Exhibit 12 SUB18-02

JOB # 286

STERLING DESIGN, INC.
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PRELIMINARY TECHNICAL INFORMATION REPORT

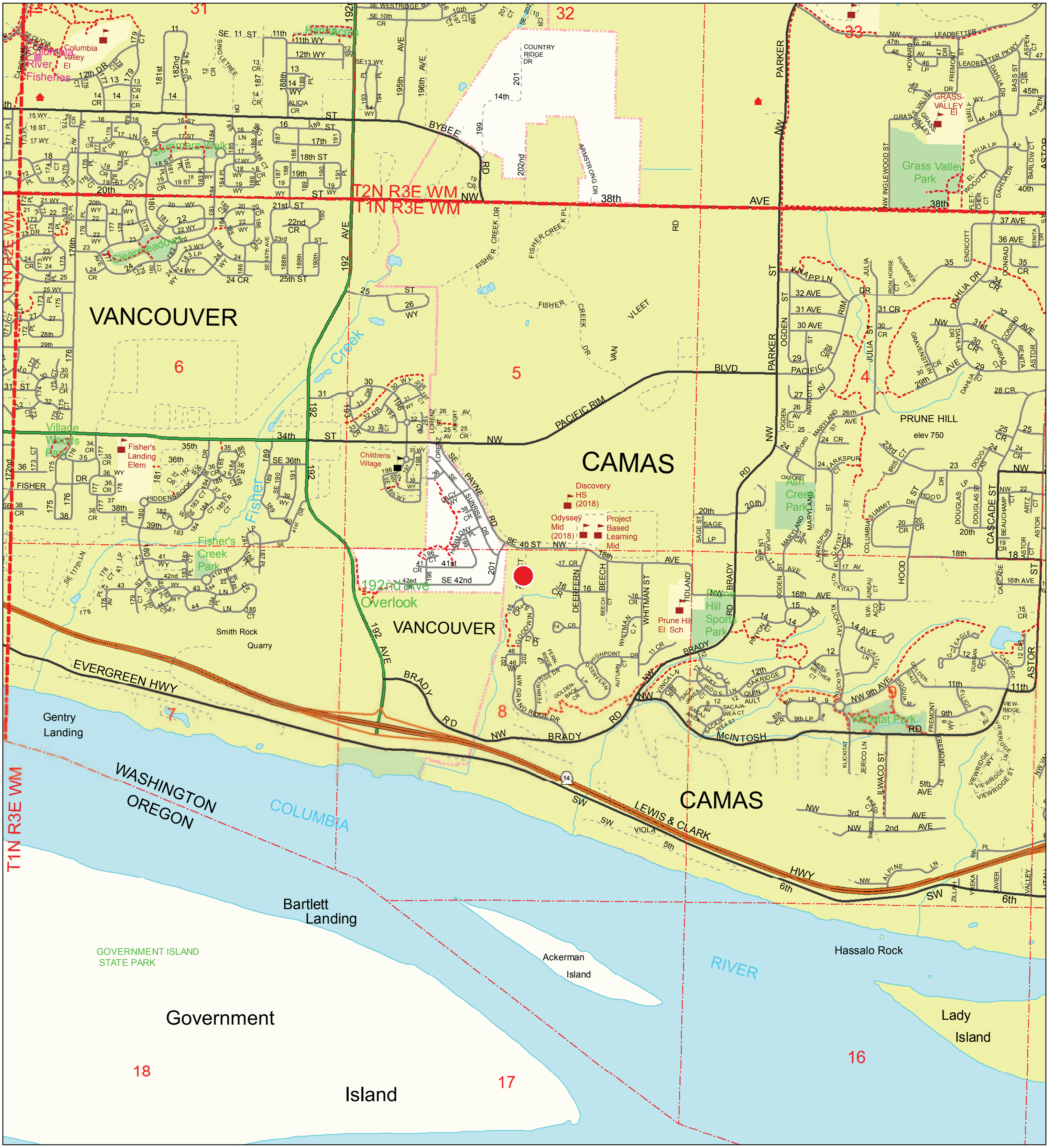
Valley View Estates Subdivision

June 2018

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

JOEL GREGORY STIRLING
36324

6/25/18



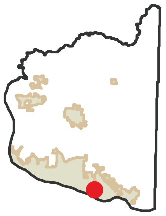
General Location

Printed on: March 26, 2018

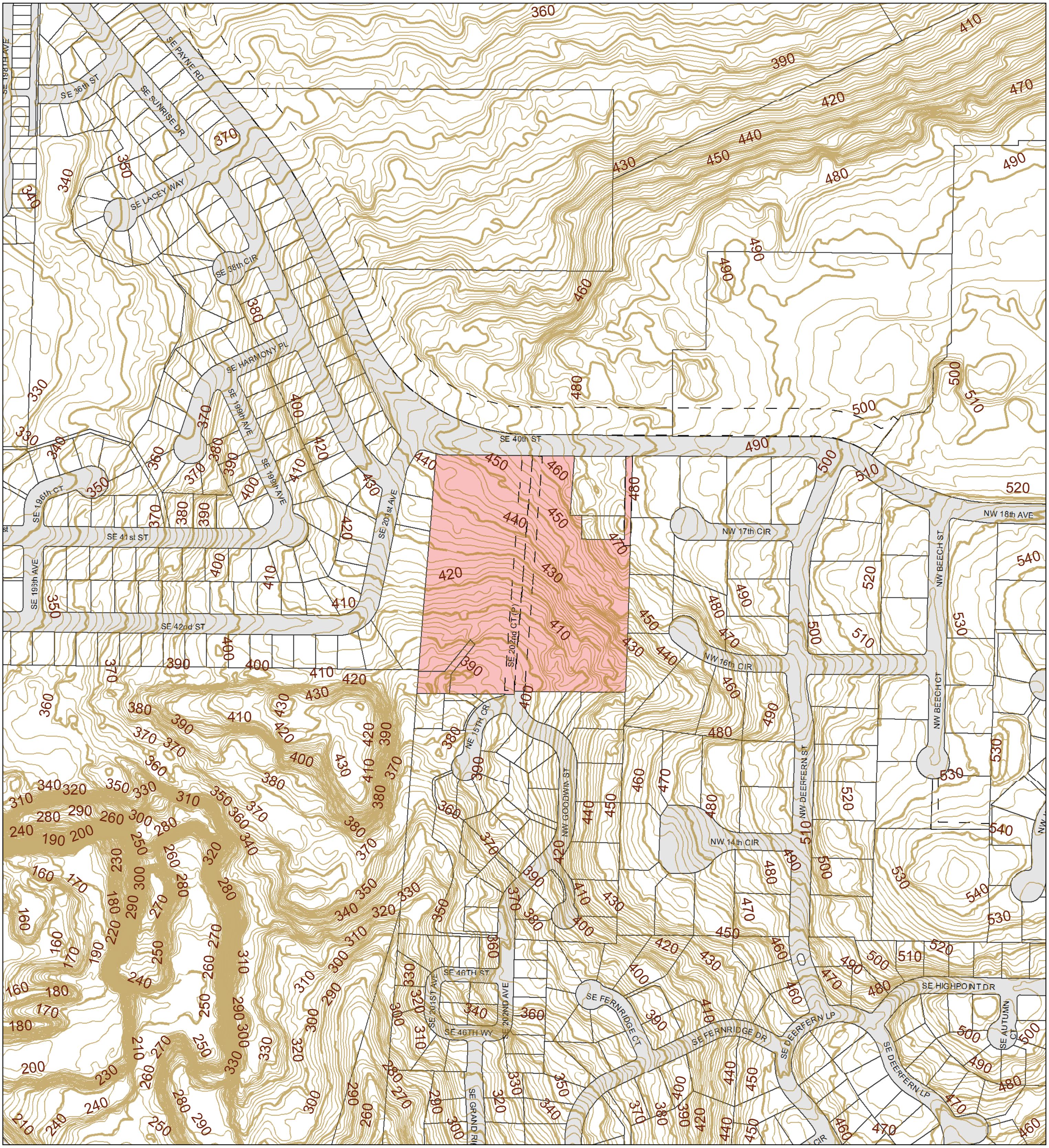
Account: 125635000, 125646000
Owner: FIRESTONE STAN
Address: PO BOX 61928
C/S/Z: VANCOUVER, WA 98666

CLARK COUNTY, WASHINGTON
Geographic Information System

0 1,000 2,000
Feet



● Location of Subject Property(s)



Elevation Contours

Account: 125635000, 125646000
Owner: FIRESTONE STAN
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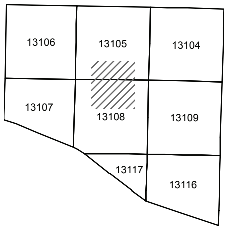


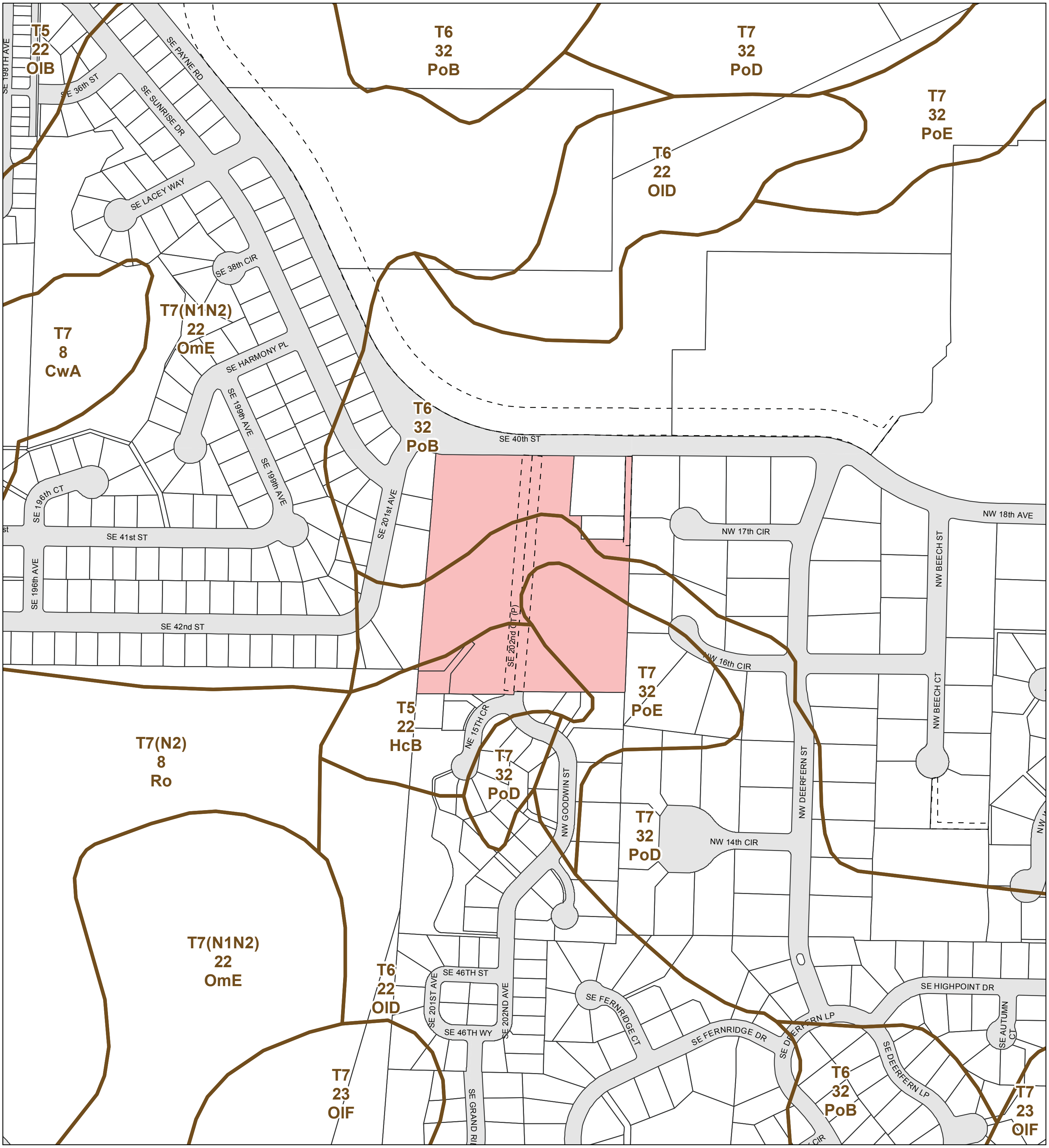
🟥 Subject Property(s)
⬜ Public Road
- - - Transportation or Major Utility Easement
─ 10' Elevation Contours
─ 2' Elevation Contours

CLARK COUNTY, WASHINGTON
Geographic Information System

N

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.



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: 125635000, 125646000
Owner: FIRESTONE STAN
Address: PO BOX 61928
C/S/Z: VANCOUVER, WA 98666

🟥 Subject Property(s)
⬜ Public Road
- - - Transportation or Major Utility Easement
▭ Soil Type Boundary

Printed on: March 26, 2018

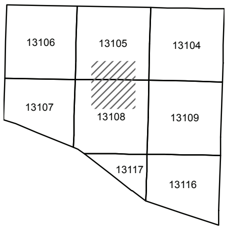


TABLE OF CONTENTS

List of Figures:

Vicinity Map(s)
Soils Map

Report:

Section A – Project Overview 1
Section B – Minimum Requirements..1
Section C – Soils Evaluation 1
Section D – Source Control 2
Section E – Onsite Stormwater Management BMP's 2
Section F – Runoff Treatment Analysis and Design 2
Section G – Flow Control Analysis and Design 3
Section H – Flow Control System Plan...3
Section I – Wetlands Protection 3
Section J – Other Permits 4
Section K – Conveyance System Analysis and Design 4
Section L – Offsite Analysis 4
Section M – Groundwater Monitoring Program 4
Section N – Maintenance and Operations Manual 5

Technical Appendix:

I – WWHM2012 Hydrology Calculations
II – Perk Filter Information
III – Geotechnical Report
IV – Maintenance Manual

List of References:

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

Valley View Estates Subdivision

Section A – Project Overview

The “Valley View Estates” Subdivision proposal is to develop one existing 9.26 acre parcel of land into 36 single family building lots within the R-7.5 zoning district. The site is located at 20109 SE 40th Street in Camas, Washington; known as tax lots 59 & 48, serial number 125646-000 & 125635-000, and is located in the Northwest quarter of Section 8, Township 1 North, Range 3 East of the Willamette Meridian, Clark County, Washington.

The site topography is hilly and rolls from a gradual to a moderate slope from the Northeast corner down to the Southwest property line. Natural drainage flows from the property to a field inlet and public storm system, installed with the recently constructed "Brecken Ridge" Subdivision, which conveys it through the project to an unnamed wetland and natural seasonal drainage way to the south. There is some potential for contributing drainage from two (2) parcels of land along the Northeastern portion of the project and this area has been considered in the design of the stormwater management systems. The entire site has one (1) single family home on it with the remaining portion of the property covered with field grasses, blackberry bushes and a few undernourished trees. All existing man-made stormwater systems on the site are shown within the proposed development plans.

The existing subdivision, "Knight Point at Prune Hill", is located along the Eastern property line of the proposed Valley View Estates project which discharges stormwater from its stormwater management facilities at the Southeastern portion of the proposed project. The drainage from those facilities has been conveyed overland within a 12" ADS pipe system, to the Southern property line, for many years. As part of the proposed Valley View Estates improvements, a permanent stormwater conveyance system will be constructed to connect to the stormwater conveyance system from the Knight Point at Prune Hill stormwater management facilities, to route the drainage around the proposed stormwater management systems that will be constructed as part of the Valley View Estates Subdivision.

Construction of the Valley View Estates Subdivision will consist of grading approximately 8 acres of the site for construction of utilities, a public trail, public roads, stormwater facilities and grading building pads for the future single family home sites. The design of the stormwater management system was influenced primarily by the property topography and the location of the public storm system connection that was installed with the Breckenridge Subdivision to collect the stormwater drainage from the project. Quality control is required for this project and will be met through the use of multiple Cartridge Treatment Structures that are sized to meet the standards of the WWHM and the City of Camas stormwater management standards. Stormwater flow rates and durations will be controlled using two (2) detention ponds located along the Southern property line of the project.

Section B – Minimum Requirements

The Valley View Estates 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. The property currently contains a single family home and a large area of private gravel road which is not being considered within the stormwater management pre-developed flow calculations.

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 Hesson clay loam (HcB), and Powell silt loam (PoB & PoD). Both soils are 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 using multiple Treatment Cartridge Systems 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

Basic stormwater treatment is required for this project and will be met through the use of Stormwater Treatment Cartridge system(s) 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 Treatment Cartridge System(s) have been designed according to the latest Stormwater Management Manual for Western Washington. The treatment cartridge system(s) are sized to treat at least 91% of all runoff based on the Water Quality flows calculated by the WWHM computer program.

The stormwater management facilities are design to collect and treat all proposed improvements and also include providing stormwater water quality and quantity control for the two (2) existing single-family home sites that are located at the Northeastern corner of the property. NW 18th Street is located along the Northern property line and will be improved with approximately 8' of additional pavement and a 6' wide sidewalk. The road transitions to a shed section that drains all stormwater along the Valley View Estates project to the north, making it impossible to pick up and manage. To mitigate for the small area of drainage that is able to be collected and managed onsite, the two (2) homes and driveways that are outside the project boundaries have been included within the stormwater management facilities rather then conveying the unmanaged stormwater from these offsite improvements around the proposed stormwater facilities. Another factor that is considered with this proposed area exchange is that the City of Camas is currently in the process of installing a public trail connection along NW 18th Street along the project frontage. This drainage will also flow to the North and is not be considered within the Valley View Estates stormwater management facilities which makes the proposed stormwater mitigation measures even more conservative.

Section G – Flow Control Analysis and Design

Stormwater flow rates and durations will be controlled using two (2) detention pond(s) located along the southern portion of the project. The stormwater flow control analysis was done using WWHM2012 to match developed flow rate durations to pre-developed flow rate durations for all flows between ½ the 2-year discharge rate and up to the 50-year discharge rate as required by City of Camas Municipal Code. The detention pond control structures were sized utilizing the WWHM2012 computer analysis program and will be located within each of the detention ponds. The detention ponds will have vertical walls located on all sides of the facilities as allowed by Volume III section 3.2 - Side Slopes from the 2014 SMMWW (also included herein). The section recommends that 25% of detention ponds be vegetated slope, however, gives the option to have 100% of the perimeter as vertical walls as long as:

> **(a) they are constructed of reinforced concrete per Section 3.2.3, Material;**
> **(b) a fence is provided along the top of the wall;**
> **(c) the entire pond perimeter may be retaining walls, ...**
> **(d) the design is stamped by a licensed engineer with structural expertise. If the entire pond is to be retaining walls, ladders should be provided on the walls for safety reasons.**

The detention pond walls will be designed by a licensed engineer with structural expertise and ladders will be provided on all sides of the detention pond as required. All retaining walls will comply with CMC18.17.060. A 5:1 maintenance access ramp is also proposed for access into the pond facilities and fencing with a locked access gate will also be provided on each facility.

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 with the Breckenridge Subdivision. The conveyance system from the Breckenridge Subdivision conveys the stormwater to a discharge point approximately 400' South of the Valley View Estates Southern property boundary. From there stormwater continues to flow south within a well vegetated natural drainage ravine along the Western boundary of the Grand Ridge Phase(s) 4 and 1. Stormwater flows from the proposed Valley View Estates 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 detaining to pre-development 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 Valley View Estates 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: Hydrology Calculations

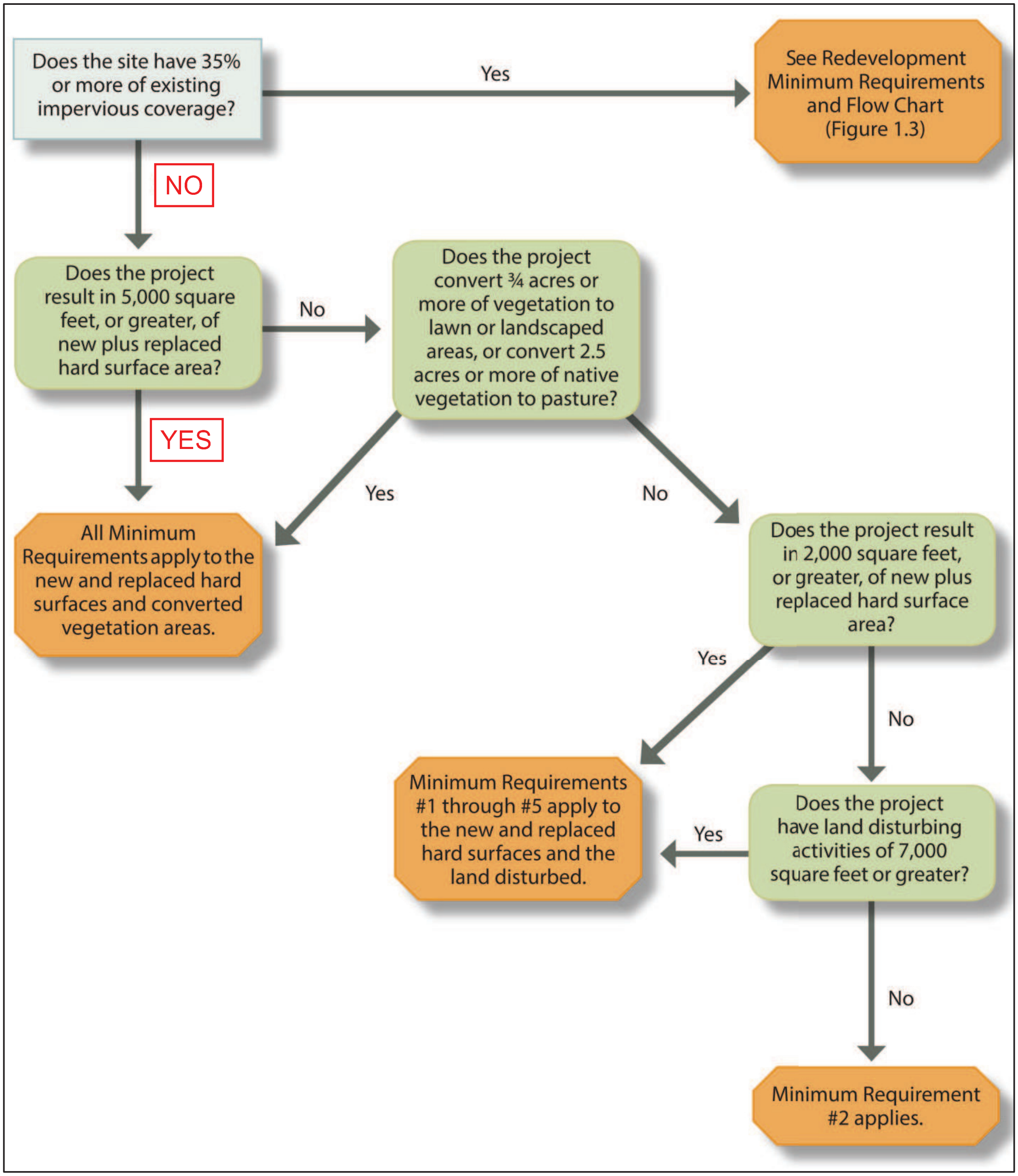
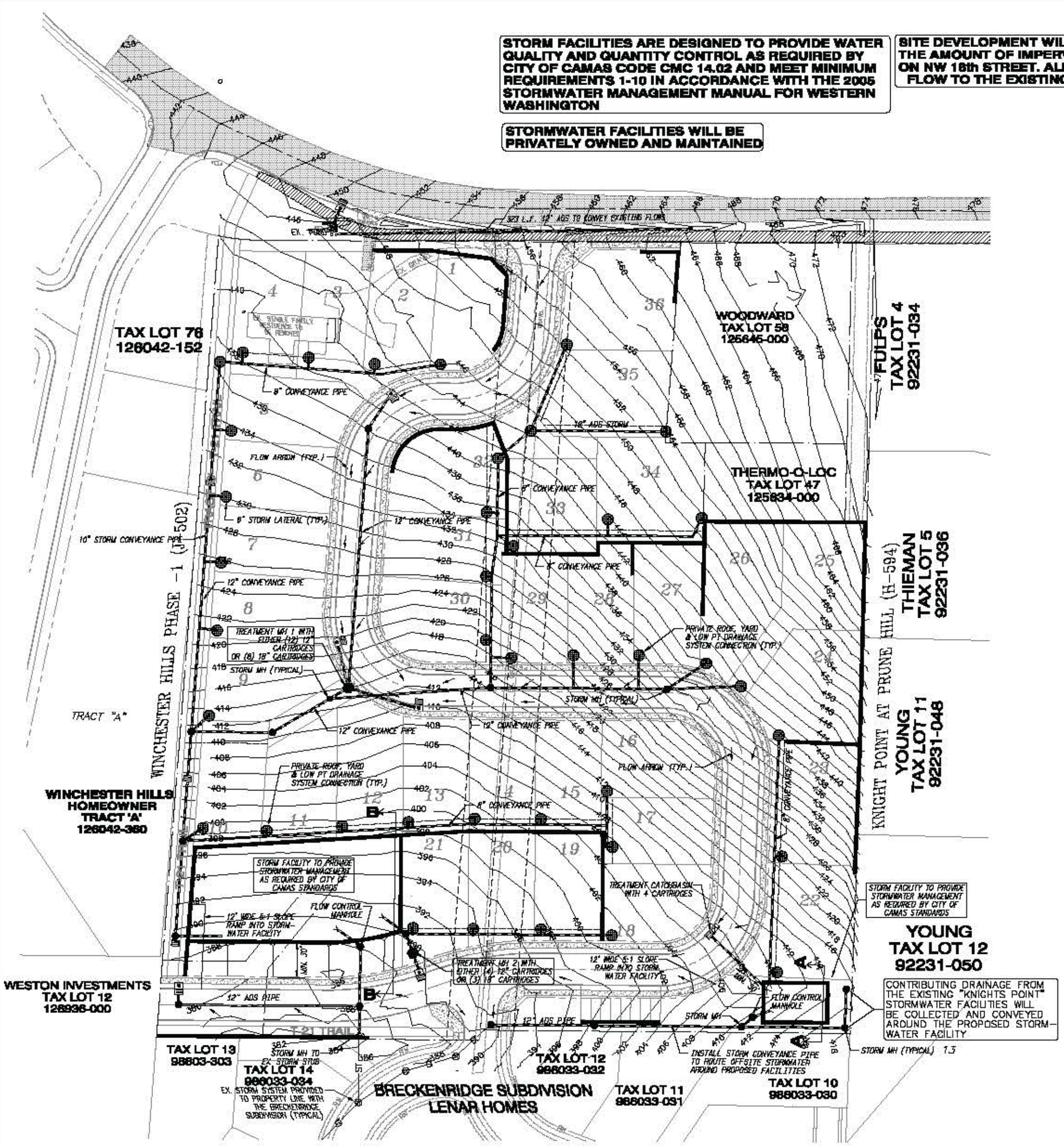


Figure 1.2: New Development Flow Chart



STORM FACILITIES ARE DESIGNED TO PROVIDE WATER QUALITY AND QUANTITY CONTROL AS REQUIRED BY CITY OF CAMAS CODE CMC 14.02 AND MEET MINIMUM REQUIREMENTS 1-10 IN ACCORDANCE WITH THE 2005 STORMWATER MANAGEMENT MANUAL FOR WESTERN WASHINGTON

SITE DEVELOPMENT WILL NOT INCREASE THE AMOUNT OF IMPERVIOUS SURFACES ON NW 16th STREET. ALL DRAINAGE WILL FLOW TO THE EXISTING FLOW ROUTES

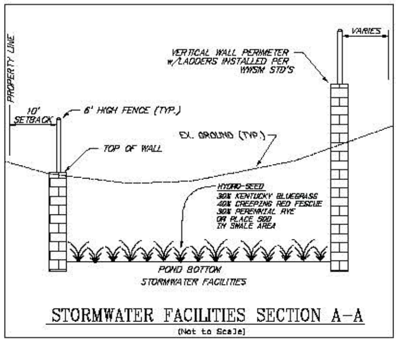
STORMWATER FACILITIES WILL BE PRIVATELY OWNED AND MAINTAINED

STORM FACILITY TO PROVIDE STORMWATER MANAGEMENT AS REQUIRED BY CITY OF CAMAS STANDARDS

CONTRIBUTING DRAINAGE FROM THE EXISTING "KNIGHTS POINT" STORMWATER FACILITIES WILL BE COLLECTED AND CONVEYED AROUND THE PROPOSED STORMWATER FACILITY

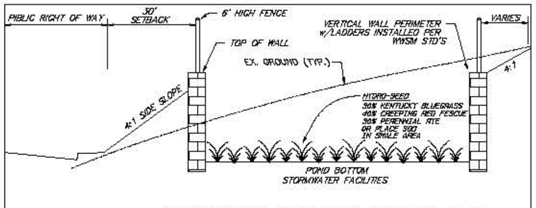
STORM CONSTRUCTION NOTES:

1. ALL TRENCH EXCAVATION AND PIPE INSTALLATION SHALL CONFORM TO THE MOST RECENTLY ADOPTED EDITION OF THE W.S.D.O.T. STANDARD SPECIFICATIONS SECTION 7-08.3(1) AND SECTION 7-08.3(2). ALL EXCESS MATERIAL FROM THE TRENCH EXCAVATION SHALL BE DISPOSED OF ON AN APPROVED SITE.
2. PIPE BEDDING, PIPE ZONE MATERIAL AND TRENCH BACKFILL SHALL BE AN APPROVED GRANULAR MATERIAL OF EITHER WASHED SCREENINGS OR 5/8 INCH MINUS CRUSHED ROCK. SAND BACKFILL IS NOT ALLOWED.
3. TRENCH COMPACTION SHALL BE PER THE MOST RECENTLY ADOPTED EDITION OF THE W.S.D.O.T. STANDARD SPECIFICATIONS SECTION 7-08.3(3). CONTRACTOR TO DETERMINE THE TYPE OF EQUIPMENT AND METHOD TO USE TO ACHIEVE THE REQUIRED COMPACTION. EACH LIFT SHALL BE COMPACTED TO A MINIMUM OF 95 PERCENT OF THE MAXIMUM DENSITY AS DETERMINED BY THE A.A.S.H.T.O. T-180 TEST METHOD.
4. SETTLEMENT OF THE FINISHED SURFACE WITHIN THE WARRANTY PERIOD SHALL BE CONSIDERED TO BE A RESULT OF IMPROPER COMPACTION AND SHALL BE PROMPTLY REPAIRED BY THE CONTRACTOR AT NO EXPENSE TO THE CITY.
5. ALL STORM PIPE SHALL BE PVC OR N-12 WITH DOUBLE BELLED COUPLINGS WITH O-RING TYPE GASKETS OR APPROVED EQUAL.
6. ALL STORM PIPE LATERALS TO BE A MINIMUM 10 INCHES DIAMETER WITH A MINIMUM SLOPE OF S=0.0100 UNLESS SPECIFIED OTHERWISE IN THE PLANS.
7. ALL MANHOLES LOCATED IN UNIMPROVED EASEMENTS AND RIGHT OF WAYS SHALL BE PROVIDED WITH TAMPER PROOF LIDS AND SHALL BE SET 6 INCHES ABOVE FINISHED GRADE.
8. VIDEO INSPECTION TAPES AND REPORTS MAY BE REQUIRED AT THE CITY'S DISCRETION. MANDREL TESTING MAY BE REQUIRED AT THE CITY'S DISCRETION.



STORMWATER FACILITIES SECTION A–A

(Not to Scale)



STORMWATER FACILITIES SECTION B–B

(Not to Scale)

NOTE:

Existing utilities shown are approximate only from utility records and as visible at the site. Contractor shall verify presence, location, depth & slope of any and all existing utilities prior to construction. Contact One Call Concepts at (800) 424–5555.

SITE INFORMATION

ALIGNMENT & FIELD DATA: MINISTER & GLAESER SURVEYING, INC. (360) 694–3313

SOIL TYPE(s): HcB, PoB & PoD — HYDROLOGIC GROUP: C — AASHTO CLASSIFICATION: A – 4

SOILS TESTING BY: RAPID SOIL SOLUTIONS (503) 816–3689 — DATE: MARCH 2014

SITE LOCATION: CLARK COUNTY, WA — APPROX. SURFACE ELEV.: 385'–466'

SITE AREA: 9.26 ACRES — FILENAME: 286/: Preliminary.pro

PREPARED BY:

STERLING DESIGN, INC.
2208 E.EVERGREEN BLVD
VANCOUVER, WA 98661
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FAX (360) 759-4983
mail@sterlingdesign.biz

STERLING DESIGN, INC.

Sheet Description:

PRELIMINARY STORMWATER MANAGEMENT PLAN

Project:

VALLEY VIEW ESTATES SUBDIVISION

05/18/18

Scale: AS SHOWN

Project Number: 286

Design/Drawn JGS/BC

Drawing Date: MAY 2018

Sheet 6 of 9 Sheet(s)

Hydrologic Soil Groups for Soils in Clark County

U.S. Department of Agriculture
Soil Conservation Service

WATER FEATURES

Survey Area: CLARK COUNTY, WASHINGTON

Map Symbol	Soil Name	Hydrologic Group	Clark County WWHM Soils Group
BpB	BEAR PRARIE	B	2
BpC	BEAR PRARIE	B	2
CnB	CINEBAR	B	2
CnD	CINEBAR	B	2
CnE	CINEBAR	B	2
CnG	CINEBAR	B	2
CrE	CINEBAR	B	2
CrG	CINEBAR	B	2
CsF	CISPUS	B	2
CtA	CLOQUATO	B	2
CvA	COVE	D	4
CwA	COVE	D	4
DoB	DOLLAR	C	3
Fn	FILL LAND	In-situ	N/A
GeB	GEE	C	4
GeD	GEE	C	4
GeE	GEE	C	4
GeF	GEE	C	4
GuB	GUMBOOT	D	4
HcB *	HESSON *	C *	3 *
HcD	HELLSON	C	3
HcE	HESSON	C	3
HcF	HESSON	C	3
HgB	HESSON	C	3
HgD	HESSON	C	3
HhE	HESSON	C	3
HIA	HILLSBORO	B	2
HIB	HILLSBORO	B	2

Map Symbol	Soil Name	Hydrologic Group	Clark County WWHM Soils Group
NbA	NEWBERG	B	2
NbB	NEWBERG	B	2
OdB	ODNE	D	4
OeD	OLEQUA	B	3
OeE	OLEQUA	B	3
OeF	OLEQUA	B	3
OhD	OLEQUA VARIANT	C	4
OhF	OLEQUA VARIANT	C	4
OIB	OLYMPIC	B	3
OID	OLYMPIC	B	3
OIE	OLYMPIC	B	3
OIF	OLYMPIC	B	3
OmE	OLYMPIC	B	3
OmF	OLYMPIC	B	3
OpC	OLYMPIC VARIANT	C	3
OpE	OLYMPIC VARIANT	C	3
OpG	OLYMPIC VARIANT	C	3
OrC	OLYMPIC VARIANT	C	3
PhB	PILCHUCK	C	2
PoB *	POWELL *	C *	3 *
PoD *	POWELL *	C *	3 *
PoE	POWELL	C	3
PuA	PUYALLUP	B	2
Ra	RIVERWASH	D	N/A
Rc	RIVERWASH	D	N/A
Rk	ROCK LAND	D	N/A
Ro	ROUGH BROKEN LAND	A	1
SaC	SALKUM	B	2
SIB	SARA	D	4
SID	SARA	D	4
SIF	SARA	D	4
SmA	SAUVIE	B	3
SmB	SAUVIE	B	3
SnA	SAUVIE	D	3
SpB	SAUVIE	B	3

TABLE 7.—*Estimated physical and chemical properties of the soils*—Continued

Soil series and map symbols	Depth from surface	Classification			Percentage passing sieve—			*Perme-ability	Available water capacity	Re-action
		Dominant USDA texture	Unified	AASHO	No. 4 (4.76 mm.)[1]	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)			
	Inches							*Inches per hour*	*Inches per inch of soil*	*pH*
Minniece: MnA, MnD.	0–48	Silty clay and clay	CH	A–7	90–95	85–95	65–75	<0.06	0.06–0.08	6.1–7.8
	48	Basalt bedrock.								
MoA.	0–12	Silt loam	ML	A–4	100	95–100	65–75	0.63–2.0	0.19–0.21	6.1–6.5
	12–22	Silty clay	CH	A–7	95–100	95–100	80–90	0.06–0.2	0.12–0.14	6.1–6.5
	22–60	Very gravelly clay loam (weakly cemented).	GC	A–2	35–50	30–50	20–35	<0.06	0.03–0.05	5.6–6.5
Mossyrock: MsB.	0–23	Silt loam	OL or OH	A–5	95–100	95–100	50–60	0.63–2.0	0.19–0.21	6.1–6.5
	23–60	Silt loam	ML	A–5	100	95–100	55–65	0.63–2.0	0.19–0.21	6.6–7.3
	60–74	Loam	ML	A–4	100	95–100	70–80	0.63–2.0	0.16–0.18	6.1–7.3
Newberg: NbA, NbB.	0–7	Silt loam	ML	A–4	--------	100	70–80	0.63–2.0	0.19–0.21	5.6–6.5
	7–52	Fine sandy loam and sandy loam.	SM or ML	A–4	--------	100	40–55	2.0–6.3	0.13–0.15	6.1–7.3
	52–72	Sand	SM	A–1	--------	100	5–15	0.63–20.0	0.05–0.07	6.6–7.3
Odne: OdB.	0–50	Silt loam, silty clay loam, clay loam, and loam.	CL	A–4 or A–6	--------	100	75–85	<0.06	0.10–0.12	5.0–6.5
Olequa: OeD, OeE, OeF.	0–17	Silt loam	ML	A–7	--------	100	75–85	0.63–2.0	0.19–0.21	6.1–6.5
	17–90	Heavy silt loam and silty clay loam.	CL	A–7	--------	100	80–90	0.2–0.63	0.19–0.21	4.5–6.5
OhD, OhF.	0–32	Silty clay loam	CL	A–7	95–100	90–95	85–95	0.2–0.63	0.19–0.21	5.1–6.0
	32–82	Silty clay and clay	CH	A–7	95–100	90–95	85–95	<0.06	0.06–0.08	5.1–6.5
Olympic: OlB, OlD, OlE, OlF, OmE, OmF.	0–44	Clay loam and silty clay loam.	ML or CL	A–7	90–100	90–100	75–85	0.2–0.63	0.19–0.21	5.1–6.0
	44–59	Gravelly clay loam.	GC	A–4	75–90	70–85	35–50	0.2–0.63	0.10–0.12	4.5–5.5
	59	Fractured basalt.								
OpC, OpE, OpG, OrC.	0–30	Heavy clay loam and heavy silty clay loam.	ML or CL	A–7	90–95	90–95	75–85	0.2–0.63	0.19–0.21	5.1–6.0
	30	Fractured basalt.								
Pilchuck: PhB.	0–60	Fine sand	SM	A–3	95–100	90–100	5–10	6.3–20.0	0.05–0.07	6.1–7.3
*Powell: PoB, PoD, PoE.	0–23	Silt loam	ML	A–4	--------	100	80–90	0.63–0.20	0.18–0.20	5.1–6.0
	23–63	Slit loam (fragipan).	ML	A–4	--------	100	80–90	0.06–0.20*	0.06–0.08	5.1–6.0
Puyallup: PuA.	0–27	Stratified fine sandy loam, loam, and loamy sand.	SM	A–4	100	95–100	35–50	2.0–6.3	0.10–0.12	5.6–6.5
	27–60	Gravelly sand	SP or SW	A–1	70–90	65–85	0–5	6.3–20.0	0.04–0.06	6.6–7.3
Riverwash, sandy: Ra.	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Riverwash, cobbly: Rc.	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Rock land: Rk.	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Rough broken land: Ro.	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

See footnotes at end of table.

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	Valley View Estates
Site Name:	Valley View Estates
Site Address:	20109 SE 40TH ST
City:	Camas
Report Date:	4/26/2018
Gage:	Lacamas
Data Start:	1948/10/01
Data End:	2008/09/30
Timestep:	15 Minute
Precip Scale:	1.300
Version Date:	2017/07/05
Version:	4.2.13

POC Thresholds

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

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
SG3, Forest, Steep	9.8
Pervious Total	9.8
Impervious Land Use	acre
ROADS STEEP	0.2
Impervious Total	0.2
Basin Total	10

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
SG3, Lawn, Mod	2.2
Pervious Total	2.2
Impervious Land Use	acre
ROOF TOPS FLAT	1
DRIVEWAYS FLAT	0.5
Impervious Total	1.5
Basin Total	3.7

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 1	Trapezoidal Pond 1	

Basin 2

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
ROADS MOD	1
Impervious Total	1
Basin Total	1

Element Flows To:

Surface	Interflow	Groundwater
Flow Splitter 1	Flow Splitter 1	

Basin 3

Bypass: No

GroundWater: No

Pervious Land Use	acre
SG3, Lawn, Mod	1.9
Pervious Total	1.9

Impervious Land Use	acre
ROOF TOPS FLAT	0.9
DRIVEWAYS FLAT	0.4
Impervious Total	1.3

Basin Total	3.2

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 1	Trapezoidal Pond 1	

Basin 4

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
ROADS MOD	0.2
Impervious Total	0.2
Basin Total	0.2

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 1	Trapezoidal Pond 1	

Basin 5

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
ROADS MOD	0.3
Impervious Total	0.3
Basin Total	0.3

Element Flows To:

Surface	Interflow	Groundwater
Flow Splitter 2	Flow Splitter 2	

Basin 6

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
SG3, Lawn, Steep	0.4
Pervious Total	0.4
Impervious Land Use	acre
ROOF TOPS FLAT	0.2
DRIVEWAYS FLAT	0.1
Impervious Total	0.3
Basin Total	0.7

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 2	Trapezoidal Pond 2	

Basin 7

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
ROADS STEEP	0.3
Impervious Total	0.3
Basin Total	0.3

Element Flows To:

Surface	Interflow	Groundwater
Flow Splitter 3	Flow Splitter 3	

Basin 8

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
SG3, Lawn, Flat	0.07
Pervious Total	0.07
Impervious Land Use	acre
PARKING FLAT	0.03
Impervious Total	0.03
Basin Total	0.1

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 2	Trapezoidal Pond 2	

Basin 9

Bypass:	Yes
GroundWater:	No
Pervious Land Use	acre
SG3, Lawn, Flat	0.3
Pervious Total	0.3
Impervious Land Use	acre
ROADS FLAT	0.2
Impervious Total	0.2
Basin Total	0.5

Element Flows To:

Surface	Interflow	Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

Trapezoidal Pond 1

Bottom Length: 180.00 ft.
Bottom Width: 90.00 ft.
Depth: 7 ft.
Volume at riser head: 2.0537 acre-feet.
Infiltration On
Infiltration rate: 0.5
Infiltration safety factor: 0.5
Total Volume Infiltrated (ac-ft.): 739.733
Total Volume Through Riser (ac-ft.): 459.106
Total Volume Through Facility (ac-ft.): 1198.839
Percent Infiltrated: 61.7
Total Precip Applied to Facility: 84.997
Total Evap From Facility: 15.042
Side slope 1: 0 To 1
Side slope 2: 0 To 1
Side slope 3: 0 To 1
Side slope 4: 0 To 1
Discharge Structure
Riser Height: 5.5 ft.
Riser Diameter: 18 in.
Orifice 1 Diameter: 1.9 in. Elevation:0 ft.
Orifice 2 Diameter: 3 in. Elevation:4 ft.
Element Flows To:
Outlet 1 Outlet 2

Pond Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**Infilt(cfs)**
0.0000	0.371	0.000	0.000	0.000
0.0778	0.371	0.028	0.027	0.093
0.1556	0.371	0.057	0.038	0.093
0.2333	0.371	0.086	0.047	0.093
0.3111	0.371	0.115	0.054	0.093
0.3889	0.371	0.144	0.061	0.093
0.4667	0.371	0.173	0.066	0.093
0.5444	0.371	0.202	0.072	0.093
0.6222	0.371	0.231	0.077	0.093
0.7000	0.371	0.260	0.082	0.093
0.7778	0.371	0.289	0.086	0.093
0.8556	0.371	0.318	0.090	0.093
0.9333	0.371	0.347	0.094	0.093
1.0111	0.371	0.376	0.098	0.093
1.0889	0.371	0.405	0.102	0.093
1.1667	0.371	0.433	0.105	0.093
1.2444	0.371	0.462	0.109	0.093
1.3222	0.371	0.491	0.112	0.093
1.4000	0.371	0.520	0.115	0.093
1.4778	0.371	0.549	0.119	0.093
1.5556	0.371	0.578	0.122	0.093
1.6333	0.371	0.607	0.125	0.093
1.7111	0.371	0.636	0.128	0.093
1.7889	0.371	0.665	0.131	0.093
1.8667	0.371	0.694	0.133	0.093

1.9444	0.371	0.723	0.136	0.093
2.0222	0.371	0.752	0.139	0.093
2.1000	0.371	0.781	0.142	0.093
2.1778	0.371	0.809	0.144	0.093
2.2556	0.371	0.838	0.147	0.093
2.3333	0.371	0.867	0.149	0.093
2.4111	0.371	0.896	0.152	0.093
2.4889	0.371	0.925	0.154	0.093
2.5667	0.371	0.954	0.156	0.093
2.6444	0.371	0.983	0.159	0.093
2.7222	0.371	1.012	0.161	0.093
2.8000	0.371	1.041	0.163	0.093
2.8778	0.371	1.070	0.166	0.093
2.9556	0.371	1.099	0.168	0.093
3.0333	0.371	1.128	0.170	0.093
3.1111	0.371	1.157	0.172	0.093
3.1889	0.371	1.186	0.174	0.093
3.2667	0.371	1.214	0.177	0.093
3.3444	0.371	1.243	0.179	0.093
3.4222	0.371	1.272	0.181	0.093
3.5000	0.371	1.301	0.183	0.093
3.5778	0.371	1.330	0.185	0.093
3.6556	0.371	1.359	0.187	0.093
3.7333	0.371	1.388	0.189	0.093
3.8111	0.371	1.417	0.191	0.093
3.8889	0.371	1.446	0.193	0.093
3.9667	0.371	1.475	0.195	0.093
4.0444	0.371	1.504	0.248	0.093
4.1222	0.371	1.533	0.284	0.093
4.2000	0.371	1.562	0.310	0.093
4.2778	0.371	1.590	0.331	0.093
4.3556	0.371	1.619	0.350	0.093
4.4333	0.371	1.648	0.367	0.093
4.5111	0.371	1.677	0.382	0.093
4.5889	0.371	1.706	0.397	0.093
4.6667	0.371	1.735	0.411	0.093
4.7444	0.371	1.764	0.424	0.093
4.8222	0.371	1.793	0.436	0.093
4.9000	0.371	1.822	0.448	0.093
4.9778	0.371	1.851	0.460	0.093
5.0556	0.371	1.880	0.471	0.093
5.1333	0.371	1.909	0.482	0.093
5.2111	0.371	1.938	0.492	0.093
5.2889	0.371	1.966	0.502	0.093
5.3667	0.371	1.995	0.512	0.093
5.4444	0.371	2.024	0.522	0.093
5.5222	0.371	2.053	0.584	0.093
5.6000	0.371	2.082	1.042	0.093
5.6778	0.371	2.111	1.731	0.093
5.7556	0.371	2.140	2.558	0.093
5.8333	0.371	2.169	3.449	0.093
5.9111	0.371	2.198	4.328	0.093
5.9889	0.371	2.227	5.121	0.093
6.0667	0.371	2.256	5.771	0.093
6.1444	0.371	2.285	6.249	0.093
6.2222	0.371	2.314	6.583	0.093
6.3000	0.371	2.343	6.954	0.093
6.3778	0.371	2.371	7.263	0.093

6.4556	0.371	2.400	7.559	0.093
6.5333	0.371	2.429	7.842	0.093
6.6111	0.371	2.458	8.116	0.093
6.6889	0.371	2.487	8.380	0.093
6.7667	0.371	2.516	8.636	0.093
6.8444	0.371	2.545	8.885	0.093
6.9222	0.371	2.574	9.126	0.093
7.0000	0.371	2.603	9.361	0.093
7.0778	0.371	2.632	9.590	0.093

Flow Splitter 1

Bottom Length:	10.00 ft.
Bottom Length:	10.00 ft.
Depth:	10 ft.
Side slope 1:	0 To 1
Side slope 2:	0 To 1
Side slope 3:	0 To 1
Side slope 4:	0 To 1

Control Structure Splitter Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Primary(cfs)	Secondary(cfs)
0.000	0.002	0.000	0.000	0.000
0.111	0.002	0.000	5.210	0.000
0.222	0.002	0.000	7.368	0.000
0.333	0.002	0.000	9.024	0.000
0.444	0.002	0.001	10.42	0.000
0.555	0.002	0.001	11.65	0.000
0.666	0.002	0.001	12.76	0.000
0.777	0.002	0.001	13.78	0.000
0.888	0.002	0.002	14.73	0.000
1.000	0.002	0.002	15.63	0.000
1.111	0.002	0.002	16.47	0.000
1.222	0.002	0.002	17.28	0.000
1.333	0.002	0.003	18.04	0.000
1.444	0.002	0.003	18.78	0.000
1.555	0.002	0.003	19.49	0.000
1.666	0.002	0.003	20.17	0.000
1.777	0.002	0.004	20.84	0.000
1.888	0.002	0.004	21.48	0.000
2.000	0.002	0.004	22.10	0.000
2.111	0.002	0.004	22.71	0.000
2.222	0.002	0.005	23.30	0.000
2.333	0.002	0.005	23.87	0.000
2.444	0.002	0.005	24.43	0.000
2.555	0.002	0.005	24.98	0.000
2.666	0.002	0.006	25.52	0.000
2.777	0.002	0.006	26.05	0.000
2.888	0.002	0.006	26.56	0.000
3.000	0.002	0.006	27.07	0.000
3.111	0.002	0.007	27.57	0.000
3.222	0.002	0.007	28.05	0.000
3.333	0.002	0.007	28.53	0.000
3.444	0.002	0.007	29.01	0.000
3.555	0.002	0.008	29.47	0.000
3.666	0.002	0.008	29.93	0.000
3.777	0.002	0.008	30.38	0.000
3.888	0.002	0.008	30.82	0.000
4.000	0.002	0.009	31.26	0.000
4.111	0.002	0.009	31.69	0.000
4.222	0.002	0.009	32.11	0.000
4.333	0.002	0.009	32.53	0.000
4.444	0.002	0.010	32.95	0.000
4.555	0.002	0.010	33.36	0.000
4.666	0.002	0.010	33.76	0.000
4.777	0.002	0.011	34.16	0.000
4.888	0.002	0.011	34.56	0.000
5.000	0.002	0.011	34.95	0.000
5.111	0.002	0.011	35.33	0.000

5.222	0.002	0.012	35.72	0.000
5.333	0.002	0.012	36.09	0.000
5.444	0.002	0.012	36.47	0.000
5.555	0.002	0.012	36.84	0.000
5.666	0.002	0.013	37.20	0.000
5.777	0.002	0.013	37.57	0.000
5.888	0.002	0.013	37.93	0.000
6.000	0.002	0.013	38.28	0.000
6.111	0.002	0.014	38.64	0.000
6.222	0.002	0.014	38.99	0.000
6.333	0.002	0.014	39.33	0.000
6.444	0.002	0.014	39.68	0.000
6.555	0.002	0.015	40.02	0.000
6.666	0.002	0.015	40.35	0.000
6.777	0.002	0.015	40.69	0.000
6.888	0.002	0.015	41.02	0.000
7.000	0.002	0.016	41.35	0.000
7.111	0.002	0.016	41.68	0.000
7.222	0.002	0.016	42.00	0.000
7.333	0.002	0.016	42.32	0.000
7.444	0.002	0.017	42.64	0.000
7.555	0.002	0.017	42.96	0.000
7.666	0.002	0.017	43.28	0.000
7.777	0.002	0.017	43.59	0.000
7.888	0.002	0.018	43.90	0.000
8.000	0.002	0.018	44.21	0.000
8.111	0.002	0.018	44.51	0.000
8.222	0.002	0.018	44.82	0.000
8.333	0.002	0.019	45.12	0.000
8.444	0.002	0.019	45.42	0.000
8.555	0.002	0.019	45.72	0.000
8.666	0.002	0.019	46.01	0.000
8.777	0.002	0.020	46.31	0.000
8.888	0.002	0.020	46.60	0.000
9.000	0.002	0.020	46.89	0.000
9.111	0.002	0.020	47.18	0.000
9.222	0.002	0.021	47.46	0.000
9.333	0.002	0.021	47.75	0.000
9.444	0.002	0.021	48.03	0.000
9.555	0.002	0.021	48.31	0.000
9.666	0.002	0.022	48.59	0.000
9.777	0.002	0.022	48.87	0.000
9.888	0.002	0.022	49.15	0.000
10.00	0.002	0.023	49.42	0.000
10.11	0.002	0.023	49.70	0.000

Discharge Structure
Riser Height: 0 ft.
Riser Diameter: 0 in.
Orifice 1 Diameter: 24 in. Elevation:0 ft.
Element Flows To:

Outlet 1	Outlet 2
Trapezoidal Pond 1	Trapezoidal Pond 1

Flow Splitter 2

Bottom Length:	10.00 ft.
Bottom Length:	10.00 ft.
Depth:	10 ft.
Side slope 1:	0 To 1
Side slope 2:	0 To 1
Side slope 3:	0 To 1
Side slope 4:	0 To 1

Control Structure Splitter Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Primary(cfs)	Secondary(cfs)
0.000	0.002	0.000	0.000	0.000
0.111	0.002	0.000	5.210	0.000
0.222	0.002	0.000	7.368	0.000
0.333	0.002	0.000	9.024	0.000
0.444	0.002	0.001	10.42	0.000
0.555	0.002	0.001	11.65	0.000
0.666	0.002	0.001	12.76	0.000
0.777	0.002	0.001	13.78	0.000
0.888	0.002	0.002	14.73	0.000
1.000	0.002	0.002	15.63	0.000
1.111	0.002	0.002	16.47	0.000
1.222	0.002	0.002	17.28	0.000
1.333	0.002	0.003	18.04	0.000
1.444	0.002	0.003	18.78	0.000
1.555	0.002	0.003	19.49	0.000
1.666	0.002	0.003	20.17	0.000
1.777	0.002	0.004	20.84	0.000
1.888	0.002	0.004	21.48	0.000
2.000	0.002	0.004	22.10	0.000
2.111	0.002	0.004	22.71	0.784
2.222	0.002	0.005	23.30	2.205
2.333	0.002	0.005	23.87	3.979
2.444	0.002	0.005	24.43	5.917
2.555	0.002	0.005	24.98	7.826
2.666	0.002	0.006	25.52	9.523
2.777	0.002	0.006	26.05	10.86
2.888	0.002	0.006	26.56	11.81
3.000	0.002	0.006	27.07	12.59
3.111	0.002	0.007	27.57	13.28
3.222	0.002	0.007	28.05	13.92
3.333	0.002	0.007	28.53	14.54
3.444	0.002	0.007	29.01	15.14
3.555	0.002	0.008	29.47	15.71
3.666	0.002	0.008	29.93	16.26
3.777	0.002	0.008	30.38	16.79
3.888	0.002	0.008	30.82	17.31
4.000	0.002	0.009	31.26	17.81
4.111	0.002	0.009	31.69	18.30
4.222	0.002	0.009	32.11	18.78
4.333	0.002	0.009	32.53	19.24
4.444	0.002	0.010	32.95	19.69
4.555	0.002	0.010	33.36	20.14
4.666	0.002	0.010	33.76	20.57
4.777	0.002	0.011	34.16	20.99
4.888	0.002	0.011	34.56	21.41
5.000	0.002	0.011	34.95	21.82
5.111	0.002	0.011	35.33	22.22

