Stormwater Control Plan

G14 Parking Lot Expansion,
1 Harpst Street,
Arcata, Humboldt County, California

Prepared for:

California State Polytechnic University,
Humboldt

April 2026

025149

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812 W. Wabash Ave.
Eureka, CA 95501-2138
(707) 441-8855

April 2026

QA/QC:JOB___
Reference: 025149

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Abbreviations & Acronyms

Units of Measure

Term	Definition
CFS	cubic feet per second
in/hr	inches per hour
SF	square feet

Additional Terms

Term	Definition
B-#	boring-number
CPH	California State Polytechnic University, Humboldt
DMA	Drainage management area
FTPD	Filterra Peak Diversion
LID	Low-impact development
O&M	Operation and maintenance
MS4	Small Municipal Separate Storm Sewer System
SWRCB	State Water Resources Control Board

1.0 Project Information and Description

California State Polytechnic University, Humboldt (CPH) is proposing an expansion of the G14 parking lot in order to increase on-campus parking capacity and improve accessibility. The proposed project would take place at the former Walter and Mary Warren House site, located at 150 14th Street in Arcata, California. The project site consists of a 0.78-acre parcel situated on 14th Street between "A" and B Streets, at the southern edge of the CPH campus.

1.1 Existing Conditions

The existing site currently consists of a grass-covered lot following the recent demolition of the former structures. Stormwater runoff from the site drains into a network of existing drain inlets that convey flows through underground piping to the municipal storm drain system located at 14th and B Streets.

Immediately north of the project site is an existing paved parking lot. Runoff from this area is directed to an existing stormwater treatment feature before discharging into the storm drain system along B Street. A figure showing the existing site conditions is included in Appendix 1, Figure 1.

The pre-project area of 36,128 square feet (SF) includes:

- 6,926 SF of impervious area
- 29,202 SF of pervious area

A portion of the existing parking lot located north of the project site will be resurfaced as part of the proposed project. However, the existing stormwater treatment feature that currently directs runoff from this parking area will remain in place and continue to function as designed. A small portion of the treatment feature and its associated permeable areas may be temporarily disturbed during construction but will be restored to existing conditions upon project completion. Additional details are provided in Section "3.2: Runoff Reduction Measures by DMA."

SHN performed a geotechnical investigation in 2017 for reconstruction of the existing G14 Parking Lot located north of and adjacent to the subject site. The results of that investigation were presented in the report titled "Geotechnical Investigation Report, Parking Lots G14 and G15 Reconstruction Project, Humboldt State University, Arcata, California, Revision 2,: dated April 19, 2017. The 2017 report was prepared for improvements that have since been completed.

An additional geotechnical investigation was conducted in 2023 for the proposed Energy Research and Sustainability Center Project, which is no longer planned for construction. The 2023 investigation included three borings (B-01-2023, B-02-2023, and B-03-2023) advanced to depths of approximately 51.5 feet, 31.5 feet, and 31.5 feet below ground surface, respectively. Groundwater was not encountered in any of the borings during drilling (SHN, 2023). A figure showing the boring locations and logs from the 2023 investigation is included in Appendix 1 (Figure 2).

In 2026, geotechnical recommendations for the proposed G14 Parking Lot expansion project were developed based on the results of previous investigations. Subsurface data and laboratory testing from the 2023 investigation within the project area were evaluated to develop geotechnical recommendations for the design and construction of the proposed parking lot improvements (SHN, 2026).

1.2 Proposed Project Conditions

The proposed project consists of demolition and removal of existing landscaping, curbs, asphalt pavement, signage, and storm drainage infrastructure. The project will also include locating and protecting, capping, or removing existing utilities; site grading; and construction of a new parking lot with associated improvements including sidewalks, landscaping, accessible parking spaces, a pedestrian shelter, and lighting.

Runoff from the proposed impervious surfaces will be conveyed to a Contech Filterra Peak Diversion unit, which will overflow to the existing storm drain system located in B Street. To support the development, new utilities will be installed to serve the parking lot, as will a new storm drain system. A figure showing the proposed project layout is included in Appendix 1 (Figure 3).

The project area of 36,128 SF includes:

- 29,446 SF of new impervious area
- 6,682 SF of new pervious area

The north, south, and east sides of the site are bound by existing sidewalks and roadways, and the west side is adjacent to a previously developed site. In these areas, a portion of site runoff will be conveyed to existing infrastructure and treatment basins. An existing bioretention facility is located in the northern portion of the site and is used to treat stormwater from the northern parking lot. This basin will remain in place and will continue to treat runoff from the northern portion of the lot located outside the proposed development area.

In the western portion of the site, an existing asphalt drive will be removed, and a concrete sidewalk is proposed to connect the development to B Street. Much of this area will be replaced with permeable landscaping, although the existing stormwater collection system will remain in place. Runoff from Drainage Management Area 1 (DMA 1) will be collected and conveyed through valley gutters to new drain inlets, then routed through below-grade storm drain piping to a Filterra treatment unit before tying into the existing storm drain system in B Street. The proposed storm drain layout is shown in Appendix 1 (Figure 4).

2.0 Project Stormwater Mitigation Requirements

The total post-project impervious surface area is approximately 29,446 SF (0.68 acres) and consists of new walkways, parking stalls, and accessible paths of travel. The project site has one DMA, as shown in Appendix 1 (Figure 5).

The project will create 22,520 SF of new impervious surface and replace/update the existing 6,926 SF of pervious surface. The total impervious surface area of the project is 29,446 SF. Given that this area is greater than 5,000 SF, it is classified as a "Regulated Project" according to the Phase II Small Municipal

Separate Storm Sewer System (MS4) Program, Section E.12.c(ii). However, the project does not create or replace more than 1 acre (43,560 SF) of impervious surface; therefore, hydromodification controls are not required.

The completed forms for the Humboldt County low-impact development (LID) Manual Stormwater Control Plan can be found in Appendix 2, Figures 1-3, including the "Stormwater Information Sheet," the "Stormwater Control Plan for Regulated Projects," and the "Regulated Project Worksheets."

3.0 Stormwater Mitigation

As stated above, the site is classified as a "Regulated Project" and has one DMA, see Appendix 1, Figure 5. Regulated projects under the Phase II Small MS4 Program, Section E.12.e(ii).c.2.a, are required to capture and treat runoff from a rain event equal to at least 0.2 inches per hour (in/hr) intensity. Capture and treatment of stormwater can be achieved with various runoff reduction measures that are applied as site design measure credits as described in the Humboldt LID Stormwater Manual v3.0.

3.1 Design Measures

A "Regulated Project Worksheet" from the LID Manual was used for the DMA to apply site design measure credits and determine the post-credit DMA runoff volume for the 85th percentile, 24-hour duration design storm (Appendix 2, Figure 3). Due to the specific project constraints outlined in Section 1.2 above, the project will use a Filterra Peak Diversion unit as an Alternative Design facility to meet the requirements of the MS4 permit. Although Filterra facilities are not listed as an approved treatment method in the Humboldt LID Manual, they are applicable as an Alternative Design measure according to Section E.12.e(ii).g of the MS4 Permit. Appendix 3, Figure 2 specifies how each of the criteria outlined in the Alternative Designs section of the MS4 Permit are met using Filterra facilities.

The Filterra treatment capacity is determined by taking the rainfall intensity found in the flow-based criteria section of the MS4 Permit (E.12.e(ii).c.2.a) of 0.2 in/hr and using the rational method to determine a water quality flowrate. This flowrate is divided by the infiltration rate of the Filterra soil media, 175 in/hr, see "Ecology's Conditions of Use," Item 2 (Appendix 3, Figure 3). The appropriately sized Filterra unit is then selected from the Filterra Peak Diversion (FTPD) Configuration Table (Appendix 3, Figure 4). The "Equivalency Analysis and Design Criteria" as well as the "Filterra Operation & Maintenance (O&M) Manual" are included in Appendix 3, Figures 3 and 7, respectively.

3.2 Runoff Reduction Measures

The following runoff reduction measures were established for the DMA to comply with the requirements for regulated projects as described in the Phase II Small MS4 Program. See Appendix 1, Figure 5 for DMA references. Due to the site constraints outlined above, Filterra units are the only runoff reduction measure applied to this project. Table 2 shows Filterra sizing for the DMA, and Appendix 3, Figure 4 shows the available Filterra configurations.

DMA 1—Lot Expansion: DMA 1 includes 29,202 SF of new or replaced impervious surface, and 6,926 SF of permeable surface. The runoff will be conveyed through valley gutters to a below-grade storm drain system, into a Filterra Peak Diversion unit adjacent to the Marketing and Communication Building located on the western side of the property.

No runoff reduction credits have been applied to this DMA, so the Filterra is sized to treat all the required stormwater runoff. A summary of the rational method variables used to determine the size of the Filterra unit is found in Tables 1 and 2. Using the rational method calculation, the calculated soil media surface area for the Filterra unit is 48 SF for a 15-inch-thick media layer. This requirement is satisfied by a 6-foot.-by-8-foot. Filterra unit, providing 48 SF of treatment surface area.

Sizing for the Filterra units is shown in Tables 1 and 2.

Table 1. Drainage Management Areas (DMAs) and Runoff

DMA[a]	Overall Area (Acre)	Impervious Area (Acre)	Pervious Area (Acre)	Impervious Area Runoff Coefficient-C	Pervious Area Runoff Coefficient-C	Composite Runoff Coefficient-C	Time of Concentration (minutes)
1	0.83	0.68	0.15	0.95	0.35	0.84	5

Table 2. Filterra Unit Sizing

Water Quality Rainfall Intensity (in/hr.)[b]	Bypass Storm Event Intensity (in/hr.)	Water Quality Flowrate Q (CFS)[c]	Bypass Flowrate Q (CFS)	Required Filterra Media Surface Area (SF)[d]	Required Filterra Media Bay Size[e]	Provided Filterra Media Surface Area (SF)
0.2	5.06	0.13	3.52	15-Inch Media: 48	6 feet x 8 feet	15-Inch Media: 48.00

a. DMA: Drainage Management Area
b. in/hr: inches per hour
c. CFS: cubic feet per second
d. SF: square feet
e. Available Configurations: Appendix 3, Figure 6

4.0 Opportunities and Constraints

The following opportunities and constraints were considered for the LID improvements.

Opportunities for LID include:

- use of small footprint Filterra units to treat all stormwater runoff, and
- the site configuration, which allows stormwater to be conveyed by gravity to the Filterra unit and into the existing storm drain system.

Constraints on the site include:

- site grading, which is constrained by existing tie-in points on all sides of the project area.

5.0 Stormwater Mitigation Summary

This project meets the stormwater mitigation requirements of the Phase II Small MS4 Program for Regulated Projects through the use of Filterra Peak Diversion Vault units. DMA 1 utilizes this treatment method to meet the runoff volume required from new or replaced impervious surfaces for the 0.2 in/hr intensity storm, meeting the requirements of the Phase II Small MS4 Program for Regulated Projects per sections E.12.e(ii).c.2.a and E.12.e(ii).g.

6.0 References

County of Humboldt. (August 18, 2021). “Humboldt Low Impact Development Stormwater Manual v3.0.” Eureka, CA:Humboldt County.

SHN. (July 5, 2023). “Geotechnical Investigation Report, Alternative Site for the Proposed Energy Research and Sustainability Center Project, Cal Poly Humboldt, Arcata, California.” Eureka, CA:SHN.

---. (January 20, 2026). “Geotechnical Recommendations, Parking Lot G14, Cal Poly Humboldt, Arcata, California.” Eureka, CA:SHN.

State Water Resources Control Board. (August 2019). “California Phase II LID Sizing Tool Documentation Manual.” Sacramento, CA:SWRCB. Accessed at: https://www.owp.csus.edu/LIDTool/Content/PDF/LID_Tool_Manual.pdf

---. (April 24, 2019). “Phase II Small Municipal Separate Storm Sewer System (MS4) Program.” Sacramento, CA:SWRCB. Accessed at: Phase II Small Municipal Separate Storm Sewer System (MS4) Program | California State Water Resources Control Board

Appendix 1
Existing and Proposed Project Figures

NOTES

HORIZONTAL DATUM: BASED ON POINTS USED DURING TOPOGRAPHIC SURVEY OF "NEW SITE FOR ENERGY RESEARCH/ SUSTAINABILITY CENTER". POINTS PROVIDED BY KELLY-O'HERN ASSOCIATES, ON 10/23/25. AT CONTROL POINT #101.

VERTICAL DATUM: BASED ON POINTS USED DURING TOPOGRAPHIC SURVEY OF "NEW SITE FOR ENERGY RESEARCH/ SUSTAINABILITY CENTER". POINTS PROVIDED BY KELLY-O'HERN ASSOCIATES, ON 10/23/25. AT CONTROL POINT #101.

UNDERGROUND UTILITY NOTE:
UNDERGROUND UTILITY INFORMATION SHOWN IS BASED ON VISIBLE EVIDENCE.
SHN MAKES NO GUARANTEE REGARDING LOCATION, TYPE, SIZE, NOR PRESENCE OR ABSENCE OF UNDERGROUND UTILITIES.
IRRIGATION SYSTEM NOT MAPPED.

OVERHEAD UTILITY NOTE:
OVERHEAD LINES OFF OF THE PROJECT SITE ARE NOT FULLY MAPPED.
INFORMATION SHOWN IS BASED ON VISIBLE EVIDENCE. NO MAPPING OBTAINED FOR PHONE AND CABLE TELEVISION FACILITIES. PHONE AND CABLE TELEVISION LINE LOCATIONS NOT VERIFIED.

UTILITY DEMOLITION NOTE: UTILITY INFORMATION SHOWN BY PREVIOUS SURVEY PROVIDED BY CLIENT HAS BEEN REMOVED INSIDE SHN SURVEY AREA. FOR PURPOSES OF THIS MAP. SHN MAKES NO GUARANTEE REGARDING THE LOCATION, TYPE, SIZE, NOR PRESENCE OR ABSENCE OF ANY UTILITIES REMOVED DURING DEMOLITION.

SHN PERFORMED A TOPOGRAPHIC SURVEY WHICH INCLUDED ADDING A SURFACE AT THE LOCATION OF COMPLETED DEMOLITION WORK. SHN'S SURFACE IS ADJACENT TO THE SURFACE CREATED BY KELLY-O'HERN ASSOCIATES.

TIN SURFACE, POINTS, AND LINEWORK, WERE PROVIDED BY CLIENT, AND WERE BASED ON SURVEY BY KELLY-O'HERN ASSOCIATES. SOME MODIFICATIONS HAVE BEEN MADE IN LOCATIONS ADJACENT TO AND ALONG SHN'S SURVEY BOUNDARY TO BEST FIT WITH NEW DATA OBTAINED DURING SHN'S SURVEY. SHN DID SPOT CHECK ELEVATIONS ON THE SURFACE AND DETERMINED THE SURFACE WAS WITHIN ACCURACIES NEEDED FOR THIS SURVEY.

SHN PERFORMED FIELD SURVEYS ON DATES 10-28-25 TO 11-20-25 USING TRIMBLE S6 TOTAL STATION. DATA WAS HELD TO A MINIMUM HORIZONTAL AND VERTICAL ACCURACY OF 0.10 FEET.

A PORTION OF THE PREVIOUS SURVEY'S SURFACE HAS BEEN REMOVED SOUTHWEST OF "B" STREET FOR THE PURPOSES OF THIS MAP.

NOTES BELOW OBTAINED FROM PREVIOUS MAP BY KELLY O'HERN ASSOCIATES SURVEY PERFORMED PRIOR TO DEMOLITION WORK:

NOTES

1. PURPOSE: THE PURPOSE OF THIS SURVEY IS TO PROVIDE TOPOGRAPHIC INFORMATION TO AID IN SITE PLANNING.
2. DATE OF SURVEY: MAY 2023
3. PROPERTY LINE INFORMATION: NO PROPERTY LINES WERE CALCULATED OR SHOWN ON THIS MAP.
4. DATUM: NGVD 29 BASED ON HUMBOLDT STATE COLLEGE MONUMENT (HCSM) NO. 8 (14th STREET AND UNION STREET) ELEVATION = 102.38 FEET
5. UNDERGROUND DISCLAIMER: NO RESEARCH OR INVESTIGATION REGARDING UNDERGROUND PIPES, ELECTRIC LINES, OR OTHER SUBSURFACE FEATURES HAS BEEN CONDUCTED FOR THIS MAP. NO LIABILITY IS ASSUMED FOR ANY UNDERGROUND INFORMATION.
6. BEFORE ANY EARTHWORK IS PERFORMED ON SUBJECT PROPERTY, PROPERTY OWNER IS ADVISED TO CONTACT UNDERGROUND SERVICES ALERT (USA) FOR ACCURATE LOCATION OF UNDERGROUND UTILITIES (800-227-2600).
7. EXISTING UTILITY LINE LOCATIONS SHOWN HEREON ARE PER MAPPING PROVIDED BY CAL POLY HUMBOLDT AND HAVE NOT BEEN VERIFIED BY THIS SURVEY.

LEGEND

AC	ASPHALT-CONCRETE	ICVB	IRRIGATION CONTROL VALVE BOX
AD	AREA DRAIN	LP	LIGHT POLE WITH CONCRETE BASE
AL	AREA LIGHT	MH	MANHOLE
CB	CONCRETE BORDER	PM	PARKING METER
CF	CONCRETE FOOTING	RICVB	ROUND IRRIGATION CONTROL VALVE BOX
CG	CONCRETE GUTTER	SDCO	STORM DRAIN CLEANOUT
CONC	CONCRETE	SSCO	SANITARY SEWER CLEANOUT
CR	CONCRETE RAMP	SSMH	SANITARY SEWER MANHOLE
CS	CONCRETE SLAB	TB	TELEPHONE BOX
CSW	CONCRETE SIDWALK	WM	WATER METER
CVG	CONCRETE VALLEY GUTTER	WV	WATER VALVE
CW	CONCRETE WALL	—x—	EXISTING FENCE
DI	DROP INLET		EXISTING OVERHEAD WIRES
EB	ELECTRIC BOX		EXISTING GAS LINE
EM	ELECTRIC METER	—SD—	EXISTING STORM DRAIN
FH	FIRE HYDRANT	—SS—	EXISTING SEWER LINE
GM	GAS METER	—T—	EXISTING TELECOMMUNICATION LINE
GV	GAS VALVE	—W—	EXISTING WATER LINE
HVAC	HEATING, VENTILATION & AIR CONDITIONING		

} SEE NOTE 7

SYMBOL LEGEND

SYMBOL	INDICATES
AC	ASPHALT SURFACE
	DROP INLET
	FOUND MONUMENT
	CONTROL POINT
	TREE
CNC	CONCRETE

LINE LEGEND

MINOR CONTOUR
MAJOR CONTOUR
EDGE OF PAVEMENT
ASPHALT CURB
CONCRETE

CERTIFICATION

THIS PLAT REPRESENTS A SURVEY MADE BY ME OR UNDER MY DIRECTION IN NOVEMBER, 2025.

Preliminary X/X/25

THOMAS A. GALLUP PLS 7768 DATE

LICENSED LAND SURVEYOR THOMAS A GALLUP No. 7768 Preliminary 12/31/2025 STATE OF CALIFORNIA

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SHN
812 W. WABASH AVE.
EUREKA, CA. 95501
WWW.SHN-ENGR.COM
707-441-8855

NO.	DATE	REVISION	BY

DSGN
DR BMG
CHK TAG
APVD

California State Polytechnic University Humboldt
G14 PARKING LOT
130 14th Street, Arcata CA 95521

EXISTING CONDITIONS SURVEY

SHEET 1
SEQ 1 OF 1
DATE 11/25
PROJ. NO. 025149

SAVED: 11/25/2025 10:33 AM BGAGNON, PLOTTED: 11/25/2025 10:58 AM BENJAMIN GAGNON
P:\Eureka\2025\025149-CPH-G14-Parking-Lot\100-Survey-Update\Dwgs\025149-SVY.dwg

P:\Eureka\2023\023098-CPH-ERSCalt-GEO\GIS\GEO_Fig2_GeotechBoringLocations.mxd USER: mrose DATE: 7/5/23, 9:48AM

Cal Poly Humboldt
Geotechnical Investigation for ERSC
Arcata, California

Geotechnical Boring Locations

July 2023 - 023098

Figure 2

BORING NUMBER B-01-2023

CLIENT Cal Poly Humboldt
PROJECT NAME Energy Research Sustainability Center (alternate site)
PROJECT NUMBER 023098
PROJECT LOCATION Arcata, Humboldt County, CA
DATE STARTED 6/1/23 **COMPLETED** 6/1/23
GROUND ELEVATION 94 ft (approx.) **HOLE SIZE** 8"
DRILLING CONTRACTOR 14
GROUNDWATER DEPTH
DRILLING METHOD Solid Flight Augers/ Hollow Stem Augers
AT TIME OF DRILLING --- No free groundwater encountered.
LOGGED BY A. Troia **CHECKED BY**
NOTES Borehole backfilled with Portland cement.

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
0	Began drilling with solid flight augers. Approximately 2" of ASPHALT. Switched to hollow stem rotary at 1'.										
	(GW) SANDY GRAVEL, dry, medium sand, well-graded subrounded gravels, (FILL/BASE ROCK).	MCS S1, S2	100	4-4-4 (8)	1.75	79	40				
	(CL-ML) SILTY LEAN CLAY with SAND, moist, very dark brown, low plasticity, low toughness, slightly mottled, (FILL).										
	(CL) GRAVELLY LEAN CLAY, medium stiff, dark brown, moist, low plasticity with low toughness; weak cementation; rounded gravels, max. size 1", (FILL/NATIVE TOPSOIL?).	MCS S3, S4	100	2-4-10 (14)	4.5	98	26	32	21	11	
5	(CL) LEAN CLAY with SAND, stiff, moist, yellowish brown with gray mottling, medium plasticity with moderate toughness; fine sand, (FALOR FM.) **UC Test** Undrained Shear Strength = 2947 psf. Becomes very stiff, dry to moist; increase cementation, difficult to break samples; very fine roots (?).	MCS S5, S6	100	9-11-18 (29)	4.0	105	23				
	(CL) LEAN CLAY, very stiff, dry to moist, yellowish brown with gray mottling, medium plasticity with high toughness; strong cementation; manganese flecks and small nodules.	MCS S7, S8	100	8-13-17 (30)	>4.5	107	27				
10	(SC) Grades to CLAYEY SAND, medium dense, moist, yellowish brown and gray; medium plasticity fines; strong cementation, fine sand. Interbedded fine gravels at 11.5'.	MCS S9, S10, S11	100	7-10-18 (28)							82
	Grades to olive. Grades to yellowish brown at 13'.	MCS S12, S13, S14	100	6-12-15 (27)							
15	(CL) SANDY LEAN CLAY to LEAN CLAY with SAND, medium stiff, moist to wet, light bluish gray; fine sand; low plasticity with low toughness, moderate cementation; interbedded medium angular sand, occasional very coarse angular sand; occasional fine organic (root or wood fiber).	SPT S15	100	4-3-4 (7)							
20											

(Continued Next Page)

BORING NUMBER B-01-2023

CLIENT Cal Poly Humboldt | **PROJECT NAME** Energy Research Sustainability Center (alternate site)

PROJECT NUMBER 023098 | **PROJECT LOCATION** Arcata, Humboldt County, CA

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
20		(SC) CLAYEY SAND, loose, wet, bluish gray; mostly fine sand, some medium to coarse quartz-rich sand; strong cohesion, moderate cementation; occasional wood fibers.	SPT S16	100	3-4-5 (9)							48
25		(SC-SM) POORLY GRADED SAND with CLAY, medium dense, wet, gray; fine sand with minor medium to coarse sand, occasional fine subrounded gravels; moderate cementation.	SPT S17	100	10-12-8 (20)							
30		(CL-ML) SILTY LEAN CLAY, stiff, moist, dark gray, medium plasticity with low toughness, moderate cementation; minor very fine sand; upright wood fibers from 30-30.5'.	MCS S18, S19	100	4-6-11 (17)							
35												
40		Becomes dry to moist, low plasticity.	SPT S20	100	2-3-8 (11)							

(Continued Next Page)

BORING NUMBER B-01-2023

CLIENT Cal Poly Humboldt
PROJECT NAME Energy Research Sustainability Center (alternate site)
PROJECT NUMBER 023098
PROJECT LOCATION Arcata, Humboldt County, CA

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
45		(CL-ML) SILTY LEAN CLAY, stiff, moist, dark gray, medium plasticity with low toughness, moderate cementation; minor very fine sand; upright wood fibers from 30-30.5'. *(continued)*										
		(CL) SANDY LEAN CLAY, stiff, dry, gray, mostly fine sand with coarse, angular quartz-rich sand; low to medium plasticity with moderate toughness, moderate cementation.	SPT S21	100	5-6-10 (16)							
50		(CL) LEAN CLAY, very stiff, dry, very dark grayish brown, medium plastiity, grades to gray at 51.5', strong cementation, high toughness; wood fragments at bottom.	MCS S23, S24	100	6-13-25 (38)							

Bottom of borehole at 51.5 feet.

BORING NUMBER B-02-2023

CLIENT Cal Poly Humboldt
PROJECT NAME Energy Research Sustainability Center (alternate site)
PROJECT NUMBER 023098
PROJECT LOCATION Arcata, Humboldt County, CA
DATE STARTED 6/1/23 **COMPLETED** 6/1/23
GROUND ELEVATION 91 ft (approx.) **HOLE SIZE** 8"
DRILLING CONTRACTOR 14
GROUNDWATER DEPTH
DRILLING METHOD Solid Flight Augers/ Hollow Stem Augers
AT TIME OF DRILLING --- No free groundwater encountered.
LOGGED BY A. Troia **CHECKED BY**
NOTES Borehole backfilled with Portland cement.

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
0	Began drilling with solid flight augers to 0.75'. Approximately 3" of ASPHALT.										
	Hand augered from 0.75 to 1.5', switched to hollow stem rotary at 1.5'.										
	GRAVELLY SAND, dry, medium sand, well-graded subrounded gravel, (FILL/BASE ROCK).	MCS S1, S2	100	6-7-12 (19)		94	29				
	(CL-ML) SILTY LEAN CLAY with SAND, moist, very dark brown, low plasticity, low toughness, slightly mottled, (FILL).				4.25						
	(CL) LEAN CLAY, stiff, dry, yellowish brown with gray mottling, medium plasticity with high toughness, moderate to strong cementation; very fine roots, (FALOR FM.) **UC Test** Undrained Shear Strength = 2615 psf **UC Test** Undrained Shear Strength = 3722 psf	MCS S3, S4	100	5-8-12 (20)	3.0 4.0	92	29				
5											
	Becomes very stiff, strong cementation; trace fine sand.	MCS S5, S6	100	7-12-17 (29)	3.75	96	28				
10	Becomes stiff; dry to moist.	MCS S7, S8	100	5-7-10 (17)	2.5	92	33				
15	Becomes moist, bluish gray to olive with yellowish-brown patches; medium plasticity with high toughness, strong cementation, trace fine sand; plant fibers.	SPT S9	100	3-4-5 (9)							
20											

(Continued Next Page)

BORING NUMBER B-02-2023

CLIENT Cal Poly Humboldt

PROJECT NAME Energy Research Sustainability Center (alternate site)

PROJECT NUMBER 023098

PROJECT LOCATION Arcata, Humboldt County, CA

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
20		(CL) SANDY LEAN CLAY, stiff, moist, bluish gray to greenish gray, medium plasticity with low to moderate toughness, moderate to strong cementation; fine sand; fine upright plant fibers.	MCS S10, S11	100	4-6-9 (15)	1.0						
25		(SC) CLAYEY SAND, medium dense, moist, bluish gray and olive; medium plasticity fines, strong cohesion, moderate to strong cementation.	SPT S12	100	3-5-10 (15)	2.25						
30		(CL) SANDY LEAN CLAY, stiff, moist to wet, bluish gray, low plasticity; fine sand.	MCS S13, S14	100	4-6-9 (15)	1.0 2.0						

Bottom of borehole at 31.5 feet.

BORING NUMBER B-03-2023

CLIENT Cal Poly Humboldt
PROJECT NAME Energy Research Sustainability Center (alternate site)
PROJECT NUMBER 023098
PROJECT LOCATION Arcata, Humboldt County, CA
DATE STARTED 6/2/23 **COMPLETED** 6/2/23
GROUND ELEVATION 99 ft (approx.) **HOLE SIZE** 8"
DRILLING CONTRACTOR 14
GROUNDWATER DEPTH
DRILLING METHOD Solid Flight Augers/ Hollow Stem Augers
AT TIME OF DRILLING --- No free groundwater encountered.
LOGGED BY A. Troia **CHECKED BY**
NOTES Borehole backfilled with Portland cement.

