Drainage Report

Stormwater Infiltration Gallery

for

United Parcel Service – Tumwater

(UIC 23315)

7383 New Market Street SW
Tumwater, WA 98501

Prepared By:

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Joseph M. Hopper, P.E.

December 12, 2012 PED Job No. 12026

Facility:
UPS-Tumwater (WATUM)

WSDOE Underground Injection Control (UIC) Site Number:
23315

Facility Address:
7383 New Market Street SW, Tumwater, WA 98501

County:
Thurston

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Report Status:
Final

TABLE OF CONTENTS

- StormTech® MC-3500 Design Manual.
- StormTech® MC-3500 Technical Specifications
- StormTech® MC-3500 Construction Guide
- StormTech® Isolator™ Row O&M Manual
- Contech® CDS® Guide: Operation, Design, Performance and Maintenance
- Contech® CDS® CDS2015-4 Standard Detail
- Contech® CDS® Inspection and Maintenance Guide
- Contech® Storm Water Treatment Device Specifications
- Geotechnical Engineering Report, Geotech Consultants, Inc. Dated: 10/18/12.
- City of Tumwater Drainage Design & Erosion Control Manual, Appendix III-A, Methods for Determining Design Infiltration Rates.
- City of Tumwater Drainage Design & Erosion Control Manual, Appendix V-C, Maintenance Guidelines.
    - Table C-4. Maintenance Checklist for Infiltration Basins, Infiltration Trenches, and Bioinfiltration Swale.
    - Table C-13. Maintenance Checklist for Catch Basins and Inlets.
    - Table C-14. Maintenance Checklist for Energy Dissipators.

I. Project Overview

The site is located northwest of the Port of Olympia Airport. The site is more specifically located at 7383 New Market Street SW in Tumwater, Washington. The site is leased from the Port of Olympia by United Parcel Service to house a package distribution facility.

The goal of this project is to replace the infiltration gallery that infiltrates the storm water runoff from the western portion of the site with a new system.

The existing infiltration gallery appears to not work effectively at certain times during the rainy season. The gallery pipes may be plugged with sediment due to the age of the system and lack of proper maintenance. Storm water backs up into the parking lot during some storm events.

The site has been registered with the Washington State Department of Ecology (WSDOE) Underground Injection Control (UIC) Program. UIC Registration with WSDOE took place in 2004 and the site is listed as UIC site number 23315.

Existing Site Conditions

The site is located between Tumwater Boulevard (Airdustrial Way) and 73rd Ave SW, west of New Market Street SW. The site drains in two directions and can be defined as two separate basins, East and West. The eastern third of the site drains to the east toward New Market Street SW. The western two-thirds of the site drain to the west.

East Basin:
The eastern portion of the building's roof drains to the east and flows through downspouts that discharge onto the parking surface in front of the building. The surface drainage flows away from the building to the east to a landscape strip between the parking lot and New Market Street. The drainage flows to an existing drywell and is infiltrated into the ground. No improvements are proposed in this basin area.

West Basin:
The western portion of the building's roof drains to the west and flows through downspouts that discharge onto the parking surface. The surface drainage flows away from the building and generally to the west. Surface drainage is collected in two catch basins to the west of the building in the middle of the parking lot. CB1 and CB2 collect all the surface runoff in the west basin and convey the drainage to the north through a system of underground pipes. The pipes are routed through an oil/water separator and continue to the north to the infiltration gallery located north of the parking lot in a landscape area.

Fueling Area:
The fueling area roof drains through a downspout that discharges to the west through an underground pipe that is connected to CB1. The fueling area pavement surface is isolated from

the rest of the parking lot and is collected in a catch basin located to the east of the fuel pumps. The drainage is conveyed to the east through an underground pipe that is routed through an oil/water separator. The flow continues to the east and connects to the Sanitary Sewer system. Surface runoff from the fueling area does not flow to the above mentioned infiltration gallery.

Infiltration Gallery:
The existing infiltration gallery identified in a site visit on August 24, 2012, is two parallel 8-inch perforated PVC pipes that run east-west. The gallery is located directly behind the northerly curb line in the northwest landscape area. Pipe ends of two 8-inch pipes were located approximately 100-feet west of the northwest corner of the building. It appears that these pipe ends are the east end of the infiltration gallery. It could not be determined where the west end of the gallery is located, nor the extents of the gallery trench. No records have been found to further identify the dimensions of the existing gallery.

Proposed Infiltration and Water Quality Facility

Infiltration Gallery:
An underground infiltration gallery system underneath the landscape area in the northwestern portion of the site will be used to discharge stormwater runoff into the ground. The existing infiltration gallery will be removed and replaced with a new system. The proposed system includes 27 StormTech® MC-3500 chambers. The first series of chambers will be wrapped in filter fabric to create an "Isolator Row", a proprietary water quality treatment element incorporating the StormTech® chambers, to remove sediment from the stormwater prior to infiltration.

CDS® Hydrodynamic Separator:
After the stormwater flows through the existing oil/water separator and prior to discharging to the proposed infiltration gallery, the stormwater will be routed through a Contech® CDS® Hydrodynamic Separator. This water quality element utilizes a patented continuous deflective separation technology to screen, separate and trap debris, sediment, and oil and grease from the stormwater runoff.

II. Flow Control and Water Quality Analysis

Hydraulic Analysis

The design for the proposed infiltration facility utilizes City of Tumwater drainage analysis standards. This requires using a continuous flow model such as the Western Washington Hydrology Model (WWHM).

Existing Conditions:
The total basin area for the West Basin is 1.53-acres. Existing site conditions as modeled reflect the pre-developed historic condition of the site. The calculations assume existing site conditions to be forested.

Existing condition:
Total Area = 1.53 acres
Impervious Area = 0.00 acres
Pervious Area (A/B Forest Flat) = 1.53 acres

Existing peak runoff rates:
Q_2 year = 0.0019 cfs.
Q_{10} year = 0.007 cfs.
Q_{100} year = 0.078 cfs.