5.222	0.002	0.012	35.72	22.61
5.333	0.002	0.012	36.09	23.00
5.444	0.002	0.012	36.47	23.38
5.555	0.002	0.012	36.84	23.75
5.666	0.002	0.013	37.20	24.12
5.777	0.002	0.013	37.57	24.48
5.888	0.002	0.013	37.93	24.84
6.000	0.002	0.013	38.28	25.19
6.111	0.002	0.014	38.64	25.54
6.222	0.002	0.014	38.99	25.88
6.333	0.002	0.014	39.33	26.22
6.444	0.002	0.014	39.68	26.56
6.555	0.002	0.015	40.02	26.89
6.666	0.002	0.015	40.35	27.21
6.777	0.002	0.015	40.69	27.53
6.888	0.002	0.015	41.02	27.85
7.000	0.002	0.016	41.35	28.17
7.111	0.002	0.016	41.68	28.48
7.222	0.002	0.016	42.00	28.79
7.333	0.002	0.016	42.32	29.09
7.444	0.002	0.017	42.64	29.39
7.555	0.002	0.017	42.96	29.69
7.666	0.002	0.017	43.28	29.99
7.777	0.002	0.017	43.59	30.28
7.888	0.002	0.018	43.90	30.57
8.000	0.002	0.018	44.21	30.86
8.111	0.002	0.018	44.51	31.14
8.222	0.002	0.018	44.82	31.42
8.333	0.002	0.019	45.12	31.70
8.444	0.002	0.019	45.42	31.98
8.555	0.002	0.019	45.72	32.25
8.666	0.002	0.019	46.01	32.52
8.777	0.002	0.020	46.31	32.79
8.888	0.002	0.020	46.60	33.06
9.000	0.002	0.020	46.89	33.33
9.111	0.002	0.020	47.18	33.59
9.222	0.002	0.021	47.46	33.85
9.333	0.002	0.021	47.75	34.11
9.444	0.002	0.021	48.03	34.37
9.555	0.002	0.021	48.31	34.63
9.666	0.002	0.022	48.59	34.88
9.777	0.002	0.022	48.87	35.13
9.888	0.002	0.022	49.15	35.38
10.00	0.002	0.023	49.42	35.63
10.11	0.002	0.023	49.70	35.88

Discharge Structure
Riser Height: 0 ft.
Riser Diameter: 0 in.
Orifice 1 Diameter: 24 in. Elevation:0 ft.
Element Flows To:

Outlet 1	Outlet 2
Trapezoidal Pond 1	Trapezoidal Pond 1

Trapezoidal Pond 2

Bottom Length: 55.00 ft.
Bottom Width: 30.00 ft.
Depth: 7 ft.
Volume at riser head: 0.1915 acre-feet.
Infiltration On
Infiltration rate: 0.5
Infiltration safety factor: 0.5
Total Volume Infiltrated (ac-ft.): 44.415
Total Volume Through Riser (ac-ft.): 117.146
Total Volume Through Facility (ac-ft.): 161.56
Percent Infiltrated: 27.49
Total Precip Applied to Facility: 8.667
Total Evap From Facility: 1.514
Side slope 1: 0 To 1
Side slope 2: 0 To 1
Side slope 3: 0 To 1
Side slope 4: 0 To 1
Discharge Structure
Riser Height: 5 ft.
Riser Diameter: 12 in.
Orifice 1 Diameter: 1.5 in. Elevation:0 ft.
Orifice 2 Diameter: 1 in. Elevation:4 ft.
Element Flows To:
Outlet 1 Outlet 2

Pond Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**Infilt(cfs)**
0.0000	0.037	0.000	0.000	0.000
0.0778	0.037	0.002	0.017	0.009
0.1556	0.037	0.005	0.024	0.009
0.2333	0.037	0.008	0.029	0.009
0.3111	0.037	0.011	0.034	0.009
0.3889	0.037	0.014	0.038	0.009
0.4667	0.037	0.017	0.041	0.009
0.5444	0.037	0.020	0.045	0.009
0.6222	0.037	0.023	0.048	0.009
0.7000	0.037	0.026	0.051	0.009
0.7778	0.037	0.029	0.053	0.009
0.8556	0.037	0.032	0.056	0.009
0.9333	0.037	0.035	0.059	0.009
1.0111	0.037	0.038	0.061	0.009
1.0889	0.037	0.041	0.063	0.009
1.1667	0.037	0.044	0.065	0.009
1.2444	0.037	0.047	0.068	0.009
1.3222	0.037	0.050	0.070	0.009
1.4000	0.037	0.053	0.072	0.009
1.4778	0.037	0.056	0.074	0.009
1.5556	0.037	0.058	0.076	0.009
1.6333	0.037	0.061	0.078	0.009
1.7111	0.037	0.064	0.079	0.009
1.7889	0.037	0.067	0.081	0.009
1.8667	0.037	0.070	0.083	0.009
1.9444	0.037	0.073	0.085	0.009
2.0222	0.037	0.076	0.086	0.009

2.1000	0.037	0.079	0.088	0.009
2.1778	0.037	0.082	0.090	0.009
2.2556	0.037	0.085	0.091	0.009
2.3333	0.037	0.088	0.093	0.009
2.4111	0.037	0.091	0.094	0.009
2.4889	0.037	0.094	0.096	0.009
2.5667	0.037	0.097	0.097	0.009
2.6444	0.037	0.100	0.099	0.009
2.7222	0.037	0.103	0.100	0.009
2.8000	0.037	0.106	0.102	0.009
2.8778	0.037	0.109	0.103	0.009
2.9556	0.037	0.112	0.105	0.009
3.0333	0.037	0.114	0.106	0.009
3.1111	0.037	0.117	0.107	0.009
3.1889	0.037	0.120	0.109	0.009
3.2667	0.037	0.123	0.110	0.009
3.3444	0.037	0.126	0.111	0.009
3.4222	0.037	0.129	0.113	0.009
3.5000	0.037	0.132	0.114	0.009
3.5778	0.037	0.135	0.115	0.009
3.6556	0.037	0.138	0.116	0.009
3.7333	0.037	0.141	0.118	0.009
3.8111	0.037	0.144	0.119	0.009
3.8889	0.037	0.147	0.120	0.009
3.9667	0.037	0.150	0.121	0.009
4.0444	0.037	0.153	0.128	0.009
4.1222	0.037	0.156	0.133	0.009
4.2000	0.037	0.159	0.137	0.009
4.2778	0.037	0.162	0.140	0.009
4.3556	0.037	0.165	0.143	0.009
4.4333	0.037	0.167	0.146	0.009
4.5111	0.037	0.170	0.149	0.009
4.5889	0.037	0.173	0.151	0.009
4.6667	0.037	0.176	0.154	0.009
4.7444	0.037	0.179	0.156	0.009
4.8222	0.037	0.182	0.158	0.009
4.9000	0.037	0.185	0.160	0.009
4.9778	0.037	0.188	0.163	0.009
5.0556	0.037	0.191	0.303	0.009
5.1333	0.037	0.194	0.676	0.009
5.2111	0.037	0.197	1.146	0.009
5.2889	0.037	0.200	1.618	0.009
5.3667	0.037	0.203	2.007	0.009
5.4444	0.037	0.206	2.263	0.009
5.5222	0.037	0.209	2.453	0.009
5.6000	0.037	0.212	2.618	0.009
5.6778	0.037	0.215	2.773	0.009
5.7556	0.037	0.218	2.920	0.009
5.8333	0.037	0.221	3.059	0.009
5.9111	0.037	0.223	3.192	0.009
5.9889	0.037	0.226	3.319	0.009
6.0667	0.037	0.229	3.442	0.009
6.1444	0.037	0.232	3.560	0.009
6.2222	0.037	0.235	3.674	0.009
6.3000	0.037	0.238	3.785	0.009
6.3778	0.037	0.241	3.893	0.009
6.4556	0.037	0.244	3.997	0.009
6.5333	0.037	0.247	4.099	0.009

6.6111	0.037	0.250	4.198	0.009
6.6889	0.037	0.253	4.295	0.009
6.7667	0.037	0.256	4.390	0.009
6.8444	0.037	0.259	4.483	0.009
6.9222	0.037	0.262	4.573	0.009
7.0000	0.037	0.265	4.662	0.009
7.0778	0.037	0.268	4.750	0.009

Flow Splitter 3

Bottom Length:	10.00 ft.
Bottom Length:	10.00 ft.
Depth:	10 ft.
Side slope 1:	0 To 1
Side slope 2:	0 To 1
Side slope 3:	0 To 1
Side slope 4:	0 To 1

Control Structure Splitter Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Primary(cfs)**	**Secondary(cfs)**
0.000	0.002	0.000	0.000	0.000
0.111	0.002	0.000	5.210	0.000
0.222	0.002	0.000	7.368	0.000
0.333	0.002	0.000	9.024	0.000
0.444	0.002	0.001	10.42	0.000
0.555	0.002	0.001	11.65	0.000
0.666	0.002	0.001	12.76	0.000
0.777	0.002	0.001	13.78	0.000
0.888	0.002	0.002	14.73	0.000
1.000	0.002	0.002	15.63	0.000
1.111	0.002	0.002	16.47	0.000
1.222	0.002	0.002	17.28	0.000
1.333	0.002	0.003	18.04	0.000
1.444	0.002	0.003	18.78	0.000
1.555	0.002	0.003	19.49	0.000
1.666	0.002	0.003	20.17	0.000
1.777	0.002	0.004	20.84	0.000
1.888	0.002	0.004	21.48	0.000
2.000	0.002	0.004	22.10	0.000
2.111	0.002	0.004	22.71	0.784
2.222	0.002	0.005	23.30	2.205
2.333	0.002	0.005	23.87	3.979
2.444	0.002	0.005	24.43	5.917
2.555	0.002	0.005	24.98	7.826
2.666	0.002	0.006	25.52	9.523
2.777	0.002	0.006	26.05	10.86
2.888	0.002	0.006	26.56	11.81
3.000	0.002	0.006	27.07	12.59
3.111	0.002	0.007	27.57	13.28
3.222	0.002	0.007	28.05	13.92
3.333	0.002	0.007	28.53	14.54
3.444	0.002	0.007	29.01	15.14
3.555	0.002	0.008	29.47	15.71
3.666	0.002	0.008	29.93	16.26
3.777	0.002	0.008	30.38	16.79
3.888	0.002	0.008	30.82	17.31
4.000	0.002	0.009	31.26	17.81
4.111	0.002	0.009	31.69	18.30
4.222	0.002	0.009	32.11	18.78
4.333	0.002	0.009	32.53	19.24
4.444	0.002	0.010	32.95	19.69
4.555	0.002	0.010	33.36	20.14
4.666	0.002	0.010	33.76	20.57
4.777	0.002	0.011	34.16	20.99
4.888	0.002	0.011	34.56	21.41
5.000	0.002	0.011	34.95	21.82
5.111	0.002	0.011	35.33	22.22

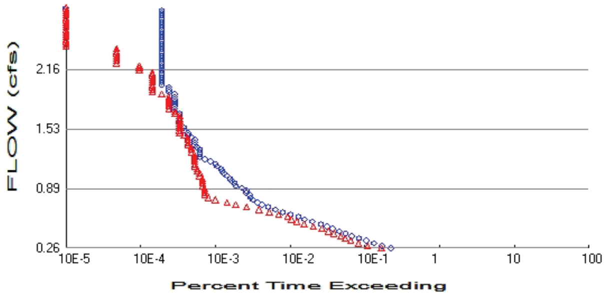
5.222	0.002	0.012	35.72	22.61
5.333	0.002	0.012	36.09	23.00
5.444	0.002	0.012	36.47	23.38
5.555	0.002	0.012	36.84	23.75
5.666	0.002	0.013	37.20	24.12
5.777	0.002	0.013	37.57	24.48
5.888	0.002	0.013	37.93	24.84
6.000	0.002	0.013	38.28	25.19
6.111	0.002	0.014	38.64	25.54
6.222	0.002	0.014	38.99	25.88
6.333	0.002	0.014	39.33	26.22
6.444	0.002	0.014	39.68	26.56
6.555	0.002	0.015	40.02	26.89
6.666	0.002	0.015	40.35	27.21
6.777	0.002	0.015	40.69	27.53
6.888	0.002	0.015	41.02	27.85
7.000	0.002	0.016	41.35	28.17
7.111	0.002	0.016	41.68	28.48
7.222	0.002	0.016	42.00	28.79
7.333	0.002	0.016	42.32	29.09
7.444	0.002	0.017	42.64	29.39
7.555	0.002	0.017	42.96	29.69
7.666	0.002	0.017	43.28	29.99
7.777	0.002	0.017	43.59	30.28
7.888	0.002	0.018	43.90	30.57
8.000	0.002	0.018	44.21	30.86
8.111	0.002	0.018	44.51	31.14
8.222	0.002	0.018	44.82	31.42
8.333	0.002	0.019	45.12	31.70
8.444	0.002	0.019	45.42	31.98
8.555	0.002	0.019	45.72	32.25
8.666	0.002	0.019	46.01	32.52
8.777	0.002	0.020	46.31	32.79
8.888	0.002	0.020	46.60	33.06
9.000	0.002	0.020	46.89	33.33
9.111	0.002	0.020	47.18	33.59
9.222	0.002	0.021	47.46	33.85
9.333	0.002	0.021	47.75	34.11
9.444	0.002	0.021	48.03	34.37
9.555	0.002	0.021	48.31	34.63
9.666	0.002	0.022	48.59	34.88
9.777	0.002	0.022	48.87	35.13
9.888	0.002	0.022	49.15	35.38
10.00	0.002	0.023	49.42	35.63
10.11	0.002	0.023	49.70	35.88

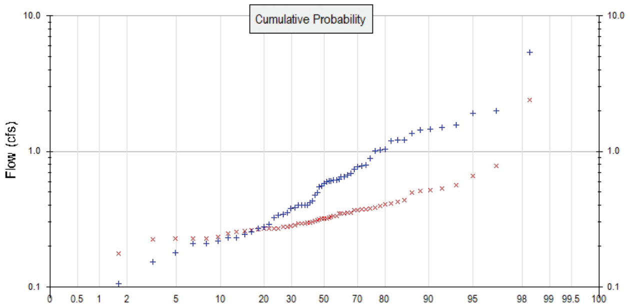
Discharge Structure
Riser Height: 0 ft.
Riser Diameter: 0 in.
Orifice 1 Diameter: 24 in. Elevation:0 ft.
Element Flows To:

Outlet 1	Outlet 2
Trapezoidal Pond 2	Trapezoidal Pond 2

Analysis Results

POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 9.8
Total Impervious Area: 0.2

Mitigated Landuse Totals for POC #1
Total Pervious Area: 4.87
Total Impervious Area: 5.13

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.521641
5 year	1.010245
10 year	1.448232
25 year	2.150329
50 year	2.7932
100 year	3.548955

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.320254
5 year	0.45499
10 year	0.563746
25 year	0.725969
50 year	0.866626
100 year	1.02587

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.472	0.515
1950	0.420	0.286
1951	1.217	0.312
1952	0.386	0.320
1953	0.646	0.319
1954	1.432	0.380
1955	0.544	0.256
1956	1.355	0.493
1957	0.888	0.314
1958	0.625	0.368

1959	0.351	0.224
1960	0.289	0.248
1961	0.688	0.395
1962	0.336	0.276
1963	0.401	0.283
1964	0.495	0.301
1965	0.764	0.425
1966	0.598	0.293
1967	0.558	0.263
1968	0.610	0.349
1969	0.791	0.437
1970	5.377	0.656
1971	0.254	0.234
1972	0.580	0.271
1973	0.219	0.307
1974	1.015	0.534
1975	0.376	0.269
1976	1.030	0.317
1977	0.092	0.227
1978	1.560	0.412
1979	0.232	0.345
1980	0.401	0.298
1981	1.210	0.406
1982	0.785	0.353
1983	1.978	0.347
1984	0.326	0.278
1985	0.277	0.322
1986	0.243	0.292
1987	1.189	0.333
1988	0.229	0.292
1989	0.209	0.228
1990	0.210	0.226
1991	0.606	0.268
1992	0.612	0.268
1993	0.401	0.367
1994	0.429	0.332
1995	0.269	0.512
1996	1.916	2.394
1997	1.507	0.785
1998	0.607	0.384
1999	0.650	0.376
2000	0.663	0.174
2001	0.105	0.176
2002	1.456	0.375
2003	1.033	0.354
2004	0.154	0.256
2005	0.178	0.265
2006	0.736	0.296
2007	0.341	0.567
2008	0.399	0.326

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	**Predeveloped**	**Mitigated**
1	5.3773	2.3937
2	1.9782	0.7849
3	1.9164	0.6556
4	1.5598	0.5668

5	1.5072	0.5343
6	1.4563	0.5148
7	1.4316	0.5124
8	1.3549	0.4934
9	1.2172	0.4368
10	1.2102	0.4249
11	1.1888	0.4122
12	1.0331	0.4064
13	1.0295	0.3947
14	1.0151	0.3836
15	0.8876	0.3805
16	0.7911	0.3758
17	0.7845	0.3753
18	0.7640	0.3684
19	0.7359	0.3671
20	0.6875	0.3538
21	0.6633	0.3535
22	0.6496	0.3489
23	0.6456	0.3468
24	0.6247	0.3454
25	0.6121	0.3328
26	0.6102	0.3316
27	0.6071	0.3264
28	0.6065	0.3221
29	0.5983	0.3198
30	0.5800	0.3192
31	0.5580	0.3171
32	0.5443	0.3142
33	0.4952	0.3125
34	0.4725	0.3068
35	0.4290	0.3011
36	0.4203	0.2975
37	0.4012	0.2962
38	0.4007	0.2927
39	0.4005	0.2921
40	0.3995	0.2920
41	0.3865	0.2864
42	0.3762	0.2829
43	0.3512	0.2783
44	0.3410	0.2762
45	0.3362	0.2708
46	0.3260	0.2692
47	0.2892	0.2682
48	0.2770	0.2680
49	0.2694	0.2654
50	0.2543	0.2631
51	0.2435	0.2565
52	0.2316	0.2559
53	0.2289	0.2476
54	0.2187	0.2341
55	0.2096	0.2281
56	0.2087	0.2269
57	0.1784	0.2259
58	0.1536	0.2239
59	0.1049	0.1761
60	0.0916	0.1738

Duration Flows
The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.2608	4668	3511	75	Pass
0.2864	3530	2281	64	Pass
0.3120	2794	1722	61	Pass
0.3376	2203	1360	61	Pass
0.3631	1749	1149	65	Pass
0.3887	1412	990	70	Pass
0.4143	1150	813	70	Pass
0.4399	963	686	71	Pass
0.4655	782	558	71	Pass
0.4910	650	428	65	Pass
0.5166	543	323	59	Pass
0.5422	414	260	62	Pass
0.5678	330	220	66	Pass
0.5934	272	194	71	Pass
0.6189	212	147	69	Pass
0.6445	168	110	65	Pass
0.6701	132	81	61	Pass
0.6957	107	55	51	Pass
0.7213	88	39	44	Pass
0.7468	77	30	38	Pass
0.7724	67	21	31	Pass
0.7980	62	17	27	Pass
0.8236	61	15	24	Pass
0.8492	55	15	27	Pass
0.8747	54	15	27	Pass
0.9003	47	15	31	Pass
0.9259	39	14	35	Pass
0.9515	38	14	36	Pass
0.9770	35	14	40	Pass
1.0026	33	14	42	Pass
1.0282	30	13	43	Pass
1.0538	27	13	48	Pass
1.0794	26	12	46	Pass
1.1049	25	12	48	Pass
1.1305	22	11	50	Pass
1.1561	21	11	52	Pass
1.1817	18	11	61	Pass
1.2073	15	11	73	Pass
1.2328	13	11	84	Pass
1.2584	13	11	84	Pass
1.2840	13	10	76	Pass
1.3096	13	10	76	Pass
1.3352	12	10	83	Pass
1.3607	11	9	81	Pass
1.3863	11	9	81	Pass
1.4119	11	9	81	Pass
1.4375	10	9	90	Pass
1.4631	9	8	88	Pass
1.4886	9	7	77	Pass
1.5142	8	7	87	Pass
1.5398	8	7	87	Pass
1.5654	7	7	100	Pass
1.5910	7	7	100	Pass

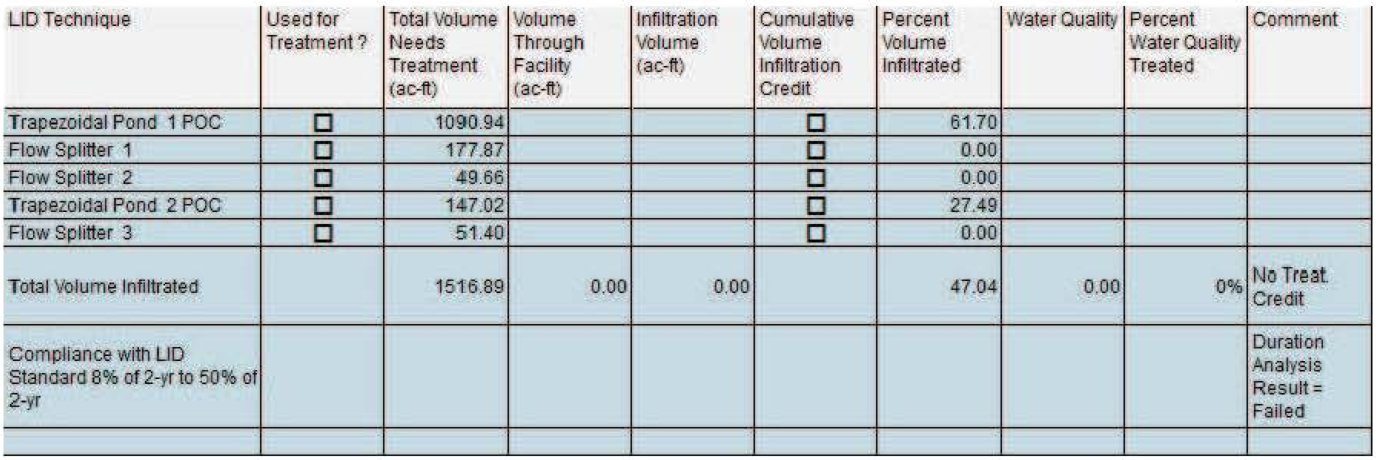
1.6165	7	7	100	Pass
1.6421	7	7	100	Pass
1.6677	7	7	100	Pass
1.6933	7	6	85	Pass
1.7189	6	6	100	Pass
1.7444	6	5	83	Pass
1.7700	6	5	83	Pass
1.7956	6	5	83	Pass
1.8212	6	5	83	Pass
1.8468	6	5	83	Pass
1.8723	6	5	83	Pass
1.8979	6	4	66	Pass
1.9235	5	3	60	Pass
1.9491	5	3	60	Pass
1.9747	5	3	60	Pass
2.0002	4	3	75	Pass
2.0258	4	3	75	Pass
2.0514	4	3	75	Pass
2.0770	4	3	75	Pass
2.1026	4	3	75	Pass
2.1281	4	3	75	Pass
2.1537	4	2	50	Pass
2.1793	4	2	50	Pass
2.2049	4	2	50	Pass
2.2304	4	1	25	Pass
2.2560	4	1	25	Pass
2.2816	4	1	25	Pass
2.3072	4	1	25	Pass
2.3328	4	1	25	Pass
2.3583	4	1	25	Pass
2.3839	4	1	25	Pass
2.4095	4	0	0	Pass
2.4351	4	0	0	Pass
2.4607	4	0	0	Pass
2.4862	4	0	0	Pass
2.5118	4	0	0	Pass
2.5374	4	0	0	Pass
2.5630	4	0	0	Pass
2.5886	4	0	0	Pass
2.6141	4	0	0	Pass
2.6397	4	0	0	Pass
2.6653	4	0	0	Pass
2.6909	4	0	0	Pass
2.7165	4	0	0	Pass
2.7420	4	0	0	Pass
2.7676	4	0	0	Pass
2.7932	4	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report



LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Trapezoidal Pond 1 POC	☐	1090.94			☐	61.70			
Flow Splitter 1	☐	177.87			☐	0.00			
Flow Splitter 2	☐	49.66			☐	0.00			
Trapezoidal Pond 2 POC	☐	147.02			☐	27.49			
Flow Splitter 3	☐	51.40			☐	0.00			
Total Volume Infiltrated		1516.89	0.00	0.00		47.04	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

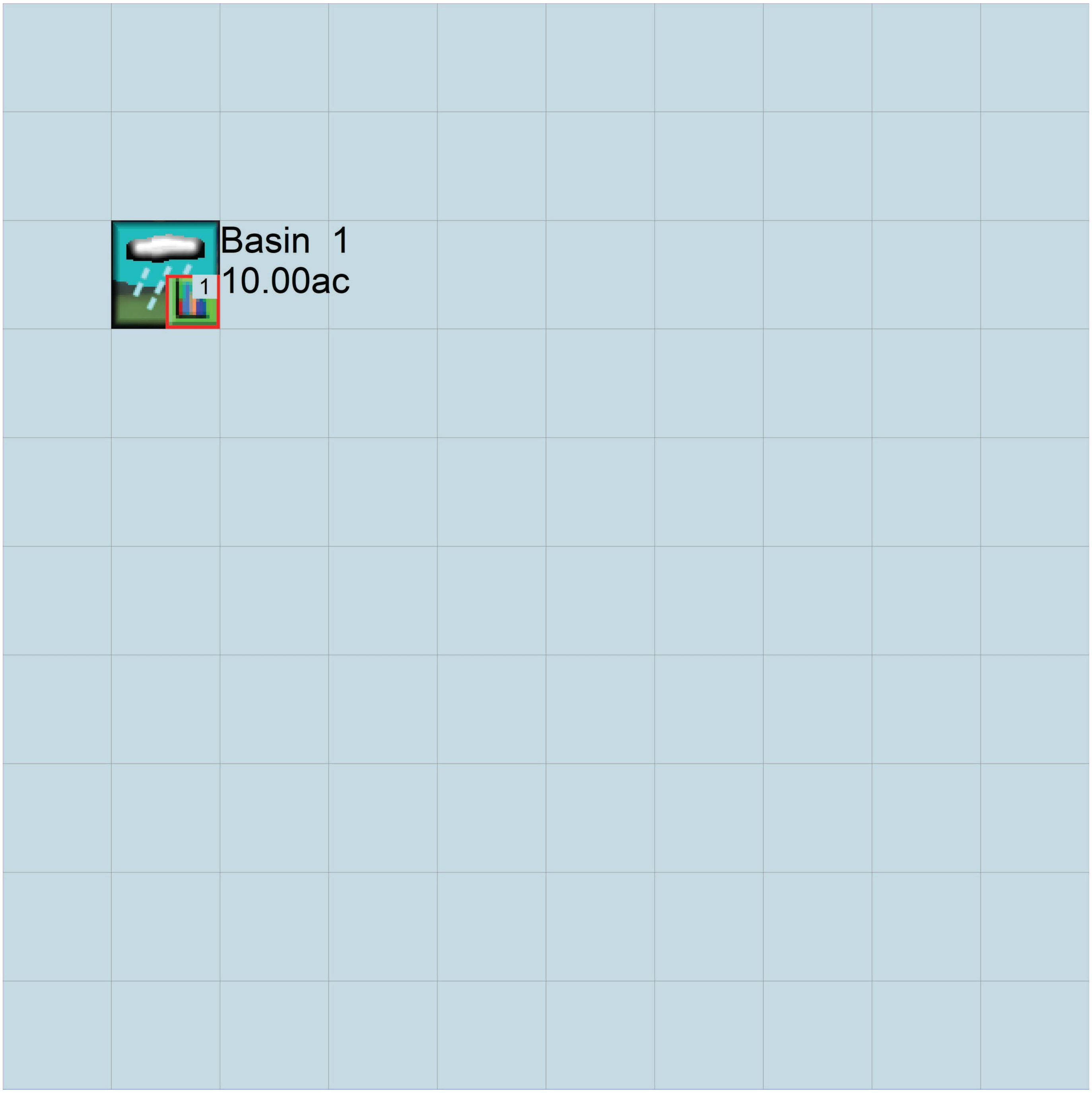
No PERLND changes have been made.

IMPLND Changes

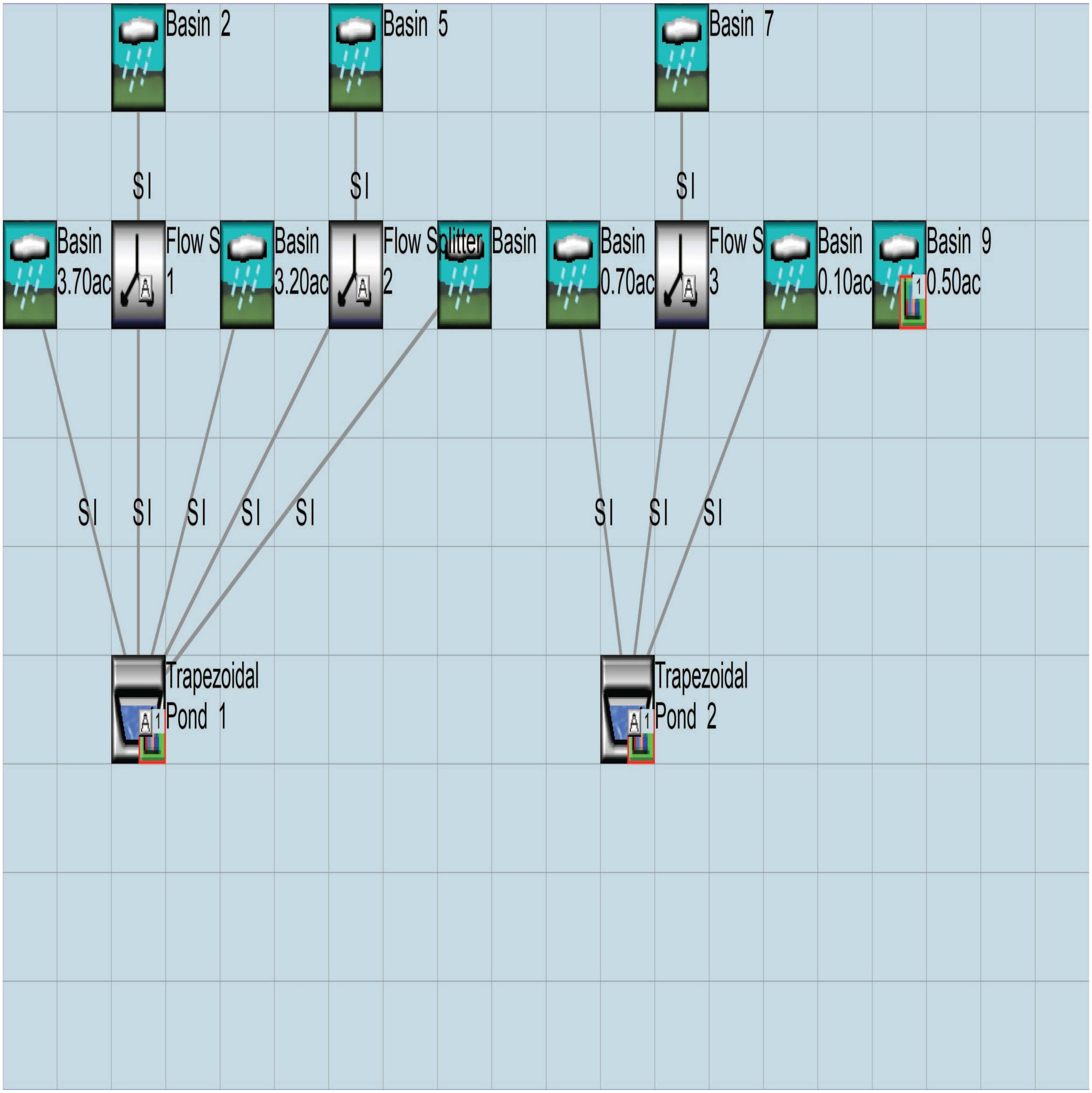
No IMPLND changes have been made.

Appendix

Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

```
RUN

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

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   Valley View Estates.wdm
MESSU      25   PreValley View Estates.MES
           27   PreValley View Estates.L61
           28   PreValley View Estates.L62
           30   POCValley View Estates1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND       21
      IMPLND        3
      COPY        501
      DISPLY        1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                    MAX                    1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                            User  t-series Engl Metr ***
                                           in  out           ***
   21      SG3, Forest, Steep      1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   21          0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   21          0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
```

```
  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   21         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   21              0         9      0.08       400      0.15         0      0.96
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   21              0         0       2.5         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   21            0.2         1      0.35         4       0.4       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   21              0         0         0         0         3         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                     in  out          ***
    3      ROADS/STEEP           1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    3         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    3         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    3         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    3            400       0.1       0.1      0.05
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    3              0         0
```

```
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    3              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <--factor-->   <Name>   #   Tbl#   ***
Basin     1***
PERLND  21                         9.2     COPY   501     12
PERLND  21                         9.2     COPY   501     13
IMPLND   3                         0.2     COPY   501     15

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

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



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

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

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

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

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

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

SPEC-ACTIONS
```

```
END SPEC-ACTIONS
FTABLES
END FTABLES

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

END EXT SOURCES

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

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

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

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


END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

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

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   Valley View Estates.wdm
MESSU      25   MitValley View Estates.MES
           27   MitValley View Estates.L61
           28   MitValley View Estates.L62
           30   POCValley View Estates1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      26
      IMPLND       4
      IMPLND       5
      IMPLND       2
      PERLND      27
      IMPLND       3
      PERLND      25
      IMPLND      11
      IMPLND       1
      RCHRES       1
      RCHRES       2
      RCHRES       3
      RCHRES       4
      RCHRES       5
      COPY         1
      COPY       501
      COPY       601
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Trapezoidal Pond  2         MAX                   1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  601         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                           in  out           ***
```

```
   26     SG3, Lawn, Mod          1    1    1    1   27    0
   27     SG3, Lawn, Steep        1    1    1    1   27    0
   25     SG3, Lawn, Flat         1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   26         0    0    1    0    0    0    0    0    0    0    0    0
   27         0    0    1    0    0    0    0    0    0    0    0    0
   25         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   26         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   27         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   25         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   26         0    0    0    0    0    0    0    0    0    0    0
   27         0    0    0    0    0    0    0    0    0    0    0
   25         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   26             0         9      0.05       400       0.1         0      0.96
   27             0         9      0.05       400      0.15         0      0.96
   25             0         9      0.05       400      0.05         0      0.96
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   26             0         0       2.5         2         0         0         0
   27             0         0       2.5         2         0         0         0
   25             0         0       2.5         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   26           0.1       0.8      0.25         4       0.4      0.25
   27           0.1       0.8      0.25         4       0.4      0.25
   25           0.1       0.8      0.25         4       0.4      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   26             0         0         0         0         3         1         0
   27             0         0         0         0         3         1         0
   25             0         0         0         0         3         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name-------> Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                      in  out           ***
    4      ROOF TOPS/FLAT         1    1    1   27    0
```

```
  5      DRIVEWAYS/FLAT         1    1    1   27    0
  2      ROADS/MOD              1    1    1   27    0
  3      ROADS/STEEP            1    1    1   27    0
 11      PARKING/FLAT           1    1    1   27    0
  1      ROADS/FLAT             1    1    1   27    0
END GEN-INFO
*** Section IWATER***

ACTIVITY
  <PLS > ************* Active Sections ****************************
  # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
  4         0    0    1    0    0    0
  5         0    0    1    0    0    0
  2         0    0    1    0    0    0
  3         0    0    1    0    0    0
 11         0    0    1    0    0    0
  1         0    0    1    0    0    0
END ACTIVITY

PRINT-INFO
  <ILS > ******** Print-flags ******** PIVL  PYR
  # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
  4         0    0    4    0    0    0    1    9
  5         0    0    4    0    0    0    1    9
  2         0    0    4    0    0    0    1    9
  3         0    0    4    0    0    0    1    9
 11         0    0    4    0    0    0    1    9
  1         0    0    4    0    0    0    1    9
END PRINT-INFO

IWAT-PARM1
  <PLS >  IWATER variable monthly parameter value flags  ***
  # -  # CSNO RTOP  VRS  VNN RTLI     ***
  4         0    0    0    0    0
  5         0    0    0    0    0
  2         0    0    0    0    0
  3         0    0    0    0    0
 11         0    0    0    0    0
  1         0    0    0    0    0
END IWAT-PARM1

IWAT-PARM2
  <PLS >      IWATER input info: Part 2         ***
  # -  # ***  LSUR     SLSUR      NSUR     RETSC
  4            400      0.01       0.1       0.1
  5            400      0.01       0.1       0.1
  2            400      0.05       0.1      0.08
  3            400       0.1       0.1      0.05
 11            400      0.01       0.1       0.1
  1            400      0.01       0.1       0.1
END IWAT-PARM2

IWAT-PARM3
  <PLS >      IWATER input info: Part 3         ***
  # -  # ***PETMAX    PETMIN
  4              0         0
  5              0         0
  2              0         0
  3              0         0
 11              0         0
  1              0         0
END IWAT-PARM3

IWAT-STATE1
  <PLS > *** Initial conditions at start of simulation
  # -  # ***  RETS      SURS
  4              0         0
  5              0         0
  2              0         0
  3              0         0
```

```
   11              0         0
    1              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  26                         2.2     RCHRES   5      2
PERLND  26                         2.2     RCHRES   5      3
IMPLND   4                           1     RCHRES   5      5
IMPLND   5                         0.5     RCHRES   5      5
Basin  2***
IMPLND   2                           1     RCHRES   1      5
Basin  3***
PERLND  26                         1.9     RCHRES   5      2
PERLND  26                         1.9     RCHRES   5      3
IMPLND   4                         0.9     RCHRES   5      5
IMPLND   5                         0.4     RCHRES   5      5
Basin  4***
IMPLND   2                         0.2     RCHRES   5      5
Basin  5***
IMPLND   2                         0.3     RCHRES   2      5
Basin  6***
PERLND  27                         0.4     RCHRES   4      2
PERLND  27                         0.4     RCHRES   4      3
IMPLND   4                         0.2     RCHRES   4      5
IMPLND   5                         0.1     RCHRES   4      5
Basin  7***
IMPLND   3                         0.3     RCHRES   3      5
Basin  8***
PERLND  25                        0.07     RCHRES   4      2
PERLND  25                        0.07     RCHRES   4      3
IMPLND  11                        0.03     RCHRES   4      5
Basin  9***
PERLND  25                         0.3     COPY   501     12
PERLND  25                         0.3     COPY   601     12
PERLND  25                         0.3     COPY   501     13
PERLND  25                         0.3     COPY   601     13
IMPLND   1                         0.2     COPY   501     15
IMPLND   1                         0.2     COPY   601     15

******Routing******
PERLND  26                         2.2     COPY     1     12
IMPLND   4                           1     COPY     1     15
IMPLND   5                         0.5     COPY     1     15
PERLND  26                         2.2     COPY     1     13
RCHRES   1                           1     RCHRES   5      7
RCHRES   1                                 COPY     1     17
RCHRES   1                           1     RCHRES   5      8
RCHRES   1                                 COPY     1     18
PERLND  26                         1.9     COPY     1     12
IMPLND   4                         0.9     COPY     1     15
IMPLND   5                         0.4     COPY     1     15
PERLND  26                         1.9     COPY     1     13
IMPLND   2                         0.2     COPY     1     15
RCHRES   2                           1     RCHRES   5      7
RCHRES   2                                 COPY     1     17
RCHRES   2                           1     RCHRES   5      8
RCHRES   2                                 COPY     1     18
PERLND  27                         0.4     COPY     1     12
IMPLND   4                         0.2     COPY     1     15
IMPLND   5                         0.1     COPY     1     15
PERLND  27                         0.4     COPY     1     13
RCHRES   3                           1     RCHRES   4      7
RCHRES   3                                 COPY     1     17
RCHRES   3                           1     RCHRES   4      8
RCHRES   3                                 COPY     1     18
```

```
PERLND  25                        0.07     COPY     1     12
IMPLND  11                        0.03     COPY     1     15
PERLND  25                        0.07     COPY     1     13
RCHRES   5                           1     COPY   501     17
RCHRES   4                           1     COPY   501     17
END SCHEMATIC

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



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

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG           ***
                                          in  out                            ***
    1     Flow Splitter  1-010    2    1    1    1   28    0    1
    2     Flow Splitter  2-013    2    1    1    1   28    0    1
    3     Flow Splitter  3-018    2    1    1    1   28    0    1
    4     Trapezoidal Pond-015    2    1    1    1   28    0    1
    5     Trapezoidal Pond-006    2    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
    2         1    0    0    0    0    0    0    0    0    0
    3         1    0    0    0    0    0    0    0    0    0
    4         1    0    0    0    0    0    0    0    0    0
    5         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
    2         4    0    0    0    0    0    0    0    0    0    1    9
    3         4    0    0    0    0    0    0    0    0    0    1    9
    4         4    0    0    0    0    0    0    0    0    0    1    9
    5         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *          ***
    1        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
    2        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
    3        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
    4        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
    5        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1             1      0.01       0.0       0.0       0.5       0.0
    2             2      0.01       0.0       0.0       0.5       0.0
    3             3      0.01       0.0       0.0       0.5       0.0
    4             4      0.01       0.0       0.0       0.5       0.0
```

```
    5              5      0.03       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1           0         4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    2           0         4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    3           0         4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    4           0         4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    5           0         4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      5
   91    5
     Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
      (ft)   (acres) (acre-ft)    (cfs)     (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.371901  0.000000  0.000000  0.000000
  0.077778  0.371901  0.028926  0.027321  0.093750
  0.155556  0.371901  0.057851  0.038637  0.093750
  0.233333  0.371901  0.086777  0.047321  0.093750
  0.311111  0.371901  0.115702  0.054642  0.093750
  0.388889  0.371901  0.144628  0.061091  0.093750
  0.466667  0.371901  0.173554  0.066922  0.093750
  0.544444  0.371901  0.202479  0.072284  0.093750
  0.622222  0.371901  0.231405  0.077275  0.093750
  0.700000  0.371901  0.260331  0.081962  0.093750
  0.777778  0.371901  0.289256  0.086396  0.093750
  0.855556  0.371901  0.318182  0.090613  0.093750
  0.933333  0.371901  0.347107  0.094642  0.093750
  1.011111  0.371901  0.376033  0.098507  0.093750
  1.088889  0.371901  0.404959  0.102225  0.093750
  1.166667  0.371901  0.433884  0.105813  0.093750
  1.244444  0.371901  0.462810  0.109283  0.093750
  1.322222  0.371901  0.491736  0.112647  0.093750
  1.400000  0.371901  0.520661  0.115912  0.093750
  1.477778  0.371901  0.549587  0.119089  0.093750
  1.555556  0.371901  0.578512  0.122182  0.093750
  1.633333  0.371901  0.607438  0.125200  0.093750
  1.711111  0.371901  0.636364  0.128146  0.093750
  1.788889  0.371901  0.665289  0.131026  0.093750
  1.866667  0.371901  0.694215  0.133844  0.093750
  1.944444  0.371901  0.723140  0.136604  0.093750
  2.022222  0.371901  0.752066  0.139309  0.093750
  2.100000  0.371901  0.780992  0.141963  0.093750
  2.177778  0.371901  0.809917  0.144568  0.093750
  2.255556  0.371901  0.838843  0.147127  0.093750
  2.333333  0.371901  0.867769  0.149642  0.093750
  2.411111  0.371901  0.896694  0.152116  0.093750
  2.488889  0.371901  0.925620  0.154550  0.093750
  2.566667  0.371901  0.954545  0.156946  0.093750
  2.644444  0.371901  0.983471  0.159306  0.093750
  2.722222  0.371901  1.012397  0.161632  0.093750
  2.800000  0.371901  1.041322  0.163925  0.093750
  2.877778  0.371901  1.070248  0.166186  0.093750
  2.955556  0.371901  1.099174  0.168417  0.093750
  3.033333  0.371901  1.128099  0.170618  0.093750
  3.111111  0.371901  1.157025  0.172792  0.093750
  3.188889  0.371901  1.185950  0.174939  0.093750
  3.266667  0.371901  1.214876  0.177059  0.093750
  3.344444  0.371901  1.243802  0.179155  0.093750
  3.422222  0.371901  1.272727  0.181226  0.093750
  3.500000  0.371901  1.301653  0.183274  0.093750
  3.577778  0.371901  1.330579  0.185299  0.093750
  3.655556  0.371901  1.359504  0.187302  0.093750
```

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3.733333  0.371901  1.388430  0.189284  0.093750
3.811111  0.371901  1.417355  0.191246  0.093750
3.888889  0.371901  1.446281  0.193187  0.093750
3.966667  0.371901  1.475207  0.195110  0.093750
4.044444  0.371901  1.504132  0.248502  0.093750
4.122222  0.371901  1.533058  0.284283  0.093750
4.200000  0.371901  1.561983  0.309990  0.093750
4.277778  0.371901  1.590909  0.331338  0.093750
4.355556  0.371901  1.619835  0.350082  0.093750
4.433333  0.371901  1.648760  0.367040  0.093750
4.511111  0.371901  1.677686  0.382675  0.093750
4.588889  0.371901  1.706612  0.397276  0.093750
4.666667  0.371901  1.735537  0.411040  0.093750
4.744444  0.371901  1.764463  0.424108  0.093750
4.822222  0.371901  1.793388  0.436585  0.093750
4.900000  0.371901  1.822314  0.448550  0.093750
4.977778  0.371901  1.851240  0.460069  0.093750
5.055556  0.371901  1.880165  0.471191  0.093750
5.133333  0.371901  1.909091  0.481959  0.093750
5.211111  0.371901  1.938017  0.492408  0.093750
5.288889  0.371901  1.966942  0.502567  0.093750
5.366667  0.371901  1.995868  0.512461  0.093750
5.444444  0.371901  2.024793  0.522112  0.093750
5.522222  0.371901  2.053719  0.584275  0.093750
5.600000  0.371901  2.082645  1.042934  0.093750
5.677778  0.371901  2.111570  1.731359  0.093750
5.755556  0.371901  2.140496  2.558530  0.093750
5.833333  0.371901  2.169421  3.449815  0.093750
5.911111  0.371901  2.198347  4.328725  0.093750
5.988889  0.371901  2.227273  5.121849  0.093750
6.066667  0.371901  2.256198  5.771055  0.093750
6.144444  0.371901  2.285124  6.249903  0.093750
6.222222  0.371901  2.314050  6.583203  0.093750
6.300000  0.371901  2.342975  6.954791  0.093750
6.377778  0.371901  2.371901  7.263491  0.093750
6.455556  0.371901  2.400826  7.559016  0.093750
6.533333  0.371901  2.429752  7.842939  0.093750
6.611111  0.371901  2.458678  8.116541  0.093750
6.688889  0.371901  2.487603  8.380881  0.093750
6.766667  0.371901  2.516529  8.636850  0.093750
6.844444  0.371901  2.545455  8.885204  0.093750
6.922222  0.371901  2.574380  9.126590  0.093750
7.000000  0.371901  2.603306  9.361569  0.093750
END FTABLE  5
FTABLE      1
 90    5
   Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
    (ft)   (acres) (acre-ft)    (cfs)     (cfs)   (ft/sec)    (Minutes)***
0.000000  0.002296  0.000000  0.000000  0.000000
0.111111  0.002296  0.000255  5.210267  0.000000
0.222222  0.002296  0.000510  7.368430  0.000000
0.333333  0.002296  0.000765  9.024447  0.000000
0.444444  0.002296  0.001020  10.42053  0.000000
0.555556  0.002296  0.001275  11.65051  0.000000
0.666667  0.002296  0.001530  12.76249  0.000000
0.777778  0.002296  0.001786  13.78507  0.000000
0.888889  0.002296  0.002041  14.73686  0.000000
1.000000  0.002296  0.002296  15.63080  0.000000
1.111111  0.002296  0.002551  16.47631  0.000000
1.222222  0.002296  0.002806  17.28050  0.000000
1.333333  0.002296  0.003061  18.04889  0.000000
1.444444  0.002296  0.003316  18.78588  0.000000
1.555556  0.002296  0.003571  19.49503  0.000000
1.666667  0.002296  0.003826  20.17928  0.000000
1.777778  0.002296  0.004081  20.84107  0.000000
1.888889  0.002296  0.004336  21.48248  0.000000
2.000000  0.002296  0.004591  22.10529  0.000000
2.111111  0.002296  0.004846  22.71103  0.000000
2.222222  0.002296  0.005102  23.30102  0.000000
2.333333  0.002296  0.005357  23.87644  0.000000
```

```
2.444444  0.002296  0.005612  24.43832  0.000000
2.555556  0.002296  0.005867  24.98756  0.000000
2.666667  0.002296  0.006122  25.52499  0.000000
2.777778  0.002296  0.006377  26.05133  0.000000
2.888889  0.002296  0.006632  26.56725  0.000000
3.000000  0.002296  0.006887  27.07334  0.000000
3.111111  0.002296  0.007142  27.57014  0.000000
3.222222  0.002296  0.007397  28.05814  0.000000
3.333333  0.002296  0.007652  28.53781  0.000000
3.444444  0.002296  0.007907  29.00954  0.000000
3.555556  0.002296  0.008162  29.47372  0.000000
3.666667  0.002296  0.008418  29.93070  0.000000
3.777778  0.002296  0.008673  30.38081  0.000000
3.888889  0.002296  0.008928  30.82435  0.000000
4.000000  0.002296  0.009183  31.26160  0.000000
4.111111  0.002296  0.009438  31.69281  0.000000
4.222222  0.002296  0.009693  32.11824  0.000000
4.333333  0.002296  0.009948  32.53810  0.000000
4.444444  0.002296  0.010203  32.95262  0.000000
4.555556  0.002296  0.010458  33.36198  0.000000
4.666667  0.002296  0.010713  33.76639  0.000000
4.777778  0.002296  0.010968  34.16600  0.000000
4.888889  0.002296  0.011223  34.56100  0.000000
5.000000  0.002296  0.011478  34.95153  0.000000
5.111111  0.002296  0.011733  35.33775  0.000000
5.222222  0.002296  0.011989  35.71979  0.000000
5.333333  0.002296  0.012244  36.09779  0.000000
5.444444  0.002296  0.012499  36.47187  0.000000
5.555556  0.002296  0.012754  36.84215  0.000000
5.666667  0.002296  0.013009  37.20875  0.000000
5.777778  0.002296  0.013264  37.57177  0.000000
5.888889  0.002296  0.013519  37.93131  0.000000
6.000000  0.002296  0.013774  38.28748  0.000000
6.111111  0.002296  0.014029  38.64037  0.000000
6.222222  0.002296  0.014284  38.99007  0.000000
6.333333  0.002296  0.014539  39.33665  0.000000
6.444444  0.002296  0.014794  39.68021  0.000000
6.555556  0.002296  0.015049  40.02082  0.000000
6.666667  0.002296  0.015305  40.35855  0.000000
6.777778  0.002296  0.015560  40.69348  0.000000
6.888889  0.002296  0.015815  41.02568  0.000000
7.000000  0.002296  0.016070  41.35521  0.000000
7.111111  0.002296  0.016325  41.68213  0.000000
7.222222  0.002296  0.016580  42.00651  0.000000
7.333333  0.002296  0.016835  42.32841  0.000000
7.444444  0.002296  0.017090  42.64787  0.000000
7.555556  0.002296  0.017345  42.96496  0.000000
7.666667  0.002296  0.017600  43.27973  0.000000
7.777778  0.002296  0.017855  43.59222  0.000000
7.888889  0.002296  0.018110  43.90249  0.000000
8.000000  0.002296  0.018365  44.21058  0.000000
8.111111  0.002296  0.018621  44.51654  0.000000
8.222222  0.002296  0.018876  44.82041  0.000000
8.333333  0.002296  0.019131  45.12223  0.000000
8.444444  0.002296  0.019386  45.42205  0.000000
8.555556  0.002296  0.019641  45.71990  0.000000
8.666667  0.002296  0.019896  46.01583  0.000000
8.777778  0.002296  0.020151  46.30986  0.000000
8.888889  0.002296  0.020406  46.60204  0.000000
9.000000  0.002296  0.020661  46.89240  0.000000
9.111111  0.002296  0.020916  47.18097  0.000000
9.222222  0.002296  0.021171  47.46779  0.000000
9.333333  0.002296  0.021426  47.75288  0.000000
9.444444  0.002296  0.021681  48.03629  0.000000
9.555556  0.002296  0.021937  48.31803  0.000000
9.666667  0.002296  0.022192  48.59813  0.000000
9.777778  0.002296  0.022447  48.87663  0.000000
9.888889  0.002296  0.022702  49.15356  0.000000
END FTABLE  1
FTABLE      2
```

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  90    5
   Depth       Area     Volume  Outflow1  Outflow2  Velocity  Travel Time***
    (ft)    (acres) (acre-ft)    (cfs)     (cfs)   (ft/sec)     (Minutes)***
 0.000000  0.002296  0.000000  0.000000  0.000000
 0.111111  0.002296  0.000255  5.210267  0.000000
 0.222222  0.002296  0.000510  7.368430  0.000000
 0.333333  0.002296  0.000765  9.024447  0.000000
 0.444444  0.002296  0.001020  10.42053  0.000000
 0.555556  0.002296  0.001275  11.65051  0.000000
 0.666667  0.002296  0.001530  12.76249  0.000000
 0.777778  0.002296  0.001786  13.78507  0.000000
 0.888889  0.002296  0.002041  14.73686  0.000000
 1.000000  0.002296  0.002296  15.63080  0.000000
 1.111111  0.002296  0.002551  16.47631  0.000000
 1.222222  0.002296  0.002806  17.28050  0.000000
 1.333333  0.002296  0.003061  18.04889  0.000000
 1.444444  0.002296  0.003316  18.78588  0.000000
 1.555556  0.002296  0.003571  19.49503  0.000000
 1.666667  0.002296  0.003826  20.17928  0.000000
 1.777778  0.002296  0.004081  20.84107  0.000000
 1.888889  0.002296  0.004336  21.48248  0.000000
 2.000000  0.002296  0.004591  22.10529  0.000000
 2.111111  0.002296  0.004846  22.71103  0.784769
 2.222222  0.002296  0.005102  23.30102  2.205262
 2.333333  0.002296  0.005357  23.87644  3.979211
 2.444444  0.002296  0.005612  24.43832  5.917238
 2.555556  0.002296  0.005867  24.98756  7.826549
 2.666667  0.002296  0.006122  25.52499  9.523132
 2.777778  0.002296  0.006377  26.05133  10.86741
 2.888889  0.002296  0.006632  26.56725  11.81283
 3.000000  0.002296  0.006887  27.07334  12.59852
 3.111111  0.002296  0.007142  27.57014  13.28001
 3.222222  0.002296  0.007397  28.05814  13.92819
 3.333333  0.002296  0.007652  28.53781  14.54752
 3.444444  0.002296  0.007907  29.00954  15.14154
 3.555556  0.002296  0.008162  29.47372  15.71312
 3.666667  0.002296  0.008418  29.93070  16.26462
 3.777778  0.002296  0.008673  30.38081  16.79803
 3.888889  0.002296  0.008928  30.82435  17.31501
 4.000000  0.002296  0.009183  31.26160  17.81700
 4.111111  0.002296  0.009438  31.69281  18.30523
 4.222222  0.002296  0.009693  32.11824  18.78076
 4.333333  0.002296  0.009948  32.53810  19.24456
 4.444444  0.002296  0.010203  32.95262  19.69743
 4.555556  0.002296  0.010458  33.36198  20.14013
 4.666667  0.002296  0.010713  33.76639  20.57330
 4.777778  0.002296  0.010968  34.16600  20.99753
 4.888889  0.002296  0.011223  34.56100  21.41337
 5.000000  0.002296  0.011478  34.95153  21.82128
 5.111111  0.002296  0.011733  35.33775  22.22170
 5.222222  0.002296  0.011989  35.71979  22.61504
 5.333333  0.002296  0.012244  36.09779  23.00165
 5.444444  0.002296  0.012499  36.47187  23.38186
 5.555556  0.002296  0.012754  36.84215  23.75600
 5.666667  0.002296  0.013009  37.20875  24.12433
 5.777778  0.002296  0.013264  37.57177  24.48712
 5.888889  0.002296  0.013519  37.93131  24.84462
 6.000000  0.002296  0.013774  38.28748  25.19704
 6.111111  0.002296  0.014029  38.64037  25.54460
 6.222222  0.002296  0.014284  38.99007  25.88750
 6.333333  0.002296  0.014539  39.33665  26.22591
 6.444444  0.002296  0.014794  39.68021  26.56001
 6.555556  0.002296  0.015049  40.02082  26.88996
 6.666667  0.002296  0.015305  40.35855  27.21591
 6.777778  0.002296  0.015560  40.69348  27.53801
 6.888889  0.002296  0.015815  41.02568  27.85638
 7.000000  0.002296  0.016070  41.35521  28.17115
 7.111111  0.002296  0.016325  41.68213  28.48244
 7.222222  0.002296  0.016580  42.00651  28.79037
 7.333333  0.002296  0.016835  42.32841  29.09504
```

