level spreaders are damaged, sunken, or bypassed by erosion, repair them to design standards.

If there is a problem with grass dying due to the swale being flooded during the wet season, there are two options: convert the swale vegetation to a plant variety that can stand being flooded or find a way to fix the swale so it drains better.

Call the Public Works Department at 817-7231 for information on approved plants. **Design modifications to any storm sewer facility cannot be made without prior approval from the City of Camas.**

## Filter Strips

Filter strips are linear strips of grass that remove sediment and oils from stormwater by filtering it. Stormwater is treated as it runs across the filter. Usually, filter strips are placed along the edge of linear paved areas, such as parking lots and roads. Where designed filter strips are installed; road shoulders should only be graded to maintain level flow off the road.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R7 Maintain or restore the intended infrastructure function.
- R10 Meet public expectations for aesthetics.

**Procedures**

*Inspection*

Filter strips are easy to inspect and need to be well maintained to treat stormwater. Make frequent visual inspections for problems such as channeling flow, rills, bare ground, oily material, and debris.

Identify and remove pollutant sources.

*Cleaning*

Clear inlets and outlets to prevent blockage.

Remove litter when mowing or litter accumulates.

Use a rake and/or shovel to remove sediment and debris accumulations greater than 2-inches thick that cover grass areas; avoid vegetation removal. Remove sediment and re-level the slope to an even surface so that water spreads and does not form channels. Reseed bare areas.

*Vegetation Management*

Mow to keep grass at the optimum height (6-inches). Mow to no less then 4-inches in height and a minimum of four cutting per year.

Remove clippings from the treatment area. They may be spread elsewhere on site where they will not reenter the stormwater facility.

Preserve healthy vegetation or reestablish vegetation where needed. Seed bare spots.

Use appropriate BMP's to cover bare soils. BMP's include hydroseeding or mulches.

Storm sewer facilities are, in effect, water body buffers where pesticides and fertilizers are not to be used. See Vegetation Management in Storm Sewer Systems for more information.

*Repairs*
Where possible, correct the underlying problem before trying to repair the symptom.

The flow spreader must be level and spread flow evenly across the filter strip. Immediately repair any defects in the flow spreader.

If ruts develop, fill them with coarse soil, level the surface and reseed.

## Detention Ponds/Facility

Detention pond facilities are designed to hold and slowly release stormwater by use of a pond and a specially designed control structure. Styles vary greatly from well manicured to natural appearing. Generally, native vegetation is preferred for reduced maintenance and enhance wildlife habitat. Some facilities are designed to appear as natural water bodies or are in a park-like setting.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the work area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R3 Avoid or minimize vegetation removal.
- R7 Maintain or restore the intended infrastructure function.
- R8 Prevent or reduce flooding.
- R10 Meet public expectations for aesthetics.

**Procedures**

*Inspection*

Facilities should be inspected, at a minimum, once a year. Inspect the facility for litter, dead vegetation, invasion of trees and noxious weeds, accumulated sediment, oil and other pollutants. Identify pollutant sources to the facility.

*Cleaning*

Remove litter when litter accumulates.

Remove any pollutants greater in volume then a surface sheen.

Remove trees and noxious weeds that are growing within the pond, on side slopes/berms, or within the emergency overflow area.

Remove sediment when it accumulates to 10 percent of the designed pond depth (plans can be obtained for Public Works Department). Sediment removal should be undertaken during the summer months (drier time of the year). Ponds are not to be altered from the original approved design without prior permission from the City of Camas.

*Material Handling*

Disposal of waste, e.g. sediment or standing water, from the maintenance of these facilities shall be conducted in accordance with federal, state, and local regulations, including the Minimum Functional Standards for Solid Waste handling Chapter 173-304 WAC; guidelines for disposal of waste materials; and where appropriate, Dangerous Waste Regulations, Chapter 173-303 WAC.

*Vegetation Management*

Where a facility has a natural area (open space/buffer/wetlands), vegetation management should be timed to avoid or minimize impacts on wildlife. An example is a facility used by breeding birds such as red-winged black birds.

Mow, or rotary weed trim, vegetation to match surrounding area or sustain any other intended use of the facility, such as wildlife habitat or recreation area.

Use mechanical methods to control weeds. Pesticides, herbicides and fertilizers are not to be used in stormwater control facilities. See Vegetation Management in Storm Sewer Systems for more information.

If plants need replacing, please contact the City for a list of native plants.

Trees are not allowed to grow in the pond, on emergency overflows, or on berms. Trees can block flows and roots can lead to berm failure.

Trees and shrubbery may be allowed to grow around the perimeter of the pond unless growth interferes with the facility function or maintenance activities.

Blackberry removal is required and should be done 2-3 times a year. Pesticide use is **not** allowed around water. After cutting down of blackberries, vines are to be bagged and removed from the area.

*Repairs*

Repair and seed bare areas. Repair eroded slopes when rills form. Use cover BMP's on exposed soils.

Rodent holes in a dam or berm can serve as a means of piping water out of the pond. Remove the rodents, preferably by trapping, and repair the dam or berm. Check with the Washington Department of Fish and Wildlife before removing a game animal or fur-bearer, for example muskrat, beaver, and nutria.

Where applicable, repair the pond liner if it is visible and repair or replace where there are more than three holes greater than ¼-inch diameter.

If berms or dams show signs of settlement or sinkholes, serious problems may be occurring. Consult a licensed professional engineer to determine the cause of the settlement or sinkhole. Spillway areas should be completely covered by minimum of 12-inches of rock. **Design modifications to any storm sewer facility cannot be made without prior approval from the City of Camas.**

## Infiltration Facilities (Basins/Ponds/Trenches)

Infiltration facilities dispose of water by holding it in an area where it can soak into the ground. These are open facilities that may either drain rapidly and have grass bases, or have perpetual ponds where water levels rise and fall with stormwater flows. Infiltration facilities may be designed to handle all of the runoff from an area or they may overflow and bypass larger storms.