Developed Conditions:
Developed site conditions as modeled reflect the current developed condition of the site. The proposal is to replace the existing infiltration facility with a new facility, no other new development activities are proposed.

Developed condition drainage area to proposed StormTech® chamber infiltration system:
Total Area = 1.53 acres
Impervious Area (Parking) = 1.20 acres
Impervious Area (Roof Flat) = 0.30 acres
Pervious Area (A/B Lawn Flat) = 0.03 acres

Developed peak runoff rates before infiltration:
Q_2 year = 0.050 cfs.
Q_{10} year = 0.096 cfs.
Q_{100} year = 0.186 cfs.

Infiltration Facility Design

The infiltration facility has been sized to detain up to the 100-year storm event in accordance with City of Tumwater drainage standards.

Washington State Department of Ecology's Western Washington Hydrology Model (WWHM) program was used to calculate the runoff rates and size the infiltration facility. Design infiltration rate used was 10in/hr. (see Geotechnical Engineering Report, Geotech Consultants, Inc., Dated: 10/18/12 in the appendix)

StormTech® Chamber Detention/Infiltration System:
Based on the calculations the live storage required for detention prior to infiltration is 5,174 cubic feet in accordance with WWHM modeling requirements in the 2009 DOE Stormwater Manual. The proposed system includes 27 StormTech® MC-3500 chambers (total 2 rows, 1 isolator row, 1 standard row) and a 120'Lx15'Wx5.5'H infiltration trench. The proposed design will provide at least 5,294 cubic feet of live storage (including storage in the trench, manifold pipes and manholes) between elevations 183.50 to 189.00'. (See WWHM Project Report and StormTech® Provided Calculations in the Appendix)

Water Quality Facility Design

Water Quality Volumes:

Water Quality Design Storm Volume per City of Tumwater's 2009 Drainage Design & Erosion Control Manual, Volume III, Chapter 2.1.3.:

> ***Preceding detention facilities or when detention facilities are not required:*** *The flow rate at or below which 91 percent of the runoff volume, as estimated by an approved continuous runoff model, shall be used as the design flow rate.*

Q_{100} year = 0.186 cfs x 91% = 0.169 cfs

The existing stormwater system will be intercepted prior to discharging to the StormTech® Chamber detention/infiltration system. Stormwater flows will be directed through a Contech® CDS® CDS2015-4 hydrodynamic separator.

Contech® CDS® Stormwater Treatment System:
Stormwater enters the diversion chamber where the diversion weir guides the flow into the unit's separation chamber and pollutants are removed from the flow. All flows up to the system's treatment design capacity enter the separation chamber and are treated. Swirl concentration and screen deflection force floatables and solids to the center of the separation chamber where 100% of floatables and neutrally buoyant debris larger than the screen apertures are trapped. Stormwater then moves through the separation screen, under the oil baffle and exits the system. The separation screen remains clog free due to continuous deflection. During the flow events

exceeding the design capacity, the diversion weir bypasses excessive flows around the separation chamber, so captured pollutants are retained in the separation cylinder.

The maximum treatment capacity of the CDS separator specified above is 0.7cfs. The calculated 100 year storm event is 0.186cfs, so the CDS separator can convey the maximum flow rate from the site. The diversion weir in the CDS Separator will be sized to treat the Water Quality Treatment Volume of 0.169cfs and will safely convey or bypass flows greater than the 100 year peak flows.

III. Temporary Erosion and Sedimentation Control

Erosion and sedimentation control will be provided by utilizing BMPs selected from the 2010 City of Tumwater Drainage Design & Erosion Control Manual. These BMPs include, but are not necessarily limited to, silt fencing around the limits of construction, construction safety fencing as needed, plastic sheeting of stockpiles, straw mulch, hydro-seeding, and catch basin protection to prevent migration of soils from the construction area to surrounding catch basins.

A Temporary Sedimentation and Erosion Control Plan is included as part of the final construction documents detailing the means by which sediment and erosion control will be handled during construction. Notes, details and maintenance specifications of all BMPs are included on the plans.

Appendix

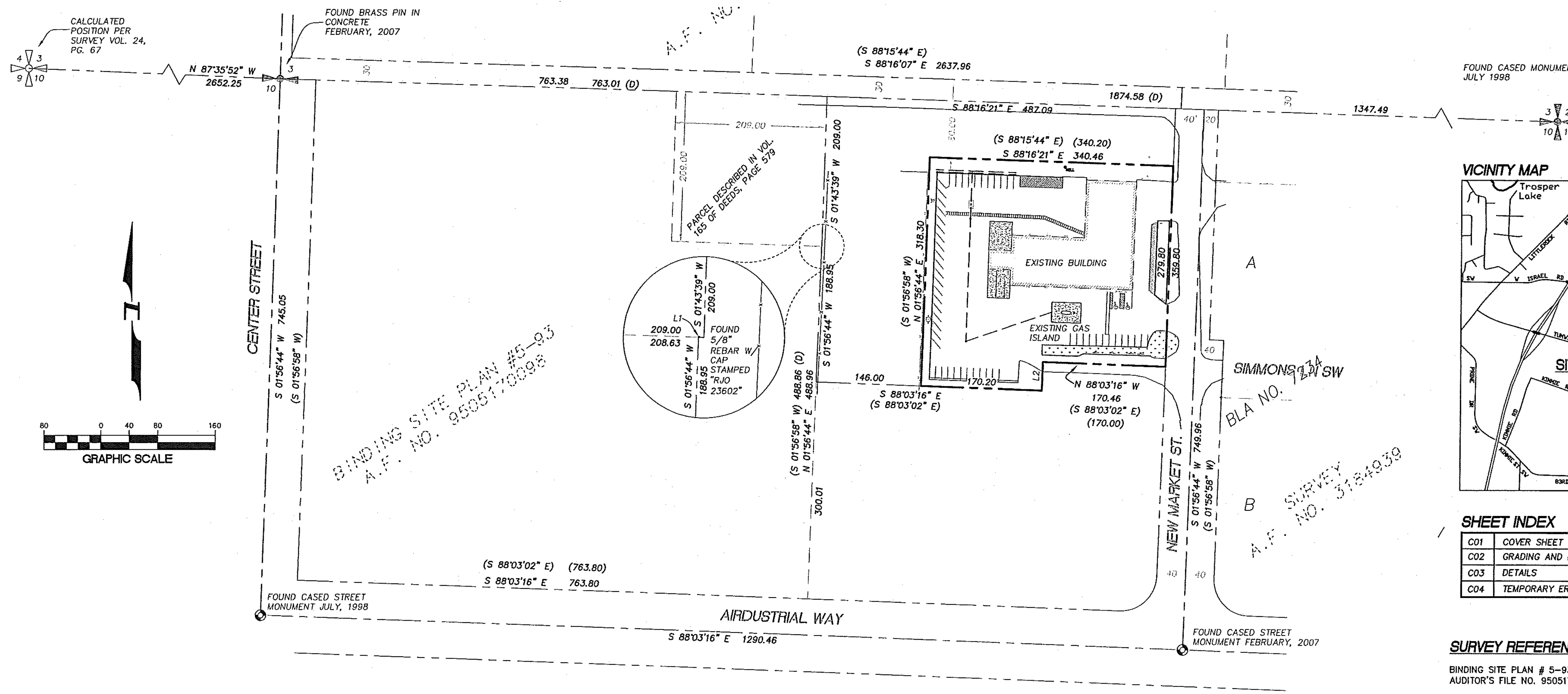
REVISIONS:

SW 1/4, SW 1/4 SEC. 10, T. 17 N., R. 2 W., W.M.

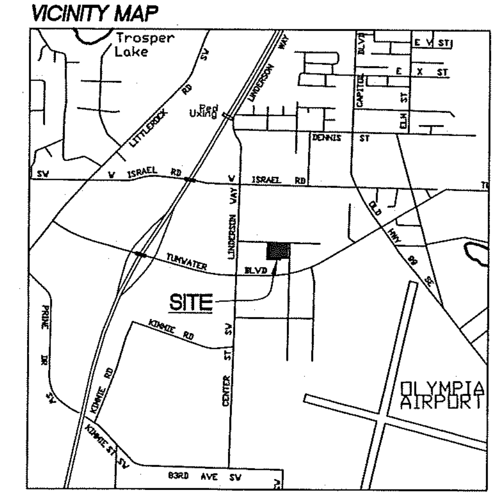
TUMWATER UPS

TUMWATER, WA

(PROJECT NO. 12026)



VICINITY MAP



SHEET INDEX

C01	COVER SHEET
C02	GRADING AND DRAINAGE
C03	DETAILS
C04	TEMPORARY EROSION AND SEDIMENTATION CONTROL PLAN

SURVEY REFERENCES:

BINDING SITE PLAN # 5-93 AS RECORDED MAY 17, 1995 UNDER AUDITOR'S FILE NO. 9505170098

BASIS OF BEARING:

CITY OF TUMWATER COORDINATE SYSTEM BASED UPON THE NORTH LINE OF THE NORTHEAST QUARTER OF SECTION 10, TOWNSHIP 17 NORTH, RANGE 2 WEST, W.M. EQUALS SOUTH 88°16'21" EAST

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ISSUE DATE: 12/12/12
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COVER SHEET

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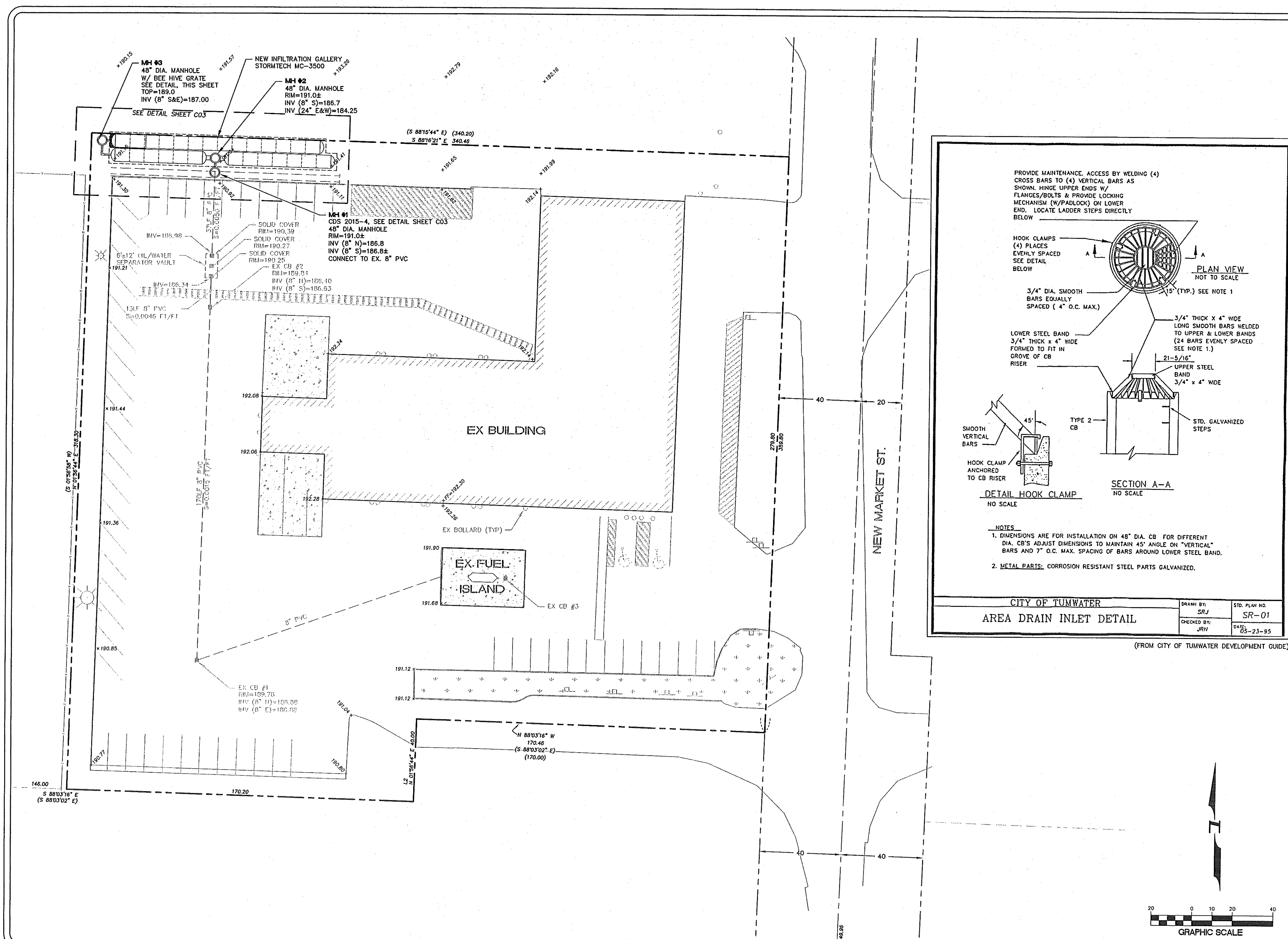
C01