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0	Began drilling with solid flight augers. Approximately 2" of ASPHALT										
	Switched to hollow stem rotary at 1'.										
	(GW) SANDY GRAVEL, dry, medium sand, subrounded medium gravel, (FILL/BASE ROCK).	MCS S1, S2	100	3-5-9 (14)	2.5	104	23	34	22	12	
	(CL) SANDY LEAN CLAY with SILT, moist, very dark brown, low to medium plasticity with low toughness, well-graded sand, (FILL/NATIVE TOPSOIL?).										
	(CL) LEAN CLAY, stiff, dry to moist, yellowish Brown, medium plasticity with moderate toughness, moderate cementation; trace very fine sand, slightly mottled, (FALOR FM.) Layer of fine sand at 2.5'	MCS S3, S4	100	6-6-7 (13)	3.25	102	23				
5	(CL) LEAN CLAY, stiff, dry to moist, yellowish brown; medium plasticity with high toughness and moderate to strong cementation. Grades to olive, medium stiff, moist; iron-oxide staining.	MCS S5, S6	100	4-5-7 (12)	3.0	95	29				
	Interbeds of fine sand; gray and yellowish brown mottling, iron-oxide staining.	MCS S7, S8	100	4-7-8 (15)	3.25						
10	Becomes stiff; manganese flecks; occasional fine rounded quartz-rich gravel; trace very fine sand.	SPT S9	100	8-10-12 (22)	4.0						
15	(CL) LEAN CLAY with SAND, very stiff, dry to moist, dark yellowish brown; mostly very fine to fine sand wtih trace coarse, angular sand; some fine organics (roots?), manganese flecks.	MCS S10, S11	100	8-10-15 (25)	>4.5						
20											

(Continued Next Page)

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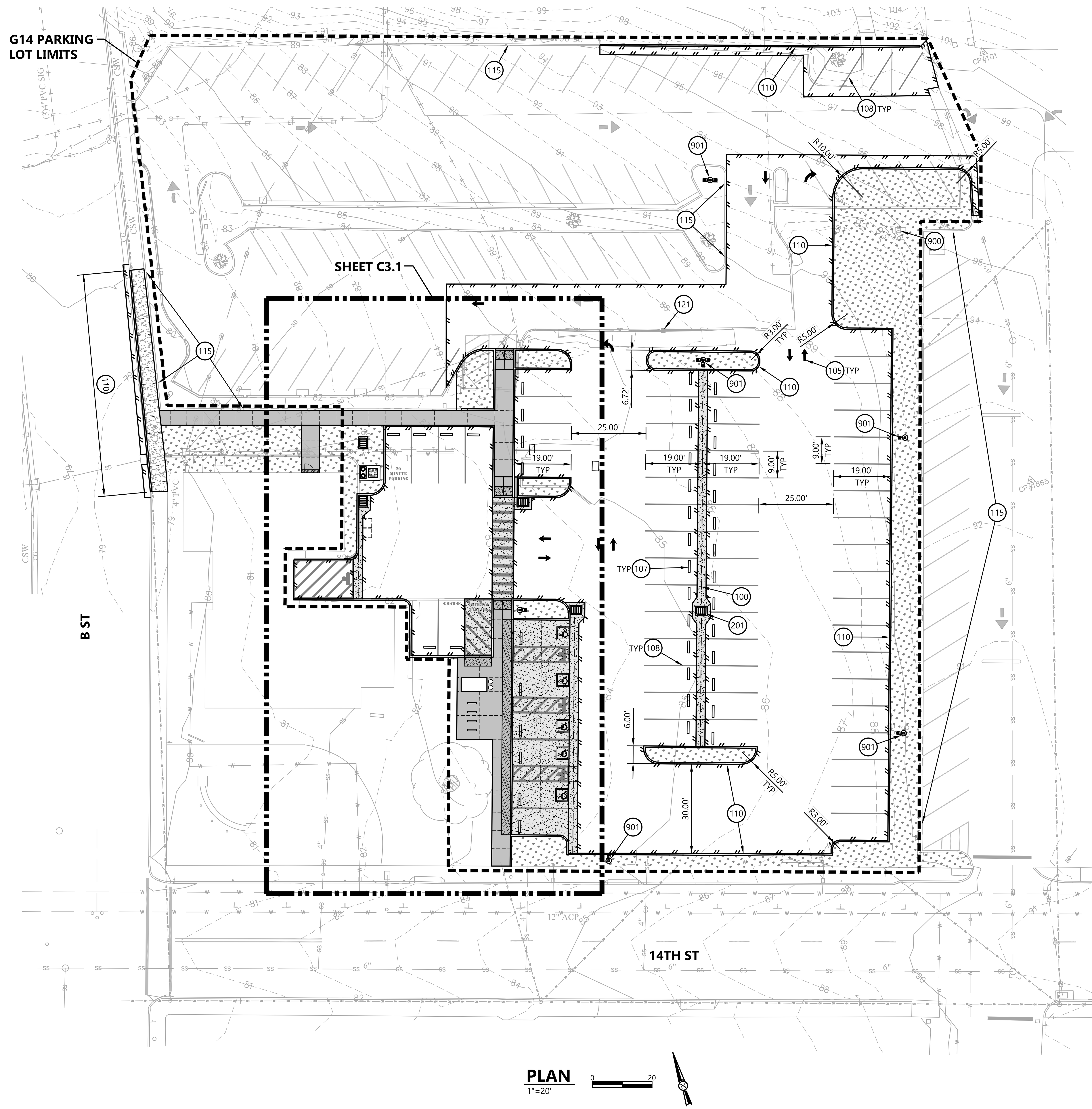
BORING NUMBER B-03-2023

CLIENT Cal Poly Humboldt
PROJECT NAME Energy Research Sustainability Center (alternate site)
PROJECT NUMBER 023098
PROJECT LOCATION Arcata, Humboldt County, CA

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
20		(SC) CLAYEY SAND, medium dense, moist, yellowish brown; laminated beds of fine, quartz-rich sand.	SPT S12	100	5-7-7 (14)							48
25			MCS S13	33	6-9-14 (23)							
30		Becomes bluish gray, slight increase in moisture, moderate cementation.	SPT S14	100	4-5-6 (11)							

Bottom of borehole at 31.5 feet.



KEYNOTES

NO.	DESCRIPTION	DETAIL	SHEET
100	CONCRETE VALLEY GUTTER	10	C7.0
101	BIKE RACK	6	C7.1
102	BUS SHELTER	SEE SHEET C7.4	
103	TRASH RECEPTACLE	SEE SHEET C7.5	
104	DETECTABLE WARNING SURFACE	5	C7.1
105	DIRECTIONAL ARROW STRIPING	2	C7.1
106	CURB RAMP	-	-
107	WHEEL STOP	4	C7.1
108	4" WHITE PARKING STALL STRIPING	-	-
109	CROSSWALK	3	C7.1
110	CONCRETE CURB	5	C7.0
111	ACCESSIBLE PARKING STALLS	1	C7.3
112	RAISED CURB	9	C7.0
113	CURB END	6	C7.0
114	CONCRETE CURB AND GUTTER	7	C7.1
115	EXISTING CURB TO REMAIN	-	-
116	TRASH BINS (NIC)	-	-
117	FLUSH CURB	-	-
118	DRAINAGE CHANNEL	-	-
119	THICKENED EDGE AT BUILDING	8	C7.0
120	TRAFFIC RATED BOX AND LID	-	-
121	RAISE INLET STRUCTURE TO GRADE	SEE DEMOLITION PLAN	
200	FILTERRA STORMWATER TREATMENT CHAMBER	SEE SHEET C5.0	
201	DRAINAGE INLET	SEE SHEET C5.0	
900	IRRIGATION CONTROLLER TO REMAIN	SEE LANDSCAPE SHEETS	
901	LUMINARE	SEE ELECTRICAL SHEETS	
902	SIGNAGE PLAN AND DETAILS	SEE ARCHITECTURAL SHEETS	

LEGEND

SYMBOL	DESCRIPTION	DETAIL	SHEET
	SIDEWALK CONCRETE PAVING (NO REINFORCEMENT)	1	C7.1
	PEDESTRIAN CONCRETE PAVING	2	C7.0
	VEHICULAR CONCRETE PAVING	3	C7.0
	DETECTABLE WARNING SURFACE	5	C7.1
	AC PAVING LIMITS	7	C7.0
	THICKENED EDGE	8	C7.0
	CONTRACTION JOINTS	1	C7.0
	PLANTER	SEE LANDSCAPE SHEETS	

812 W. WABASH AVE.
EUREKA, CA. 95501
WWW.SHN-ENGR.COM
707-441-8855

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

REGISTERED PROFESSIONAL ENGINEER
JARED S. O'BARR
No. 76125
CIVIL
STATE OF CALIFORNIA
2/25/26

NO.	DATE	REVISION

CAL POLY HUMBOLDT
PLY14 G14 PARKING EXPANSION
14TH & B STREET, ARCATA, CALIFORNIA

SITE PLAN

DATE	02/2026	DSGN	KWR
		DR	CDN/JWF
PROJ. NO.	025149	CHK	JSO
SHEET	C3.0		

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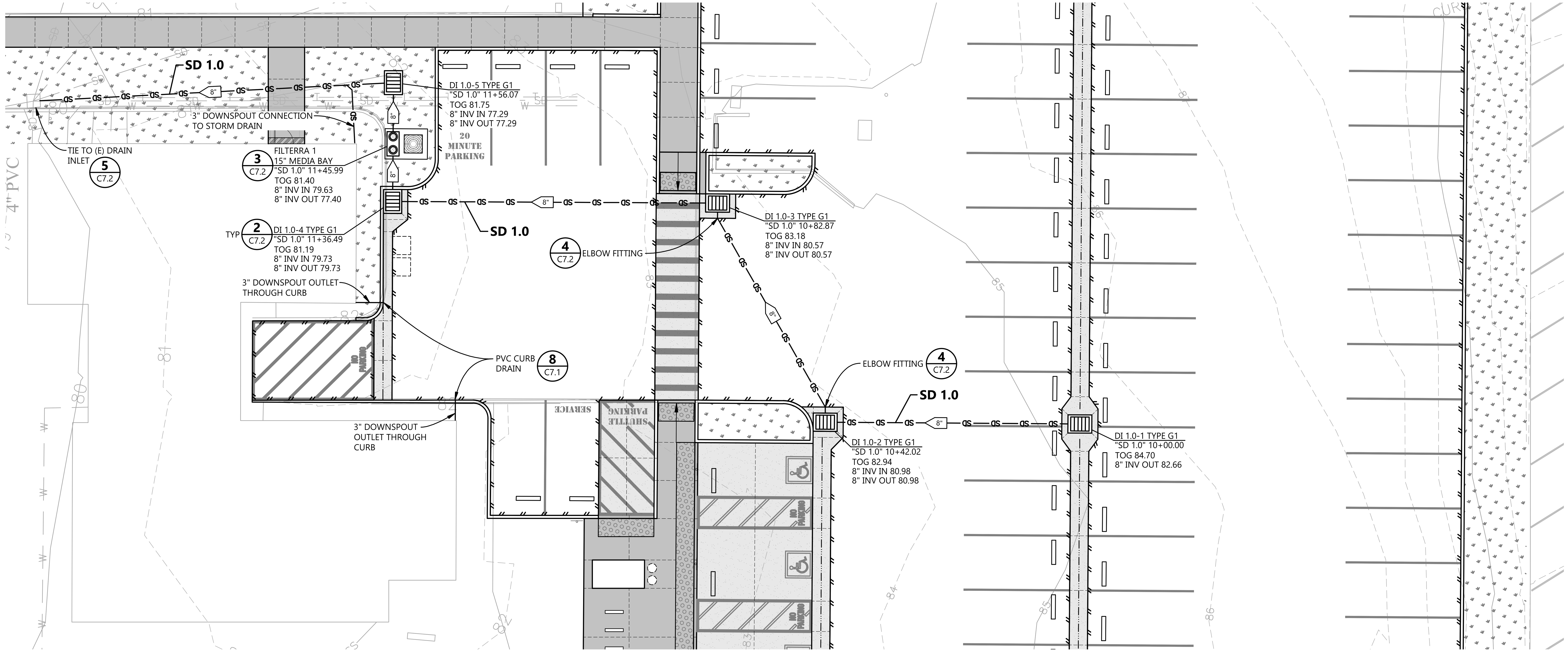
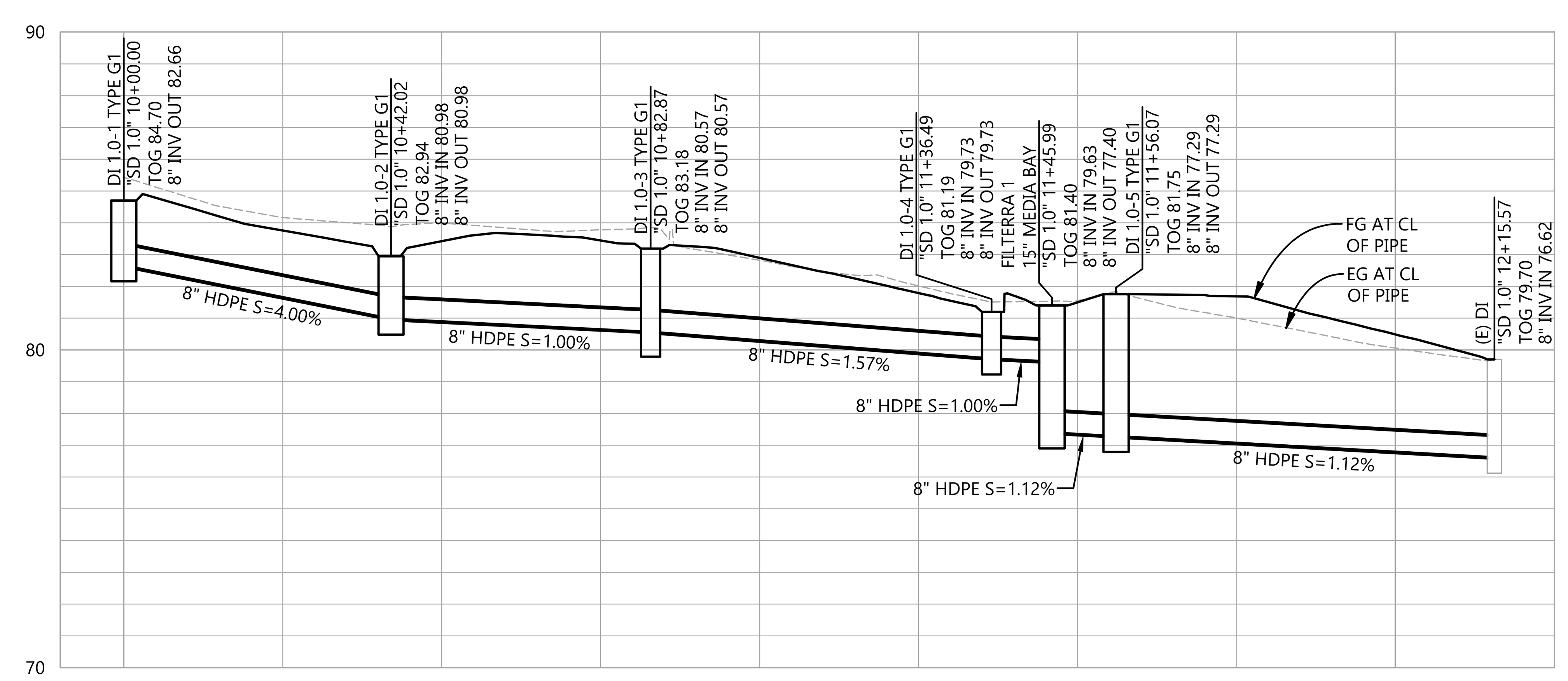


PLAN
1"=10'



"SD 1.0" PROFILE
1"=20' H
1"=4' V

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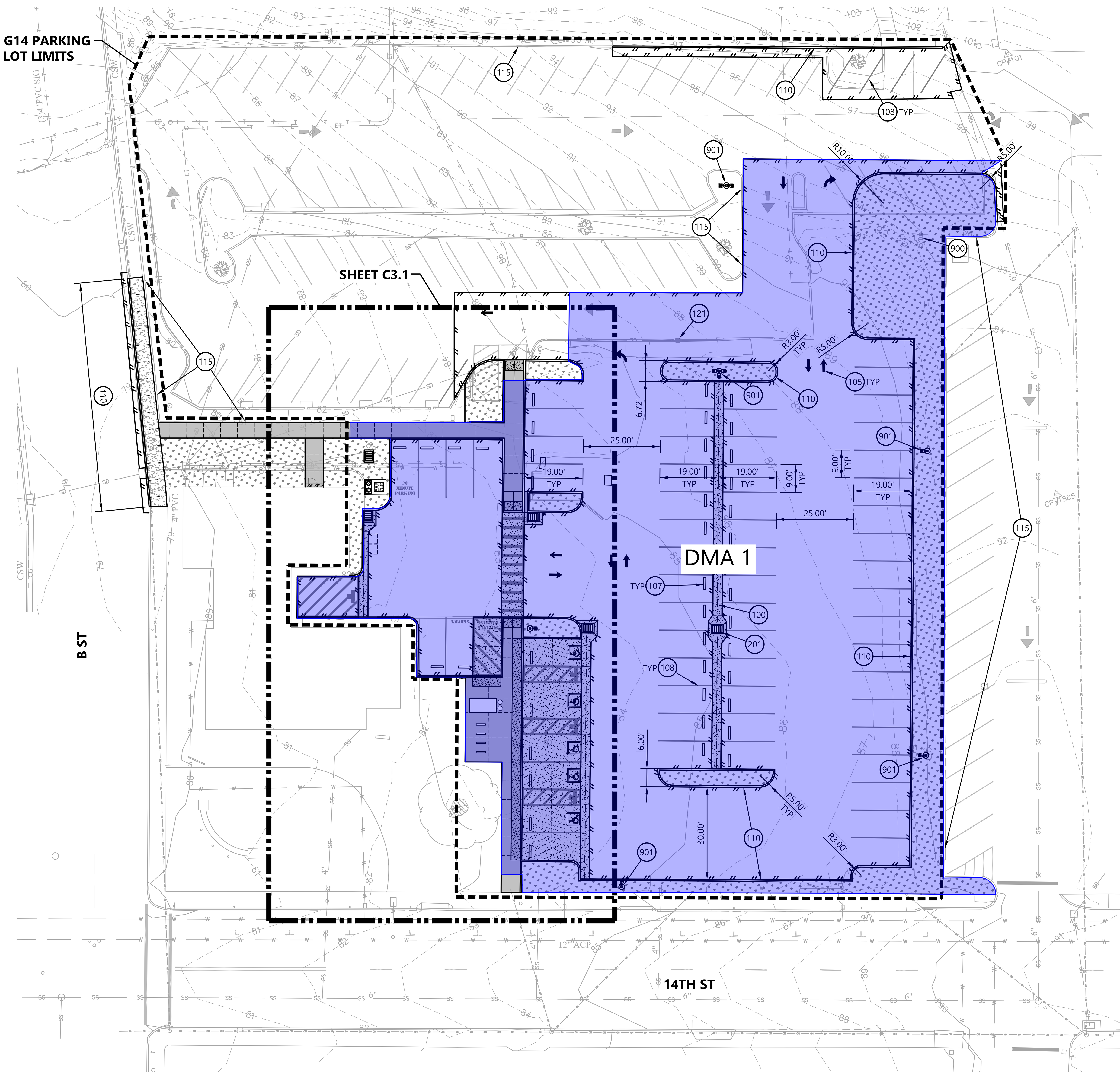
REGISTERED PROFESSIONAL ENGINEER
JARED S. O'BARR
No. 76125
CIVIL
STATE OF CALIFORNIA
2/25/26

NO.	DATE	REVISION

CAL POLY HUMBOLDT
PLY14 G14 PARKING EXPANSION
14TH & B STREET, ARCATA, CALIFORNIA

STORM DRAIN PLAN

DATE	02/2026	DSGN	KWR
PROJ. NO.	025149	DR	CDN/JWF
		CHK	JSO
SHEET	C5.0		



PLAN
1"=20'

KEYNOTES

NO.	DESCRIPTION	DETAIL	SHEET
100	CONCRETE VALLEY GUTTER	10	C7.0
101	BIKE RACK	6	C7.1
102	BUS SHELTER	SEE SHEET C7.4	
103	TRASH RECEPTACLE	SEE SHEET C7.5	
104	DETECTABLE WARNING SURFACE	5	C7.1
105	DIRECTIONAL ARROW STRIPING	2	C7.1
106	CURB RAMP	-	-
107	WHEEL STOP	4	C7.1
108	4" WHITE PARKING STALL STRIPING	-	-
109	CROSSWALK	3	C7.1
110	CONCRETE CURB	5	C7.0
111	ACCESSIBLE PARKING STALLS	1	C7.3
112	RAISED CURB	9	C7.0
113	CURB END	6	C7.0
114	CONCRETE CURB AND GUTTER	7	C7.1
115	EXISTING CURB TO REMAIN	-	-
116	TRASH BINS (NIC)	-	-
117	FLUSH CURB	-	-
118	DRAINAGE CHANNEL	-	-
119	THICKENED EDGE AT BUILDING	8	C7.0
120	TRAFFIC RATED BOX AND LID	-	-
121	RAISE INLET STRUCTURE TO GRADE	SEE DEMOLITION PLAN	
200	FILTERRA STORMWATER TREATMENT CHAMBER	SEE SHEET C5.0	
201	DRAINAGE INLET	SEE SHEET C5.0	
900	IRRIGATION CONTROLLER TO REMAIN	SEE LANDSCAPE SHEETS	
901	LUMINARE	SEE ELECTRICAL SHEETS	
902	SIGNAGE PLAN AND DETAILS	SEE ARCHITECTURAL SHEETS	

LEGEND

SYMBOL	DESCRIPTION	DETAIL	SHEET
	SIDEWALK CONCRETE PAVING (NO REINFORCEMENT)	1	C7.1
	PEDESTRIAN CONCRETE PAVING	2	C7.0
	VEHICULAR CONCRETE PAVING	3	C7.0
	DETECTABLE WARNING SURFACE	5	C7.1
	AC PAVING LIMITS	7	C7.0
	THICKENED EDGE	8	C7.0
	CONTRACTION JOINTS	1	C7.0
	PLANTER	SEE LANDSCAPE SHEETS	

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VERIFY SCALES
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0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

REGISTERED PROFESSIONAL ENGINEER
JARED S. O'BARR
No. 76125
CIVIL
STATE OF CALIFORNIA
2/25/26

NO.	DATE	REVISION

CAL POLY HUMBOLDT
PLY14 G14 PARKING EXPANSION
14TH & B STREET, ARCATA, CALIFORNIA

SITE PLAN

DATE	02/2026	DSGN	KWR
		DR	CDN/JWF
PROJ. NO.	025149	CHK	JSO

SHEET
C3.0

SAVED: 2/25/2026 1:50 PM CNEWELL, PLOTTED: 2/25/2026 1:52 PM NEWELL, CHRIS
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Appendix 2
LID Manual Stormwater Control Plan Completed Forms

STORMWATER INFORMATION SHEET

Instructions

Construction and development projects within portions of unincorporated Humboldt County (McKinleyville, the greater Eureka area, and Shelter Cove) and the Cities of Eureka, Arcata, Fortuna, and Trinidad are subject to stormwater runoff and pollution control requirements of State Water Resources Control Board Water Quality Order No. 2013-0001-DWQ; NPDES General Permit No. CAS0000004 [Municipal Separate Storm Sewer (MS4) General Permit].

The following checklist is to be completed by you (the applicant) to determine which plans and specifications for stormwater runoff control are required as part of a Building or Development Permit application for projects located in areas subject to MS4 requirements.

I. Construction Project Information and Checklist (Completed by Applicant)

Site Location Address: 1 Harpst Street Arcata, CA 95521

Assessor Parcel Number (APN): 020-046-001-000

Anticipated Construction Start Date: 5/1/2026   dfjdf

Anticipated Construction Completion Date: 10/15/2026

Total area of Land Surface Disturbance: 34,848 square ft. or 0.8 acres

If project disturbs ≥ 1 acre of land surface then provide the State Construction General Permit WDID No.: ____________

Check and/or list all applicable permits directly associated with project construction or grading activity:

- ☐ State Construction General Permit (CGP)
- ☐ State 401 Water Quality Certification
- ☐ U.S. Army Corps 404 Permit
- ☐ CA Fish and Wildlife 1600
- ☐ Other (list): ____________

Is the construction site part of larger common plan of development or sale (check as applicable)?

☐ YES ☑ NO ☐ Unknown

Name of larger common plan/project (if applicable): ____________

Impervious Surface Area:

Pre-Project Impervious Surface:	New or Replaced Impervious Surface:	Total Post-Project Impervious Surface:
6,926 square ft.	22,520 square ft.	29,446 square ft.

Check Project Type as determined from LID Manual Part A, Table 1 - Applicable Post-Construction Standards Based on Project Type

Project Type:	Notes:
☐ Exempt	Sign and Certify this form.
☐ Small Project	Sign and Certify this form. Follow instructions in Part B of LID Manual.
☑ Regulated Project	Sign and Certify this form. Follow instructions in Part C of LID Manual
☐ Regulated Project with ≥ 1 acre of created or replaced impervious surface	Sign and Certify this form. Follow instructions in Part C of LID Manual.
☐ Regulated Redevelopment, Roads, or Linear Underground Project	Sign and Certify this form. Requirements vary; contact County or City Department with project jurisdiction.

Stormwater runoff from the project site discharges to (check as applicable):

- ☑ Storm Drain System (including road side ditches and other conveyances)
- ☐ Directly to waters of the State or U.S. (e.g. river, lake, stream, ocean, wetland) Name of Waterbody: ____________

Name of nearest waterbody receiving runoff from site: Humboldt Bay

Indicate distance from project site to nearest watercourse: 500 ft.

If your project is covered under the State Water Resources Control Board Construction General Permit (CGP), attach a copy of the submitted Stormwater Pollution Prevention Plan (SWPPP) including the Notice of Intent and WDID Number.

If a CGP is not required for your project, submit appropriate construction site BMP plans as required by County or City Department with project jurisdiction. to be submitted

II. Certification (Completed by Owner or Authorized Applicant/Agent)

I, the below signed, confirm that I have accurately described my project to the best of my ability, and that I have not purposely omitted any detail affecting my project's classification for stormwater regulation

Printed Name:

Signature: Date:

III. For Official Use Only

Permit No.: Submittal Date: Received By:

Stormwater Control Plan for Regulated Projects (≥ 5000 sq. ft.)

For Office Use Only
Application No.______________________________
Received By: ______________________________

Instructions
Based on the Stormwater Information Sheet in Humboldt LID Stormwater Manual – Part A, you have determined that your project is classified as a Regulated Project. Use this form to assist you in designing your project to comply with the MS4 General Permit post-construction requirements for Regulated Projects. This completed and signed Stormwater Control Plan for Regulated Projects including additional supporting documents as required, must be submitted with your project application to the applicable PBS department with project location jurisdiction.

A. Project Information and Description

Project Name: California State Polytechnic University, PLY114 G14 Parking Expansion
Physical Site Address: 150 14th Street Arcata, CA 95521
Assessor's Parcel Number: 020-046-001-000
Project Applicant: California State Polytechnic University , Humboldt
Mailing Address: 1 Harpst Street, Arcata, CA 95521
Phone: (707) 826-3011
Email: fmservice@humboldt.edu

Name, email and address of project consultant, if any (e.g., engineer, architect, designer):
Name: Jared O'Barr
Firm: SHN Engineers & Geologists
Address: 812 W. Wabash Avenue Eureka, CA 95501
Phone: (707) 441-8855
Email: jobarr@shn-engr.com

Type of Application/Project:
What type of application is this checklist accompanying?

- [x] **Grading Permit**
- [ ] **Use Permit**
- [ ] **Subdivision**
- [ ] **Building Permit**
- [ ] **Design Review**
- [ ] **Other (please specify)** ________________

Project Type and Description:	Site preparation and grading for parking lot expansion
Total Pre-Project Impervious Surface Area (square feet)	6,926 SF
Total New or Replaced Impervious Surface Area (square feet) [Sum of impervious area that will be constructed as part of the project]	22,520 SF
Total Post-Project Impervious Surface Area (square feet)	29,446 SF

This Regulated Projects Stormwater Control Plan provides guidelines and methods for assessing site conditions, determining runoff values for site DMAs, implementing site design measures with the goal of reducing stormwater runoff values from impervious surfaces, and determining the size of bioretention facilities (if required). Strategic use of site design measures may enable compliance without the need for bioretention facilities or equivalent.

Stormwater Control Plan for Regulated Projects (≥ 5000 sq. ft.)

B. Site Assessment (Opportunities and Constraints)

1. Soil Characteristics

I. Soil characterization method Geotechnical soil borings

II. Were infiltration rates assessed for the site? ☐ Yes ☑ No

If Yes, please attach soils testing report

2. Depth to Groundwater

I. What is the depth (below ground surface) to groundwater (in feet)? unknown

II. How was this determined? groundwater was not encountered during soil investigation

3. Existing Vegetation and Natural Areas

I. Are there any key natural vegetation areas, sensitive habitats, or mature trees on the site?

☐ Yes ☑ No

If yes, please draw and label these features on the existing conditions site plan map and attach to this document.