Since the facility is designed to pass water into the ground, generally after passing through a sediment trap/manhole, anything that can cause the base to clog will reduce the performance and is a large concern. Generally, infiltration basins are managed like detention ponds, but with greater emphasis on maintaining the capacity to infiltrate stormwater.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R3 Avoid or minimize vegetation removal.
- R7 Maintain or restore the intended infrastructure function.
- R8 Prevent or reduce flooding.
- R10 Meet public expectations for aesthetics.

**Procedures**

*Inspection*

During the first year after construction, the sediment trap shall be monitored after every large storm (>1-inch per 24 hours) and monthly from October 1 through May 31 to ensure the facility is draining as intended.

Check once per year after a rainstorm to see if the facility is draining as intended. Inspect all features of the facility annually.

A thorough inspection of the observation points should be made if there is a decrease in retention basin capacity. Inspection points can include monitoring ports built into the base of the facility and water table depth monitoring wells. Water levels in these inspection points can provide information about the performance of the facility. It will probably require a licensed professional engineer or other professional trained in hydraulics to interpret the information.

Identify and remove pollutant sources to the facility. Inspect the facility for oil and other pollutants and remove any pollutants greater in volume than a surface sheen.

*Cleaning*

Trash is to be removed as it accumulates.

Remove sediment when it accumulates to 2-inches or if the facility does not drain between storms or meet 90 percent of design capabilities.

If the facility has a sediment trap/manhole, clean out the sediment when one-half foot accumulates.

*Materials Handling*
Disposal of waste from maintenance of drainage facilities shall be conducted in accordance with federal, state, and local regulations, including the Minimum Functional Standards for Solid Waste handling Chapter 173-304 WAC; guidelines for disposal of waste materials; and where appropriate, Dangerous Waste Regulations, Chapter 173-303 WAC.

*Vegetation Management*
Where a facility has a natural area (open space/buffer/wetlands), vegetation management should be timed to avoid or minimize impacts on wildlife. An example is a facility used by breeding birds such as red-winged black birds.

Mow, or rotary weed trim, vegetation to match surrounding area or sustain any other intended use of the facility, such as wildlife habitat or recreation area.

Use mechanical methods to control weeds. Pesticides, herbicides and fertilizers are not to be used in stormwater control facilities. See Vegetation Management in Storm Sewer Systems for more information.

If plants need replacing, please contact the City for a list of native plants.

Trees should not be allowed to grow in the pond, over the trench, on emergency overflows, or on berms that are greater than 4-feet in height. Trees can block flows and roots can lead to berm failure. Remove any trees growing on emergency overflows, berms greater than 4-feet in height, or within the pond.

Trees and shrubbery should be allowed to grow around the perimeter of the facility unless growth interferes with the facility function or maintenance activities. Any cut trees should be salvaged for habitat enhancement or converted to mulch or firewood.

*Repairs*
If the facility is overflowing for a storm that is it was designed to infiltrate, it needs to be repaired. This may require removing accumulated sediment and cleaning or rebuilding the system so that it works according to design.

Repair and seed bare areas. Repair eroded slopes when rills form. Use cover BMP's on exposed soils.

Rodent holes on a dam or berm can serve as a means of piping water out of the pond. Remove the rodents, preferably by trapping, and repair the dam or berm. Check with the Washington Department of Fish and Wildlife before removing a game animal or fur-bearer, for example muskrat, beaver, and nutria.

Spillway areas should be completely covered with more a minimum of 12-inches of rock.

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## Wet Biofiltration Ponds, Swales, and Treatment Wetlands

Wet biofiltration swales and treatment wetlands use dense wetland vegetation and settling to filter sediment and oily materials out of stormwater. These stormwater treatment devices must be properly maintained to sustain pollutant removal capacity. In some cases, biofiltration swales that were designed to drain between storms remain wet and need to be rebuilt or converted to wetland swales. A designed wet biofiltration swale uses wetland plants instead of grass.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R7 Maintain or restore the intended infrastructure function.
- R10 Meet public expectations for aesthetics.

**Procedures**

*Inspection*

Swales are easy to inspect and need to be well maintained to treat stormwater. Make frequent visual inspections for problems such as bare ground, sediment and oily material.

Identify and remove sources of pollutants to the swale.

*Cleaning*

Clear inlets and outlets of debris in order to prevent blockage.

Remove litter and trash when it collects.

Where possible, use a rake and/or shovel to remove sediment accumulations greater than 2-inches thick in 10 percent of the treatment area.

*Vegetation Management*

Sparse vegetation or dense clumps of cattail do not properly treat stormwater. Try to find the cause of the problem and fix it to ensure dense vegetation. Cut back excessive cattail shoots. Normally, wetland vegetation does not need to be harvested unless there is an excessive die back that causes water quality problems.

If there is a problem with grass dying due to the swale being flooded during the wet season, there are two options: plant varieties that can stand being flooded or find a way to fix the swale so it drains better. Call the Public Works Department at 817-7231 for information on plants and possible swale modifications.

Outside of the treatment area, preserve healthy vegetation or reestablish vegetation where needed. Seed bare spots. Use cover BMP's on bare soils.

Trees and shrubbery should be allowed to grow unless they interfere with facility function or maintenance activities. Any cut trees should be salvaged for habitat enhancement or converted to mulch or firewood.

Stormwater control facilities are, in effect, water body buffers in which pesticides and fertilizer are not used. See Vegetation Management in Stormwater Control Facilities for more information.

*Repairs*

Often swales have problems due to flooding or erosion. Where possible, correct the underlying problem before trying to repair the symptom.

Repair any defect that causes the wet swale to dry out during the wet season.

Replace stormwater facility signs that are broken, damaged, or stolen.

## Drainage Ditches

Ditches are often manmade open-channels that carry only stormwater. These ditches are maintained to prevent localized flooding by draining stormwater. Maintenance includes removing sediment, debris, litter, and overgrown vegetation.

Many manmade drainage ditches carry water when it is not raining. This water comes from groundwater seepage and wetlands. These ditches can be recognized by the presence of wetland plants, such as cattails. Any work that disturbs these channels is probably subject to a variety of environmental regulations and may require an HPA permit from the Washington Department of Fish and Wildlife. Contact the Washington Department of Fish and Wildlife and the City of Camas Public Words Department before beginning any work.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R3 Avoid or minimize vegetation removal.
- R4 Preserve natives plants.
- R7 Maintain or restore the intended infrastructure function.
- R8 Prevent or reduce flooding.
- R9 Protect infrastructure.