SHEET 01 OF 04

REVISIONS:



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GRADING AND DRAINAGE

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SHEET 02 OF 04

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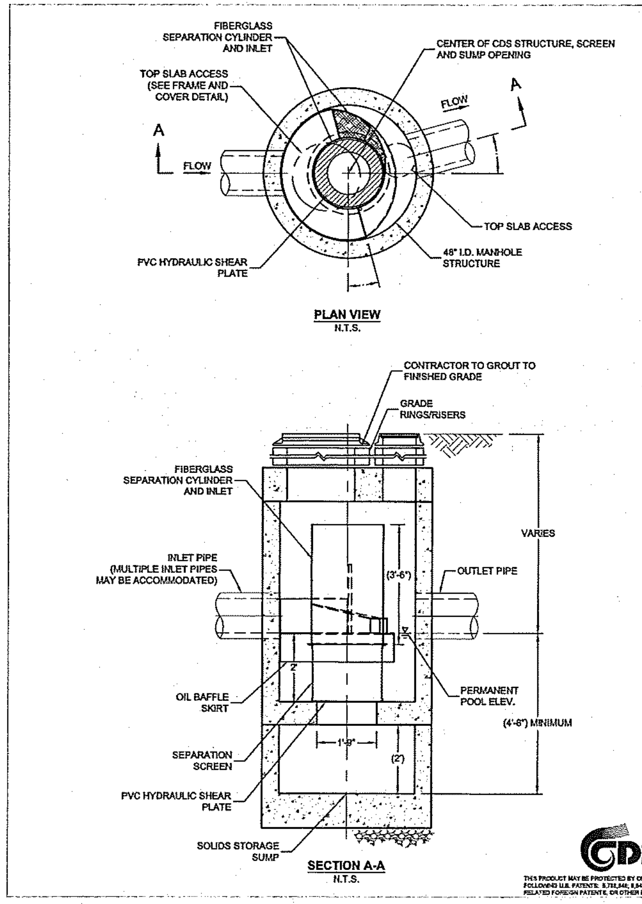


CDS2015-4 DESIGN NOTES

CDS2015-4 RATED TREATMENT CAPACITY IS 0.7 CFS, OR PER LOCAL REGULATIONS. MAXIMUM HYDRAULIC INTERNAL BYPASS CAPACITY IS 10.0 CFS. IF THE SITE CONDITIONS EXCEED 10.0 CFS, AN UPSTREAM BYPASS STRUCTURE IS REQUIRED.

THE STANDARD CDS2015-4 CONFIGURATION IS SHOWN. ALTERNATE CONFIGURATIONS ARE AVAILABLE AND ARE LISTED BELOW. SOME CONFIGURATIONS MAY BE COMBINED TO SUIT SITE REQUIREMENTS.

DESIGNATION (MODEL SUFFIX)	CONFIGURATION DESCRIPTION
G	GRATED INLET ONLY (NO INLET PIPE)
GP	GRATED INLET WITH INLET PIPE OR PIPES
K	CURB INLET ONLY (NO INLET PIPE)
KP	CURB INLET WITH INLET PIPE OR PIPES

SITE SPECIFIC DATA REQUIREMENTS

STRUCTURE ID			MH #1
WATER QUALITY FLOW RATE (CFS)			0.169
PEAK FLOW RATE (CFS)			0.186
RETURN PERIOD OF PEAK FLOW (YRS)			100
SCREEN APERTURE (2400 OR 4700)			2400
PIPE DATA:	I.E.	MATERIAL	DIAMETER
INLET PIPE 1	186.8	PVC	8"
INLET PIPE 2	*	*	*
OUTLET PIPE	186.8	ADS N-12	8"
RIM ELEVATION			191.0
ANTI-FLOTATION BALLAST		WIDTH	HEIGHT
		*	*
NOTES/SPECIAL REQUIREMENTS:			