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7.444444  0.002296  0.017090  42.64787  29.39655
7.555556  0.002296  0.017345  42.96496  29.69500
7.666667  0.002296  0.017600  43.27973  29.99048
7.777778  0.002296  0.017855  43.59222  30.28307
7.888889  0.002296  0.018110  43.90249  30.57287
8.000000  0.002296  0.018365  44.21058  30.85995
8.111111  0.002296  0.018621  44.51654  31.14438
8.222222  0.002296  0.018876  44.82041  31.42623
8.333333  0.002296  0.019131  45.12223  31.70558
8.444444  0.002296  0.019386  45.42205  31.98249
8.555556  0.002296  0.019641  45.71990  32.25702
8.666667  0.002296  0.019896  46.01583  32.52924
8.777778  0.002296  0.020151  46.30986  32.79920
8.888889  0.002296  0.020406  46.60204  33.06695
9.000000  0.002296  0.020661  46.89240  33.33255
9.111111  0.002296  0.020916  47.18097  33.59605
9.222222  0.002296  0.021171  47.46779  33.85751
9.333333  0.002296  0.021426  47.75288  34.11695
9.444444  0.002296  0.021681  48.03629  34.37444
9.555556  0.002296  0.021937  48.31803  34.63002
9.666667  0.002296  0.022192  48.59813  34.88372
9.777778  0.002296  0.022447  48.87663  35.13559
9.888889  0.002296  0.022702  49.15356  35.38567
END FTABLE  2
FTABLE      4
 91    5
   Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
    (ft)   (acres) (acre-ft)    (cfs)     (cfs)   (ft/sec)    (Minutes)***
0.000000  0.037879  0.000000  0.000000  0.000000
0.077778  0.037879  0.002946  0.017028  0.009549
0.155556  0.037879  0.005892  0.024082  0.009549
0.233333  0.037879  0.008838  0.029494  0.009549
0.311111  0.037879  0.011785  0.034056  0.009549
0.388889  0.037879  0.014731  0.038076  0.009549
0.466667  0.037879  0.017677  0.041710  0.009549
0.544444  0.037879  0.020623  0.045052  0.009549
0.622222  0.037879  0.023569  0.048163  0.009549
0.700000  0.037879  0.026515  0.051085  0.009549
0.777778  0.037879  0.029461  0.053848  0.009549
0.855556  0.037879  0.032407  0.056476  0.009549
0.933333  0.037879  0.035354  0.058987  0.009549
1.011111  0.037879  0.038300  0.061396  0.009549
1.088889  0.037879  0.041246  0.063714  0.009549
1.166667  0.037879  0.044192  0.065950  0.009549
1.244444  0.037879  0.047138  0.068113  0.009549
1.322222  0.037879  0.050084  0.070209  0.009549
1.400000  0.037879  0.053030  0.072245  0.009549
1.477778  0.037879  0.055976  0.074224  0.009549
1.555556  0.037879  0.058923  0.076152  0.009549
1.633333  0.037879  0.061869  0.078033  0.009549
1.711111  0.037879  0.064815  0.079869  0.009549
1.788889  0.037879  0.067761  0.081664  0.009549
1.866667  0.037879  0.070707  0.083421  0.009549
1.944444  0.037879  0.073653  0.085141  0.009549
2.022222  0.037879  0.076599  0.086827  0.009549
2.100000  0.037879  0.079545  0.088481  0.009549
2.177778  0.037879  0.082492  0.090105  0.009549
2.255556  0.037879  0.085438  0.091700  0.009549
2.333333  0.037879  0.088384  0.093267  0.009549
2.411111  0.037879  0.091330  0.094809  0.009549
2.488889  0.037879  0.094276  0.096326  0.009549
2.566667  0.037879  0.097222  0.097820  0.009549
2.644444  0.037879  0.100168  0.099291  0.009549
2.722222  0.037879  0.103114  0.100740  0.009549
2.800000  0.037879  0.106061  0.102169  0.009549
2.877778  0.037879  0.109007  0.103579  0.009549
2.955556  0.037879  0.111953  0.104969  0.009549
3.033333  0.037879  0.114899  0.106341  0.009549
3.111111  0.037879  0.117845  0.107696  0.009549
3.188889  0.037879  0.120791  0.109034  0.009549
```

```
3.266667  0.037879  0.123737  0.110355  0.009549
3.344444  0.037879  0.126684  0.111661  0.009549
3.422222  0.037879  0.129630  0.112952  0.009549
3.500000  0.037879  0.132576  0.114229  0.009549
3.577778  0.037879  0.135522  0.115491  0.009549
3.655556  0.037879  0.138468  0.116740  0.009549
3.733333  0.037879  0.141414  0.117975  0.009549
3.811111  0.037879  0.144360  0.119197  0.009549
3.888889  0.037879  0.147306  0.120408  0.009549
3.966667  0.037879  0.150253  0.121606  0.009549
4.044444  0.037879  0.153199  0.128513  0.009549
4.122222  0.037879  0.156145  0.133454  0.009549
4.200000  0.037879  0.159091  0.137267  0.009549
4.277778  0.037879  0.162037  0.140587  0.009549
4.355556  0.037879  0.164983  0.143609  0.009549
4.433333  0.037879  0.167929  0.146424  0.009549
4.511111  0.037879  0.170875  0.149084  0.009549
4.588889  0.037879  0.173822  0.151621  0.009549
4.666667  0.037879  0.176768  0.154057  0.009549
4.744444  0.037879  0.179714  0.156409  0.009549
4.822222  0.037879  0.182660  0.158687  0.009549
4.900000  0.037879  0.185606  0.160901  0.009549
4.977778  0.037879  0.188552  0.163059  0.009549
5.055556  0.037879  0.191498  0.303895  0.009549
5.133333  0.037879  0.194444  0.676889  0.009549
5.211111  0.037879  0.197391  1.146064  0.009549
5.288889  0.037879  0.200337  1.618721  0.009549
5.366667  0.037879  0.203283  2.007702  0.009549
5.444444  0.037879  0.206229  2.263316  0.009549
5.522222  0.037879  0.209175  2.453042  0.009549
5.600000  0.037879  0.212121  2.618508  0.009549
5.677778  0.037879  0.215067  2.773643  0.009549
5.755556  0.037879  0.218013  2.920181  0.009549
5.833333  0.037879  0.220960  3.059418  0.009549
5.911111  0.037879  0.223906  3.192352  0.009549
5.988889  0.037879  0.226852  3.319776  0.009549
6.066667  0.037879  0.229798  3.442325  0.009549
6.144444  0.037879  0.232744  3.560523  0.009549
6.222222  0.037879  0.235690  3.674805  0.009549
6.300000  0.037879  0.238636  3.785540  0.009549
6.377778  0.037879  0.241582  3.893039  0.009549
6.455556  0.037879  0.244529  3.997574  0.009549
6.533333  0.037879  0.247475  4.099377  0.009549
6.611111  0.037879  0.250421  4.198654  0.009549
6.688889  0.037879  0.253367  4.295584  0.009549
6.766667  0.037879  0.256313  4.390329  0.009549
6.844444  0.037879  0.259259  4.483029  0.009549
6.922222  0.037879  0.262205  4.573813  0.009549
7.000000  0.037879  0.265152  4.662796  0.009549
END FTABLE  4
FTABLE      3
 90    5
   Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
    (ft)   (acres) (acre-ft)    (cfs)     (cfs)   (ft/sec)    (Minutes)***
0.000000  0.002296  0.000000  0.000000  0.000000
0.111111  0.002296  0.000255  5.210267  0.000000
0.222222  0.002296  0.000510  7.368430  0.000000
0.333333  0.002296  0.000765  9.024447  0.000000
0.444444  0.002296  0.001020  10.42053  0.000000
0.555556  0.002296  0.001275  11.65051  0.000000
0.666667  0.002296  0.001530  12.76249  0.000000
0.777778  0.002296  0.001786  13.78507  0.000000
0.888889  0.002296  0.002041  14.73686  0.000000
1.000000  0.002296  0.002296  15.63080  0.000000
1.111111  0.002296  0.002551  16.47631  0.000000
1.222222  0.002296  0.002806  17.28050  0.000000
1.333333  0.002296  0.003061  18.04889  0.000000
1.444444  0.002296  0.003316  18.78588  0.000000
1.555556  0.002296  0.003571  19.49503  0.000000
1.666667  0.002296  0.003826  20.17928  0.000000
```

```
1.777778  0.002296  0.004081  20.84107  0.000000
1.888889  0.002296  0.004336  21.48248  0.000000
2.000000  0.002296  0.004591  22.10529  0.000000
2.111111  0.002296  0.004846  22.71103  0.784769
2.222222  0.002296  0.005102  23.30102  2.205262
2.333333  0.002296  0.005357  23.87644  3.979211
2.444444  0.002296  0.005612  24.43832  5.917238
2.555556  0.002296  0.005867  24.98756  7.826549
2.666667  0.002296  0.006122  25.52499  9.523132
2.777778  0.002296  0.006377  26.05133  10.86741
2.888889  0.002296  0.006632  26.56725  11.81283
3.000000  0.002296  0.006887  27.07334  12.59852
3.111111  0.002296  0.007142  27.57014  13.28001
3.222222  0.002296  0.007397  28.05814  13.92819
3.333333  0.002296  0.007652  28.53781  14.54752
3.444444  0.002296  0.007907  29.00954  15.14154
3.555556  0.002296  0.008162  29.47372  15.71312
3.666667  0.002296  0.008418  29.93070  16.26462
3.777778  0.002296  0.008673  30.38081  16.79803
3.888889  0.002296  0.008928  30.82435  17.31501
4.000000  0.002296  0.009183  31.26160  17.81700
4.111111  0.002296  0.009438  31.69281  18.30523
4.222222  0.002296  0.009693  32.11824  18.78076
4.333333  0.002296  0.009948  32.53810  19.24456
4.444444  0.002296  0.010203  32.95262  19.69743
4.555556  0.002296  0.010458  33.36198  20.14013
4.666667  0.002296  0.010713  33.76639  20.57330
4.777778  0.002296  0.010968  34.16600  20.99753
4.888889  0.002296  0.011223  34.56100  21.41337
5.000000  0.002296  0.011478  34.95153  21.82128
5.111111  0.002296  0.011733  35.33775  22.22170
5.222222  0.002296  0.011989  35.71979  22.61504
5.333333  0.002296  0.012244  36.09779  23.00165
5.444444  0.002296  0.012499  36.47187  23.38186
5.555556  0.002296  0.012754  36.84215  23.75600
5.666667  0.002296  0.013009  37.20875  24.12433
5.777778  0.002296  0.013264  37.57177  24.48712
5.888889  0.002296  0.013519  37.93131  24.84462
6.000000  0.002296  0.013774  38.28748  25.19704
6.111111  0.002296  0.014029  38.64037  25.54460
6.222222  0.002296  0.014284  38.99007  25.88750
6.333333  0.002296  0.014539  39.33665  26.22591
6.444444  0.002296  0.014794  39.68021  26.56001
6.555556  0.002296  0.015049  40.02082  26.88996
6.666667  0.002296  0.015305  40.35855  27.21591
6.777778  0.002296  0.015560  40.69348  27.53801
6.888889  0.002296  0.015815  41.02568  27.85638
7.000000  0.002296  0.016070  41.35521  28.17115
7.111111  0.002296  0.016325  41.68213  28.48244
7.222222  0.002296  0.016580  42.00651  28.79037
7.333333  0.002296  0.016835  42.32841  29.09504
7.444444  0.002296  0.017090  42.64787  29.39655
7.555556  0.002296  0.017345  42.96496  29.69500
7.666667  0.002296  0.017600  43.27973  29.99048
7.777778  0.002296  0.017855  43.59222  30.28307
7.888889  0.002296  0.018110  43.90249  30.57287
8.000000  0.002296  0.018365  44.21058  30.85995
8.111111  0.002296  0.018621  44.51654  31.14438
8.222222  0.002296  0.018876  44.82041  31.42623
8.333333  0.002296  0.019131  45.12223  31.70558
8.444444  0.002296  0.019386  45.42205  31.98249
8.555556  0.002296  0.019641  45.71990  32.25702
8.666667  0.002296  0.019896  46.01583  32.52924
8.777778  0.002296  0.020151  46.30986  32.79920
8.888889  0.002296  0.020406  46.60204  33.06695
9.000000  0.002296  0.020661  46.89240  33.33255
9.111111  0.002296  0.020916  47.18097  33.59605
9.222222  0.002296  0.021171  47.46779  33.85751
9.333333  0.002296  0.021426  47.75288  34.11695
9.444444  0.002296  0.021681  48.03629  34.37444
```

```
  9.555556  0.002296  0.021937  48.31803  34.63002
  9.666667  0.002296  0.022192  48.59813  34.88372
  9.777778  0.002296  0.022447  48.87663  35.13559
  9.888889  0.002296  0.022702  49.15356  35.38567
  END FTABLE  3
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.3            PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.3            IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.8            PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.8            IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC     ENGL    1.3            RCHRES   4     EXTNL  PREC
WDM      2 PREC     ENGL    1.3            RCHRES   5     EXTNL  PREC
WDM      1 EVAP     ENGL    0.8            RCHRES   4     EXTNL  POTEV
WDM      1 EVAP     ENGL    0.8            RCHRES   5     EXTNL  POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   5 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   5 HYDR   O      1 1        1      WDM   1006 FLOW     ENGL      REPL
RCHRES   5 HYDR   O      2 1        1      WDM   1007 FLOW     ENGL      REPL
RCHRES   5 HYDR   STAGE  1 1        1      WDM   1001 STAG     ENGL      REPL
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
COPY   601 OUTPUT MEAN   1 1     48.4      WDM    901 FLOW     ENGL      REPL
RCHRES   1 HYDR   RO     1 1        1      WDM   1010 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      1 1        1      WDM   1011 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      2 1        1      WDM   1012 FLOW     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1013 STAG     ENGL      REPL
RCHRES   2 HYDR   RO     1 1        1      WDM   1014 FLOW     ENGL      REPL
RCHRES   2 HYDR   O      1 1        1      WDM   1015 FLOW     ENGL      REPL
RCHRES   2 HYDR   O      2 1        1      WDM   1016 FLOW     ENGL      REPL
RCHRES   2 HYDR   STAGE  1 1        1      WDM   1017 STAG     ENGL      REPL
RCHRES   4 HYDR   RO     1 1        1      WDM   1018 FLOW     ENGL      REPL
RCHRES   4 HYDR   O      1 1        1      WDM   1019 FLOW     ENGL      REPL
RCHRES   4 HYDR   O      2 1        1      WDM   1020 FLOW     ENGL      REPL
RCHRES   4 HYDR   STAGE  1 1        1      WDM   1021 STAG     ENGL      REPL
RCHRES   3 HYDR   RO     1 1        1      WDM   1022 FLOW     ENGL      REPL
RCHRES   3 HYDR   O      1 1        1      WDM   1023 FLOW     ENGL      REPL
RCHRES   3 HYDR   O      2 1        1      WDM   1024 FLOW     ENGL      REPL
RCHRES   3 HYDR   STAGE  1 1        1      WDM   1025 STAG     ENGL      REPL
END EXT TARGETS

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

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

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

  MASS-LINK        7
RCHRES     OFLOW  OVOL   1                 RCHRES         INFLOW IVOL
  END MASS-LINK    7

  MASS-LINK        8
RCHRES     OFLOW  OVOL   2                 RCHRES         INFLOW IVOL
```

```
  END MASS-LINK    8

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

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

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

  MASS-LINK       17
RCHRES     OFLOW  OVOL   1                 COPY           INPUT  MEAN
  END MASS-LINK   17

  MASS-LINK       18
RCHRES     OFLOW  OVOL   2                 COPY           INPUT  MEAN
  END MASS-LINK   18


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

Legal Notice

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

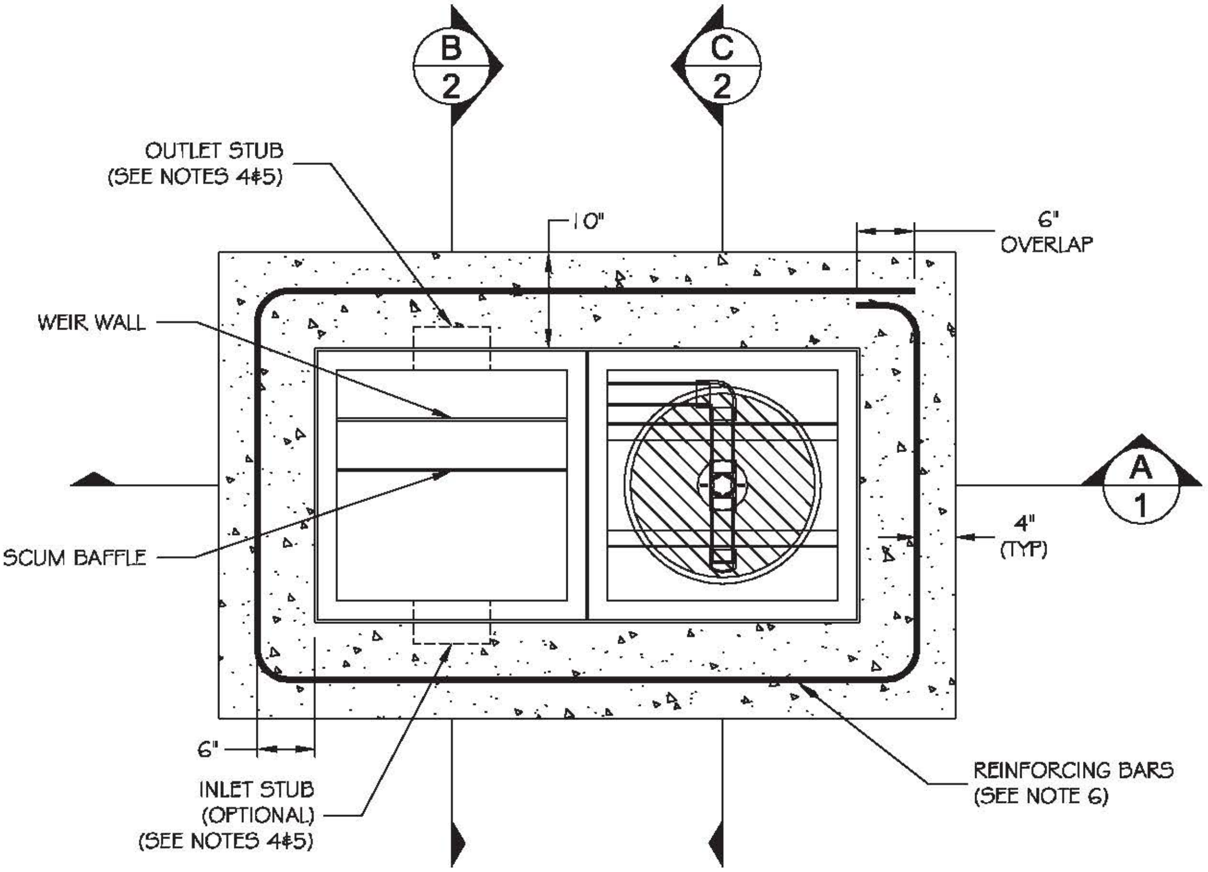
www.clearcreeksolutions.com

Appendix II: Perk Filter Information

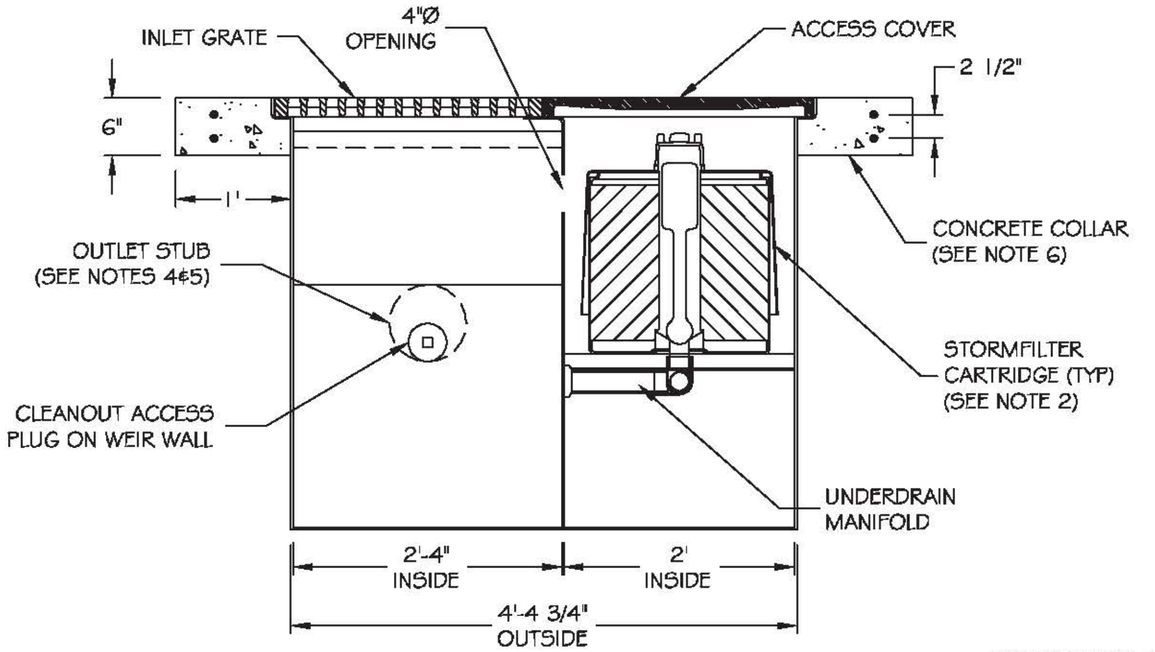
Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.



1-CARTRIDGE CATCHBASIN - PLAN VIEW 1/1



1-CARTRIDGE CATCHBASIN - SECTION VIEW A/1

THE STORMWATER MANAGEMENT
StormFilter®
U.S. PATENT No. 5,322,629,
No. 5,707,527, No. 6,027,639
No. 6,649,048, No. 5,624,576,
AND OTHER U.S. AND FOREIGN
PATENTS PENDING

CONTECH®
STORMWATER
SOLUTIONS INC.
contechstormwater.com

STEEL CATCHBASIN STORMFILTER
PLAN AND SECTION VIEWS
STANDARD DETAIL - 1 CARTRIDGE UNIT

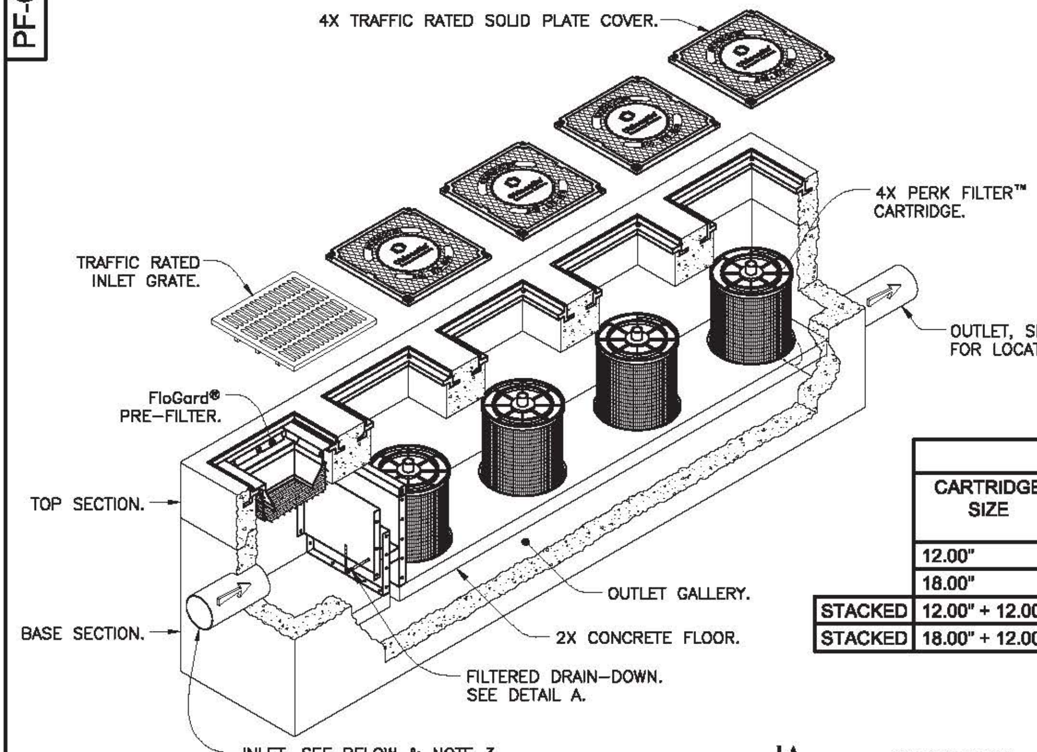
DRAWING
1
1/3

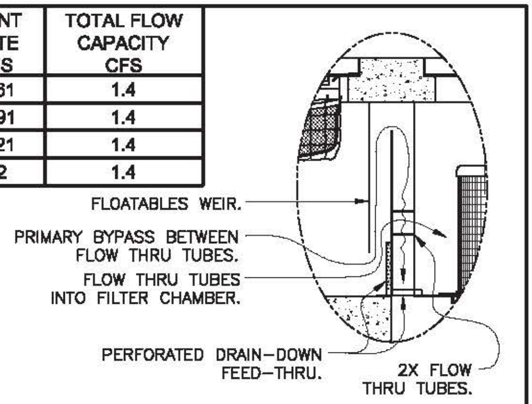
DATE: 11/01/05 | SCALE: NONE | FILE NAME: CBSF1-S-DTL | DRAWN: MJW | CHECKED: ARG

PF-CCB-WA-0006

Washington GULD*

	CARTRIDGE SIZE	TREATMENT FLOW RATE GPM / CFS	TOTAL FLOW CAPACITY CFS
	12.00"	27.2 / 0.061	1.4
	18.00"	40.8 / 0.091	1.4
STACKED	12.00" + 12.00"	54.4 / 0.121	1.4
STACKED	18.00" + 12.00"	68 / 0.152	1.4

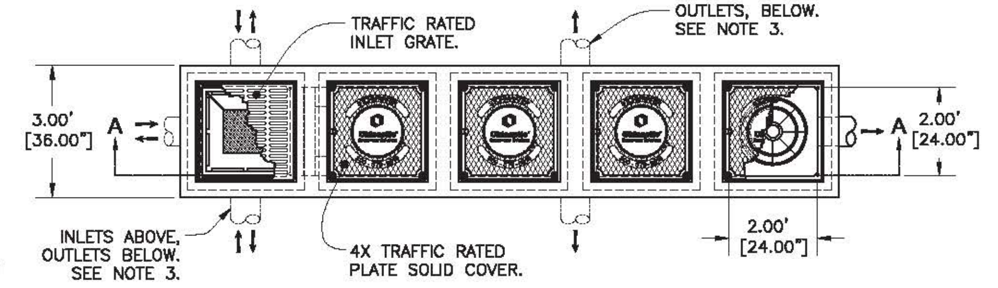




DETAIL A

INLET / BYPASS ASSEMBLY & DRAIN-DOWN SCALE: 2X

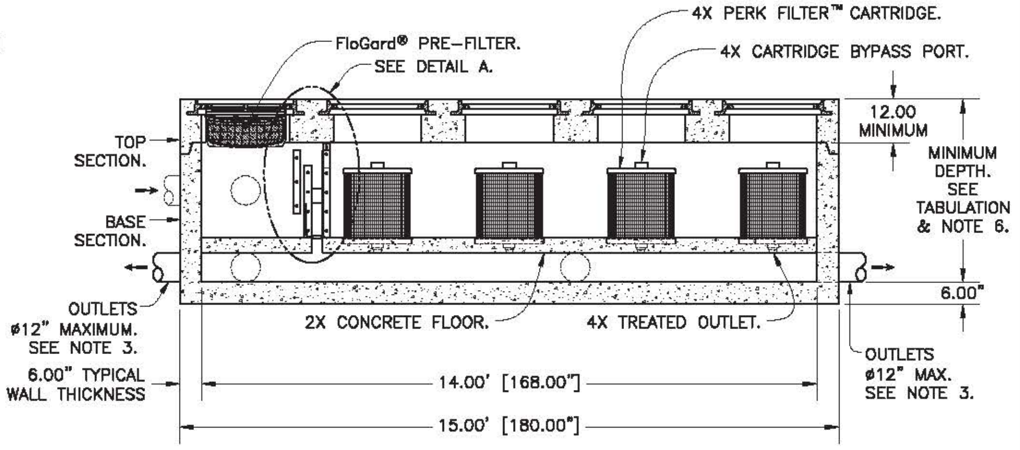
	MINIMUM DEPTHS (SEE NOTE 6)				
	CARTRIDGE SIZE	Ø 6.0" OUTLET PIPE (IN INCHES)	Ø 8.0" OUTLET PIPE (IN INCHES)	Ø 10.0" OUTLET PIPE (IN INCHES)	Ø 12.0" OUTLET PIPE (IN INCHES)
	12.00"	39	41	43	45
	18.00"	46	48	50	52
STACKED	12.00" + 12.00"	56	58	60	62
STACKED	18.00" + 12.00"	63	65	67	69



Notes:

1. Precast concrete structure shall be manufactured in accordance with ASTM Designation C857 and C858.
2. Perk Filter™ Catch basin shall be supplied with traffic rated (H20) bicycle-proof grates and solid plate cover.
3. Inlet pipe(s) may enter device on three sides of the inlet chamber. Outlet pipe(s) may exit on all four sides. All pipe is Ø 12" maximum.
4. Inlet chamber shall be supplied with a drain-down device designed to remove standing water between storm events.
5. Perk Filter™ catch basin shall be supplied with FloGard® pre-filter device. FloGard® pre-filter and Perk Filter™ cartridge shall be maintained in accordance with manufacturer recommendations.
6. For depths less than the specified minimum contact Oldcastle® Stormwater Solutions for engineering assistance.

*** Treatment Flow Rates shown conform to Washington State GULD Specifications.**



SECTION A-A

FOUR CARTRIDGE CONCRETE CATCH BASIN
(END GRATE CONFIGURATION)

Media Filtration

Perk Filter™

Concrete Catch Basin
Four Cartridge
Washington State GULD
(End Grate Configuration)

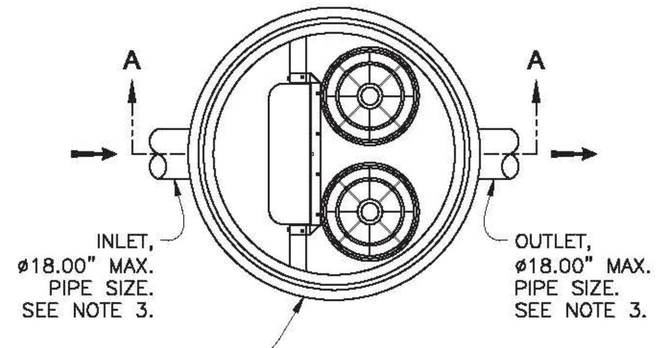
Oldcastle®
Stormwater Solutions

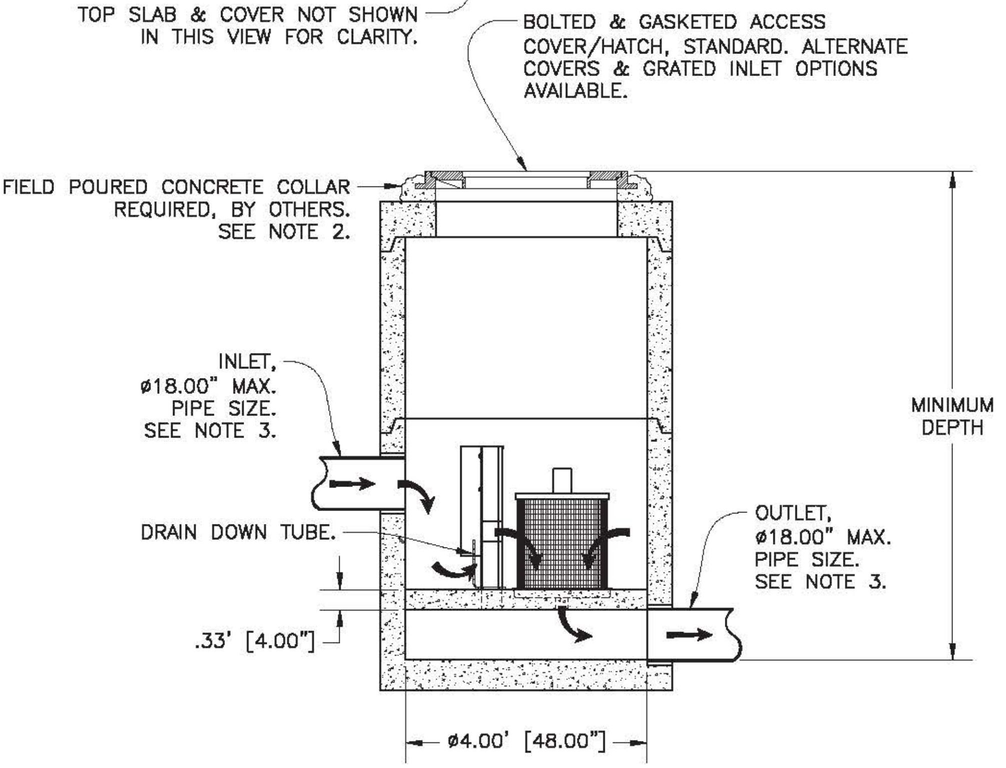
7921 Southpark Plaza, Suite 200 | Littleton, CO | 80120 | Ph: 800.579.8819 | oldcastlestormwater.com

DRAWING NO.	REV	ECO	DATE	
PF-CCB-WA-0006	E	ECO-0140 JPR 4/18/16	JPR 3/2/11	SHEET 1 OF 1

PF-MH-48-WA

Washington GULD*





SECTION A-A

Minimum Depth

PIPE SIZE	Ø6.00"	Ø8.00"	Ø10.00"	Ø12.00"	Ø15.00"	Ø18.00"
CARTRIDGE TYPE	MINIMUM DEPTH RIM TO OUTLET	MINIMUM DEPTH RIM TO OUTLET	MINIMUM DEPTH RIM TO OUTLET	MINIMUM DEPTH RIM TO OUTLET	MINIMUM DEPTH RIM TO OUTLET	MINIMUM DEPTH RIM TO OUTLET
12"	3.67' [44.00"]	3.92' [47.00"]	4.17' [50.00"]	4.42' [53.00"]	4.67' [56.00"]	4.92' [59.00"]
18"	4.42' [53.00"]	4.67' [56.00"]	4.92' [59.00"]	5.17' [62.00"]	5.42' [65.00"]	5.67' [68.00"]
12" + 12"	5.17' [62.00"]	5.42' [65.00"]	5.67' [68.00"]	5.92' [71.00"]	6.17' [74.00"]	6.42' [77.00"]
12" + 18"	5.67' [68.00"]	5.92' [71.00"]	6.17' [74.00"]	6.42' [77.00"]	6.67' [80.00"]	6.92' [83.00"]

Ø48.00" PERK FILTER MANHOLE
TREATMENT FLOW RATES, TOTAL FLOW CAPACITIES & MAXIMUM HEAD LOSS

CARTRIDGE STACK QUANTITY	CARTRIDGE STACK CONFIGURATION							
	12"		18"		12" & 12"		12" & 18"	
	TREATMENT FLOW RATE (GPM / CFS)	TOTAL FLOW CAPACITY (CFS)	TREATMENT FLOW RATE (GPM / CFS)	TOTAL FLOW CAPACITY (CFS)	TREATMENT FLOW RATE (GPM / CFS)	TOTAL FLOW CAPACITY (CFS)	TREATMENT FLOW RATE (GPM / CFS)	TOTAL FLOW CAPACITY (CFS)
1	6.8 / 0.015	2.47	10.2/ 0.022	3.05	13.6 / 0.03	3.45	17 / 0.037	3.62
2	13.6 / 0.03	2.47	20.4 / 0.045	3.05	27.2 / 0.06	3.45	34 / 0.075	3.62
MAXIMUM HEAD LOSS	1.7 FEET		2.3 FEET		2.9 FEET		3.5 FEET	

Media
Filtration

Perk Filter™

Ø48.00" Manhole

Washington State GULD

One to Two Cartridges / Stacks

Oldcastle®
Stormwater Solutions

7921 Southpark Plaza, Suite 200 | Littleton, CO | 80120 | Ph: 800.579.8819 | oldcastlestormwater.com

DRAWING NO.	REV	ECO	DATE	
PF-MH-48-WA	NR	ECO-0132 ISM 4/27/15	ISM 4/27/15	SHEET 2 OF 2

Appendix III: Geotechnical Report

Geotechnical Report

Valley View Sub-division

Camas, Washington

Prepared for:
Stan Firestone
Vancouver, Washington
30 April 2014
Updated 1 May 2018

MIA MAHEDY-SEXTON
42135

Rapid
Soil Solutions LLC
3915 SW Plum St
Portland, OR
503-816-3689

TABLE OF CONTENTS

1.0 GENERAL INFORMATION 3
2.0 SITE CONDITIONS 3
  2.1 Surface Conditions 3
  2.2 Regional Geology 3
  2.3 Field Explorations and Surfaces Conditions 4
    2.3.1 Field Explorations 4
    2.3.2 Surface Conditions 4
    2.3.3 Groundwater 4
3.0 GEOTECHNICAL DESIGN RECOMMENDATIONS 4
  3.1 Foundation 4
  3.2 Retaining Walls 5
  3.3 Seimic Design 6
  3.4 Hazards 6
4.0 CONSTRUCTION RECOMMENDATIONS 7
  4.1 Site Preparation 7
    4.1.1 Proof Rolling 7
    4.1.2 Wet Soil Conditions 8
  4.2 Excavation 8
  4.3 Structural Fills 8
    4.3.1 Native Soils 8
    4.3.2 Imported Granular Fill 8
    4.3.3 Floor Slab and Base Rock Aggregate 9
  4.4 Drainage 9
5.0 CONSTRUCTION OBSERVATIONS **.......... 9**
6.0 LIMITATIONS **.......... 9**

SUPPORTING DATA
  Appendix A - Figures
    Figure 1 Location Plan
    Figure 2 Site Plan
  Appendix B – Laboratory data and Soil Logs

1.0 PROJECT AND SITE DESCRIPTIONS

Introduction

Rapid Soil Solutions has prepared this Geotechnical Report to provide bearing capacity, roadway design values, soil parameters for earth work operations and installation of utilities for the 30 lot sub-division.

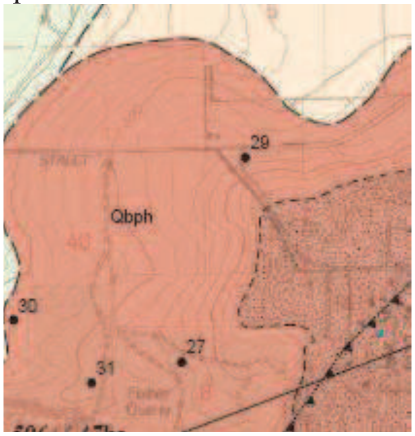
2.0 SITE CONDITIONS

2.1 Surface Conditions

The property is located in the Clark County Washington, accessed off of SE 40th Street. The site was cleared in past. The site was covered with tall grasses and weeds. See below site photo.

2.2 Regional Geology

The Camas Quadrangle developed in 2008 by Evarts and O'Connor maps the site as boring volcanic rock. However, the rock is far below the site and the site is cover with fine grained flood deposits.



2.3 Field Exploration and Subsurface Conditions

2.3.1 Field Explorations

Four (4) hand augur holes were excavated. The location of the augur holes are shown on Figure 2 in Appendix A. A registered professional engineer performed the excavation and logged the subsurface materials. Hand augur logs detailing materials encountered is in Appendix B. The logs were created using the Unified Soil Classification and Visual Manual Procedure (ASTM-D 2488).

2.3.1 Subsurface Conditions

The soil conditions were fine grained stiff damp sandy SILT. The soil conditions in all augur holes were consistent with each other and local geology map. Moistures ranged from 23.1 % to 28%.

2.3.2 Groundwater

No ground water was found during the explorations.

3.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

3.1 Foundation Design

The building foundations may be installed on either engineered fill or firm native sub-grade that is found at a depth of about 0.5 feet. This depth may be locally variable and should be confirmed by a geotechnical engineer or their representative at the time of construction.

Continuous wall and isolated spread footings should be at least 16 and 24 inches wide, respectively. The bottom of exterior footings should be at least 16 inches below the lowest adjacent exterior grade. The bottom of interior footings should be at least 12 inches below the base of the floor slab.

Footings placed on engineered fill or firm native sub-grade should be designed for an allowable bearing capacity of 2,000 *pounds per square foot* (**psf**) by IBC 2012/2015 code. The recommended allowable bearing pressure can be doubled for short-term loads such as those resulting from wind or seismic forces.

Based on our analysis the total post-construction settlement is calculated to be less than 1 inch, with differential settlement of less than 0.5 inch over a 50-foot span for maximum column, perimeter footing loads of less than 100 kips and 6.0 kips per linear foot.

Lateral loads on footings can be resisted by passive earth pressure on the sides of the structures and by friction at the base of the footings. An allowable lateral bearing pressure of 150 *pounds per cubic foot* (**psf/f**) below grade may be used. Adjacent floor slabs, pavements or the upper 12-inch depth of adjacent, unpaved areas should not be considered when calculating passive resistance. An angle of internal friction of 30 degrees can be used.

If construction is undertaken during periods of rain, then I recommend a 2-inch (or greater) layer of compacted, crushed rock be placed over the native soil. The silty soil is moisture sensitive. Meaning when dry it is firm and non-yielding but exposed to season rains it will lose its strength and need to be excavated and replaced with rock. See section 4.1.2 for wet weather conditions.

3.2 Retaining Walls

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

Unrestrained site walls that retain native soils should be designed to resist an active equivalent fluid unit weight of 35 pcf where supporting slopes are flatter than 4H: 1V. If retaining walls are restrained from rotation prior to being backfilled, the active equivalent fluid unit weight shall be increased to 50 pcf. For embedded building walls, a superimposed seismic lateral force should be calculated based on a dynamic force of $5H^2$ pounds per lineal foot of wall, where H is the height of the wall in feet, and applied at 0.6H from the base of the wall. If other surcharges (e.g., slopes steeper than 4H:1V, foundations, vehicles, etc.) are located within a horizontal distance from the back of a wall equal to twice the height of the wall, then additional pressures will need to be accounted for in the wall design. Our office should be contacted for appropriate wall surcharges based upon the actual magnitude and configuration of the applied loads.

The wall footings should be designed in accordance with the guidelines provided in the “Foundation Design” section of this report.

These design parameters have been provided assuming that back-of-wall drains will be installed to prevent buildup of hydrostatic pressures behind all walls.

The backfill material placed behind the walls and extending a horizontal distance equal to at least half of the height of the retaining wall should consist of granular retaining wall backfill as specified in the “Structural Fill” section of this report.

The wall backfill should be compacted to a minimum of 92 percent of the maximum dry density, as determined by ASTM D1557. However, backfill located within a horizontal distance of 3 feet from the retaining walls should only be compacted to approximately 90 percent of the maximum dry density, as determined by ASTM D1557. Backfill placed within 3 feet of the wall should be compacted in lifts less than 6 inches thick using hand-operated tamping equipment (e.g., jumping jack or vibratory plate compactors). If flat work (e.g., sidewalks or pavements) will be placed atop the wall backfill, we recommend that the upper

2 feet of material be compacted to 92 percent of the maximum dry density, as determined by ASTM D1557.

A minimum 12-inch-wide zone of drain rock, extending from the base of the wall to within 6 inches of finished grade, should be placed against the back of all retaining walls. Perforated collector pipes should be embedded at the base of the drain rock. The drain rock should meet the requirements provided in the “Structural Fill” section of this report. The perforated collector pipes should discharge at an appropriate location away from the base of the wall. The discharge pipe(s) should not be tied directly into storm water drain systems, unless measures are taken to prevent backflow into the wall’s drainage system.

Settlements of up to 1 percent of the wall height commonly occur immediately adjacent to the wall as the wall rotates and develops active lateral earth pressures. Consequently, we recommend that construction of flat work adjacent to retaining walls be postponed at least 4 weeks after backfilling of the wall, unless survey data indicates that settlement is complete prior to that time.

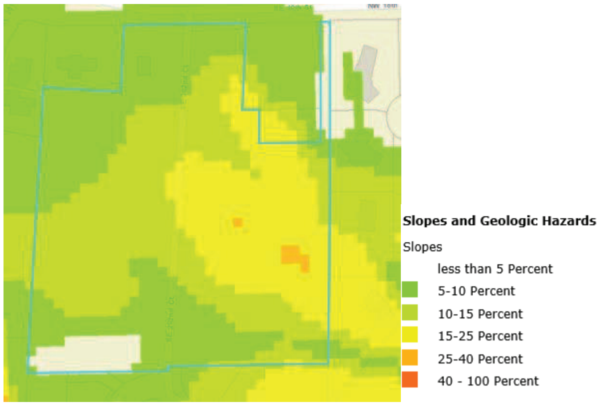
3.3 Seismic Design Criteria

The seismic design criteria for this project USGS Earthquake Hazards Program. A summary of IBC 2012/2015 seismic design criterion below: using a Lat of 45.5909 and Long of -122.4650, site class D.

	Short Period	**1 Second**
Maximum Credible Earthquake Spectral Acceleration	Ss = 0.94	S1 = 0.38
Adjusted Spectral Acceleration	Sms = 1.05	Sm1 = 0.38
Design Spectral Response Acceleration Perimeters	Sds = 0.70	Sd1= 0.42

3.4 Hazards

Slopes: The field reconnaissance on 27 March 2014 showed the steepest slopes are located in the southern end of the property. Here the slopes vary from less than 5% to 25% in the SE corner of the lot. See below figure from Clark County GIS mapping of the site.



Liquefaction: From the Liquefaction Susceptibility Map of Clark County, Washington

2004. The site has very little susceptibility.

Landslide Hazards

RSS site reconnaissance on 27 March 2014 found no signs of land slide hazards. Site is covered with black berries, grasses. See site photo's of the slopes. Figure 3 shows the mapped landslides in Clark County as well as slope stability map of the Vancouver area. As well as IMS -43, this uses LIDAR to map landslides. LIDAR is a bare earth photo that shows landside and slow moving slopes as the lines on the map become fuzzy when the ground is moving. *There are no mapped slides on the project site. Figure 3 also lists the site has having little to no issues with liquefaction.*

From field reconnaissance RSS reviewed all the steep slopes surrounding the project site. There are no signs of slope instability, any sages, slumps or fan of debris from slides on the slopes in the SW corner of the property. There also no surface water features on the property. No seeps springs or other surface expressions of ground water were found when RSS was on site on 3/27/14.

4.0 CONSTRUCTION RECOMMENDATIONS

4.1 Site Preparation

Demolition should include removal of existing improvements throughout the project site. Underground utility lines, vaults, basement walls or tanks should be removed or grouted full if left in place. I recommend that soil disturbed during grubbing operations be removed to firm, undisturbed sub-grade. The excavations should then be backfilled with compacted structural fill. On this site only disturb the area in which can be covered with rock during the day. The moisture sensitive SILT soil when exposed to wet weather becomes soft and yielding. See wet weather conditions below.

4.1.1 Proof Rolling

Following stripping and prior to placing aggregate base course, pavement the exposed sub-grade should be evaluated by proof rolling. The sub-grade should be proof rolled to identify soft, loose, or unsuitable areas. Please give 24 hour notice to observe the proof rolling. Soft or loose zones identified during the field evaluation should be compacted to an unyielding condition or be excavated and replaced with structural fill, as discussed in the *Structural Fill* section of this report.

4.1.2 Wet Weather Conditions

The near-surface soils will be difficult during or after extended wet periods or when the moisture content of the surface soil is more than a few percentage points above optimum. Soils that have been disturbed during site preparation activities, or soft or loose zones identified during probing or proof rolling, should be removed and replaced with compacted structural fill. Track-mounted excavating equipment will be required during wet weather. The imported granular material should be placed in one lift over the prepared, undisturbed sub-grade and compacted using a smooth drum, non-vibratory roller. Additionally, a geo-textile fabric should be placed as a barrier between the sub-grade and imported granular material in areas of repeated traffic.

4.2 Excavation

Subsurface conditions of accessible cleared areas of the project site show predominately sands, silty soil to the depth explored (4.0 feet). Excavations in the upper soils may be readily accomplished with conventional earthwork equipment with smooth and teeth faced bucket.

4.3 Structural Fills

Fills should be placed over sub-grade prepared in compliance with Section 4.1 of this report. Material used, as structural fill should be free of organic matter or other unsuitable materials and should meet specifications provided in WSDOT, depending upon the application. A discussion of these materials is in the following sections.

4.3.1 Native Soils

Native soil can be used for filling operations to raise the site grades for flat backyards. Compaction testing of native soils shall use a standard ASTM D698 proctor and achieve 95%. See lab results in appendix b. Compaction testing is required as per WSDOT every 18in of fill material. Native soils can only be used if they are within optimum moisture content.

4.3.2 Imported Granular Fill

Material meeting WSDOT 9.03.12(1) B or WSDOT 9.03.11 Imported granular material should be placed in lifts 8 to12 inches and be compacted to at least 95% of the maximum dry density, as determined by ASTM D 698. Where imported granular material is placed over wet or soft soil sub-grades, we recommend that a geo-textile serve as a barrier between the sub-grade and imported granular material. Compaction testing is required as per WSDOT every 18in of fill material.

4.3.3 Floor Slab Base and Footing Base Aggregate

Base aggregate for floor slabs should be clean, crushed rock or crushed gravel meeting WSDOT 9.03.12(1) B Class B Gravel Backfill for Foundations, if acceptable WSDOT 9.03.11 Recycled Portland Cement Concrete Rubble can be used. The imported granular material should be placed in lifts and compacted to at least 95% of the maximum dry density, as determined by ASTM D 698. Compaction testing is required as per WSDOT every 18in of fill material.

4.4 Surface and Subsurface Drainage Requirements

The Contractor shall be made responsible for temporary drainage of surface water and groundwater as necessary to prevent standing water and/or erosion at the working surface. We recommend removing only the foliage necessary for construction to help minimize erosion. Slope the ground surface around the structures to create a minimum gradient of 2% away from the building foundations for a distance of at least 5 feet. Surface water should be directed away from all buildings into drainage swales or into a storm drainage system.

5.0 CONSTRUCTION OBSERVATIONS

Satisfactory pavement and earthwork performance depends on the quality of construction. Sufficient monitoring of the activities of the contractor is a key part of determining that the work is completed in accordance with the construction drawings and specifications. I recommend that a geotechnical engineer observe general excavation, stripping, fill placement, and sub-grades in addition to base. Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions requires experience. Therefore, qualified personnel should visit the site with sufficient frequency to detect whether subsurface conditions changes significantly from those anticipated.

6.0 LIMITATIONS

This report has been prepared for the exclusive use of the addressee, and their architects and engineers for aiding in the design and construction of the proposed development. It is the addressee's responsibility to provide this report to the appropriate design professionals, building officials, and contractors to ensure correct implementation of the recommendations. The opinions, comments and conclusions presented in this report were based upon information derived from our literature review, field investigation, and laboratory testing. Conditions between, or beyond, our exploratory borings may vary from those encountered. Unanticipated soil conditions and seasonal soil moisture variations are commonly encountered and cannot be fully determined by merely taking soil samples or soil borings. Such variations may result in changes to our recommendations and may require that additional expenditures be made to attain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

If there is more than 2years time between the submission of this report and the start of work at the site; if conditions have changed due to natural causes or construction operations at, or adjacent to, the site; or, if the basic project scheme is significantly modified from that assumed, it is recommended this report be reviewed to determine the applicability of the conclusions and recommendations.

The work has been conducted in general conformance with the standard of care in the field of geotechnical engineering currently in practice in the Pacific Northwest for projects of this nature and magnitude. No warranty, express or implied, exists on the information presented in this report. By utilizing the design recommendations within this report, the addressee acknowledges and accepts the risks and limitations of development at the site, as outlined within the report.