4. Drainage and Hydrograph

I. Are there any natural drainage or wet area features such as: natural ponds, springs, vernal pools, marshes, and wet meadows on the site or directly adjacent to the site?

☐ Yes ☑ No

If yes, consult with applicable PBS department staff with jurisdiction for project location as additional project area restrictions may apply.

5. Potential Contamination

I. Is the project site within or near to a registered contaminated site, according to the State Water Resources Control Board Geotracker Website (http://geotracker.waterboards.ca.gov/)?

☐ Yes ☑ No

If yes, please attach the applicable contaminated site report from the Geotracker website, and note the location of the contaminated site on the existing conditions site plan map. Please attach a description explaining how this contamination will affect your project design.

Stormwater Control Plan for Regulated Projects (≥ 5000 sq. ft.)

C. Project Layout Optimization

Optimizing the site layout can be done through the following methods:

1. Define the development envelope and protected areas, identifying areas that are most suitable for development and areas to be left undisturbed.
2. Concentrate development on portions of the site with less permeable soils and preserve areas that can promote infiltration.
3. Limit overall impervious coverage of the site from paving and roofs.
4. Set back development from creek, wetlands, and riparian habitats, to maximize vegetative buffer widths.
5. Preserve significant trees.
6. Conform the site layout along natural landforms.
7. Avoid excessive grading and disturbance of vegetation and soils.
8. Replicate the site's natural drainage patterns.
9. Detain and retain runoff throughout the site.

Based on the features included in the existing conditions site plan, please ensure your project site plan applies project layout optimization measures to the greatest extent practicable, while still meeting the objectives of your project.

Have you attached a short description of how site optimization techniques have been integrated into the project design?

☑ Yes ☐ No

The existing site naturally slopes from the north-east to the south-west which the project design maintained. Impervious surfaces were established to provide accessible access to the campus while treating runoff to the furthest extent.

D. Source Controls

Does your project contain potential pollutant-generating activities or sources?

☐ Yes ☑ No

If Yes, please complete the Source Control Worksheet (Appendix 7) and list and identify the source or treatment control measure and locations and include as an attachment to the SCP document.

Stormwater Control Plan for Regulated Projects (≥ 5000 sq. ft.)

E. Drainage Management Areas

On the project site plan please delineate and label all drainage management areas (refer to Sec. 6 of the manual).

For each Drainage Management Area identified on the project site plan, complete the Regulated Projects Runoff Worksheets (attached) to document runoff values, implementation of Site Design Measures, and bioretention facility sizing (if required). Every DMA within the project shall be listed in Worksheet 1(attached)

In accordance with section E.12 of the MS4 General Permit, Site Design Measures shall be implemented based on the objective of capturing (retaining) stormwater runoff from the 85th percentile 24-hour storm event, to the extent technically feasible. Any remaining runoff, from impervious DMAs, may then be directed to one or more bioretention facilities or equivalent. Projects over 1 acre must adhere to hydromodification standards if applicable. (refer to Sec. 5.8 of the manual).

F. Runoff Reduction Measures

Worksheet 1 provides a method for project applicants to document compliance with runoff reduction requirements through a site design methodology that directs stormwater runoff from impervious surface areas to pervious self-retaining areas for capture and infiltration (as detailed in LID Manual – Section 6.0). Using this methodology, all stormwater runoff from the 85th percentile 24-hour storm event for each DMA can be captured and retained on site and compliance with the MS4 General Permit runoff reduction requirements can be met.

Capturing stormwater runoff using the site design methodology where runoff from impervious surface areas is directed to pervious self-retaining areas is a convenient alternative for achieving compliance with the MS4 General Permit runoff reduction requirements, while avoiding the need for bioretention facilities. Worksheet 1 provides a simple calculation for determining if stormwater runoff reduction measures have been met using this design methodology.

Due to site constraints, not all projects or project DMAs may be able to achieve compliance with runoff reduction requirements by directing impervious surface stormwater runoff to pervious self-retaining areas. The project applicant will need to complete Worksheet 2 for each DMA (*6.0 Documenting Your Design*) that cannot meet compliance with runoff reduction measures as determined using Worksheet 1.

Worksheet 2 will be used to apply Site Design Measures in addition to any pervious self-retaining areas with the goal of reducing stormwater runoff values from impervious surfaces such that a no net stormwater runoff value (using the design storm) for each DMA is achieved. The worksheet process is an iterative exercise. If compliance cannot be met during the first iteration of calculations alter the site design measures to increase capturing capacity and rerun the calculator.

Site Design Measures include the following:

- ☐ 1. Tree Planting and Preservation
- ☐ 2. Rain Barrels or Cisterns
- ☐ 3. Impervious Area Disconnection
- ☑ 4. Soil Quality Improvement
- ☐ 5. Green Roof
- ☐ 6. PPPP (alternative engineered hardscapes)
- ☐ 7. Vegetated Swales
- ☐ 8. Stream Setbacks and Buffers
- ~~☐ 9. On-site Infiltration (trench, dry well, gallery, or system)~~

Multiple Site Design Measures may be applied to best meet site conditions in order to reduce stormwater runoff values from impervious surface areas.

After application of Site Design Measures, any remaining stormwater runoff from each DMA, must then be directed to one or more bioretention facilities or equivalent in accordance with Section 6.3 of the manual and the MS4 General Permit.

G. Bioretention Facility

Indicate whether a Bioretention Facility or equivalent is required for this project.

☑ Yes ☐ No

Stormwater Control Plan for Regulated Projects (≥ 5000 sq. ft.)

H. Operation and Maintenance in Perpetuity

Indicate whether an *Operation and Maintenance Plan* is accompanying this document, required for bioretention facilities or equivalent).

☑ Yes ☐ No

I. Signature and Certification:

This Stormwater Control Plan is required for all Regulated Projects. This document will be used by the plan checker to confirm that adequate stormwater control measures are being implemented on the project.

Indicate whether all supporting materials and worksheets are accompanying this document, Stormwater Control *Plan*

☑ Yes ☐ No

I, the below signed, confirm that I have accurately described my project to the best of my ability, and that I have not purposely omitted any detail affecting my project's classification for storm water regulation. I hereby certify that the site design measures and storm water flow treatment measures identified herein as being incorporated into my project have been designed in accordance with the Site Design Measure sheets or equivalent and are included in the final site plans submitted to the applicable Planning and/or Building Services Department with project location jurisdiction. I also hereby certify that my project meets the storm water runoff reduction criteria identified in the SCP, or as determined through other approved means.

______________________________ ____________________
Signature Date

____
Print Name

I am the:

☐ Property Owner ☐ Contractor ☐ Applicant

Stormwater Control Plan for Regulated Projects (≥ 5000 sq. ft.)

J. Checklist:

Items on Site Plan	Items within the SCP
☑ Site Boundary	☑ Narrative of site features and conditions that constrain or provide opportunity for stormwater control
☐ Soil types and areal extents. Test pit/infiltration test locations (if required)	☑ Narrative describing the use of runoff reduction measures (sec. F), building features, pavement selections, etc., that reduce runoff
☐ Environmentally-sensitive areas and areas to be preserved	☑ Completed Worksheet 1 self-retaining area
☐ Existing natural hydrological features (depressions, watercourses, wetlands, riparian areas, undisturbed natural areas)	☑ Completed Worksheet 2 site design runoff reduction measures for each DMA
☑ Existing and proposed sited drainage network and connections to MS4 conveyances off-site	☑ Treatment/Bioretention Operation and Maintenance Plan, including: inspection and , maintenance schedule, checklist and certification form and legally binding agreement
☑ Proposed site design measures used to reduce runoff	☑ Bioretention Checklist (if utilized)
☑ DMA delineation labeled with unique identifier	☑ Narrative describing (treatment/ baseline hydromodification)/bioretention facilities including the calculations and location of each facility.
☑ Proposed locations and footprints of improvements creating new, or replaced, impervious surfaces	☐ Source Control Worksheet (if required)
☑ Locations and footprints of bioretention (treatment/baseline hydromodification) facilities (if required)	☐ Soil percolation/infiltration testing documentation
☐ Areas of soil and/or groundwater contamination	
☑ Existing utilities and easements	
☐ Pollutant generation source areas, including loading docks, food service areas, refuse areas, outdoor processing and storage areas, vehicle cleaning facilities/areas, repair or maintenance areas, fuel dispensing area, equipment washing areas	

Regulated Projects Worksheet 1 - Humboldt Low Impact Development Stormwater Manual

DMA Name	Total Post Project Impervious Surface Area (square feet)	Pervious Self-Retaining Area[1] (square feet)	Ratio of Impervious Surface Area to Self-Retaining Pervious Surface Area	Does Ratio Achieve 3.5 : 1 ratio or better of Impervious Surface Area to Self-Retaining Pervious Surface Area (Yes or No)[2]
Example A	500	150	3.3 : 1	YES
Example B	500	100	5.0 : 1	NO
DMA 1	29446	0	:	
		0	:	
		0	:	
		0	:	
		0	:	
		0	:	
		0	:	
		0	:	
		0	:	
		0	:	
		0	:	
		0	:	
		0	:	
			:	

1: Self-Retaining Areas where impervious surface runoff is directed to the Pervious Self-Retaining Area in accordance with Humboldt LID Manual - Part C, Section 6.0

2: If "Yes", Ratio of Impervious Surface Area to Self-Retaining Pervious Surface Area is equal to 3.5:1 or better (1.3:1 or better in the Shelter Cove MS4 area), then compliance with runoff reduction measures have been met for DMA.
If "No", Ratio of Impervious Surface Area to Self-Retaining Pervious Surface Area does not achieve 3.5:1 or better (1.3:1 in Shelter Cove), then compliance with runoff reduction measures have not been met for DMA (Complete Worksheet 2).

Regulated Projects Worksheet 2
Humboldt Low Impact Development Stormwater Manual

						Formulas/Notes
Project Information						
DMA Name:						
Total Post-Project Impervious Surface Area (square feet)			A	29,446.00	square feet	
24 hour - 85th Percentile Design Storm			B	0.65	inch	B = Select Design Storm Value (0.65-inch Humboldt Bay Area, 1.3-inch Shelter Cove)
Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm value)			C	11883	Gallons per 24 hours	C = A x B x 0.083 x 7.48
Pervious Self-Retaining Area (SRA) Credit (if applicable, if none enter 0)						
Self-Retaining Area (square feet)	0	3.5	SRA Credit	0	square feet	SRA Credit = Self-Retaining Area x Multiplier. Select Multiplier (3.5 Humboldt Bay Area, 1.3 Shelter Cove)
Site Design Measure Credits						
Tree Planting and Preservation						
New Trees		# of trees				
100 square feet per deciduous tree	D	0	E	0	square feet	E = D x 100
200 square feet per evergreen tree	F	0	G	0	square feet	G = F x 200
Existing Trees (Credit for 50% of existing canopy area)		Canopy diameter (feet)				
Tree #1	H_1	0	J_1	0	square feet	$J_1 = 3.14 \times (H_1/2)^2 \times 0.50$
Tree #2	H_2	0	J_2	0	square feet	$J_2 = 3.14 \times (H_2/2)^2 \times 0.50$
Tree #3	H_3	0	J_3	0	square feet	$J_3 = 3.14 \times (H_3/2)^2 \times 0.50$
Rain Barrel or Cisterns (55 gallon minimum)						
Square foot credit per gallon based on 24-hour, 85th Percentile Design Storm	K	2.48				K = Select square foot credit per gallon (2.48 Humboldt Bay Area, 1.24 Shelter Cove)
		Gallons				
Rain Barrels	L	0	M	0	square feet	M = L x K
Cisterns	N	0	O	0	square feet	O = N x K
~~Infiltration Trench/Basin (55 gallon minimum ~21 ft^3**)~~		~~cubic feet~~				
~~volume(ft^3) = length x width x depth~~	P	~~0~~	~~Q~~	~~0~~	~~square feet~~	~~Q = P x R x K x 7.48~~
~~porosity (approximate %)~~	R	~~35%~~				
~~Subsurface Infiltrators (55 gallon minimum)~~						
~~Proprietary units vary, insert estimated storage in ft^3~~	S	~~0~~	~~T~~	~~0~~	~~square feet~~	~~T = S x 7.48~~
Impervious Area Disconnection						
Credit per square foot of impervious area feeding into pervious area			U	0	square feet	U = Enter square foot value
Soil Quality Improvement						
Credit per square foot of soil quality improvement			V	0	square feet	V = Enter square foot value
Green Roof						
Credit per square foot of green roof installation			W	0	square feet	W = Enter square foot value
PPPP (Alternative engineered hardscaping surfaces)						
Credit per square foot of PPPP			X	0	square feet	X = Enter square foot value
Vegetated Swales						
Credit per square foot of vegetated swale			Y	0	square feet	Y = Enter square foot value
Stream Setbacks and Buffers						
Credit per square foot of stream setback and buffer#			Z	0	square feet	Z = Enter square foot value
Credits Total			AA	0	square feet	AA = SRA Credit + E + G + J_1 + J_2 + J_3 + M + O + Q + T + U + V + W + X + Y + Z
Post-Project Impervious Surface Area minus Site Design Measure Credits			BB	29446	square feet	BB = A - AA
NEW Impervious Surface Runoff Value (Potential Stormwater Runoff due to impervious surface area and design storm after implementation of Site Design Measures)			CC	11883	Gallons per 24 hours	CC = BB x B x 0.083 x 7.48
Percent reduction in Impervious Surface Runoff Value*			DD	0.0	%	DD = ((C - CC) / C) x 100%

***If value for DD is not greater than or equal to %100 then bioretention is required for treating remaining runoff from impervious area indicated by value BB.**
Design and implement bioretention facility in accordance with Humboldt LID Stormwater Manual - Part C.

~~**Infiltration Trench/Basin calculations are based on porosity (35%). Increased trench dimensions (volume) are required to meet 55 gallon minimum capacity.~~

Green	Fill In [Enter Value]	Conversions Used:
Red	Calculated Value	1 inch = 0.083 feet
Black	Fixed Value/Selectable Value	1 cubic foot = 7.48 gallons

Regulated Projects Worksheet 2, Version 2.0 - June 29, 2016

check with agency with project area jurisdiction for requirements

Appendix 3
Filterra Data

CONTECH ENGINEERED SOLUTIONS
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Filterra® Bioretention System Compliance with the Phase II Small MS4 General Permit
July 28th, 2017

Phase II Small MS4 General Permit 2013-0001-DWQ February 5, 2013
E.12. Post-Construction Storm Water Management Program
E.12.e. Low Impact Development (LID) Design Standards

E.12.e.(ii)(f) Storm Water Treatment Measures and Baseline Hydromodification Management Measures - After implementation of Site Design Measures, remaining runoff from impervious DMAs must be directed to one or more facilities designed to infiltrate, evapotranspire, and/or bioretain. Facilities must be demonstrated to be at least as effective as the prescribed 5in/hr bioretention system (this represents a minimum control measure).

E.12.e.(ii)(g) Alternative Designs — Facilities, or a combination of facilities, of a different design than in Section E.12.e.(ii)(f) may be permitted if all of the following measures of equivalent effectiveness are demonstrated:

1) Equal or greater amount of runoff infiltrated or evapotranspired;
2) Equal or lower pollutant concentrations in runoff that is discharged after biotreatment;
3) Equal or greater protection against shock loadings and spills;
4) Equal or greater accessibility and ease of inspection and maintenance.

The Filterra® Bioretention System through demonstrating the 4 measures of equivalent effectiveness to bioretention will meet the Phase II Small MS4 General Permit, *Section E.12.e.(ii)(g) Alternative Deigns* for Low Impact Development (LID) Design Standards.

- Filterra is an engineered biofiltration device with components that make it similar to bioretention in pollutant removal and application, but has been optimized for high volume/flow treatment in a compact system. Its small footprint allows Filterra to be used on highly developed sites such as landscaped areas, parking lots, and streetscapes. Filterra is adaptable and can be used alone or in combination with perforated pipes or chambers to optimize runoff reduction.[1]

Figure 1. Filterra® Bioretention System

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1) Equal or greater amount of runoff infiltrated or evapotranspired;
The Filterra® Bioretention System either standalone, with a perforated bottom or when combined with underground storage for infiltration demonstrates equal or greater amounts of runoff infiltrated.
   - For infiltrating soils (HSGs A and B) additional underground storage will be required to satisfy infiltration requirements. If the entire Volumetric Criteria, per Section E.12.e.(ii)(c), can be infiltrated using underground storage see *Underground Infiltration Compliance with the Phase II Small MS4 General Permit*.
   - For low permeable soils (HSGs C and D) it is assumed that no quantifiable infiltration will occur.
   - For sites where infiltration is technically infeasible, no quantifiable infiltration is permitted.
   - Note that The Filterra® Bioretention System is likely to require significantly less irrigation than larger conventional bioretention systems due to their compact footprint and the fact that over 70% of annual evapotranspiration occurs in the dry summer months.

2) Equal or lower pollutant concentrations in runoff that is discharged after biotreatment;
The Filterra® Bioretention System demonstrates equal or lower pollutant concentrations in runoff that is discharged after biotreatment.
   - The Filterra design is an optimized form of bioretention that includes all the same unit processes facilitating pollutant removal.[2]
     - 9” surface reservoir depth (Phase II, E.12.e. (f) requires 6” surface reservoir depth)
     - 3” mulch depth
     - 21” engineered media depth (plant medium containing organics), (Phase II, E.12.e. (f) requires 18” planting medium containing organics)
     - Over 300 drought tolerant tree, plant and shrub choices
     - 6”-12” drainage (gravel) layer with underdrain
   - Effluent concentrations achieved in the full-scale studies were generally equal to or lower than median effluent concentrations for the biofilter and media filter classes of BMPs reported in the International Stormwater BMP Database.[3][4]
   - Filterra showed statistically significant removals for a broader range of pollutants than were shown for the biofilter and media filter categories in the International Stormwater BMP Database.[3][4]
   - Filterra media’s pollutant removal performance (demonstrated by effluent concentration) is comparable to or better than traditional bioretention systems.[4]
   - Filterra system continues to meet pollutant removal performance expectations as the systems age and receive regular maintenance.[5]
   - Performance of the Filterra (using 165 sampled data pairs) showed equal or lower pollutant concentrations than that of conventional bioretention (using 234 sampled data pairs from bioretention with a similar specification to CA bioretention). [6]

3) Equal or greater protection against shock loadings and spills;
The Filterra® Bioretention System demonstrates equal or greater protection against shock loadings and spills.
   - The Filterra system has a 9” surface reservoir depth that is available to capture and retain trash, sediment and debris loads. If heavy loads of particulate materials enter the system, they will be predominately be retained by the mulch layer which can be easily cleaned or removed and replaced.
   - All Filterra systems are off-line, with flows in excess of the design treatment flow rate routed around the bioretention cell, so there is minimal risk of exporting previously captured pollutants at extreme flow rates.
   - The influence of reduction in bioretention media flow rate on capture efficiency is relatively minor; a reduction in media flow rate of 50 percent from 140 to 70 inches/hour results in an expected decline in capture efficiency of less than 10 percent.[3][4]

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- Filterra is effective at capturing hydrocarbons. Field monitoring has demonstrated a TPH removal efficiency of 96 percent and a median TPH effluent concentration of 1.2 mg/L.[3]
- Volatilization may also occur if VOCs (i.e. Gasoline) are captured in the filter media.[3]
- *NJCAT Verification, 4.2 Sediment Mass Loading Testing*: Over 4.5 years, and with no maintenance, 384lbs of sediment was loaded into the Filterra unit without any decrease in infiltration and removal rates.[7]
- *NJCAT Verification, 4.3 Scour Testing*: Less than 1% mass loss during scour testing.[7]
- Field installations have demonstrated The Filterra® Bioretention System to be able to withstand a 100-year event, flash flooding and large amounts of debris and sediment with performance as expected and no damage to the system and components.[8]

4) Equal or greater accessibility and ease of inspection and maintenance.
   The Filterra® Bioretention System demonstrates equal or greater accessibility and ease of inspection and maintenance.
   - Inspection and maintenance is a simple, inexpensive and safe operation that does not require confined space access, pumping or vacuum equipment or specialized tools.[9]
   - Properly trained landscape personnel can effectively inspect and maintain Filterra systems by following instructions in this manual. [9]
   - Maintenance typically requires only minor trash removal and replacement of mulch. [9]
   - Maintenance typically requires only 0.5 man hours per system. [9]
   - Maintenance typically costs $100-$300 per year per system.
   - It has been found that in regions which receive between 30-50 inches of annual rainfall, (2) two visits are generally required; regions with less rainfall often only require (1) one visit per annum. [9]
   - The semiannual maintenance schedule recommended for east coast installations and annual maintenance schedule for west coast installations appears to be sufficient, based on results from maximum capacity flow rate tests demonstrating that the media flow rate was maintained at or above 100 to 140 inches/hour for Filterra systems of varying age and varying maintenance periods.[3]
   - As long as routine maintenance is performed, the Filterra® system will theoretically last indefinitely, since it essentially sequesters and recycles nutrients, metals, and organics in the biomass (i.e., plant and microbes).[3]
   - Commercial Filterra units have been field-tested in our long-term performance studies to show almost NO appreciable reduction in flowrate despite maintenance not being performed for 1 ½ to 2 years.[4]

Please contact Contech Engineering Solutions for more information.

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References:
1. *Filterra® Bioretention System Solution Guide*
2. *Key Features of High Performance Biofiltration*
3. *Filterra® Bioretention Systems: Technical Basis for High Flow Rate Treatment and Evaluation of Stormwater Quality Performance*
4. *Filterra High-Performance Media: A New Standard of Performance in Stormwater Quality Treatment*
5. *Filterra Performance Over Time*
6. *Filterra Equivalency Analysis and Design Criteria*
7. *NJCAT Technology Verification; Filterra® Bioretention Systems, May 2014*
8. *Case Study; Ellicott City Parking Lot E*
9. *Filterra Operation & Maintenance (OM) Manual v01*

FILTERRA EQUIVALENCY ANALYSIS AND DESIGN CRITERIA

Pursuant to:

Los Angeles County MS4 Permit (Order R4-2012-0175)

Prepared for

CONTECH Engineered Solutions

Prepared by

Geosyntec consultants
engineers | scientists | innovators

621 SW Morrison Street, Suite 600
Portland, Oregon 97205

August 2015

TABLE OF CONTENTS

1 INTRODUCTION

The Los Angeles County MS4 Permit (Order No. R4-2012-0175) (MS4 Permit) defines "biofiltration" based on specific design and sizing criteria[1]. In addition, the MS4 Permit allows the Los Angeles County Regional Water Quality Control Board (Regional Board) Executive Officer to approve alternate biofiltration design criteria. The purpose of this analysis was to develop a design basis for Filterra systems such that these systems will provide reasonably equivalent performance to biofiltration BMPs as defined in the MS4 Permit. This report is provided to the Executive Officer of the Regional Board to support approval of alternative design criteria for Filterra systems. This report describes the basis for evaluating equivalency, details the design approach and equivalency criteria for Filterra systems to achieve equivalent performance to conventional biofiltration, and provides the supporting rationales for these equivalency criteria.

The remainder of this report is organized as follows:

Section 2 – BMP Descriptions

Section 3 – Basis and Methodology for Evaluating Equivalency

Section 4 – Filterra Design Approach and Equivalency Criteria

Section 5 – Discussion and Conclusions

Section 6 – References

Appendix A – Design Assumptions for Conventional Biofiltration

Appendix B – SWMM Modeling Methodology and Assumptions

Appendix C – Datasets and Analysis Methods for Pollutant Treatment Evaluation

Appendix D – Results of BMP Treatment Performance Evaluation

[1] BMPs sized and designed per these criteria are referred to in this memorandum as "traditional biofiltration."

2 BMP DESCRIPTIONS

2.1 Conventional Biofiltration

Biofiltration (also known as bioretention with underdrain) consists of shallow landscaped depressions that capture and filter stormwater runoff through a planted engineered media. These facilities function as soil and plant-based filtration systems that remove pollutants through a variety of physical, biological, and chemical treatment processes. Biofiltration facilities normally consist of a ponding area, mulch layer, planting soils, and plantings (see typical schematic in Figure 1). An optional gravel layer added below the planting soil coupled with an upturned elbow (or similar hydraulic control approach) can provide additional storage volume for infiltration. As stormwater passes down through the planting soil, pollutants are filtered, adsorbed, and biodegraded by the soil and plants. As defined in Attachment H of the 2012 Los Angeles County MS4 Permit, biofiltration designs must meet a number of specific criteria to be considered "biofiltration" as part of compliance with the MS4 Permit. Conventional biofiltration is typically designed as a "volume-based" BMP, meaning that is it sized based on capture of the runoff from a specific size of storm event.

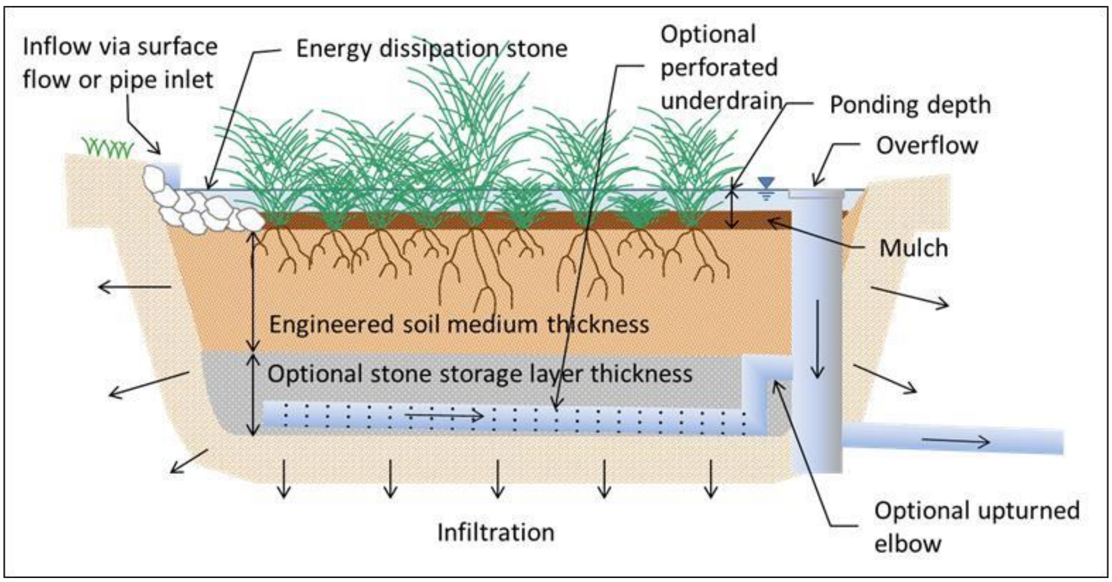

Figure 1. Cross sections of typical biofiltration system

2.2 Filterra Systems

Filterra systems include engineered filter media topped with mulch housed in a precast concrete curb inlet structure with a tree frame and grate cast in the top slab. In addition to the water quality filtering/sorption of stormwater, the engineered media and mulch supports the growth of a tree or other type of plant (see typical configuration in Figure 2). There are three key components of the Filterra system that contribute to pollutant removal: mulch, engineered filter media, and vegetation and other system biota. Filterra systems can be configured so that underdrains discharge into downstream retention storage systems. In contrast to conventional biofiltration, the media filtration rates of Filterra systems are substantially higher, and therefore the footprint of these systems tends to be substantially smaller than conventional biofiltration systems. As a result of smaller footprints, the amount of volume reduction (via infiltration and evapotranspiration) that is typically observed in these systems when not coupled with infiltration systems tends to be relatively low. Because these systems provide relatively limited ponded water volume above the surface of the media, they are typically sized as "flow-based" BMPs based on a design intensity of rainfall rather than "volume-based" BMP based on a design storm depth.

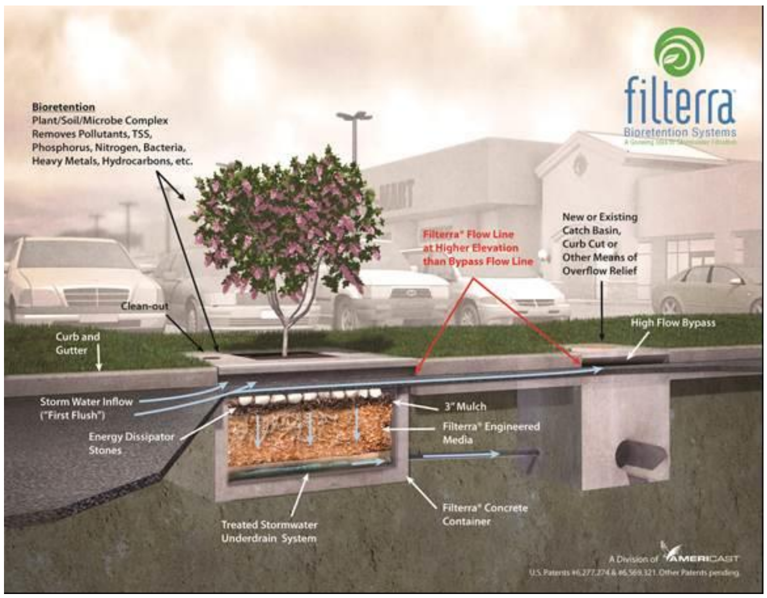

Figure 2. Diagram of the Filterra system (Contech, 2015 via web).