**Procedures**

*Inspection*

Inspect ditches during routine site maintenance or at least once per year.

*Cleaning*

Land disturbing activities that remove vegetation or disturb soil are subject to erosion/sediment control requirements per CMC 15.32. A good time to clean drainage ditches is during the growing season, when it's easiest to reestablish vegetation.

Cleaning or excavating within seasonally dry or ditched watercourses may require an HPA from WDFW. Consult the official state DNR water type maps or contact the City of Camas for assistance in determining whether watercourses are typed streams (e.g. type 1, 2, 3, 4 or 5) that are regulated by WDFW. *Contact VTDFW Region Five office for additional information on whether specific watercourses are regulated under the State Hydraulic Code, or if unmapped streams are encountered.*

If feasible, remove small amounts of sediment by hand when performing routine site maintenance.

Vegetation should only be removed when it reduces free movement of water through the ditch. Never remove more vegetation than is absolutely needed.

Only remove sediment when it reaches 20 percent of the ditch depth or affects the historic or designed hydraulic capacity.

Alternate cleaning areas with undisturbed areas, leaving undisturbed sections to act as sediment trapping filters between worked areas.

Trap sediment that is generated by ditch maintenance to keep it from entering water bodies. Use sediment-trapping BMP's such as bio-filter bags at the lower end of each excavated area.

Prevent sediment from eroding when ditch work is performed. Perform work during dry weather unless there is an emergency, such as property or road flooding.

Vegetate bare soils by hydroseeding or cover bare soils with an approved BMP. Hand seed for smaller areas.

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# Operation & Maintenance Procedures

# Stormwater Structures

# Public & Private Systems

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## Catch Basins and Curb Inlets

Catch basins and curb inlets trap sediment and some oils that are washed off the road surface during a storm event. This sediment and the oils if not removed from the basins and inlets have the potential to pollute water bodies. They need to be inspected and cleaned at a minimum annually, more often if necessary; to remove accumulated sediment, fluids, and trash.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the work area.
- R2 Prevent parking areas, roads, drainage systems, facilities, and property from becoming pollutant sources.
- R7 Maintain or restore the intended infrastructure function
- R8 Prevent or reduce flooding.
- R9 Protect infrastructure.

**Procedures**

*Inspection*

Inspect catch basins and curb inlets at least once per year, more often if necessary.

Periodically inspect the catch basin or curb inlets and surrounding areas for pollutants, such as leaks from dumpsters, minor spills, and oil dumping. Act to have the pollutant source removed. Ensure that grass clippings and leave debris is not being blown into the streets.

*Cleaning*

Clean catch basins and curb inlets when they become one third full in order to maintain sediment-trapping capacity. Catch basin, curb inlet, and manhole cleaning should be performed in a manner that keeps removed sediment and contaminated water from being discharged back into the storm sewer.

Clean putrid materials from the catch basins and curb inlets when discovered or reported.

Keep the inlet grates cleared of debris and litter.

*Safety*

Work inside underground structures (e.g. manholes) requires special OSHA-required confined space equipment and procedures. The most practical option may be to contract with a sewer-cleaning contractor for this work.

*Materials Handling*

Disposal of waste from maintenance of drainage facilities shall be conducted in accordance with federal, state, and local regulations, including the Minimum Functional Standards for Solid Waste handling Chapter 173-304 WAC; guidelines for disposal of waste materials; and where appropriate, Dangerous Waste Regulations, Chapter 173-303 WAC.

Removed sediment must be disposed of in the garbage as solid waste. Contaminated water should be disposed of in a sanitary sewer after oils are removed using oil absorbent materials or other mechanical means. Used oil absorbents should be recycled or disposed according to the manufacture's instructions.

*Repairs*

Repair any damages that prevent the catch basin or curb inlet from functioning as designed. An example is a broken or missing outlet elbow.

Follow the Procedures described under the Activity: Installation, Repair and Replacement of Enclosed Drainage Systems.

## Debris Barriers/Trash Racks

Debris barriers and trash racks are barred covers to pipe openings. They prevent large objects from entering pipes and keeps pets and people out of the pipes as well. In cases where there is fish migration, maintaining unblocked trash racks allows fish passage.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the work area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R5 Protect public safety and health.
- R6 Prevent catastrophique infrastructure failures.
- R7 Maintain or restore the intended infrastructure function.
- R8 Prevent or reduce flooding.
- R9 Protect infrastructure.

**Procedures**

*Inspection*

Inspect debris barriers and trash racks at least once per year in the fall.

*Cleaning*

Clean debris barriers and trash racks when debris is plugging more then 20 percent of the openings or when obstruction to fish passages are created. Consult the Washington Department of Wildlife is in a fish-bearing waterway.

*Repairs*

Immediately replace missing racks and bars.

Replace bars that are deteriorated to the point where they may be easily removed.

Straighten bent bars back into position.

Follow the Procedures described in the Activity: Installation, Repair and Replacement of Enclosed Drainage Systems.

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## Energy Dissipaters

Energy dissipaters are critical for preventing erosion at storm drain outfalls. There are a variety of designs, including wire gabion baskets, rock splash pads, trenches, and specially designed pools or manholes.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the work area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R7 Maintain or restore the intended infrastructure function.
- R8 Prevent or reduce flooding.
- R9 Protect infrastructure.

**Procedures**

*Inspection*

Inspect at least once per year.

*Cleaning*

Remove any accumulated litter.

Dispersion trenches: remove sediment from pipe when it reaches 20 percent of the pipe diameter.

*Repairs*

Rock splash pads: replace missing or moved rocks to cover exposed soil and meet design standards.

Dispersion trenches: repair conditions that cause concentrated flow along the trench. Clean pipe perforations when one-half of them are plugged or if flows bypass or overflow the trench.

Manhole/Chamber: when the structure deteriorates to one-half its original size or it becomes structurally unsound, replace it to the design standards.

Follow the practice described under the Activity: Installation, Repair and Replacement of Enclosed Drainage Systems.