* PER ENGINEER OF RECORD

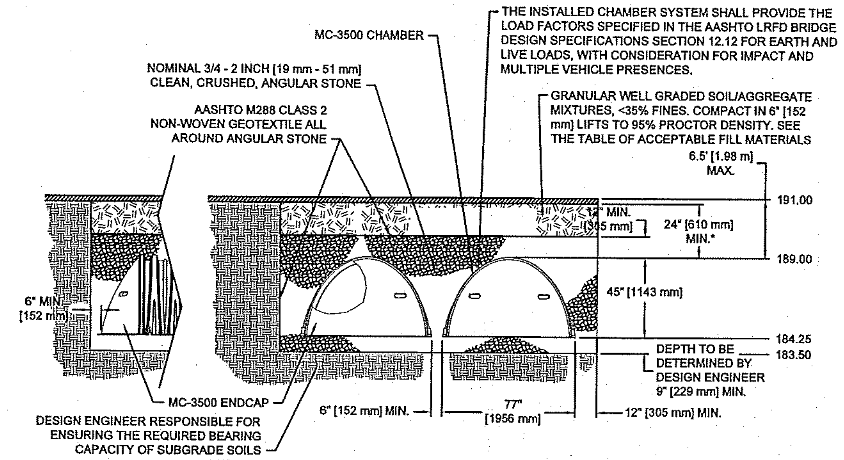
GENERAL NOTES

1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. DIMENSIONS MARKED WITH ( ) ARE REFERENCE DIMENSIONS. ACTUAL DIMENSIONS MAY VARY.
3. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR CONTECH STORMWATER SOLUTIONS REPRESENTATIVE. www.contechstormwater.com
4. CDS WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
5. STRUCTURE AND CASTINGS SHALL MEET AASHTO HS20 LOAD RATING.
6. PVC HYDRAULIC SHEAR PLATE IS PLACED ON SHELF AT BOTTOM OF SCREEN CYLINDER. REMOVE AND REPLACE AS NECESSARY DURING MAINTENANCE CLEANING.

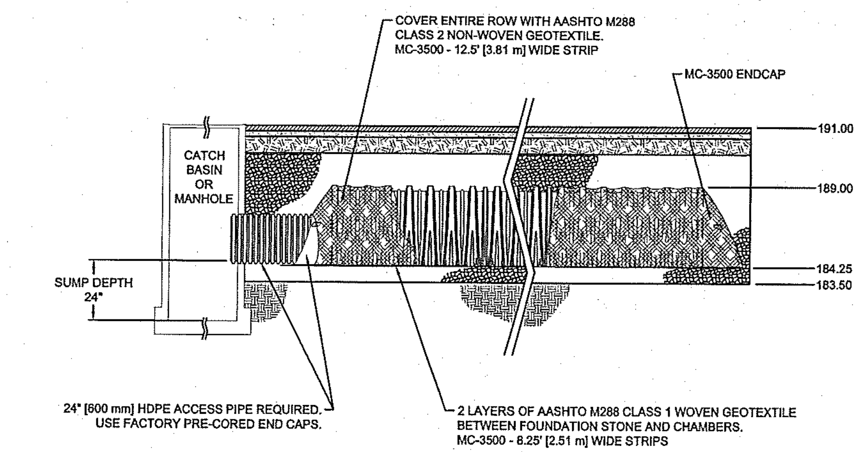
INSTALLATION NOTES

1. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
2. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE CDS MANHOLE STRUCTURE (LIFTING CLUTCHES PROVIDED).
3. CONTRACTOR TO ADD JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS, AND ASSEMBLE STRUCTURE.
4. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES. MATCH PIPE INVERTS WITH ELEVATIONS SHOWN.
5. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

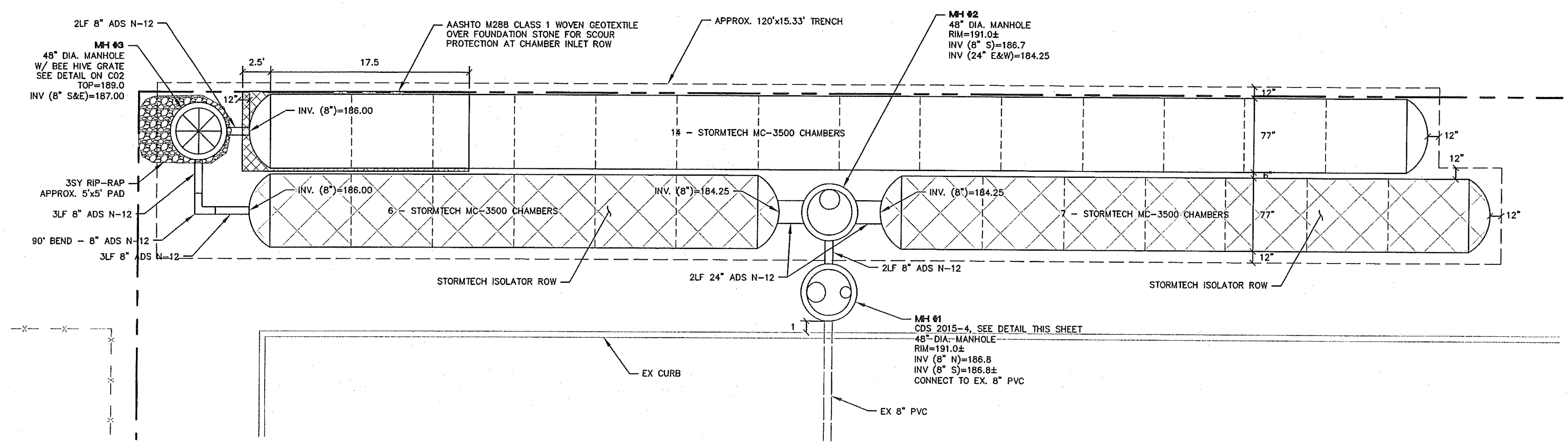
CDS2015-4
PRECAST CONCRETE WATER QUALITY SYSTEM
STANDARD DETAIL



STORMTECH MC-3500 - CROSS SECTION DETAIL
NTS



ISOLATOR ROW DETAIL
NTS



STORMTECH MC-3500 - PLAN VIEW DETAIL
SCALE: 1"=5'