3 BASIS AND METHDOLOGY FOR EVALUATING EQUIVALENCY

3.1 Basis for Equivalency

Equivalency was evaluated between conventional biofiltration BMPs meeting the criteria of the MS4 Permit (specifically Attachment H) and Filterra systems as an alternate biofiltration BMP. Equivalency was determined based on the factors that influence the pollutant load reduction performance of stormwater BMPs:

- **Capture efficiency**: The percent of long term stormwater runoff volume that is "captured" and managed by the BMP (i.e., treated or reduced; not overflowed or bypassed).
- **Volume reduction**: The percent of long term stormwater runoff volume that is "lost" or "reduced" in the BMP to infiltration and evapotranspiration.
- **Concentration reduction**: For the volume that is treated and not reduced, the average difference in concentration between the influent volume and the treated effluent volume.

The equivalency analysis consisted of three parts:

1) The baseline performance of conventional biofiltration (capture efficiency, volume reduction, and concentration reduction) was estimated.
2) Applying the same methods as used to evaluate the performance of conventional biofiltration, sizing criteria were developed for Filterra (accompanied by supplemental infiltration systems, where needed) such that Filterra systems will provide equivalent performance to conventional biofiltration.
3) A design methodology for Filterra systems was developed to ensure consistent application of the equivalent sizing criteria in the design of Filterra systems.

The following subsections provide information about this analysis.

3.2 Methods and Assumptions for Establishing Baseline Biofiltration Performance

The following subsections summarize the methods and assumptions that were used to evaluate the baseline performance of conventional biofiltration BMPs consistent with Attachment H of the MS4 Permit.

3.2.1 Hydrologic Performance (Capture Efficiency and Volume Reduction)

Attachment H of the MS4 Permit specifies a number of criteria that influence the hydrologic performance of the conventional biofiltration BMPs:

- 6 to 18-inch ponding area above media
- Optional layer of mulch
- 2 to 3 feet of engineered filter media (2 feet typical) with a design infiltration rate of 5 to 12 inches/hour; the Attachment H specification calls for a mix of 60 to 80% fine sand and 20 to 40% compost

- Gravel storage layer below the bioretention media to promote infiltration
- Underdrain placed near the top of the gravel layer (or an infiltration sump otherwise provided via an equivalent hydraulic control approach) in cases where underlying soil allows incidental infiltration
- Underdrain discharge to the storm drain
- Capacity (including stored and filtered water) adequate to biofilter 150 percent of the portion of the SWQDv not reliably retained.

Within the bounds established by these criteria, a relatively wide range of actual biofiltration designs could result as a function of site infiltration conditions as well as designer and local jurisdiction preferences. An example of potential design variability is illustrated in Appendix A. For the purpose of this analysis, representative design assumptions were developed within the range of potential design assumptions. These assumptions are also presented in Appendix A with supporting rationales. Long term continuous simulation SWMM modeling was conducted using 15 years of 5-minute resolution precipitation data, as described in Appendix B, to estimate the long term capture efficiency and volume reduction of the baseline biofiltration design scenario for a range of site infiltration rates. Biofiltration BMPs will tend to provide more volume reduction when installed in sites with higher incidental infiltration rates. Table 1 describes the baseline hydrologic performance of biofiltration BMPs.

Table 1. Baseline Biofiltration Hydrologic Performance

Site Soil Infiltration Rate, in/hr	Long Term Capture Efficiency (percent of total runoff volume)	Long Term Volume Reduction (percent of total runoff volume) (ET + Infiltration)
0	92 to 94%[1] (93% capture is representative)	4%
0.01		6%
0.05		11%
0.15		22%
0.30[2]		35%

1 - Capture efficiency varies slightly as a function of soil infiltration rate (and associated differences in design profile) and land use imperviousness. These differences are relatively minor and are considered to be less important than the variability in performance that may result from different design approaches and maintenance conditions that may be encountered. Therefore a single baseline value of 93 percent long term capture was used in this analysis.
2 - A maximum soil infiltration rate of 0.3 inches per hour was evaluated because for soil infiltration rates greater than 0.3 inches per hour the MS4 Permit requires that infiltration be evaluated.

3.2.2 Pollutant Treatment

Pollutant treatment performance was evaluated based on analysis of bioretention with underdrain studies in the International Stormwater BMP Databases. Analyses were conducted based on all studies (28 studies) and a screened subset of studies that were considered to be most representative of Attachment H design criteria (16 studies). Additionally, two recent studies from the University of Maryland were added which followed rigorous protocols and evaluated systems sharing many similarities to Attachment H design criteria. Biofiltration research in California is very limited. Two recent monitoring studies were conducted in the San Francisco Bay area (led by the San Francisco Estuary Institute) on systems with media composition, sizing and design that would conform to Attachment H of the Los Angeles MS4 Permit. While these studies did not collect flow weighted composite influent and effluent samples, they were included in the data set.

Treatment performance was characterized using a moving window bootstrapping method that accounts for the influence of influent concentration on effluent concentration and characterizes the relative uncertainty in performance estimates within each range of influent quality. Both the median and mean summary statistics were evaluated using these methods. Additionally, literature on the influence of biofiltration design variables on performance was summarized to support the criteria that were used to select the 20 BMP studies that were included in the screened dataset. The pollutant treatment evaluation was based on total suspended solids, total phosphorus, total nitrogen, total copper, and total zinc. Influent concentrations characteristic of single family, multi family, commercial, and light industrial land uses were applied to estimate effluent concentrations and concentration change.

Generally, biofiltration provided good removal of TSS, moderate removal of copper and zinc, and generally showed export of nutrients. Export of nutrients tended to be greater when influent concentrations were low. Also, the dataset that was screened to include studies more similar to Attachment H design criteria (i.e., 5 to 12 inches per hour, with compost) showed substantially greater frequency of observed export of nutrients.

Details about pollutant treatment analyses are provided in Appendix C, and results of these analyses are provided in Appendix D.

3.3 <u>Filterra Analysis to Determine Equivalent Design Criteria</u>

The following paragraphs describe the analyses that were conducted for Filterra systems to determine the sizing criteria under which Filterra systems provide equivalent performance to conventional biofiltration.

3.3.1 Capture Efficiency

Filterra capture efficiency is a function of the design precipitation intensity used in sizing the Filterra system and the time of concentration (Tc) of the tributary area. Continuous simulation modeling using the SWMM model, with 15 years of 5-minute resolution precipitation, as described in Appendix B, was used to determine the relationship between design precipitation intensity, Tc, and long term capture efficiency (Figure 3). Based on this chart, the design guidance presented in Section 4 requires that approved methods, appropriate for the site, are used for calculating Tc and selecting a runoff coefficient equation to convert the design intensity to a design flowrate.

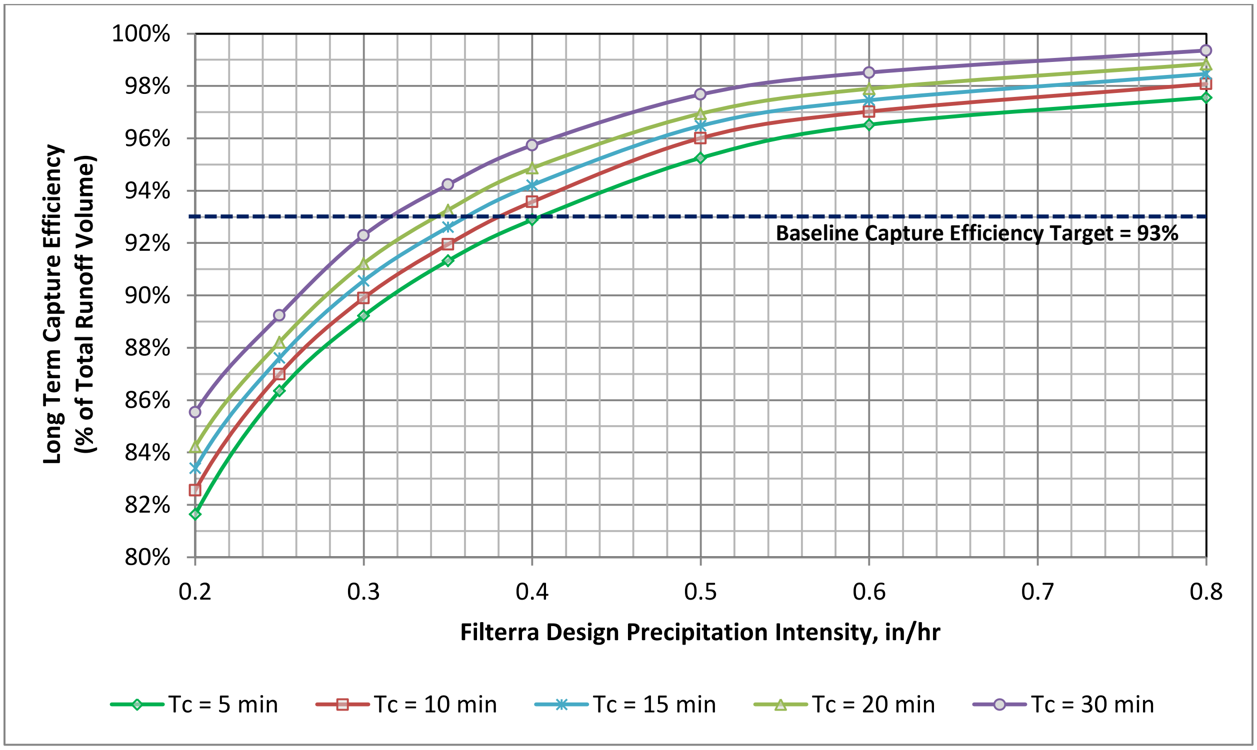

Figure 3. Chart of Filterra Capture Efficiency

3.3.2 Volume Reduction (Filterra and Supplemental Infiltration Storage)

Filterra systems, sized within the range needed to match conventional biofiltration capture efficiency, were estimated to provide approximately 1 percent long term volume reduction via evapotranspiration from soil pores (determined from SWMM modeling described above). This relatively small value is a function of the relatively small surface area of typical Filterra systems.

For site conditions in which conventional biofiltration BMPs would achieve appreciable volume reduction, supplemental infiltration systems (located either upstream or downstream of Filterra systems) may be needed to result in volume reduction equal to what would be achieved by conventional biofiltration BMPs under the same site conditions. Volume reduction is a function of the storage volume provided, the surface area of the storage/soil interface, and the infiltration rate of the soil (and associated drawdown time of the stored water). As described in Appendix B, SWMM modeling was conducted to determine the long term volume reduction of supplemental infiltration storage as a function of storage volume (with a reasonable surface area) and soil infiltration rate (Figure 4). The supplemental retention volume is specified as a fraction of the site-specific SWQDv, which is a standardized calculation in each jurisdiction and accounts for different precipitation depths around Los Angeles County as well as infiltration rates. The design methodology (Section 4) also provides guidance about the allowable depth of the supplemental retention storage systems so that stored water will infiltrate in a reasonable amount of time.

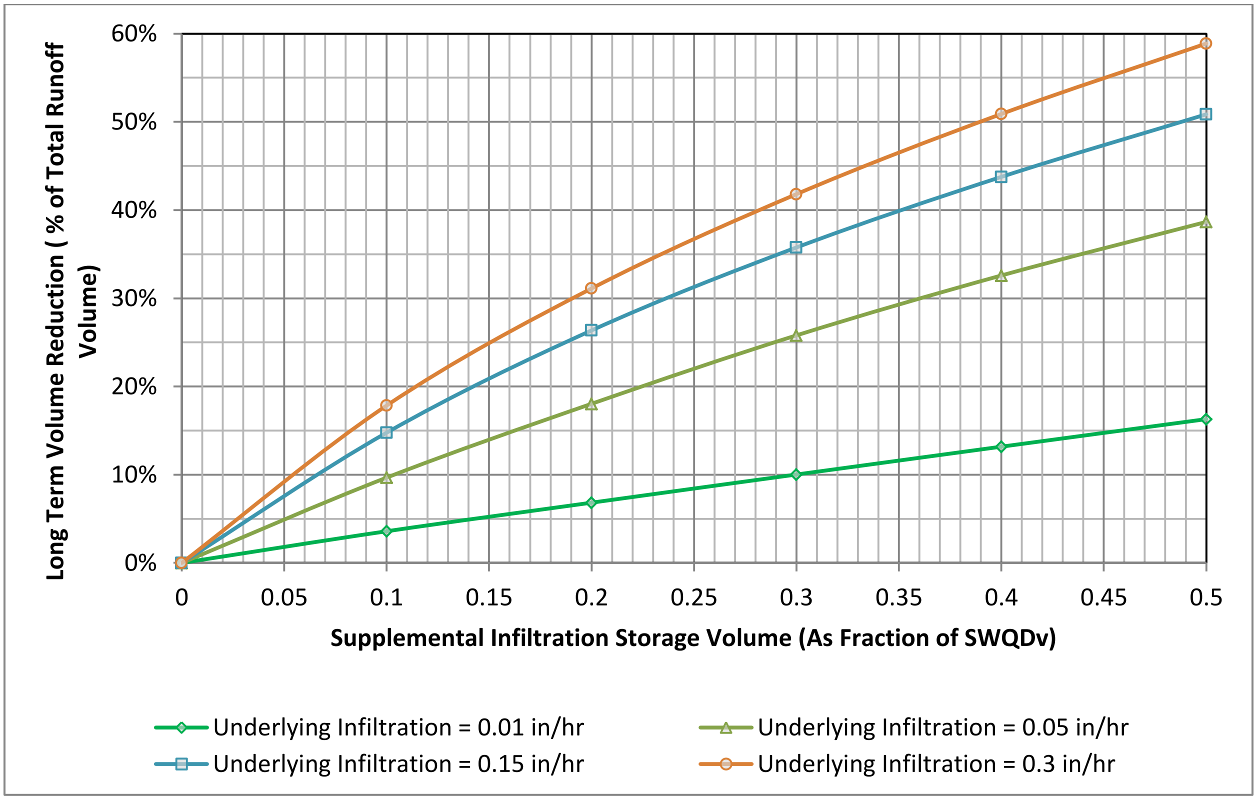

Figure 4. Chart of Volume Reduction in Supplemental Infiltration Storage

3.3.3 Pollutant Treatment

Filterra performance data were analyzed using the same moving window bootstrapping methods used for conventional biofiltration. Data from 6 third party studies conducted over the last 11 years (including some studies monitored periodically since 2007) were utilized in this analysis. This analysis sought to determine whether Filterra performance is reasonably similar to the treatment performance of conventional biofiltration BMPs under representative ranges of influent quality. This analysis was based on the same pollutant and land uses described above for conventional biofiltration.

The following bullets summarize the comparison of pollutant concentration reduction for conventional biofiltration and Filterra systems. Detailed comparison tables and plots are provided in Appendix D.

- **TSS:** Filterra performed somewhat better than conventional biofiltration systems for TSS across all representative land use concentrations considered. Both systems showed relatively strong performance for TSS.
- **Copper and Zinc:** Performance was generally similar between Filterra and conventional biofiltration for copper and zinc. Filterra showed better performance for some representative influent concentrations and conventional biofiltration showed better concentration reductions for others. In general, both provided moderate concentration

reductions of metals. The sample size for Filterra for sites with high metals concentrations is somewhat small, which results in wider confidence intervals for land uses with higher concentrations. Specifically, there was only one study (Port of Tacoma TAPE, station POT2) that had high zinc concentrations; this site was notable/unique in its high concentrations and the degree of dissolved zinc as a fraction of total zinc. For this site, average zinc influent concentrations were approximately 1,000 ug/L of which approximately 85 percent was dissolved zinc, on average. The concentration reductions for this site were still moderate (approximately 50 percent average removal).

- **Nitrogen and Phosphorus:** Filterra systems appear to provide much better pollutant concentration reduction than conventional biofiltration for nitrogen and phosphorus. Filterra does not appear to exhibit the export issues that were noted for conventional biofiltration within the representative range of land use concentrations considered. Variability in pollutant reduction performance was also lower for Filterra.

Given these findings, Filterra are expected to provide similar or better pollutant concentration reduction for all pollutants across the representative site conditions considered.

3.3.4 Additional Capture In Lieu of Volume Reduction

As described in Section 3.3.2 and Section 4, one approach for matching the pollutant load reduction of conventional biofiltration is to provide supplemental infiltration storage upstream or downstream of Filterra systems to match the volume reduction that would be achieved by conventional biofiltration.

For Filterra applications with minor deficiencies in volume reduction compared to conventional biofiltration, another option is to capture and treat additional long term runoff volume (via increased sizing) to achieve equivalent load reductions in lieu of providing supplemental infiltration storage. As a simple approach for minor volume reduction deficiencies, the pollutant treatment performance of Filterra systems for TSS was used as a simple method. Based on a minimum removal efficiency of 80 percent (actual performance is expected to be higher), a BMP must treat and discharge 5 parts of water for every 4 parts of water that would be lost to infiltration or ET. This means that for every 1 percent of volume reduction deficit, 1.25 percent of long term volume must be treated or 0.25 percent additional capture for every 1 percent of volume reduction deficit. This concept is illustrated in Figure 5. Calculations of required additional capture efficiency are provided in Table 2.

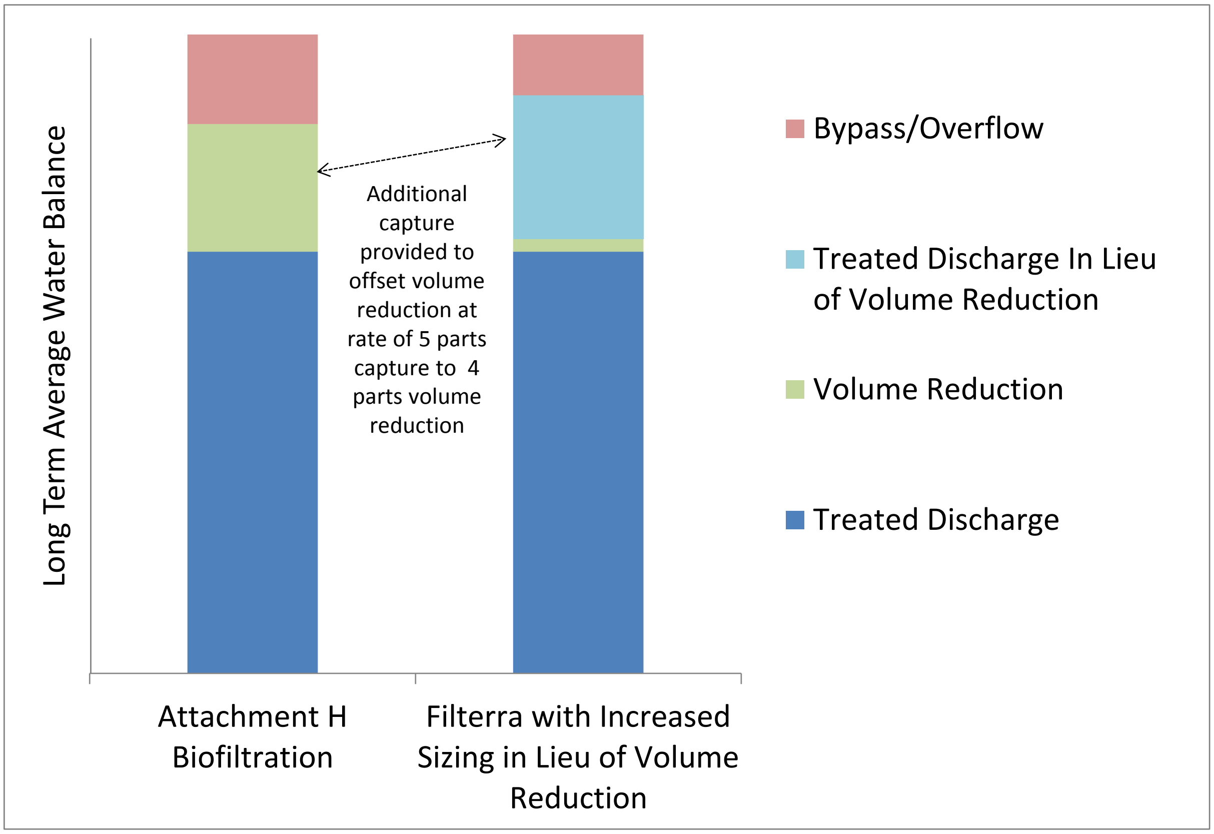

Figure 5. Illustration of Additional Capture In Lieu of Volume Reduction (Not to scale)

Table 2. Additional Capture Efficiency in Lieu of Volume Reduction

Site Soil Infiltration Rate, in/hr	Attachment H Biofiltration Long Term Volume Reduction[1, 2]	Filterra Long Term Volume Reduction[1] (ET only)	Volume Reduction Deficit	Additional Capture Efficiency in Lieu of Volume Reduction[3]	Adjusted Target Capture Efficiency
0	4%	1%	3%	0.8%	93.8%
0.01	6%	1%	5%	1.3%	94.3%
0.05	11%	1%	10%	2.5%	95.5%
0.10	16.5%	1%	15.5%	3.9%	96.9%
0.15	22%	1%	21%	5.3%	98.3%
0.30	35%	1%	34%	8.5%	N/A

1 – Based on modeling of ET from soil pores and standing water.
2 – Includes infiltration losses, where feasible
3 – Required additional capture calculated at a rate of 1 part additional for every 4 parts volume reduction deficit.

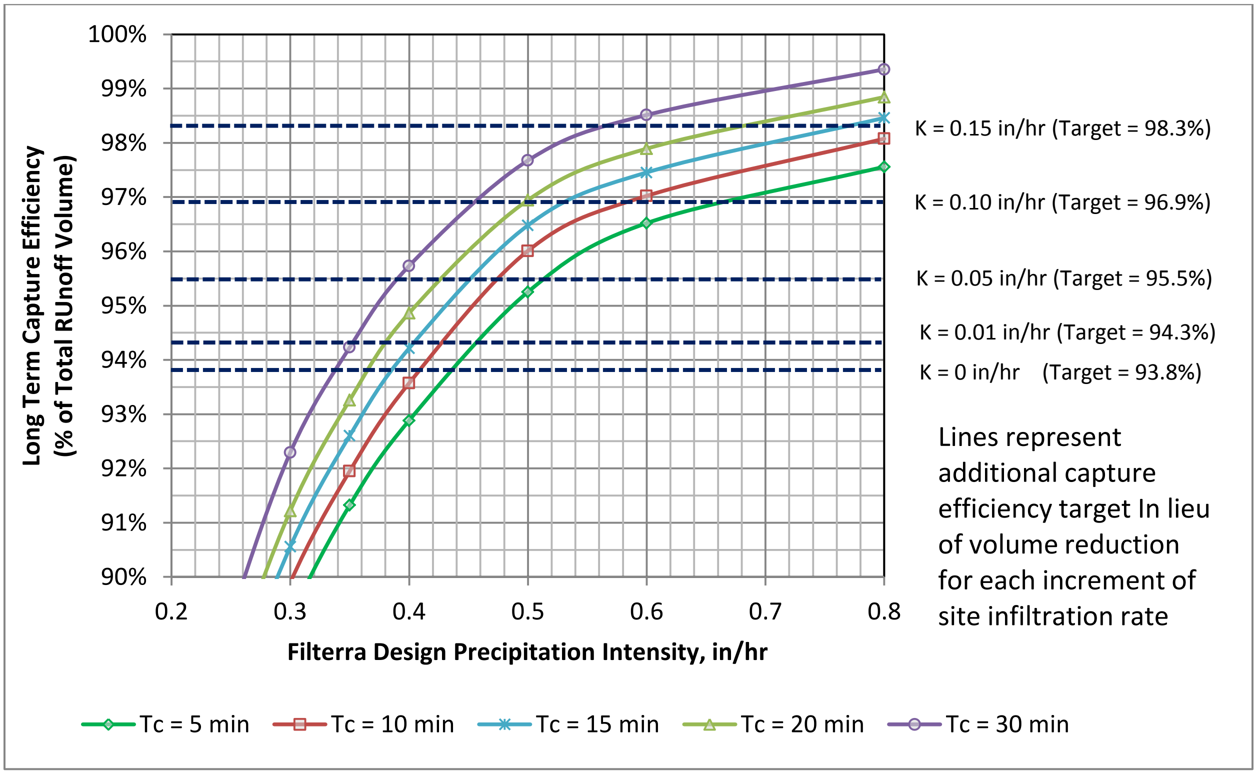

Figure 6. Additional Capture Targets In Lieu of Volume Reduction (same chart as Figure 4, with adjusted axis limits)

4 DESIGN METHODOLOGY AND EQUIVALENCY CRITERIA

In order to apply the equivalency relationships developed in Section 3, a standardized design methodology was developed. As a result of applying this design methodology, Filterra systems are expected to perform equivalently to conventional Attachment H biofiltration. This methodology consists of three parts, as described below.

Part A - Characterize Site and Determine Key Attributes

1. Delineate the tributary area to each Filterra BMP.

2. Estimate the imperviousness of the tributary area; use this value to estimate a runoff coefficient for use in stormwater quality design flowrate (SWQDf) and stormwater quality design volume (SWQDv) calculations. The runoff coefficient shall account for imperviousness and be based on standard methods acceptable to the reviewing jurisdiction.

3. Calculate the time of concentration (Tc) for each Filterra tributary area using methods acceptable to the local jurisdiction.

4. Estimate the long term reliable infiltration rate of the soils underlying each BMP location using appropriate methods, subject to the approval of the reviewing agency.

5. Determine local 85th percentile, 24-hour precipitation depth for the project. The 85th percentile, 24-hour rain event shall be determined from the Los Angeles County 85th percentile precipitation isohyetal map[2] or analysis of local long term precipitation data.

6. Calculate the SWQDv for each Filterra tributary area, using locally-approved methods.

7. Calculate the site "Scaling Factor" as the ratio of the project-specific 85th percentile, 24-hour storm event to the LAX 85th percentile, 24-hour storm event (1.02 inches).

Part B – Design Filterra for Equivalent Long Term Capture Efficiency

8. Consult Design Table 1 to determine the appropriate Filterra Design Precipitation Intensity associated with the Tc for each tributary area. For Tc less than 5 minutes, round up to 5 minutes. For Tc greater than 30 minutes, round down to 30 minutes. Interpolation between values in this table is permissible.

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[2] http://www.ladpw.org/wrd/publication/engineering/Final_Report-Probability_Analysis_of_85th_Percentile_24-hr_Rainfall1.pdf

Design Table 1 - Filterra Design Chart for Equivalent Long Term Capture Efficiency

Time of Concentration of Tributary Area, minutes	Filterra Design Precipitation Intensity, inches per hour[1]
5	0.41
10	0.38
15	0.36
20	0.34
30	0.32

1 - Sizing requirements are based on Filterra size required to achieve a target capture efficiency of 93% of long term runoff volume at the Los Angeles Airport gage. For different locations, the site scaling factor must be applied.

9. Apply the rational method to determine the design flowrate required for each Filterra.

$$Q_{required} = \textit{Runoff Coefficient (unitless)} \times \textit{Filterra Design Precipitation Intensity (in/hr)} \times \textit{Site Scaling Factor (unitless)} \times \textit{Tributary Area (ac)} \times (43560\ \textit{sq-ft/ac}/(12\ \textit{in/ft} \times 3600\ \textit{sec/hr}))$$

10. Select a Filterra model with a treatment flow rate that is equal to or greater than the design flowrate based on a maximum treatment flow rate of 1.45 gallons per minute per square foot of Filterra surface area. This is equivalent to a treatment rate of 140 inches per hour.

Part C, Option 1 - Design for Equivalent Long Term Volume Reduction

The design of a Filterra system must mitigate for deficiency in volume reduction compared to conventional biofiltration. As one option, the designer may include supplemental infiltration, either upstream or downstream of the Filterra to compensate for the volume reduction deficit between conventional biofiltration and Filterra systems.

11. Consult Design Table 2 to determine the fraction of the SWQDv that needs to be provided in supplemental retention. It is appropriate to linearly interpolate within this table. For long term reliable infiltration rates greater than 0.3 inches per hour, full infiltration of the SWQDv must be considered.