APPENDIX A

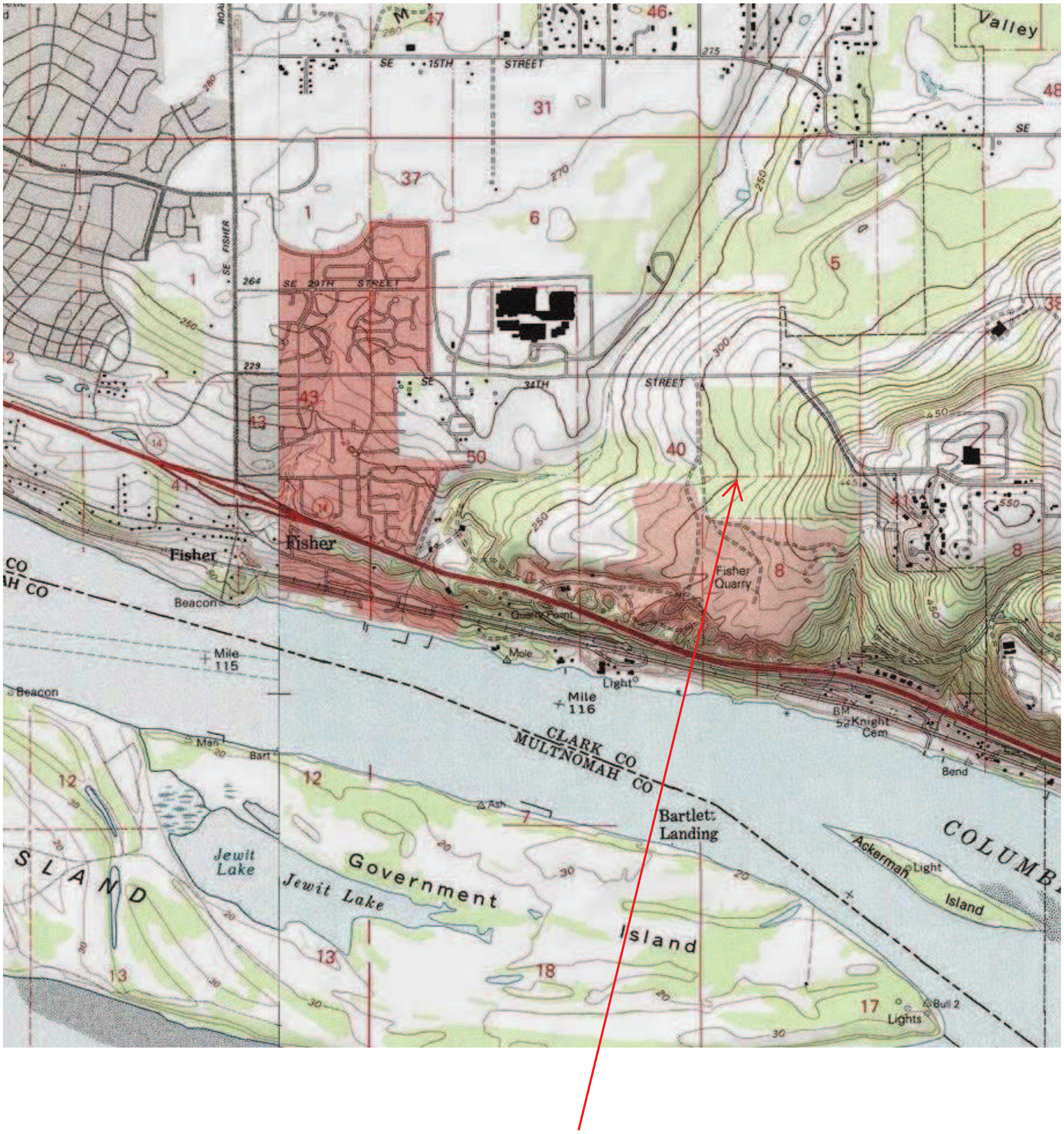


Figure 1 – Site locations

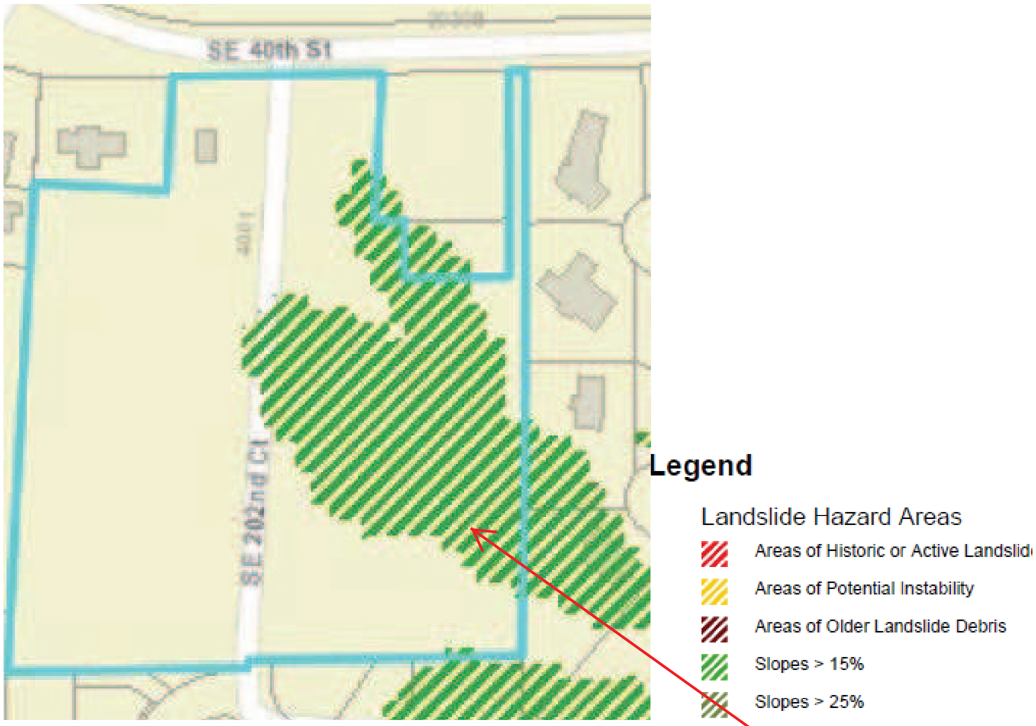
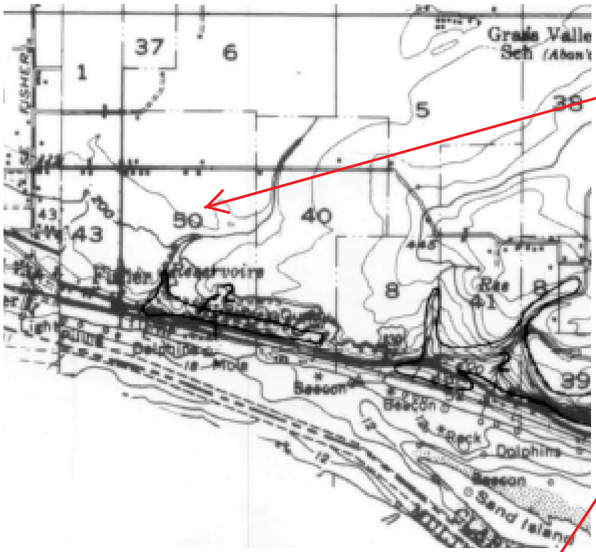
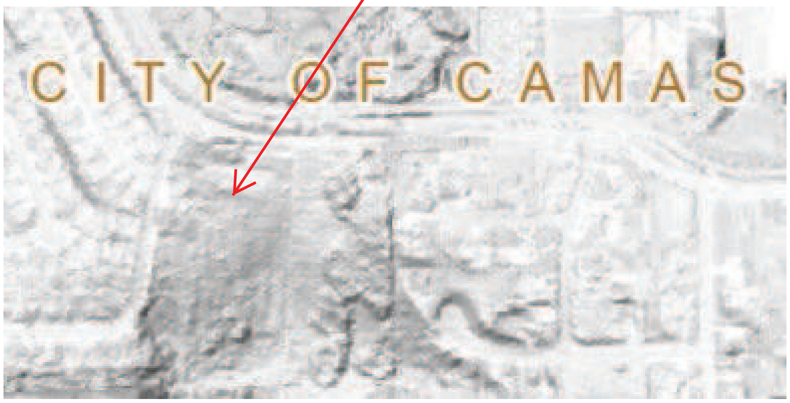


Figure 3 – Landslide hazards

Project site is clear of landslide hazards



SLOPE STABILITY
CLARK COUNTY WASHINGTON
ALLEN FIKSDAL
1975



IMS-43

APPENDIX B

503.443.3799

7409 SW Tech Center Dr, #145
Tigard, OR 97223
phn: 503-443-3799
fax: 503-620-2748

RAPID SOIL SOLUTIONS
3915 SW PLUM STREET
PORTLAND, OR 97219-6018

PROJECT: RSS 2014 LAB SERVICES
LOCATION: VALLEY VIEW ESTATES
SAMPLE SOURCE: SEE BELOW

JOB NO: 14-4790
WORK ORDER NO: N/A
DATE SAMPLED: 4/18/14

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (ASTM D-2487)

				Silt or Clay	SAND								GRAVEL									COBBLES	
					Fine			Medium			Coarse		Fine				Coarse						
Location & Depth	**USCS**	**LL**	**PI**	**#200**	**#100**	**#50**	**#40**	**#30**	**#16**	**#10**	**#8**	**#4**	**1/4"**	**3/8"**	**1/2"**	**3/4"**	**1"**	**1 1/4"**	**1 1/2"**	**2"**	**3"**	**6"**	**Lab #**

PERCENT PASSING BY WEIGHT

HA1@2'		27	3																				7267
HA2@ 4'		28	9																				7267

BORING	DEPTH	MC%
HA1@2'		25.9
HA2 @ 4'		28.0
HA3@ 4'		23.1
HA4@ 4'		24.9

REVIEWED BY

DE/js

#1

Surface Elevation: 414
Boring Date: 4/23/14
Boring Location: Camas, WA
Drilling Method: Hand Augur

Depth	Remarks	Moisture (%)	Dry Density	Blow Counts	Sample Type	Water Table		
0								Top Soil
							ML	Damp, medium light brown, fine grained medium plastic SILT
1								
2	PI=3, LL=27	25.9					ML	End hand augur hole
3								
4								
5								
6								
7								

SuperLog CivilTech Software, USA www.civiltech.com File: D:\Users\Mia\Desktop\MIA WORK\2014\Reports\Report to end April\Happy Valley Dental Clinic\HA 1.log Date: 4/30/2014

LOG OF BORING

Rapid Soil Solutions

Valley View Sub-division
Stan Firestone

Plate 1

#2

Surface Elevation: 464
Boring Date: 4/23/14
Boring Location: Camas, WA
Drilling Method: Hand Augur

Depth	Remarks	Moisture (%)	Dry Density	Blow Counts	Sample Type	Water Table		
0								Top Soil
							ML	Damp, dark brown, fine grained medium plastic SILT
1								
							ML	Damp, dark to medium brown clayey SILT trace gray
2								
3								
4		28					ML	End hand augur hole
5								
6								
7								

LOG OF BORING

Rapid Soil Solutions

Valley View Sub-division
Stan Firestone

Plate 1

#3

Surface Elevation: 418
Boring Date: 4/23/14
Boring Location: Camas, WA
Drilling Method: Hand Augur

Depth	Remarks	Moisture (%)	Dry Density	Blow Counts	Sample Type	Water Table			
0									Top Soil
								ML	Damp, dark brown, fine grained medium plastic clayey SILT
1									
2									
3									
4	PI=9, LL=28	23.1						ML	End hand augur hole
5									
6									
7									

LOG OF BORING

Rapid Soil Solutions	**Valley View Sub-division** **Stan Firestone**	**Plate 1**

#4

Surface Elevation: 448
Boring Date: 4/23/14
Boring Location: Camas, WA
Drilling Method: Hand Augur

Depth	Remarks	Moisture (%)	Dry Density	Blow Counts	Sample Type	Water Table		
0								Top Soil
							ML	Damp, dark brown, fine grained medium plastic clayey SILT
1								
2								
3								
4		23.1					ML	End hand augur hole
5								
6								
7								

SuperLog CivilTech Software, USA www.civiltech.com File: D:\Users\Mia\Desktop\MIA WORK\2014\Reports\Report to end April\Valley View\HA 3.log Date: 4/30/2014

LOG OF BORING

Rapid Soil Solutions

Valley View Sub-division
Stan Firestone

Plate 1

Appendix IV: Maintenance Manual (Clark County Version)

4.6 Maintenance Standards for Drainage Facilities

The facility-specific maintenance standards contained in this section are intended to be conditions for determining if maintenance actions are required as identified through inspection. They are not intended to be measures of the facility's required condition at all times between inspections. In other words, exceedence of these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, based upon inspection observations, the inspection and maintenance schedules shall be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

Table 4.5.2 Maintenance Standards

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	~~No contaminants or pollutants present.~~
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
	Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard Trees
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a licensed civil engineer should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
	Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Emergency Overflow/ Spillway and Berms over 4 feet in height.	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping. Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm/spillway restoration.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway	Emergency Overflow/ Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	See “Side Slopes of Pond”	

No. 2 – Infiltration

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Poisonous/Noxious Vegetation	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Contaminants and Pollution	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Rodent Holes	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1)
Storage Area	Sediment	Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. Treatment basins should infiltrate Water Quality Design Storm Volume within 48 hours, and empty within 24 hours after cessation of most rain events. (A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. Test every 2 to 5 years. If two inches or more sediment is present, remove).	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
Filter Bags (if applicable)	Filled with Sediment and Debris	Sediment and debris fill bag more than 1/2 full.	Filter bag is replaced or system is redesigned.
Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Gravel in rock filter is replaced.
Side Slopes of Pond	Erosion	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Emergency Overflow Spillway and Berms over 4 feet in height.	Tree Growth	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Piping	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Emergency Overflow Spillway	Rock Missing	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Erosion	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Pre-settling Ponds and Vaults	Facility or sump filled with Sediment and/or debris	6" or designed sediment trap depth of sediment.	Sediment is removed.

No. 3 – Closed Detention Systems (Tanks/Vaults)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage Area	Plugged Air Vents	One-half of the cross section of a vent is blocked at any point or the vent is damaged.	Vents open and functioning.
	Debris and Sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for 1/2 length of storage vault or any point depth exceeds 15% of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than 1/2 length of tank.)	All sediment and debris removed from storage area.
	Joints Between Tank/Pipe Section	Any openings or voids allowing material to be transported into facility. (Will require engineering analysis to determine structural stability).	All joint between tank/pipe sections are sealed.
	Tank Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape. (Review required by engineer to determine structural stability).	Tank/pipe repaired or replaced to design.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.	No cracks more than 1/4-inch wide at the joint of the inlet/outlet pipe.
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Catch Basins	See “Catch Basins” (No. 5)	See “Catch Basins” (No. 5).	See “Catch Basins” (No. 5).

No. 4 – Control Structure/Flow Restrictor

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

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

No. 6 – Debris Barriers (e.g., Trash Racks)

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

No. 7 – Energy Dissipaters

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

No. 8 – Typical Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits on grass treatment area of the bio-swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
	Standing Water	When water stands in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
	Constant Baseflow	When small quantities of water continually flow through the swale, even when it has been dry for weeks, and an eroded, muddy channel has formed in the swale bottom.	Add a low-flow pea-gravel drain the length of the swale or by-pass the baseflow around the swale.
	Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10% of the swale bottom.	Determine why grass growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals. Or re-seed into loosened, fertile soil.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
	Excessive Shading	Grass growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
	Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
	Trash and Debris Accumulation	Trash and debris accumulated in the bio-swale.	Remove trash and debris from bioswale.
	Erosion/Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.

No. 9 – Wet Biofiltration Swale

Maintenance Component	**Defect or Problem**	**Condition When Maintenance is Needed**	**Recommended Maintenance to Correct Problem**
General	Sediment Accumulation	Sediment depth exceeds 2-inches in 10% of the swale treatment area.	Remove sediment deposits in treatment area.
	Water Depth	Water not retained to a depth of about 4 inches during the wet season.	Build up or repair outlet berm so that water is retained in the wet swale.
	Wetland Vegetation	Vegetation becomes sparse and does not provide adequate filtration, OR vegetation is crowded out by very dense clumps of cattail, which do not allow water to flow through the clumps.	Determine cause of lack of vigor of vegetation and correct. Replant as needed. For excessive cattail growth, cut cattail shoots back and compost off-site. Note: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.
	Inlet/Outlet	Inlet/outlet area clogged with sediment and/or debris.	Remove clogging or blockage in the inlet and outlet areas.
	Trash and Debris Accumulation	See "Detention Ponds" (No. 1).	Remove trash and debris from wet swale.
	Erosion/Scouring	Swale has eroded or scoured due to flow channelization, or higher flows.	Check design flows to assure swale is large enough to handle flows. By-pass excess flows or enlarge swale. Replant eroded areas with fibrous-rooted plants such as Juncus effusus (soft rush) in wet areas or snowberry (Symphoricarpos albus) in dryer areas.

No. 10 – Filter Strips

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits, re-level so slope is even and flows pass evenly through strip.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and Debris from filter.
	Erosion/Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width.

No. 11 – Wetponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Water level	First cell is empty, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.
	Trash and Debris	Accumulation that exceeds 1 CF per 1000-SF of pond area.	Trash and debris removed from pond.
	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material.	No clogging or blockage in the inlet and outlet piping.
	Sediment Accumulation in Pond Bottom	Sediment accumulations in pond bottom that exceeds the depth of sediment zone plus 6-inches, usually in the first cell.	Sediment removed from pond bottom.
	Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant wetland plants such as Juncus effusus (soft rush) which can uptake small concentrations of oil.
	Erosion	Erosion of the pond's side slopes and/or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent.	Slopes stabilized using proper erosion control measures and repair methods.
	Settlement of Pond Dike/Berm	Any part of these components that has settled 4-inches or lower than the design elevation, or inspector determines dike/berm is unsound.	Dike/berm is repaired to specifications.
	Internal Berm	Berm dividing cells should be level.	Berm surface is leveled so that water flows evenly over entire length of berm.
	Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks replaced to specifications.

No. 12 – Wetvaults

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash/Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet/outlet (includes floatables and non-floatables).	Remove trash and debris from vault.
	Sediment Accumulation in Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6-inches.	Remove sediment from vault.
	Damaged Pipes	Inlet/outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened or removed, especially by one person.	Pipe repaired or replaced to proper working specifications.
	Ventilation	Ventilation area blocked or plugged.	Blocking material removed or cleared from ventilation area. A specified % of the vault surface area must provide ventilation to the vault interior (see design specifications).
	Vault Structure Damage - Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	Maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection staff.	Baffles repaired or replaced to specifications.
	Access Ladder Damage	Ladder is corroded or deteriorated, not functioning properly, not attached to structure wall, missing rungs, has cracks and/or misaligned. Confined space warning sign missing.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel. Replace sign warning of confined space entry requirements. Ladder and entry notification complies with OSHA standards.

No. 13 – Sand Filters (above ground/open)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Above Ground (open sand filter)	Sediment Accumulation on top layer	Sediment depth exceeds 1/2-inch.	No sediment deposit on grass layer of sand filter that would impede permeability of the filter section.
	Trash and Debris Accumulations	Trash and debris accumulated on sand filter bed.	Trash and debris removed from sand filter bed.
	Sediment/ Debris in Clean-Outs	When the clean-outs become full or partially plugged with sediment and/or debris.	Sediment removed from clean-outs.
	Sand Filter Media	Drawdown of water through the sand filter media takes longer than 24-hours, and/or flow through the overflow pipes occurs frequently.	Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material).
	Prolonged Flows	Sand is saturated for prolonged periods of time (several weeks) and does not dry out between storms due to continuous base flow or prolonged flows from detention facilities.	Low, continuous flows are limited to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.
	Short Circuiting	When flows become concentrated over one section of the sand filter rather than dispersed.	Flow and percolation of water through sand filter is uniform and dispersed across the entire filter area.
	Erosion Damage to Slopes	Erosion over 2-inches deep where cause of damage is prevalent or potential for continued erosion is evident.	Slopes stabilized using proper erosion control measures.
	Rock Pad Missing or Out of Place	Soil beneath the rock is visible.	Rock pad replaced or rebuilt to design specifications.
	Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed across sand filter.	Spreader leveled and cleaned so that flows are spread evenly over sand filter.
	Damaged Pipes	Any part of the piping that is crushed or deformed more than 20% or any other failure to the piping.	Pipe repaired or replaced.

No. 14 –Sand Filters (below ground/enclosed)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground Vault.	Sediment Accumulation on Sand Media Section	Sediment depth exceeds 1/2-inch.	No sediment deposits on sand filter section that which would impede permeability of the filter section.
	Sediment Accumulation in Pre-Settling Portion of Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6-inches.	No sediment deposits in first chamber of vault.
	Trash/Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault and inlet/outlet piping.
	Sediment in Drain Pipes/Cleanouts	When drain pipes, cleanouts become full with sediment and/or debris.	Sediment and debris removed.
	Short Circuiting	When seepage/flow occurs along the vault walls and corners. Sand eroding near inflow area.	Sand filter media section re-laid and compacted along perimeter of vault to form a semi-seal. Erosion protection added to dissipate force of incoming flow and curtail erosion.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover. Maintenance person cannot remove cover using normal lifting pressure.	Cover repaired to proper working specifications or replaced.
	Ventilation	Ventilation area blocked or plugged	Blocking material removed or cleared from ventilation area. A specified % of the vault surface area must provide ventilation to the vault interior (see design specifications).
	Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab.	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles/Internal walls	Baffles or walls corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel.

No. 15 – Manufactured Media Filters)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground Vault	Sediment Accumulation on Media.	Sediment depth exceeds 0.25-inches.	No sediment deposits which would impede permeability of the compost media.
	Sediment Accumulation in Vault	Sediment depth exceeds 6-inches in first chamber.	No sediment deposits in vault bottom of first chamber.
	Trash/Debris Accumulation	Trash and debris accumulated on compost filter bed.	Trash and debris removed from the compost filter bed.
	Sediment in Drain Pipes/Clean-Outs	When drain pipes, clean-outs, become full with sediment and/or debris.	Sediment and debris removed.
	Damaged Pipes	Any part of the pipes that are crushed or damaged due to corrosion and/or settlement.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened; one person cannot open the cover using normal lifting pressure, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking warping, and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.
Below Ground Cartridge Type	Media	Drawdown of water through the media takes longer than 1 hour, and/or overflow occurs frequently.	Media cartridges replaced.
	Short Circuiting	Flows do not properly enter filter cartridges.	Filter cartridges replaced.

No. 16 – Baffle Oil/Water Separators (API Type)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with out thick visible sheen.
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6-inches in depth.	No sediment deposits on vault bottom that would impede flow through the vault and reduce separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulation in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
	Oil Accumulation	Oil accumulations that exceed 1-inch, at the surface of the water.	Extract oil from vault by vactoring. Disposal in accordance with state and local rules and regulations.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Damage - Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	See “Catch Basins” (No. 5)	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

No. 17 – Coalescing Plate Oil/Water Separators

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with no thick visible sheen.
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6-inches in depth and/or visible signs of sediment on plates.	No sediment deposits on vault bottom and plate media, which would impede flow through the vault and reduce separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
	Oil Accumulation	Oil accumulation that exceeds 1-inch at the water surface.	Oil is extracted from vault using vactoring methods. Coalescing plates are cleaned by thoroughly rinsing and flushing. Should be no visible oil depth on water.
	Damaged Coalescing Plates	Plate media broken, deformed, cracked and/or showing signs of failure.	A portion of the media pack or the entire plate pack is replaced depending on severity of failure.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and or replaced.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Vault Structure Damage - Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

No. 18 – Catchbasin Inserts

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment Accumulation	When sediment forms a cap over the insert media of the insert and/or unit.	No sediment cap on the insert media and its unit.
	Trash and Debris Accumulation	Trash and debris accumulates on insert unit creating a blockage/restriction.	Trash and debris removed from insert unit. Runoff freely flows into catch basin.
	Media Insert Not Removing Oil	Effluent water from media insert has a visible sheen.	Effluent water from media insert is free of oils and has no visible sheen.
	Media Insert Water Saturated	Catch basin insert is saturated with water and no longer has the capacity to absorb.	Remove and replace media insert
	Media Insert-Oil Saturated	Media oil saturated due to petroleum spill that drains into catch basin.	Remove and replace media insert.
	Media Insert Use Beyond Normal Product Life	Media has been used beyond the typical average life of media insert product.	Remove and replace media at regular intervals, depending on insert product.

No. 19 – MEDIA FILTER DRAIN (MFD)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation on grass filter strip	Sediment depth exceeds 2 inches or creates uneven grading that interferes with sheet flow.	Remove sediment deposits on grass treatment area of the embankment. When finished, embankment should be level from side to side and drain freely toward the toe of the embankment slope. There should be no areas of standing water once inflow has ceased.
	No-vegetation zone/flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire embankment width.	Level the spreader and clean to spread flows evenly over entire embankment width.
	Poor vegetation coverage	Grass is sparse or bare, or eroded patches are observed in more than 10% of the grass strip surface area.	Determine why grass growth is poor and correct the offending condition. Reseed into loosened, fertile soil or compost; or, replant with plugs of grass from the upper slope.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow vegetation or remove nuisance vegetation to not impede flow. Mow grass to a height of 6 inches.
	Media filter drain mix replacement	Water is seen on the surface of the media filter drain mix long after the storms have ceased. Typically, the 6-month, 24-hour precipitation event should drain within 48 hours. More common storms should drain within 24 hours. Maintenance also needed on a 10-year cycle and during a preservation project.	Excavate and replace all of the media filter drain mix contained within the media filter drain.
	Excessive shading	Grass growth is poor because sunlight does not reach embankment.	If possible, trim back overhanging limbs and remove brushy vegetation on adjacent slopes.
	Trash and debris	Trash and debris have accumulated on embankment.	Remove trash and debris from embankment.
	Flooding of Media filter drain	When media filter drain is inundated by flood water	Evaluate media filter drain material for acceptable infiltration rate and replace if media filter drain does not meet long-term infiltration rate standards.

No. 20 – COMPOST AMENDED VEGETATED FILTER STRIP (CAVFS)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation on grass	Sediment depth exceeds 2 inches.	Remove sediment deposits. Relevel so slope is even and flows pass evenly through strip.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow grass and control nuisance vegetation so that flow is not impeded. Grass should be mowed to a height of 6 inches.
	Trash and debris	Trash and debris have accumulated on the vegetated filter strip.	Remove trash and debris from filter.
	Erosion/scouring	Areas have eroded or scoured due to flow channelization or high flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with a 50/50 mixture of crushed gravel and compost. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the vegetated filter strip should be regraded and reseeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width

No. 21 - Maintenance Standards and Procedures for Bioretention Facilities.

Note that the inspection and routine maintenance frequencies listed below are recommended by Ecology. They do not supersede or replace the municipal stormwater permit requirements for inspection frequency required of municipal stormwater permittees for "stormwater treatment and flow control BMPs/facilities."

Maintenance Component	**Recommended Frequency** [a]		**Condition when Maintenance is Needed (Standards)**	**Action Needed (Procedures)**
	Inspection	**Routine Maintenance**		
Facility Footprint				
Earthen side slopes and berms	B, S		Erosion (gullies/ rills) greater than 2 inches deep around inlets, outlet, and alongside slopes	• Eliminate cause of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control matting) • For deep channels or cuts (over 3 inches in ponding depth), temporary erosion control measures should be put in place until permanent repairs can be made. • Properly designed, constructed and established facilities with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems persist, the following should be reassessed: (1) flow volumes from contributing areas and bioretention facility sizing; (2) flow velocities and gradients within the facility; and (3) flow dissipation and erosion protection strategies at the facility inlet.
	A		Erosion of sides causes slope to become a hazard	Take actions to eliminate the hazard and stabilize slopes
	A, S		Settlement greater than 3 inches (relative to undisturbed sections of berm)	Restore to design height
	A, S		Downstream face of berm wet, seeps or leaks evident	Plug any holes and compact berm (may require consultation with engineer, particularly for larger berms)
	A		Any evidence of rodent holes or water piping in berm	• Eradicate rodents (see "Pest control") • Fill holes and compact (may require consultation with engineer, particularly for larger berms)
Concrete sidewalls	A		Cracks or failure of concrete sidewalls	• Repair/ seal cracks • Replace if repair is insufficient
Rockery sidewalls	A		Rockery side walls are insecure	Stabilize rockery sidewalls (may require consultation with engineer, particularly for walls 4 feet or greater in height)
Facility area		All maintenance visits (at least biannually)	Trash and debris present	Clean out trash and debris
Facility bottom area	A, S		Accumulated sediment to extent that infiltration rate is reduced (see "Ponded water") or surface storage capacity significantly impacted	• Remove excess sediment • Replace any vegetation damaged or destroyed by sediment accumulation and removal • Mulch newly planted vegetation • Identify and control the sediment source (if feasible) • If accumulated sediment is recurrent, consider adding presettlement or installing berms to create a forebay at the inlet
		During/after fall leaf drop	Accumulated leaves in facility	Remove leaves if there is a risk to clogging outlet structure or water flow is impeded
Low permeability check dams and weirs	A, S		Sediment, vegetation, or debris accumulated at or blocking (or having the potential to block) check dam, flow control weir or orifice	Clear the blockage
	A, S		Erosion and/or undercutting present	Repair and take preventative measures to prevent future erosion and/or undercutting
	A		Grade board or top of weir damaged or not level	Restore to level position

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

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No. 21 (continued) - Maintenance Standards and Procedures for Bioretention Facilities.

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Facility Footprint (cont'd)				
Ponded water	B, S		Excessive ponding water: Water overflows during storms smaller than the design event or ponded water remains in the basin 48 hours or longer after the end of a storm.	Determine cause and resolve in the following order: 1) Confirm leaf or debris buildup in the bottom of the facility is not impeding infiltration. If necessary, remove leaf litter/debris. 2) Ensure that underdrain (if present) is not clogged. If necessary, clear underdrain. 3) Check for other water inputs (e.g., groundwater, illicit connections). 4) Verify that the facility is sized appropriately for the contributing area. Confirm that the contributing area has not increas ed. If steps #1-4 do not solve the problem, the bioretention soil is likely clogged by sediment accumulation at the surface or has become overly compacted. Dig a small hole to observe soil profile and identify compaction depth or clogging front to help determine the soil depth to be removed or otherwise rehabilitated (e.g., tilled). Consultation with an engineer is recommended.
Bioretention soil media	As needed		Bioretention soil media protection is needed when performing maintenance requiring entrance into the facility footprint	• Minimize all loading in the facility footprint (foot traffic and other loads) to the degree feasible in order to prevent compaction of bioretention soils. • Never drive equipment or apply heavy loads in facility footprint. • Because the risk of compaction is higher during saturated soil conditions, any type of loading in the cell (including foot traffic) should be minimized during wet conditions. • Consider measures to distribute loading if heavy foot traffic is required or equipment must be placed in facility. As an example, boards may be placed across soil to distribute loads and minimize compaction. • If compaction occurs, soil must be loosened or otherwise rehabilitated to original design state.
Inlets/Outlets/Pipes				
Splash block inlet	A		Water is not being directed properly to the facility and away from the inlet structure	Reconfigure/ repair blocks to direct water to facility and away from structure
Curb cut inlet/outlet	M during the wet season and before severe storm is forecasted	Weekly during fall leaf drop	Accumulated leaves at curb cuts	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
Pipe inlet/outlet	A		Pipe is damaged	Repair/ replace
	W		Pipe is clogged	Remove roots or debris
	A, S		Sediment, debris, trash, or mulch reducing capacity of inlet/outlet	• Clear the blockage • Identify the source of the blockage and take actions to prevent future blockages
		Weekly during fall leaf drop	Accumulated leaves at inlets/outlets	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
		A	Maintain access for inspections	• Clear vegetation (transplant vegetation when possible) within 1 foot of inlets and outlets, maintain access pathways • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Erosion control at inlet	A		Concentrated flows are causing erosion	Maintain a cover of rock or cobbles or other erosion protection measure (e.g., matting) to protect the ground where concentrated water enters the facility (e.g., a pipe, curb cut or swale)

No. 21 (continued) - Maintenance Standards and Procedures for Bioretention Facilities.

Maintenance Component	**Recommended Frequency** [a]		**Condition when Maintenance is Needed (Standards)**	**Action Needed (Procedures)**
	Inspection	**Routine Maintenance**		
Inlets/Outlets/Pipes (cont'd)				
Trash rack	S		Trash or other debris present on trash rack	Remove/dispose
	A		Bar screen damaged or missing	Repair/replace
Overflow	A, S		Capacity reduced by sediment or debris	Remove sediment or debris/dispose
Underdrain pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	• Plant roots, sediment or debris reducing capacity of underdrain • Prolonged surface ponding (see "Ponded water")	• Jet clean or rotary cut debris/roots from underdrain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly.
Vegetation				
Facility bottom area and upland slope vegetation	Fall and Spring		Vegetation survival rate falls below 75% within first two years of establishment (unless project O&M manual or record drawing stipulates more or less than 75% survival rate).	• Determine cause of poor vegetation growth and correct condition • Replant as necessary to obtain 75% survival rate or greater. Refer to original planting plan, or approved jurisdictional species list for appropriate plant replacements (See Appendix 3 - Bioretention Plant List, in the LID Technical Guidance Manual for Puget Sound). • Confirm that plant selection is appropriate for site growing conditions • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Vegetation (general)	As needed		Presence of diseased plants and plant material	• Remove any diseased plants or plant parts and dispose of in an approved location (e.g., commercial landfill) to avoid risk of spreading the disease to other plants • Disinfect gardening tools after pruning to prevent the spread of disease • See Pacific Northwest Plant Disease Management Handbook for information on disease recognition and for additional resources • Replant as necessary according to recommendations provided for "facility bottom area and upland slope vegetation".
Trees and shrubs		All pruning seasons (timing varies by species)	Pruning as needed	• Prune trees and shrubs in a manner appropriate for each species. Pruning should be performed by landscape professionals familiar with proper pruning techniques • All pruning of mature trees should be performed by or under the direct guidance of an ISA certified arborist
	A		Large trees and shrubs interfere with operation of the facility or access for maintenance	• Prune trees and shrubs using most current ANSI A300 standards and ISA BMPs. • Remove trees and shrubs, if necessary.
	Fall and Spring		Standing dead vegetation is present	• Remove standing dead vegetation • Replace dead vegetation within 30 days of reported dead and dying plants (as practical depending on weather/planting season) • If vegetation replacement is not feasible within 30 days, and absence of vegetation may result in erosion problems, temporary erosion control measures should be put in place immediately. • Determine cause of dead vegetation and address issue, if possible • If specific plants have a high mortality rate, assess the cause and replace with appropriate species. Consultation with a landscape architect is recommended.
	Fall and Spring		Planting beneath mature trees	• When working around and below mature trees, follow the most current ANSI A300 standards and ISA BMPs to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil). • Planting of small shrubs or groundcovers beneath mature trees may be desirable in some cases; such plantings should use mainly plants that come as bulbs, bare root or in 4-inch pots; plants should be in no larger than 1-gallon containers.

No. 21 (continued) - Maintenance Standards and Procedures for Bioretention Facilities.

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Vegetation (cont'd)				
Trees and shrubs (cont'd)	Fall and Spring		Planting beneath mature trees	• When working around and below mature trees, follow the most current ANSI A300 standards and ISA BMPs to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil). • Planting of small shrubs or groundcovers beneath mature trees may be desirable in some cases; such plantings should use mainly plants that come as bulbs, bare root or in 4-inch pots; plants should be in no larger than 1-gallon containers.
	Fall and Spring		Presence of or need for stakes and guys (tree growth, maturation, and support needs)	• Verify location of facility liners and underdrain (if any) prior to stake installation in order to prevent liner puncture or pipe damage • Monitor tree support systems: Repair and adjust as needed to provide support and prevent damage to tree. • Remove tree supports (stakes, guys, etc.) after one growing season or maximum of 1 year. • Backfill stake holes after removal.
Trees and shrubs adjacent to vehicle travel areas (or areas where visibility needs to be maintained)	A		Vegetation causes some visibility (line of sight) or driver safety issues	• Maintain appropriate height for sight clearance • When continued, regular pruning (more than one time/ growing season) is required to maintain visual sight lines for safety or clearance along a walk or drive, consider relocating the plant to a more appropriate location. • Remove or transplant if continual safety hazard • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Flowering plants		A	Dead or spent flowers present	Remove spent flowers (deadhead)
Perennials		Fall	Spent plants	Cut back dying or dead and fallen foliage and stems
Emergent vegetation		Spring	Vegetation compromises conveyance	• Hand rake sedges and rushes with a small rake or fingers to remove dead foliage before new growth emerges in spring or earlier only if the foliage is blocking water flow (sedges and rushes do not respond well to pruning)
Ornamental grasses (perennial)		Winter and Spring	Dead material from previous year's growing cycle or dead collapsed foliage	• Leave dry foliage for winter interest • Hand rake with a small rake or fingers to remove dead foliage back to within several inches from the soil before new growth emerges in spring or earlier if the foliage collapses and is blocking water flow
Ornamental grasses (evergreen)		Fall and Spring	Dead growth present in spring	• Hand rake with a small rake or fingers to remove dead growth before new growth emerges in spring • Clean, rake, and comb grasses when they become too tall • Cut back to ground or thin every 2-3 years as needed
Noxious weeds		M (March – October, preceding seed dispersal)	Listed noxious vegetation is present (refer to current county noxious weed list)	• By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately • Reasonable attempts must be made to remove and dispose of class C noxious weeds • It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions • Apply mulch after weed removal (see "Mulch")

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

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No. 21 (continued) - Maintenance Standards and Procedures for Bioretention Facilities.

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Vegetation (cont'd)				
Weeds		M (March – October, preceding seed dispersal)	Weeds are present	• Remove weeds with their roots manually with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate • Follow IPM protocols for weed management (see "Additional Maintenance Resources" section for more information on IPM protocols)
Excessive vegetation		Once in early to mid-May and once in early- to mid-September	Low-lying vegetation growing beyond facility edge onto sidewalks, paths, or street edge poses pedestrian safety hazard or may clog adjacent permeable pavement surfaces due to associated leaf litter, mulch, and soil	• Edge or trim groundcovers and shrubs at facility edge • Avoid mechanical blade-type edger and do not use edger or trimmer within 2 feet of tree trunks • While some clippings can be left in the facility to replenish organic material in the soil, excessive leaf litter can cause surface soil clogging
	As needed		Excessive vegetation density inhibits stormwater flow beyond design ponding or becomes a hazard for pedestrian and vehicular circulation and safety	• Determine whether pruning or other routine maintenance is adequate to maintain proper plant density and aesthetics • Determine if planting type should be replaced to avoid ongoing maintenance issues (an aggressive grower under perfect growing conditions should be transplanted to a location where it will not impact flow) • Remove plants that are weak, broken or not true to form; replace in-kind • Thin grass or plants impacting facility function without leaving visual holes or bare soil areas • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
	As needed		Vegetation blocking curb cuts, causing excessive sediment buildup and flow bypass	• Remove vegetation and sediment buildup
Mulch				
Mulch		Following weeding	Bare spots (without mulch cover) are present or mulch depth less than 2 inches	• Supplement mulch with hand tools to a depth of 2 to 3 inches • Replenish mulch per O&M manual. Often coarse compost is used in the bottom of the facility and arborist wood chips are used on side slopes and rim (above typical water levels) • Keep all mulch away from woody stems
Watering				
Irrigation system (if any)		Based on manufacturer's instructions	Irrigation system present	• Follow manufacturer's instructions for O&M
	A		Sprinklers or drip irrigation not directed/located to properly water plants	• Redirect sprinklers or move drip irrigation to desired areas
Summer watering (first year)		Once every 1-2 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in first year of establishment period	• 10 to 15 gallons per tree • 3 to 5 gallons per shrub • 2 gallons water per square foot for groundcover areas • Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist • Use soaker hoses or spot water with a shower type wand when irrigation system is not present ○ Pulse water to enhance soil absorption, when feasible ○ Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff • Add a tree bag or slow-release watering device (e.g., bucket with a perforated bottom) for watering newly installed trees when irrigation system is not present

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

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No. 21 (continued) - Maintenance Standards and Procedures for Bioretention Facilities.

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Watering (cont'd)				
Summer watering (second and third years)		Once every 2-4 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in second or third year of establishment period	• 10 to 15 gallons per tree • 3 to 5 gallons per shrub • 2 gallons water per square foot for groundcover areas • Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist • Use soaker hoses or spot water with a shower type wand when irrigation system is not present ○ Pulse water to enhance soil absorption, when feasible ○ Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff
Summer watering (after establishment)		As needed	Established vegetation (after 3 years)	• Plants are typically selected to be drought tolerant and not require regular watering after establishment; however, trees may take up to 5 years of watering to become fully established • Identify trigger mechanisms for drought-stress (e.g., leaf wilt, leaf senescence, etc.) of different species and water immediately after initial signs of stress appear • Water during drought conditions or more often if necessary to maintain plant cover
Pest Control				
Mosquitoes	B, S		Standing water remains for more than 3 days after the end of a storm	• Identify the cause of the standing water and take appropriate actions to address the problem (see "Ponded water") • To facilitate maintenance, manually remove standing water and direct to the storm drainage system (if runoff is from non pollution-generating surfaces) or sanitary sewer system (if runoff is from pollution-generating surfaces) after getting approval from sanitary sewer authority. • Use of pesticides or *Bacillus thuringiensis israelensis* (Bti)may be considered only as a temporary measure while addressing the standing water cause. If overflow to a surface water will occur within 2 weeks after pesticide use, apply for coverage under the Aquatic Mosquito Control NPDES General Permit.
Nuisance animals	As needed		Nuisance animals causing erosion, damaging plants, or depositing large volumes of feces	• Reduce site conditions that attract nuisance species where possible (e.g., plant shrubs and tall grasses to reduce open areas for geese, etc.) • Place predator decoys • Follow IPM protocols for specific nuisance animal issues (see "Additional Maintenance Resources" section for more information on IPM protocols) • Remove pet waste regularly • For public and right-of-way sites consider adding garbage cans with dog bags for picking up pet waste.
Insect pests	Every site visit associated with vegetation management		Signs of pests, such as wilting leaves, chewed leaves and bark, spotting or other indicators	• Reduce hiding places for pests by removing diseased and dead plants • For infestations, follow IPM protocols (see "Additional Maintenance Resources" section for more information on IPM protocols)

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

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No. 22 - Maintenance Standards and Procedures for Permeable Pavement.

Note that the inspection and routine maintenance frequencies listed below are recommended by Ecology. They do not supersede or replace the municipal stormwater permit requirements for inspection frequency required of municipal stormwater permittees for "stormwater treatment and flow control BMPs/facilities."

Component	**Recommended Frequency** [a]		**Condition when Maintenance is Needed (Standards)**	**Action Needed (Procedures)**
	Inspection	**Routine Maintenance**		
Surface/Wearing Course				
Permeable Pavements, all	A, S		Runoff from adjacent pervious areas deposits soil, mulch or sediment on paving	• Clean deposited soil or other materials from permeable pavement or other adjacent surfacing • Check if surface elevation of planted area is too high, or slopes towards pavement, and can be regraded (prior to regrading, protect permeable pavement by covering with temporary plastic and secure covering in place) • Mulch and/or plant all exposed soils that may erode to pavement surface
Porous asphalt or pervious concrete		A or B	None (routine maintenance)	Clean surface debris from pavement surface using one or a combination of the following methods: • Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Vacuum/sweep permeable paving installation using: ○ Walk-behind vacuum (sidewalks) ○ High efficiency regenerative air or vacuum sweeper (roadways, parking lots) ○ ShopVac or brush brooms (small areas) • Hand held pressure washer or power washer with rotating brushes Follow equipment manufacturer guidelines for when equipment is most effective for cleaning permeable pavement. Dry weather is more effective for some equipment.
	A[b]		Surface is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	• Review the overall performance of the facility (note that small clogged areas may not reduce overall performance of facility) • Test the surface infiltration rate using ASTM C1701 as a corrective maintenance indicator. Perform one test per installation, up to 2,500 square feet. Perform an additional test for each additional 2,500 square feet up to 15,000 square feet total. Above 15,000 square feet, add one test for every 10,000 square feet. • If the results indicate an infiltration rate of 10 inches per hour or less, then perform corrective maintenance to restore permeability. To clean clogged pavement surfaces, use one or combination of the following methods: • Combined pressure wash and vacuum system calibrated to not dislodge wearing course aggregate. • Hand held pressure washer or power washer with rotating brushes • Pure vacuum sweepers Note: If the annual/biannual routine maintenance standard to clean the pavement surface is conducted using equipment from the list above, corrective maintenance may not be needed.
	A		Sediment present at the surface of the pavement	• Assess the overall performance of the pavement system during a rain event. If water runs off the pavement and/or there is ponding then see above. • Determine source of sediment loading and evaluate whether or not the source can be reduced/eliminated. If the source cannot be addressed, consider increasing frequency of routine cleaning (e.g., twice per year instead of once per year).
	Summer		Moss growth inhibits infiltration or poses slip safety hazard	• Sidewalks: Use a stiff broom to remove moss in the summer when it is dry • Parking lots and roadways: Pressure wash, vacuum sweep, or use a combination of the two for cleaning moss from pavement surface. May require stiff broom or power brush in areas of heavy moss.
	A		Major cracks or trip hazards and concrete spalling and raveling	• Fill potholes or small cracks with patching mixes • Large cracks and settlement may require cutting and replacing the pavement section. Replace in-kind where feasible. Replacing porous asphalt with conventional asphalt is acceptable if it is a small percentage of the total facility area and does not impact the overall facility function. • Take appropriate precautions during pavement repair and replacement efforts to prevent clogging of adjacent porous materials

[a] Frequency: A= Annually; B= Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

No. 22 (continued) - Maintenance Standards and Procedures for Permeable Pavement.

Component	**Recommended Frequency** [a]		**Condition when Maintenance is Needed (Standards)**	**Action Needed (Procedures)**
	Inspection	**Routine Maintenance**		
Surface/Wearing Course (cont'd)				
Interlocking concrete paver blocks and aggregate pavers		A or B	None (routine maintenance)	Clean pavement surface using one or a combination of the following methods: • Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Vacuum/sweep permeable paving installation using: ○ Walk-behind vacuum (sidewalks) ○ High efficiency regenerative air or vacuum sweeper (roadways, parking lots) ○ ShopVac or brush brooms (small areas) • Note: Vacuum settings may have to be adjusted to prevent excess uptake of aggregate from paver openings or joints. Vacuum surface openings in dry weather to remove dry, encrusted sediment.
	A [b]		Surface is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)]	• Review the overall performance of the facility (note that small clogged areas may not reduce overall performance of facility) • Test the surface infiltration rate using ASTM C1701 as a corrective maintenance indicator. Perform one test per installation, up to 2,500 square feet. Perform an additional test for each additional 2,500 square feet up to 15,000 square feet total. Above 15,000 square feet, add one test for every 10,000 square feet. • If the results indicate an infiltration rate of 10 inches per hour or less, then perform corrective maintenance to restore permeability. • Clogging is usually an issue in the upper 2 to 3 centimeters of aggregate. Remove the upper layer of encrusted sediment, and fines, and/or vegetation from openings and joints between the pavers by mechanical means and/or suction equipment (e.g., pure vacuum sweeper). • Replace aggregate in paver cells, joints, or openings per manufacturer's recommendations
	A		Sediment present at the surface of the pavement	• Assess the overall performance of the pavement system during a rain event. If water runs off the pavement and/or there is ponding, then see above. • Determine source of sediment loading and evaluate whether or not the source can be reduced/eliminated. If the source cannot be addressed, consider increasing frequency of routine cleaning (e.g., twice per year instead of once per year).
	Summer		Moss growth inhibits infiltration or poses slip safety hazard	• Sidewalks: Use a stiff broom to remove moss in the summer when it is dry • Parking lots and roadways: Vacuum sweep or stiff broom/power brush for cleaning moss from pavement surface
	A		Paver block missing or damaged	Remove individual damaged paver blocks by hand and replace or repair per manufacturer's recommendations
	A		Loss of aggregate material between paver blocks	Refill per manufacturer's recommendations for interlocking paver sections
	A		Settlement of surface	May require resetting
Open-celled paving grid with gravel		A or B	None (routine maintenance)	• Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Follow equipment manufacturer guidelines for cleaning surface.
	A [b]		Aggregate is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)]	• Use vacuum truck to remove and replace top course aggregate • Replace aggregate in paving grid per manufacturer's recommendations
	A		Paving grid missing or damaged	• Remove pins, pry up grid segments, and replace gravel • Replace grid segments where three or more adjacent rings are broken or damaged • Follow manufacturer guidelines for repairing surface.
	A		Settlement of surface	May require resetting
	A		Loss of aggregate material in paving grid	Replenish aggregate material by spreading gravel with a rake (gravel level should be maintained at the same level as the plastic rings or no more than 1/4 inch above the top of rings). See manufacturer's recommendations.
		A	Weeds present	• Manually remove weeds • Presence of weeds may indicate that too many fines are present (refer to Actions Needed under "Aggregate is clogged" to address this issue)

[a] Frequency: A= Annually; B= Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

No. 22 (continued) - Maintenance Standards and Procedures for Permeable Pavement.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Surface/Wearing Course (cont'd)				
Open-celled paving grid with grass		A or B	None (routine maintenance)	• Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Follow equipment manufacturer guidelines for cleaning surface.
	A [b]		Aggregate is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)]	• Rehabilitate per manufacturer's recommendations.
	A		Paving grid missing or damaged	• Remove pins, pry up grid segments, and replace grass • Replace grid segments where three or more adjacent rings are broken or damaged • Follow manufacturer guidelines for repairing surface.
	A		Settlement of surface	• May require resetting
	A		Poor grass coverage in paving grid	• Restore growing medium, reseed or plant, aerate, and/or amend vegetated area as needed • Traffic loading may be inhibiting grass growth; reconsider traffic loading if feasible
		As needed	None (routine maintenance)	• Use a mulch mower to mow grass
		A	None (routine maintenance)	• Sprinkle a thin layer of compost on top of grass surface (1/2" top dressing) and sweep it in • Do not use fertilizer
		A	Weeds present	• Manually remove weeds • Mow, torch, or inoculate and replace with preferred vegetation
Inlets/Outlets/Pipes				
Inlet/outlet pipe	A		Pipe is damaged	Repair/replace
	A		Pipe is clogged	Remove roots or debris
Underdrain pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	Plant roots, sediment or debris reducing capacity of underdrain (may cause prolonged drawdown period)	• Jet clean or rotary cut debris/roots from underdrain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly
Raised subsurface overflow pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	Plant roots, sediment or debris reducing capacity of underdrain	• Jet clean or rotary cut debris/roots from underdrain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly
Outlet structure	A, S		Sediment, vegetation, or debris reducing capacity of outlet structure	• Clear the blockage • Identify the source of the blockage and take actions to prevent future blockages

[a] Frequency: A= Annually; B= Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

No. 22 (continued) - Maintenance Standards and Procedures for Permeable Pavement.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Inlets/Outlets/Pipes (cont'd)				
Overflow	B		Native soil is exposed or other signs of erosion damage are present at discharge point	Repair erosion and stabilize surface
Aggregate Storage Reservoir				
Observation port	A, S		Water remains in the storage aggregate longer than anticipated by design after the end of a storm	If immediate cause of extended ponding is not identified, schedule investigation of subsurface materials or other potential causes of system failure.
Vegetation				
Adjacent large shrubs or trees		As needed	Vegetation related fallout clogs or will potentially clog voids	• Sweep leaf litter and sediment to prevent surface clogging and ponding • Prevent large root systems from damaging subsurface structural components
		Once in May and Once in September	Vegetation growing beyond facility edge onto sidewalks, paths, and street edge	Edging and trimming of planted areas to control groundcovers and shrubs from overreaching the sidewalks, paths and street edge improves appearance and reduces clogging of permeable pavements by leaf litter, mulch and soil.
Leaves, needles, and organic debris		In fall (October to December) after leaf drop (1-3 times, depending on canopy cover)	Accumulation of organic debris and leaf litter	Use leaf blower or vacuum to blow or remove leaves, evergreen needles, and debris (i.e., flowers, blossoms) off of and away from permeable pavement

[a] Frequency: A= Annually; B= Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

GUIDANCE DOCUMENT

WESTERN WASHINGTON LOW IMPACT DEVELOPMENT (LID) OPERATION AND MAINTENANCE (O&M)

Prepared for
Washington State Department of Ecology
Water Quality Program

Prepared by
Herrera Environmental Consultants, Inc.
and
Washington Stormwater Center

Note:
Some pages in this document have been purposely skipped or blank pages inserted so that this document will copy correctly when duplexed.

GUIDANCE DOCUMENT

WESTERN WASHINGTON LOW IMPACT DEVELOPMENT (LID) OPERATION AND MAINTENANCE (O&M)

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CONTENTS

Acknowledgments v

- LID Maintenance Advisory Committee v
- LID Maintenance Administrative Issues Advisory Committee v

Introduction 1

- Purpose 1
- Ecology Requirements for LID BMP Maintenance 1
  - Phase I Permit Special Conditions 2
  - Phase II Permit Special Conditions 3
  - Summary 4
- How to Use this Guidance Document 5
  - Maintaining LID BMPs Section 5
  - Programmatic and Administrative Guidance Section 5
- Definitions/Acronyms 6

Maintaining LID BMPs 9

- All LID BMPs 11
  - Maintenance Standards and Procedures 11
  - Equipment and Materials 13
  - Skills 13
- Bioretention Facilities 15
  - Key Maintenance Considerations 15
  - Key Operations to Preserve Facility Function 16
  - Maintenance Standards and Procedures 16
  - Additional Maintenance Resources 29
  - Equipment and Materials 30
  - Skills and Staffing 31
- Rain Gardens 33
  - Key Maintenance Considerations 33
  - Key Operations to Preserve Facility Function 33
  - Maintenance Standards and Procedures 33
  - Additional Maintenance Resources 39
  - Equipment and Materials 39
- Permeable Pavement 41
  - Key Maintenance Considerations 41
  - Key Operations to Preserve Facility Function 42
  - Maintenance Standards and Procedures 43
  - Equipment and Materials 53
  - Skills and Staffing 54
- Vegetated Roofs 57
  - Key Maintenance Considerations 57

Key Operations to Preserve Facility Function 58
Maintenance Standards and Procedures 58
Additional Maintenance Resources 64
Equipment and Materials 65
Skills and Staffing 66
Downspout Full Infiltration Systems 67
Key Maintenance Considerations 67
Key Operations to Preserve Facility Function 67
Maintenance Standards and Procedures 68
Equipment and Materials 71
Skills 71
Downspout, Sheet Flow, and Concentrated Dispersion Systems 73
Key Maintenance Considerations 73
Key Operations to Preserve Facility Function 74
Maintenance Standards and Procedures 74
Equipment and Materials 79
Skills 79
Compost-amended Soils 81
Key Maintenance Considerations 81
Key Operations to Preserve Facility Function 81
Maintenance Standards and Procedures 81
Equipment and Materials 85
Skills 85

Programmatic and Administrative Guidance 87

Ecology Requirements for LID BMP Maintenance Programs 87
Tools for Implementing an LID Maintenance Program 93
Stormwater Code / Manual 99
Legal Agreements and Recordable Documents 100
Project-Specific BMP Maintenance Requirements 101
Financial Surety Measures 102
Record Keeping & Tracking Process 102
Inspection Programs 103
Mapping 104
Private Property Owner Education 105

References 107

Appendix A Examples of Covenants
Appendix B Examples of Private Property Owner Education

(*Note: The examples provided in the appendices were included as examples based on format only; the content of these examples has not been reviewed for consistency with the 2013-2018 Permit requirements or the material included in this guidance document.*)

TABLES

Table 1. Maintenance Standards and Procedures for All LID BMPs. 12

Table 2. Equipment and Materials List for All LID BMPs. 13

Table 3. Maintenance Standards and Procedures for Bioretention Facilities. 17

Table 4. Bioretention Equipment and Materials List. 30

Table 5. Maintenance Frequency and Staffing for Bioretention Facilities. 31

Table 6. Maintenance Standards and Procedures for Rain Gardens. 34

Table 7. Rain Garden Equipment and Materials List. 39

Table 8. Maintenance Standards and Procedures for Permeable Pavement. 45

Table 9. Permeable Pavement Equipment and Materials List. 53

Table 10. Maintenance Frequency and Staffing for Permeable Pavement. 55

Table 11. Maintenance Standards and Procedures for Vegetated Roofs. 59

Table 12. Vegetated Roof Equipment and Materials List. 65

Table 13. Maintenance Frequency and Staffing for Vegetated Roofs. 66

Table 14. Maintenance Standards and Procedures for Downspout Full Infiltration Systems. 69

Table 15. Downspout Full Infiltration System Equipment and Materials List. 71

Table 16. Maintenance Standards and Procedures for Downspout, Sheet Flow, and Concentrated Dispersion Systems. 75

Table 17. Downspout, Sheet Flow, and Concentrated Dispersion Systems Equipment and Materials List. 79

Table 18. Maintenance Standards and Procedures for Compost-amended Soils. 82

Table 19. Compost Amended Soils Equipment and Materials List. 85

Table 20. Phase I Permit Requirements and 2012 SWMMWW Guidance Related to LID BMP Maintenance Programs. 88

Table 21. Phase II WWA Permit Requirements and 2012 SWMMWW Guidance Related to LID BMP Maintenance Programs. 90

Table 22. Administrative Tools to Implement O&M Programs. 95

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INTRODUCTION

Purpose

As local governments in western Washington implement the Washington State Department of Ecology (Ecology) National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater permits (Permits), our region will increasingly rely on low impact development (LID) practices to protect water quality and aquatic natural resources. LID is a stormwater and land use management strategy that strives to mimic the pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation, use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into a project design. LID best management practices (BMPs), such as bioretention and permeable pavements, are also commonly known as green stormwater infrastructure, integrated management practices, and on-site stormwater management BMPs.

This guidance provides recommendations on LID operations and maintenance (O&M) to help ensure that LID BMPs continue to function as designed in the long-term and is intended to support municipal stormwater Permittees in implementing their LID maintenance programs. While intended for a municipal audience, some guidance in this document may also be useful for private entities. Ecology encourages local governments to draw on this document to educate developers, homeowners' associations, and private property owners who are responsible for the O&M of LID BMPs.

Ecology Requirements for LID BMP Maintenance

The Phase I and Western Washington Phase II Municipal Stormwater Permits (Phase I Permit and Phase II Permit, or "Permits"), effective from August 2013 to July 2018, include provisions for municipalities to adopt and implement O&M programs and to facilitate proper O&M of LID BMPs. The Permit maintenance-related requirements for "On-site Stormwater Management BMPs" differ depending on if they are classified as "Stormwater Treatment and Flow Control BMPs/Facilities[1]". The side bars below highlight the distinctions made for Stormwater Treatment and Flow Control BMPs/Facilities. In general, the O&M Permit requirements for Stormwater Treatment and Flow Control BMPs/Facilities are more extensive and include, for example, long-term inspection and maintenance obligations that do not apply to other LID BMPs. The Phase I and Phase II Permits provisions that apply to LID BMPs are summarized in the following sections.

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[1] This document does not include guidance for traditional end of pipe treatment and detention facilities; though these facilities are included in the definition of "Stormwater Treatment and Flow Control BMPs/Facilities".

Phase I Permit Special Conditions

The Phase I Permit[2] (Ecology 2012a) special conditions that pertain to LID BMP maintenance are listed below:

- **S5.C.5.a.v.(4)** – Requires municipalities to inspect all permitted development sites, that meet certain thresholds, upon completion of construction and prior to final approval or occupancy to ensure proper installation of permanent storm water facilities. It also requires identification of a party responsible for maintenance, and verification of a maintenance plan for all Stormwater Treatment and Flow Control BMPs/Facilities.
- **S5.C.9.a.** – Requires adoption of maintenance standards that are at least as protective of facility function as those in Chapter 4 of Volume V of the 2012 Stormwater Management Manual for Western Washington (2012 SWMMWW).
- **S5.C.9.b.i.** – Requires adoption of an ordinance or other enforceable mechanism requiring maintenance of all permanent Stormwater Treatment and Flow Control BMPs/Facilities regulated by the Permittee.
- **S5.C.9.b.ii.** – Requires annual inspections of all Stormwater Treatment and Flow Control BMPs/Facilities regulated by the Permittee. Permittees must enforce compliance with the adopted maintenance standards as needed based on inspection.