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## Manholes

Manholes are large cylindrical vaults usually set at storm sewer pipe connections. Unless you have OSHA approved training and equipment, never enter a manhole. There is a considerable risk of poisonous gas and injury.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the work area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R7 Maintain or restore the intended infrastructure function.
- R8 Prevent or reduce flooding.
- R9 Protect infrastructure.

**Procedures**

*Inspection*

Inspect the manhole once per year. Check frame and lid for cracks and wear, such as rocking lids or lids move by traffic.

Periodically inspect the manhole and surrounding areas for pollutants such as leaks from dumpsters, minor spills, and oil dumping. Take action to have the pollutant source removed.

*Cleaning*

Clean manholes when there is a blockage of the stormwater channel. Cleaning should be performed in a way that ensures removed sediment and water is not discharged back into the storm sewer.

*Safety*

**Never** enter a confined space without proper training and safety gear. Work inside underground structures requires special OSHA-required confined space equipment and procedures. The most practical option may be to contract with a sewer-cleaning contractor.

*Materials Handling*

Disposal of waste from maintenance of drainage facilities shall be conducted in accordance with federal, state, and local regulations, including the Minimum Functional Standards for Solid Waste handling Chapter 173-304 WAC; guidelines for disposal of waste materials; and where appropriate, Dangerous Waste Regulations, Chapter 173-303 WAC.

Removed sediment must be disposed of in the garbage as solid waste. Contaminated water should be disposed of in a sanitary sewer after oils are removed using oil absorbent materials or other mechanical means. Used oil absorbents should be recycled or disposed according to the manufacture's instructions.

*Repairs*

Repair all security and access features so they are fully functional. This includes locking lids, cover, and ladder rungs.

Replace broken parts or lids that rock or are moved by traffic.

Follow the practice described under the Activity: Installation, Repair and Replacement of Enclosed Drainage Systems.

## Oil/Water Separators and Buried Wet Vaults

An oil/water separator is an underground vault that treats stormwater by mechanically separating oil from water. The oil rises to the surface and floats on the water and sediment settles to the bottom. Buried wet vaults are similar to oil/water separators in that they are sub-surface vaults that separate sediment and floating materials from stormwater.

These facilities have special problems for maintenance and should be serviced by contractors. The main issues are working in confined spaces and properly handling any sludge and oil cleaned from vaults or oil/water separators. Manufacturer's recommendations for maintenance should be followed at a minimum.

**Maintenance Results**

R1 Avoid or minimize sediment and pollutant discharges from the work area.
R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
R7 Maintain or restore the intended infrastructure function.
R9 Protect infrastructure.

**Procedures**

*Inspection*

Periodically check stormwater flow out of the facility. It should be clear and not have a thick visible oil sheen.

Annually check for cracks large enough to let soil enter the vault, broken or defective plates and baffles, and crushed or damaged pipes.

Periodically inspect the surrounding areas for pollutants, such as leaks from dumpsters, minor spills, and oil dumping. Take action to the pollutant source removed.

*Cleaning*

Remove trash and litter from the vault, inlet, and piping.

Remove oil when it reaches one-inch thickness.

Remove sediment when it accumulates to 6-inches in depth.

*Safety*

Work inside underground structures requires special OSHA-required confined space equipment and procedures. The most practical option may be to contract with a sewer-cleaning contractor.

*Materials Handling*

Disposal of waste from maintenance of drainage facilities shall be conducted in accordance with federal, state, and local regulations, including the Minimum Functional Standards for Solid

Waste handling Chapter 173-304 WAC; guidelines for disposal of waste materials; and where appropriate, Dangerous Waste Regulations, Chapter 173-303 WAC.

Removed sediment must be disposed of in the garbage as solid waste. Contaminated water should be disposed of in a sanitary sewer after oils are removed using oil absorbent materials or other mechanical means. Used oil absorbents should be recycled or disposed according to the manufacture's instructions.

*Repairs*

Repair any cracked or defective plates or baffles. Cracks are repaired so that no cracks greater than ¼-inch are present. Repair any leaks that allow water levels to drop and cause oil to be washed from the unit.

Repair all security and access features so they are fully functional. This includes locking lids, covers, and ladder rungs.

Follow the practice described under the Activity: Installation, Repair and Replacement of Enclosed Drainage Systems.

## Flow Control Structures/Flow Restrictors

Flow control structures and flow restrictors direct or restrict flow in or out of a facility. Outflow controls on detention facilities are a common example where flow control structures slowly release stormwater at a specific rate. If these flow controls are damaged, plugged, bypassed, or not working properly, the facility could overtop or be releasing water at too high of a rate. This would likely damage streams habitat and property. Site plans should have detailed drawings showing how the flow control structures should appear. Consult a licensed professional engineer or the City of Camas Public Works Department for assistance.

### Maintenance Results

R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
R7 Maintain or restore the intended infrastructure function.
R9 Protect infrastructure.

### Procedures

*Inspection*

Inspect at least once per year for all features listed under Cleaning and Repairs, or when a facility does not drain properly or other problems occur.

*Cleaning*

Remove sediment within 18-inches of the bottom of an orifice plate.

Remove trash and debris that may block the orifice plate.

Remove any trash or debris that may bloc an overflow pipe.

*Safety*

Work inside underground structures requires special OSHA-required confined space equipment and procedures. The most practical option may be to contract with a sewer-cleaning contractor.

*Materials Handling*

Disposal of waste from maintenance of drainage facilities shall be conducted in accordance with federal, state, and local regulations, including the Minimum Functional Standards for Solid Waste handling Chapter 173-304 WAC; guidelines for disposal of waste materials; and where appropriate, Dangerous Waste Regulations, Chapter 173-303 WAC.

Removed sediment must be disposed of in the garbage as solid waste. Contaminated water should be disposed of in a sanitary sewer after oils are removed using oil absorbent materials or other mechanical means. Used oil absorbents should be recycled or disposed according to the manufacture's instructions.

*Repairs*

Repair or replace to original design specification any outlet orifice that is enlarged, bypassed, or damaged.

Make certain that overflow outlets are not blocked.

Structures should be securely in place and within 10 percent of vertical.