Design Table 2 - Supplemental Infiltration Volume for Equivalent Long Term Volume Reduction

Estimated Long Term Reliable Infiltration Rate below Site, inches per hour	Long Term Volume Reduction Deficit, % of Long Term Runoff	Required Supplemental Infiltration Storage Volume as Fraction of Local SWQDv, unitless[1]
0	3%	Not a feasible option; see Part C, Option 2
0.01	5%	0.15
0.05	10%	0.11
0.15	21%	0.17
0.3	34%	0.26

1 – Values are not expected to follow a continually increasing trend. A 2.1 foot effective depth is assumed for supplemental storage.

12. Multiply the site-specific SWQDv for each Filterra Tributary area calculated above by the ratio from Design Table 2 to determine the required supplemental retention volume. Design Table 2 is based on the assumption that the Contech ChamberMaxx product will be used, with an equivalent storage depth of 2.1 feet. Shallower or deeper storage would require different sizing factors. Supplemental calculations can be provided to demonstrate that an alternative storage configuration would provide equivalent long term volume reduction.

Part C, Option 2 - Design for Additional Capture In Lieu of Volume Reduction

As an alternative option, the designer may increase the size of the Filterra systems to provide additional capture in lieu of providing supplemental infiltration volume.

13. Consult Design Table 3 to determine the adjusted design precipitation intensity needed to compensate for volume reduction deficiency.

Design Table 3 – Upsizing of Filterra to Provide Additional Capture Efficiency in Lieu of Volume Reduction

Time of Concentration of Tributary Area, minutes	Site Infiltration Rate				
	0 in/hr Target Capture Efficiency = 93.8%	**0.01 in/hr** Capture Efficiency Target = 94.3%	**0.05 in/hr** Capture Efficiency Target = 95.5%	**0.10 in/hr** Capture Efficiency Target = 96.9%	**0.15 in/hr** Capture Efficiency Target = 98.3%
	Adjusted Filterra Design Precipitation Intensities, in/hr				
5	0.44	0.46	0.52	0.66	NA
10	0.41	0.43	0.48	0.58	NA
15	0.39	0.41	0.45	0.53	0.76
20	0.37	0.38	0.43	0.50	0.68
30	0.34	0.35	0.39	0.46	0.56

NA = additional capture is not a viable option to offset volume reduction in these cases.

14. Apply the rational method to determine the adjusted design flowrate required for each Filterra.

$$Q_{required} = \textit{Runoff Coefficient (unitless)} \times \textit{Adjusted Filterra Design Precipitation Intensity (in/hr)} \times \textit{Site Scaling Factor (unitless)} \times \textit{Tributary Area (ac)} \times \textit{(43560 sq-ft/ac/(12 in/ft} \times \textit{3600 sec/hr))}$$

15. Select a Filterra model with a treatment flow rate that is equal or greater than $Q_{required}$ based on a maximum treatment flow rate of 1.45 gallons per minute per square foot of Filterra surface area (140 inches per hour).

5 DISCUSSION AND CONCLUSIONS

5.1 Key Observations and Findings

This analysis and associated research yielded a number of key observations:

- The baseline level of capture efficiency and volume reduction provided by conventional biofiltration BMPs, if effectively designed per Attachment H, is relatively high. This establishes a relatively high baseline standard for Filterra systems to meet in providing equivalent performance.
- There is substantial leeway within the Attachment H criteria and local implementation guidance that is expected to result in design variations of conventional biofiltration throughout Los Angeles County. These variations are expected to result in fairly important variations in hydrologic performance. Additionally, variations in operations and maintenance conditions over time (i.e., decline in media rates, reduction in active storage volume from sedimentation) are also expected to influence performance.
- It is possible to design Filterra systems to match the capture efficiency of conventional biofiltration BMPs. This requires larger sizes of Filterra systems than was required for treatment control BMPs under the previous MS4 Permit. This also requires a commitment to regular maintenance consistent with Filterra standard maintenance requirements.
- Filterra systems alone are not expected to match the volume reduction performance provided by conventional biofiltration that is effectively designed, even in lined systems. However, it is possible for Filterra systems to mitigate for deficiency in volume reduction via either supplemental infiltration storage or increasing the size of Filterra systems to increase their capture efficiency thereby providing equivalent load reductions.
- For water that is treated and released, Filterra performance studies generally showed similar or better concentration reduction compared to conventional biofiltration. Filterra performance tended to be less variable in most cases. Filterra systems also did not exhibit the potential for major nutrient export that is relatively common in conventional biofiltration.
- When studies from the International BMP Database were screened to best match conventional biofiltration designs per Attachment H (specifically compost and sand fractions), the treatment performance tended to decline somewhat. This is consistent with findings related to use of compost in biofiltration media from other studies. This indicates that there is still progress to be made in addressing nutrient export issues in conventional biofiltration systems. For example, in Western Washington results of rigorous testing of media comprised of sand and compost conforming to local specifications have led to limitations on the use of biofiltration in nutrient sensitive watersheds and have stimulated research into alternative media blends.

Overall, if Filterra systems are designed based on the methodology and criteria presented in Section 4 and effectively operated and maintained these systems are expected to match or exceed the performance of conventional biofiltration within a reasonable margin of uncertainty.

5.2 Reliability and Limitations

There are a number of uncertainties that influence the reliability of the findings presented in this report. These are addressed in the paragraphs below.

Modeled hydrologic performance estimates. Performance estimates were based on models which were not calibrated. This introduces some uncertainty. This uncertainty was mitigated by applying identical input parameters and modeling approaches for conventional biofiltration and Filterra systems, as appropriate. This has the effect of offsetting the majority of potential sources of bias.

Treatment performance estimates for conventional biofiltration. Treatment performance estimates were based on peer reviewed studies from the International BMP Database and other peer reviewed third party studies that were selected to be representative of the BMPs being compared. Due to limited sample size of conventional biofiltration monitoring studies and some deficiencies in documentation of these studies, it was not possible to quantitatively evaluate whether performance estimates are specifically representative of Attachment H biofiltration. Additionally, performance has been observed to vary greatly from site to site, indicative of the importance of design factors such as sizing, media composition, sources of media components, and other design factors. The screened and unscreened datasets analyzed are believed to provide reliable information about the range of potential performance that may be expected from conventional biofiltration in Los Angeles County; however they are not intended to be used as a predictive tool for any one variation of biofiltration design. Reliability of these data was improved through the application of robust statistical methods that account for the influence of influent concentration and provide a quantification of uncertainty.

Treatment performance estimates for Filterra systems. Filterra systems have been evaluated in a range of sites and climates; however none of these sites were in Los Angeles and not all studies are necessarily representative of the influent quality from typical Los Angeles land uses. Additionally, the sample size of Filterra datasets is still somewhat low in comparison to conventional biofiltration BMPs. These factors are mitigated to a large extent by the standardized design that accounts for rainfall intensity/duration differences and ensures consistency in media composition of Filterra systems. These factors improve the transferability of findings between regions. Additionally, the reliability of Filterra performance data was improved by applying the same robust statistical methods as used for conventional biofiltration, which help adjust for differences in influent quality between studies.

TSS removal as a surrogate for additional capture in lieu of volume reduction. For small deficiencies in volume reduction, a TSS treatment removal rate of 80 percent was used to calculate required additional capture efficiency in lieu of volume reduction. A multi-parameter approach would be more complex and would need to account for the export of nutrients in conventional biofiltration as well as the observation that metals performance tends to vary substantially with influent concentration (i.e., where influent concentration is relatively low, the removal efficiency tends to be lower, but the resulting effluent concentration is still below typical water quality standards). Given that this approach is only intended to offset minor volume reduction (up to about 20%), this is considered to be a reasonable approach.

Sensitivity to site conditions. The effectiveness of volume reduction processes is particularly sensitive to estimates of site infiltration rate. It may not be possible to anticipate, with certainty, what the final long term infiltration rate will be in the post construction condition. This limitation is largely mitigated for the purpose of this analysis because the uncertainty in infiltration rate influences the design and performance of conventional biofiltration and Filterra with infiltration storage similarly. Additionally, estimating the site infiltration rate is now a standard part of developing a BMP plan for a site, therefore approaches for developing this estimate should improve in reliability with time. Finally, both systems provide excellent TSS treatment prior to infiltration and long term infiltration rates should therefore be more reliable.

Variability in design and construction process. The analyses and criteria presented in this report are based on the assumption that the BMPs will be effectively designed and constructed consistent with a typical standard of care. It is inherent that design of non-proprietary conventional biofiltration BMP provides a greater degree of freedom and associated professional judgment as part of preparing design calculations, design drawings, and specifications. This introduces a wider potential range of resulting designs. Some may be better than average, some may be worse. Additionally, there are typically a number of specialized elements in the construction of a biofiltration BMP that may introduce variability in as-built condition as a result of contractor preferences and/or quality control issues. There are many examples of biofiltration facilities that have failed due to design and construction issues. In comparison, there is likely to be substantially less variability in the design and construction of Filterra system compared to biofiltration BMPs.

Sensitivity to operations and maintenance. Both types of systems are susceptible to decline in performance over time. **<u>Neither system will work if they are not regularly and effectively maintained.</u>** Filterra systems may be more susceptible to rapid clogging because of their relatively small footprint. However, this is mitigated by Filterra having a standard maintenance plan that has been informed by feedback from O&M of numerous facilities.

Overall, the analyses are believed to result in reliable design assumptions. Where substantial uncertainties exist, the analyses and assumptions have tended to err on the side of estimating somewhat higher performance for conventional biofiltration and somewhat lower performance for Filterra systems, which likely results in more conservatism in Filterra equivalency sizing.

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APPENDIX A – CONVENTIONAL BIOFILTRATION DESIGN ASSUMPTIONS FOR PERFORMANCE MODELING

The following criteria from Attachment H were considered to be important for evaluating pollutant load reduction performance of "conventional biofiltration" scenarios:

- 6 to 18-inch ponding area above media
- Optional layer of mulch
- 2 to 3 feet of engineered filter media (2 feet typical) with a design infiltration rate of 5 to 12 inches/hour; the Attachment H specification calls for a mix of 60 to 80% fine sand and 20 to 40% compost
- Gravel storage layer below the bioretention media to promote infiltration
- Underdrain placed near the top of the gravel layer (or an infiltration sump otherwise provided via an equivalent hydraulic control approach) in cases where underlying soil infiltration rates allow
- Underdrain discharge to the storm drain
- Total physical water storage volume sized to be equal to at least the stormwater quality design volume (SWQDv = runoff volume from the 85th percentile, 24-hour storm event)
- Capacity (including stored and filtered water) adequate to biofilter 150 percent of the portion of the SWQDv not reliably retained.

Within the bounds established by these criteria, a relatively wide range of actual biofiltration designs could result as a function of site infiltration conditions as well as designer and local jurisdiction preferences. An example of potential design variability is illustrated in Table A.1 below. For the purpose of this analysis, representative design assumptions were developed within the range of potential design assumptions. These assumptions are also presented in Table A.1 with supporting rationales.

Table A.1 Biofiltration Design Assumptions from Various Sources and Selected Representative Design Assumptions

Design Assumption	Design References					Selected Representative Design Assumption	Rationale for Selected Design Assumption
	MS4 Permit Attachment H	Los Angeles County LID Manual, static method	Los Angeles County LID Manual, routing method	City of Los Angeles LID Manual	Ventura County TGM		
Ponding Depth, ft	0.5 to 1.5	0.5 to **1.5**	0.5 to **1.5**	0.5 to **1.5**	0.5 to **1.5**	1.5	Many designers will utilize deepest depth allowable because of space efficiency.
Media Depth, ft	2 to 3	**2** to 3	**2** to 3	**2** to 3	**2** to 3	2	Typical design approach is to use minimum depth due to cost of media.
Gravel "sump" depth below underdrain, ft	Not specified; narrative	Not specified, narrative	Not specified, narrative	At least 1 feet; up to **2** feet if soils allow incidental infiltration	**0.5** minimum below underdrain	Depth that would drain in 24 hours. For example, 1.5 ft if site infiltration rate estimated at just less than 0.3 in/hr	Approach produces a reasonable design that considers infiltration rates; Attachment H states that volume infiltrated within 24 hours can be considered retained.
Media Filtration Rate, in/hr	5 to 12	**5** to 12	**5** to 12	**5** to 12	1 to 12 **(5)**	5	Representative of long term operation after some clogging
Allowable Routing Period for Biofiltration Treatment, hrs	Not specified	Routing is not part of simple method	Allows routing of **24-hour** design hydrograph from LA County HydroCalc model	**3** hours, unless using a routing model	Depth up to ponding depth (**1.5 ft**) can be considered routed	6 hours[1]	Based on evaluation of storm durations for events similar to design event. See footnote 1.
Resulting Footprint Factor at 0.3 in/hr Infiltration Rate, in/hr (% of impervious area)	Not enough information to calculate	7.5%	1.4%	2.4% (1.4% with routing similar to LA County)	2.8%	2.0%	Calculated based on assumptions.

Note: where a range of guidance is allowed, the bolded number indicates the value that was used in calculations. The design values were selected based on developing the most economical and space-efficient design that meets the applicable criteria.

1 – The allowable routing period was estimated based on the typical storm duration associated with events similar to the 85th percentile, 24-hour storm depth (1.0 inches at LAX). This was estimated in two ways. For days with precipitation totals between 0.9 and 1.1 inches, the total number of hours with rainfall was tabulated (average = 11 hours; 10th percentile = 6 hours). This does not consider dry periods between hours with rainfall, therefore is somewhat conservative in estimating the period of time available for routing biofiltered water during a given day. For unique precipitation events, separated by 6 hour dry period (potentially spanning across breaks in calendar days), with precipitation totals between 0.9 and 1.1 inches, the total storm durations were tabulated (average = 16 hours; 10th percentile = 7 hours). Based on this analysis, a 6 hour routing period is considered to be defensible and conservative in estimating the amount of water that can be routed through a biofiltration system during typical storm events similar to the design storm event.

APPENDIX B – SWMM MODELING METHODOLOGY AND ASSUMPTIONS

Equivalency Scenarios

The relative performance of Filterra systems and conventional biofiltration was compared under the following climate and site conditions:

- Climate (and associated precipitation and ET): Los Angeles
- Land Use (and associated imperviousness and runoff quality): Multi-family Residential
- Soil infiltration rate: 0, 0.01, 0.05, 0.15, and 0.3 inches per hour
- A hypothetical 1-acre catchment was used for this analysis and was not varied.

For conventional biofiltration, the sizing and design criteria described in Appendix A were followed.

For Filterra systems, all combinations of the following sizing criteria were evaluated for each combination of climate and site conditions:

- Design precipitation intensity: 10 sizing increments were evaluated between 0.1 and 0.8 inches per hour.
- Catchment time of concentration: 5 increments were evaluated between 5 minutes and 30 minutes
- Downstream retention storage volume: 5 increments were evaluated between 0% (absent) and 50% of the runoff from the 85th percentile, 24-hour storm event.

Specific SWMM modeling representations of each combination of site conditions and BMP parameters are described in this Appendix.

Overview of SWMM Analysis Framework

SWMM was used to estimate the long-term capture efficiency and volume reduction from conventional biofiltration BMPs and Filterra systems for each scenario. SWMM compartmentalizes its computations based on several physically-based processes including surface runoff, evaporation, infiltration, and flow routing. A conceptual representation of the SWMM model framework used for this analysis is provided in Figure B.1. Within this framework, parameters were adjusted for each scenario to account for soil condition and BMP sizing and design attributes.

In SWMM, subcatchment elements are used to generate a runoff hydrograph. Input data defining the surface characteristics include subcatchment area, imperviousness, width, depression storage, surface roughness, surface slope, and infiltration parameters. SWMM performs a mass balance of inflows and outflows to determine runoff from a subcatchment. The inflows to this mass balance are precipitation and any runoff directed from another subcatchment. The outflows from the mass balance include evaporation, infiltration, and runoff. The runoff parameters assumed for this analysis are discussed in this Appendix.

A variety of hydraulic flow routing elements exist in SWMM, but fundamentally, the program includes nodes (i.e., storage units, manholes, and outfalls) and links (i.e., conduits, pipes, pumps, weirs, orifices, and outlets). Storage units were used in this equivalency analysis to represent the storage and routing attributes of BMPs. The elements defining the storage volume and related discharge were adjusted based on the various sizing and design criteria evaluated in the equivalency scenarios, the details of which are discussed in this Appendix.

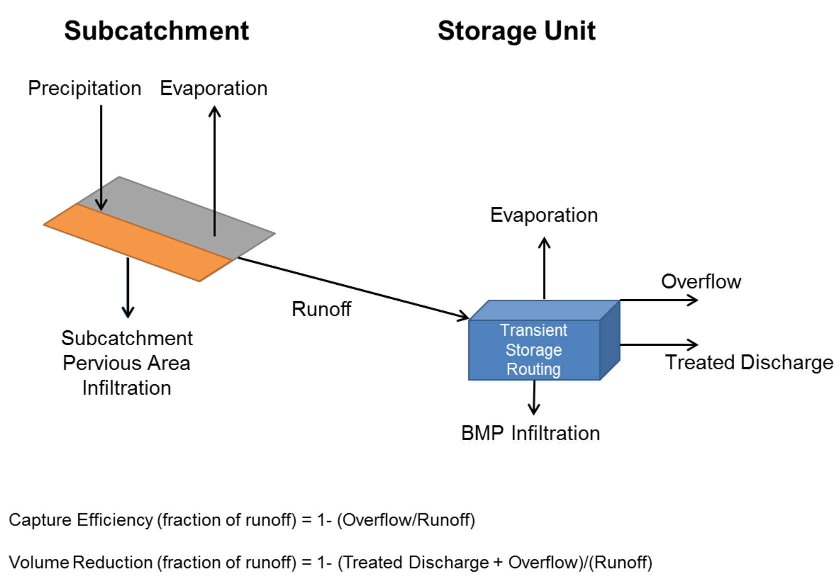

Figure B.1. Schematic SWMM modeling framework in support of equivalency analysis

SWMM was run in continuous simulation mode over a 15-year period (2000-2015). A continuous hydrograph of runoff was generated and routed through the model representations of BMPs. The results were tracked and reported in terms of long term runoff volume, long term volume lost in the BMP, long term volume bypassing or overflowing the BMP, and long term volume treated in the BMP. The 15-year period of record was selected based on the availability of high quality 5-minute resolution precipitation data, which are important for representing urban catchments with short time of concentration. To ensure comparability, the same forcing data (rainfall, ET) were applied to conventional biofiltration scenarios and Filterra scenarios.

Meteorological Inputs

Precipitation

Precipitation data utilized this study included continuous hourly precipitation data collected by the National Climatic Data Center (NCDC) and five-minute precipitation data from the Automated Surface Observation System (ASOS); both part of the National Oceanic and Atmospheric Administration (NOAA). The hourly precipitation datasets from NCDC provided an extensive record of precipitation data from 1948 through February 2015. NCDC precipitation datasets at major airports are known to be of high quality with few areas of missing or unreportable data and therefore were used as a quality standard to compare to the ASOS dataset as well as the basis for estimating long term precipitation statistics. The ASOS dataset does not receive the same level of quality review that the NCDC data and has considerably shorter period of data (ASOS dataset is from 2000 to February 2015). However, the ASOS data is collected at 5-minute intervals, providing considerably better temporal resolution for precipitation when modeling of urban BMPs, particularly for small catchments. Therefore, NCDC data were used to define the 85th percentile 24-hour sizing criteria and to validate the ASOS data, while the ASOS data was used as the input to comparative model simulations. The period of record of ASOS data (15 years) is less than ideal for characterizing long term averages, however because the same dataset was used for both conventional biofiltration and Filterra systems, this length if record is ample to provide a valid comparison of performance.

The Los Angeles Airport location was included in this analysis (NCDC: 045114, ASOS: KLAX). The 85th percentile 24-hour precipitation depth was determined using the entire length of record at the NCDC gage and compared to the values produced from the ASOS gages (Table B-1). In determining the 85th percentile, 24-hour depth, days with 0.1 inches or less were excluded from both datasets. The resulting 85th percentile, 24-hour depths are well matched between the NCDC and ASOS gage. Scatter plot comparisons of NCDC and ASOS datasets for monthly and 24-hour totals at each location also show good agreement (Figure B-1 and Figure B-2). This indicates that the ASOS data provide a reasonable estimate of absolute long term performance in addition to providing a reliable comparison between BMP types.

Table B.1. Summary of 85th percentile 24-hour storm depths.

Storms	Gage Location	85th Percentile 24-Hour Depth (in)
All NCDC Storms > 0.1 inch (1948-2015)	Los Angeles Airport (045114)	1.01
All ASOS Storms > 0.1 inch (2000-2015)	Los Angeles Airport (KLAX)	0.96

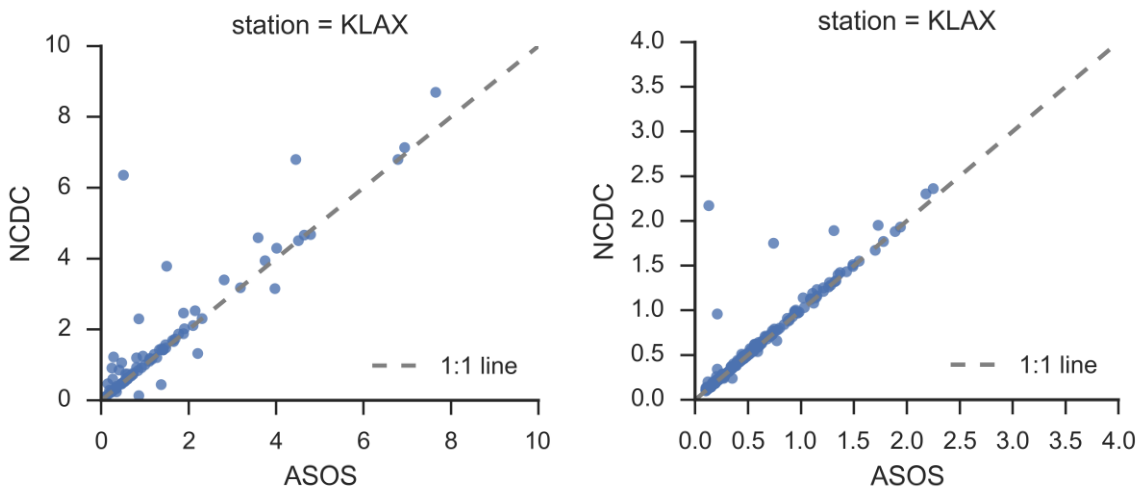

Figure B.2. Scatter plot comparisons of monthly (left) and daily (right) precipitation depths for NCDC and ASOS datasets.

ET Parameters

Reference ET values for Zone 4 of the California Irrigation Management Information System were used to estimate evaporation for all simulations (CDWR 2015). Zone 4 represents coastal areas; actual ET may be higher in inland areas and is likely higher on average in Southern California than the San Francisco Bay Area, however the influence of this assumption is minor and will tend to cancel out in comparison between BMP types. Average ET conditions were represented by setting the modeled evaporation values equal to 60% of the reference ET values to represent a mix of urban conditions with varied plant pallets and shading conditions based on guidance provided by CIMIS (CDWR 2015). The assumed ET values for this analysis are presented in Table B.2.

Table B.2. Assumed ET values for all scenarios

Month	Evapotranspiration Rates			60%
	inch / day	days / month	inch / month	inch / month
January	0.05	31	1.55	0.93
February	0.08	28	2.24	1.34
March	0.12	31	3.72	2.23
April	0.17	30	5.1	3.06
May	0.22	31	6.82	4.09
June	0.26	30	7.8	4.68
July	0.28	31	8.68	5.21
August	0.25	31	7.75	4.65

Month	Evapotranspiration Rates			60%
	inch / day	days / month	inch / month	inch / month
September	0.19	30	5.7	3.42
October	0.13	31	4.03	2.42
November	0.07	30	2.1	1.26
December	0.05	31	1.55	0.93
Total (year)		365	57.04	34.22

Runoff Parameters

The key SWMM parameters used to estimate surface runoff are subcatchment area, width, imperviousness, depression storage, surface roughness, surface slope, and infiltration parameters. The majority of surface characteristics were kept constant for both BMP systems and across all land use types. The values assumed for each of these parameters are in Table B.3. Imperviousness was varied for different land uses as described in the Ventura County Technical Guidance Manual for Stormwater Quality Control Measures (Larry Walker Associates and Geosyntec 2011) and is presented for each land use within Table B.3. Additionally, for Filterra simulations, the width parameter (defines the overland flow length for runoff to travel), were adjusted to reflect differences in time of concentrations. The values applied within the model were estimated through an iterative process during the modeling phase.

Runoff estimation is affected by losses to infiltration processes over pervious areas of the subcatchment. The Green-Ampt method of estimating infiltration was used to represent this process. Three input parameters were used to characterize infiltration with this method: initial deficit, saturated hydraulic conductivity, and suction head. These parameters represent surface conditions and are not necessarily related to the saturated infiltration processes that may occur below a BMP (typically several feet below the surface). Because the purpose of this equivalency analysis was to isolate differences between two BMP types, the subcatchment infiltration parameters were held fixed for all scenarios. Parameters were selected to represent typical urban conditions with disturbed urban soils (Table B.3).

Table B.3. Summary of SWMM parameters to represent runoff parameters

SWMM Runoff Parameters	Units	Values	Source/Rationale
Wet time step	seconds	150	Set to half the time steps of precipitation input data (300 seconds)
Dry time step	seconds	14,400	Equivalent to 4 hours.
Period of Record		January 2000-December 2014	Availability of ASOS data

SWMM Runoff Parameters	Units	Values	Source/Rationale
Percent of Impervious Area	percent	Multifamily Residential = 74	Los Angeles County Hydrology Manual (2006)
Impervious Manning's n	unitless	0.012	James and James, 2000
Pervious Manning's n	unitless	0.15	James and James, 2000 (mix of dense grass and mulched landscaping)
Drainage area	acres	1	Hypothetical for purpose of analysis
Width	feet	174 feet by default (equates to 250-ft path length) For Filterra scenarios, variable to represent different time of concentrations	Typical assumption for urban drainage patterns
Slopes	ft/ft	0.03 (represents average of roofs, landscaping, and streets)	Professional judgment
Evaporation	in / month	60% of reference ET values (Table B.4)	CIMIS (CWDR, 2015)
Depression storage, impervious	inches	0.02	James and James, 2000
Depression storage, pervious	inches	0.06	James and James, 2000
Saturated Hydraulic Conductivity (in/hr)	in/hr	0.15	EPA SWMM User's Manual for typical disturbed urban soils
Initial Moisture Deficit (in/in)	in/in	0.29	EPA SWMM User's Manual for typical disturbed urban soils
Maximum Suction Head (inches)	inches	8	EPA SWMM User's Manual for typical disturbed urban soils

BMP Representation

Both the conventional biofiltration BMPs and Filterra systems were simulated using a storage unit with outlets to represent infiltration losses (if present) and treated discharge, and a weir to represent overflow/bypass. The elevations of these elements within the storage unit were used to represent the design profiles of these systems. Storage compartments were broken into: evaporation storage (i.e., water stored in soil that is not freely drained); infiltration storage (i.e., water stored below the lowest outlet that can either infiltration or ET only); and freely drained storage (i.e., water that can drain through the underdrains of the system at a rate controlled by the media hydraulic conductivity). In some scenarios an additional storage unit was located downstream of the Filterra BMP to represent additional retention storage.

Conventional Biofiltration

Sizing criteria for the conventional biofiltration system was based on the runoff from the 85th percentile, 24-hour storm depth (1.0 for LAX). For each scenario, this depth was applied to the catchment area and imperviousness to compute an estimated runoff volume. Storage profiles for the conventional biofiltration system were established to represent typical profiles for conventional biofiltration consistent with what is required by Attachment H of the MS4 Permit, which are presented in Appendix A. The storage profiles included equivalent storage volumes provided in the ponding depth, media depth (divided between ET storage and freely drained storage), gravel layer, and placement of the underdrain system specific to the site conditions. Based on the equivalent storage depth in these profiles and the design storm runoff volume, the required footprints were calculated. For gravel, a porosity of 0.4 was assumed. For media, a porosity of 0.4 in/in was assumed, divided as 0.15 in/in soil suction storage (i.e. ET storage) and 0.25 in/in freely drained storage. The profiles used for this analysis and the typical footprints are presented in Table B.4.

For the purpose of estimating long term volume reduction and baseline capture efficiency, the entire pore volume was assumed to be immediately available. However, because water takes time to travel through the soil column, it is possible for a biofiltration BMP to overflow before the entire soil poor volume is utilized. Based on analysis of flow monitoring data, Davis et al. (2011) found that the volume immediately available within a storm is better represented by the bowl volume (surface ponding) and the freely drained pores within the root zone (approximately the top 1 foot of soil). To check whether this condition controlled, parallel model runs were conducted where the storage volume equaled the bowl volume plus freely drained pores in the soil root zone, and the drawdown time was adjusted for only this volume. The result was that this condition reduced capture efficiency by approximately 2 percent. This indicates that this condition controls performance relatively rarely, but is not negligible.