"On-site Stormwater Management BMPs"

"On-site Stormwater Management BMPs" (also known as LID BMPs) used to meet Permit Minimum Requirement #5 (On-site Stormwater Management) include:

- Rain Gardens (BMP T5.14A)
- Bioretention (BMP T5.14B)
- Permeable Pavement (BMP T5.15)
- Vegetated Roofs (BMP T5.17)
- Downspout Full Infiltration (BMP T5.10B)
- Downspout Dispersion (BMP T5.10A)
- Concentrated Flow Dispersion (BMP T5.11)
- Sheet Flow Dispersion (BMP T5.12)
- Compost-amended soils (BMP T5.13)

Permit requirements for On-site Stormwater Management BMPs that are not also Stormwater Treatment and Flow Control BMPs/Facilities are less extensive and include, for example, construction inspections to ensure proper installation.

"Stormwater treatment and flow control BMPs/facilities"

The LID BMPs listed below are considered to be "Stormwater Treatment and Flow Control BMPs/Facilities" if they are used to help meet Minimum Requirements #6 (Treatment) and/or #7 (Flow Control):

- Bioretention (BMP T5.14B)
- Permeable Pavement (BMP T5.15)
- Vegetated Roofs (BMP T5.17)

Permit requirements for Stormwater Treatment and Flow Control BMPs/Facilities are more extensive and include, for example, long-term inspection and maintenance obligations.

---

[2] The special conditions listed in this document are for city and county permittees. Secondary permittees should refer Section S6 of the permit for their special conditions that pertain to LID BMP maintenance.

- **S5.C.9.b.iii.** – Requires inspection of all permanent Stormwater Treatment and Flow Control BMPs/Facilities and catch basins regulated by the Permittee every 6 months during construction of residential developments until 90 percent of the lots are constructed (or when construction is stopped and the site is fully stabilized). Permittees must identify maintenance needs and enforce compliance with maintenance standards as needed.

- **S5.C.9.c.i.** – Requires annual inspection of all permanent Stormwater Treatment and Flow Control BMPs/Facilities owned or operated by the Permittee. Permittees are to implement appropriate maintenance action(s) in accordance with adopted maintenance standards.

- **S5.C.9.c.ii.** – Requires spot checks of potentially damaged permanent Stormwater Treatment and Flow Control BMPs/Facilities after major storm events. If spot checks indicate widespread damage/maintenance needs, inspect all Stormwater Treatment and Flow Control BMPs/Facilities that may be affected. Conduct repairs or perform maintenance in accordance with the standards established under S5.C.9.a.

Phase II Permit Special Conditions

The Phase II Permit[3] (Ecology 2012b) special conditions that pertain to LID BMP maintenance are listed below:

- **S5.C.4.b.iv.** – Requires municipalities to inspect all permitted development sites upon completion of construction and prior to final approval or occupancy to ensure proper installation of permanent stormwater facilities. Municipalities must require identification of a party responsible for maintenance, and a maintenance plan for all Stormwater Treatment and Flow Control BMPs/Facilities.

- **S5.C.4.c.** – Requires a program to verify adequate operation and maintenance of Stormwater Treatment and Flow Control BMPs/Facilities that have been and will be approved and built under local code requirements adopted to comply with the 2007, 2012, and 2013 NPDES municipal stormwater Permits. The program must include:

    i) Implementation of an ordinance or other enforceable mechanism that requires identification of a party responsible for maintenance, and requires inspections of facilities in accordance with ii) through iv) below.

    ii) Requires establishment of maintenance standards that are at least as protective of facility function as those in Chapter 4 of Volume V of the 2012 SWMMWW.

    iii) Requires annual inspection of all Stormwater Treatment and Flow Control BMPs/Facilities that discharge to the MS4 and were permitted according to S5.C.4.b. including those permitted pursuant to the 2007 – 2012 Permit.

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[3] The special conditions listed in this document are for city and county permittees. Secondary permittees should refer Section S6 of the permit for their special conditions that pertain to LID BMP maintenance.

iv) Requires inspections of permanent Stormwater Treatment and Flow Control BMPs/Facilities and catch basins every 6 months during construction of residential developments until 90 percent of the lots are constructed (or when construction is stopped and the site is fully stabilized).

- **S5.C.5.a.** – Requires implementation of maintenance standards that are at least as protective of facility function as those in Chapter 4 of Volume V of the 2012 SWMMWW.
- **S5.C.5.b.** – Requires annual inspections of all municipally owned or operated permanent Stormwater Treatment and Flow Control BMPs/Facilities, and taking appropriate maintenance actions in accordance with the adopted maintenance standards.
- **S5.C.5.c.** – Requires spot checks of potentially damaged permanent Stormwater Treatment and Flow Control BMPs/Facilities after major storm events. If spot checks indicate widespread damage/maintenance needs, inspect all "storm water treatment and flow control BMPs" that may be affected. Conduct repairs or perform maintenance in accordance with the standards established under S5.C.5.a.

Summary

Both Phase I and Phase II municipal Permittees bear long-term inspection and enforcement responsibilities to require proper maintenance of Stormwater Treatment and Flow Control BMPs/Facilities. Although the On-site Stormwater Management BMPs that are not Stormwater Treatment and Flow Control BMPs/Facilities do not require long-term inspections, municipalities are obligated to inspect these BMPs upon completion of construction to ensure proper installation.

The Permits also require Permittees to adopt site planning requirements (Western Washington Phase II Permit – S5.C.4.a.ii; Western Washington Phase I Permit – S5.C.5.a.ii). They can choose to use the site planning requirements in the 2012 SWMMWW, or they can adopt requirements that protect water quality, reduce the discharge of pollutants to the maximum extent practicable (MEP), and satisfy the "all known, available and reasonable" provisions of State statute (Chapter 90.48 RCW). The 2012 SWMMWW site planning guidance includes information on the production, submission and recording of legal documents that provide both design information and maintenance instructions for each On-site Stormwater Management BMP, and help allow local government access to these BMPs.

Ecology encourages local governments to use the guidance in this document to meet their Permit obligation to adopt maintenance standards for LID BMPs. Additionally, they can use the guidance to gain an understanding of the procedures, equipment, materials, legal documents and staffing they will need to meet their inspection and maintenance responsibilities.

How to Use this Guidance Document

This guidance document is organized into two sections. The first section, "Maintaining LID BMPs," provides detailed maintenance guidance for LID BMPs, recommendations for equipment and materials, and information on what types of skills and staffing may be needed. The second section, "Programmatic and Administrative Guidance," includes guidance to support jurisdictions in administering their LID maintenance programs.

Maintaining LID BMPs Section

The "Maintaining LID BMPs" section is intended to be used by municipal maintenance staff and private parties who are responsible for LID BMP O&M. The tables and guidance in this document may be used:

- To create O&M manuals for Stormwater Treatment and Flow Control BMPs/Facilities
- As maintenance instructions that can be submitted as part of the stormwater site plan for LID BMPs that are not Stormwater Treatment and Flow Control BMPs/Facilities
- As a reference to help homeowners maintain on-site LID BMPs

The guidance provides support by:

- Explaining how LID BMPs function (e.g., how water moves through the facility and the importance of key facility components) to provide a framework for the maintenance standards and procedures, and support smart maintenance decisions in the field
- Providing clear guidance on LID BMP maintenance frequencies, standards and procedures in an easy-to-use table. These tables can easily be reformatted as maintenance checklists.
- Providing a comprehensive equipment and materials list for each BMP
- Providing information on staff skills needed for O&M
- Providing information on the level of effort required to maintain bioretention, permeable pavement, and vegetated roofs

The maintenance standards and procedures presented in this guidance should be used by municipalities for the long-term inspection and maintenance of Stormwater Treatment and Flow Control BMPs/Facilities. While not required, long-term observation of all on-site systems by municipal inspectors is recommended, particularly when the property is subject to inspection for Stormwater Treatment and Flow Control BMPs/Facilities.

Programmatic and Administrative Guidance Section

The Programmatic and Administrative Guidance section is intended to be used by municipal staff responsible for developing and implementing LID BMP maintenance programs. The guidance provides support by:

- Presenting Ecology’s requirements that relate to LID BMP maintenance programs, such as systems for permitting, plan review, inspections, enforcement and record keeping

- Providing guidance regarding administrative tools for implementing these requirements, such as municipal stormwater codes, stormwater manuals, legal agreements, financial surety measures, inspection programs, and mapping systems

- Providing examples of administrative tools, including covenants and easements, and private property owner education

Definitions/Acronyms

- **Applicant:** Individuals, associations, organizations, partnerships, firms, corporations, developers, or other entities applying for a development proposal, permit, or approval.

- **Bond:** A surety bond, cash deposit or escrow account, assignment of savings, irrevocable letter of credit or other means acceptable to or required by the manager to guarantee that work is completed in compliance with the project's drainage plan and in compliance with all local government requirements. Bonds can also be used to protect and guarantee the performance of a stormwater BMP after construction.

- **Codes:** Collections of laws and regulations which have been codified based on the activities they regulate. These laws are ordinances that are enforced locally in addition to state and federal law. City or county stormwater codes may include laws regulating the requirements for maintenance of private stormwater facilities, the right of the jurisdiction to intervene in maintenance or repair of the facility, or any documents or contracts required for the construction of a stormwater facility.

- **Covenants:** Binding legal documents in which a person (commonly a property owner) promises the local government to either engage in or refrain from a certain action. A jurisdiction’s code, at the jurisdiction’s option, may require a covenant or easement agreement for the construction of a stormwater facility. The agreement may require the facility owner to perform certain maintenance activities and grants the jurisdiction limited authority to access the site (through an easement or agreement) for facility inspection, maintenance, or repair work.

- **Developer:** A person who purchases and develops property, primarily by preparing a site for residential or commercial use.

- **Director:** Typically the Public Works Director, Planning and Development Services Director, or Natural Resources and Parks Director (depending on the organization of the City or County and what department the stormwater program is included in) or an appointed representative or designee with an appropriate background.

- **Green stormwater infrastructure:** A synonym for Low Impact Development BMPs (see definition below).

- **Integrated management practices:** Used in the LID Technical Guidance Manual for Puget Sound as a synonym for Low Impact Development BMPs (see definition below).
- **Low impact development (LID):** A stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation, use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into a project design.
- **LID best management practices (BMPs):** Distributed stormwater management practices, integrated into a project design, that emphasize pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration. LID BMPs include, but are not limited to, bioretention/rain gardens, permeable pavements, roof downspout controls, dispersion, soil quality and depth, vegetated roofs, minimum excavation foundations, and water re-use.
- **On-site Stormwater Management BMPs:** A synonym for Low Impact Development BMPs.
- **Pollution-generating surfaces:** Any hard or impervious surface considered to be a significant source of pollutants in stormwater runoff, or any pervious surface that is subject to rainfall and vehicular use, industrial activities, storage of erodible or leachable materials, wastes, or chemicals, or use of pesticides or fertilizers, or loss of soil.
- **Property owner:** The person who is the legal record owner of the parcel.
- **Responsible party:** The parties (e.g., property owners, homeowners' associations, corporations, public agencies) responsible for maintaining stormwater features at a site and/or in a public right-of-way.
- **Stormwater Treatment and Flow Control BMPs:** Detention facilities, treatment BMPs/facilities, bioretention, vegetated roofs, and permeable pavements that help meet Appendix 1 Minimum Requirements #6 (treatment), #7 (flow control), or both.
- **Surety:** A surety is a bond or other security signed by the contractor and a surety company that assures the project owner or municipality the contract will be completed. A surety can include bonds or assignment of accounts (also called assignment of savings).

MAINTAINING LID BMPS

This section is organized by BMP type and includes guidance for the following LID BMPs:

- Bioretention facilities
- Rain gardens
- Permeable pavement
- Vegetated roofs
- Downspout full infiltration systems
- Downspout, sheet flow, and concentrated dispersion systems
- Compost-amended soils

Each BMP section includes the following information:

- **BMP Description:** brief description of the BMP and how the facility functions (i.e., how water moves through the facility).
- **Key Maintenance Considerations:** summary of key facility maintenance considerations for each main BMP components, such as inlets, aggregate, soil, vegetation.
- **Key Operations to Preserve Facility Function:** operational considerations that may reduce routine maintenance needs and prevent the need for corrective maintenance.
- **Maintenance Standards and Procedures:** a table providing detailed guidance for regular maintenance (e.g., bioretention vegetation care) and some guidance for corrective maintenance (e.g., bioretention soil replacement). The table lists the recommended inspection frequency, conditions when maintenance is needed (maintenance “standards”) and the associated maintenance actions triggered by those conditions (maintenance “procedures”).
- **Equipment and Material List:** a sample list of equipment and materials that field crews can take into the field.
- **Skills and Staffing:** a list of the skills needed for routine and corrective maintenance, and summary of the staffing resources recommended for BMP maintenance based on input from local jurisdictions and other nationally-recognized LID programs (for the Stormwater Treatment and Flow Control BMPs/Facilities only).

This section’s detailed maintenance guidance can be pared down to meet project-specific needs. For example, tables can be tailored to show only site-specific BMPs and their subcomponents (e.g., underdrains). Additionally, the routine maintenance frequencies should be tailored to minimize a site's need for corrective maintenance (e.g., specify more frequent sweeping of permeable pavement located under deciduous tree canopies).

Jurisdictions may also want to consider tailoring the tables to address "level of service" (i.e., the BMP conditions that trigger maintenance procedures). As an example, the City of Seattle maintains public facilities to levels of service "A" through "D", with level A being the highest degree of maintenance. Lower levels of service require only maintenance activities that preserve facility function (not aesthetics). While this guidance document includes recommended quantitative thresholds for some BMP maintenance actions (e.g., supplemental planting is triggered when bioretention vegetative coverage falls below 75 percent), jurisdictions may wish to develop their own maintenance triggers and/or establish ranges of triggers based on higher levels of service. Such decisions will affect the maintenance resources required to maintain public projects.

The maintenance standards provided in this section are not intended to be a measure of the facility's required condition at all times between inspections. However, the inspection and maintenance schedules should be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

All LID BMPs

The maintenance recommendations included in this section are applicable to all LID BMPs.

Maintenance Standards and Procedures

Table 1 provides the recommended maintenance frequencies, standards, and procedures for spill prevention, spill response, and pest management actions common to all LID BMP facilities included in this guidance document.

Table 1. Maintenance Standards and Procedures for All LID BMPs.

Category	Recommended Frequency		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
General				
Facility presence	All visits		None (ongoing inspections)	Inspect to ensure the facility is present on site as shown on the as-built (or record drawings) and previous photos.
Spill Prevention and Response				
Spill prevention	Ongoing		None (ongoing inspections)	All sites must implement BMPs to prevent hazardous or solid wastes or excessive oil and sediment from contaminating stormwater.
Spill cleanup	As needed		Release of pollutants	• Call your local or regional hotline number to report any spills or other illicit discharges • Clean up spills as soon as possible to prevent contamination of stormwater • Restore BMP facility design and function per the record drawings
Pests				
Pest management	As needed		Pest of concern is present and impacting BMP facility function	• Pesticide use should be generally discouraged, even conditionally prohibited in some cases • Pesticides include the following: herbicides, fungicides, insecticides, rodenticides, and pediculicides • If pesticide use is planned in or near LID BMPs, make sure to check the following current regulations: 1) Federal- Environmental Protection Agency (EPA) Federal Insecticide and Rodenticide Act 2) State- Ecology, Washington State Department of Agriculture, Washington Department of Fish and Wildlife, Natural Resources Conservation Services 3) Local city or county ordinances/codes, and/or applicable Integrated Pest Management (IPM) plan • For the protection of health and safety, check the following: 1) Washington State Department of Labor & Industries 2) Washington State Department of Health (local branch if applicable)

Equipment and Materials

Table 2 includes recommendations for equipment and materials common to all LID BMPs included in this guidance document.

Table 2. Equipment and Materials List for All LID BMPs.

- ☐ **Camera**
- ☐ **Safety gear/equipment (including boots, long sleeves and pants, gloves, eye and ear protection, and/or high visibility safety vest)**
- ☐ **Shovel (to check depth and condition of soils)**
- ☐ **Measuring tape**
- ☐ **Photos, reports, and/or checklists from past maintenance visits (to help identify changes such as thinning plants and changing pavement conditions)**
- ☐ **Copy of the site's O&M manual or maintenance plan**
- ☐ **O&M checklist**
- ☐ **As-built (i.e., record) drawings of the facility, including site drawings with facility location(s)**
- ☐ **Manufacturer information (if applicable)**

Skills

The required skills common to maintenance of all LID BMPs are listed in the text box to the right.

Skills Needed for Maintenance of all LID BMPs

- Understanding of as-built (or record) drawings of the facility
- Understanding of facility design and intent (to identify issues that would inhibit function)
- General labor (manual tool skills)

Bioretention Facilities

Bioretention facilities are engineered facilities that store and treat stormwater by filtering it through a specified soil profile. Water that enters the facility ponds in an earthen depression or other basin (e.g., concrete planter) before it infiltrates into the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is either infiltrated into the underlying native soil or collected by an underdrain and discharged. Bioretention facilities are considered Stormwater Treatment and Flow Control BMPs/Facilities when used to help meet Minimum Requirements #6 (treatment), #7 (flow control), or both.

Key Maintenance Considerations

The main components of bioretention facilities are listed below with descriptions of their function and key maintenance considerations.

- **Inlet**: Stormwater can flow into a bioretention facility in a number of ways including: dispersed flow across vegetated areas, sheet flow across impervious areas, or concentrated flow through curb cuts and/or piped flow inlets. Inlets must be maintained to be unobstructed to ensure that stormwater enters the facility as designed. Erosion control measures must also be maintained in areas of concentrated flows (e.g., pipes inlets or narrow curb cuts).
- **Facility footprint**: The facility footprint is typically an earthen depression or another type of basin (e.g., concrete planter box) that provides surface storage for stormwater before it infiltrates into the underlying bioretention soil. If the facility is located on a slope, low permeability check dams may be included (oriented perpendicular to the slope) to encourage ponding. Key maintenance considerations for the facility footprint include the following:
  - The integrity of earthen berms and basin walls must be maintained, soil areas must be protected from erosion, and accumulated sediment must be removed.
  - Bioretention facilities are designed to infiltrate all ponded water within a 24- to 48-hour “drawdown” time after the end of a storm. This allows the soil to dry out periodically in order to restore the hydraulic capacity of the system and prevent conditions supportive of mosquito breeding. Slower drawdown times may indicate that the underdrain (if present) is plugged or the bioretention soil is overly compacted, clogged, or does not meet design specifications. Corrective maintenance may include clearing underdrain obstructions or partial or complete replacement of bioretention soil to restore bioretention facility function.
- **Bioretention soil**: Infiltration of stormwater through the engineered bioretention soil mix provides water quality treatment. All maintenance activities must be performed in a manner to prevent compaction of the bioretention soil.
- **Mulch**: The bioretention soil is covered by a layer of mulch, comprised of arborist wood chips, compost, and/or rocks. Mulch reduces weed establishment. Organic

mulches regulate soil temperatures and moisture, and add organic matter to soil. The mulch layer must be supplemented regularly.

- **Vegetation**: Bioretention systems rely on vegetation (i.e., grasses, shrubs, and sometimes trees) to intercept, uptake, and evapotranspire stormwater. In addition, plant roots improve soil structure and increase infiltration capacity. Regular maintenance activities associated with vegetation include weeding and pruning. Plants also require irrigation during the first 2 to 3 years of establishment and during extended dry periods.
- **Overflow**: Flows exceeding the capacity of the facility are discharged via an overflow structure (e.g., pipe, curb cut, earthen channel). It is important to maintain clear outlet pipes and overflow structures to ensure that stormwater can be safely conveyed to a designated discharge point (e.g., storm drain system).
- **Underdrains (optional)**: Underdrains are optional components of a bioretention facility that may be included in bioretention systems where, for example, infiltration to underlying soil is not prudent or feasible. Underdrains are installed under the bioretention soil layer to collect and convey treated water. An underdrain system can be comprised of perforated or slotted pipe, wrapped in an aggregate blanket. It is important to maintain clear drains so that water moves through system as designed. Maintenance may include occasional cleaning to remove plant roots or debris. If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be inspected and cleaned regularly.

Nutrient sensitivity of the receiving water is also an important maintenance consideration, particularly in watersheds draining to phosphorous limited water bodies. The addition of excess fertilizers to the system and/or systems operating in bypass, can increase the potential for export of phosphorous found in bioretention soil or compost and increase nutrient loads to downstream receiving waters.

Key Operations to Preserve Facility Function

For a bioretention system to function properly, stormwater must infiltrate freely through the bioretention soil. The soil infiltration rate can be reduced if the soil is subject to compaction (e.g., foot and vehicle traffic loads). To limit the likelihood of corrective maintenance (e.g., bioretention soil replacement), the facility footprint area should be protected from external loads. Because the risk of compaction is higher when soils are saturated, any type of loading in the bioretention facility (including foot traffic) should be avoided during wet conditions.

Signage can also be used to identify the vegetated area as a stormwater BMP and inform maintenance crews and the general public about protecting the facility’s function.

Maintenance Standards and Procedures

Table 3 provides the recommended maintenance frequencies, standards, and procedures for bioretention facility components. The level of routine maintenance required and the frequency of corrective maintenance actions may increase for facilities subject to high sediment loads from the contributing drainage area.

Table 3. Maintenance Standards and Procedures for Bioretention Facilities.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Facility Footprint				
Earthen side slopes and berms	B, S		Erosion (gullies/ rills) greater than 2 inches deep around inlets, outlet, and alongside slopes	• Eliminate cause of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control matting) • For deep channels or cuts (over 3 inches in ponding depth), temporary erosion control measures should be put in place until permanent repairs can be made. • Properly designed, constructed and established facilities with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems persist, the following should be reassessed: (1) flow volumes from contributing areas and bioretention facility sizing; (2) flow velocities and gradients within the facility; and (3) flow dissipation and erosion protection strategies at the facility inlet.
	A		Erosion of sides causes slope to become a hazard	Take actions to eliminate the hazard and stabilize slopes
	A, S		Settlement greater than 3 inches (relative to undisturbed sections of berm)	Restore to design height
	A, S		Downstream face of berm wet, seeps or leaks evident	Plug any holes and compact berm (may require consultation with engineer, particularly for larger berms)
	A		Any evidence of rodent holes or water piping in berm	• Eradicate rodents (see "Pest control") • Fill holes and compact (may require consultation with engineer, particularly for larger berms)
Concrete sidewalls	A		Cracks or failure of concrete sidewalls	• Repair/ seal cracks • Replace if repair is insufficient
Rockery sidewalls	A		Rockery side walls are insecure	Stabilize rockery sidewalls (may require consultation with engineer, particularly for walls 4 feet or greater in height)
Facility area		All maintenance visits (at least biannually)	Trash and debris present	Clean out trash and debris
Facility bottom area	A, S		Accumulated sediment to extent that infiltration rate is reduced (see “Ponded water”) or surface storage capacity significantly impacted	• Remove excess sediment • Replace any vegetation damaged or destroyed by sediment accumulation and removal • Mulch newly planted vegetation • Identify and control the sediment source (if feasible) • If accumulated sediment is recurrent, consider adding presettlement or installing berms to create a forebay at the inlet
		During/after fall leaf drop	Accumulated leaves in facility	Remove leaves if there is a risk to clogging outlet structure or water flow is impeded
Low permeability check dams and weirs	A, S		Sediment, vegetation, or debris accumulated at or blocking (or having the potential to block) check dam, flow control weir or orifice	Clear the blockage
	A, S		Erosion and/or undercutting present	Repair and take preventative measures to prevent future erosion and/or undercutting
	A		Grade board or top of weir damaged or not level	Restore to level position

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

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Table 3 (continued). Maintenance Standards and Procedures for Bioretention Facilities.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Facility Footprint (cont'd)				
Ponded water	B, S		Excessive ponding water: Water overflows during storms smaller than the design event or ponded water remains in the basin 48 hours or longer after the end of a storm.	Determine cause and resolve in the following order: 1) Confirm leaf or debris buildup in the bottom of the facility is not impeding infiltration. If necessary, remove leaf litter/debris. 2) Ensure that underdrain (if present) is not clogged. If necessary, clear underdrain. 3) Check for other water inputs (e.g., groundwater, illicit connections). 4) Verify that the facility is sized appropriately for the contributing area. Confirm that the contributing area has not increased. If steps #1-4 do not solve the problem, the bioretention soil is likely clogged by sediment accumulation at the surface or has become overly compacted. Dig a small hole to observe soil profile and identify compaction depth or clogging front to help determine the soil depth to be removed or otherwise rehabilitated (e.g., tilled). Consultation with an engineer is recommended.
Bioretention soil media	As needed		Bioretention soil media protection is needed when performing maintenance requiring entrance into the facility footprint	• Minimize all loading in the facility footprint (foot traffic and other loads) to the degree feasible in order to prevent compaction of bioretention soils. • Never drive equipment or apply heavy loads in facility footprint. • Because the risk of compaction is higher during saturated soil conditions, any type of loading in the cell (including foot traffic) should be minimized during wet conditions. • Consider measures to distribute loading if heavy foot traffic is required or equipment must be placed in facility. As an example, boards may be placed across soil to distribute loads and minimize compaction. • If compaction occurs, soil must be loosened or otherwise rehabilitated to original design state.
Inlets/Outlets/Pipes				
Splash block inlet	A		Water is not being directed properly to the facility and away from the inlet structure	Reconfigure/ repair blocks to direct water to facility and away from structure
Curb cut inlet/outlet	M during the wet season and before severe storm is forecasted	Weekly during fall leaf drop	Accumulated leaves at curb cuts	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
Pipe inlet/outlet	A		Pipe is damaged	Repair/ replace
	W		Pipe is clogged	Remove roots or debris
	A, S		Sediment, debris, trash, or mulch reducing capacity of inlet/outlet	• Clear the blockage • Identify the source of the blockage and take actions to prevent future blockages
		Weekly during fall leaf drop	Accumulated leaves at inlets/outlets	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
		A	Maintain access for inspections	• Clear vegetation (transplant vegetation when possible) within 1 foot of inlets and outlets, maintain access pathways • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Erosion control at inlet	A		Concentrated flows are causing erosion	Maintain a cover of rock or cobbles or other erosion protection measure (e.g., matting) to protect the ground where concentrated water enters the facility (e.g., a pipe, curb cut or swale)

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

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Table 3 (continued). Maintenance Standards and Procedures for Bioretention Facilities.

	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
Component	**Inspection**	**Routine Maintenance**		
Inlets/Outlets/Pipes (cont'd)				
Trash rack	S		Trash or other debris present on trash rack	Remove/dispose
	A		Bar screen damaged or missing	Repair/replace
Overflow	A, S		Capacity reduced by sediment or debris	Remove sediment or debris/dispose
Underdrain pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	• Plant roots, sediment or debris reducing capacity of underdrain • Prolonged surface ponding (see "Ponded water")	• Jet clean or rotary cut debris/roots from underdrain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly.
Vegetation				
Facility bottom area and upland slope vegetation	Fall and Spring		Vegetation survival rate falls below 75% within first two years of establishment (unless project O&M manual or record drawing stipulates more or less than 75% survival rate).	• Determine cause of poor vegetation growth and correct condition • Replant as necessary to obtain 75% survival rate or greater. Refer to original planting plan, or approved jurisdictional species list for appropriate plant replacements (See Appendix 3 - Bioretention Plant List, in the LID Technical Guidance Manual for Puget Sound). • Confirm that plant selection is appropriate for site growing conditions • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Vegetation (general)	As needed		Presence of diseased plants and plant material	• Remove any diseased plants or plant parts and dispose of in an approved location (e.g., commercial landfill) to avoid risk of spreading the disease to other plants • Disinfect gardening tools after pruning to prevent the spread of disease • See Pacific Northwest Plant Disease Management Handbook for information on disease recognition and for additional resources • Replant as necessary according to recommendations provided for "facility bottom area and upland slope vegetation".
Trees and shrubs		All pruning seasons (timing varies by species)	Pruning as needed	• Prune trees and shrubs in a manner appropriate for each species. Pruning should be performed by landscape professionals familiar with proper pruning techniques • All pruning of mature trees should be performed by or under the direct guidance of an ISA certified arborist
	A		Large trees and shrubs interfere with operation of the facility or access for maintenance	• Prune trees and shrubs using most current ANSI A300 standards and ISA BMPs. • Remove trees and shrubs, if necessary.
	Fall and Spring		Standing dead vegetation is present	• Remove standing dead vegetation • Replace dead vegetation within 30 days of reported dead and dying plants (as practical depending on weather/planting season) • If vegetation replacement is not feasible within 30 days, and absence of vegetation may result in erosion problems, temporary erosion control measures should be put in place immediately. • Determine cause of dead vegetation and address issue, if possible • If specific plants have a high mortality rate, assess the cause and replace with appropriate species. Consultation with a landscape architect is recommended.
	Fall and Spring		Planting beneath mature trees	• When working around and below mature trees, follow the most current ANSI A300 standards and ISA BMPs to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil). • Planting of small shrubs or groundcovers beneath mature trees may be desirable in some cases; such plantings should use mainly plants that come as bulbs, bare root or in 4-inch pots; plants should be in no larger than 1-gallon containers.

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

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Table 3 (continued). Maintenance Standards and Procedures for Bioretention Facilities.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Vegetation (cont'd)				
Trees and shrubs (cont'd)	Fall and Spring		Planting beneath mature trees	• When working around and below mature trees, follow the most current ANSI A300 standards and ISA BMPs to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil). • Planting of small shrubs or groundcovers beneath mature trees may be desirable in some cases; such plantings should use mainly plants that come as bulbs, bare root or in 4-inch pots; plants should be in no larger than 1-gallon containers.
	Fall and Spring		Presence of or need for stakes and guys (tree growth, maturation, and support needs)	• Verify location of facility liners and underdrain (if any) prior to stake installation in order to prevent liner puncture or pipe damage • Monitor tree support systems: Repair and adjust as needed to provide support and prevent damage to tree. • Remove tree supports (stakes, guys, etc.) after one growing season or maximum of 1 year. • Backfill stake holes after removal.
Trees and shrubs adjacent to vehicle travel areas (or areas where visibility needs to be maintained)	A		Vegetation causes some visibility (line of sight) or driver safety issues	• Maintain appropriate height for sight clearance • When continued, regular pruning (more than one time/ growing season) is required to maintain visual sight lines for safety or clearance along a walk or drive, consider relocating the plant to a more appropriate location. • Remove or transplant if continual safety hazard • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Flowering plants		A	Dead or spent flowers present	Remove spent flowers (deadhead)
Perennials		Fall	Spent plants	Cut back dying or dead and fallen foliage and stems
Emergent vegetation		Spring	Vegetation compromises conveyance	• Hand rake sedges and rushes with a small rake or fingers to remove dead foliage before new growth emerges in spring or earlier only if the foliage is blocking water flow (sedges and rushes do not respond well to pruning)
Ornamental grasses (perennial)		Winter and Spring	Dead material from previous year's growing cycle or dead collapsed foliage	• Leave dry foliage for winter interest • Hand rake with a small rake or fingers to remove dead foliage back to within several inches from the soil before new growth emerges in spring or earlier if the foliage collapses and is blocking water flow
Ornamental grasses (evergreen)		Fall and Spring	Dead growth present in spring	• Hand rake with a small rake or fingers to remove dead growth before new growth emerges in spring • Clean, rake, and comb grasses when they become too tall • Cut back to ground or thin every 2-3 years as needed
Noxious weeds		M (March – October, preceding seed dispersal)	Listed noxious vegetation is present (refer to current county noxious weed list)	• By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately • Reasonable attempts must be made to remove and dispose of class C noxious weeds • It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions • Apply mulch after weed removal (see "Mulch")

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

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Table 3 (continued). Maintenance Standards and Procedures for Bioretention Facilities.

	Recommended Frequency [a]			
Component	**Inspection**	**Routine Maintenance**	**Condition when Maintenance is Needed (Standards)**	**Action Needed (Procedures)**
Vegetation (cont'd)				
Weeds		M (March – October, preceding seed dispersal)	Weeds are present	• Remove weeds with their roots manually with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate • Follow IPM protocols for weed management (see “Additional Maintenance Resources” section for more information on IPM protocols)
Excessive vegetation		Once in early to mid- May and once in early- to mid-September	Low-lying vegetation growing beyond facility edge onto sidewalks, paths, or street edge poses pedestrian safety hazard or may clog adjacent permeable pavement surfaces due to associated leaf litter, mulch, and soil	• Edge or trim groundcovers and shrubs at facility edge • Avoid mechanical blade-type edger and do not use edger or trimmer within 2 feet of tree trunks • While some clippings can be left in the facility to replenish organic material in the soil, excessive leaf litter can cause surface soil clogging
	As needed		Excessive vegetation density inhibits stormwater flow beyond design ponding or becomes a hazard for pedestrian and vehicular circulation and safety	• Determine whether pruning or other routine maintenance is adequate to maintain proper plant density and aesthetics • Determine if planting type should be replaced to avoid ongoing maintenance issues (an aggressive grower under perfect growing conditions should be transplanted to a location where it will not impact flow) • Remove plants that are weak, broken or not true to form; replace in-kind • Thin grass or plants impacting facility function without leaving visual holes or bare soil areas • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
	As needed		Vegetation blocking curb cuts, causing excessive sediment buildup and flow bypass	• Remove vegetation and sediment buildup
Mulch				
Mulch		Following weeding	Bare spots (without mulch cover) are present or mulch depth less than 2 inches	• Supplement mulch with hand tools to a depth of 2 to 3 inches • Replenish mulch per O&M manual. Often coarse compost is used in the bottom of the facility and arborist wood chips are used on side slopes and rim (above typical water levels) • Keep all mulch away from woody stems
Watering				
Irrigation system (if any)		Based on manufacturer's instructions	Irrigation system present	• Follow manufacturer's instructions for O&M
	A		Sprinklers or drip irrigation not directed/located to properly water plants	• Redirect sprinklers or move drip irrigation to desired areas
Summer watering (first year)		Once every 1-2 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in first year of establishment period	• 10 to 15 gallons per tree • 3 to 5 gallons per shrub • 2 gallons water per square foot for groundcover areas • Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist • Use soaker hoses or spot water with a shower type wand when irrigation system is not present ○ Pulse water to enhance soil absorption, when feasible ○ Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff • Add a tree bag or slow-release watering device (e.g., bucket with a perforated bottom) for watering newly installed trees when irrigation system is not present

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

IPM – Integrated Pest Management

ISA – International Society of Arboriculture

Table 3 (continued). Maintenance Standards and Procedures for Bioretention Facilities.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Watering (cont'd)				
Summer watering (second and third years)		Once every 2-4 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in second or third year of establishment period	• 10 to 15 gallons per tree • 3 to 5 gallons per shrub • 2 gallons water per square foot for groundcover areas • Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist • Use soaker hoses or spot water with a shower type wand when irrigation system is not present ○ Pulse water to enhance soil absorption, when feasible ○ Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff
Summer watering (after establishment)		As needed	Established vegetation (after 3 years)	• Plants are typically selected to be drought tolerant and not require regular watering after establishment; however, trees may take up to 5 years of watering to become fully established • Identify trigger mechanisms for drought-stress (e.g., leaf wilt, leaf senescence, etc.) of different species and water immediately after initial signs of stress appear • Water during drought conditions or more often if necessary to maintain plant cover
Pest Control				
Mosquitoes	B, S		Standing water remains for more than 3 days after the end of a storm	• Identify the cause of the standing water and take appropriate actions to address the problem (see "Ponded water") • To facilitate maintenance, manually remove standing water and direct to the storm drainage system (if runoff is from non pollution-generating surfaces) or sanitary sewer system (if runoff is from pollution-generating surfaces) after getting approval from sanitary sewer authority. • Do not use pesticides or *Bacillus thuringiensis israelensis* (Bti)
Nuisance animals	As needed		Nuisance animals causing erosion, damaging plants, or depositing large volumes of feces	• Reduce site conditions that attract nuisance species where possible (e.g., plant shrubs and tall grasses to reduce open areas for geese, etc.) • Place predator decoys • Follow IPM protocols for specific nuisance animal issues (see "Additional Maintenance Resources" section for more information on IPM protocols) • Remove pet waste regularly • For public and right-of-way sites consider adding garbage cans with dog bags for picking up pet waste.
Insect pests	Every site visit associated with vegetation management		Signs of pests, such as wilting leaves, chewed leaves and bark, spotting or other indicators	• Reduce hiding places for pests by removing diseased and dead plants • For infestations, follow IPM protocols (see "Additional Maintenance Resources" section for more information on IPM protocols)

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

IPM – Integrated Pest Management

ISA – International Society of Arboriculture

Additional Maintenance Resources

Useful related guidance documents include the following:

- LID Technical Guidance Manual for Puget Sound: http://www.wastormwatercenter.org/files/library/lid-manual-2012-final-secure.pdf.
- Natural Lawn and Garden Care resources (King County and SPU 2008; Saving Water Partnership 2006, 2007, and 2012) include guidance on building healthy soil with compost and mulch, selecting appropriate plants, watering, using alternatives to pesticides, and implementing natural lawn care techniques.
- Integrated Pest Management (IPM) protocols (the term "pest" covers a broad range of species including harmful insects, plant pathogens, rodents, and weedy vegetation) provide an approach to pest control that uses regular monitoring to determine if and when treatments are needed, and employs physical, mechanical, cultural, and biological tactics to keep pest numbers low enough to prevent intolerable damage or annoyance (Ecology 2012c) while avoiding or minimizing the use of pesticides and fertilizers herbicides as a management strategy.
- See EPA's website for general information on IPM: www.epa.gov/pesticides/factsheets/ipm.htm
- See the City of Seattle's website for IPM Fact Sheets and Washington specific resources: www.seattle.gov/util/forbusinesses/landscapes/integrated_pest_management
- The International Society of Arboriculture (ISA) is a group that promotes the professional practice of arboriculture and fosters a greater worldwide awareness of the benefits of trees through research, technology, and education. ISA standards used for managing trees, shrubs, and other woody plants are the American National Standards Institute (ANSI) A300 standards. The ANSI A300 standards are voluntary industry consensus standards developed by the Tree Care Industry Association (TCIA) and written by the Accredited Standards Committee (ASC). The ANSI standards can be found on the ISA website: www.isa-arbor.com/education/publications/index.aspx.
- Volume IV (Source Control) of Ecology's 2012 SWMMWW provides guidance on herbicide and pesticide application and alternative management strategies for controlling weeds and pests.
- WSU Weeding Guidelines: http://gardening.wsu.edu
- Pacific Northwest Plant Disease Management Handbook for information on disease recognition and for additional resources: http://pnwhandbooks.org/plantdisease/diagnosis-and-testing/disease-diagnosis-and-control

These resources are supplemental and do not supersede guidance provided in the S*tandards and Procedures* tables.

Equipment and Materials

Table 4 includes recommendations for equipment and materials commonly used to maintain bioretention facilities. Some of the equipment and materials will be used for routine maintenance activities, while other equipment and materials will be necessary for specialized maintenance.

Table 4. Bioretention Equipment and Materials List.

Landscaping equipment

☐ Gloves
☐ Weeding tool
☐ Soil knife
☐ Pruners
☐ Loppers
☐ Stakes and guys
☐ Manual edger
☐ Line trimmer (also known as a string trimmer, weed eater, or weed whacker)
☐ Rototiller
☐ Hoe
☐ Rake
☐ Wheelbarrow
☐ Shovel
☐ Push broom
☐ Hand tamper
☐ Blade sharpeners
☐ Tarp/ Buckets (to remove leaf litter/debris)
☐ Garbage bags (for disposal of trash/noxious weeds)
☐ Bark and mulch blower
☐ Boards to stand on during maintenance to prevent soil compaction (if maintenance is necessary during periods when Bioretention media is wet)

Watering equipment

☐ Soaker hose
☐ Hose/shower-type wand
☐ Sprinklers
☐ Tree watering bags
☐ Buckets
☐ Keys for irrigation boxes
☐ Water source (e.g., watering truck), if necessary

Landscaping materials*

☐ Plants
☐ Stakes and ties

Erosion control material*

☐ Rock or cobbles for rock pad
☐ Erosion control matting

Mulch

☐ Arborist wood chip mulch
☐ Coarse compost mulch
☐ Rock mulch

Pipe/structure inspection and maintenance equipment

☐ Hand tools
☐ Wrench or manhole lifter (for opening manhole lids, grates, etc.)
☐ Flashlight
☐ Mirror (for viewing pipes without entering structure)
☐ Garden hose
☐ Plumbing snake
☐ Measuring tape or ruler

Specialized equipment*

☐ Mini excavator
☐ Vactor truck
☐ Manual seed broadcaster
☐ Soil monitoring equipment (T handle core sampler, soil auger, soil nutrient test kit)
☐ Flame weeder or hot water weeder
☐ Water jet or root saw (Vactor truck tools) for clearing roots from underdrains
☐ Equipment for infiltration testing

Bioretention soil*

☐ Bioretention soil per design specifications

* Items not required for routine maintenance

Skills and Staffing

The skills required for maintenance of bioretention facilities are listed in the text box to the right. Additional specialized skills may also be required for corrective maintenance such as: horticulturalists, arborists, erosion control specialists, engineers, landscape architects, and soil scientists.

The staff effort required for maintenance varies. Table 5 provides some examples of staffing estimates from Washington jurisdictions, the City of Portland, a study conducted among Minnesota jurisdictions (Wilson et al. 2008), and the BMP and LID Whole Life Cost Models (WERF 2009). Annual staff hours are listed for an individual facility (i.e., a "typical" facility of undefined area), 1,000 square feet of facility, or 1,000 linear feet of facility.

Skills Needed for Maintenance of Bioretention Facilities

- Landscaping skills (e.g., general plant care)
- Plant identification skills (weeds vs. planted species, invasive vs. common weeds, how to dispose of invasive weeds, timing of weed seed dispersal)
- Erosion control knowledge
- General drainage system maintenance skills (e.g., inlet/pipe/underdrain cleaning experience, inlet/ pipe maintenance or repair experience)
- Operation of specialized equipment
- Engineer and/or landscape architect for major maintenance
- Certified arborist (or equivalently trained staff) for pruning of mature trees

Table 5. Maintenance Frequency and Staffing for Bioretention Facilities.

Routine Maintenance Activity	Frequency [a]	Annual Staff Hours	Source
General (no activity specified)	A or B	1 to 16 hours (per facility)	Maintenance of Stormwater BMPs: Frequency, Effort, and Cost (Wilson et al. 2008)
Vegetation management	A	0 to 2 hours (per facility)	BMP and LID Whole Life Cost Models (WERF 2009)
General (no activity specified)	M	24 hours (per 1,000 sf)	City of Bellevue
General (no activity specified)	M	16 hours (per facility)	Kitsap County
Weeding	M (May-Sept)	7 hours (per 1,000 lf)	Thurston County
Replanting and mulching	A		
Typical facility maintenance	Q	10 to 30 hours [b] (per 1,000 sf)	City of Portland
More complex site maintenance [c]	> Q	14 to 38 hours [b] (per 1,000 sf)	
General (no activity specified)	Unspecified	10 hours (per 1,000 sf)	City of Olympia

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; Q = Quarterly (four times per year)
[b] Low end of range pertains to City staff and high end of range pertains to Contractor staff
[c] Deciduous canopy, poor soils, adjacent weed vectors, unmaintained commercial right-of-way
lf = linear feet
sf = square feet

Staffing estimates averaged approximately 16 to 22 hours per bioretention facility on an annual basis. The City of Portland estimated that bioretention facilities with more complex maintenance requirements could require up to 38 hours of staff time when using less seasoned maintenance crews.

Rain Gardens

Rain gardens are non-engineered, shallow, landscaped depressions with compost-amended soils and adapted plants. The depression temporarily stores stormwater runoff from adjacent areas. Some or all of the influent stormwater passes through the amended soil profile and into the underlying native soil. Stormwater that exceeds the storage capacity is designed to overflow to an adjacent drainage system.

Key Maintenance Considerations

The main components of rain gardens (and the associated maintenance considerations) are very similar to those listed for bioretention facilities. However, rain gardens do not require an engineered soil mix (native soils may be amended) and usually do not have underdrains or other control structures.

Fertilizer use should be avoided in rain gardens, particularly those located in watersheds draining to phosphorous limited water bodies.

Key Operations to Preserve Facility Function

As explained for bioretention facilities, rain gardens must be protected from foot traffic, vehicles and other loads, particularly during wet conditions, to prevent compaction of the amended soil and preserve infiltration capacity.

Signage can also be used to identify the vegetated area as a stormwater BMP and inform maintenance crews and the general public about protecting the rain garden’s function (e.g., no walking in the garden).

Maintenance Standards and Procedures

Table 6 provides the recommended maintenance frequencies, standards, and procedures for rain garden components. For guidance on underdrains, check dams and other control structures, see “Bioretention Facilities”.

Table 6. Maintenance Standards and Procedures for Rain Gardens.

	Recommended Frequency [a]			
Component	**Inspection**	**Routine Maintenance**	**Condition when Maintenance is Needed (Standards)**	**Action Needed (Procedures)**
Rain Garden Footprint				
Earthen side slopes	B (during the wet season)		Persistent soil erosion on slopes	If erosion persists, water may be flowing into the garden too rapidly. In this case, the slope of the pipe or swale directing water to the garden, or the amount of water may need to be reduced (see “Erosion control at inlet”)
Rockery sidewalls	A		Rockery side walls are insecure	Stabilize rockery sidewalls (may require consultation with engineer, particularly for walls 4 feet or greater in height)
Rain garden footprint		B	Trash and debris present	Clean out trash and debris
Rain garden bottom area	A		Visible sediment deposition in the rain garden that reduces drawdown time of water in the rain garden	• Remove sediment accumulation • If sediment is deposited from water entering the rain garden, determine the source and stabilize the area
		During/after fall leaf drop	Accumulated leaves in rain garden (may reduce infiltration capacity of rain garden or clog overflow)	Remove leaves
Ponded water	B, S		Excessive ponding water: Ponded water remains in the basin more than 3 days after the end of a storm	Confirm leaf, debris or sediment buildup in the bottom of the rain garden is not impeding infiltration. If necessary, remove leaf litter/debris/sediment. If this does not solve the problem, consultation with a professional with rain garden expertise is recommended to evaluate the following: • Check for other water inputs (e.g., groundwater, illicit connections) • Verify that the facility is sized appropriately for the contributing area. Confirm that the contributing area has not increased • Determine if the soil is clogged by sediment accumulation at the surface or if the soil has become overly compacted

[a] Frequency: A = Annually; B = Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

Table 6 (continued). Maintenance Standards and Procedures for Rain Gardens.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Inlets/Outlets/Pipes				
Splash block inlet	A		Water is not being directed properly to the rain garden and away from the building	Reconfigure/ repair blocks to direct water to the rain garden and away from building
Pipe inlet/ outlet	A		Pipe capacity is reduced by sediment or debris (can cause backups and flooding)	Clear pipes of sediment and debris
	A		Damaged/cracked drain pipes	• Repair/seal cracks • Replace when repair is insufficient
Erosion control at inlet	A		Rock or cobble is removed or missing and concentrated flows are contacting soil	Maintain a cover of rock or cobbles to protect the ground where concentrated water flows into the rain garden from a pipe or swale
Vegetation				
Vegetation		As needed	Dying, dead, or unhealthy plants	• Maintain a healthy cover of plants • Remove any diseased plants or plant parts and dispose of in commercial landfill to avoid risk of spreading the disease to other plants • Disinfect gardening tools after pruning to prevent the spread of disease • Re-stake trees if they need more support, but plan to remove stakes and ties after the first year • Cars can damage roots – protect root areas of trees and plants from vehicle traffic
		As needed	Vegetation inhibits sight distances and sidewalks	Keep sidewalks and sight distances on roadways clear
		As needed	Broken, dead, or sucker vegetation is present	Remove broken or dead branches and suckers
		As needed	Vegetation is crowding inlets and outlets	Keep water inlets and outlets in the rain garden clear of vegetation

[a] Frequency: A = Annually; B = Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

Table 6 (continued). Maintenance Standards and Procedures for Rain Gardens.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Vegetation (cont'd)				
Vegetation (cont'd)		As needed	Broken, dead, or sucker vegetation is present	Remove broken or dead branches and suckers
		As needed	Vegetation is crowding inlets and outlets	Keep water inlets and outlets in the rain garden clear of vegetation
	One time March through June		• Yellowing: possible Nitrogen (N) deficiency • Poor growth: possible Phosphorous (P) deficiency • Poor flowering, spotting or curled leaves, or weak roots or stems: possible Potassium (K) deficiency	• Test soil to identify specific nutrient deficiencies • Consult with a professional knowledgeable in the area of natural amendments or refer to Natural Lawn and Garden Care resources and avoid synthetic fertilizers • Consider selecting different plants for soil conditions
Weeds		As needed, preceding seed dispersal	Problem weeds are present	• Remove weeds by hand, especially in spring when the soil is moist and the weeds are small • Dig or pull weeds out by the roots before they go to seed • Apply mulch after weeding (see "Mulch")
Mulch				
Mulch		Following weeding	Bare spots (without mulch cover) are present or mulch depth less than 2 inches	• Supplement mulch with hand tools to a depth of 2 to 3 inches • Use coarse compost in the bottom of the rain garden and arborist wood chips on side slopes and rim (above typical water levels) • Keep all mulch from being in contact with woody stems.

[a] Frequency: A = Annually; B = Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

Table 6 (continued). Maintenance Standards and Procedures for Rain Gardens.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Watering				
Summer watering (first year)		Once every 1-2 weeks or as needed during prolonged dry periods	Tree, shrubs and groundcovers in first year of establishment period	• 10 to 15 gallons per tree • 3 to 5 gallons per shrub • 2 gallons water per square foot for groundcover areas • Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist • Use soaker hoses or spot water with a shower type wand when irrigation system is not present • Add a tree bag or slow-release watering device (e.g., bucket with a perforated bottom) for watering newly installed trees when irrigation system is not present
Summer watering (second and third years)		Once every 2-4 weeks or as needed during prolonged dry periods	Tree, shrubs and groundcovers in second or third year of establishment period	• 10 to 15 gallons per tree • 3 to 5 gallons per shrub • 2 gallons water per square foot for groundcover areas • Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist • Use soaker hoses or spot water with a shower type wand when irrigation system is not present
Summer watering (after establishment)		As needed	Established vegetation (after 3 years)	• Water during drought conditions or more often if necessary to maintain plant cover • Identify trigger mechanisms for drought-stress (e.g., leaf wilt, leaf senescence, etc.) of different rain garden species and water immediately after initial signs of stress appear

[a] Frequency: A = Annually; B = Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

Table 6 (continued). Maintenance Standards and Procedures for Rain Gardens.				
	Recommended Frequency [a]			
Component	Inspection	Routine Maintenance	Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
Pest Control				
Mosquitoes	B, S		Standing water remains for more than 3 days after the end of a storm	• Identify the cause of the standing water and take appropriate actions to address the problem (see "Ponded water") • Do not use pesticides or *Bacillus thuringiensis israelensis* (Bti)

[a] Frequency: A = Annually; B = Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

Additional Maintenance Resources

In addition to the resources listed for bioretention, useful guidance for rain gardens can be found in the Rain Garden Handbook for Western Washington Homeowners (http://www.wastormwatercenter.org/low-impact/). These resources are supplemental and do not supersede guidance provided in the Standards and Procedures tables.

Equipment and Materials

Table 7 includes recommendations for equipment and materials commonly used to maintain rain gardens. Some of the equipment and materials will be used for routine maintenance activities, while other equipment and materials will be necessary for specialized maintenance.

Table 7. Rain Garden Equipment and Materials List.

Landscaping equipment

- ☐ **Gloves**
- ☐ **Weeding tool**
- ☐ **Soil knife**
- ☐ **Pruners**
- ☐ **Loppers**
- ☐ **Stakes and guys**
- ☐ **Manual edger**
- ☐ **Line trimmer (also known as a string trimmer, weed eater, or weed whacker)**
- ☐ **Rototiller**
- ☐ **Hoe**
- ☐ **Rake**
- ☐ **Wheelbarrow**
- ☐ **Shovel**
- ☐ **Push broom**
- ☐ **Hand tamper**
- ☐ **Blade sharpeners**
- ☐ **Tarp/Buckets (to remove leaf litter/debris)**
- ☐ **Garbage bags (for disposal of trash/noxious weeds)**

Watering equipment

- ☐ **Soaker hose**
- ☐ **Hose/shower-type wand**
- ☐ **Sprinklers**
- ☐ **Tree watering bags**
- ☐ **Buckets**

Mulch

- ☐ **Arborist wood chip mulch**
- ☐ **Coarse compost mulch**
- ☐ **Rock mulch**

Landscaping materials*

- ☐ **Plants**

Erosion control materials*

- ☐ **Rock or cobbles for rock pad**
- ☐ **Erosion control matting**

Soil*

- ☐ **Compost (for soil amendment)**
- ☐ **Bioretention soil mix**

* Items not required for routine maintenance

Permeable Pavement

Permeable pavement is a paving system which allows rainfall to percolate through the surface into the underlying soil or an aggregate bed, where stormwater is stored and infiltrated to underlying subgrade, or removed by an overflow drainage system. Permeable pavement facilities are considered Stormwater Treatment and Flow Control BMPs and can be used to meet Minimum Requirements #6 (treatment), #7 (flow control), or both. To satisfy Minimum Requirement #6, stormwater must be infiltrated into underlying soils that meet Ecology's soil treatment requirements or filtered through an engineered treatment layer included in the pavement section.

Key Maintenance Considerations

The main components of permeable pavement facilities are listed below with descriptions of their function and key maintenance considerations.

- **Wearing course**: The surface layer of any permeable pavement system is the wearing course. Categories of wearing courses include:
    - Porous asphalt**:** A flexible pavement similar to standard asphalt that uses a bituminous binder to adhere aggregate. However, the fine material (sand and finer) is reduced or eliminated, resulting in the formation of voids between the aggregate in the pavement surface that allows water to infiltrate to the underlying aggregate base.
    - Pervious concrete**:** A rigid pavement similar to conventional concrete that uses a cementitious material to bind aggregate together. However, the fine aggregate (sand) component is reduced or eliminated in the gradation, resulting in the formation of voids between the aggregate in the pavement surface that allows water to infiltrate to the underlying aggregate base.
    - Interlocking concrete paver blocks: Solid, precast, manufactured modular units. Pavements constructed with these units create joints that are filled with permeable aggregate and installed on an open-graded aggregate base.
    - Aggregate Pavers (or Pervious Pavers): Modular precast paving units made with uniformly sized aggregates and bound with Portland cement concrete using a high strength adhesive. Unlike concrete paver blocks, these pavers are permeable. Pavements constructed with these units create joints that are filled with permeable aggregate and installed on an open-graded aggregate base.
    - Open-celled paving grid with gravel**:** Concrete or plastic grids that are filled with permeable aggregate. The system can be installed on an open-graded aggregate base.
    - Open-celled paving grid with grass**:** Concrete or plastic grids that are filled with a mix of sand, gravel, and topsoil for planting vegetation. The cells can be planted with a variety of non-turf forming grasses or low-growing groundcovers. The system can be installed on an open-graded aggregate base.

A critical component of a successful maintenance program is regular removal of sediment and debris, excessive moss from the facility surface to prevent clogging of the permeable wearing course.

- **Inlet (optional):** While permeable pavement facilities often manage only the rain falling directly on the pavement surface, they may also be designed to accept stormwater runoff from additional areas (e.g., adjacent impervious areas, nearby rooftops). Runoff can be directed to the facility by two main methods:
    - Sheet flow to the surface: Surface areas of the facility receiving runoff contributions will likely be prone to clogging due to sediment inputs, particularly in areas of concentrated inflow. These areas should be carefully inspected and corrective maintenance should be performed as necessary to maintain the function of the pavement at these sites. In addition, the source of the sediment loads should be evaluated to determine if modifications to features in the drainage area landscape (e.g., stabilization of adjacent planted areas) would help to prevent clogging.
    - Piped flow into the aggregate base: Pipes dispersing water into the aggregate bed should be designed with cleanout access to allow pipe maintenance. Runoff that is piped into the aggregate base should be pretreated for sediment removal (e.g., screens, sumps) to protect the subbase from sedimentation and clogging. The pretreatment system must be maintained to remove accumulated sediment.
- **Aggregate Base / Storage Reservoir:** Stormwater passes through the wearing course to an underlying aggregate storage reservoir where it is stored prior to infiltration into the underlying soil. This aggregate bed also provides the structural function of supporting design loads (e.g., vehicle loading) for flexible pavement systems. To allow inspection of the aggregate course, some facilities have an observation port (typically installed during construction) that allows monitoring of the water levels in the aggregate bed to determine if the facility is draining properly.
- **Overflow:** Unless designed to provide full infiltration of stormwater, permeable pavement facilities have an overflow. Facility overflow can be provided by subsurface slotted drain pipe(s) (elevated in the aggregate bed) routed to an inlet or catch basin structure or by lateral flow through the storage reservoir to a daylighted drainage system.
- **Underdrain with flow restrictor (optional):** A slotted drain pipe with flow restrictor assembly may be installed at the bottom of or elevated within the aggregate storage reservoir. Permeable pavement facilities with underdrains and flow restrictors operate as underground detention systems with some infiltration.