Repair outlet pipe structures that have leaking connections or holes not specified by the design.

Repair or replace a non-functional or damaged cleanout gate.

Repair or replace damaged orifice plates to original design specification.

No outflow controls can be modified with approval of the City of Camas Public Works Department engineer.

Follow the practice described under the Activity: Installation, Repair and Replacement of Enclosed Drainage Systems.

## Storm Sewer/Drain Pipe

Storm sewer pipes convey stormwater. Storm pipes are constructed of many different types of materials and are sometimes perforated to allow groundwater to be collected by the storm system. Storm pipes are cleaned to remove sediment or blockages when problems are identified. Storm pipes must be clear of obstructions and breaks to prevent localized flooding.

**Maintenance Results**

- O1 Avoid or minimize sediment and pollutant discharges from the work area.
- O2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- O7 Maintain or restore the intended infrastructure function.
- O8 Prevent or reduce flooding.
- O9 Protect infrastructure.

**Procedures**

*Inspection*

Pipes are difficult to inspect requiring special equipment and training. Usually, if a problem occurs the owner needs to call a sewer of plumbing contractor to inspect, repair, or clean pipelines.

*Cleaning*

Clean pipes when sediment depth is greater than 20 percent of pipe diameter. When cleaning a pipe, minimize sediment and debris discharges from pipes to the storm sewer. Install downstream debris traps (where applicable) before cleaning and then remove material.

Generally, use mechanical methods to remove root obstructions from inside storm sewer pipes. Do not put root-dissolving chemicals in storm sewer pipes. If there is a problem, remove the vegetation over the line.

*Safety*

Work inside underground structures requires special OSHA-required confined space equipment and procedures. The most practical option may be to contract with a sewer-cleaning contractor.

*Materials Handling*

Sediment and debris from pipes should be disposed in the garbage as solid waste. Pick out any rocks first.

*Repairs*

Repair or replace pipes when a dent or break closes more than 20 percent of the pipe diameter.

Repair or replace pipes damaged by rust or deterioration.

Follow the practice described under the Activity: Installation, Repair, and Replacement of Enclosed Drainage Systems.

## Underground Detention Systems

Some detention systems consist of underground tanks or vaults that are usually placed under paved areas. They hold and slowly release stormwater runoff from roofs and pavement.

Tanks and vaults are confined spaces where work requires special OSHA-required training and equipment.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the work area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R7 Maintain or restore the intended infrastructure function.
- R9 Protect infrastructure.

**Procedures**

*Inspection*

Inspect annually for the features listed under Cleaning and Repairs.

Periodically inspect the manhole and surrounding areas for pollutants such as leaks from dumpsters, minor spills, and oil dumping. Take action to have the pollutant source removed.

*Cleaning*

Remove trash and litter from the vault, inlet, and piping.

Clean air vents that have one-half of their area plugged.

Remove sediment when it accumulates to $1/10^{th}$ the depth of a rectangular vault or $1/10^{th}$ the diameter of a round tank or pipe.

*Safety*

Work inside underground structures requires special OSHA-required confined space equipment and procedures. The most practical option may be to contract with a sewer-cleaning contractor.

*Materials Handling*

Disposal of waste from maintenance of drainage facilities shall be conducted in accordance with federal, state, and local regulations, including the Minimum Functional Standards for Solid Waste handling Chapter 173-304 WAC; guidelines for disposal of waste materials; and where appropriate, Dangerous Waste Regulations, Chapter 173-303 WAC.

Removed sediment must be disposed of in the garbage as solid waste. Contaminated water should be disposed of in a sanitary sewer after oils are removed using oil absorbent materials or other mechanical means. Used oil absorbents should be recycled or disposed according to the manufacture's instructions.

*Repairs*

Repair any cracked or defective plates or baffles. Cracks are repaired so that no cracks greater than ¼-inch are present.

Any part of a tank or pipe that is bent out of shape more than 10 percent of its design shape must be replaced or repaired.

Repair any joints that are cracked and allow soil into the facility.

Repair all security and access features so they are fully functional. This includes locking lids, covers, and ladder rungs.

Follow the practice described under the Activity: Installation, Repair and Replacement of Enclosed Drainage Systems.

# Operation & Maintenance Procedures

# Special Facilities

# Public & Private Systems

September 2009

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## Drywells

Drywells are perforated, open-bottomed manholes used to infiltrate stormwater into the ground. While not the intended use, drywells trap sediment and some of the oil pollutants in stormwater runoff. Drywells are more likely to fill with oily sediment in areas that lack swales or other treatment facilities. Fine oil sediment can clog drywells and lead to localized street flooding. Also, pollutants discharged into drywells can migrate into groundwater. Drywells were often installed in closed topographic depressions, areas with will-drained soils, or areas having inadequate storm sewers. Often, drywells contain groundwater.

**Maintenance Results**

R1 Avoid or minimize sediment and pollutant discharges from the work area.
R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
R7 Maintain or restore the intended infrastructure function.
R8 Prevent or reduce flooding.
R9 Protect infrastructure.

**Procedures**

*Inspection*

Drywells should be inspected at least once a year and no less than once every five years.

Periodically inspect the manhole and surrounding areas for pollutants such as leaks from dumpsters, minor spills, and oil dumping. Take action to have the pollutant source removed.

If a problem with flooding or slow drainage occurs, observe or inspect the drywell for infiltration rate and observe water level depths if monitoring wells are installed.

*Cleaning*

Clean out drywells when sediment depth is greater than 1/3 of the distance between the vase and inlet pipe.

Drywell cleaning should be performed in a way that makes certain removed sediment and water is not discharged back into the storm sewer.

*Safety*

Work inside underground structures requires special OSHA-required confined space equipment and procedures. The most practical option may be to contract with a sewer-cleaning contractor.

*Materials Handling*

Disposal of waste from maintenance of drainage facilities shall be conducted in accordance with federal, state, and local regulations, including the Minimum Functional Standards for Solid Waste handling Chapter 173-304 WAC; guidelines for disposal of waste materials; and where appropriate, Dangerous Waste Regulations, Chapter 173-303 WAC.