Table B.4. Summary of conventional biofiltration profiles

Infiltration Rate, in/hr	Retention Sump Depth (as gravel depth)[1], ft	Effective Water Storage in Retention Sump (ft)	Media Depth, ft	Effective Water Storage in Media[2], ft	Ponding Depth, ft	Total Effective Water Depth (ft)	Approximate Footprint Sizing Factor (Los Angeles)[3]
0.3	1.5	0.60	2	0.8	1.5	2.9	1.5%
0.15	0.75	0.30	2	0.8	1.5	2.6	1.6%
0.05	0.25	0.10	2	0.8	1.5	2.4	1.7%
0.01	0.05	0.02	2	0.8	1.5	2.32	1.7%
0	0	0.00	2	0.8	1.5	2.3	1.8%

1 Sump storage was determined based on the depth of water that would infiltrate in 24 hours based on guidance provided in Attachment H.
2 Media storage depth divided as 0.3 ft suction storage and 0.5 ft freely drained storage.
3 Expressed as BMP footprint as percent of tributary area; Multi-family density of 74% impervious was used as a representative value for simulations.

Filterra

An array of flow-based sizing increments were applied to define the physical dimensions of the Filterra system to be modeled in each scenario. Ten increments of uniform design intensities ranging from 0.1 inches/hour up to 0.8 inches/hour (0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.5, 0.6, 0.8) were established to represent a range of potential Filterra sizing criteria to achieve equivalency. For each scenario, the design intensity was applied to the catchment area and imperviousness to calculate the runoff flowrate. The treatment capacity of the Filterra system was set at 140 in/hr (or 0.0032 cu-ft/sec per sq-ft). Based on the required treatment flowrate and the Filterra treatment capacity, the required Filterra footprint was determined.[3] Similar to the conventional biofiltration system, a vertical profile was also established as an input to the model, including ponding depth, pore space in mulch and media, and underdrains (Table B.5). The volume of the Filterra system is negligible; however the entire volume was assumed to be available as a result of the very high infiltration rate of the Filterra media.

Further scenarios were developed for the Filterra system that included supplemental downstream retention. These supplemental storage volumes were sized based on a percentage of the runoff volume from the 85th percentile, 24-hour depth (0% (absent), 10%, 20%, 30%, 40%, 50%). For these scenarios, an additional storage unit was simulated and received the treated flow from the

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[3] In practice, designers would select a standard Filterra size that meets or exceeds the required design flowrate, therefore many systems will tend to be oversized in practice; the approach used for this equivalency analysis is conservative in that it assumes exactly the minimum size is used.

upstream Filterra storage unit. The profile of the Filterra system is described in Table B.5. The downstream retention unit was modeled with an assumed depth of 2.1 feet, based on typical Contech ChamberMaxx system geometry, assuming 6 inches gravel above and below the ChamberMaxx units.

Table B.5. Summary of profile for Filterra systems

Media Filtration Rate, in/hr	Gravel Underdrain[1], ft	Effective Water Storage in Retention Sump (ft)	Media Depth, ft	Effective Water Storage in Media[2], ft	Ponding Depth, ft	Total Effective Water Depth (ft)	Approximate Footprint Sizing for 0.3 in/hr scenario[3]
140	0.5	0.2	2	0.5	0.5	2.4	0.19%

1 Gravel layer based on typical Filterra design; all of the gravel layer was assumed to drain freely to the underdrain
2 Media storage depth divided as 0.3 ft suction storage and 0.5 ft freely drained storage.
3 Expressed as BMP footprint as percent of tributary impervious area (varies by land use and sizing increment; for example purposes only).

APPENDIX C – DATASETS AND ANALYSIS METHODS FOR POLLUTANT TREATMENT EVALUATION

Data Development and Analysis Framework

BMP performance is considered to be a function of BMP type, BMP design parameters, influent water quality characteristics, and other factors. As part of this analysis, it was necessary to develop a statistical description of BMP performance that accounted for the difference between conventional biofiltration and Filterra systems and also accounted for the influence of land use runoff quality (i.e., BMP influent quality) on the expected BMP performance. The data development and analysis framework used for this project included four steps:

1) Compile and review data from monitoring studies of conventional bioretention systems; then screen these studies to identify studies that are reasonably representative of conventional biofiltration designs that would meet the MS4 Permit requirements, particularly focusing on factors that would influence treated effluent quality.
2) Compile and review monitoring data from full-scale monitoring studies of Filterra systems.
3) Apply a common statistical analysis framework to analyze the data from both datasets.
4) Determine representative land use runoff quality.
5) Based on results from step 3 and 4, estimate the effluent quality expected for conventional biofiltration and Filterra systems for each pollutant for a range of land use types.

Compilation and Screening of Conventional Biofiltration Studies

The International Stormwater BMP Database (www.bmpdatabase.org) includes storm event monitoring data from 28 peer-reviewed studies of bioretention BMPs with underdrains. These data were used as the primary source for characterizing the treatment performance of conventional biofiltration BMPs in this study. In addition to the 28 studies from the International BMP Database, four peer-reviewed research studies (Davis 2007; Li and Davis 2009; David et al., 2011; Gilbreath et al. 2012) not contained in the International BMP Database were added to the sample pool for analysis. Two of these studies were conducted recently in the San Francisco Bay area, which has biofiltration design standards and media specifications nearly identical to Attachment H of the Los Angeles MS4 Permit. The two other additional studies were included due to their similarity to Attachment H design criteria and rigor of their analytical methods.

Screening Process for Developing Conventional Biofiltration Sample Pool

To our knowledge, there have yet to be any BMPs monitored in Southern California that have been constructed to the specific criteria of Attachment H. Additionally, the two studies monitored in the San Francisco Bay area (designed to very similar standards as Attachment H)

(David et al., 2011; Gilbreath et al. 2012) provide a relatively small sample size and did not monitor for nutrients. Therefore, it was necessary to broaden the scope of studies to represent conventional biofiltration.

In general, the bioretention BMPs in the International BMP Database are considered to be representative of the range of designs that could meet the MS4 Permit Attachment H requirements. Most of the bioretention studies in the BMP Database were completed fairly recently (most in the last 10 years) and have typically been designed, constructed, and/or monitored under the supervision of experienced researchers. Many of these systems have been designed with BMP profiles (i.e., ponding depth, media depth), media filtration rates, and media composition that are similar to the criteria in Attachment H. However, where design attributes indicated that performance would be expected to be poorer than Attachment H designs and/or representativeness could not be evaluated, these studies were screened out of the analysis pool for this study. Systems that were expected to achieve similar or better performance than a typical BMP designed per Attachment H were kept in the pool; this is a conservative approach when evaluating Filterra equivalency because it tends to establish a higher baseline for comparison than if these BMPs were excluded.

Screening criteria were developed based on professional judgment, as informed by review of literature and BMP performance studies. Our understanding of the influence of design parameters on bioretention performance was informed by studies in the BMP Database (see various summary reports at www.bmpdatabase.org), a recent evaluation by Roseen and Stone (2013), and review of recent bioretention media research in Washington State. A summary of the relevant findings are provided in the paragraphs below.

Roseen and Stone (2013) conducted an evaluation of biofiltration performance to determine how design criteria and media composition influence performance. As part of their research, they compiled site, design, and performance data for 80 field bioretention systems and 114 lab columns/mesocosms. Data from the International BMP Database were included in this pool as well as other research studies. Performance data were compiled as study summaries (e.g., study median influent, effluent, and removal efficiency). Roseen and Stone then utilized design information to categorizing systems into groups based on common combinations of factors. They then conducted a statistical evaluation of how performance was influenced by design factors such as presence/absence of mulch layers, use of compost in media, infiltration rate of media, ratio of tributary to biofiltration area, presence/absence of pretreatment, presence/absence of internal storage layers, etc. Roseen and Stone found that the presence of compost in mixes strongly influences the variability in performance and potential export of pollutants, including phosphorus, nitrogen, and copper. Systems without compost and/or with a high fraction of sand tended to provide the most consistent and best performance for these pollutants. Systems with an internal water storage zone tended to perform better for nutrients than systems without an internal water storage zone. Finally, they found that media flowrate and depth of media bed tended to have an influence on performance. Beyond these findings, the influence of other parameters was less conclusive.

Recent bioretention studies, many in Washington State (Herrera 2014b, 2015a, 2015b), have identified the potential severity of pollutant export of nitrogen, phosphorus, and copper from conventional biofiltration systems and have evaluated the potential sources of these issues. For example, a full scale field monitoring study in the City of Redmond (WA) observed export of nitrate on the scale of 100 mg/L higher than influent quality and dissolved copper on the scale of 10 to 20 ug/L higher than influent. Follow up research has shown that compost is consistently associated with export of copper, nitrogen and phosphorus, even when the highest quality compost products available are used in designs and at proportions as low as 10% of the media blend by volume. This research also found that some sand products can also contain elevated levels of phosphorus and copper. These studies are relevant because the standard biofiltration media specifications for Western Washington are very similar to Attachment H, calling for 60 to 65 percent sand and 35 to 40 percent compost. It should also be noted that the compost certification criteria in Washington State (Washington Department of Ecology, 2014) allow for half as much metals content as allowed in the Attachment H specification, therefore should theoretically have less potential for export of metals than compost meeting the Attachment H specification.

Based on these literature findings and best professional judgment, the following criteria were applied as part of screening bioretention studies:

- Systems with media filtration rates substantially higher than 12 inches per hour were excluded – while higher rate media has been found to provide good performance in some cases, the general trends observed by Roseen and Stone (2013) indicated a decline in performance for some parameters with increased infiltration rates.
- Systems with sizing factors (BMP area as fraction of tributary area) substantially smaller than the 3 to 5 percent (20:1 to 30:1 ratio of tributary area to BMP area) were excluded – this parameter is related to media filtration rate and is an indicator of the degree of hydraulic loading.
- Systems that were observed to have very infrequent underdrain discharge (i.e., mostly infiltration) were excluded – for these designs, the effluent that was sampled for water quality was likely not representative of the entire storm event.
- Systems with internal water storage zones were kept in the pool of data; these systems are believed to provide better control of nutrients than systems without internal water storage; Attachment H does not require internal water storage to be provided.

- Based on the findings of Roseen and Stone (2013) as well as recent research in Washington State, mixes with less compost and a higher fraction of sand than the Attachment H specification were kept in the sample pool because they are believed to provide more reliable performance and less potential for export of pollutants on average than a 70-30 sand/compost mix.
- Systems that contained media with experimental components were excluded.
- Finally, systems were excluded if there was not enough design information reported to be able to evaluate representativeness, and/or any other factors were noted by the original study researchers that were believed to contribute to poorer performance than average. For example, some studies were noted as underperforming studies due to construction issues, premature clogging, etc.

Overall, the screening that was applied is believed to improve the representativeness of the sample pool and generally increase the average performance of the sample pool compared to the entire pool of studies contained in the International BMP Database. As discussed above, establishing a higher baseline level of performance for conventional biofiltration is conservative in the context of this evaluation.

Screening Results

Table C.2 summarizes the number of data points for each constituent after applying screening to remove unrepresentative studies and without screening.

Table C.2. Summary of data points by parameter for conventional biofiltration BMPs

Constituent	Number of Screened Data Pairs	Number of Unscreened Data Pairs
Total Suspended Solids	234	354
Total Phosphorus	242	384
Total Nitrogen	71	184
Total Copper	190	216
Total Zinc	200	252

Inventory of Bioretention Studies and Screening Results/Rationales

Table C.4 (located at the end of this Appendix) provides an inventory of studies of bioretention with underdrains from the International BMP Database, screening results, and brief rationales for screening.

Compilation of Filterra Studies

Data were compiled from various field-scale Filterra monitoring studies from 2004 through 2014. The design of the Filterra system has not changed appreciably over time; therefore a screening step to determine representative studies was not necessary. The studies used in this analysis are summarized in Table 3 below. Full citations for these studies can be found in the references section.

Table C.3. Inventory of studies and data points by parameter for Filterra systems

Pollutant (total count of data pairs)	Data Pairs by Study	Reference
Total Suspended Solids (n= 165)	11	TARP (2004-2005) : Yu and Stanford (2006)
	7	TARP Addendum (2006-2007): ATR Associates (2009)
	25	Perf. Over Time: Cal's Pizza (2008-2014): Americast (2009b; 2015)
	24	Perf. Over Time: Jiffy Lube (2008-2011): Americast (2009b; 2015)
	13	Perf. Over Time: Coliseum (2007-2014): Americast (2009b, 2015)
	29	NCDNR Fayetteville (2013-14): NCSU (2015a)
	22	TAPE Bellingham (2013): Herrera (2014a)
	34	TAPE Port of Tacoma (2009): Herrera (2009)
Total Phosphorus (n=146)	14	TARP (2004-2005) : Yu and Stanford (2006)
	6	TARP Addendum (2006-2007): ATR Associates (2009)
	71	Perf. Over Time: Cal's Pizza (2008-2014): Americast (2009b; 2015)
	33	NCDNR Fayetteville (2013-14): NCSU (2015a)
	22	TAPE Bellingham (2013): Herrera (2014a)
Total Nitrogen (n = 34)	34	NCDNR Fayetteville (2013-14): NCSU (2015a)
Total Copper (n = 112)	8	TARP (2004-2005): Yu and Stanford (2006)
	24	Perf. Over Time: Jiffy Lube (2008-2011): Americast (2009b; 2015)
	21	Perf. Over Time: Coliseum (2007-2014): Americast (2009b, 2015)
	13	NCDNR Fayetteville (2013-14): NCSU (2015a)
	29	TAPE Port of Tacoma (2009): Herrera (2009)
	17	TAPE Bellingham (2013): Herrera (2014a)

Pollutant (total count of data pairs)	Data Pairs by Study	Reference
Total Zinc (n = 120)	16	TARP (2004-2005): Yu and Stanford (2006)
	24	Perf. Over Time: Jiffy Lube (2008-2011): Americast (2009b; 2015)
	21	Perf. Over Time: Coliseum (2007-2014): Americast (2009b, 2015)
	13	NCDNR Fayetteville (2013-14): NCSU (2015a)
	29	TAPE Port of Tacoma (2009): Herrera (2009)
	17	TAPE Bellingham (2013): Herrera (2014a)

<u>Key to acronyms:</u>
TARP: Technology Acceptance Reciprocity Partnership
TAPE: Technology Acceptance Protocol-Ecology (Washington State)
NCDNR: North Carolina Department of Natural Resources
NCSU: North Carolina State University

Data Analysis Method

The most common ways to characterize BMP performance include (1) removal efficiency (percent removal) in various forms, and (2) effluent probability. In general, the effluent probability approach is recommended for evaluating BMP performance and applying BMP performance to pollutant load models (Geosyntec and Wright Water, 2009). This method involves conducting a statistical comparison of influent and effluent quality to determine if effluent is significantly different from influent. If effluent is significantly different from influent, then the effluent quality is characterized by a statistical distribution developed from all effluent data points. Probability plots are prepared indicating the probability that a certain effluent quality is achieved.

However, to isolate differences in performance between two BMP types, the effluent probability method requires the assumption that the influent quality was similar between the studies of the two BMP types being compared. This assumption is generally reliable for categorical analysis of BMPs in the International BMP Database because of the large number of studies in the most categories in the Database. However, when comparing BMP types with a relatively limited number of study sites (such as the Filterra dataset), this assumption may not be reliable.

To address these challenges and help ensure a valid comparison between conventional biofiltration and Filterra systems, a moving bootstrap method (Leisenring et al., 2009) was applied to both datasets. This method characterizes influent-effluent relationships such that the BMPs compared do not need to have been studied under conditions with similar influent quality. In this approach, all data pairs are used to form the total sample population. Then for each increment of influent quality, a subsample of the overall population is formed including only those data pairs that lie within a certain span of the selected influent quality. Applying bootstrap principles (Singh and Xie, 2008), the median and the confidence interval around the median is computed as well the mean and the confidence interval around the mean. Then a new increment of influent quality is selected and the process is repeated with a new subsample population until a statistical description of effluent quality has been developed for each increment of influent quality over the range of the data. Rules are also imposed regarding selection the initial span of the moving window and expansion the span of the window, if needed, to ensure monotonicity (i.e., ensure that effluent quality always increases or stays the same with increasing influent quality).

Resulting tables and plots from this analysis are presented in Appendix D.

Land Use Stormwater Quality Inputs and Assumptions

Representative stormwater runoff concentrations for the land use condition used in this analysis were developed based on the land use stormwater quality monitoring data reported in the Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report, 2000 and Los Angeles County 2000-2001 Stormwater Monitoring Report, 2001(LA County 2000; LA County 2001). The median and mean runoff quality values from this dataset were used as representative influent water quality conditions for the purpose of evaluating BMP performance. These concentrations represent only one land use monitoring station in one geographic area; actual conditions for a given drainage area in a given region are anticipated to vary. Beyond the range of water quality presented in this table, this analysis did not attempt to characterize the uncertainty/variability in runoff water quality. This simplification is considered appropriate for evaluating equivalency in BMP performance.

Land use runoff quality is reported in Appendix D.

Table C.4. Inventory of conventional biofiltration studies from the International BMP Database and screening rationale

Source	Site Name	Sponsoring Entity	State	City	Selected?	Selection/Rejection Reasons
Int. BMP Database	Rocky Mount Grassed Bioretention Cell 1	North Carolina State	NC	Rocky Mount	Yes	Aligns with Att. H; Has internal water storage zone and underdrain
Int. BMP Database	Rocky Mount Mulch/Shrub Bioretention Cell 1	North Carolina State	NC	Rocky Mount	Yes	Aligns with Att. H; Has internal water storage zone and underdrain
Int. BMP Database	CHS_BioFilter	The Thomas Jefferson Planning District Commission	VA	Charlottesville	Yes	Aligns with Att. H; Has internal water storage zone, underdrain, and mulch layer (0.25 feet)
Int. BMP Database	Parks & Forestry Bioretention	City of Overland Park	KS	Overland Park	Yes	Aligns with Att. H; Has internal water storage zone, underdrain, and mulch layer
Int. BMP Database	Bioretention 6	Johnson County	KS	Shawnee	Yes	Aligns with Att. H; Has internal water storage zone and underdrain
Int. BMP Database	G2	North Carolina State	NC	Greensboro	Yes	Aligns with Att. H; Has underdrain, and mulch layer (7-10 cm)
Int. BMP Database	G1	North Carolina State	NC	Greensboro	Yes	Aligns with Att. H; Has underdrain, and mulch layer (7-10 cm)
Int. BMP Database	L1	North Carolina State	NC	Louisburg	Yes	Aligns with Att. H; Appropriate loading ratio
Int. BMP Database	Bioretention 3B	Johnson County	KS	Shawnee	Yes	Aligns with Att. H; Has internal water storage zone and underdrain
Int. BMP Database	Parking Lot Bioretention Cell	City of Fort Collins	CO	Fort Collins	Yes	Aligns with Att. H; Has internal water storage zone and mulch layer

Source	Site Name	Sponsoring Entity	State	City	Selected?	Selection/Rejection Reasons
Int. BMP Database	Bioretention Cells	Johnson County SMP	KS	Overland Park	Yes	Aligns with Att. H; Has internal water storage zone, underdrain, and mulch layer
Int. BMP Database	Bioretention Cell	Johnson County SMP	KS	Overland Park	Yes	Aligns with Att. H; Has internal water storage zone and underdrain
Int. BMP Database	Bioretention System (D1)	UNH/Cooperative Institute for Coastal and Estuarine Environmental Technology	NH	Durham	Yes	Aligns with Att. H; Has pretreatment, internal water storage zone, underdrain, and mulch layer
Int. BMP Database	UDFCD Rain Garden	Urban Drainage and Flood Control District	CO	Lakewood	Yes	Aligns with Att. H; Has internal water storage zone, underdrain, and compost layer
Int. BMP Database	Hal Marshall Bioretention Cell	City of Charlotte, North Carolina	NC	Charlotte	Yes	Aligns with Att. H; Has underdrain, and mulch layer
Int. BMP Database	Rocky Mount Grassed Bioretention Cell 2	The Cooperative Institute for Coastal and Estuarine Environmental Technology	NC	Rocky Mountain	Yes	Aligns with Att. H; Has internal water storage zone and underdrain
Li and Davis (2009)	Bioretention Cell 1	Prince George's County Department of Environmental Resources/ U of MD	MD	College Park	Yes	Aligns with Att. H
Li and Davis (2009)	Bioretention Cell 2	Prince George's County Department of Environmental Resources/U of MD	MD	Silver Spring	Yes	Aligns with Att. H
Davis (2007)	Bioretention Cell 1	Prince George's County Department of Environmental Resources/U of MD	MD	College Park	Yes	Aligns with Att. H
David et al. (2011)	Daly City Library Rain Gardens	San Francisco Estuary Institute	CA	Daly City	Yes	Aligns with Att. H
Gilbreath et al. (2012)	San Pablo Ave Green Streets	San Francisco Estuary Institute	CA	El Cerrito	Yes	Aligns with Att. H
Int. BMP Database	Bioretention Area	Virginia Department of Conservation and Recreation	VA	Charlottesville	No	Not enough design info provided
Int. BMP Database	Small Cell	North Carolina Department of Transportation	NC	Knightdale	No	Infiltration rate low; noted to be underperforming BMP by

Source	Site Name	Sponsoring Entity	State	City	Selected?	Selection/Rejection Reasons
						study researchers
Int. BMP Database	BRC_B	North Carolina State	NC	Nashville	No	Infiltration too low and undersized
Int. BMP Database	North cell	North Carolina State	NC	Raleigh	No	Media very different from Att. H
Int. BMP Database	WA Ecology Embankment at SR 167 MP 16.4	Washington State Dept. of Transportation	WA	Olympia	No	Linear design; lateral flow; not representative of typical biofiltration design
Int. BMP Database	Bioretention Cell	Delaware Department of Transportation	DE	Dover	No	Design is very different from Att. H
Int. BMP Database	East 44th St. Pond	City of Tacoma	WA	Tacoma	No	No design data
Int. BMP Database	Tree Filter	UNH/Cooperative Institute for Coastal and Estuarine Environmental Technology	NH	Durham	No	Design is very different from Att. H
Int. BMP Database	BRC_A	North Carolina State University	NC	Raleigh	No	Infiltration rate very low; noted to be a partially clogged/failing system
Int. BMP Database	Cub_Run_Biorete ntion	Fairfax County	VA	Fairfax	No	No design data provided
Int. BMP Database	South cell	North Carolina State University (BAE)	NC	Raleigh	No	Design is very different from Att. H
Int. BMP Database	R Street	City of Tacoma	WA	Tacoma	No	No design data provided

APPENDIX D – RESULTS OF POLLUTANT TREATMENT DATA ANALYSIS

The data analysis methods described in Appendix C were applied to the datasets described in Appendix C. The following pages present tabular and graphical results of this analysis.

Table D.1. Summary Statistics - Bioretention Studies and Filterra Studies

Median Statistics

Land Use	Pollutant	Units	Median Representative Runoff Quality	Conventional Biofiltration Effluent (Screened)		Conventional Biofiltration Effluent (Unscreened)		Filterra Effluent	
				Median	95th percentile UCL on Median	Median	95th percentile UCL on Median	Median	95th percentile UCL on Median
Commercial	TSS	mg/L	53	12	13.7	11	12	4.9	5
	Total Phosphorus	mg/L	0.27	**0.46**	0.55	0.26	0.37	0.06	0.08
	Total Nitrogen	mg/L	2.3	1.6	2.9	1.19	1.52	1	1.6
	Copper	ug/L	22	12	15	12	14	10	10
	Zinc	ug/L	192	35	44	36	40	70	77
High Density Single Family Residential	TSS	mg/L	61	12	15	12	13	5.0	5.0
	Total Phosphorus	mg/L	0.32	**0.47**	0.55	0.28	0.43	0.09	0.11
	Total Nitrogen	mg/L	2	1.6	2.9	1.2	1.5	1	1.6
	Copper	ug/L	11	5.3	5.9	5.3	6.4	5.5	6.0
	Zinc	ug/L	66	20	27	18	26	31	35
Light Industrial	TSS	mg/L	129	16	18	16	18	5.2	7.0
	Total Phosphorus	mg/L	0.3	**0.47**	0.55	0.27	0.42	0.09	0.11
	Total Nitrogen	mg/L	2.4	1.6	2.9	1.2	1.5	1.3	1.6
	Copper	ug/L	21	12	15	12	13.85	10	10
	Zinc	ug/L	366	35	44	36	40	80	95
Multi-family Residential	TSS	mg/L	24	10.8	12.5	9.9	9.9	3	3
	Total Phosphorus	mg/L	0.14	**0.39**	0.45	**0.21**	0.25	0.04	0.05
	Total Nitrogen	mg/L	1.5	**1.6**	2.9	1.2	1.5	0.9	1
	Copper	ug/L	12	5.6	6.1	5.6	6.6	5.5	6.0
	Zinc	ug/L	89	20	27	18	26	35	37

Mean Statistics

Land Use	Pollutant	Units	Mean Representative Runoff Quality	Conventional Biofiltration Effluent (Screened)		Conventional Biofiltration Effluent (Unscreened)		Filterra Effluent	
				Mean	95th percentile UCL on Mean	Mean	95th percentile UCL on Mean	Mean	95th percentile UCL on Mean
Commercial	TSS	mg/L	66	28	49	25	39	6.0	7.9
	Total Phosphorus	mg/L	0.39	**0.80**	1.3	**0.65**	1.0	0.11	0.14
	Total Nitrogen	mg/L	3.6	2.9	4.3	2.1	2.8	NA	NA
	Copper	ug/L	39	19	29	16	24	18	29
	Zinc	ug/L	241	65	145	59	108	69	105
High Density Single Family Residential	TSS	mg/L	95	28	49	25	39	6.0	8.5
	Total Phosphorus	mg/L	0.39	**0.80**	1.3	**0.65**	1.0	0.11	0.14
	Total Nitrogen	mg/L	3.0	2.9	4.3	2.1	2.8	NA	NA
	Copper	ug/L	15	13	21	13	19	12	19
	Zinc	ug/L	79	33	50	32	46	28	45
Light Industrial	TSS	mg/L	240	46	105	40	87	16	31
	Total Phosphorus	mg/L	0.41	**0.80**	1.3	**0.65**	1.0	0.11	0.14
	Total Nitrogen	mg/L	3.1	2.9	4.3	2.1	2.8	NA	NA
	Copper	ug/L	32	19	29	16	24	18	29
	Zinc	ug/L	639	NA	NA	59	108	168	285
Multi-family Residential	TSS	mg/L	46	18	28	18	27	6.0	7.9
	Total Phosphorus	mg/L	0.2	**0.8**	1.3	**0.6**	1.0	0.06	0.07
	Total Nitrogen	mg/L	2.1	**2.9**	4.3	**2.1**	2.8	1.1	1.5
	Copper	ug/L	12	10	15	9	14	9	15
	Zinc	ug/L	146	45	90	32	46	38	60

NA - Average values could not be computed for because the land use average influent is outside of the range of influent observed in monitoring studies.

Key to cell formatting

Red bold indicates median or mean effluent concentration higher than influent concentration. This is indicative of the potential for pollutant export.

Blue indicates upper confidence interval of effluent concentration is higher than the influent concentration. This is not a conclusive indicator, but is provided for reference.