Key Operations to Preserve Facility Function

There are several permeable pavement operational actions that can limit the likelihood of corrective maintenance actions or replacement including the following:

- Prohibiting use of sealant on porous asphalt
- Protecting from construction site runoff with proper temporary erosion and sediment controls and flow diversion measures
- Modifying utility cut procedures for permeable pavements. Protocols should *recommend* restoring permeable pavement section in-kind, where feasible, and *require* restoring permeable pavement section in-kind where replacement with conventional pavement would impact overall facility function. Replacing permeable pavement with conventional pavement is acceptable if it is a small percentage of the total facility area and does not impact the overall facility function.
- Modifying snow removal procedures such as:
    - Using a snow plow with skids or rollers to slightly raise the blade above permeable pavers or open-celled paving grid systems to prevent loss of top course aggregate and damage to paver blocks or grids
    - Avoiding stockpiling plowed snow (i.e., dirty snow) directly on top of permeable pavement
    - Avoiding application of sand to pervious pavement and adjacent streets where vehicles may track it onto the pervious pavement. If sand is applied, on an emergency basis during snowy conditions, vacuum sweep surface as soon as possible after the sand is no longer needed.
    - Use alternative deicers in moderation (e.g., salt, molasses-based and chemical deicers).
- Protecting the surface from stockpiles of landscaping materials (e.g., mulch, soil, compost) being used for adjacent pervious areas
- Stabilizing adjacent landscaped areas to avoid eroding soil and clogging surfaces or sloping adjacent landscaped areas away from permeable pavement , if possible

Signage or pavement marking can also be used to identify permeable pavement as a stormwater BMP and inform maintenance crews and the general public about protecting the facility’s function (e.g., no stockpiling of soils or mulch on pavement surface).

Maintenance Standards and Procedures

Table 8 provides the recommended maintenance frequencies, standards, and procedures for permeable pavement components. The level of routine maintenance required and the frequency of corrective maintenance actions may increase for facilities receiving high sediment loads (e.g., sanding) or facilities subject to extended wet, shady conditions where moss may accumulate.

Table 8. Maintenance Standards and Procedures for Permeable Pavement.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Surface/Wearing Course				
Permeable Pavements, all	A, S		Runoff from adjacent pervious areas deposits soil, mulch or sediment on paving	• Clean deposited soil or other materials from permeable pavement or other adjacent surfacing • Check if surface elevation of planted area is too high, or slopes towards pavement, and can be regraded (prior to regrading, protect permeable pavement by covering with temporary plastic and secure covering in place) • Mulch and/or plant all exposed soils that may erode to pavement surface
Porous asphalt or pervious concrete		A or B	None (routine maintenance)	Clean surface debris from pavement surface using one or a combination of the following methods: • Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Vacuum/sweep permeable paving installation using: ○ Walk-behind vacuum (sidewalks) ○ High efficiency regenerative air or vacuum sweeper (roadways, parking lots) ○ ShopVac or brush brooms (small areas) • Hand held pressure washer or power washer with rotating brushes Follow equipment manufacturer guidelines for when equipment is most effective for cleaning permeable pavement. Dry weather is more effective for some equipment.
	A[b]		Surface is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	• Review the overall performance of the facility (note that small clogged areas may not reduce overall performance of facility) • Test the surface infiltration rate using ASTM C1701 as a corrective maintenance indicator. Perform one test per installation, up to 2,500 square feet. Perform an additional test for each additional 2,500 square feet up to 15,000 square feet total. Above 15,000 square feet, add one test for every 10,000 square feet. • If the results indicate an infiltration rate of 10 inches per hour or less, then perform corrective maintenance to restore permeability. To clean clogged pavement surfaces, use one or combination of the following methods: • Combined pressure wash and vacuum system calibrated to not dislodge wearing course aggregate. • Hand held pressure washer or power washer with rotating brushes • Pure vacuum sweepers Note: If the annual/biannual routine maintenance standard to clean the pavement surface is conducted using equipment from the list above, corrective maintenance may not be needed.
	A		Sediment present at the surface of the pavement	• Assess the overall performance of the pavement system during a rain event. If water runs off the pavement and/or there is ponding then see above. • Determine source of sediment loading and evaluate whether or not the source can be reduced/eliminated. If the source cannot be addressed, consider increasing frequency of routine cleaning (e.g., twice per year instead of once per year).
	Summer		Moss growth inhibits infiltration or poses slip safety hazard	• Sidewalks: Use a stiff broom to remove moss in the summer when it is dry • Parking lots and roadways: Pressure wash, vacuum sweep, or use a combination of the two for cleaning moss from pavement surface. May require stiff broom or power brush in areas of heavy moss.
	A		Major cracks or trip hazards and concrete spalling and raveling	• Fill potholes or small cracks with patching mixes • Large cracks and settlement may require cutting and replacing the pavement section. Replace in-kind where feasible. Replacing porous asphalt with conventional asphalt is acceptable if it is a small percentage of the total facility area and does not impact the overall facility function. • Take appropriate precautions during pavement repair and replacement efforts to prevent clogging of adjacent porous materials

[a] Frequency: A= Annually; B= Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

Table 8 (continued). Maintenance Standards and Procedures for Permeable Pavement.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Surface/Wearing Course (cont'd)				
Interlocking concrete paver blocks and aggregate pavers		A or B	None (routine maintenance)	Clean pavement surface using one or a combination of the following methods: • Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Vacuum/sweep permeable paving installation using: ○ Walk-behind vacuum (sidewalks) ○ High efficiency regenerative air or vacuum sweeper (roadways, parking lots) ○ ShopVac or brush brooms (small areas) • Note: Vacuum settings may have to be adjusted to prevent excess uptake of aggregate from paver openings or joints. Vacuum surface openings in dry weather to remove dry, encrusted sediment.
	A [b]		Surface is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)]	• Review the overall performance of the facility (note that small clogged areas may not reduce overall performance of facility) • Test the surface infiltration rate using ASTM C1701 as a corrective maintenance indicator. Perform one test per installation, up to 2,500 square feet. Perform an additional test for each additional 2,500 square feet up to 15,000 square feet total. Above 15,000 square feet, add one test for every 10,000 square feet. • If the results indicate an infiltration rate of 10 inches per hour or less, then perform corrective maintenance to restore permeability. • Clogging is usually an issue in the upper 2 to 3 centimeters of aggregate. Remove the upper layer of encrusted sediment, and fines, and/or vegetation from openings and joints between the pavers by mechanical means and/or suction equipment (e.g., pure vacuum sweeper). • Replace aggregate in paver cells, joints, or openings per manufacturer's recommendations
	A		Sediment present at the surface of the pavement	• Assess the overall performance of the pavement system during a rain event. If water runs off the pavement and/or there is ponding, then see above. • Determine source of sediment loading and evaluate whether or not the source can be reduced/eliminated. If the source cannot be addressed, consider increasing frequency of routine cleaning (e.g., twice per year instead of once per year).
	Summer		Moss growth inhibits infiltration or poses slip safety hazard	• Sidewalks: Use a stiff broom to remove moss in the summer when it is dry • Parking lots and roadways: Vacuum sweep or stiff broom/power brush for cleaning moss from pavement surface
	A		Paver block missing or damaged	Remove individual damaged paver blocks by hand and replace or repair per manufacturer's recommendations
	A		Loss of aggregate material between paver blocks	Refill per manufacturer's recommendations for interlocking paver sections
	A		Settlement of surface	May require resetting
Open-celled paving grid with gravel		A or B	None (routine maintenance)	• Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Follow equipment manufacturer guidelines for cleaning surface.
	A [b]		Aggregate is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)]	• Use vacuum truck to remove and replace top course aggregate • Replace aggregate in paving grid per manufacturer's recommendations
	A		Paving grid missing or damaged	• Remove pins, pry up grid segments, and replace gravel • Replace grid segments where three or more adjacent rings are broken or damaged • Follow manufacturer guidelines for repairing surface.
	A		Settlement of surface	May require resetting
	A		Loss of aggregate material in paving grid	Replenish aggregate material by spreading gravel with a rake (gravel level should be maintained at the same level as the plastic rings or no more than 1/4 inch above the top of rings). See manufacturer's recommendations.
		A	Weeds present	• Manually remove weeds • Presence of weeds may indicate that too many fines are present (refer to Actions Needed under "Aggregate is clogged" to address this issue)

[a] Frequency: A= Annually; B= Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).
[b] Inspection should occur during storm event.

Table 8 (continued). Maintenance Standards and Procedures for Permeable Pavement.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Surface/Wearing Course (cont'd)				
Open-celled paving grid with grass		A or B	None (routine maintenance)	• Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Follow equipment manufacturer guidelines for cleaning surface.
	A [b]		Aggregate is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)]	• Rehabilitate per manufacturer's recommendations.
	A		Paving grid missing or damaged	• Remove pins, pry up grid segments, and replace grass • Replace grid segments where three or more adjacent rings are broken or damaged • Follow manufacturer guidelines for repairing surface.
	A		Settlement of surface	• May require resetting
	A		Poor grass coverage in paving grid	• Restore growing medium, reseed or plant, aerate, and/or amend vegetated area as needed • Traffic loading may be inhibiting grass growth; reconsider traffic loading if feasible
		As needed	None (routine maintenance)	• Use a mulch mower to mow grass
		A	None (routine maintenance)	• Sprinkle a thin layer of compost on top of grass surface (1/2" top dressing) and sweep it in • Do not use fertilizer
		A	Weeds present	• Manually remove weeds • Mow, torch, or inoculate and replace with preferred vegetation
Inlets/Outlets/Pipes				
Inlet/outlet pipe	A		Pipe is damaged	Repair/replace
	A		Pipe is clogged	Remove roots or debris
Underdrain pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	Plant roots, sediment or debris reducing capacity of underdrain (may cause prolonged drawdown period)	• Jet clean or rotary cut debris/roots from underdrain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly
Raised subsurface overflow pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	Plant roots, sediment or debris reducing capacity of underdrain	• Jet clean or rotary cut debris/roots from under-drain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly
Outlet structure	A, S		Sediment, vegetation, or debris reducing capacity of outlet structure	• Clear the blockage • Identify the source of the blockage and take actions to prevent future blockages

[a] Frequency: A= Annually; B= Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

Table 8 (continued). Maintenance Standards and Procedures for Permeable Pavement.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Inlets/Outlets/Pipes (cont'd)				
Overflow	B		Native soil is exposed or other signs of erosion damage are present at discharge point	Repair erosion and stabilize surface
Aggregate Storage Reservoir				
Observation port	A, S		Water remains in the storage aggregate longer than anticipated by design after the end of a storm	If immediate cause of extended ponding is not identified, schedule investigation of subsurface materials or other potential causes of system failure.
Vegetation				
Adjacent large shrubs or trees		As needed	Vegetation related fallout clogs or will potentially clog voids	• Sweep leaf litter and sediment to prevent surface clogging and ponding • Prevent large root systems from damaging subsurface structural components
		Once in May and Once in September	Vegetation growing beyond facility edge onto sidewalks, paths, and street edge	Edging and trimming of planted areas to control groundcovers and shrubs from overreaching the sidewalks, paths and street edge improves appearance and reduces clogging of permeable pavements by leaf litter, mulch and soil.
Leaves, needles, and organic debris		In fall (October to December) after leaf drop (1-3 times, depending on canopy cover)	Accumulation of organic debris and leaf litter	Use leaf blower or vacuum to blow or remove leaves, evergreen needles, and debris (i.e., flowers, blossoms) off of and away from permeable pavement

[a] Frequency: A= Annually; B= Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

Equipment and Materials

Table 9 includes recommendations for equipment and materials commonly used to maintain permeable pavement. Some of the equipment and materials will be used for routine maintenance activities, while other equipment and materials will be necessary for specialized maintenance.

Table 9. Permeable Pavement Equipment and Materials List.

Equipment to address clogging of wearing course, such as:	***Weed / vegetation removal equipment, such as:***
☐ **Hand held pressure washer or power washer with rotating brushes (not recommended for open-celled aggregate-filled systems)** ☐ **Walk-behind vacuum (sidewalks)** ☐ **Pure vacuum sweeper** ☐ **ShopVac (small areas)** ☐ **Combined higher pressure wash and vacuum system**	☐ **Weeding tools** ☐ **Weed burner** ☐ **Edging and trimming equipment to control groundcover and other vegetation from extending onto pavement surface**
Equipment to remove sediment, debris, and leaf litter, such as:	***Additional equipment for grass-filled open-celled grid systems***
☐ **High efficiency regenerative air or vacuum sweeper (roadways, parking lots)** ☐ **Push broom (can also be used to spread and clean aggregate in gravel-filled open-celled grid and permeable paver systems)** ☐ **Brush broom (course bristled broom) to remove moss** ☐ **Leaf blower**	☐ **Mower or mulch mower** ☐ **Topdress grass seed** ☐ **Compost** ☐ **Replacement grid segments**
Erosion control equipment (to stabilize adjacent landscaped areas and protect pavement from sediment inputs)*	***Additional equipment for gravel-filled open-celled grid systems***
☐ **Erosion control matting** ☐ **Rocks** ☐ **Mulch** ☐ **Plants** ☐ **Landscaping tools** ☐ **Tarps (to protect pavement in area of landscaping from clogging, e.g., mulch stockpiles)**	☐ **Rakes and shovels** ☐ **Aggregate to replace material after vacuuming or to replenish material in high use areas** ☐ **Replacement grid segments** ☐ **Wheelbarrow (for transporting replacement aggregate)**
Pipe/structure inspection and maintenance equipment	***Additional equipment for permeable paver systems***
☐ **Hand tools** ☐ **Wrench or manhole opener (for opening manhole lids, grates, etc.)** ☐ **Flashlight** ☐ **Mirror (for viewing pipes without entering structure)** ☐ **Garden hose** ☐ **Plumbing snake** ☐ **Measuring tape or ruler**	☐ **Rakes and shovels** ☐ **Extra pavers and bedding material** ☐ **Aggregate to replace materials between pavers after vacuuming** ☐ **Wheelbarrow (for transporting replacement aggregate)** ***Snow removal equipment, such as:*** ☐ **Plow with skids to prevent damage to permeable pavement** ☐ **Snow blower**

* Items not required for routine maintenance

Skills and Staffing

The skills required for the maintenance of permeable pavement facilities are listed in the text box to the right.

Skills Needed for Maintenance of Permeable Pavement

- Sweeper and equipment operation
- Commercial driver's license (CDL)
- Landscaping skills (e.g., general plant care) for grass-filled open-celled grid systems
- Engineer and/or landscape architect for major maintenance

The staff effort required for maintenance varies based on the type of facility, sediment loading, and site conditions. Table 10 provides some examples of staffing estimates from Washington jurisdictions, Washington contractors/vendors, a study conducted among Minnesota jurisdictions (Wilson et al. 2008), and the BMP and LID Whole Life Cost Models (WERF 2009). Staff estimates are listed as the number of hours to maintain an individual facility (i.e., a "typical" facility of undefined area) per year or as the area of facility maintained per hour of staff time. Staffing estimates ranged from 1 to 24 hours per facility on an annual basis, with an average of approximately 4 to 6 hours per permeable pavement facility on an annual basis. Cleaning estimates in sf/hr ranged from 1,000 to 87,000 sf/hr depending on the type of maintenance activity.

Table 10. Maintenance Frequency and Staffing for Permeable Pavement.

Type of Pavement	Routine Maintenance Activity	Frequency [a]	Annual Staff Hours	Source
Permeable Pavement (all)	NG	A or B	1 to 4 hours (per facility)	Maintenance of Stormwater BMPs: Frequency, Effort, and Cost (Wilson et al. 2008)
Permeable Pavement (all)	Permeable Pavement Sweeping; Litter and Minor Debris Removal; and Recordkeeping	A	4 to 6 hours (per facility)	BMP and LID Whole Life Cost Models (WERF 2009)
Permeable Pavement (all)	Cleaning	A	4,000 sf/hour	City of Olympia
Permeable Pavement (all)	NG	B	4 hours (per facility)	Kitsap County
Permeable Pavement (all)	NG	3 times/year	24 hours (per facility)	Pierce County
Pervious Concrete	Parking lot (dry)	Q	6,000-9,000 sf/hr	Backstrom Curb & Sidewalk
	Sidewalk (dry)	B	1,000 sf/hr	
GrassPave2	Mowing	Weekly to M	22,000-33,000 sf/hr	Northwest Linings & Geotextile
	Fertilizing and liming		65,000-87,000 sf/hr	
GravelPave2	Gravel raking / re-distribution		11,000-22,000 sf/hr	
	Weed control		65,000-87,000 sf/hr	

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; Q = Quarterly (four times per year); NG = no guidance provided

sf/hr = square feet per hour

Vegetated Roofs

Vegetated roofs (also known as ecoroofs and green roofs) are thin layers of engineered soil and vegetation constructed on top of a conventional roof. Vegetated roofs consist of four basic components: a waterproof membrane, drainage layer, lightweight growth medium, and vegetation. Deeper installations, referred to as “intensive” roofs, are comprised of at least 6 inches of growth media and are planted with groundcovers, grasses, shrubs and sometimes trees. These intensive systems require regular landscape maintenance. Shallower installations, referred to as “extensive” roofs, are comprised of less than 6 inches of growth media and use a planting palette of drought-tolerant, low maintenance groundcovers. The procedures outlined below focus on extensive roof systems, and different procedures for intensive roofs are noted.

Key Maintenance Considerations

The main components of vegetated roof facilities are listed below with descriptions of their function and key maintenance considerations. Components are listed in the order of installation from the roof deck upwards.

- **Waterproof membrane**: Waterproof membranes are installed on the roof deck below the vegetated roof system. Systems also include a protection layer and root barrier to preserve the integrity of the waterproof membrane. These components are not visible, so inspection is typically not possible unless a leak detection system is installed. During maintenance, sharp tools, lawn staples, and stakes should be avoided to prevent damage to membrane.

- **Drainage layer**: All vegetated roofs have a drainage component that routes excess water to the roof drain system. Usually this takes the form of a manufactured drain mat or granular drainage media. A separation layer (e.g., filter fabric) is typically installed above the drainage mat or granular drainage media to prevent fine components of the growth media from being washed into the roof drain system. This component is also not visible, so inspection is difficult. During maintenance, sharp tools, lawn staples, and stakes should be avoided to prevent damage to the drainage layer.

- **Growth media**: Vegetated roofs use a light-weight growth medium with adequate fertility and drainage capacity to support plant growth and allow infiltration and storage of water. In general the media is composed of porous and lightweight mineral aggregates such as pumice, lave rock, expanded shale and expanded slate. The growth media may be covered by a mat (or other erosion control measure) to prevent surface erosion due to rain and wind scour before plants are established.

- **Vegetation**: The plants on vegetated roofs are typically succulents, grass, herbs, and/or wildflowers adapted to the harsh conditions (minimal soils, seasonal drought, high winds, and strong sun exposure) prevalent on rooftops. A wider variety of vegetation types may be used on intensive roofs, but these typically require additional maintenance. Regular maintenance activities associated with vegetation include weeding and pruning. Plants also require watering during establishment and extended dry periods.

- **Structural drainage elements**: The roof drainage system routes water from the vegetated roof drainage layer to a nearby drainage system. It is important to maintain unobstructed outlet pipes and structures to ensure that stormwater is safely conveyed from the roof to a discharge point. There are also other structural components of a roof that may interface with the vegetated roof (e.g., flashing, roof ventilation points, utilities).
- **Border zone:** This zone forms an area, composed of gravel and devoid of vegetation, around the perimeter of the vegetated roof, typically used as a fire prevention method and to prevent water damage.
- **Gravel stops:** These are sheet metal edges, typically installed outside of the border zone, along the perimeter of the roof to prevent growth medium from blowing or washing off of the roof.

Key Operations to Preserve Facility Function

For vegetated roofs to function properly, stormwater must filter through several layers. Similar to bioretention facilities, filtration can be reduced if the growth media is subject to compaction (e.g., foot traffic). To limit the likelihood of corrective maintenance (e.g., growth media), the planted area of the vegetated roof should be protected from external loads. The risk of compaction is higher when soils are saturated, therefore any type of loading in the planted areas of the vegetated roof (including foot traffic) should be avoided or minimized during wet conditions.

Signage is recommended to identify the planted areas of the vegetated roof as a stormwater BMP and educate maintenance crews and the general public about protecting the facility's function (e.g., no walking on the facility). Clear walkways or pathways should be present to discourage foot traffic on the planted portions of the vegetated roof.

Maintenance Standards and Procedures

Table 11 provides the recommended maintenance frequencies, standards, and procedures for vegetated roof components.

Each vegetated roof installation will have specific O&M guidelines provided by the manufacturer and installer. The following guidelines provide a general set of standards for prolonged vegetated roof performance. Note that some maintenance recommendations are different for extensive versus intensive vegetated roof systems. The procedures outlined below focus on extensive roof systems, and different procedures for intensive roofs are noted.

Table 11. Maintenance Standards and Procedures for Vegetated Roofs.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Growth medium area				
Growth medium	A [b]		Water does not permeate growth media (runs off soil surface) or crusting is observed	Aerate (e.g., rake) or replace medium taking care not to damage the waterproof membrane
	A		Growth medium thickness is less than design thickness (due to erosion and plant uptake)	Supplement growth medium to design thickness
	B, W		Fallen leaves or debris are present	Remove/dispose
	A, W, S		Growth media erosion/scour is visible (e.g., gullies)	• Take steps to repair or prevent erosion • Fill, hand tamp, or lightly compact, and stabilize with additional soil substrate/growth medium (similar in nature to the original material) and additional plants
Erosion control measures	B [c]		Mat or other erosion control is damaged or depleted during plant establishment period	• Repair/replace erosion control measures until 90% vegetation coverage attained • Avoid application of mulch on extensive vegetated roofs
System Drainage and Structural Components				
Roof drain	B, S		Sediment, vegetation, or debris reducing capacity of inlet structure	• Clear blockage • Identify and correct any problems that led to blockage
	A		Pipe is clogged	Remove roots or debris
	A		Inlet pipe is in poor condition	Repair/replace

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

[c] Inspection should occur during plant establishment period (typically first 2 years).

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Table 11 (continued). Maintenance Standards and Procedures for Vegetated Roofs.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
System Drainage and Structural Components (cont'd)				
Border zone	A		Vegetation is encroaching into border zone aggregate	Remove and dispose of weeds and transplant desirable vegetation to growth medium area
Flashing, gravel stops, utilities, or other structures on roof	A		Flashing, utilities or other structures on roof are deteriorating (can serve as source of metal pollution in vegetated roof runoff)	Repair (e.g., recoat) or replace to eliminate potential pollutant source. Note that any work done around flashings and drains should be done with care to protect the waterproof membrane.
Access and safety	B		Insufficient egress/ingress routes and fall protection	• Maintain egress and ingress routes to design standards and fire codes • Ensure appropriate fall protection
Vegetation				
Plant coverage	B		Vegetative coverage falls below 90% (unless design specifications stipulate less than 90% coverage)	• Plant bare areas with vegetation • If necessary, install erosion control measures until percent coverage goal is attained
Sedums		A (first 2 years in Spring); As needed (after first 2 years)	Extensive roof with low density sedum population	• Mulch mow sedums- creating cuttings from existing plants to encourage colonization
Dead plants	Fall and Spring		Dead vegetation is present	Normally dead plant material can be recycled on the roof; however, specific plants or aesthetic considerations may warrant removing and replacing dead material (see manufacturer's recommendations).
Trees and shrubs–intensive vegetated roof		All pruning seasons (timing varies by species)	Pruning as needed	All pruning of mature trees should be performed by or under the direct guidance of an ISA certified arborist

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

[c] Inspection should occur during plant establishment period (typically first 2 years).

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Table 11 (continued). Maintenance Standards and Procedures for Vegetated Roofs.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Vegetation (cont'd)				
Fertilization– extensive vegetated roof	A		Poor plant establishment and possible nutrient deficiency in growth medium	• Allow organic debris to replenish and maintain long-term nutrient balance and growth medium structure • Conduct annual soil test 2-3 weeks prior to the spring growth flush to assess need for fertilizer. Utilize test results to adjust fertilizer type and quantity appropriately. • Apply minimum amount slow-release fertilizer necessary to achieve successful plant establishment. • Apply fertilizer only after acquiring required approval from facility owner and operator. Note that extensive vegetated roofs are designed to require zero to minimal fertilization after establishment (excess fertilization can contribute to nutrient export)
Fertilization– intensive vegetated roof	A		Fertilization may be necessary during establishment period or for plant health and survivability after establishment	• Conduct annual soil test 2-3 weeks prior to the spring growth flush to assess need for fertilizer. Utilize test results to adjust fertilizer type and quantity appropriately. • Apply minimum amount slow-release fertilizer necessary to achieve successful plant establishment. • Apply fertilizer only after acquiring required approval from facility owner and operator. • Intensive vegetated roofs may require more fertilization than extensive vegetated roofs

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

[c] Inspection should occur during plant establishment period (typically first 2 years).

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Table 11 (continued). Maintenance Standards and Procedures for Vegetated Roofs.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	**Routine Maintenance**		
Vegetation (cont'd)				
Weeds		M (March – October, preceding seed dispersal)	Weeds are present	• Remove weeds with their roots manually with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate • Follow IPM protocols for weed management (see "Additional Maintenance Resources" for more information on IPM protocols)
Noxious weeds		M (March – October, proceeding seed dispersal)	Listed noxious vegetation is present (refer to current county noxious weed list)	• By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately • Reasonable attempts must be made to remove and dispose of class C noxious weeds • It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions
Irrigation System (or Watering)				
Irrigation system (if any)		Based on manufacturer's instructions	Irrigation system present	Follow manufacturer's instructions for operation and maintenance
Summer watering – extensive vegetated roof		Once every 1-2 weeks as needed during prolonged dry periods	Vegetation in establishment period (1-2 years)	Water weekly during periods of no rain to ensure plant establishment (30 to 50 gallons per 100 square feet)
		As needed	Established vegetation (after 2 years)	Water during drought conditions or more often if necessary to maintain plant cover (30 to 50 gallons per 100 square feet)

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

[c] Inspection should occur during plant establishment period (typically first 2 years).

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Table 11 (continued). Maintenance Standards and Procedures for Vegetated Roofs.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Irrigation System (or Watering) (cont'd)				
Summer watering – intensive vegetated roof		Once every 1-2 weeks as needed during prolonged dry periods	Vegetation in establishment period (1-2 years)	• Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist • Use soaker hoses or spot water with a shower type wand when irrigation system not present
		As needed	Established vegetation (after 2 years)	Water during drought conditions or more often if necessary to maintain plant cover
Pest Control				
Mosquitoes	B, S		Standing water remains for more than 3 days after the end of a storm	• Identify the cause of the standing water and take appropriate actions to address the problem (e.g., aerate or replace medium, unplug drainage) • Manually remove standing water and direct to storm drainage system • Do not use pesticides or *Bacillus thuringiensis israelensis* (Bti)
Nuisance animals	As needed		Nuisance animals causing erosion, damaging plants, or depositing large volumes of feces	• Reduce site conditions that attract nuisance species • Place predator decoys • Follow IPM protocols for specific nuisance animal issues (see "Additional Maintenance Resources" in Bioretention Facilities section for more information on IPM protocols)

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during storm event.

[c] Inspection should occur during plant establishment period (typically first 2 years).

IPM – Integrated Pest Management

ISA – International Society of Arboriculture

Additional Maintenance Resources

Useful related guidance documents include the following:

- Vegetation resources listed for bioretention
- LID Technical Guidance Manual for Puget Sound: http://www.wastormwatercenter.org/files/library/lid-manual-2012-final-secure.pdf
- Green Roof ANSI standards developed in conjunction with Green Roofs for Healthy Cities (GRHC). GRHC is a group working to increase awareness of the economic, social, and environmental benefits of vegetated roofs through education and outreach. GRHC standards used for fire and wind uplift design of vegetated roofs are the ANSI RP-14 and VF-1 standards. These standards cover several key design components of vegetated roofs that, once installed, require upkeep to maintain the functionality of these features.
- Integrated Pest Management (IPM) protocols (the term “pest” covers a broad range of species including harmful insects, plant pathogens, rodents, and weedy vegetation) provide an approach to pest control that uses regular monitoring to determine if and when treatments are needed, and employs physical, mechanical, cultural, and biological tactics to keep pest numbers low enough to prevent intolerable damage or annoyance (Ecology 2012c) while avoiding or minimizing the use of pesticides and fertilizers herbicides as a management strategy.
- See EPA’s website for general information on IPM: www.epa.gov/pesticides/factsheets/ipm.htm.
- See the City of Seattle’s website for IPM Fact Sheets and Washington specific resources: www.seattle.gov/util/forbusinesses/landscapes/integrated_pest_management
- The International Society of Arboriculture (ISA) is a group that promotes the professional practice of arboriculture and fosters a greater worldwide awareness of the benefits of trees through research, technology, and education. ISA standards used for managing trees, shrubs, and other woody plants are the American National Standards Institute (ANSI) A300 standards. The ANSI A300 standards are voluntary industry consensus standards developed by the Tree Care Industry Association (TCIA) and written by the Accredited Standards Committee (ASC). The ANSI standards can be found on the ISA website: www.isa-arbor.com/education/publications/index.aspx.

These resources are supplemental and do not supersede guidance provided in the S*tandards and Procedures* tables.

Equipment and Materials

Table 12 includes recommendations for equipment and materials commonly used to maintain vegetated roofs. Some of the equipment and materials will be used for routine maintenance activities, while other equipment and materials will be necessary for specialized maintenance.

Table 12. Vegetated Roof Equipment and Materials List.

General gardening and landscaping equipment

- ☐ **Gloves**
- ☐ **Weeding tool**
- ☐ **Soil knife**
- ☐ **Hand tamper**
- ☐ **Hoe**
- ☐ **Rake**
- ☐ **Push broom**
- ☐ **Buckets**
- ☐ **Garbage bags (for disposal of noxious weeds)**

Additional equipment for intensive roofs:

- ☐ **Pruners**
- ☐ **Loppers**
- ☐ **Manual edger**
- ☐ **Line trimmer (also known as a string trimmer, weed eater, or weed whacker)**
- ☐ **Wheelbarrow**
- ☐ **Shovel**
- ☐ **Stakes and guys**

Gardening and landscaping materials

- ☐ **Plants/seeds**
- ☐ **Growing media**
- ☐ **Fertilizer (encapsulated, slow release)**

Erosion control material*

- ☐ **Mulch (intensive roofs)**
- ☐ **Erosion control matting**

Equipment and materials for subsurface or drip irrigation system repairs

- ☐ **Soaker hose**
- ☐ **Hose/shower-type wand**
- ☐ **Sprinklers**
- ☐ **Tree watering bags**
- ☐ **Buckets**
- ☐ **Water source, if necessary**

Safety equipment

- ☐ **Fall protection as applicable**

* Items not required for routine maintenance

Skills and Staffing

The skills required for the maintenance of vegetated roofs are listed in the text box to the right. Additional specialized skills may also be required for corrective maintenance of intensive vegetated roofs such as: horticulturalists and arborists.

The maintenance associated with vegetated roofs may sometimes pose safety hazards and require controls (e.g., fall protection) currently covered under the Washington State Department of Labor & Industries.

Table 13 provides some examples of staffing estimates from the City of Olympia and the BMP and LID Whole Life Cost Models (WERF 2009). The WERF (2009) study provides annual staffing estimates for a "typical" facility of undefined area, while the City of Olympia provided a staffing estimate as the area of vegetated roof that can be maintained per hour of staff time. Staffing estimates presented below range from 53 to 90 hours per facility from the WERF (2009) study (summing all of the routine maintenance activities) or 2,000 sf/hr for the City of Olympia.

Skills Needed for Maintenance of Vegetated Roofs

- Landscaping skills (e.g., general plant care)
- Plant identification skills (weeds vs. planted species, invasive vs. common weeds, how to dispose of invasive weeds, timing of weed seed dispersal)
- General drainage system maintenance skills (e.g., subsurface or drip irrigation system repair)
- Roof work safety training
- Engineer and/or landscape architect for major maintenance
- Certified arborist (or equivalently trained staff) for pruning of mature trees (intensive vegetated roofs)

Table 13. Maintenance Frequency and Staffing for Vegetated Roofs.

Routine Maintenance Activity	Frequency [a]	Annual Staff Hours	Source
Vegetation management	Every 2 months	30 to 60 hours (per facility)	BMP and LID Whole Life Cost Models (WERF 2009)
Irrigation repair	A	5 to 10 hours (per facility)	
Corrective maintenance [b]	A	8 hours (per facility)	
Soil replacement	A	8 hours (per facility)	
Recordkeeping	A	2 to 4 hours (per facility)	
General (no activity specified)	M	2,000 sf/hr	City of Olympia

[a] Frequency: A = Annually; M = Monthly

[b] Membrane patching, re-vegetation, component failure

sf/hr = square feet per hour

Downspout Full Infiltration Systems

Downspout full infiltration systems include infiltration trenches or drywells intended only for use in infiltrating runoff from roof downspout drains. Infiltration trenches and drywells are backfilled withwashed drain rock, allowing for temporary storage of stormwater runoff in the voids of the drain rock material. Stored runoff gradually infiltrates into the surrounding soil. These systems are considered On-site Stormwater Management BMPs and can be used to help meet Minimum Requirements #5 (On-site Stormwater Management BMPs), #7 (flow control), or both.

Key Maintenance Considerations

The main components of downspout full infiltration systems are listed below with descriptions of their function and key maintenance considerations.

- **Rock trench/well**: Trenches and drywells are excavated depressions filled with uniformly graded washed drain rock. Non-woven geotextile fabric may be used along the walls, bottom, and top of the drain rock. The surface of the trench can be covered with grating, pavement, and/or consist of stone, gabion, sand, or a grassed covered area with a surface inlet. To allow inspection of the drain rock trench/well, some facilities have an observation port (typically installed during construction) that allows monitoring of the water levels in the drain rock bed to determine if the facility is dewatering properly.

- **Inlet:** Stormwater runoff is typically routed to a trench/well with a solid-wall pipe and then distributed into the drain rock bed using a perforated or slotted subsurface pipe. Some trenches are designed to receive sheet flow that enters the facility by infiltrating through a top course of drain rock or sand. Maintenance must be performed to ensure inlets (e.g., pipes) are unobstructed and that surface sheet flow first passes through a grass buffer strip to remove larger sediment particles.

- **Storage sump:** Trenches and drywells designed to receive concentrated flows (e.g., piped flow) typically include a storage sump to settle particulates from inflow. Concentrated flows must be distributed into the aggregate using a perforated or slotted subsurface pipe. The sump must be maintained to remove accumulated sediment.

Key Operations to Preserve Facility Function

When the rock trench/well is designed to receive inflow from the surface via a grate or by infiltrating through an exposed top course of drain rock or sand, the following operational actions can limit the need for corrective maintenance actions or replacement:

- Protecting the surface inlet from stockpiles of landscaping materials (e.g., mulch, soil, compost)

- Prevent discharge of debris to the infiltration trench from roof cleaning practices (e.g., moss removal)

- Stabilize adjacent landscaped areas to avoid runoff mobilizing soil into the surface inlet

Maintenance Standards and Procedures

Table 14 provides the recommended maintenance frequencies, standards, and procedures for downspout full infiltration system components. The level of routine maintenance required and the frequency of corrective maintenance actions may increase for facilities subject to high sediment loads from the contributing drainage area.

Table 14. Maintenance Standards and Procedures for Downspout Full Infiltration Systems.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Rock Trench/Well				
Surface of trench/well (i.e., water enters through exposed aggregate)	Fall and Spring		Accumulated trash, debris, or sediment on drain rock surface impedes sheet flow into facility	Remove/dispose in accordance with local solid waste requirements
	A, W		Vegetation/moss present on drain rock surface impedes sheet flow into facility	Maintain open, freely draining drain rock surface
Drain rock	Fall and Spring		• If water enters the facility from the surface, inspect to see if water is ponding at the surface during storm events • If buried drain rock, observe drawdown through observation port or cleanout	• Clear piping through facility when ponding occurs • Replace rock/sand reservoirs as necessary • Tilling of subgrade below reservoir may be necessary (for trenches) prior to backfill
Inlet/ Outlet Pipe Conveyance				
Pipe(s)	A, W		Accumulation of trash, debris, or sediment in roof drains, gutters, driveway drains, area drains, etc.	Remove/ dispose
	A, W		Pipe from sump to trench or drywell has accumulated sediment or is plugged	Clear sediment from inlet/outlet pipe screen and inlet/outlet pipe
	A, W		Cracked, collapsed, broken, or misaligned drain pipes	• Repair/seal cracks • Replace when repair is insufficient
Roof downspout	B, W		Splash pad missing or damaged	Repair/ replace
	A, W		Leaves or other debris plugging downspout	Remove/ dispose

[a] Frequency: A= Annually; B= Biannually (twice per year); W= At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves).

Table 14 (continued). Maintenance Standards and Procedures for Downspout Full Infiltration Systems.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Storage Sump				
Sump	A		Sediment in the sump	Remove/ dispose in accordance with local solid waste requirements
Access lid	A		Cannot be easily opened	Repair/ replace
	A		Buried	Refer to record drawings for design intent. If the access lid was designed to be exposed, expose and restore to surface grade
	A		Cover missing	Replace

[a] Frequency: A= Annually; B= Biannually (twice per year); W= At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves).

Equipment and Materials

Table 15 includes recommendations for equipment and materials commonly used to maintain downspout full infiltration systems.

Table 15. Downspout Full Infiltration System Equipment and Materials List.

Pipe/ structure system inspection and maintenance equipment	***Weed / vegetation removal equipment, such as:***
☐ **Hand tools** ☐ **Flashlight** ☐ **Mirror (for viewing pipes without entering structure)** ☐ **Garden hose** ☐ **Plumbing snake**	☐ **Weeding tools** ☐ **Weed burner** ☐ **Buckets** ***Equipment to clear accumulated sediment from sump*** ☐ **Shop-Vac** ☐ **Shovel**

Skills

The skills required for the maintenance of downspout full infiltration systems are listed in the text box to the right.

Skills Needed for Maintenance of Downspout Full Infiltration Systems

- General drainage system maintenance skills (e.g., inlet/pipe cleaning experience, inlet/pipe maintenance or repair experience)
- Landscape or drainage contractor for major maintenance

Downspout, Sheet Flow, and Concentrated Dispersion Systems

Dispersion attenuates peak flows by slowing the runoff entering into the conveyance system, allowing some infiltration, and providing some water quality benefits. The following three types of dispersion systems are covered in this section:

- **Downspout dispersion systems**: Splash blocks or gravel-filled trenches, which serve to spread roof runoff over vegetated pervious areas.
- **Sheet flow dispersion systems**: Sheet flow dispersion is the simplest method of runoff control. This BMP can be used for any impervious or pervious surface that is graded to avoid concentrating flows. Because flows are already dispersed as they leave the surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and treatment.
- **Concentrated dispersion systems**: Dispersion of concentrated flows from driveways or other pavement through a vegetated pervious area.

Key Maintenance Considerations

The main components of dispersion systems are listed below with descriptions of their function and key maintenance considerations.

- **Splash block (downspout dispersion):** Splash blocks are used to spread stormwater runoff from a downspout drain over vegetated pervious area. A downspout extension may be included if the ground is fairly level, if the structure includes a basement, or if foundation drains are proposed.
- **Dispersion trench (downspout dispersion):** Gravel-filled trenches are also used to spread stormwater runoff from a downspout drain over a vegetated pervious area. Downspout drains are routed to a trench via a perforated or slotted pipe. The trench typically includes a notched grade board or other device to distribute flow equally along the length of the trench. This board must be maintained at a level grade to prevent concentrated flow. Downspout drains are directed to the trench via a storage sump that must be maintained to remove accumulated sediment.
- **Transition zone (sheet flow dispersion):** A 2-foot-wide transition zone is typically included to discourage channeling between the edge of the impervious surface (or building eaves) and the downslope vegetation. This transition zone may consist of an extension of subgrade material (crushed rock), modular pavement, drain rock, or other material.
- **Rock pad at discharge point (concentrated flow dispersion):** A rock pad must be maintained at any point that a concentrated flow enters a dispersion area.
- **Dispersal area:** Stormwater is dispersed to an area vegetated with well-established lawn or pasture, landscaping with well-established groundcover, or native vegetation with natural groundcover. The required vegetated flow path is 50 feet for splash

blocks and concentrated dispersion, 25 feet when using a dispersion trench and varies for sheet flow dispersion. The groundcover for the extent of the flow must be maintained to be dense enough to help disperse and infiltrate flows and to prevent erosion.

Key Operations to Preserve Facility Function

For dispersion practices to be effective, the dispersion area must remain covered with dense, well-established vegetation. Site uses should protect vegetation and avoid compaction.

Maintenance Standards and Procedures

Table 16 provides the recommended maintenance frequencies, standards, and procedures for dispersion system components.

Table 16. Maintenance Standards and Procedures for Downspout, Sheet Flow, and Concentrated Dispersion Systems.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Splash Block (Downspout Dispersion)				
Splash block	B		Water is being directed towards building structure	Reconfigure/ repair blocks to direct water away from building structure
	B		Water disrupts soil media	Reconfigure/ repair blocks
Transition Zone (Sheet Flow Dispersion)				
Transition zone	A		Adjacent soil erosion; uneven surface creating concentrated flow discharge; or less than 2 foot of width	Repair/replace transition zone to meet design criteria and eliminate concentrated flows
Dispersion Trench (Downspout Dispersion)				
Dispersion trench	A		Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" from edge of trench; intent is to prevent erosion damage)	• Remove debris from trench surface, if necessary • Realign notched grade board or other distributor type, if possible • Rebuild trench to standards, if necessary
Surface of trench	Fall and Spring		Accumulated trash, debris, or sediment on drain rock surface impedes sheet flow from facility	• Remove/dispose in accordance with local solid waste requirements
	A, W		Vegetation/moss present on drain rock surface impedes sheet flow from facility	• Maintain open, freely draining drain rock surface
Pipe(s) to trench	A, W		Accumulation of trash, debris, or sediment in roof drains, gutters, driveway drains, area drains, etc.	• Remove/ dispose
	A, W		Pipe from sump to trench or drywell has accumulated sediment or is plugged	• Clear sediment from inlet/outlet pipe screen and inlet/outlet pipe
	A, W		Cracked, collapsed, broken, or misaligned drain pipes	• Repair/seal cracks • Replace when repair is insufficient
Sump	A		Sediment in the sump	• Remove/ dispose in accordance with local solid waste requirements • Clear sediment from inlet/outlet pipe screen and/or inlet/outlet pipe
Access lid	A		Cannot be easily opened	• Repair/ replace
	A		Buried	• Refer to record drawings for design intent. If the access lid was designed to be exposed, expose and restore to surface grade
	A		Cover missing	• Replace
Rock Pad (Concentrated Flow Dispersion)				
Rock pad	A		Only one layer of rock exists above native soil in area 6 square feet or larger, or any exposure of native soil	• Replace/ repair rock pad to meet design standards • Enlarge pad size or add additional courses of rock, if necessary
	A		Soil erosion in or adjacent to rock pad	Repair/replace rock pad to meet design standards
Dispersal Area				
Dispersal area (general)	B, S		Erosion (gullies/ rills) greater than 2 inches deep in dispersal area	Eliminate cause of erosion and stabilize damaged area (regrade, rock, revegetate)
	B, S		Accumulated sediment or debris to extent that blocks or channelizes flow path	• Remove excess sediment or debris • Identify and control the sediment source (if feasible)
Ponded water	B, S		Standing surface water in dispersion area remains for more than 3 days after the end of a storm event	• Identify the cause of the standing water (e.g., grade depressions, compacted soil) and take appropriate actions to address the problem (e.g., regrade to eliminate depressions or aerate/ amend soils)

[a] Frequency: A= Annually; B= Biannually (twice per year); W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during plant establishment period (1-2 years, or additional 3rd year during extreme dry weather). IPM – Integrated Pest Management

Table 16 (continued). Maintenance Standards and Procedures for Downspout, Sheet Flow, and Concentrated Dispersion Systems.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Dispersal Area (cont'd)				
Plant establishment	B	Once every 1-2 weeks or as needed during prolonged dry periods [b]	Dispersal area vegetation in establishment period (1-2 years, or additional 3rd year during extreme dry weather)	Water weekly during periods of no rain to ensure plant establishment
Vegetation	As needed		Poor vegetation cover such that erosion is occurring	• Ensure proper care (e.g., watering) • Assess for nutrient deficiencies • Replant as needed with appropriate plant species for the soil and moisture conditions • Consider amending soils to promote plant health
	B, S		Vegetation inhibits dispersed flow along flow path	Trim, weed or replant to restore dispersed flow path
Storage Sump				
Sump	A		Accumulated sediment in the sump	• Remove/ dispose in accordance with local solid waste requirements • Clear sediment from inlet/outlet pipe screen and/or inlet/outlet pipe
Access lid	A		Cannot be easily opened	Repair/ replace
	A		Buried	Expose and restore to surface grade
	A		Cover missing	Replace
Pest Control				
General Pests	As needed		Signs of pest infestations (IPM protocol threshold(s) are exceeded)	• Follow IPM protocols for weed and pest management (see "Additional Maintenance Resources" in Bioretention Facilities section for more information on IPM protocols)
Mosquitoes	B, S		Standing surface water in dispersion area remains for more than 3 days after the end of a storm	• Identify the cause of the standing water and take appropriate actions to address the problem (see "Ponded water") • Do not use pesticides or *Bacillus thuringiensis israelensis* (Bti)
Rodents	As needed		Rodent holes or mounds disturb dispersion flow paths	Fill and compact soil around the holes and vegetate to restore flow path

[a] Frequency: A= Annually; B= Biannually (twice per year); W = At least once during the wet season (for debris/clog related maintenance, this visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

[b] Inspection should occur during plant establishment period (1-2 years, or additional 3rd year during extreme dry weather).

Equipment and Materials

Table 17 includes recommendations for equipment and materials commonly used to maintain downspout, sheet flow, and concentrated dispersion systems.

Table 17. Downspout, Sheet Flow, and Concentrated Dispersion Systems Equipment and Materials List.

Pipe/ structure system inspection and maintenance equipment

- ☐ **Hand tools**
- ☐ **Flashlight**
- ☐ **Mirror (for viewing pipe s without entering structure)**
- ☐ **Garden hose**
- ☐ **Plumbing snake**
- ☐ **Level**

Equipment to clear accumulated sediment from sump

- ☐ **Shop-Vac**
- ☐ **Shovel**

Material to replenish rock pad for concentrated dispersion

- ☐ **Aggregate**

General landscaping equipment and materials to maintain dispersal area

- ☐ **Mower**
- ☐ **Gloves**
- ☐ **Weeding tool**
- ☐ **Soil knife**
- ☐ **Manual edger**
- ☐ **Line trimmer (also known as a string trimmer, weed eater, or weed whacker)**
- ☐ **Hoe**
- ☐ **Rake**
- ☐ **Shovel**
- ☐ **Push broom**
- ☐ **Compost**
- ☐ **Seeds**
- ☐ **Plants**
- ☐ **Watering equipment**

* Items not required for routine maintenance

Skills

The skills required for the maintenance of downspout, sheet flow, and concentrated dispersion systems are listed in the text box to the right. Additional specialized skills may also be required for corrective maintenance such as: horticulturalists, arborists, erosion control specialists, and soil scientists.

Skills Needed for Maintenance of Dispersion Systems

- General drainage system maintenance skills (e.g., inlet/pipe cleaning experience, inlet/pipe maintenance or repair experience)
- Landscaping skills (e.g., general plant care)
- Landscape or drainage contractor for major maintenance

Compost-amended Soils

Naturally occurring (undisturbed) soil and vegetation provide important stormwater functions including: water infiltration; nutrient, sediment, and pollutant adsorption; sediment and pollutant biofiltration; water interflow storage and transmission; and pollutant decomposition. Compaction from construction can reduce the soils natural ability to provide these functions. Establishing a minimum soil quality and depth in the post-development landscape can regain some of these stormwater functions including increased treatment of pollutants and sediments that result from development and habitation, and minimizes the need for some landscaping chemicals. Sufficient organic content is a key to soil quality. Soil organic matter can be attained through numerous amendments such as compost, composted woody material, biosolids, and forest product residuals.

Key Maintenance Considerations

Key maintenance considerations for compost-amended soils include the replenishment of soil media as needed (as a result of erosion) and addressing compacted, poorly draining soils. Site uses should protect vegetation and avoid compaction.

Key Operations to Preserve Facility Function

The full benefits of compost-amended soils are realized when desired soil media depths are maintained and soil compaction is minimized. Care should be taken to prevent compaction of soils via vehicular loads and/or excessive foot traffic, especially during wet conditions.

Maintenance Standards and Procedures

Table 18 provides the recommended maintenance frequencies, standards, and procedures for compost-amended soils. The level of routine maintenance required and the frequency of corrective maintenance actions may increase for facilities prone to erosion due to site conditions such as steep slopes or topography tending to concentrate flows.

Table 18. Maintenance Standards and Procedures for Compost-amended Soils.

	Recommended Frequency[a]			
Component	**Inspection**	**Routine Maintenance**	**Condition when Maintenance is Needed (Standards)**	**Action Needed (Procedures)**
General				
Soil media (maintain high organic soil content)	A		Vegetation not fully covering ground surface or vegetation health is poor	• Maintain 2 to 3 inches of mulch over bare areas in landscape beds • Add plants if sufficient space • Re-seed bare turf areas until the vegetation fully covers ground surface
		Ongoing	None (routine maintenance)	Return leaf fall and shredded woody materials from the landscape to the site when possible in order to replenish soil nutrients and structure
		Ongoing	None (routine maintenance)	On turf areas, "grasscycle" (mulch-mow or leave the clippings) to build turf health
		Ongoing	None (routine maintenance)	Avoiding use of pesticides (bug and weed killers), like "weed & feed", which damage the soil
		A	None (routine maintenance)	• Where fertilization is needed (mainly turf and annual flower beds), a moderate fertilization program should be used which relies on compost, natural fertilizers or slow-release synthetic balanced fertilizers • Follow IPM protocols for fertilization procedures (see "Additional Maintenance Resources" in Bioretention Facilities section for more information on IPM protocols)
Soil media (maintain infiltration)	A[b]		Soils become waterlogged, do not appear to be infiltrating	• To remediate compaction, aerate soil, till to at least 8-inch depth, or further amend soil with compost and re-till • If areas are turf, aerate compacted areas and topdress them with 1/4 to 1/2 inch of compost to renovate them • If drainage is still slow, consider investigating alternative causes (e.g., high wet season groundwater levels, low permeability soils) • Also consider site use and protection from compacting activities

[a] Frequency: A= Annually; B= Biannually (twice per year); M = monthly; S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval); W = At least one inspection/maintenance visit should occur during the wet season (for debris/clog related maintenance, this maintenance visit should occur in the early fall, after deciduous trees have lost their leaves).

[b] Inspection should occur during storm event.

IPM – Integrated Pest Management

Table 18 (continued). Maintenance Standards and Procedures for Compost-amended Soils.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
General (cont'd)				
Erosion/ Scouring	A, W, S		Areas of potential erosion are visible	• Identify and address cause of erosion (e.g., concentrate flow entering area, channelization of runoff) and stabilize damaged area (regrade, rock, vegetation, erosion control matting) • For deep channels or cuts (over 3 inches in ponding depth), temporary erosion control measures should be put in place until permanent repairs can be made.
Grass/ Vegetation		A	Less than 75% of planted vegetation is healthy with a generally good appearance.	• Take appropriate maintenance actions (e.g., remove/ replace plants) • If problem persists, evaluate if vegetation is appropriate for the location (e.g., exposure, soil, soil moisture)
Noxious weeds		M (March – October, preceding seed dispersal)	Listed noxious vegetation is present (refer to current county noxious weed list)	• By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately • Reasonable attempts must be made to remove and dispose of class C noxious weeds • Watch for and respond to new occurrences of especially aggressive weeds such as Himalayan blackberry, Japanese knotweed, morning glory, English ivy, and reed canary grass to avoid invasions • It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions

[a] Frequency: A= Annually; B= Biannually (twice per year); M = monthly; S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).; W = At least one inspection/maintenance visit should occur during the wet season (for debris/clog related maintenance, this maintenance visit should occur in the early fall, after deciduous trees have lost their leaves).

[b] Inspection should occur during storm event.

IPM – Integrated Pest Management

Table 18 (continued). Maintenance Standards and Procedures for Compost-amended Soils.

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
General (cont'd)				
Weeds		M (March – October, preceding seed dispersal)	Weeds are present	• Remove weeds with their roots manually with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate • Follow IPM protocols for weed management(see "Additional Maintenance Resources" in Bioretention Facilities section for more information on IPM protocols)

[a] Frequency: A= Annually; B= Biannually (twice per year); M = monthly; S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).; W = At least one inspection/maintenance visit should occur during the wet season (for debris/clog related maintenance, this maintenance visit should occur in the early fall, after deciduous trees have lost their leaves).

[b] Inspection should occur during storm event.

IPM – Integrated Pest Management

Equipment and Materials

Table 19 includes recommendations for equipment and materials commonly used to maintain compost-amended soils. Some of the equipment and materials will be used for routine maintenance activities, while other equipment and materials will be necessary for specialized maintenance.

Table 19. Compost Amended Soils Equipment and Materials List.

General landscaping equipment

☐ **Gloves**
☐ **Pincer-type weeding tool**
☐ **Soil knife**
☐ **Pruners**
☐ **Loppers**
☐ **Hoe**
☐ **Rake**
☐ **Wheelbarrow**
☐ **Shovel**
☐ **Push broom**
☐ **Garbage bags (for disposal of noxious weeds)**

General landscaping materials

☐ **Arborist wood chip mulch (around trees and woody plants)**
☐ **Compost or leaf mulch (around annuals)**
☐ **Fertilizer (natural fertilizers or slow-release synthetic balanced fertilizers)**

Specialized equipment*

☐ **Deep tine aerator and compost (or compost/sand mixture) to fill aeration holes (if necessary to correct overly compacted soil)**
☐ **Flame weeder or hot water weeder**
☐ **Rototiller**
☐ **Soil probe**

* Items not required for routine maintenance

Skills

The skills required for the maintenance of compost-amended soils are listed in the text box to the right. Additional specialized skills may also be required for corrective maintenance of compost-amended soils such as: horticulturalists, arborists, erosion control specialists, and soil scientists.

Skills Needed for Maintenance of Compost-amended Soils

- Landscaping skills (e.g., general plant care)
- Landscaper for major maintenance

PROGRAMMATIC AND ADMINISTRATIVE GUIDANCE

To implement the new Phase I Permit and Phase II Permit requirements for LID BMP maintenance, local governments may face a variety of programmatic and administrative challenges. This section summarizes Ecology's requirements that relate to LID BMP maintenance and provides guidance regarding administrative tools for implementing these requirements.

This section is not intended to identify specific administrative actions for meeting LID BMP maintenance requirements (e.g., specify how jurisdictions administer bonds) but rather to support jurisdictions by providing optional and flexible guidance for administrative procedures and tools related to LID BMP maintenance programs.

Ecology Requirements for LID BMP Maintenance Programs

Phase I and Phase II municipal stormwater Permittees are required to:

- Adopt an ordinance or other enforceable mechanism requiring maintenance of all permanent Stormwater Treatment and Flow Control BMPs/Facilities
- Adopt maintenance standards that are at least as protective of facility function as those in Chapter 4 of Volume V of the 2012 Stormwater Management Manual for Western Washington (2012 SWMMWW)
- Establish legal authority to inspect private stormwater facilities and enforce maintenance standards
- Implement permitting, plan review, inspections, and enforcement programs to meet the Permit standards for both private and public projects

To implement these requirements, Permittees may need to revise their programs and procedures to support plan review, inspection, enforcement, record keeping, and mapping for LID BMPs. Tables 20 and 21 summarize and reference municipal Permit requirements and 2012 SWMMWW guidance in regard to O&M of LID BMPs. Please refer to the Permits and 2012 SWMMWW for more complete and accurate descriptions.