Removed sediment must be disposed of in the garbage as solid waste. Contaminated water should be disposed of in a sanitary sewer after oils are removed using oil absorbent materials or other mechanical means. Used oil absorbents should be recycled or disposed according to the manufacture's instructions.

*Repairs*
If the drywell does not dissipate stormwater, it should be replaced or repaired.

It is possible to restore some drywell capacity by water-jetting clogged openings.

Another option is installing a new drywell or drainage trench, and converting the clogged drywell into a sediment trap. This has the advantage of providing a sediment trap and some amount of spill trapping. The sediment trap conversion requires grouting the holes, covering the base with concrete, and adding piping. Alterations to any storm facility **cannot** be done without approval from the City of Camas.

If there is standing water in a drywell, it probably is into the water table. Drywells in the water table should be rebuilt to prevent stormwater from going directly into groundwater.

Repair all security and access features so they are fully functional. This includes locking lids, covers, and ladder rungs.

Follow the practice described under the Activity: Installation, Repair, and Replacement of Enclosed Drainage Systems.

## StormFilter™ (Leaf Compost Filter)

The StormFilter is a patented system for treating stormwater. The systems have evolved during the last 10 years from very simple above ground filter beds to a variety of vault devices containing cylindrical filters filled with leaf compost pellets. StormFilter facilities consist of cartridges filled with one or a combination of media. Media can be selected to target pollutants specific to a particular site. The cartridges are housed in pre-cast or cast in-place concrete vaults or in a steel catch basin configuration. Each configuration uses baffles to promote settling of solids and separation of oils and other floatable materials. The majority of pollutants are captured by the media and held in the cartridges. Some additional settling will occur in the inlet and cartridge bays of each vault.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the work area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R7 Maintain or restore the intended infrastructure function.
- R9 Protect infrastructure.

**Procedures**

*Inspection*

Inspect the StormFilter every six months. The inspection should determine sediment depth and the specific maintenance and repairs needed.

Inspect annually for cracks large enough to let soil enter the vault, broken or defective plates and baffles, and crushed or damaged pipes.

Periodically inspect the manhole and surrounding areas for pollutants such as leaks from dumpsters, minor spills, and oil dumping. Take action to have the pollutant source removed.

*Cleaning*

Remove trash and litter from the vault, inlet, and piping.

Remove sediment when it accumulates to 6-inches in depth in settling chambers.

Remove sediment when it accumulates on filter media.

Replace media cartridges per manufacture's recommendation.

*Safety*

Work inside underground structures requires special OSHA-required confined space equipment and procedures. The most practical option may be to contract with a sewer-cleaning contractor.

*Materials Handling*

Disposal of waste from maintenance of drainage facilities shall be conducted in accordance with federal, state, and local regulations, including the Minimum Functional Standards for Solid

Waste handling Chapter 173-304 WAC; guidelines for disposal of waste materials; and where appropriate, Dangerous Waste Regulations, Chapter 173-303 WAC.

Removed sediment must be disposed of in the garbage as solid waste. Contaminated water should be disposed of in a sanitary sewer after oils are removed using oil absorbent materials or other mechanical means. Used oil absorbents should be recycled or disposed according to the manufacture's instructions.

*Repairs*

Repair any cracked or defective plates or baffles. Cracks are repaired so that no cracks greater than ¼-inch are found.

Replace media cartridges if it takes longer than an hour for water to empty through media or if water frequently overflows the treatment chamber. Replace defective cartridges.

Repair all security and access features so they are fully functional. This includes locking lids, covers, and ladder rungs.

Follow the practice described under the Activity: Installation, Repair, and Replacement of Enclosed Drainage Systems.

## Infiltration Systems (work in-progress)

Due to the dominance of clay soils within the City of Camas, infiltrations systems are not allowed, except on a case-by-case basis.

**Maintenance Results**

R1 Avoid or minimize sediment and pollutant discharges from the work area.
R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
R7 Maintain or restore the intended infrastructure function.
R10 Meet public expectations for aesthetics

**Procedures**

*Inspection*

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# Operation & Maintenance Procedures

# Miscellaneous Activities

# Public & Private Systems

September 2009

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## Fences, Gates, and Water Quality Signs

Fences are installed around the perimeter of storm sewer facilities as a means of protecting the public, as they restrict entrance to the facility. Gates are installed to allow for maintenance access. Gates will be secured shut, typically with a double lock system that allows access to the City and to the property owner's maintenance crew.

Water Quality Signs are installed on the fences, or on sign poles, within public view as a means of educating the public as to the presence of a storm sewer facility. These signs also have a number located in the upper right hand corner that is cross referenced, at the City, to an address and maintenance responsibility.

**Maintenance Results**

R5 Protect public safety and health.
R7 Maintain or restore the intended infrastructure function.
R9 Protect infrastructure.

**Procedures**

*Inspection*

Inspect fences, gates, and water quality signs during facility maintenance.

*Repairs*

Repair any opening that allows entry into the facility, including access beneath the fence.

Replace any missing gates.

Repair broken gate hinges or gates which do not close and lock properly.

Replace any missing signs or signs that have more than a 20 percent unreadable surface.

Repair sign posts that lean more than 8-inches off vertical.

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## Access Roads and Easements

Most stormwater facilities have access roads to bring in heavy equipment for facility maintenance. These roads should be maintained for inspection access and ease of equipment access.

**Maintenance Results**

- R1 Avoid or minimize sediment and pollutant discharges from the work area.
- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R7 Maintain or restore the intended infrastructure function.
- R10 Meet public expectations for aesthetics.

**Procedures**

*Inspection*

Inspect once a year or when facilities are maintained.

*Cleaning*

Remove litter when mowing or when there is any accumulation.

Remove any debris that blocks roads or may damage tires.

*Vegetation Management*

Manage vegetation as for the rest of the facility. Trees and shrubs may be removed from access roads and easements if they block access for necessary maintenance or will prevent or harm intended stormwater facility function. Use of pesticides is prohibited unless prior approval is received from the City.

*Repairs*

Correct any bare or eroded soils by seeding or a cover BMP.

Repair road surfaces when they may lead to erosion or limit equipment access.