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DETAILS

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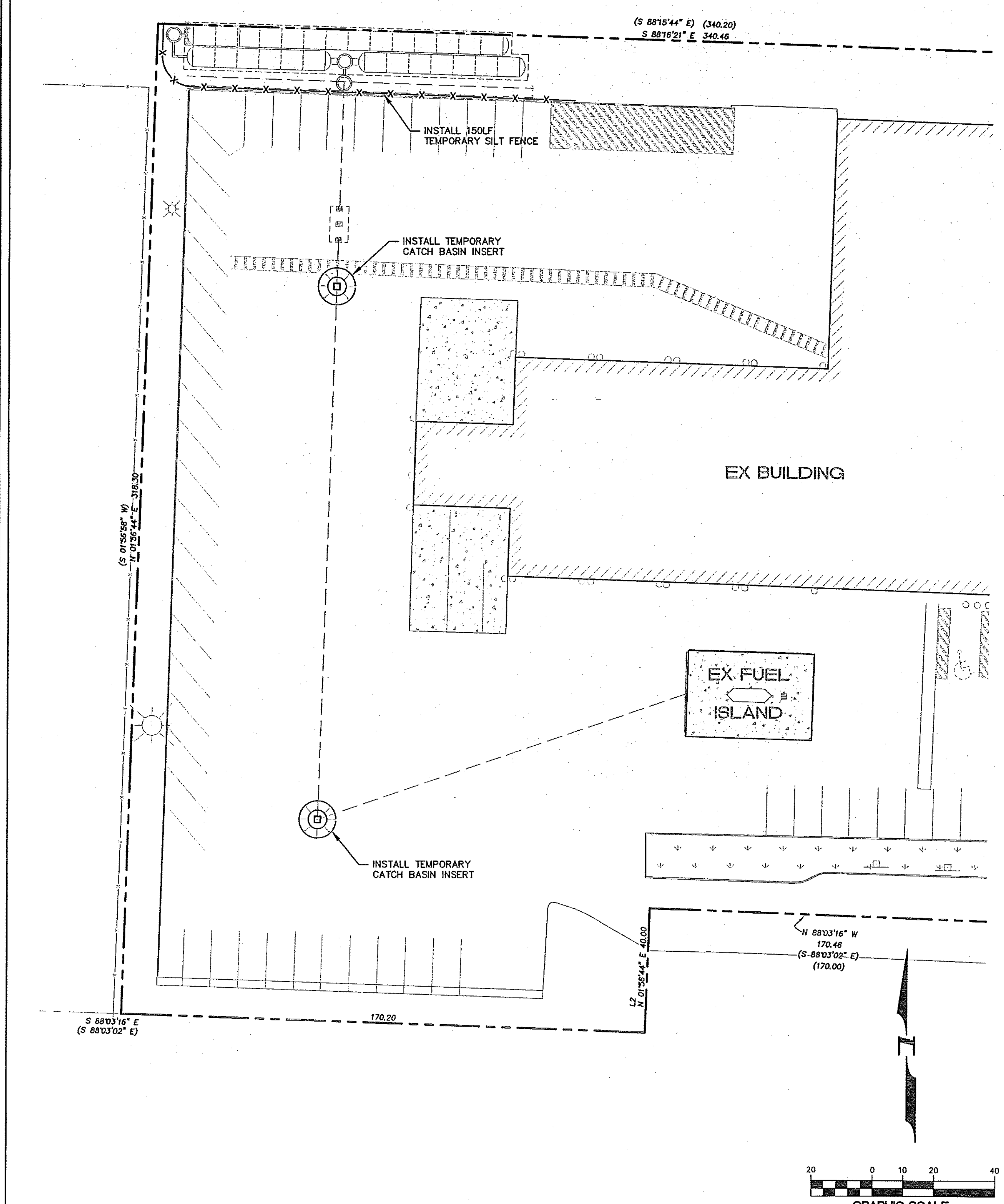
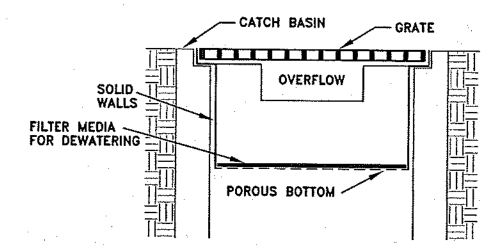




NOTE: THIS DETAIL IS ONLY SCHEMATIC. ANY INSERT IS ALLOWED THAT HAS A MIN. 0.5 C.F. OF STORAGE, THE MEANS TO DEWATER THE STORED SEDIMENT, AN OVERFLOW, AND CAN BE EASILY MAINTAINED.

CATCH BASIN INSERT

NTS

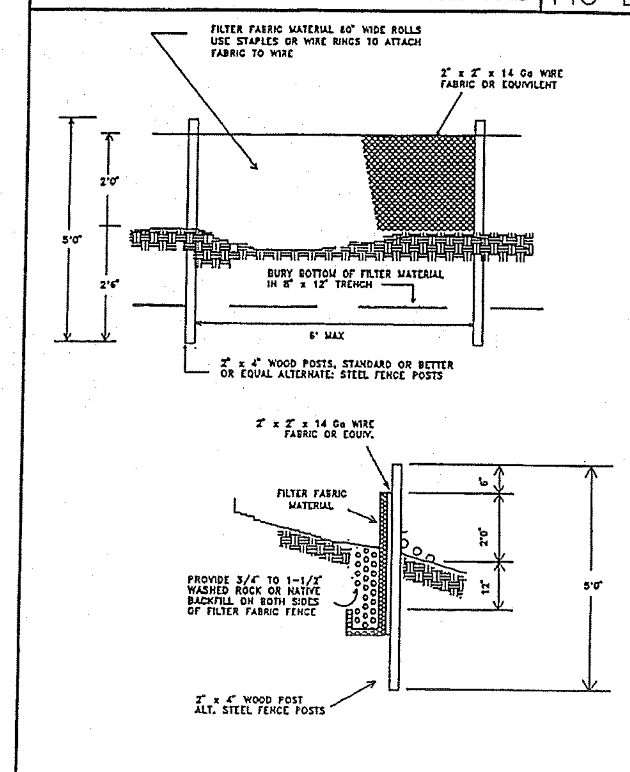
TEMPORARY EROSION AND SEDIMENT CONTROL STANDARD NOTES:

1. APPROVAL OF THIS EROSION/SEDIMENTATION CONTROL (ESC) PLAN DOES NOT CONSTITUTE AN APPROVAL OF PERMANENT ROAD OR DRAINAGE DESIGN (E.G. SIZE AND LOCATION OF ROADS, PIPES, RESTRICTORS, CHANNELS, RETENTION FACILITIES, UTILITIES, ETC.).
2. THE IMPLEMENTATION OF THESE ESC PLANS AND THE CONSTRUCTION, MAINTENANCE, REPLACEMENT, AND UPGRADING OF THESE ESC FACILITIES IS THE RESPONSIBILITY OF THE APPLICANT/CONTRACTOR UNTIL ALL CONSTRUCTION IS COMPLETED AND APPROVED AND VEGETATION/LANDSCAPING IS ESTABLISHED.
3. THE BOUNDARIES OF THE CLEARING LIMITS SHOWN ON THIS PLAN SHALL BE CLEARLY FLAGGED IN THE FIELD PRIOR TO CONSTRUCTION. DURING THE CONSTRUCTION PERIOD, NO DISTURBANCE BEYOND THE FLAGGED CLEARING LIMITS SHALL BE PERMITTED. THE FLAGGING SHALL BE MAINTAINED BY THE APPLICANT/CONTRACTOR FOR THE DURATION OF CONSTRUCTION.
4. THE ESC FACILITIES SHOWN ON THIS PLAN MUST BE CONSTRUCTED IN CONJUNCTION WITH ALL CLEARING AND GRADING ACTIVITIES, AND IN SUCH A MANNER AS TO INSURE THAT SEDIMENT AND SEDIMENT LADEN WATER DO NOT ENTER THE DRAINAGE SYSTEM, ROADWAYS, OR VIOLATE APPLICABLE WATER STANDARDS.
5. THE ESC FACILITIES SHOWN ON THIS PLAN ARE THE MINIMUM REQUIREMENTS FOR ANTICIPATED SITE
6. CONDITIONS. DURING THE CONSTRUCTION PERIOD, THESE ESC FACILITIES SHALL BE UPGRADED AS NEEDED FOR UNEXPECTED STORM EVENTS AND TO ENSURE THAT SEDIMENT AND SEDIMENT-LADEN WATER DO NOT LEAVE THE SITE.
7. THE ESC FACILITIES SHALL BE INSPECTED DAILY BY THE APPLICANT/CONTRACTOR AND MAINTAINED AS NECESSARY TO ENSURE THEIR CONTINUED FUNCTIONING.
8. THE ESC FACILITIES ON INACTIVE SITES SHALL BE INSPECTED AND MAINTAINED A MINIMUM OF ONCE A MONTH OR WITHIN THE 48 HOURS FOLLOWING A MAJOR STORM EVENT.
9. AT NO TIME SHALL MORE THAN ONE FOOT OF SEDIMENT BE ALLOWED TO ACCUMULATE WITHIN A TRAPPED CATCH BASIN. ALL CATCH BASINS AND CONVEYANCE LINES SHALL BE CLEANED PRIOR TO PAVING. THE CLEANING OPERATION SHALL NOT FLUSH SEDIMENT LADEN WATER INTO THE DOWNSTREAM SYSTEM.
10. STABILIZED CONSTRUCTION ENTRANCES SHALL BE INSTALLED AT THE BEGINNING OF CONSTRUCTION AND MAINTAINED FOR THE DURATION OF THE PROJECT. ADDITIONAL MEASURES MAY BE REQUIRED TO INSURE THAT ALL PAVED AREAS ARE KEPT CLEAN FOR THE DURATION OF THE PROJECT.

CONSTRUCTION SEQUENCE:

1. PRE-CONSTRUCTION MEETING.
2. FLAG OR FENCE CLEARING LIMITS.
3. INSTALL CATCH BASIN PROTECTION IF REQUIRED.
4. INSTALL PERIMETER PROTECTION (SILT FENCE, BRUSH BARRIER, ETC.).
5. MAINTAIN EROSION CONTROL MEASURES IN ACCORDANCE WITH KING COUNTY STANDARDS AND MANUFACTURER'S RECOMMENDATIONS.
6. RELOCATE EROSION CONTROL MEASURES OR INSTALL NEW MEASURES SO THAT AS SITE CONDITIONS CHANGE THE EROSION AND SEDIMENT CONTROL IS ALWAYS IN ACCORDANCE WITH THE CITY OF TUMWATER EROSION AND SEDIMENT CONTROL STANDARDS.
7. COVER ALL AREAS THAT WILL BE UNWORKED FOR MORE THAN SEVEN DAYS DURING THE DRY SEASON OR TWO DAYS DURING THE WET SEASON WITH STRAW, WOOD FIBER MULCH, COMPOST, PLASTIC SHEETING OR EQUIVALENT.
8. STABILIZE ALL AREAS THAT REACH FINAL GRADE WITHIN SEVEN DAYS.
9. SEED OR SOD ANY AREAS TO REMAIN UNWORKED FOR MORE THAN 30 DAYS.
10. UPON COMPLETION OF THE PROJECT, ALL DISTURBED AREAS MUST BE STABILIZED AND BMPS REMOVED IF APPROPRIATE.

STORM DRAINAGE DESIGN MANUAL | FIG B2



REFERENCE:
KING COUNTY, WASHINGTON, SURFACE WATER DESIGN MANUAL

DATE:
FEB. 1991

FILTER FABRIC FENCE DETAIL

(FROM CITY OF TUMWATER DEVELOPMENT GUIDE)