Table 20. Phase I Permit[4] Requirements and 2012 SWMMWW Guidance Related to LID BMP Maintenance Programs.

Requirement	LID BMP Type	
	On-site Stormwater Management BMPs	Stormwater Treatment and Flow Control BMPs/Facilities (MR #6 and/or MR #7)
Standards		
Implement maintenance standards	S5.C.9.a	S5.C.9.a
Update ordinance or other enforceable documents	N/A	S5.C.9.b.i
Implement practices, policies, & procedures to reduce stormwater impacts associated with runoff	N/A	S5.C.9.e
Plan Review		
Verify that a maintenance plan is completed and responsibility for maintenance is assigned for each Stormwater Treatment and Flow Control BMP	N/A	S5.C.5.a.v.4
Verify submission of maintenance instructions for each On-site Stormwater Management BMP	Vol. I, Section 3.1.5	Vol. 1, Section 3.1.5
Verify that an O&M manual is complete for each Stormwater Treatment and Flow Control BMP	N/A	Appendix 1 (Section 4.9) and Vol. 1, Section 3.1.7
Review and approve declaration of covenant (including design details, figures, and maintenance instructions for each On-site Stormwater Management BMP) and grant of easement	Vol. 1, Section 3.1.7	Vol. 1, Section 3.1.7
Inspections		
Legal authority to inspect private stormwater facilities and enforce maintenance standards for all new and redevelopment	S5.C.5.a.iv	S5.C.5.a.iv
Conduct post-construction inspections to ensure proper installation	S5.C.5.a.v.4	S5.C.5.a.v.4
Conduct inspections during construction for all permanent Stormwater Treatment and Flow Control BMPs/Facilities and catch basins in new residential developments (every 6 months until 90% of the lots are constructed or when construction is stopped and the site is fully stabilized)	N/A	S5.C.9.b.iii
Conduct ongoing annual inspections	N/A	S5.C.9.b.ii and c.i
Perform spot checks of potentially damaged BMPs owned or operated by the Permittee after major storm events	N/A	S5.C.9.c.ii

BMPs = best management practices
N/A = not applicable
Note: Phase I Permit references are from Ecology (2012a) and 2012 SWMMWW references are from Ecology (2012c).

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[4] The special conditions listed in this document are for city and county permittees. Secondary permittees should refer Section S6 of the permit for their special conditions that pertain to LID BMP maintenance.

Table 20 (continued). Phase I Permit Requirements and 2012 SWMMWW Guidance Related to LID BMP Maintenance Programs.

Requirement	LID BMP Type	
	On-site Stormwater Management BMPs	Stormwater Treatment and Flow Control BMPs/Facilities (MR #6 and/or MR #7)
Enforcement		
Enforce compliance with maintenance standards as needed based on inspections	N/A	S5.C.9.b.ii
Training		
Train staff involved in plan review, permitting, construction site inspections, and enforcement.	S5.C.5.a.vii	S5.C.5.a.vii
Implement an ongoing training program for employees who have primary O&M job functions that may impact stormwater quality	S5.C.9.f	S5.C.9.f
Record Keeping		
Keep records of inspections and enforcement actions (e.g., inspection reports, notices of violations)	S5.C.5.a.v.6 and S5.C.9.h	S5.C.5.a.v.6 and S5.C.9.h
Mapping		
Scale drawing of the lot(s), and any public-right-of-way that displays the location of On-site Stormwater Management BMPs	Vol. I, Section 3.1.5	Vol. I, Section 3.1.5
Map Stormwater Treatment and Flow Control BMPs/Facilities owned or operated by the Permittee	N/A	S5.C.2.a.iii
Map connections between Stormwater Treatment and Flow Control BMPs/Facilities and tributary conveyances mapped in accordance with S5.C.2	N/A	S5.C.2.b.iv

BMPs = best management practices
N/A = not applicable
Note: Phase I Permit references are from Ecology (2012a) and 2012 SWMMWW references are from Ecology (2012c).

Table 21. Phase II[5] WWA Permit Requirements and 2012 SWMMWW Guidance Related to LID BMP Maintenance Programs.

Requirement	LID BMP Type	
	On-site Stormwater Management BMPs	Stormwater Treatment and Flow Control BMPs/Facilities (MR #6 and/or MR #7)
Standards		
Implement maintenance standards	S5.C.5.a	S5.C.4.c.ii and S5.C.5.a
Adopt and make effective ordinance or other enforceable mechanisms	N/A	S5.C.4.a
Implement practices, policies, & procedures to reduce stormwater impacts associated with runoff	N/A	S5.C.5.f
Plan Review		
Verify that maintenance plan is completed and responsibility for maintenance is assigned for each Stormwater Treatment and Flow Control BMP.	N/A	S5.C.4.b.iv
Verify submission of maintenance instructions for each On-site Stormwater Management BMP	Vol. I, Section 3.1.5	Vol. 1, Section 3.1.5
Verify that an O&M manual is complete for each Stormwater Treatment and Flow Control BMP	N/A	Appendix 1 (Section 4.9) and Vol. 1, Section 3.1.7
Review and approve declaration of covenant (including design details, figures and maintenance instructions for each BMP) and grant of easement	Vol. 1, Section 3.1.7	Vol. 1, Section 3.1.7
Inspections		
Legal authority to inspect private stormwater facilities and enforce maintenance standards for all new and redevelopment	S5.C.4.a.iii	S5.C.4.a.iii
Conduct post-construction inspections to ensure proper installation	S5.C.4.a.iv	S5.C.4.a.iv
Conduct inspections during construction for all permanent Stormwater Treatment and Flow Control BMPs/Facilities in new residential developments (every 6 months until 90% of the lots are constructed or when construction is stopped and the site is fully stabilized)	N/A	S5.C.4.c.iv
Conduct ongoing annual inspections	N/A	S5.C.4.c.iii and S5.C.5.b
Perform spot checks of potentially damaged BMPs owned or operated by the Permittee after major storm events	N/A	S5.C.5.c

BMPs = best management practices
N/A = not applicable
Note: Phase II Permit references are from Ecology (2012b) and 2012 SWMMWW references are from Ecology (2012c).

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[5] The special conditions listed in this document are for city and county permittees. Secondary permittees should refer Section S6 of the permit for their special conditions that pertain to LID BMP maintenance.

Table 21 (continued). Phase II WWA Permit Requirements and 2012 SWMMWW Guidance Related to LID BMP Maintenance Programs.

Requirement	LID BMP Type	
	On-site Stormwater Management BMPs	Stormwater Treatment and Flow Control BMPs/Facilities (MR #6 and/or MR #7)
Enforcement		
Enforce compliance with maintenance standards as needed based on inspections	N/A	S5.C.4.b.iii and iv
Training		
Train staff involved in plan review, permitting, construction site inspections, and enforcement.	S5.C.4.e	S5.C.4.e
Implement an ongoing training program for employees who have primary O&M job functions that may impact stormwater quality	S5.C.5.g	S5.C.5.g
Record Keeping		
Keep records of inspections and enforcement actions (e.g., inspection reports, notices of violations)	S5.C.4.c.vii and S5.C.5.i	S5.C.4.c.vii and S5.C.5.i
Mapping		
Scale drawing of the lot(s), and any public-right-of-way that displays the location of On-site Stormwater Management BMPs	Vol. I, Section 3.1.5	Vol. I, Section 3.1.5
Map Stormwater Treatment and Flow Control BMPs/Facilities owned or operated by the Permittee	N/A	S5.C.3.a.iii

BMPs = best management practices

N/A = not applicable

Note: Phase II Permit references are from Ecology (2012b) and 2012 SWMMWW references are from Ecology (2012c).

Tools for Implementing an LID Maintenance Program

This section discusses a range of administrative tools available to assist jurisdictions in implementing the LID BMP maintenance requirements outlined above. The following key tools are discussed in detail below.

- Stormwater code/manual
- Legal agreements (such as declarations of covenant and access easements between a property owner and the City/County)
- Project-specific BMP maintenance requirements
- Financial surety measures
- Record keeping and tracking process
- Inspection programs
- Mapping
- Private property owner education

Table 22 summarizes the utility of these tools for typical elements of a maintenance program (e.g., plan review, inspection program). A local government can select and tailor the tools described in this section to meet Permit requirements in a manner that fits within their existing program.

Table 22. Administrative Tools to Implement O&M Programs.

Maintenance Program Element	Administrative Tool
Maintenance Requirements	
Require maintenance of all permanent Stormwater Treatment and Flow Control BMPs/Facilities	• Stormwater code/manual
Set forth minimum inspection and O&M requirements	• Stormwater code/manual
Plan Review	
Define permitting and plan review process to meet NPDES Permit requirements for both private and public projects	• Stormwater code/manual • Permitting and plan review processes are typically streamlined or modified for public projects
List required development project submittal elements	• Stormwater code/manual
Identify and characterizes stormwater features on site	• Stormwater Site Plan including scale drawing of the lot(s), and any public-right-of-way that displays the location of On-site Stormwater Management BMPs • Legal agreements/documents should include scale drawings, design details, figures, and maintenance instructions as attachments or refer to building permit, plan, or document in public files
Provide project-specific (or BMP-specific) inspection, operation, and maintenance requirements	• Legal agreements (direct responsible party to code and/or project-specific maintenance requirements) • Stormwater code/manual provides general requirements • Project-specific maintenance requirements include maintenance instructions for each On-site Stormwater Management BMP and project O&M manual for each Stormwater Treatment and Flow Control BMP/Facility • Private property owner education
Identify the party responsible for the retention, protection and maintenance of the BMPs	• Stormwater code/manual sets forth requirements for legal agreements • Legal agreements describe maintenance responsibility
Describe how the responsibility for maintenance is transferred when property ownership changes	• Stormwater code/manual sets forth requirements for legal agreements • Legal agreements describe maintenance responsibility
Inspection	
Set forth inspection process to meet NPDES Permit requirements for both private and public projects	• Stormwater code/manual or internal procedures
Establish legal authority of local government to inspect private stormwater facilities	• Stormwater code/manual sets forth requirements for legal agreements • Legal agreements help allow access for inspection
Ensure proper construction of BMPs	• Inspections during construction and immediately after construction • Inspection checklists
Ensure long-term maintenance of BMPs	• Ongoing annual inspections and inspections after large storm events (review record drawings during inspection) • Inspection checklists
Enforcement	
Set forth enforcement process to meet NPDES Permit requirements for both private and public projects	• Stormwater code/manual or internal procedures • Enforcement processes may not be necessary for public projects, but are helpful to include in contractor specifications/contract language
Establish legal authority of local government to enforce BMP maintenance standards	• Stormwater code/manual
Establish enforcement mechanisms, such as fee triggers and schedule for unmaintained facilities	• Stormwater code/manual lists escalating enforcement actions • Stormwater code/manual sets forth requirement for financial surety measures (e.g., bonds) for development plats to guarantee maintenance of BMPs after construction

Table 22 (continued). Administrative Tools to Implement O&M Programs.

Maintenance Program Element	Administrative Tool
Record Keeping and Tracking Process	
Keep records of inspections and enforcement actions (e.g., inspection reports, notices of violations)	• Develop interdepartmental record keeping and tracking process
Mapping	
Implement ongoing program for mapping BMPs	• Update mapping program as needed, including procedures for mapping distributed LID BMPs within a larger development.
Education/Training	
Train inspectors and staff on LID maintenance	• Develop / update internal training program • Develop /update a public outreach and education program for LID maintenance
Train developers and contractors on LID maintenance	• Develop and provide training on LID maintenance requirements in stormwater code/manual or internal procedures

Stormwater Code / Manual

A stormwater code can be used to require maintenance of private LID BMPs, and legally authorize local governments to inspect BMPs and enforce BMP maintenance requirements. While codes can be written to explicitly address all maintenance requirements, they often refer to a stormwater manual for details (i.e., 2012 SWMMWW or equivalent). Stormwater code and manuals can be used to accomplish the following:

- Require maintenance of all permanent stormwater BMPs and facilities
- Set forth minimum inspection, operation, and maintenance requirements
- Define permitting and plan review processes
- List required development project submittal elements (e.g., Stormwater Site Plans, legal agreements, project O&M manual)
- Require legal agreements with private property owners that identify the party responsible for retention, protection, and maintenance of BMPs
- Require legal agreements with private property owners that describe how the responsibility for maintenance of BMPs is transferred when property ownership changes
- Define the inspection process
- Establish legal authority of local government to inspect private stormwater facilities
- Define the enforcement process
- Establish legal authority of local government to enforce BMP maintenance standards
- Establish enforcement mechanisms, such as fee triggers and schedule, for unmaintained facilities
- Set forth requirement for financial surety measures (e.g., bonds) for development plats to guarantee maintenance of BMPs after construction

Incorporating private facilities into a City/County stormwater maintenance program

Cities and counties generally have a maintenance program in place and have made decisions regarding whether they assume maintenance responsibility for private facilities. The jurisdiction’s decision regarding LID BMP maintenance responsibility would be evaluated in the context of its existing program approach. Options include the following:

1) City/County could inspect facilities and require that the property owner hire a qualified contractor to conduct necessary maintenance
2) City/County could require facility owners to contract with a third party inspector and provide an inspection certification letter to the City/County, as well as proof that any required maintenance has been completed
3) City/County could perform maintenance and charge the property owner
4) City/County could assume maintenance responsibilities through a deed or easement.

- Establish limited legal authority to conduct maintenance when not conducted in a timely manner and bill the property owner for the costs.

Often the owner of the property on which the BMP is located is responsible for LID BMP maintenance. However, the local government can choose to incorporate private BMPs into a City/County stormwater maintenance program (see the sidebar for tips).

Legal Agreements and Recordable Documents

Legal agreements between a private party, responsible for BMP maintenance, and the local government can be recorded against a property title to help require and ensure long-term facility maintenance. Examples of these agreements include declarations of covenant and grants of access easement. Some type of legal agreements and recordable documents are necessary to accomplish the following:

- Identify and characterize the stormwater features on site (i.e., attach as-built drawing of the lot with the location of the On-site Stormwater Management BMPs and the area served by them, design details, figures, and maintenance instructions)

- Require inspection and O&M activities and direct responsible party to local municipal code, manual, and/or project-specific O&M manual

- Identify the party responsible for retention, protection, and maintenance of BMPs

- Describe how the responsibility for maintenance of BMPs is transferred when property ownership changes

- Help give the local government legal access for inspection of BMPs

What happens when a property is sold?

When a property is sold, it is important that the new owner is informed of their maintenance responsibilities and that the local government tracks the sale to ensure legal agreements are in place. Options include the following:

- Include language in the covenant that the property owner must inform all future purchasers of the existence and maintenance requirements of the stormwater BMPs on their property and transfer possession of the project O&M manual (or in the case of lots without Stormwater Treatment and Flow Control BMPs/Facilities, maintenance instructions) to the new property owner
- Require informational handouts at point-of-sale inspections
- Require escrow companies to fax or e-mail the City/County when they perform the “tap and connection” check at time of sale to help the local government track the responsible party
- If a financial surety is in place, require the new owner to obtain one before releasing the existing bond

Several example covenants and access easements from Washington jurisdictions are included in Appendix A. Note that a covenant to be recorded against the property can be used to identify the LID BMPs on the property and the land owner’s obligations to protect, operate, and maintain the BMPs. If the covenant does not cover access for maintenance then a separate legal agreement is necessary.

Permittees should review the local process for recording legal agreements through the recorder's office/county assessor in order to address barriers or time-consuming delays. For example, if an easement requires city/county council approval, solutions could include:

- Using a covenant instead
- Exempting access easements for maintenance from city/county council approval
- Streamlining or simplifying the process in other ways.

An administrative challenge related to legal agreements is establishing procedures to inform new property owners of their maintenance responsibilities for BMPs on their site. See side bar "What Happens When a Property is Sold" for tips.

Some local governments make the legal agreements with homeowners' associations (HOAs). An advantage of this is that it may be easier to work with the HOA than with individual property owners. The HOA can conduct maintenance or arrange for a qualified third party professional to conduct the maintenance. Another advantage of HOAs is as a point of contact for outreach and education. An incentive to encourage ongoing HOA responsibility for stormwater facility maintenance could include a reduced stormwater utility fee. A disadvantage of assigning responsibility to the HOA through a legal agreement is that some HOAs dissolve over time. The legal agreement can be written to transfer the maintenance responsibility for a shared facility to the individual property owners if an HOA goes defunct. For subdivisions, it is important to list the individual homeowners or lots on permit documents to simplify future enforcement actions, if necessary.

Tips for tracking LID BMP information

To establish an efficient inspection and maintenance program, it is critical to track and link pertinent information. Consider the following

- Establish an interdepartmental coordination process between information technology (IT), GIS, and different permitting administrators
- Develop a geodatabase or web-based database with tags to link electronic "as builts" or "record drawings", inspection forms, O&M manuals, and other BMP information to the BMP location. Consider indexing the BMP(s) by an identifier that will not change over time (e.g., parcel numbers can change).
- Tagging a property will alert plan review staff of the existence of a BMP and help to ensure the BMP is protected or replaced during redevelopment activities
- Conduct an end of the year audit to ensure that everything has been tracked and require that information is transferred between departments (e.g., from permitting administrators to department(s) responsible for inspections and enforcement)

Project-Specific BMP Maintenance Requirements

For development projects subject only to Minimum Requirements #1 through #5, Stormwater Site Plans should include maintenance instructions for On-Site Stormwater Management BMPs.

For projects subject to Minimum Requirements #1 through #9, maintenance instructions should also be developed for all On-site Stormwater Management BMPs that are not defined as Stormwater Treatment and Flow Control BMPs/Facilities.

Where projects must meet MR #6 and/or MR #7, O&M manuals must be developed for each Stormwater Treatment and Flow Control BMP. That means a manual for every bioretention, permeable pavement, and vegetated roof built as part of the project. These manuals identify the party responsible for maintenance, specify maintenance activities, and contain maintenance logs and a maintenance schedule.

At private facilities, a copy of each O&M manual must be retained onsite, or within reasonable access to the site, and must be transferred with the property to the new owner. If the LID BMPs are distributed on individual lots, then each property owner should have an O&M manual. For public facilities, a copy of the project O&M manual must be retained in the appropriate department. A log of maintenance activity, indicating actions taken, must be kept and made available for review upon request by the local government.

The project-specific maintenance requirements must be at least as stringent as those in the local maintenance standards. Because maintenance requirements and recommended procedures may evolve over time, consider allowing project proponents to include a reference to a document that can be updated periodically. The agreement can refer to “the current version of” the document. Some jurisdictions have online maintenance manuals that can be referenced in legal agreements, so that the most up-to-date maintenance information is available for property owners.

Financial Surety Measures

One mechanism for ensuring that LID BMPs are protected and maintained after construction is to require a financial surety, such as a bond or an assignment of accounts (also called an assignment of savings). If authorized by the jurisdiction’s code, local governments can require that sureties are obtained by developers (surety measures are typically not used for single infill lots). The financial surety allows the government to enforce maintenance requirements (e.g., by pulling the bond) until the plat is fully constructed, or longer. This is particularly important if a jurisdiction assumes responsibility for private facility maintenance once construction has been completed. It is critical to ensure that adequate funds are available in the event of a non-compliant facility. One drawback to sureties is that they are generally only valid for two years before they are released (RCW 58.17.130), and if LID BMPs are on individual lots, they may not all be in place within 2 years.

Record Keeping & Tracking Process

An effective maintenance program requires the collection and tracking of LID BMP and maintenance information, beginning with the plan review process and continuing for the life of the facility. The following information should be included in a City/County record keeping system for BMP maintenance:

- Parcel information
- City/County permit (right-of-way permit for roads and utilities for a subdivision, and/or building permits for individual lots)

- Relevant sections of the Stormwater Site Plan (e.g., Permanent Stormwater Control Plan) and attached documents
- “As-builts” or “record drawings” for individual lots and for public rights-of-way
- Legal agreements (e.g., covenants or easements)
- Location information (e.g., GPS data, digital maps)
- Project O&M manual (where applicable, see Tables 20 and 21)
- Maintenance logs (typically included in a project O&M manual)
- Inspection forms (e.g., during construction, post-construction, ongoing annual)
- Enforcement documents

It is critical for local governments to develop effective interdepartmental recording and record management procedures to support ongoing annual inspections. The information including, but not limited to, the items listed above should be “linked” for individual property and to a related subdivision (if applicable). See the sidebar for some tips on how to approach tracking.

Inspection Programs

Inspections are required for all LID BMPs immediately post-construction. These inspections are critical to check that the BMPs are installed per plan and functioning properly. Inspections are also required for all permanent Stormwater Treatment and Flow Control BMPs/Facilities in new residential developments every 6 months until 90 percent of the lots are constructed (or when construction is stopped and the site is fully stabilized) to identify maintenance needs and enforce compliance with maintenance standards, as needed. These inspections can require interdepartmental coordination because the site/building inspection process may include multiple departments administering different permits.

Challenges & tips for larger development sites

Large subdivision development sites pose challenges for LID BMP maintenance programs because:

- Subdivisions may include numerous distributed LID BMPs with a large number of responsible parties
- The developer may not have all BMPs sited and designed at time of plan review
- There is a risk that the plat will be cleared and the project abandoned
- Lots could be sold to multiple builders and construction could occur over a long period of time

Local governments could consider the following:

- Require bonding until full build out and stormwater BMP construction
- Ensure financial surety amount is sufficient
- Require recording of multi-party covenants for BMPs in the right-of-way (e.g., roadside bioretention) for each lot adjacent to the right-of-way
- Prohibiting or limiting wholesale clearing (mass grading) of sites
- Require recording of covenant and access easement agreements prior to final plat or final short plat
- Revise/supplement plan review checklist and procedures to record, track and establish agreements for single lots in addition to full plats

Ongoing annual inspections are required for all Stormwater Treatment and Flow Control BMPs/Facilities (designed to meet or help meet MR #6 and/or MR #7). While legal agreements authorize some access to the BMP, the local jurisdiction procedures may include requirements to provide written notice and secure consent from the property owner prior to the inspection. Securing consent may help to avoid potential conflict and allows a “contact” and opportunity for education of the private property owner. In addition, educational door hangers or handouts can be distributed prior to and during inspections to inform property owners of the BMPs located on their site, how the BMP functions, and where to find BMP maintenance requirements.

Local governments could consider allowing third party inspection for BMPs in settings that are difficult for a City/County inspector to access (e.g., backyard of a private residence) or if property owners do not want City/County inspectors on their properties. The property owner would be required to provide the City/County with inspection documentation from an approved third party inspector, or inspections and maintenance could be arranged through the HOA. This would reduce the potential liability concerns and reduce staffing needs while still allowing the jurisdiction to meet their annual inspection requirements. Local governments could consider mitigating the cost to the private property owner by crediting the inspection fee on their utility bill.

Inspectors should be trained on the function of LID BMPs and proper procedures for BMP inspection during and after construction. Inspection checklists for LID BMPs are a good tool to support consistent inspection practices and can be used for record keeping. The project specific O&M document and record drawings should be reviewed before and during the inspection.

Mapping

Jurisdictions increasingly rely on Global Positioning System (GPS) data, digital maps, and field-accessible databases to locate and track inspection and maintenance of stormwater facilities. Unlike traditional centralized stormwater facilities, LID BMPs are small, distributed features. Because there are typically many LID BMPs scattered across development sites, mapping can be a challenge. Local governments can consider the following options for mapping LID BMPs:

- Placing single points on stormwater system maps that reference permanent stormwater control plans (also referred to as “as-builts,” or “record drawings”). These plans typically contain the information to support inspections, provided they are maintained, to reflect any modifications made to the facilities, and are readily accessible to inspectors in the field. With this approach, single points would be placed on the map near the center of the dispersed LID BMPs.

- Mapping the location of each LID BMP. This may be more time consuming and clutter some stormwater system maps; however, it will provide the location of each known LID BMP and may be easier to track inspections and maintenance.

Private Property Owner Education

Education is a key component to ensuring that private property owners understand LID BMPs and their maintenance requirements. Some suggestions for public education include:

- Door hangers or handouts distributed at maintenance inspections
- Booklet on how to maintain LID features (e.g., rain gardens), provided to the homeowner, along with other property documentation, by the developer
- Homeowner education program(s) that require realtors to inform potential home buyers of the presence of LID features, their maintenance requirements, and recommends inspection prior to purchase (similar to side sewer education model)
- Placard in the house or signage outside of the house that identifies the LID BMP and refers to maintenance information
- Program for homeowner education provided at the permit counter (e.g., scheduled meeting in which the review staff "walk" the homeowner through the property "as builts" and explain how the BMPs function
- Program for HOA education provided in the classroom and as a site visit. Staff meet with the HOA to go through the property "as builts" and explain how the BMPs function. Staff also describe maintenance techniques specific to the HOA's LID BMPs and review Operations & Maintenance manuals or maintenance instructions for the LID BMPs that HOA maintains. Then staff and the HOA visit their LID BMPs so that staff can teach the HOA about inspecting their LID BMPs and additional maintenance techniques.
- Classes for homeowners/private property owners/HOAs through universities or groups such as extension programs, Conservation Districts, or Master Gardeners Associations
- Educational handouts/fact sheets distributed via local partnerships and programs
- Utility bill inserts
- Broader community outreach through media, web resources, or activities at community events.

An excerpt from Pierce County's stormwater maintenance manual for private facilities is included in Appendix B. Note that this document is provided as an example based on format only; the content has not been reviewed for consistency with the 2013-2018 Permit requirements or the material included in this guidance document.

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APPENDIX A

Examples of Covenants and Easements

When Recorded, Return to

Department of Planning and Development
700 5th Ave, Suite 1800
P.O. Box 34019
Seattle, WA 98124-4019

11/08/11

MEMORANDUM OF DRAINAGE CONTROL
(SMC 22.807.020)

GRANTOR: 1) ________________________________

2) ________________________________

3) ________________________________

☐ Additional Owners/Grantors on page ______

GRANTEE: The City of Seattle

LEGAL DESCRIPTION (ABBREVIATED):

☐ Additional legal description on page 2.

ASSESSOR'S TAX PARCEL ID NO(S). ________________________________

Permit Street Address ____

Application No. (by DPD staff): _________________________

Date (by DPD staff): ______/______/______

Grantor's Address ____

City ________________________ State _________ Zip __________

MEMORANDUM OF DRAINAGE CONTROL
(SMC 22.807.020)

THIS Agreement is executed in favor of the City of Seattle (“City”) by the undersigned owner(s (“Grantor”) of the following described real property situated in City of Seattle, King County, State of Washington (the “Property”) (insert complete legal description):

In consideration of the City’s granting a permit for the drainage control facilities proposed by Grantor, and for the City’s allowing the connection thereof to the City’s drainage system if applicable, Grantor hereby agrees and covenants, pursuant to SMC 22.807.020, as follows:

On_____________, 20____________, Side Sewer Permit #_______________and

Building Permit #_________________were issued for the above described Property.

WHEREAS; the drainage control facilities permitted by said side sewer permit are the following and are key terms of the Property’s drainage control plan, which is documented in the drainage control plan drawing(s) as amended by the side sewer construction as-built record drawing(s) on file with the City of Seattle:

1. The following flow control best management practices (BMPs):
    - ☐ Existing Trees
    - ☐ Dispersion (downspout or sheet flow)
    - ☐ Bioretention Cells/Planters
    - ☐ Rainwater Harvesting
    - ☐ Permeable Pavement Surfaces
    - ☐ Permeable Pavement Facilities
    - ☐ Green Roof
    - ☐ Detention Cistern for a Single-Family Project
    - ☐ Infiltration Basins
    - ☐ Infiltration Trenches
    - ☐ Dry wells
    - ☐ Detention Pond
    - ☐ Detention Pipe
    - ☐ Detention Vault
    - ☐ Surface Ponding
    - ☐ Other (describe)_____________________________

MEMORANDUM OF DRAINAGE CONTROL
(SMC 22.807.020)

2. The following stormwater treatment BMPs:
    - ☐ Pretreatment Facilities___________________________
    - ☐ Biofiltration Swales
    - ☐ Filter Strips
    - ☐ Infiltration Basins, Trenches or Dry Wells
    - ☐ Bioretention System
    - ☐ Permeable Pavement Facilities
    - ☐ Sand Filtration
    - ☐ Wet Pond/Wet Vault
    - ☐ Stormwater Treatment Wetland
    - ☐ Oil Control Facilities: API / Coalescing Plate
    - ☐ StormFilter Units
    - ☐ Filterra Units
    - ☐ Other (describe)____________________________

3. The following source control structures:
    - ☐ Roof, Awning, Cover
    - ☐ Ground Surface Treatment
    - ☐ Sumps, Tanks
    - ☐ Berms, Dikes
    - ☐ Pavement
    - ☐ Containment
    - ☐ Washpad
    - ☐ Other (describe)____________________________

    to contain the following activities:
    - ☐ Cleaning and Washing
    - ☐ Material Transfer
    - ☐ Product and Application
    - ☐ Storage and Stockpiling
    - ☐ Dust Control and Soil and Sediment Control
    - ☐ Other: (describe)____________________________

4. and the following items, terms and/or limitations:
    - ☐ catch basin(s), quantity ___
    - ☐ submersible pump(s), quantity ____
    - ☐ Roof leader connections
    - ☐ Pipes with less than 2% grade
    - ☐ Invert connection less than 12 inches above main sewer or drain
    - ☐ Other (describe)____________________________

NOW THEREFORE; the Grantor, on behalf of Grantor and Grantor's heirs, successors and assigns, agrees to the following and hereby creates a covenant running with the land that shall be binding upon all parties and their heirs, successors and assigns forever:

The Grantor, on behalf of Grantor and Grantor's heirs, successors and assigns, agrees to and shall (1) inspect and maintain the above described drainage control facilities in accordance with the provisions of Seattle Municipal Code (SMC) Chapters 22.800 – 22.808 and any other provisions applicable to the facilities, as now and hereafter in effect, (2) implement the terms of the drainage control plan required by the SMC and (3) inform all future purchasers, successors and assigns of the existence of the drainage control facilities and other elements of the drainage control plan, the limitations of the drainage control facilities, and of the requirement for the facilities' continued inspection and maintenance; and

The obligations of Grantor and each of Grantor's heirs, successors and assigns under this Memorandum of Drainage Control shall terminate when that person, sells, devises or transfers the Property, or his or her interest therein, unless the obligation arises out of a claim of negligence or intentional act of that person. Further, recording of this Memorandum of Drainage Control as required herein shall satisfy the obligations to inform under subsection (3) above.

The Grantor, on behalf of Grantor and Grantor's heirs, successors and assigns, hereby grants permission for authorized representatives of the City of Seattle to enter onto the Property for inspection, monitoring, correction or abatement of conditions related to the Property's drainage control plan, drainage control facilities, Chapters SMC 22.800 – 22.808 or any other SMC provision applicable to drainage control, as now and hereafter in effect; and

The Grantor, on behalf of Grantor and Grantor's heirs, successors and assigns, (1) agrees and acknowledges that the City is not responsible for the adequacy or performance of the drainage control plan or the drainage control facilities, (2) agrees to accept any and all risks of harm, loss, or damage related to the drainage control plan or the drainage control facilities and (3) hereby waives any right to assert any and all present and future claims against the City, whether known or unknown, for any harm, loss or damage occurring either on or off the Property, related to the drainage control plan, the drainage control facilities, or drainage or erosion on the Property, except only for such harm, damages and losses that directly result from the sole negligence of the City.

This Memorandum of Drainage Control shall be recorded in the real estate records of the Office of Records and Elections of King County, Washington. If any provision of this Memorandum is held invalid, the remainder of the Memorandum is not affected.

SIGNATURES, ACKNOWLEDGEMENTS AND NOTARY (INDIVIDUAL—attach more pages if needed)

Dated:__________________

____
Owner/Grantor

____
Printed Name

____
Address

State of Washington)
) ss
County of _______________)

I certify that I know or have satisfactory evidence that________________________ is the person who appeared before me, and said person acknowledged that he/she signed this instrument and acknowledged it to be his/her free and voluntary act for the uses and purposes mentioned in the instrument.

Date: ____

NOTARY PUBLIC in and for the State of Washington
Residing at________________________________
My commission expires:_____________________
PRINT NAME: _____________________________

Use this space for Notary Seal

Dated:__________________

____
Owner/Grantor

____
Printed Name

____
Address

) ss
County of _______________)

I certify that I know or have satisfactory evidence that________________________ is the person who appeared before me, and said person acknowledged that he/she signed this instrument and acknowledged it to be his/her free and voluntary act for the uses and purposes mentioned in the instrument.

Date: ____

NOTARY PUBLIC in and for the State of Washington
Residing at_____________________________
My commission expires:___________________
PRINT NAME: ___________________________

Use this space for Notary Seal

State of Washington)

Memorandum of Drainage Control—Page No. ____

(CORPORATE OWNER, PARTNERSHIP OWNER, LIMITED LIABILITY COMPANY OWNER/OTHER LEGAL ENTITY OWNER—attach more pages if needed)

Date:___________________

____
Owner/Grantor

____
Printed Name

____
Address

By_____________________

____
Printed Name

Its_____________________

State of Washington)
)ss
County of _______________)

I certify that I know or have satisfactory evidence that______________________ is the person who appeared before me, and said person acknowledged that he/she signed this instrument, on oath stated that he/she was authorized to execute the instrument and acknowledged it as the______________________ (type of authority, e.g., partner, trustee, title of officer, personal representative, guardian, attorney in fact for a principal, etc.) of__________________________ (name of owner/entity on behalf of whom instrument was executed), to be the free and voluntary act of such party for the uses and purposes mentioned in the instrument.

Date: ____

NOTARY PUBLIC in and for the State of Washington
Residing at______________________________
My commission expires: ___________________
PRINT NAME: ___________________________

Use this space for Notary Seal

Date:___________________

____
Owner/Grantor

____
Printed Name

____
Address

By_____________________

____
Printed Name

Its_____________________

State of Washington)
)ss
County of _______________)

I certify that I know or have satisfactory evidence that______________________ is the person who appeared before me, and said person acknowledged that he/she signed this instrument, on oath stated that he/she was authorized to execute the instrument and acknowledged it as the______________________ (type of authority, e.g., partner, trustee, title of officer, personal representative, guardian, attorney in fact for a principal, etc.) of__________________________ (name of owner/entity on behalf of whom instrument was executed), to be the free and voluntary act of such party for the uses and purposes mentioned in the instrument.

Date: ____

NOTARY PUBLIC in and for the State of Washington
Residing at______________________________
My commission expires: ___________________
PRINT NAME: ___________________________

Use this space for Notary Seal

Memorandum of Drainage Control—Page No. ____

Appendix I-G3

Maintenance Agreement, Non-Residential Stormwater Facilities

(CORPORATE VERSION)

AGREEMENT TO MAINTAIN STORMWATER FACILITIES AND TO IMPLEMENT A POLLUTION SOURCE CONTROL PLAN

BY AND BETWEEN ___________________________
(HEREINAFTER "THE LOCAL GOVERNMENT") AND
__________________________________, AND
ITS HEIRS, SUCCESSORS, OR ASSIGNS
(HEREINAFTER "OWNER")

The upkeep and maintenance of stormwater facilities and the implementation of pollution source control best management practices (BMPs) is essential to the protection of water resources in ______________. All property owners are expected to conduct business in a manner that promotes environmental protection. This Agreement contains specific provisions with respect to maintenance of stormwater facilities and use of pollution source control BMPs. The authority to require maintenance and pollution source control is provided by ordinance.

LEGAL DESCRIPTION:

Whereas, Owner has constructed improvements, including but not limited to, buildings, pavement, and stormwater facilities on the property described above. In order to further the goals of the Local Government to ensure the protection and enhancement of Local Government's water resources, the Local Government and Owner hereby enter into this Agreement. The responsibilities of each party to this Agreement are identified below.

OWNER SHALL:

(1) Implement the stormwater facility maintenance program included herein as Attachment "A".

(2) Implement the pollution source control program included herein as Attachment "B".

(3) Maintain a record (in the form of a log book) of steps taken to implement the programs referenced in (1) and (2) above. The log book shall be available for inspection by Local Government staff at Owner's business during normal business hours. The log book shall catalog the action taken, who took it, when it was done, how it was done, and any problems encountered or follow-on actions recommended. Maintenance items ("problems") listed in Attachment "A" shall be inspected on a monthly or more frequent basis as necessary. Owner is encouraged to photocopy the individual checklists in Attachment A and use them to complete its monthly inspections. These completed checklists would then, in combination, comprise the monthly log book.

(4) Submit an annual report to the Local Government regarding implementation of the programs referenced in (1) and (2) above. The report must be submitted on or before May 15 of each calendar year and shall contain, at a minimum, the following:

(a) Name, address, and telephone number of the business, the person, or the firm responsible for plan implementation, and the person completing the report.

(b) Time period covered by the report.

(c) A chronological summary of activities conducted to implement the programs referenced in (1) and (2) above. A photocopy of the applicable sections of the log book, with any additional explanation needed, shall normally suffice. For any activities conducted by paid parties not affiliated with Owner, include a copy of the invoice for services.

(d) An outline of planned activities for the next year.

THE LOCAL GOVERNMENT WILL, AS RESOURCES ALLOW:

(1) Provide technical assistance to Owner in support of its operation and maintenance activities conducted pursuant to its maintenance and source control programs. Said assistance shall be provided upon request and at no charge to Owner.

(2) Review the annual report and conduct occasional site visits to discuss performance and problems with Owner.

(3) Review this agreement with Owner and modify it as necessary.

REMEDIES:

(1) If the Local Government determines that maintenance or repair work is required to be done to the stormwater facility existing on the Owner property, the Stormwater Manual Administrator shall give Owner within which the drainage facility is located, and the person or agent in control of said property if different, notice of the specific maintenance and/or repair required. The Administrator shall set a reasonable time in which such work is to be completed by the persons who were given notice. If the above required maintenance and/or repair is not completed within the time set, written notice will be sent to the persons who were given notice stating the Local Government's intention to perform such maintenance and bill Owner for all incurred expenses. The Local Government may also adjust stormwater utility charges on the Owner's bill if required maintenance is not performed.

(2) If at any time the Local Government determines that the existing system creates any imminent threat to public health or welfare, the Administrator may take immediate measures to remedy said threat. No notice to the persons listed in (1), above, shall be required under such circumstances.

(3) The Owner grants authority to the Local Government for access to any and all stormwater system features for the purpose of inspection, and performing maintenance or repair as may become necessary under Remedies (1) and/or (2).

(4) The persons listed in (1), above, shall assume all responsibility for the cost of any maintenance and for repairs to the stormwater facility. Such responsibility shall include reimbursement to the Local Government within 30 days of the receipt of the invoice for any such work performed. Overdue payments will require payment of interest at the current legal rate for liquidated judgments. If legal action ensues, any costs or fees incurred by the Local Government will be borne by the parties responsible for said reimbursements.

(5) The owner hereby grants to the Local Government a lien against the above-described property

in an amount equal to the cost incurred by the Local Government to perform the maintenance or repair work described herein.

This Agreement is intended to protect the value and desirability of the real property described above and to benefit all the citizens of the Local Government. It shall run with the land and be binding on all parties having or acquiring from Owner or their successors any right, title, or interest in the property or any part thereof, as well as their title, or interest in the property or any part thereof, as well as their heirs, successors, and assigns. They shall inure to the benefit of each present or future successor in interest of said property or any part thereof, or interest therein, and to the benefit of all citizens of the Local Government.

Dated at ____________, Washington, this ______ day of _________________, _____.

OWNER

By:________________________________
Authorized Agent for Owner

____

STATE OF WASHINGTON)
) **ss**
COUNTY OF THURSTON)

On this day and year above personally appeared before me, a Notary Public in and for the State of Washington duly commissioned and sworn, personally appeared __________________, to me known to be the ______________________ of ______________________ and acknowledge the said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated that _____ is authorized to execute the said instrument and that the seal affixed is the corporate seal of said corporation.

WITNESS my hand and official seal the day and year first above written.

____

Notary Public in and for the State of
Washington, residing in ___________________

My Commission Expires: __________________

Dated at ____________, Washington, this ______ day of _________________, _____.

LOCAL GOVERNMENT

By:______________________________
Authorized Agent for Local Government

STATE OF WASHINGTON)
) ss
COUNTY OF THURSTON)

On this day and year above personally appeared before me, ________________________, to me known to be acting as Authorized Agent for________________, a Municipal Corporation, who executed the foregoing instrument and acknowledged the said instrument to be the free and voluntary act and deed of said Municipal Corporation for the uses and purposes therein mentioned and on oath states he is authorized to execute the said instrument.

Given under my hand and official seal this ______ day of _____________, _____.

____
Notary Public in and for the State of
Washington, residing in __________________

My Commission Expires: _________________

APPROVED AS TO FORM:

____
Local Government Attorney

\\Calvin\cpd\FORMS\Agree to Maint Strmwtr Facilties-Corporation.wpd 12/9/09

Appendix I-G4

Maintenance Agreement, Residential Stormwater Facilties

(RESIDENTIAL SUBDIVISION VERSION)

AGREEMENT TO MAINTAIN
STORMWATER FACILITIES AND TO IMPLEMENT A
POLLUTION SOURCE CONTROL PLAN

BY AND BETWEEN____________________
(HEREINAFTER "THE LOCAL GOVERNMENT") AND
_________________________________, AND
ITS HEIRS, SUCCESSORS, OR ASSIGNS
(HEREINAFTER "OWNER")

The upkeep and maintenance of stormwater facilities and the implementation of pollution source control best management practices (BMPs) is essential to the protection of water resources in the Local Government's jurisdiction. All property owners are expected to conduct business in a manner that promotes environmental protection. This Agreement contains specific provisions with respect to maintenance of stormwater facilities and use of pollution source control BMPs. The authority to require maintenance and pollution source control is provided in ordinance.

LEGAL DESCRIPTION:

Whereas, Owner has constructed improvements, including but not limited to, buildings, pavement, and stormwater facilities on the property described above. In order to further the goals of the Local Government to ensure the protection and enhancement of Local Government's water resources, the Local Government and Owner hereby enter into this Agreement. The responsibilities of each party to this Agreement are identified below.

OWNER SHALL:

(1) Implement the stormwater facility maintenance program included herein as Attachment "A".

(2) Implement the pollution source control program included herein as Attachment "B".

(3) Maintain a record (in the form of a log book) of steps taken to implement the programs referenced in (1) and (2) above. The log book shall be available for inspection by Local Government staff at Owner's business during normal business hours. The log book shall catalog the action taken, who took it, when it was done, how it was done, and any problems encountered or follow-on actions recommended. Maintenance items ("problems") listed in Attachment "A" shall be inspected on a monthly or more frequent basis as necessary. Owner is encouraged to photocopy the individual checklists in Attachment A and use them to complete its monthly inspections. These completed checklists would then, in combination, comprise the monthly log book.

(4) Submit an annual report to the Local Government regarding implementation of the programs

referenced in (1) and (2) above. The report must be submitted on or before May 15 of each calendar year and shall contain, at a minimum, the following:

(a) Name, address, and telephone number of the business, the person, or the firm responsible for plan implementation, and the person completing the report.

(b) Time period covered by the report.

(c) A chronological summary of activities conducted to implement the programs referenced in (1) and (2) above. A photocopy of the applicable sections of the log book, with any additional explanation needed, shall normally suffice. For any activities conducted by paid parties not affiliated with Owner, include a copy of the invoice for services.

(d) An outline of planned activities for the next year.

THE LOCAL GOVERNMENT WILL, AS RESOURCES ALLOW:

(1) Provide technical assistance to Owner in support of its operation and maintenance activities conducted pursuant to its maintenance and source control programs. Said assistance shall be provided upon request and at no charge to Owner.

(2) Review the annual report and conduct occasional site visits to discuss performance and problems with Owner.

(3) Review this agreement with Owner and modify it as necessary.

REMEDIES:

(1) If the Local Government determines that maintenance or repair work is required to be done to the stormwater facility existing on the Owner property, the Stormwater Manual Administrator shall give Owner, and the person or agent in control of said property if different, notice of the specific maintenance and/or repair required. The Administrator shall set a reasonable time in which such work is to be completed by the persons who were given notice. If the above required maintenance and/or repair is not completed within the time set by the Administrator, written notice will be sent to the persons who were given notice stating the Local Government's intention to perform such maintenance and bill the owner for all incurred expenses. The Local Government may also adjust stormwater utility charges if required maintenance is not performed.

(2) If at any time the Local Government determines that the existing system creates any imminent threat to public health or welfare, the Administrator may take immediate measures to remedy said threat. No notice to the persons listed in (1), above, shall be required under such circumstances.

(3) The Owner grants authority to the Local Government for inspection, and access to any and all stormwater system features for the purpose of performing maintenance or repair as may become necessary under Remedies (1) and/or (2).

(4) The Owner shall assume all responsibility for the cost of any maintenance and for repairs to the stormwater facility. Such responsibility shall include reimbursement to the Local

Government within 30 days of the receipt of the invoice for any such work performed. Overdue payments will require payment of interest at the current legal rate for liquidated judgments. If legal action ensues, any costs or fees incurred by the Local Government will be borne by the parties responsible for said reimbursements.

(5) The Owner hereby grants to the Local Government a lien against the above-described property in an amount equal to the cost incurred by the Local Government to perform the maintenance or repair work described herein.

This Agreement is intended to protect the value and desirability of the real property described above and to benefit all the citizens of the Local Government. It shall run with the land and be binding on all parties having or acquiring from Owner or their successors any right, title, or interest in the property or any part thereof, as well as their title, or interest in the property or any part thereof, as well as their heirs, successors, and assigns. They shall inure to the benefit of each present or future successor in interest of said property or any part thereof, or interest therein, and to the benefit of all citizens of the Local Government.

Dated at _______________, Washington, this ______ day of _________________, ______.

OWNER

____
Authorized Agent for Owner

STATE OF WASHINGTON)
) ss
COUNTY OF THURSTON)

On this day and year above personally appeared before me, __________________ __________________________ known to be the individual(s) described, and who executed the foregoing instrument and acknowledge that they signed the same as their free and voluntary act and deed for the uses and purposes therein mentioned.

Given under my hand and official seal this ______ day of _____________, _______.

____

Notary Public in and for the
State of Washington, residing in

_______________________________.

For recording purposes, please ***do not*** write in margins.

Dated at ________________, Washington, this ______ day of ________________, ______.

LOCAL GOVERNMENT

____
Authorized Agent for the Local Government

STATE OF WASHINGTON)
) ss
COUNTY OF THURSTON)

On this day and year above personally appeared before me,_________________________, to me known to be the Authorized Agent for the Local Government, a Municipal Corporation, who executed the foregoing instrument and acknowledge the said instrument to be the free and voluntary act and deed of said Municipal Corporation for the uses and purposes therein mentioned and on oath states he is authorized to execute the said instrument.

Given under my hand and official seal this ______ day of _____________, _____.

____
Notary Public in and for the
State of Washington, residing in

______________________________.

APPROVED AS TO FORM:

____
Local Government Attorney

Z:\FORMSJ\Agree to Maint Strmwtr Facilties-Private.wpd 03/16/01

When Recorded, Return To:

City of Tacoma
Environmental Services / Science and Engineering
747 Market Street Tacoma, WA 98402

DOCUMENT TITLE:	**COVENANT AND EASEMENT** **PROJECT NAME**
Grantor(s): **DEVELOPER**	
Grantee: CITY OF TACOMA, a Municipal Corporation	
Legal Description (abbreviated): *****EXAMPLE***** See Page 4, Exhibit "A", for Legal Description	
Reference Number(s): City of Tacoma Short Plat No. xxxxxxxxx; City of Tacoma Work Order No. xxxxxxxx; City of Tacoma Building Permit No. xxxxxxxx	
Assessor's Parcel Number(s): XX-XX-XX-XX	

COVENANT AND EASEMENT – PROJECT NAME

WHEREAS DEVELOPER, hereinafter collectively referred to as the Grantor(s), owns the real property known as Project Name, located at ***insert address here*** (the "Subject Property"), which is more fully described herein; and

WHEREAS pursuant to Tacoma Municipal Code 12.08.090(D), as may be hereafter amended, a condition of developing the Subject Property requires that it have adequate stormwater drainage; and

WHEREAS pursuant to _____________ approval, private storm drainage collection systems must be provided; and

WHEREAS Grantor(s) have/has chosen to install a private storm drainage system for the Subject Property, the location of which is legally described in Exhibit A, so as to proceed with _______________ approval; and

WHEREAS such a private storm drainage system will require ongoing maintenance to ensure it operates as designed;

NOW THEREFORE, in consideration of the mutual benefits herein described, Grantor(s) hereby make the following Covenant which shall be recorded with the Pierce County Auditor encumbering the Subject Property (Assessor's Parcel Number(s) xx-xx-xx-x-xxx).

(1) The Grantor(s) shall construct and maintain at his/her/their/its own cost, a private storm drainage system on the Subject Property, in accordance with the approved construction plans under City of Tacoma Short Plat No. XXXXXXXXXXX. The private storm drainage system shall consist of storm drainage pipes, manholes, catch basins and various drainage facilities throughout the short plat including all drainage facilities located in private easements.

(2) It shall be the sole responsibility of the Grantor(s) and/or his/her/their/its successors-in-interest to maintain the private storm drainage system in its originally designed condition. Any damages caused by the failure of the system shall be the sole responsibility of the Grantor(s), owner(s) and/or his/her/their successor(s)-in-interest.

(3) This Covenant is made to ensure the proper maintenance of the storm drainage system. This Covenant shall run with the Subject Property and be binding upon the Grantor(s) and all successor(s)-in-interest. The Grantor(s) consent(s) to filing this Covenant with the Pierce County Auditor's Office once it is executed.

(4) If the private storm drainage system is not maintained in accordance with the approved or as-built design, approved under City of Tacoma Work Short Plat No. XXXXXXXXXXX incorporated herein by reference, the City may enter the Subject Property, inspect and repair the system, and assess reasonable costs for the work that may be charged against the owner of any beneficiary lot(s).

(5) No permanent structures shall be constructed over or within any private storm sewer easements located within the Subject Property. Permanent structures shall mean any concrete foundation, concrete slab, wall, building, or other site improvement that would unreasonably interfere with the ability to access the utilities in said easement(s). Permanent structures shall not mean normal landscaping, asphalt paving, firewood or chain-link fences, or other similar site improvements.

NOW THEREFORE, to this end, the Grantor(s) hereby grant(s) a perpetual easement to the City of Tacoma to enter the Subject Property, inspect the private storm drainage system, and make necessary repairs at the expense of Grantor or other benefitted owners. Name, company, Address**,** designed the private storm drainage system.

By ____________________________
Name
Company
Address
City, state, zip code

ACKNOWLEDGEMENT

STATE OF WASHINGTON)
) SS.
COUNTY OF PIERCE)

I, the undersigned, a Notary Public, do hereby certify that on this _____ day of ______________, 20___, personally appeared before me_______________________ ____to me known to be the individual(s) described in and who executed the within instrument and acknowledged that he/she/they signed and sealed the same, on oath stated that he/she/they was authorized to execute the instrument and acknowledged it as his/her/their free and voluntary act and deed for the uses and purposes therein mentioned.

Given under my hand and official seal this _____ day of ________________, 20___.

____
Notary Public in and for the State of Washington
residing at ______________________________
My Commission expires ___________________

DESCRIPTION APPROVED:

____
City Surveyor

APPROVED AS TO FORM:

____
Deputy City Attorney

EXHIBIT A

LEGAL DESCRIPTION

EXAMPLE

When Recorded Return To:

City of Tacoma
Public Works
Real Property Services
747 Market Street, Room 737
Tacoma WA 98402-3769

DOCUMENT TITLE: COVENANT AND EASEMENT *****************
Grantor(s):
Grantee: CITY OF TACOMA, a Municipal Corporation
Legal Description (abbreviated): See pages 5 thru ____, Exhibit's "A" and "B", for full Legal Description
Reference Number(s): City of Tacoma Work Order
Assessor's Parcel Number(s):

COVENANT AND EASEMENT –Short Plat

WHEREAS*****************, hereinafter referred to as the Grantor, owns the properties on *****************. hereinafter referred to as *****************, which is more fully described in the attached and incorporated Exhibit A; and

WHEREAS in order to satisfy the requirements of TMC 12.08.090 (D), Grantor intends to construct a public bioretention facility located within the planting strip of the Fawcett Avenue right-of-way, for the benefit of the *****************; and

WHEREAS in order to satisfy requirements set forth in TMC Chapter 9.17, 9.18, and 9.19, *abutting property owners* are responsible for the maintenance of the planting strip and will be responsible for ongoing maintenance of the proposed bioretention facility to ensure it operates as designed.

WHEREAS Grantor, and all successors in interest, of those certain Lots within the *****************, (hereinafter collectively referred to as "Owner"), shall be obligated to maintain the public bioretention facility in accordance with this Covenant and Easement; and

WHEREAS the bioretention facility was designed by *****************who also designed the public storm drainage system;

NOW THEREFORE, in consideration of the mutual benefits herein described, Grantor hereby makes the following Covenant which shall be recorded with the Pierce County Auditor under Parcel Number's *****************.

.

COVENANT AND EASEMENT – *****************

(1) The Grantor shall construct and maintain, at its own cost, a public storm drainage system within the right-of-way adjacent to the property legally described in Exhibit B (which is incorporated herein by this reference), and in accordance with the approved Work Order under City of Tacoma Permit Number *****************

(2) The proposed bioretention facility in the right of way will be an asset of the City of Tacoma. However per Tacoma Municipal Code Chapter 9.17, 9.18, and 9.19, *abutting property owners* are responsible for the maintenance of the planting strip and will be responsible for maintenance of the proposed bioretention facility and Grantor hereby agrees to maintain the facility as outlined herein below.

Grantor shall:

- Weed and water the bioretention facility as necessary until the plants have become established,
- Remove leaves and debris blocking storm drains and pipes to prevent local flooding on an on-going basis,

- Keep sidewalks in front of homes clear of impediments to pedestrian access and safety, also on an on-going basis.

The City shall be responsible for:

- Regular monitoring and maintenance of the Natural Drainage System "hardware" – pipes, culverts, outlets, drains, and grates, and
- Providing emergency services and repairs.

(3) This Covenant is made to ensure the proper maintenance of the storm drainage system. It is the Grantor's intent that the terms and conditions of this Covenant shall run with the land and be binding upon the Grantor(s) and all successor(s) in interest. The Grantor consents to the City filing this Covenant with the Pierce County Auditor's Office once it is executed.

____
****

STATE OF WASHINGTON)
) ss
COUNTY OF ___________)

I certify that I know or have satisfactory evidence that *****************is the person who appeared before me, and said person acknowledged that he signed this instrument, on oath stated that he was authorized to execute the instrument and acknowledged it, as the owner of the property concerned in this agreement, to be his free and voluntary act for the uses and purposes mentioned in the instrument.

Dated this ______ day of _______________, 2009

____
Notary Public in and for the
State of Washington
My Commission Expires __________________

LEGAL DESCRIPTION APPROVED:

____
****
****
/Environmental Services

____
City Surveyor

APPROVED AS TO FORM:

____
Assistant City Attorney

EXHIBIT A-- *****************

<u>EXHIBIT B</u>

Legal Description

RECORDING REQUESTED BY AND
WHEN RECORDED MAIL TO:

____

____

____

____

RECORDING COVER SHEET

DECLARATION OF COVENANT AND GRANT OF EASEMENT

Grantor: ____

Grantee: ____

Legal Description: ____

____

____

Additional Legal(s) on: ____

Assessor’s Tax Parcel ID#: ____

____

____

DECLARATION OF COVENANT AND GRANT OF EASEMENT

For Stormwater Flow Control Best Management Practices

IN CONSIDERATION of the following approved King County (check one of the following) ☐ residential building permit, ☐ commercial building permit, ☐ clearing and grading permit, ☐ subdivision permit, or ☐ short subdivision permit for Application No. ____________________ relating to real property ("Property") legally described as follows:

____
____
____
____

The Grantor(s), the owner(s) in fee of the above described parcel of land, hereby covenants with King County, a political subdivision of the state of Washington its successors in interest and assigns ("King County"), that it will observe, consent to, and abide by the conditions and obligations set forth and described in Paragraphs 1 and 2 and 4 through 7 below with regard to the Property, and hereby grants an access easement on and to the Property to King County, for the purposes described in Paragraph 3 below. Grantor(s) hereby grants, covenants, and agrees as follows:

1. Owner(s) of the Property shall retain, uphold, and protect the stormwater management devices, features, pathways, limits, and restrictions, known as flow control best management practices ("Flow Control BMPs"), shown on the approved Flow Control BMP Site Plan for the Property attached hereto and incorporated herein as Exhibit A.