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## Pavement Sweeping

Pavement sweeping is performed as a means of removing sand, dirt, and litter from streets and curb gutters. Sweeping also reduces dust during dry weather. Pavement sweeping is also part of storm sewer maintenance procedure because it limits the amount of sediment washed into the storm sewer facilities. The water quality procedure for street sweeping focuses on sediment removal and disposal. Reducing the amount of sediment washed into catch basins, curb inlets, detention facilities, drywells, and other facilities can save money because sweeping is generally cheaper that removing sediment from facilities. Sweeping also helps protect facilities from clogging with sediment.

**Maintenance Results**

- R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
- R5 Protect public safety and health.
- R10 Meet public expectations for aesthetics.

**Procedures**

*Inspection*

Inspect on a weekly basis, depending on traffic volumes.

*Cleaning*

Sweep the site to help keep sediment from entering storm sewer systems and water bodies.

Sweeping is especially useful for cleaning up work areas.

Sweeping can be as easy as using a couple of push brooms or as involved as using mechanical methods.

*Materials Handling*

Disposal of waste from maintenance of drainage facilities shall be conducted in accordance with federal, state, and local regulations, including the Minimum Functional Standards for Solid Waste handling Chapter 173-304 WAC; guidelines for disposal of waste materials; and where appropriate, Dangerous Waste Regulations, Chapter 173-303 WAC.

Sweepings should be disposed of as solid waste or under a program permitted by the Southwest Washington Health District.

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# Operation & Maintenance Procedures

# Enclosed Storm Sewers System

## Public & Private Systems

September 2009

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## Installation, Repair, and Replacement of Enclosed Drainage Systems

This chapter includes tasks such as repair and replacement of pipe, catch basins, drywells, and manholes. It also includes drainage projects that add new pipes, catch basins, or infiltration structures. New drainage projects are subject to regulations under CMC 15.36 Erosion/Sediment Control Plans.

**Maintenance Results**

R1 Avoid or minimize sediment and pollutant discharges from the work area.
R2 Prevent parking areas, roads, drainage systems, and drainage facilities from becoming pollutant sources.
R7 Maintain or restore the intended infrastructure function.
R8 Prevent or reduce flooding.

**Procedures**

*Cleaning*

Avoid or minimize vegetation removal. If work is near a stream or wetland, there are regulatory requirements to must be met.

Prevent debris, oils, cleaning agents, and sediment from entering waterways.

Avoid or minimize work in wet weather. This will reduce the problems of containing sediment.

Carry spill control kit on-site to contain and clean up possible small spills in the work area, e.g. oil spills.

Protect our storm systems:

- Install sediment traps around curb inlets and catch basins, e.g. biobags or gravel filled pillows.
- Install catch basin inserts.
- Sweep or vacuum dust and debris from the repair job. Do not wash materials into storm sewers.
- Place stockpiles away from drainage ways, wetlands, and natural wetland and habitat buffers. Cover stockpiles or contain them with berms or other containment devices.
- At stream crossings, trap material using screens or another approved form of containment. Use containment BMP's to protect roadside ditches during wet weather.

Ensure that along with the approved erosion/sediment control measures that are in-place prior to construction, that there is an emergency sediment control kit for unexpected problems; e.g. trench dewatering. This should include:

- Sediment bag,
- Additional biobags and catch basin inserts,
- Push brooms and flat edge shovels.

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## Minor Culvert Repair (not in a natural stream)

This activity is for the replacement or repair of culverts and inlets. It applies only to structures that are in ditches that are specifically for storm drainage. These are ditches that do not carry water during dry weather. If there is any question about whether the ditch is a storm drain or a stream, consult with the Washington Department of Fish and Wildlife and the City of Camas Public Works Department.

**Maintenance Results**

R1 Avoid or minimize sediment and pollutant discharges from the work area.
R3 Avoid or minimize vegetation removal.
R7 Maintain or restore the intended infrastructure function.
R8 Prevent or reduce flooding.
R9 Protect infrastructure.

**Procedures**

Comply with erosion/sediment control requirements in CMC 15.32.

Avoid or minimize vegetation removal. If work is near a stream or wetland, there are likely to be regulatory requirements.

Other than to address a threat to public safety or property due to flooding, perform work during the dry season.

Minimize soil disturbance.

Use sediment controls to trap any sediment and prevent sediment from entering the storm sewer and water bodies. Sediment trapping BMP's are to be used to the extent practical during emergencies. An emergency sediment control kit is highly recommended.

Use cover BMP's to prevent erosion of bare soil. Vegetate bare soils.

## Major Culvert Repair (at a Stream Crossing)

This activity is the replacement or repair of culverts and inlets bridging a stream or ditch with flowing water during dry weather. If there is any question about whether the ditch is a storm drain or a stream, consult the Washington Department of Fish and Wildlife and the City of Camas Public Works Department.

These projects must meet all regulatory requirements.

- SEPA
- Shoreline
- HPA Permit
- Flood Plain

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# Operation & Maintenance Procedures

# Vegetation Management

## Public & Private Systems

April 2009

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## General Goals and Philosophy

The City of Camas recognizes the special importance of the rivers, streams, wetlands, ponds, and stormwater control and treatment facilities. The sensitive nature of such habitat, their plant and animal communities, and their direct link with other waterways require that we establish specific policies to ensure their health. All landscape management decisions for controlling unwanted vegetation, diseases, and pests should follow Integrated Pest Management (IPM) principles and decision-making rationale. These are as follows:

- Proper planning and management decisions begin the IPM process.
- Cultural methods of vegetation and pest control are preferred and are first employed.
- Mechanical means of vegetation and pest control are next in line of preference, and are utilized where feasible.
- Biological methods of vegetation and pest control are considered before chemical means, where they are feasible.
- Botanical and synthetic pesticides are used only when no other feasible methods exist.

## General Procedures

*Use Only Appropriate Plants*

The City of Camas has adopted a list of approved plants for use in development projects, and to assist homeowners in choosing appropriate plantings. The list also has prohibited undesirable plants. Only plants approved for use on the City of Camas Plant List are allowed for use within the City's right-of-way, storm sewer facilities, and wetland buffers.