Figure D.1 Moving Window Plots of Medians

Screened Biofiltration Dataset | **Unscreened Biofiltration Dataset** | **Filterra Dataset**

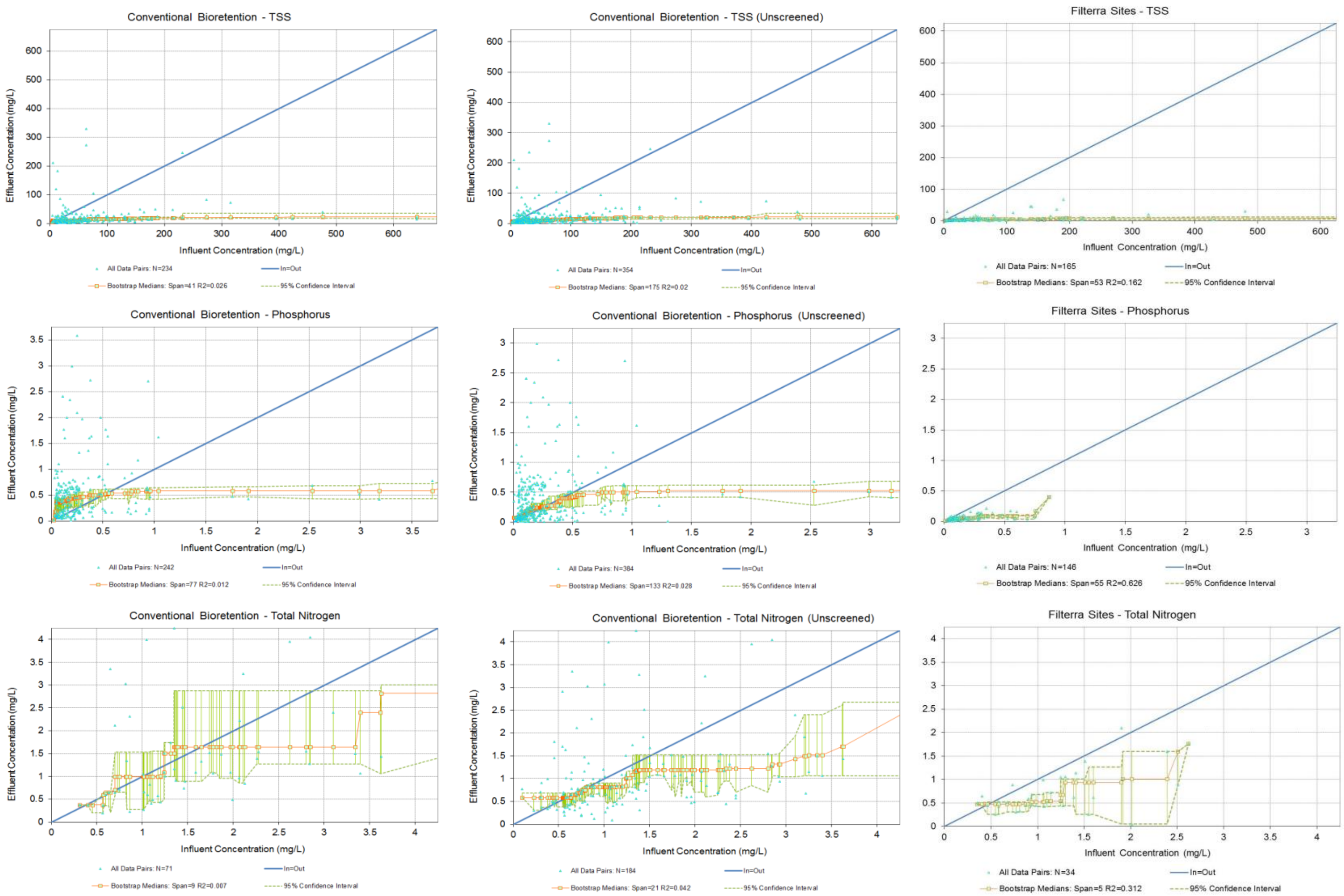


Figure D.1 Moving Window Plots of Medians

Screened Biofiltration Dataset | **Unscreened Biofiltration Dataset** | **Filterra Dataset**

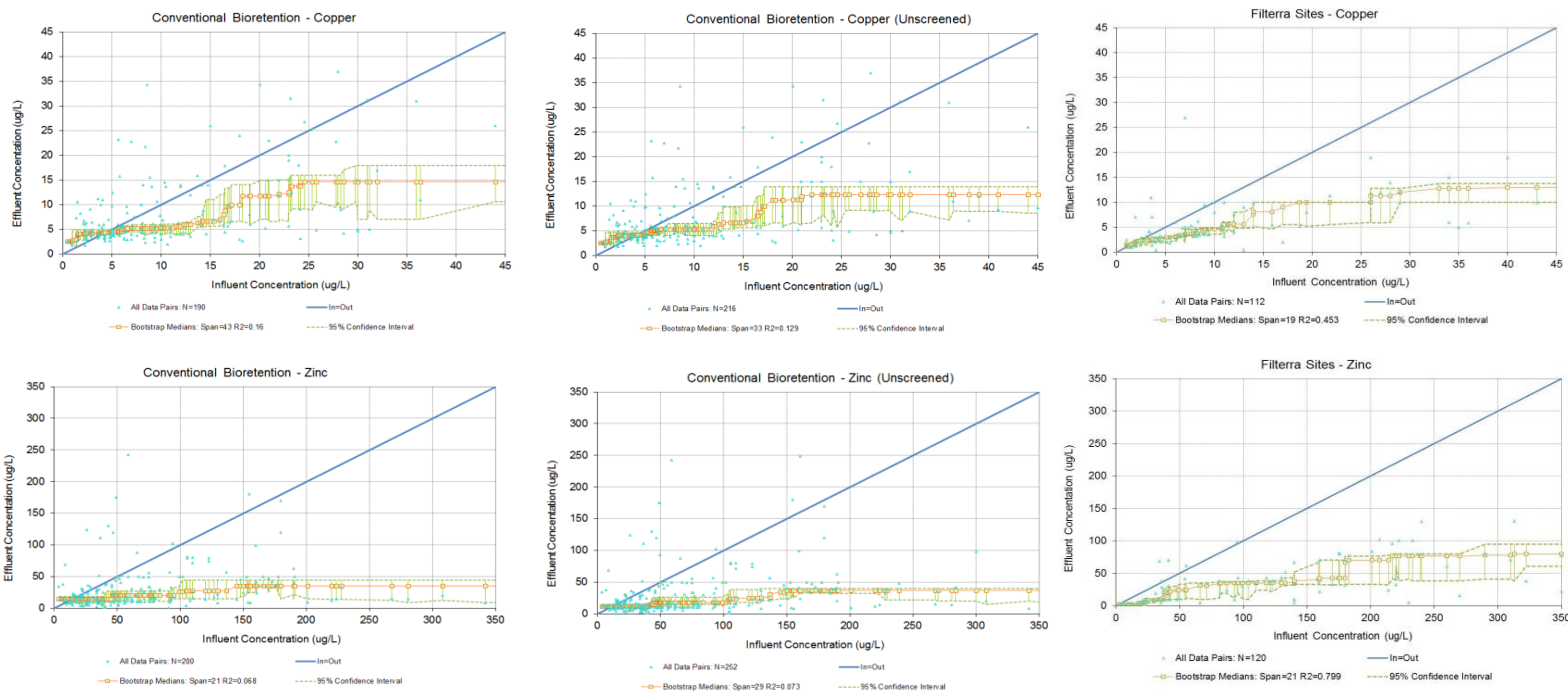


Figure D.2 Moving Window Plots of Means

Screened Biofiltration Dataset | **Unscreened Biofiltration Dataset** | **Filterra Dataset**

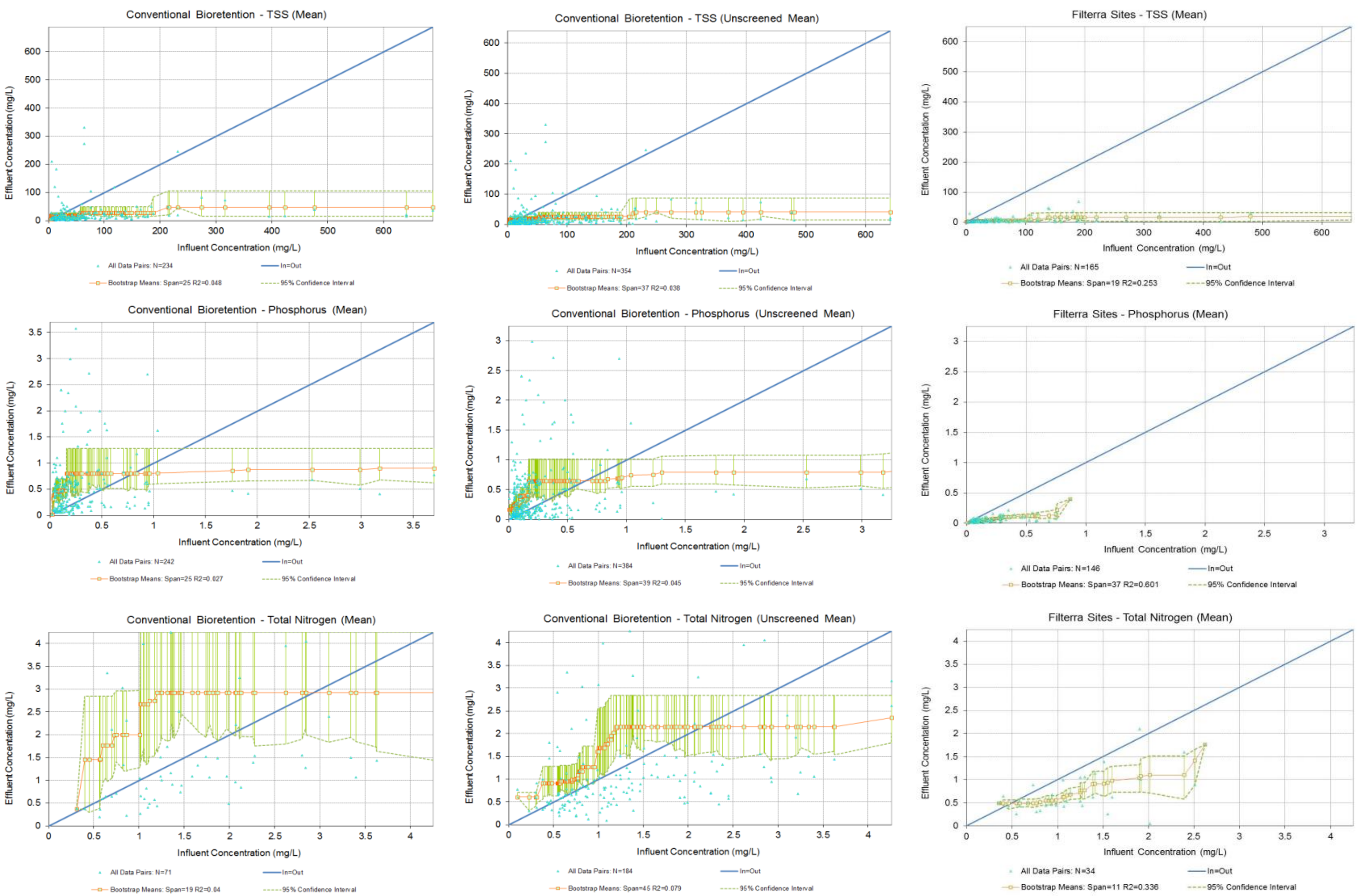
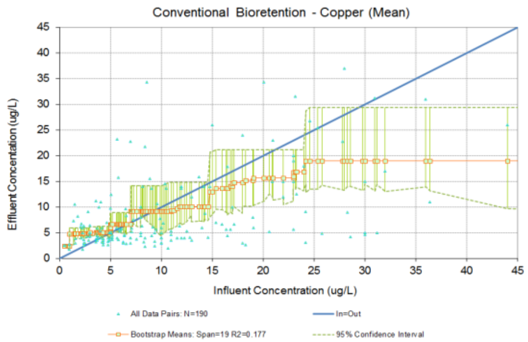
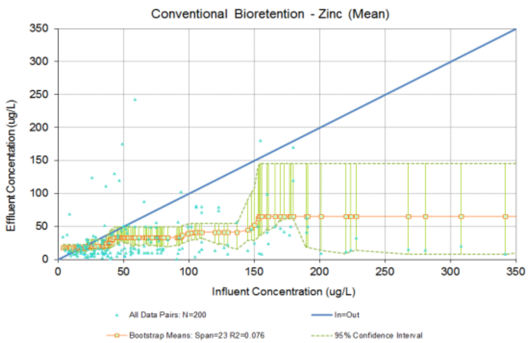


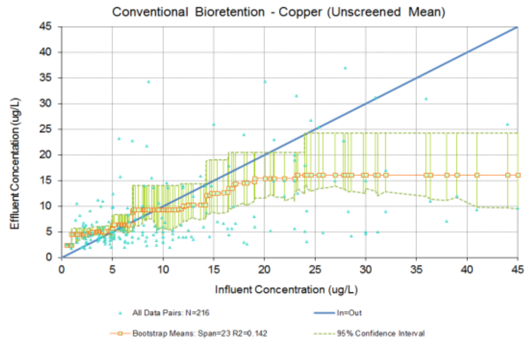
Figure D.2 Moving Window Plots of Means

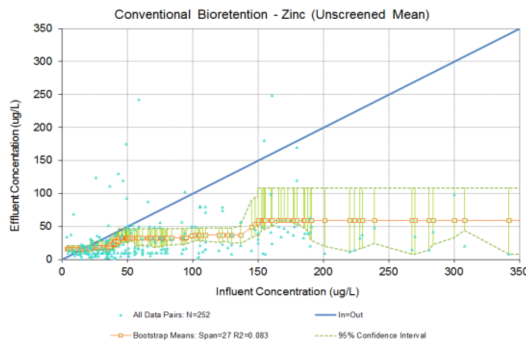
Screened Biofiltration Dataset



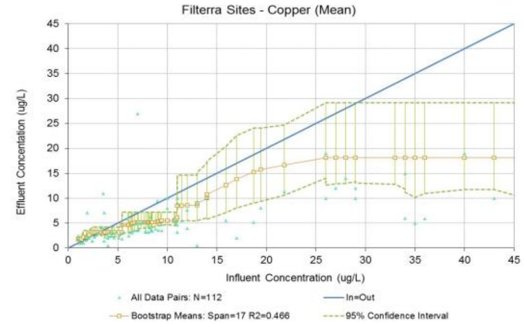


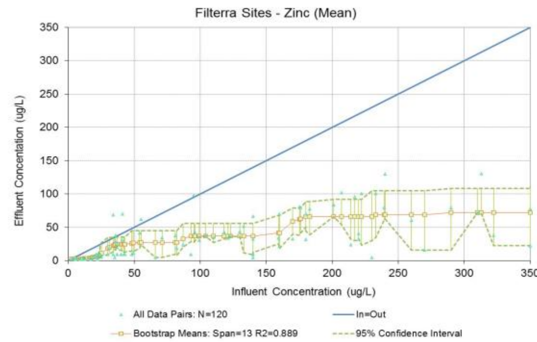
Unscreened Biofiltration Dataset





Filterra Dataset





September 2019

GENERAL USE LEVEL DESIGNATION FOR BASIC (TSS), ENHANCED, PHOSPHORUS & OIL TREATMENT

For

CONTECH Engineered Solutions Filterra®

Ecology's Decision:

Based on Contech's submissions, including the Final Technical Evaluation Reports, dated August 2019, March 2014, December 2009, and additional information provided to Ecology dated October 9, 2009, Ecology hereby issues the following use level designations:

1. A General Use Level Designation for Basic, Enhanced, Phosphorus, and Oil Treatment for the Filterra® system constructed with a minimum media thickness of 21 inches (1.75 feet), at the following water quality design hydraulic loading rates:

Treatment	Infiltration Rate (in/hr) for use in Sizing
Basic	175
Phosphorus	100
Oil	50
Enhanced	175

2. The Filterra is not appropriate for oil spill-control purposes.
3. Ecology approves Filterra systems for treatment at the hydraulic loading rates listed above, to achieve the maximum water quality design flow rate. Calculate the water quality design flow rates using the following procedures:

- Western Washington: for treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using the latest version of the Western Washington Hydrology Model or other Ecology-approved continuous runoff model.
- Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute flow rate as calculated using one of the three flow rate based methods described in Chapter 2.2.5 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.
- Entire State: For treatment installed downstream of detention, the water quality design flow rate is the full 2-year release rate of the detention facility.

4. This General Use Level Designation has no expiration date, but Ecology may revoke or amend the designation, and is subject to the conditions specified below.

Ecology's Conditions of Use:

Filterra systems shall comply with these conditions shall comply with the following conditions:

1. Design, assemble, install, operate, and maintain the Filterra systems in accordance with applicable Contech Filterra manuals and this Ecology Decision.
2. The minimum size filter surface-area for use in Washington is determined by using the design water quality flow rate (as determined in this Ecology Decision, Item 3, above) and the Infiltration Rate from the table above (use the lowest applicable Infiltration Rate depending on the level of treatment required). Calculate the required area by dividing the water quality design flow rate (cu-ft/sec) by the Infiltration Rate (converted to ft/sec) to obtain required surface area (sq-ft) of the Filterra unit.
3. Each site plan must undergo Contech Filterra review before Ecology can approve the unit for site installation. This will ensure that design parameters including site grading and slope are appropriate for use of a Filterra unit.
4. Filterra media shall conform to the specifications submitted to and approved by Ecology and shall be sourced from Contech Engineered Solutions, LLC with no substitutions.
5. Maintenance includes removing trash, degraded mulch, and accumulated debris from the filter surface and replacing the mulch layer. Use inspections to determine the site-specific maintenance schedules and requirements. Follow maintenance procedures given in the most recent version of the Filterra Operation and Maintenance Manual.
6. Maintenance: The required maintenance interval for stormwater treatment devices is often dependent upon the degree of pollutant loading from a particular drainage basin. Therefore, Ecology does not endorse or recommend a "one size fits all" maintenance cycle for a particular model/size of manufactured treatment device.
   - Contech designs Filterra systems for a target maintenance interval of 6 months in the Pacific Northwest. Maintenance includes removing and replacing the mulch layer above the media along with accumulated sediment, trash, and captured organic materials therein, evaluating plant health, and pruning the plant if deemed necessary.
   - Conduct maintenance following manufacturer's guidelines.
7. Filterra systems come in standard sizes.
8. Install the Filterra in such a manner that flows exceeding the maximum Filterra operating rate are conveyed around the Filterra mulch and media and will not resuspend captured sediment.
9. Discharges from the Filterra units shall not cause or contribute to water quality standards violations in receiving waters.

Approved Alternate Configurations

Filterra Internal Bypass - Pipe (FTIB-P)

1. The Filterra® Internal Bypass – Pipe allows for piped-in flow from area drains, grated inlets, trench drains, and/or roof drains. Design capture flows and peak flows enter the structure through an internal slotted pipe. Filterra® inverted the slotted pipe to allow design flows to drop through to a series of splash plates that then disperse the design flows over the top surface of the Filterra® planter area. Higher flows continue to bypass the slotted pipe and convey out the structure.
2. To select a FTIB-P unit, the designer must determine the size of the standard unit using the sizing guidance described above.

Filterra Internal Bypass – Curb (FTIB-C)

1. The Filterra® Internal Bypass –Curb model (FTIB-C) incorporates a curb inlet, biofiltration treatment chamber, and internal high flow bypass in one single structure. Filterra® designed the FTIB-C model for use in a "Sag" or "Sump" condition and will accept flows from both directions along a gutter line. An internal flume tray weir component directs treatment flows entering the unit through the curb inlet to the biofiltration treatment chamber. Flows in excess of the water quality treatment flow rise above the flume tray weir and discharge through a standpipe orifice; providing bypass of untreated peak flows. Americast manufactures the FTIB-C model in a variety of sizes and configurations and you may use the unit on a continuous grade when a single structure providing both treatment and high flow bypass is preferred. The FTIB-C model can also incorporate a separate junction box chamber to allow larger diameter discharge pipe connections to the structure.
2. To select a FTIB-C unit, the designer must determine the size of the standard unit using the sizing guidance described above.

Filterra® Shallow

1. The Filterra Shallow provides additional flexibility for design engineers and designers in situations where various elevation constraints prevent application of a standard Filterra configuration. Engineers can design this system up to six inches shallower than any of the previous Filterra unit configurations noted above.
2. Ecology requires that the Filterra Shallow provide a media contact time equivalent to that of the standard unit. This means that with a smaller depth of media, the surface area must increase.
3. To select a Filterra Shallow System unit, the designer must first identify the size of the standard unit using the modeling guidance described above.
4. Once the size of the standard Filterra unit is established using the sizing technique described above, use information from the following table to select the appropriate size Filterra Shallow System unit.

Shallow Unit Basic, Enhanced, and Oil Treatment Sizing

Standard Depth	Equivalent Shallow Depth
4x4	4x6 or 6x4
4x6 or 6x4	6x6
4x8 or 8x4	6x8 or 8x6
6x6	6x10 or 10x6
6x8 or 8x6	6x12 or 12x6
6x10 or 10x6	13x7

Notes:
1. Shallow Depth Boxes are less than the standard depth of 3.5 feet but no less than 3.0 feet deep (TC to INV).

Applicant: Contech Engineered Solutions, LLC.

Applicant's Address: 11815 NE Glenn Widing Drive
Portland, OR 97220

Application Documents:

- State of Washington Department of Ecology Application for Conditional Use Designation, Americast (September 2006)
- Quality Assurance Project Plan Filterra® Bioretention Filtration System Performance Monitoring, Americast (April 2008)
- Quality Assurance Project Plan Addendum Filterra® Bioretention Filtration System Performance Monitoring, Americast (June 2008)
- Draft Technical Evaluation Report Filterra® Bioretention Filtration System Performance Monitoring, Americast (August 2009)
- Final Technical Evaluation Report Filterra® Bioretention Filtration System Performance Monitoring, Americast (December 2009)
- Technical Evaluation Report Appendices Filterra® Bioretention Filtration System Performance Monitoring, Americast, (August 2009)
- Memorandum to Department of Ecology Dated October 9, 2009 from Americast, Inc. and Herrera Environmental Consultants
- Quality Assurance Project Plan Filterra® Bioretention System Phosphorus treatment and Supplemental Basic and Enhanced Treatment Performance Monitoring, Americast (November 2011)
- Filterra® letter August 24, 2012 regarding sizing for the Filterra® Shallow System.
- University of Virginia Engineering Department Memo by Joanna Crowe Curran, Ph. D dated March 16, 2013 concerning capacity analysis of Filterra® internal weir inlet tray.
- Terraphase Engineering letter to Jodi Mills, P.E. dated April 2, 2013 regarding Terraflume Hydraulic Test, Filterra® Bioretention System and attachments.
- Technical Evaluation Report, Filterra® System Phosphorus Treatment and Supplemental Basic Treatment Performance Monitoring. March 27th, 2014.
- State of Washington Department of Ecology Application for Conditional Use Level Designation, Contech Engineered Solutions (May 2015)

- Quality Assurance Project Plan Filterra® Bioretention System, Contech Engineered Solutions (May 2015)
- Filterra Bioretention System Armco Avenue General Use Level Designation Technical Evaluation Report, Contech Engineered Solutions (August 2019)

Applicant's Use Level Request:

General Level Use Designation for Basic (175 in/hr), Enhanced (175 in/hr), Phosphorus (100 in/hr), and Oil Treatment (50 in/hr).

Applicant's Performance Claims:

Field-testing and laboratory testing show that the Filterra® unit is promising as a stormwater treatment best management practice and can meet Ecology's performance goals for basic, enhanced, phosphorus, and oil treatment.

Findings of Fact:

Field Testing 2015-2019

1. Contech completed field testing of a 4 ft. x 4 ft. Filterra® unit at one site in Hillsboro, Oregon from September 2015 to July 2019. Throughout the monitoring period a total of 24 individual storm events were sampled, of which 23 qualified for TAPE sampling criteria.
2. Contech encountered several unanticipated events and challenges that prevented them from collecting continuous flow and rainfall data. An analysis of the flow data from the sampled events, including both the qualifying and non-qualifying events, demonstrated the system treated over 99 % of the influent flows. Peak flows during these events ranged from 25 % to 250 % of the design flow rate of 29 gallons per minute.
3. Of the 23 TAPE qualified sample events, 13 met requirements for TSS analysis. Influent concentrations ranged from 20.8 mg/L to 83 mg/L, with a mean concentration of 46.3 mg/L. The UCL95 mean effluent concentration was 15.9 mg/L, meeting the 20 mg/L performance goal for Basic Treatment.
4. All 23 TAPE qualified sample events met requirements for dissolved zinc analysis. Influent concentrations range from 0.0384 mg/L to 0.2680 mg/L, with a mean concentration of 0.0807 mg/L. The LCL 95 mean percent removal was 62.9 %, meeting the 60 % performance goal for Enhanced Treatment.
5. Thirteen of the 23 TAPE qualified sample events met requirements for dissolved copper analysis. Influent concentrations ranged from 0.00543 mg/L to 0.01660 mg/L, with a mean concentration of 0.0103 mg/L. The LCL 95 mean percent removal was 41.2 %, meeting the 30 % performance goal for Enhanced Treatment.
6. Total zinc concentrations were analyzed for all 24 sample events. Influent EMCs for total zinc ranged from 0.048 mg/L to 5.290 mg/L with a median of 0.162 mg/L. Corresponding effluent EMCs for total zinc ranged from 0.015 mg/L to 0.067 mg/L with a median of

0.029 mg/L. Total event loadings for the study for total zinc were 316.85 g at the influent and 12.92 g at the effluent sampling location, resulting in a summation of loads removal efficiency of 95.9 %.

7. Total copper concentrations were analyzed for all 24 sample events. Influent EMCs for total copper ranged from 0.003 mg/L to 35.600 mg/L with a median value of 0.043 mg/L. Corresponding effluent EMCs for total copper ranged from 0.002 mg/L to 0.015 mg/L with a median of 0.004 mg/L. Total event loadings for total copper for the study were 1,810.06 g at the influent and 1.90 g at the effluent sampling location, resulting in a summation of loads removal efficiency of 99.9 %.

<u>Field Testing 2013</u>

1. Filterra completed field-testing of a 6.5 ft x 4 ft. unit at one site in Bellingham, Washington. Continuous flow and rainfall data collected from January 1, 2013 through July 23, 2013 indicated that 59 storm events occurred. Water quality data was obtained from 22 storm events. Not all the sampled storms produced information that met TAPE criteria for storm and/or water quality data.
2. The system treated 98.9 % of the total 8-month runoff volume during the testing period. Consequently, the system achieved the goal of treating 91 % of the volume from the site. Stormwater runoff bypassed Filterra treatment during four of the 59 storm events.
3. Of the 22 sampled events, 18 qualified for TSS analysis (influent TSS concentrations ranged from 25 to 138 mg/L). The data were segregated into sample pairs with influent concentration greater than and less than 100 mg/L. The UCL95 mean effluent concentration for the data with influent less than 100 mg/L was 5.2 mg/L, below the 20-mg/L threshold. Although the TAPE guidelines do not require an evaluation of TSS removal efficiency for influent concentrations below 100 mg/L, the mean TSS removal for these samples was 90.1 %. Average removal of influent TSS concentrations greater than 100 mg/L (three events) was 85 %. In addition, the system consistently exhibited TSS removal greater than 80 % at flow rates equivalent to a 100 in/hr infiltration rate and was observed at 150 in/hr.
4. Ten of the 22 sampled events qualified for TP analysis. Americast augmented the dataset using two sample pairs from previous monitoring at the site. Influent TP concentrations ranged from 0.11 to 0.52 mg/L. The mean TP removal for these twelve events was 72.6 %. The LCL95 mean percent removal was 66.0, well above the TAPE requirement of 50 %. Treatment above 50 % was evident at 100 in/hr infiltration rate and as high as 150 in/hr. Consequently, the Filterra test system met the TAPE Phosphorus Treatment goal at 100 in/hr. Influent ortho-P concentrations ranged from 0.005 to 0.012 mg/L; effluent ortho-P concentrations ranged from 0.005 to 0.013 mg/L. The reporting limit/resolution for the ortho-P test method is 0.01 mg/L, therefore the influent and effluent ortho-P concentrations were both at and near non-detect concentrations.

Field Testing 2008-2009

1. Filterra completed field-testing at two sites at the Port of Tacoma. Continuous flow and rainfall data collected during the 2008-2009 monitoring period indicated that 89 storm events occurred. The monitoring obtained water quality data from 27 storm events. Not all the sampled storms produced information that met TAPE criteria for storm and/or water quality data.
2. During the testing at the Port of Tacoma, 98.96 to 99.89 % of the annual influent runoff volume passed through the POT1 and POT2 test systems respectively. Stormwater runoff bypassed the POT1 test system during nine storm events and bypassed the POT2 test system during one storm event. Bypass volumes ranged from 0.13 % to 15.3% of the influent storm volume. Both test systems achieved the 91 % water quality treatment-goal over the 1-year monitoring period.
3. Consultants observed infiltration rates as high as 133 in/hr during the various storms. Filterra did not provide any paired data that identified percent removal of TSS, metals, oil, or phosphorus at an instantaneous observed flow rate.
4. The maximum storm average hydraulic loading rate associated with water quality data is <40 in/hr, with the majority of flow rates < 25 in/hr. The average instantaneous hydraulic loading rate ranged from 8.6 to 53 in/hr.
5. The field data showed a removal rate greater than 80 % for TSS with an influent concentration greater than 20 mg/L at an average instantaneous hydraulic loading rate up to 53 in/hr (average influent concentration of 28.8 mg/L, average effluent concentration of 4.3 mg/L).
6. The field data showed a removal rate generally greater than 54 % for dissolved zinc at an average instantaneous hydraulic loading rate up to 60 in/hr and an average influent concentration of 0.266 mg/L (average effluent concentration of 0.115 mg/L).
7. The field data showed a removal rate generally greater than 40 % for dissolved copper at an average instantaneous hydraulic loading rate up to 35 in/hr and an average influent concentration of 0.0070 mg/L (average effluent concentration of 0.0036 mg/L).
8. The field data showed an average removal rate of 93 % for total petroleum hydrocarbon (TPH) at an average instantaneous hydraulic loading rate up to 53 in/hr and an average influent concentration of 52 mg/L (average effluent concentration of 2.3 mg/L). The data also shows achievement of less than 15 mg/L TPH for grab samples. Filterra provided limited visible sheen data due to access limitations at the outlet monitoring location.
9. The field data showed low percentage removals of total phosphorus at all storm flows at an average influent concentration of 0.189 mg/L (average effluent concentration of 0.171 mg/L). We may relate the relatively poor treatment performance of the Filterra system at this location to influent characteristics for total phosphorus that are unique to the Port of Tacoma site. It appears that the Filterra system will not meet the 50 % removal performance goal when the majority of phosphorus in the runoff is expected to be in the dissolved form.