2. Owner(s) of the Property shall at their own cost, operate, maintain, and keep in good repair, the Property's Flow Control BMPs as described in the approved Design and Maintenance Details for each BMP attached hereto and incorporated herein as Exhibit B.

3. King County shall have a nonexclusive perpetual access easement on the Property in order to ingress and egress over the Property for the sole purposes of inspecting and monitoring the Property's Flow Control BMPs, and if applicable in accordance with the terms of Paragraph 4 below, performing any corrective work required to bring the Property's Flow Control BMPs into compliance with Title 9 of the King County Code.

4. If King County determines that maintenance, repair, restoration, and/or mitigation work is required to be done to the Flow Control BMPs and has not been performed by the Property owner(s), the Director of the Water and Land Resources Division of the King County Department of Natural Resources and Parks shall give notice to the Property owner (s) of the specific maintenance, repair, restoration, and/or mitigation work (Work) required pursuant to Title 9 of the King County Code. The Manager shall also set a reasonable time in which the Work is to be completed by the Property owner(s). If the Work is not completed within the time set by the Division Director, King County may perform the required Work. Written notice will be sent to the Property owner(s) stating King County’s intention to perform the Work. Performance of the Work by King County will not commence until at least seven (7) days after such notice is mailed. If, within the sole discretion of the Water and Land Resources Division Director, there exists an imminent or present danger, the owner hereby waives the seven (7) day notice period and the Work will begin immediately.

5. The owner(s) of the Property shall assume all responsibility for the cost of any Work required to be done to the Flow Control BMPs. Such responsibility shall include reimbursement to King County within thirty (30) days of the receipt of the invoice for any such Work performed by King County in accordance with the terms of Paragraph 3 above. Overdue payments will require payment of interest at the current legal rate as liquidated damages. In the event that King County does not receive reimbursement within the required time frame, it may elect to place a lien on the

Property and act upon the lien in accordance with the terms and procedures specified in Chapter 23.40 of the King County Code, as amended from time to time. If legal action is taken to enforce the provisions of this Paragraph, the prevailing party is entitled to costs and attorney's fees.

6. Apart from performing routine landscape maintenance, the Property owner(s) is (are) hereby required to obtain written approval from the Water and Land Resources Division Manager of the King County Department of Natural Resources and Parks prior to performing any alterations or modifications to the Flow Control BMPs. Any notice or consent required to be given or otherwise provided for by the provisions of this Declaration of Covenant and Grant of Easement shall be effective upon personal delivery, or three (3) days after mailing by Certified Mail, return receipt requested, whichever occurs sooner.

7. This Declaration of Covenant and Grant of Easement is intended to promote the efficient and effective management of surface water drainage on the Property, and it shall inure to the benefit of all the citizens of King County, its successors and assigns. This Declaration of Covenant and Grant of Easement shall run with the land and be binding upon Grantor(s), and Grantor's (s') successors in interest and assigns.

8. This Declaration of Covenant and Grant of Easement may be terminated by execution of a written agreement by Grantor(s) and King County expressing their mutual agreement to terminate this Declaration of Covenant and Grant of Easement.

IN WITNESS WHEREOF, this Declaration of Covenant and Grant of Easement is executed this _____________day of ___________________________, 20___.

By _______________________________________

Its ________________________________

By _______________________________________

Its ________________________________

STATE OF WASHINGTON)
)SS
COUNTY OF KING)

On this ______ day of ______________________________, 20___, before me, the undersigned, a Notary Public in and for the State of _________________________, duly commissioned and sworn personally appeared , to me known to be the individual described in and who executed the foregoing instrument, and acknowledged to me that he signed and sealed the said instrument as h free and voluntary act and deed for the uses and purposes therein mentioned.

WITNESS my hand and official seal hereto affixed the day and year in this certificate above written.

____

____
Printed name
Notary Public in and for the State of Washington,
residing at ______________________________

My appointment expires ___________________

RECORDING REQUESTED BY AND
WHEN RECORDED MAIL TO:

____
____
____
____

DECLARATION OF COVENANT

FOR INSPECTION AND MAINTENANCE OF STORMWATER FACILITIES AND BMPS

Grantor: __________________________________

Grantee: King County

Legal Description: ____

____

____

Additional Legal(s) on: ____

Assessor's Tax Parcel ID#: ____

IN CONSIDERATION of the approved King County __________________________ permit for application No. ______________________ relating to the real property ("Property") described above, the Grantor(s), the owner(s) in fee of that Property, hereby covenants(covenant) with King County, a political subdivision of the state of Washington and its municipal successors in interest and assigns ("King County" and "the County", or "its municipal successor"), that he/she(they) will observe, consent to, and abide by the conditions and obligations set forth and described in Paragraphs 1 through

10 below with regard to the Property, and hereby grants(grant) an easement as described in Paragraphs 2 and 3. Grantor(s) hereby grants(grant), covenants(covenant), and agrees(agree) as follows:

1. The Grantor(s) or his/her(their) successors in interest and assigns ("Owners") shall at their own cost, operate, maintain, and keep in good repair, the Property's stormwater facilities and best management practices ("BMPs") identified in the plans and specifications submitted to King County for the review and approval of permit(s) #: ______________________________ . Stormwater facilities include pipes, swales, tanks, vaults, ponds, and other engineered structures designed to manage stormwater on the Property. Stormwater BMPs include dispersion and infiltration devices, native vegetated areas, permeable pavements, vegetated roofs, rainwater harvesting systems, reduced impervious surface coverage, and other measures designed to reduce the amount of stormwater runoff on the Property.

2. King County shall have the right to ingress and egress over those portions of the Property necessary to perform inspections of the stormwater facilities and BMPs and conduct other activities specified in this Declaration of Covenant and in accordance with King County Code ("KCC") 9.04.120 or relevant municipal successor's codes as applicable. This right of ingress and egress, right to inspect, and right to perform required maintenance or repair as provided for in Section 3 below, shall not extend over those portions of the Property shown in Exhibit "A."

3. If King County determines that maintenance or repair work is required to be done to any of the stormwater facilities or BMPs, the Director of the Water and Land Resources Division or its municipal successor in interest ("WLR") shall give notice of the specific maintenance and/or repair work required pursuant to KCC 9.04.120 or relevant municipal successor's codes as applicable. The Director shall also set a reasonable time in which such work is to be completed by the Owners. If the above required maintenance or repair is not completed within the time set by the Director, the County may perform the required maintenance or repair, and hereby is given access to the Property, subject to the exclusion in Paragraph 2 above, for such purposes. Written notice will be sent to the Owners stating the

County's intention to perform such work. This work will not commence until at least seven (7) days after such notice is mailed. If, within the sole discretion of the WLR Director, there exists an imminent or present danger, the seven (7) day notice period will be waived and maintenance and/or repair work will begin immediately.

4. If at any time King County reasonably determines that a stormwater facility or BMP on the Property creates any of the hazardous conditions listed in KCC 9.04.130 or relevant municipal successor's codes as applicable and herein incorporated by reference, the WLR Director or equivalent municipal successors official may take measures specified therein.

5. The Owners shall assume all responsibility for the cost of any maintenance or repair work completed by the County as described in Paragraph 3 or any measures taken by the County to address hazardous conditions as described in Paragraph 4. Such responsibility shall include reimbursement to the County within thirty (30) days of the receipt of the invoice for any such work performed. Overdue payments will require payment of interest at the current legal rate as liquidated damages. If legal action ensues, the prevailing party is entitled to costs or fees.

6. The Owners are hereby required to obtain written approval from the King County WLR Director prior to filling, piping, cutting, or removing vegetation (except in routine landscape maintenance) in open vegetated stormwater facilities (such as swales, channels, ditches, ponds, etc.), or performing any alterations or modifications to the stormwater facilities and BMPs referenced in this Declaration of Covenant.

7. Any notice or consent required to be given or otherwise provided for by the provisions of this Agreement shall be effective upon personal delivery, or three (3) days after mailing by Certified Mail, return receipt requested.

8. With regard to the matters addressed herein, this agreement constitutes the entire agreement between the parties, and supersedes all prior discussions, negotiations, and all agreements whatsoever whether oral or written.

9. This Declaration of Covenant is intended to protect the value and desirability of the real property described above, and shall inure to the benefit of all the citizens of King County and its municipal successors and assigns. This Declaration of Covenant shall run with the land and be binding upon Grantor(s), and Grantor's(s') successors in interest, and assigns.

10. This Declaration of Covenant may be terminated by execution of a written agreement by the Owners and King County or the municipal successor that is recorded by King County in its real property records.

IN WITNESS WHEREOF, this Declaration of Covenant for the Inspection and Maintenance of Stormwater Facilities and BMPs is executed this _____ day of ____________________, 20_____.

____
GRANTOR, owner of the Property

____
GRANTOR, owner of the Property

STATE OF WASHINGTON)
COUNTY OF KING)ss.

On this day personally appeared before me:

____, to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed, for the uses and purposes therein stated.

Given under my hand and official seal this _____ day of ____________________, 20_____.

____

____
Printed name
Notary Public in and for the State of Washington,
residing at

____

My appointment expires _______________________

Drainage Facility Maintenance Covenant

We, the owners and contract purchasers of the lands herein platted (Grantor), agree that the obligations of Grantor shall inure to the benefit of and be binding upon the heirs, successors, and assigns. Grantor agrees that this covenant touches and concerns the land described herein and shall run with the land.

Grantor by execution of this covenant acknowledges that the benefits of this covenant inure to Grantor, downstream property owners, and the general public, and that Snohomish County (County) as third-party beneficiary of this covenant has the right, but not the obligation, to enforce this covenant on behalf of downstream property owners and the general public. County requires this covenant to protect private and public property, private and public drainage infrastructure, and natural resources of downstream property owners and the general public.

Grantor, in consideration of the approval of this subdivision, hereby covenants to perform regular maintenance upon the drainage facilities installed, or to be installed, upon Grantor's property. Regular maintenance shall include, at a minimum, annual inspection of the stormwater drainage system. As applicable, the system shall include the stormwater conveyance system pipes, ditches, swales, and catch basins; stormwater flow regulation system detention ponds, vaults, pipes, retention ponds, flow regulation and control structures; infiltration systems and water quality control system.

The scope of this covenant and right of entry shall be adequate to provide for the access, inspection, and maintenance of the stormwater drainage system, and shall be subject to the following terms and conditions:

1. County shall have the perpetual right of entry across adjacent lands of the Grantor for purposes of inspecting, auditing, or conducting required maintenance of the drainage facility.

2. If County inspection determines that maintenance is not being performed, County shall endeavor to provide Grantor reasonable advance notification of the need to perform the maintenance and a reasonable opportunity for Grantor to perform it. In the event that Grantor fails to complete the required maintenance within a reasonable time period, County

shall have the right to perform or contract with others to perform it at the sole expense of the Grantor. If County in its sole discretion determines that an imminent or present danger exists, required maintenance and/or repair may begin immediately at Grantor's expense without prior notice to Grantor. In such event, County shall provide Grantor with a written statement and accounting of all work performed and the fees, charges, and expenses incurred in making such repairs. Grantor shall agree to reimburse County or pay County's vendors directly for all reasonable fees, charges, and expenses identified in County's statement.

3. If County is required to act as a result of Grantor's failure to comply with this covenant, County may remove any obstructions and/or interferences that in the sole opinion of County impair the operation of the drainage facility or the maintenance thereof. Grantor agrees to hold County, its officers, employees, and agents harmless from any and all claims, actions, suits, liability, loss, expenses, damages and judgments of any nature whatsoever, including costs and attorney's fees, incurred by the removal of vegetation or physical interference from the drainage facility.

4. When exercising the maintenance provisions of the covenant, in the event of nonpayment, County may bring suit to recover such costs, including attorney's fees, and upon obtaining a judgment, such amount shall become a lien against the property of Grantor as provided in RCW 4.56.190.

5. Grantor covenants that all of the owners, contract purchasers and lien holders of the property described herein have signed the dedication and/or declaration of this subdivision, that they have the right to grant this covenant on the property, and that the title to the property is free and clear of any encumbrances which would interfere with the ability to grant this covenant.

Return Address:
Snohomish County Property Manager
3000 Rockefeller Avenue
Mail Stop 404
Everett, WA 98201-4046
PDS Reference PFN: ___________

Drainage Facility Maintenance Covenant

Grantor(s) hereinafter referred to as **Grantor:**

1.
2.
3.

Grantee: Snohomish County, hereinafter referred to as **County,** a Political Subdivision under the Laws of the State of Washington.

Legal Description of property encumbered by covenant**:**
Abbreviated:

(if applicable, insert lot, Block, Plat Name), and/or as described in Exhibit(s) "   " *(typically Exhibit A).*

Located in   *qtr./*   *qtr.* Sec.   Twp.   N., Rge.   E., W.M.

Reference Number(s) of documents assigned, released, or modified:

Assessor's Property Tax Parcel/Account Number(s) of property(s) encumbered by the drainage covenant:

Grantor's Initials__________

Grantor has a record interest in the property encumbered by the covenant and agrees that the obligations of Grantor shall inure to the benefit of and be binding upon the heirs, successors, and assigns. Grantor agrees that this covenant touches and concerns the land described in Exhibit __________ and shall run with the land.

Grantor by execution of this covenant acknowledges that the benefits of this covenant inure to Grantor, downstream property owners, and the general public, and that the County as third-party beneficiary of this covenant has the right, but not the obligation, to enforce this covenant on behalf of downstream property owners and the general public. The County requires this covenant to protect private and public property, private and public drainage infrastructure, and natural resources of downstream property owners and the general public.

Grantor in consideration of the approval of County development permit No. _____________, relating to the real property described in Exhibit ______ and in consideration of other valuable consideration, receipt and sufficiency of which is hereby acknowledged, hereby covenants to perform regular maintenance upon the drainage facilities installed, or to be installed, upon Grantor's property. Regular maintenance shall include, at a minimum, annual inspection of the stormwater drainage system. As applicable, the system shall include the stormwater conveyance system pipes, ditches, swales, and catch basins; stormwater flow regulation system detention ponds, vaults, pipes, retention ponds, flow regulation and control structures; infiltration systems and water quality control system.

The scope of this covenant and right of entry shall be adequate to provide for the access, inspection, and maintenance of the stormwater drainage system, and shall be subject to the following terms and conditions:

1. The County shall have the perpetual right of entry across adjacent lands of the Grantor for purposes of inspecting, auditing, or conducting required maintenance of the drainage facility.

2. If County inspection determines that maintenance is not being performed, the County shall endeavor to provide Grantor reasonable advance notification of the need to perform the maintenance and a reasonable opportunity for the Grantor to perform it. In the event that Grantor fails to complete the required maintenance within a reasonable time period, the County shall have the right to perform or contract with others to perform it at the sole expense of the Grantor. If the County in its sole discretion determines that an

Grantor's Initials__________

imminent or present danger exists, required maintenance and/or repair may begin immediately at Grantor's expense without prior notice to Grantor. In such event, the County shall provide Grantor with a written statement and accounting of all work performed and the fees, charges, and expenses incurred in making such repairs. Grantor shall agree to reimburse the County or pay the County's vendors directly for all reasonable fees, charges, and expenses identified in the County's statement.

3. If the County is required to act as a result of Grantor's failure to comply with this covenant, the County may remove any obstructions and/or interferences that in the sole opinion of the County impair the operation of the drainage facility or the maintenance thereof. Grantor agrees to hold the County, its officers, employees, and agents harmless from any and all claims, actions, suits, liability, loss, expenses, damages and judgments of any nature whatsoever, including costs and attorney's fees, incurred by the removal of vegetation or physical interference from the drainage facility.

4. When exercising the maintenance provisions of the covenant, in the event of nonpayment, the County may bring suit to recover such costs, including attorney's fees, and upon obtaining a judgment, such amount shall become a lien against the property of Grantor as provided in RCW 4.56.190.

5. Grantor covenants that the owners of the property described herein are the person or persons identified on page 1 of this covenant as Grantors, that they have the right to grant this covenant on the property, and that the title to the property is free and clear of any encumbrances which would interfere with the ability to grant this covenant.

Executed this _________ day of ____________________, __________

Grantors:

Signature(s): ________________________ ________________________

Printed
Name(s): ________________________ ________________________

Title of Authorized Representative(s):
(if signing on behalf of a corporation)
________________________ ________________________

Drainage Facility Maintenance Covenant

PFN ________________________________

Additional Signatures (if needed):

____

____

Note: Signature(s) of Grantor(s) must be acknowledged by appropriate Notary Form.

Accepted and approved
for Snohomish County:

____________________________ Date: ____________
Director
Snohomish County
Department of Planning and
Development Services

Grantor’s Initials___________

CONSENT TO AND APPROVAL OF DRAINAGE MAINTENANCE COVENANT

___________________________ (*lender*), the current Beneficiary of a Deed of Trust recorded under AFN __________________ , records of Snohomish County, which deed of trust encumbers the real estate described in Exhibit ____________ of the attached Drainage Maintenance Covenant, does hereby consent to the establishment of said covenant

Signed: __________________________________

Title: __________________________________

Date: __________________

REPRESENTATIVE ACKNOWLEDGMENT

STATE OF WASHINGTON)
) ss
COUNTY OF SNOHOMISH)

I certify that I know or have satisfactory evidence that ____ is the person who appeared before me, and said person acknowledged that (he/she/they) signed this instrument , on oath stated that (he/she/they) was/were authorized to execute the instrument and acknowledged it as the ________________________________ of _________________________ to be the free and voluntary act of such party for the uses and purposes mentioned in the instrument.

Dated: _____________

Signature: _______________________________

(print name) _____________________________

(Seal or stamp)

NOTARY PUBLIC IN AND FOR THE STATE OF WASHINGTON

My appointment expires _______________

INDIVIDUAL ACKNOWLEDGMENT

STATE OF WASHINGTON)
) ss
COUNTY OF SNOHOMISH)

I certify that I know or have satisfactory evidence that

____
is/are the person(s) who appeared before me, and said person(s) acknowledged that (he/she/they) signed this instrument and acknowledged it to be (his/her/their) free and voluntary act for the uses and purposes mentioned in the instrument.

Dated: _____________

Signature: ________________________________
(print name) ______________________________
(Seal or stamp)
NOTARY PUBLIC IN AND FOR THE STATE OF WASHINGTON
My appointment expires _______________

REPRESENTATIVE ACKNOWLEDGMENT

STATE OF WASHINGTON)
) ss
COUNTY OF SNOHOMISH)

I certify that I know or have satisfactory evidence that ____ is the person who appeared before me, and said person acknowledged that (he/she/they) signed this instrument , on oath stated that (he/she/they) was/were authorized to execute the instrument and acknowledged it as the _________________________________ of __________________________ to be the free and voluntary act of such party for the uses and purposes mentioned in the instrument.

Dated: _____________

Signature: ________________________________
(print name) ______________________________
(Seal or stamp)
NOTARY PUBLIC IN AND FOR THE STATE OF WASHINGTON
My appointment expires _______________

APPENDIX B

Examples of Private Property Owner Education

Pierce County
Stormwater Maintenance Manual for Private Facilities

DRAFT 6/30/2009

1.0 Introduction: Maintaining Your Stormwater Facilites

The intent of this stormwater maintenance manual is to assist private stormwater management sytem owners in performing proper maintenance of these facilities.

Stormwater management facilities consist of a series of collection and conveyance systems, detention systems, and treatment facilities. They are typically a combination of landscape and structural components that slow, filter, detain, or infiltrate stormwater runoff on-site after a rainfall event. Properly designed, installed and maintained stormwater management facilites protect water quality and reduce flooding.

Pierce County Code Section 17A.40.020 states that private property owners are responsible for maintaining stormwater management structures that they own. Owners should have a maintenance program that addresses every component of the stormwater system, to ensure the system does not lose its intended capability to manage stormwater. Pierce County's "Stormwater Management and Site Development Manual", (Ord. 2008-59s, Ord. 96-47) requires that owners of private stormwater management facilities applying for development after the effective date of the Stormwater Manual conduct routine and non-routine inspection and maintenance of their stormwater system and prepare an annual inspection report to be submitted to Pierce County on or before May 15.

Property owners with private systems constructed prior to the effective date of the *Stormwater Manual* are also required to maintain their stormwater facilities, but are not required to submit the annual inspection and maintenance report to Pierce County.

1.1 How to Apply this Manual

Private owners should review this manual for understanding of the general function of their stormwater management facilities. After determining the type of facilities associated with the owner's site, the owner should download or copy the checklists for each facility and utilize them in facility inspection and maintenance.

It is important to note that there may be more than one facility associated with an individual site. For example, your site may include catch basins, a detention pond, and a control structure/flow restrictor. In this case, all three checklists should be utilized for inspection and maintenance.

1.2 Why Manage Stormwater Runoff?

When it rains or snows in urban areas, the stormwater runs off impervious surfaces (such as roofs and paved areas) instead of soaking into the ground. In the past stormwater runoff has mainly been directed into drains and pipes that carry it off-site for eventual discharge into a river or stream.

The past approach to stormwater management has a number of harmful effects:

- Impervious areas and residential lawns generate large volumes of runoff relatively quickly. The increased volume and rate of runoff can cause flooding and erosion of natural waterways, damage to roads and other manmade structures, and destroy natural wildlife habitat.
- The stormwater runoff picks up oil, pesticides, metals, chemicals, sediment, and other pollutants that harm water quality and fish habitat.
- During warm weather, the runoff absorbs heat from the impervious surfaces. This increases the temperature of the receiving waters, with negative impacts on fish and other aquatic life.
- Less water is able to infiltrate into the ground. This reduces groundwater recharge which reduces summer base flow in streams.

The current approach to stormwater management is for facilities to be designed to help mitigate for these negative effects of stormwater runoff by a combination of reducing or eliminating runoff, treatment of runoff, and/or retention or detention of runoff with a metered release through actions called “Best Management Practices”.

1.3 Frequently Asked Questions

1. **Q.** What are Best Management Practices (BMPs)?

A. BMPs are a series of actions that are designed to reduce stormwater pollution, prevent discharging contaminants to natural water bodies and reduce stormwater facility maintenance costs. These actions can take several different forms. Examples of these are:

Behavioral--For example, sweeping a driveway instead of hosing it into the storm drain.

Procedural--Such as implementing an inventory control program for hydraulic oil or other lubricants to identify changes in consumption. This type of program can be used to identify maintenance problems, and save the business owner money on equipment down-time and lubricant costs.

Structural--Such as building a roof over a production area, or installing an oil/water separator.

In general, behavioral and procedural type BMPs will cost the least to implement initially and may save money over time. Structural BMPs typically cost more to construct, operate, and maintain.

BMPs are separated into two broad categories, namely *source control* and *treatment BMPs*. As the name implies, source control BMPs prevent contaminants from entering stormwater runoff by controlling them at the source. Treatment BMPs are utilized to treat stormwater that is already contaminated. Most treatment BMPs require planning, designing, permitting, and construction, and none can remove 100% of the contaminants in stormwater. These factors, added to the typical expense of treatment BMPs, makes source control BMPs the preferred choice.

2. **Q.** There is a ditch in front of my home. Who is responsible for maintaining it?

A. If you are in a private development: you and your neighbors will have to maintain the drainage. If you are within a city's limits: contact your city's public works department. If you are not within a city's limits: storm drainage systems in public roads are maintained by the Transportation Division of Public Works and Utilities. The contact number for the Road Maintenance Division is (253)-798-6000. You can also use the online request system at the following URL; http://www.co.pierce.wa.us/cfapps/secure/publicworks/request.cfm

3. **Q**. What methods should we use to control unwanted pests and vegetation?

A. Pierce County encourages the use of an Integrated Pest Management (IPM) approach to control unwanted pests. Pests are any plant or animal life that adversely interferes with the function, safety, and aesthetics of the stormwater facility. IPM is a coordinated decision-making and action process that uses the most appropriate control methods and strategy in an environmentally and economically sound manner.

The IPM approach emphasizes physical, mechanical, cultural, and biological tactics to keep pests and vegetation problems low enough to limit or eliminate the use of chemical control. The major elements of IPM include:

- Preventing pest problems;
- Monitoring for the presence of pests and pest damage;
- Establishing a level of pest population that can be tolerated without being detrimental to the stormwater facilities function or aesthetics of the facility.
- Treating pest problems to reduce populations below those established levels by using the most environmentally sensitive and safe method to control the pest;
- Evaluating the effects and effectiveness of the pest treatment.

Monitoring of pest populations is key to successful IPM implementation. Pest problems are easier to control if the problem is discovered early. With IPM, pesticides are used only as a last resort in order to protect water quality and human health.

More information on IPM is available from the Washington State Department of Agriculture (http://agr.wa.gov) and the Washington State University/Pierce County Extension Service (http://www.pierce.wa.wsu.edu).

4. **Q.** There is tall grass and debris in the pond/creek near my house. Who takes care of this?

A. Publicly owned storm drainage ponds and some creeks are maintained by Surface Water Management. Call the Water Quality/ Flooding and Storm Drainage Line at 253-798-4274 to report your concern. Your call will be routed to a member of our maintenance team for inspection and the scheduling of a work crew if needed. Privately owned storm drain systems must be maintained by the property owner or homeowner’s association.

5. **Q.** *t plants should we avoid planting?*

A **.**Non-native, invasive plants should not be planted. Early detection and control of these plants are important to prevent future maintenance problems and increased maintenance costs. Some native plants, such as red alder (*Alnus rubra*), can increase maintenance costs due to leaf fall into the pond causing clogging problems. Additional plant species to avoid are: English ivy (*Hedera helix*), willow (*Salix* species), black cottonwood (*Populous balsamifera* spp. *trichocarpa*), Himalayan and evergreen blackberry (*Rubas discolor* and *laciniatus*), and cattails (*Typha*).

6. **Q.** *How can we make the stormwater facility more attractive?*

A. The Integrated Pond, a booklet produced by King County, provides information on Integrating stormwater facilities into attractive community spaces. This booklet provides information on planting appropriate vegetation around the facility to make it more attractive or to screen the facility. The booklet can be downloaded from King County's website at (http://www.kingcounty.gov/environment/waterandland/stormwater/documents/integrated-pond.aspx)

Pierce County recommends native plants be used around stormwater facilities. Native plants require less water once they are established, resist pests and diseases better, require less fertilizer and pesticides, and provide wildlife habitat.

Plants differ in their ability to cope with different soils, moisture levels, and sun exposure. When planting next to the stormwater facility, consider future maintenance requirements such as grass mowing and watering requirements. Avoid planting deciduous trees and shrubs adjacent to the facility as their falling leaves may cause blocking problems. Avoid plants with invasive root systems, such as willows, and plants that can blow over easily, such as Red alder and Cottonwood. See *The Integrated Pond* (King County) and the *Low Impact Development Technical Guidance Manual for Puget Sound – Appendices 1 and 3* at (http://www.pierce.wsu.edu/Water_Quality/LID/LID_manual2005.pdf) for a list of native plants appropriate for stormwater facilities. Additional information on native plants can be found on the Washington Native Plant Society website at (http://www.wnps.org/index.html).

To reduce maintenance costs and prevent future water flow problems, it is not recommended to plant shrubs or trees in stormwater ponds below the maximum designed water level. Planting grass or low growing, non-invasive, native plants within the facility may be appropriate but it should be done cautiously so as to not interfere with the functions of the facility. Promptly replant any bare soil areas that could contribute sediments to the stormwater system or cause erosion of the facility.

7. **Q.** *We have a limited maintenance budget. What are the most important vegetation maintenance activities we should do?*

A. The inlets and outlets should be kept clear of vegetation and other potentially blocking material. The pond should not be allowed to become overgrown with noxious or invasive vegetation.

8. **Q.** Where do I find more information on the cost of stormwater maintenance?

A. Unit costs for common maintenance procedures can be found on the Stormwater Managers Resource Center (SMRC) website at:

Stormwater Managers Resource Center (SMRC)

9. **Q.** Can I get credit for maintaining my stormwater facility?

A. A properly maintained storm drainage system can significantly reduce your Surface Water Management Fee.

Credits to the Surface Water Management Fee can be received by meeting the requirements of Pierce County Code Section 11.02.050B.

For more information on receiving stormwater credits call (253) 798-4020.

10. **Q.** Why can't I dump used motor oil and other wastes into the stormwater inlet on my street?

A. Stormwater inlets lead to stormwater management systems that discharge to natural water bodies (e.g. lakes or stream) or to the groundwater. Excessive contaminants, such as motor oils dumped into the storm system, will create the need for more frequent maintenance and higher maintenance costs.

11. **Q.** I wash my own car, how can I be environmentally responsible?

A. The best option is to use a commercial car wash where the wash water is recycled and does not drain to the storm system. Improper disposal of wash water will increase the required maintenance frequency resulting in higher maintenance costs. The Pierce County Stormwater Pollution Prevention Manual provides Best Management Practices (BMPs) for washing vehicles on private property; see additional resources section in Chapter 5.

12. **Q.** Can you make the flooding go away?

A. Not once the flooding has started, but we might be able to help keep it from flooding again. We use input from residents to figure out the best solution to flood problems and to prioritize which projects get constructed first. During a flood, sand bags can be picked up at your local Fire District Headquarters. If a blocked pipe or ditch in the public system is the cause of your flooding, the Road Maintenance Shops may also help with cleaning them out.

County Road Maintenance Hot Line .... (253) 798-6000
Requests will be acted on within 24 hours or the next business day.

Water Quality/ Flood & Storm Drainage Complaints: .... (253) 798-4274
Report flooding and private property storm drainage concerns.

13. Q. Where do I find information on the West Nile virus?

A. West Nile virus is a mosquito-borne virus that can cause encephalitis (or meningitis in humans and animals. Preventing mosquito bites and reducing mosquito-breeding habitat around your home are the best ways to protect your family. You should empty containers that hold standing water, such as old tires, buckets, and planters. Also, change the water in your birdbaths, fountains, wading pools and animal troughs weekly, and clean out your rain gutters so that they drain properly.

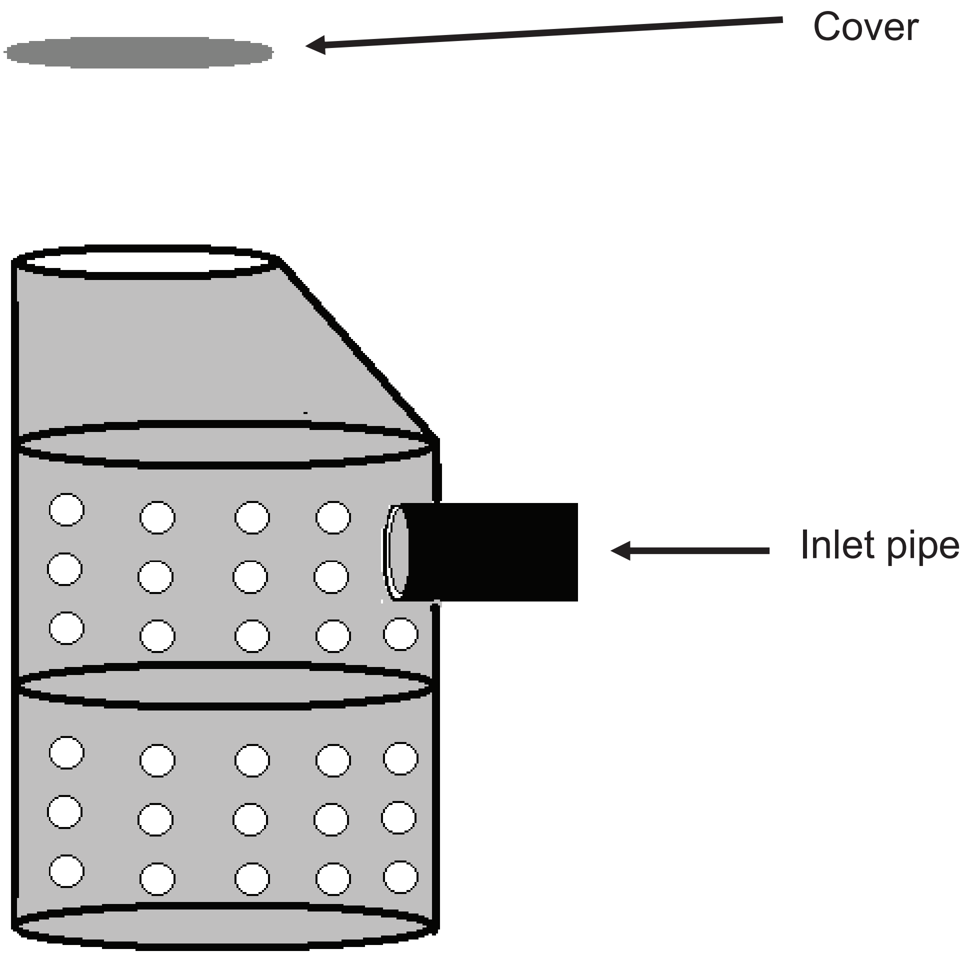
For questions related to West Nile Virus, contact the Tacoma-Pierce County Health Department at (253) 798-6578

Poorly maintained private stormwater drainage facilities can increase breeding sites for mosquitoes in your community or property. Owners of private stormwater drainage facilities can request a courtesy inspection of their system to insure proper operation by contacting Pierce County Surface Water Management at (253) 798-2725.

3.25 Drywell

A drywell is a perforated, open-bottomed manhole used to infiltrate stormwater into the ground. Drywells temporarily store stormwater runoff during rain events. Drywells do not discharge to a downstream conveyance system or nearby surface water. Instead, drywells rely on the ability of the site's soils to absorb the stormwater into the ground.

While not the intended use, drywells trap sediment and some of the oily pollutants in runoff. They 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 localize street flooding. Also, pollutants discharged into drywells can migrate into groundwater. Drywells were often installed in closed topographic depressions, areas with well drained soils, or areas having inadequate storm sewers. Often, drywells contain groundwater. Because drywells can be easily clogged and tend to concentrate pollutants in one place; pollution and sediment control practices should be used to protect them.



3.25 Drywell Checklist

		Date						
Frequency	**Drainage System Feature**	✓	✓	✓	✓	**Problem**	**Conditions to Check For**	**Conditions That Should Exist**
MONTHLY, STORM	General					Trash & Debris	Trash or debris (in the drywell) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the drywell, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the drywell.
MONTHLY	General					Contaminants and pollution	Any evidence of oil, gasoline, contaminants or other pollutants in or around facility.	Remove. (Coordinate removal and cleanup with local water quality agency).
MONTHLY	General					Cover damaged or difficult to remove	One maintenance person cannot remove lid after applying normal lifting pressure. Corrosion/deformation of cover. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and installed by one maintenance person.
MONTHLY	General					Cover not in place	Cover is missing or only partially in place. Any open manhole or catch basin requires maintenance.	Manhole or catch basin cover is closed.
MONTHLY	General					Does not dissipate stormwater	Does not dissipate stormwater	Replace or repair.
MONTHLY	General					Ladder damaged	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, cracks, corrosion, or sharp edges. Confined space warning sign is missing.	Ladder meets design standards. Allows maintenance person safe access. Replace sign warning of confined space entry requirements. Ladder and entry notification complies with OSHA standards.
ANNUAL	Structure					Structure damage	Maintenance/inspection personnel determine that drywell is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.

Drywell Checklist (Continued)

		DANNUALte						
Frequency	**Drainage System Feature**	✓	✓	✓	✓	**Problem**	**Conditions to Check For**	**Conditions That Should Exist**
ANNUAL	Structure					Structure Damage	Cracks wider than ½-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than ¼-inch at the joint of the inlet/outlet pipe.
MONTHLY	General					Opening clogged	Openings are clogged, reducing capacity.	Water-jet clogged openings; or Convert existing, clogged drywell to a sediment trap and install a new drywell or drainage trench. To convert to a sediment trap, required are grouting holes, covering the base with concrete, and adding piping.
MONTHLY	General					Sediment	Sediment is greater than 1/3 of the distance between the base and the inlet pipe.	Remove. Do not allow sediment and water to discharge back into the storm sewer.
MONTHLY	General					Standing water	Standing water indicates the drywell is into the water table.	Rebuild drywell to prevent stormwater from going directly into groundwater.

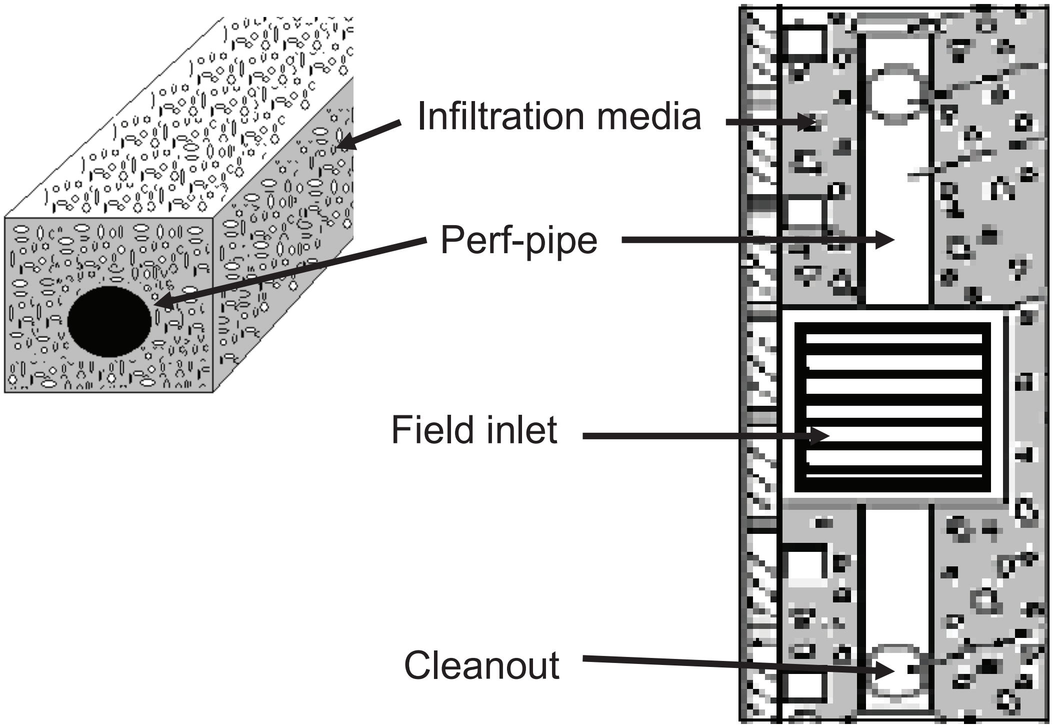
If you are unsure whether a problem exists, please contact a Professional Engineer.

Comments:

Key:
(MONTHLY) Monthly from November through April.
(ANNUAL) Once in late summer (preferable September)
(STORM) After any major storm (use 1-inch in 24 hours as a guideline).

3.28 Infiltration Trench

A stormwater infiltration trench is a closed basin built by excavating below existing ground. Infiltration trenches temporarily store stormwater runoff during rain events. Infiltration trenches do not discharge to a downstream conveyance system or nearby surface water. Instead, infiltration trenches rely on the ability of the site's soils to absorb the stormwater into the ground.



3.28 Infiltration Trench Checklist

		Date						
Frequency	**Drainage System Feature**	✓	✓	✓	✓	**Problem**	**Conditions to Check For**	**Conditions That Should Exist**
MONTHLY	General					Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants in or around facility.	Remove. (Coordinate removal and cleanup with local water quality response agency).
MONTHLY	General					Drainage Slow	Drainage Trench - decreased capacity that indicates slow drainage.	Verify facility design rate. Clean perforated drain pipe. Do not allow removed sediment and water to discharge back into the storm sewer.
MONTHLY	General					Sediment & Debris	Sediment depth is greater than 20% of pipe diameter.	Clean pipe and remove material.
MONTHLY	General					Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
MONTHLY	General					Trash & Debris	Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the trench.
MONTHLY	General					Trash & Debris	Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
MONTHLY	General					Trash & Debris	Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.

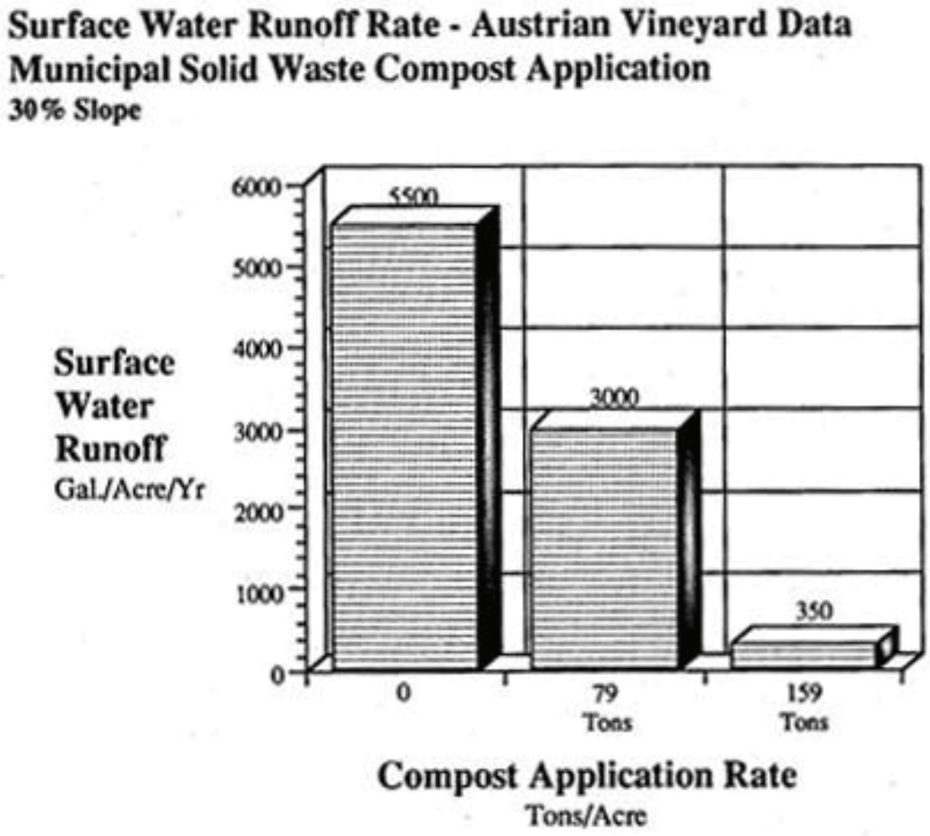
If you are unsure whether a problem exists, please contact a Professional Engineer.

Comments:

Key:
(MONTHLY) Monthly from November through April.
(ANNUAL) Once in late summer (preferable September)
(STORM) After any major storm (use 1-inch in 24 hours as a guideline).

3.31 Compost Amended Soils

Amending a soil with compost increases the soil's permeability and water holding capacity, thereby delaying and often reducing the peak stormwater run-off flow rate, and decreasing irrigation water requirements. Amending soils will also enhance the lawn's long-term aesthetics while reducing fertilizer and pesticide requirements.



3.31 Compost Amended Soil

		Date						
Frequency	**Drainage System Feature**	✓	✓	✓	✓	**Problem**	**Conditions to Check For**	**Conditions That Should Exist**
ANNUAL	General Facility Requirements					Soil media (maintain high organic soil content	Vegetation not fully covering ground surface.	Re-mulch landscape beds with 2-3 inches of mulch until the vegetation fully closes over the ground surface
Ongoing	General Facility Requirements					Soil media (maintain high organic soil content	None. Preventative maintenance	Return leaf fall and shredded woody materials from the landscape to the site as mulch.
Ongoing	General Facility Requirements					Soil media (maintain high organic soil content	None. Preventative maintenance	On turf areas, “grasscycle” (mulch-mow or leave the clippings) to build turf health
Ongoing	General Facility Requirements					Soil media (maintain high organic soil content	None. Preventative maintenance .	Avoiding broadcast use of pesticides (bug and weed killers) like “weed & feed,” which damage the soil life.
ANNUAL	General Facility Requirements					Soil media (maintain high organic soil content	None. Preventative maintenance	Where fertilization is needed (mainly turf and annual flower beds), a moderate fertilization program which relies on natural organic fertilizers (like compost) or slow release synthetic balanced fertilizers.
ANNUAL	General Facility Requirements					Compaction	Soils become waterlogged, do not appear to be infiltrating.	To remediate, aerate soil, till or further amend soil. If drainage is still slow, consider investigating alternative causes (e.g., high wet-season groundwater levels, low permeability soils). Also consider landuse and protection from compacting activities. If areas are turf, aerate compacted areas and top dress them with ¼-½ inch of compost to renovate them.
ANNUAL	General Facility Requirements					Erosion/scouring	Areas of potential erosion are visible.	Take steps to repair or prevent erosion. Identify and address the causes of erosion.
ANNUAL	General Facility Requirements					Grass/vegetation	Less than 75% of planted vegetation is healthy with a generally good appearance.	Take appropriate maintenance actions (e.g., remove/replace plants)

MONTHLY	General Facility Requirements					Noxious weeds	Listed noxious vegetation is present. See Pierce County noxious weed list.	By law, noxious weeds must be removed and disposed immediately. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.
QUARTERLY	General Facility Requirements					Weeds	Weeds are present.	Remove and dispose of weed material. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.

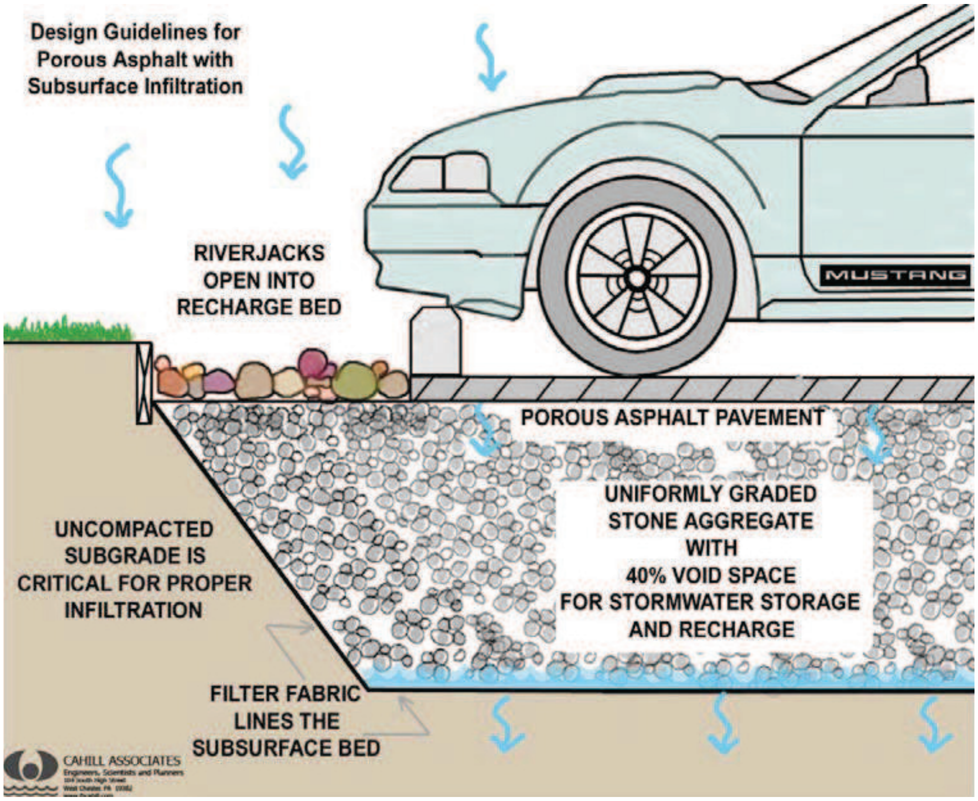
If you are unsure whether a problem exists, please contact a Professional Engineer.

Comments:

Key:
(MONTHLY) Monthly from November through April.
(ANNUAL) Once in late summer (preferable September)
(STORM) After any major storm (use 1-inch in 24 hours as a guideline).
(Biannually) Twice per year in the spring and fall
(Quarterly) 4 times per year

3.32 Pervious Pavement

Pervious paving allows water to infiltrate into layers of gravel placed below the paving and then into soil and groundwater below. By infiltrating most of the storm water on-site, the amount of water and pollution flowing into storm sewers and directly to rivers and streams is greatly reduced. This, in turn, protects water quality, maintains more stable base flows to streams, reduces flood peaks, and reduces stream bank erosion. With infiltration, groundwater is recharged and streams are replenished with cool, clean groundwater in a more natural way. Pervious paving is one component of Low Impact Development (LID).



3.32 Pervious Pavement

		Date						
Frequency	**Drainage System Feature**	✓	✓	✓	✓	**Problem**	**Conditions to Check For**	**Conditions That Should Exist**
BIANNUAL	Surface					Pervious asphalt or cement concrete	None. Maintenance to prevent clogging with fine sediment.	Use conventional street sweepers equipped with vacuums, water, and brushes or pressure washer to restore permeability. Vacuum or pressure wash the pavement two to three times annually.
Ongoing	Surface					Pervious asphalt or cement concrete	None. Maintenance to prevent clogging with fine sediment.	Prohibit use of sand and sealant application and protect from construction runoff.
ANNUAL	Surface					Pervious asphalt or cement concrete	Major cracks or trip hazards.	Fill with patching mixes. Large cracks and settlement may require cutting and replacing the pavement section.
As needed	Surface					Pervious asphalt or cement concrete	Utility cuts. .	See utility restoration protocol on SPU NDS website.
BIANNUAL	Surface					Fallen leaves / debris	Fallen leaves or debris.	Remove/dispose.
BIANNUAL	Surface					Interlocking concrete paver blocks .	Interlocking paving block missing or damaged.	Replace damaged paver block .
ANNUAL	Surface					Interlocking concrete paver blocks	Settlement of surface. .	May require resetting
BIANNUAL	Surface					Interlocking concrete paver blocks	Sediment or debris accumulation between paver blocks.	Remove/dispose
ANNUAL	Surface					Interlocking concrete paver blocks	Loss of void material between paver blocks.	Refill per manufacturer's recommendations.
Varies	Surface					Interlocking concrete paver blocks	Varied conditions.	Perform O&M per manufacturer's recommendations.
BIANNUAL	Surface					Open-celled paving grid with gravel	Sediment or debris accumulation in grid voids.	Remove/dispose
ANNUAL	Surface					Open-celled paving grid with gravel	Loss of soil and/or grass material in grid.	Refill and/or replant per manufacturer's recommendations.

Varies	Surface					Open-celled paving grid with gravel	Varied conditions.	Perform O&M per manufacturer's recommendations.
BIANNUAL	Surface					Open-celled paving grid with grass	Sediment or debris accumulation in grid voids.	Remove/dispose
ANNUAL	Surface					Open-celled paving grid with grass	Loss of soil and/or grass material in grid.	Refill and/or replant per manufacturer's recommendations.
Varies	Surface					Open-celled paving grid with grass	Varied conditions.	Perform O&M per manufacturer's recommendations.
BIANNUAL	Overflows and Emergency Spillways					Obstructions / debris	Obstructions or debris block 30% or more of outlet structure.	Remove/dispose
BIANNUAL	Overflows and Emergency Spillways					Erosion	Native soil is exposed or other signs of erosion damage are present.	Repair erosion and stabilize surface of spillway
Ongoing	Spill Prevention and Response					Spill prevention	Storage or use of potential contaminants in the vicinity of facility.	Exercise spill prevention measures whenever handling or storing potential contaminants
As needed	Spill Prevention and Response					Spill response	Release of pollutants. Call to report any spill to the the Wa Dept of Emergency Management 1-800-258-5990	Cleanup spills as soon as possible to prevent contamination of stormwater

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

Comments:

Key:
(MONTHLY) Monthly from November through April.
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5.0 Developing a Maintenance Program

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

Stormwater management facilities are most effective coupled with good housekeeping procedures. Good housekeeping includes educating facility users of proper storage and disposal of chemicals and potential pollutants, procedures for spill cleanup, proper use of fertilizers and other lawn care products, and maintenance of equipment to prevent release of pollutants to the stormwater system. Guidelines for establishing good housekeeping procedures (I.E. Source Control BMPs) and developing a training program to educate facility users can be found in the Pierce County Surface Water Management Webpage at Stormwater Pollution Prevention Manual located at:

http://www.co.pierce.wa.us/swm

5.1 Who Should Perform Maintenance Duties?

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

5.2 Working with Maintenance Contractors

The following is a guideline for researching and choosing a qualified contractor to meet your maintenance needs.

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

- Landscape maintenance contractors are typically capable of providing most routine maintenance for stormwater facilities. Special, non-routine maintenance may require an earthwork contractor or vactor company. Recently, several contractors have started specializing in stormwater facility maintenance. Private owners can choose to hire contractors when individual maintenance needs arise or enter into annual maintenance agreements where the contractor monitors and provides routine maintenance throughout the year as needed.

- Develop a list of potential contractors. Look in the Yellow Pages and/or ask friends, neighbors, relatives, and coworkers who they have used. Find out if their experiences were good or bad and why. Ask if they would use the contractor again.

- Ask contractors for references. Call your potential contractors and ask for a list of their customers or locations of completed jobs. Call references and ask whether they were satisfied with the job done, if the contractor kept to the agreed upon schedule, and whether they would hire the same contractor again.

- Ask to which trade associations the contractor belongs. Membership in a professional association is one sign the contractor recognizes the responsibilities of being a professional.

- Make sure to obtain and evaluate bids. Ask for a free written estimate of the work you want done. Be sure everyone is bidding on the same exact scope of work and including the exact materials you want. Be sure all quotes include everything you want and that there is a clear understanding of work to be performed by owner and work to be performed by contractor.

- Remember *"you get what you pay for."* A higher bid may be worth the price for better workmanship and contractor reliability.

- Make sure you understand the different types of bids you may receive. Be careful about hiring a contractor on an hourly time-and-materials, or cost-plus basis. Although the price may seem high at first, a fixed-price bid may give you the best protection and price. Also beware of "special deals," "demonstration projects," or *"a great deal from a friend of a friend."* Completely review and understand the contract prior to authorizing work.

Questions to Ask Before Hiring a Contractor

- What experience, expertise and/or certification do you have? Do you specialize?

- Who will be doing the actual work: you personally, your employees, or subcontractors?

- Who will oversee the day-to-day job? (You may really like the contractor, but that person may not be the one performing or supervising the work.)

- How many other jobs will you be working on at the same time as mine? (If there are several, yours may not get the attention you want. On the other hand, the contractor's business may be large and he may be able to handle several jobs.)

- How long will the job take? What kind of mess, noise, and inconvenience should I expect? What problems may come up? (Asking questions before the job starts helps prevent surprises later.)

- Where will you dispose of material removed from storm drainage facilities? Is there an extra fee for contaminated materials?

- Does hiring this contractor feel right? (Use intuition - if you do not feel comfortable, find someone else.)

- Do I have rapport with this contractor? Am I confident in his expertise and ideas? Does he care about my concerns? Will he be reliable, keep his appointments, and return my telephone calls?

- Can I communicate with this person? Does he seem honest and forthright? (The contractor may be top-notch at the trade, but if the final product is not what you expected, you will not be happy.)

- Am I willing to be reasonable about unexpected costs that arise and to let my contractor make a profit?

- Am I ready for the unexpected, such as digging into solid rock, major replacement, etc.?

- Can I be flexible when the job takes longer than expected?

- Are my expectations so high that I will never be satisfied with my contractor?

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

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

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

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

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

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

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

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

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

6.0 Additional Information/Resources

For more information on operation and maintenance of your stormwater management system contact:

Pierce County Department of Public Works and Utilities, Surface Water Management Division, (253) 798-2725

Or refer to information provided in the following resources:

Pierce County Stormwater Pollution Prevention Manual
http://www.co.pierce.wa.us/PC/services/home/environ/water/swm/sppman/

King County Drainage Maintenance Standards for Commercial and Multifamily Drainage Facilities, 1997.
http://dnr.metrokc.gov/wlr/stormwater/DrainMaint.htm

Puget Sound Shoreline Stewardship Guide Book,
http://dnr.metrokc.gov/wlr/watersheds/puget/puget-sound-guidebook.htm