*Mulching*

Mulches and other ground coverings are useful during the installation and restoration of landscapes as well as their ongoing maintenance. Mulches meet a variety of needs. They suppress weeds, help to retain moisture around plants, reduce possible erosion, and provide visual enhancement.

Always consider the possible impacts when using mulches, which may include:

- Inadvertent introduction of non-native plants and diseases to the site.
- Leaching of substances such as tannins from the mulch into nearby waterways.
- Migration of mulch material in waterways.
- Nutrient leaching into waterways.

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## Vegetation and Pest Management in Storm Sewer Facilities

Storm sewer facilities include biofiltration treatment swales, treatment wetlands, treatment ponds, detention ponds, open channels, and infiltration basins. Stormwater control facilities discharge to surface water or groundwater directly or through pipes or ditches. Facilities are built to remove pollutants and to control the discharge rate of stormwater.

Generally, vegetation should be maintained to blend into surrounding areas. Storm sewer facilities can also provide habitat for birds, amphibians, and other aquatic life. Promoting native vegetation, where feasible, improves habitat. Swales often blend into intensively managed landscapes. Pond perimeters can include native vegetation.

The use of pesticides, and in most cases fertilizer, is not compatible with the task of pollutant removal or where there is a direct discharge of stormwater to streams and groundwater.

**Features of Storm Sewer Facilities:**

- There is a mix of native and non-native plants.
- Generally not used by the public.
- Include areas managed to promote design function, such as turf in swales.
- Managed landscapes may be nearby.
- May be used by fish and wildlife.

**Objectives for Storm Sewer Facilities:**

- Maintain healthy plant communities.
- Avoid or minimize need for chemical intervention.
- Control invasive plants where feasible.
- No bare soil areas are allowed.
- Tolerance for natural appearance and weeds.

**Procedures**

The vegetation management focus is in establishing and maintaining healthy low-maintenance native plantings and sustaining the design function of vegetated filters, such as biofiltration swales. This includes controlling invasive plants where feasible, and planting cover on bare soils.

***Only use plants on the City of Camas approved plant list.***

In some cases, the original plantings may not be appropriate for the actual conditions at a facility. One example is a frequently flooded swale that cannot support normal turf. In cases like this, replace turf with appropriate wetland plants if the underlying drainage problem cannot be fixed.

Consider the use of soil amendments, such as compost before using fertilizer.

Limit mulch use to covering bare soil while establishing plantings.

Chemical use should be avoided within 25 feet of any area that holds or conveys surface water or stormwater. This includes the base of a biofiltration swale.

Trees or shrubs that hinder accessibility to access roads may be trimmed (or removed if within the access road) when access is required for maintenance by heavy equipment.

Trees that pose a risk to stormwater structures due to root growth should be removed and replaced by smaller shrubs.

## Vegetation and Pest Management in Wetland Areas

Constructed wetlands are built to treat stormwater. As water bodies, treatment wetlands connect to streams and groundwater. Constructed wetlands also play host to insects, fish, amphibian, and birds that are sensitive to horticultural chemicals. Because of this, chemical use should be avoided or minimized in wetland buffers. Wetland management has a low tolerance for invasive or non-native plants.

Procedures listed here apply only to those parts of a constructed wetland that are not subject to inundation or saturation during the growing season.

**Features of Constructed Wetlands:**

- Limited public access.
- Plants may or may not be well established, depending on age and condition.
- May provide fish and wildlife habitat.

**Objectives for Constructed Wetlands:**

- Maintain health plant communities.
- Avoid or minimize need for chemical intervention.
- Low tolerance of invasive and non-native plants.
- Bare soil areas are not allowed.

**Procedures**

There should be a plan for establishing and maintaining vegetation in a newly constructed wetland facility. If there is a plan, follow it. If there is not a plan, follow these Procedures. Maintenance focuses on establishing and sustaining healthy native plantings. This includes more vigorously controlling invasive plants. It also includes covering for bare soil.

***Only use plants on the City of Camas approved plant list.***

Consider the use of soil amendments such as compost before using fertilizer.

Limit mulch use to covering bare soil while establishing plantings.

Chemical intervention is to be minimized and is to be avoided, whenever possible, within 25 feet of areas subject to inundation during the growing season.

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# Operation & Maintenance Procedures

# Example "Storm Sewer System Maintenance Notification"

## Public & Private Systems

April 2009

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**CITY OF CAMAS**
**STORM SEWER SYSTEM MAINTENANCE NOTIFICATION**

Date Inspected: _____
Facility Name (subdivision/commercial/industrial): _____
Address or Location: _____
Contact Information: _____
Complete Maintenance by: _____ Re-inspected on: _____

TYPE OF FACILITY:

Detention Pond: Wet _____ Extended Dry _____ Other _____

Water Quality Swale: Yes No Wetlands in Vicinity: Yes No Possible

Other Comments: _____

GENERAL LOCATION SKETCH: Show approximate dimensions, north arrow, structure locations, access location, name of nearest road, etc. As-Builts Available: Yes No

Facility Check List:

| Item | Yes | No |
|---|---|---|
| Located Access | | |
| Located Inlet | | |
| Located Outlet | | |
| Located Orifice | | |
| Slopes (Note Excess) | | |
| Fenced / Gated | | |
| Needs a Lock | | |
| 1-3 Photos Taken | | |
| Outlet Type: Standpipe, Grated, Pipe, Open Channel, Other | | |

Other Comments:



GENERAL MAINTENANCE NEEDS:

Mowing Ability: _____% Weed Eater Ability (due to fence/steep slopes): _____%

Remove the following: Blackberries Scotch broom Thistle Trees in Pond/Swale Cattails

Silt Removal Needed: Yes No If Yes, From: Inlet / Outlet Structure Pond / Swale

Inlet Protection: Adequate / Inadequate Outlet Protection: Adequate / Inadequate

Overflow Protection: Adequate / Inadequate Protection Needs: additional rock / vegetation removal

Trash Debris and/or Vegetation Removal Needed: Yes No

Erosion Damage: Severe Minor None Recommended Repairs: _____

_____

Vegetation: Dense Average Sparse Needs: Replacement Additional Seeding

Additional Work Needed After Initial Vegetation Removal: yes / no

Description: _____

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