Laboratory Testing

1. Filterra performed laboratory testing on a scaled down version of the Filterra unit. The lab data showed an average removal from 83-91 % for TSS with influents ranging from 21 to 320 mg/L, 82-84 % for total copper with influents ranging from 0.94 to 2.3 mg/L, and 50-61 % for orthophosphate with influents ranging from 2.46 to 14.37 mg/L.
2. Filterra conducted permeability tests on the soil media.
3. Lab scale testing using Sil-Co-Sil 106 showed removals ranging from 70.1 % to 95.5 % with a median removal of 90.7 %, for influent concentrations ranging from 8.3 to 260 mg/L. Filterra ran these laboratory tests at an infiltration rate of 50 in/hr.
4. Supplemental lab testing conducted in September 2009 using Sil-Co-Sil 106 showed an average removal of 90.6 %. These laboratory tests were run at infiltration rates ranging from 25 to 150 in/hr for influent concentrations ranging from 41.6 to 252.5 mg/L. Regression analysis results indicate that the Filterra system's TSS removal performance is independent of influent concentration in the concentration rage evaluated at hydraulic loading rates of up to 150 in/hr.

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Ecology web link: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

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Department of Ecology
Water Quality Program
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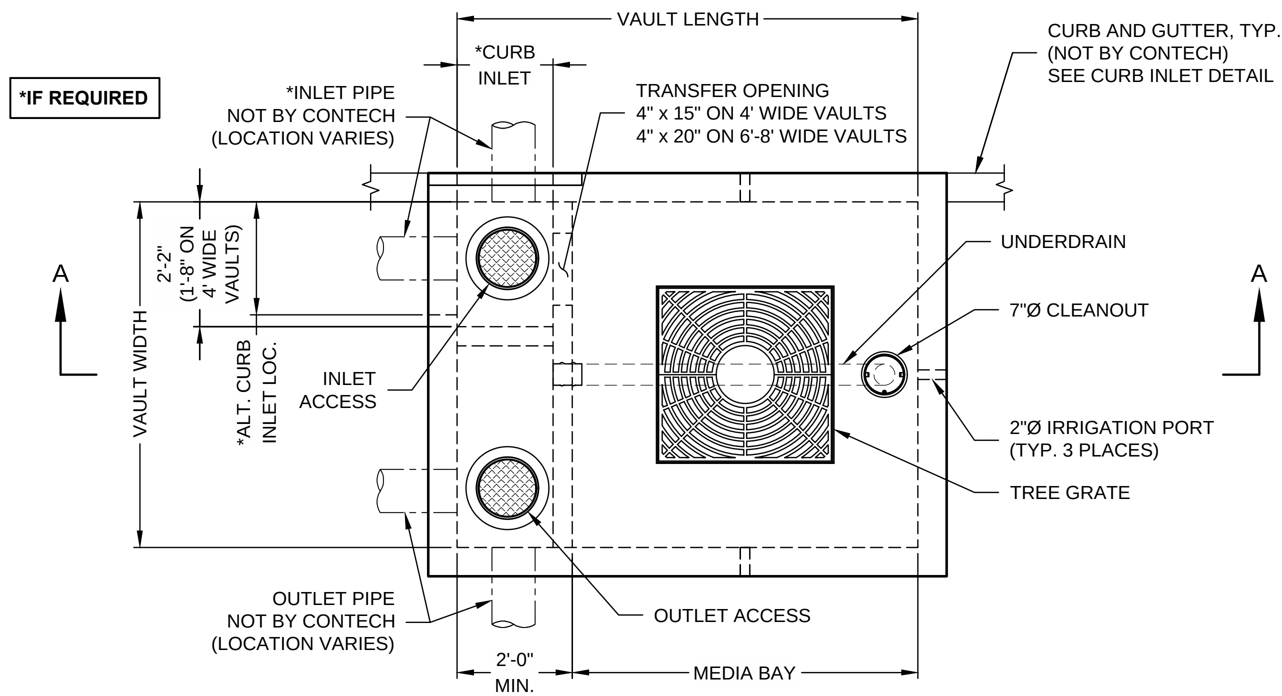
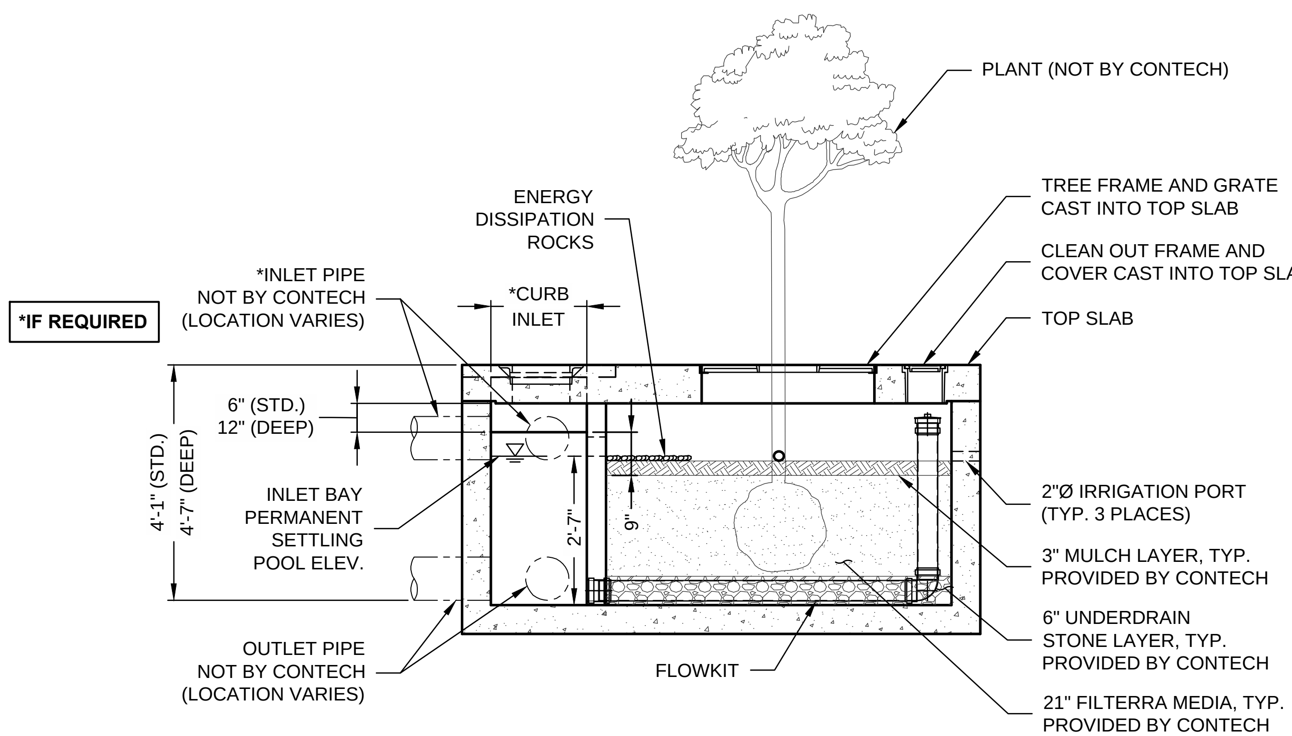
Date	Revision
December 2009	GULD for Basic, Enhanced, and Oil granted, CULD for Phosphorus
September 2011	Extended CULD for Phosphorus Treatment
September 2012	Revised design storm discussion, added Shallow System.
January 2013	Revised format to match Ecology standards, changed Filterra contact information
February 2013	Added FTIB-P system
March 2013	Added FTIB-C system
April 2013	Modified requirements for identifying appropriate size of unit

June 2013	Modified description of FTIB-C alternate configuration
March 2014	GULD awarded for Phosphorus Treatment. GULD updated for a higher flow-rate for Basic Treatment.
June 2014	Revised sizing calculation methods
March 2015	Revised Contact Information
June 2015	CULD for Basic and Enhanced at 100 in/hr infiltration rate
September 2019	GULD for Basic and Enhanced at 175 in/hr infiltration rate



PLAN VIEW



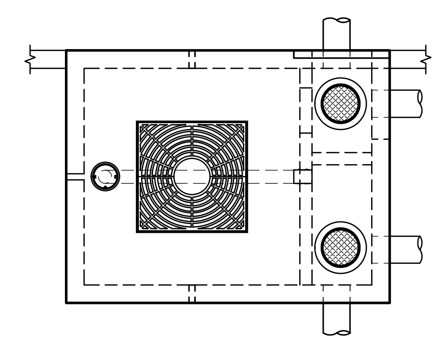
SECTION A-A
(STANDARD DEPTH SHOWN)

FTPD CONFIGURATION

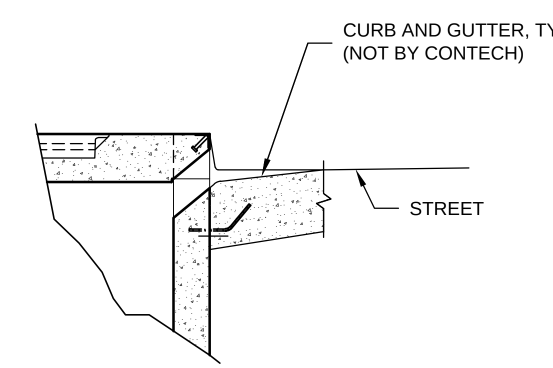
(OPTIONS: DEEP "-D", THROAT INLET "-T", PIPE INLET "-P", PIPE AND THROAT INLET "-PT')

MODEL NAME	PART NUMBER	AVAILABILITY	MEDIA AREA (SF)	MEDIA BAY SIZE	VAULT SIZE (W x L)	WEIR LENGTH/ MAX. CURB OPENING	*MAX. BYPASS FLOW (CFS) STD / DEEP	INLET/ OUTLET ACCESS DIA.	TREE GRATE QTY. AND SIZE
FTPD 4x4 (4x6 VAULT)	FTPD0404	ALL	16	4 x 4	4 x 6	1'-8"	1.4 / 4.6	12"/12"	(1) 3' x 3'
FTPD 4x6 (4x8 VAULT)	FTPD0406	ALL (EXCEPT DE, MD, NJ, PA, VA, WV)	24	4 x 6	4 x 8	1'-8"	1.4 / 4.6	12"/12"	(1) 3' x 3'
FTPD 6x4 (6x6 VAULT)	FTPD0604	ALL (EXCEPT CA, TX)	24	6 x 4	6 x 6	1'-8"	1.4 / 4.6	12"/12"	(1) 3' x 3'
FTPD 4.5x5.8 (4.5x7.8 VAULT)	FTPD045058	DE, MD, NJ, PA, VA, WV ONLY	26	4.5 x 5.83	4.5 x 7.83	1'-8"	1.4 / 4.6	12"/12"	(1) 3' x 3'
FTPD 6x6 (6x8 VAULT)	FTPD0606	ALL	36	6 x 6	6 x 8	1'-8"	1.4 / 4.6	12"/12"	(1) 3' x 3'
FTPD 6x8 (6x10 VAULT)	FTPD0608	ALL (EXCEPT CA, TX)	48	6 x 8	6 x 10	1'-8"	1.4 / 4.6	12"/12"	(1) 4' x 4'
FTPD 8x7 (8x10 VAULT)	FTPD0807	CA, TX ONLY	56	8 x 7	8 x 10	2'-6"	2.1 / 6.8	24"/24"	(1) 4' x 4'
FTPD 6x10 (6x12 VAULT)	FTPD0610	ALL (EXCEPT CA, TX)	60	6 x 10	6 x 12	1'-8"	1.4 / 4.6	12"/12"	(1) 4' x 4'
FTPD 7x10 (7x13 VAULT)	FTPD0710	ALL (EXCEPT CA, TX)	70	7 x 10	7 x 13	2'-6"	2.1 / 6.8	24"/24"	(1) 4' x 4'
FTPD 8x9 (8x12 VAULT)	FTPD0809	CA, TX ONLY	72	8 x 9	8 x 12	2' -6"	2.1 / 6.8	24"/24"	(1) 4' x 4'
FTPD 8x10.5 (8x14 VAULT)	FTPD08105	ALL	84	8 x 10.5	8 x 14	3'-0"	2.5 / 8.2	24"/24"	(1) 4' x 4'
FTPD 8x12.5 (8x16 VAULT)	FTPD08125	ALL (EXCEPT OR, WA)	100	8 x 12.5	8 x 16	3'-0"	2.5 / 8.2	24"/24"	(2) 4' x 4'
FTPD 9x11.5 (9x15 VAULT)	FTPD09115	OR, WA ONLY	103	9 x 11.5	9 x 15	3'-0"	2.5 / 8.2	24"/24"	(2) 4' x 4'

*MAX BYPASS FLOW IS INTERNAL WEIR FLOW. CAPACITIES SHOWN ARE FOR STANDARD DEPTH AND DEEP (-D), RESPECTIVELY. SITE SPECIFIC ANALYSIS IS REQUIRED TO DETERMINE CURB INLET FLOW CAPACITY.



ALTERNATE ORIENTATION



CURB INLET DETAIL

INTERNAL PIPE CONFIGURATION MAY VARY
DEPENDING UPON OUTLET LOCATION

filterra
FOR PATENT INFORMATION, GO TO www.ContechES.com/IP

CONTECH
ENGINEERED SOLUTIONS LLC
www.ContechES.com
9100 Centre Pointe Dr., Suite 400, West Chester, OH 45069
800-338-1122 513-645-7000 513-645-7993 FAX

FILTERRA PEAK DIVERSION (FTPD) CONFIGURATION DETAIL

I:\COMMON\CAD\TREATMENT\54 FILTERRA\40 STANDARD DRAWINGS\FTPD - PEAK DIVERSION\FTPD\LAYOUT DETAILS\DWG\FTPD - FILTERRA PEAK DIVERSION CONFIG DTL.DWG 3/17/2023 8:03 AM

Operation & Maintenance (OM) Manual v01

filterra®

Bioretention Systems

CONTECH®
ENGINEERED SOLUTIONS

filterra®
Bioretention Systems

Table of Contents

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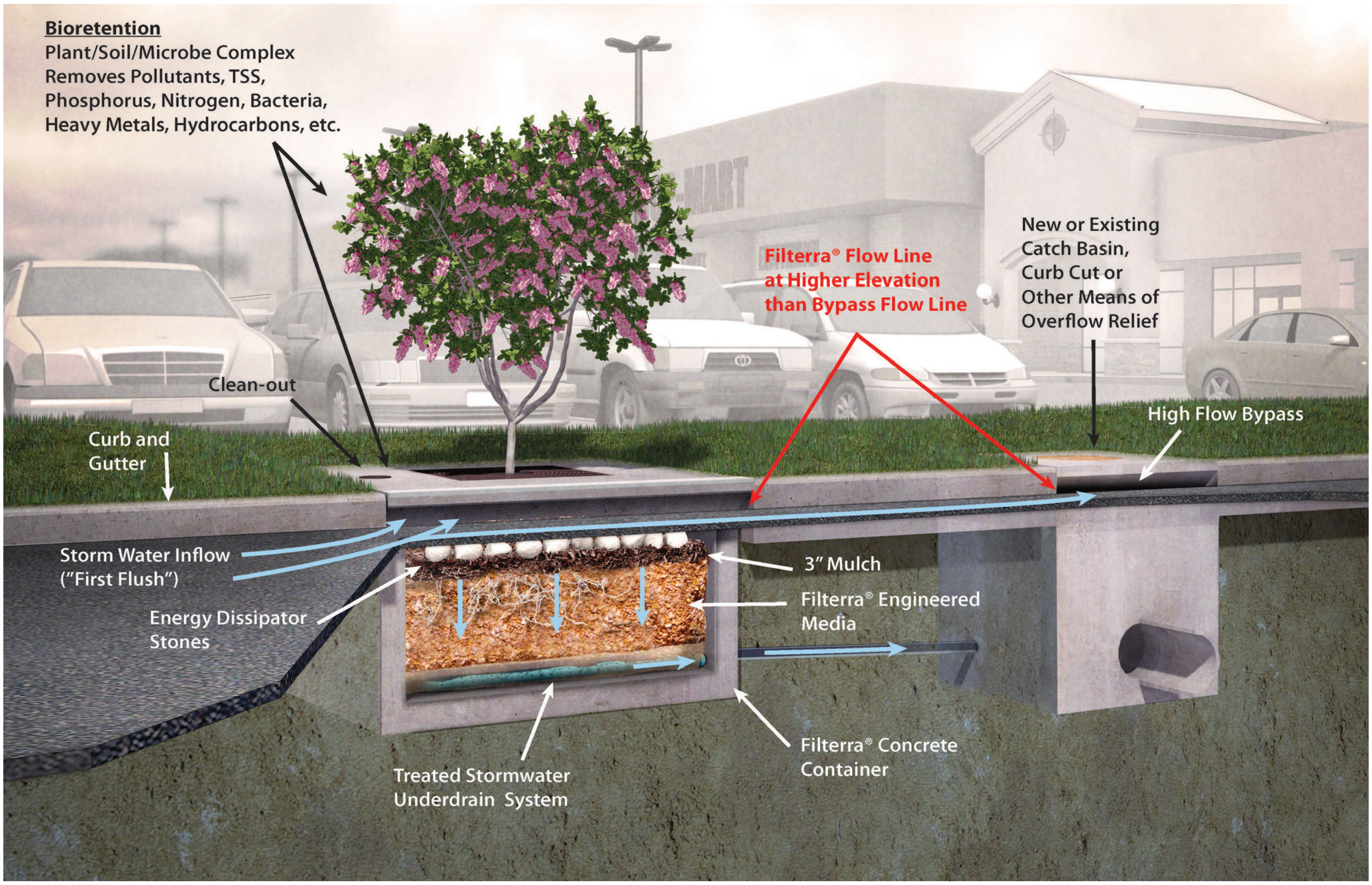
ENGINEERED SOLUTIONS

General Description

The following general specifications describe the general operations and maintenance requirements for the Contech Engineered Solutions LLC stormwater bioretention filtration system, the Filterra®. The system utilizes physical, chemical and biological mechanisms of a soil, plant and microbe complex to remove pollutants typically found in urban stormwater runoff. The treatment system is a fully equipped, pre-constructed drop-in place unit designed for applications in the urban landscape to treat contaminated runoff.



Stormwater flows through a specially designed filter media mixture contained in a landscaped concrete container. The mixture immobilizes pollutants which are then decomposed, volatilized and incorporated into the biomass of the Filterra® system's micro/macro fauna and flora. Stormwater runoff flows through the media and into an underdrain system at the bottom of the container, where the treated water is discharged. Higher flows bypass the Filterra® to a downstream inlet or outfall. Maintenance is a simple, inexpensive and safe operation that does not require confined space access, pumping or vacuum equipment or specialized tools. Properly trained landscape personnel can effectively maintain Filterra® Stormwater systems by following instructions in this manual.

Basic Operations

Filterra® is a bioretention system in a concrete box. Contaminated stormwater runoff enters the filter box through the curb inlet spreading over the 3-inch layer of mulch on the surface of the filter media. As the water passes through the mulch layer, most of the larger sediment particles and heavy metals are removed through sedimentation and chemical reactions with the organic material in the mulch. Water passes through the soil media where the finer particles are removed and other chemical reactions take place to immobilize and capture pollutants in the soil media. The cleansed water passes into an underdrain and flows to a pipe system or other appropriate discharge point. Once the pollutants are in the soil, the bacteria begin to break down and metabolize the materials and the plants begin to uptake and metabolize the pollutants. Some pollutants such as heavy metals, which are chemically bound to organic particles in the mulch, are released over time as the organic matter decomposes to release the metals to the feeder roots of the plants and the cells of the bacteria in the soil where they remain and are recycled. Other pollutants such as phosphorus are chemically bound to the soil particles and released slowly back to the plants and bacteria and used in their metabolic processes. Nitrogen goes through a very complex variety of biochemical processes where it can ultimately end up in the plant/bacteria biomass, turned to nitrogen gas or dissolves back into the water column as nitrates depending on soil temperature, pH and the availability of oxygen. The pollutants ultimately are retained in the mulch, soil and biomass with some passing out of the system into the air or back into the water.

Design and Installation

Each project presents different scopes for the use of Filterra® systems. To ensure the safe and specified function of the stormwater BMP, Contech reviews each application before supply. Information and help may be provided to the design engineer during the planning process. Correct Filterra® box sizing (by rainfall region) is essential to predict pollutant removal rates for a given area. The engineer shall submit calculations for approval by the local jurisdiction. The contractor is responsible for the correct installation of Filterra units as shown in approved plans. A comprehensive installation manual is available at www.conteches.com.

Maintenance

Why Maintain?

All stormwater treatment systems require maintenance for effective operation. This necessity is often incorporated in your property's permitting process as a legally binding BMP maintenance agreement.

- Avoid legal challenges from your jurisdiction's maintenance enforcement program.
- Prolong the expected lifespan of your Filterra media.
- Avoid more costly media replacement.
- Help reduce pollutant loads leaving your property.

Simple maintenance of the Filterra® is required to continue effective pollutant removal from stormwater runoff before discharge into downstream waters. This procedure will also extend the longevity of the living biofilter system. The unit will recycle and accumulate pollutants within the biomass, but is also subjected to other materials entering the throat. This may include trash, silt and leaves etc. which will be contained within the void below the top grate and above the mulch layer. Too much silt may inhibit the Filterra's® flow rate, which is the reason for site stabilization before activation. Regular replacement of the mulch stops accumulation of such sediment.

When to Maintain?

Contech includes a 1-year maintenance plan with each system purchase. Annual included maintenance consists of a maximum of two (2) scheduled visits. Additional maintenance may be necessary depending on sediment and trash loading (by Owner or at additional cost). The start of the maintenance plan begins when the system is activated for full operation. Full operation is defined as the unit installed, curb and gutter and transitions in place and activation (by Supplier) when mulch and plant are added and temporary throat protection removed.

Activation cannot be carried out until the site is fully stabilized (full landscaping, grass cover, final paving and street sweeping completed). Maintenance visits are scheduled seasonally; the spring visit aims to clean up after winter loads including salts and sands while the fall visit helps the system by removing excessive leaf litter.

It has been found that in regions which receive between 30-50 inches of annual rainfall, (2) two visits are generally required; regions with less rainfall often only require (1) one visit per annum. Varying land uses can affect maintenance frequency; e.g. some fast food restaurants require more frequent trash removal. Contributing drainage areas which are subject to new development wherein the recommended erosion and sediment control measures have not been implemented may require additional maintenance visits.

Some sites may be subjected to extreme sediment or trash loads, requiring more frequent maintenance visits. This is the reason for detailed notes of maintenance actions per unit, helping the Supplier and Owner predict future maintenance frequencies, reflecting individual site conditions.

Owners must promptly notify the (maintenance) Supplier of any damage to the plant(s), which constitute(s) an integral part of the bioretention technology. Owners should also advise other landscape or maintenance contractors to leave all maintenance to the Supplier (i.e. no pruning or fertilizing).

Exclusion of Services

It is the responsibility of the owner to provide adequate irrigation when necessary to the plant of the Filterra® system.

Clean up due to major contamination such as oils, chemicals, toxic spills, etc. will result in additional costs and are not covered under the Supplier maintenance contract. Should a major contamination event occur the Owner must block off the outlet pipe of the Filterra® (where the cleaned runoff drains to, such as drop inlet) and block off the throat of the Filterra®. The Supplier should be informed immediately.

Maintenance Visit Summary

Each maintenance visit consists of the following simple tasks (detailed instructions below).

1. Inspection of Filterra® and surrounding area
2. Removal of tree grate and erosion control stones
3. Removal of debris, trash and mulch
4. Mulch replacement
5. Plant health evaluation and pruning or replacement as necessary
6. Clean area around Filterra®
7. Complete paperwork

Maintenance Tools, Safety Equipment and Supplies

Ideal tools include: camera, bucket, shovel, broom, pruners, hoe/rake, and tape measure. Appropriate Personal Protective Equipment (PPE) should be used in accordance with local or company procedures. This may include impervious gloves where the type of trash is unknown, high visibility clothing and barricades when working in close proximity to traffic and also safety hats and shoes. A T-Bar or crowbar should be used for moving the tree grates (up to 170 lbs ea.). Most visits require minor trash removal and a full replacement of mulch. See below for actual number of bagged mulch that is required in each unit size. Mulch should be a double shredded, hardwood variety; do not use colored or dyed mulch. Some visits may require additional Filterra® engineered soil media available from the Supplier.

Box Length	Box Width	Filter Surface Area (ft^2)	Volume at 3" (ft^3)	# of 2 ft^3 Mulch Bags
4	4	4	4	2
6	4	6	6	3
8	4	8	8	4
6	6	9	9	5
8	6	12	12	6
10	6	15	15	8
12	6	18	18	9
13	7	23	23	12

Maintenance Visit Procedure

Keep sufficient documentation of maintenance actions to predict location specific maintenance frequencies and needs. An example Maintenance Report is included in this manual.

1. Inspection of Filterra® and surrounding area

- Record individual unit before maintenance with photograph (numbered). Record on Maintenance Report (see example in this document) the following:

Record on Maintenance Report the following:

Standing Water	yes | no
Damage to Box Structure	yes | no
Damage to Grate	yes | no
Is Bypass Clear	yes | no

If yes answered to any of these observations, record with close-up photograph (numbered).

2. Removal of tree grate and erosion control stones

- Remove cast iron grates for access into Filterra® box.
- Dig out silt (if any) and mulch and remove trash & foreign items.

Record on Maintenance Report the following:

Silt/Clay	yes | no
Cups/ Bags	yes | no
Leaves	yes | no
# of Buckets Removed	________

3. Removal of debris, trash and mulch

- After removal of mulch and debris, measure distance from the top of the Filterra® engineered media soil to the bottom of the top slab. If this distance is greater than 12", add Filterra® media (not top soil or other) to recharge to a 9" distance

Record on Maintenance Report the following:

Distance of Bottom of Top Slab (inches)	________
# of Buckets of Media Added	________

4. Mulch replacement

- Please see mulch specifications.
- Add double shredded mulch evenly across the entire unit to a depth of 3”.
- Ensure correct repositioning of erosion control stones by the Filterra® inlet to allow for entry of trash during a storm event.
- Replace Filterra® grates correctly using appropriate lifting or moving tools, taking care not to damage the plant.

5. Plant health evaluation and pruning or replacement as necessary

- Examine the plant’s health and replace if dead.
- Prune as necessary to encourage growth in the correct directions

Record on Maintenance Report the following:

Height above Grate	(Feet)
Width at Widest Point	(feet)
Health	alive | dead
Damage to Plant	yes | no
Plant Replaced	yes | no

6. Clean area around Filterra®

- Clean area around unit and remove all refuse to be disposed of appropriately.

7. Complete paperwork

- Deliver Maintenance Report and photographs to appropriate location (normally Contech during maintenance contract period).
- Some jurisdictions may require submission of maintenance reports in accordance with approvals. It is the responsibility of the Owner to comply with local regulations.

Maintenance Checklist

Drainage System Failure	Problem	Conditions to Check	Condition that Should Exist	Actions
Inlet	Excessive sediment or trash accumulation.	Accumulated sediments or trash impair free flow of water into Filterra.	Inlet should be free of obstructions allowing free distributed flow of water into Filterra.	Sediments and/or trash should be removed.
Mulch Cover	Trash and floatable debris accumulation.	Excessive trash and/or debris accumulation.	Minimal trash or other debris on mulch cover.	Trash and debris should be removed and mulch cover raked level. Ensure bark nugget mulch is not used.
Mulch Cover	"Ponding" of water on mulch cover.	"Ponding" in unit could be indicative of clogging due to excessive fine sediment accumulation or spill of petroleum oils.	Stormwater should drain freely and evenly through mulch cover.	Recommend contact manufacturer and replace mulch as a minimum.
Vegetation	Plants not growing or in poor condition.	Soil/mulch too wet, evidence of spill. Incorrect plant selection. Pest infestation. Vandalism to plants.	Plants should be healthy and pest free.	Contact manufacturer for advice.
Vegetation	Plant growth excessive.	Plants should be appropriate to the species and location of Filterra.		Trim/prune plants in accordance with typical landscaping and safety needs.
Structure	Structure has visible cracks.	Cracks wider than 1/2 inch or evidence of soil particles entering the structure through the cracks.		Vault should be repaired.
Maintenance is ideally to be performed twice annually.				

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