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TUMWATER UPS

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TEMPORARY EROSION AND SEDIMENTATION CONTROL PLAN

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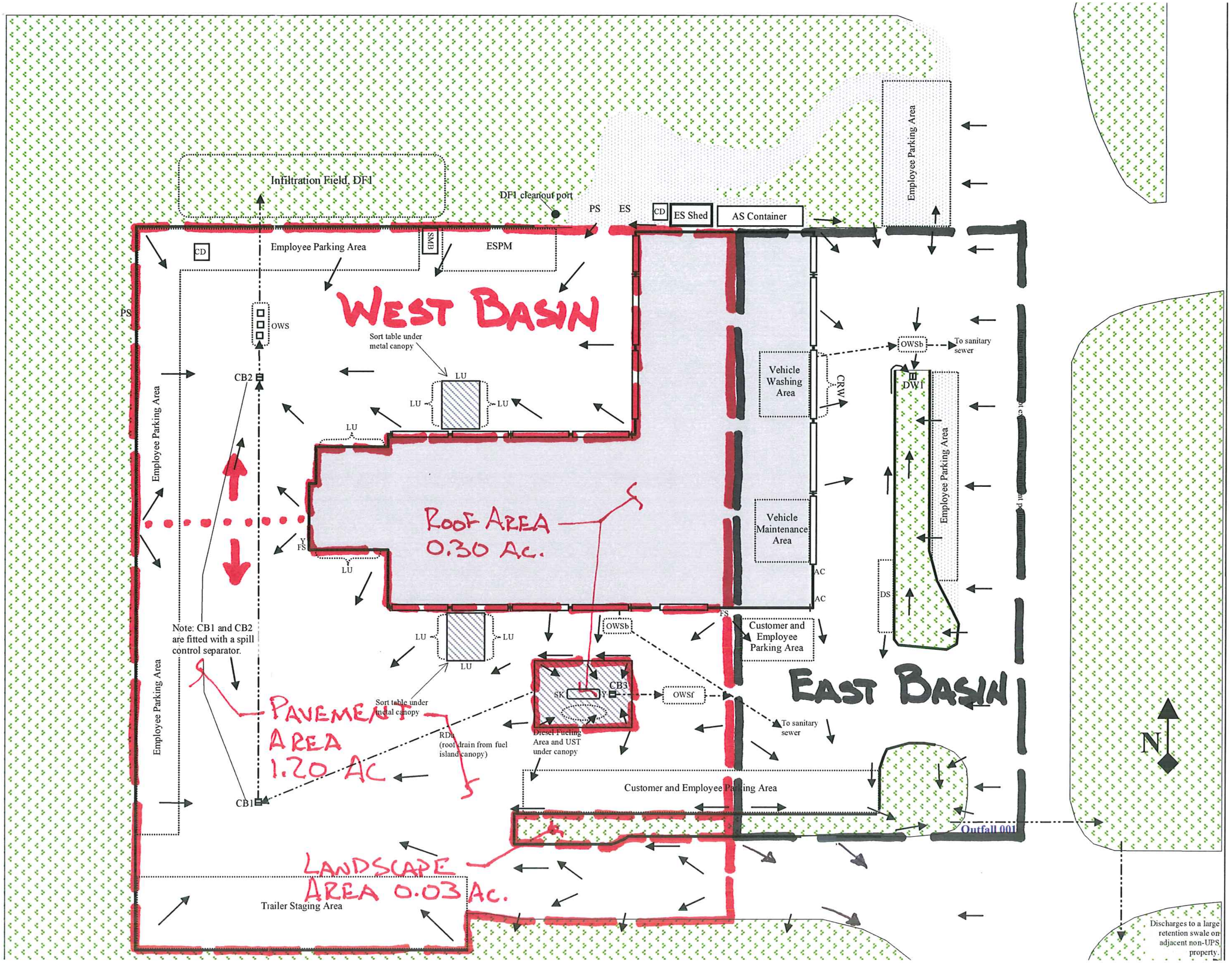
SHEET 04 OF 04



UPS-Tumwater
Site and Drainage Map

- Stormwater flow direction
- Storm sewer drain inlets
- Drywell
- Underground separate storm sewer pipe
- Underground sanitary sewer pipe
- Grass/vegetated area
- Overhead doors (vehicle entrance/exit)
- RDa
- Dirt/gravel surface

Acronym List:
AS: Automotive shop storage
CBx: Catch basin with numerical designator
CD: Covered dumpster
DFx: Drain field with numerical designator
DS: Dolly staging area
DWx: Drywell with numerical designator
ES: General equipment storage
ESPM: Equipment storage prior to maintenance area
LU: External loading/unloading area - against flush loading docks
OWSb: Oil/water separator for building floor drains (discharges to the municipal sanitary sewer system)
OWSf: Oil/water separator for fueling area stormwater discharge (discharges to the municipal sanitary sewer system)
PS: Pallet storage area (significant storage)
RDa: Roof drains that discharge aboveground
RDu: Roof drains that discharge underground
SK: Spill kit
Y: Yard trashcan – ***General*** location (covered)
UST: Underground storage tank

Allowable Non-Stormwater Discharges Present at Facility:
AC: Air conditioner condensate
CRW: Clean rinse water drag-out area
FS: Fire suppression system test discharge (potable water)

Map Notes:
- A spill control separator (elbow) has been installed in CB1 and CB2.
- **Vehicle and Floor Washing Wastewater Disposal**: The floor drains in the indoor loading/unloading, vehicle maintenance and vehicle washing areas discharge to the municipal sanitary sewer system.
- **Vehicle Maintenance:** Vehicle maintenance is performed inside the building. All vehicle maintenance materials are stored inside except scrap metal. Scrap metal is stored in a leak-free covered bin. The used oil aboveground storage tank (AST) is located inside the shop and is ~300 gallons. Transfers from the used oil AST generally only occur one to two times per year and the tanker truck parks inside the shop during the transfer. Spill cleanup material is available in the shop area (additional spill equipment is located nearby in the fueling area). Trained spill responders are available on-site to respond to spills. Mechanics are trained in spill prevention practices and spill response.
- All surfaces are paved unless otherwise indicated.

Rev. Date: 2/28/10
Not to Scale

PACIFIC ENGINEERING DESIGN LLC
CIVIL ENGINEERING AND PLANNING CONSULTANTS

JOB ____ # ____
CALCULATED BY ____ DATE ____

UPS TUMWATER BASIN AREAS

AREA CONTRIBUTING TO INFILTRATION GALLERY

PERVIOUS: LANDSCAPE = 1195 SF ~ 0.03 AC.

IMPERVIOUS: ROOF = 13,174 SF = 0.30 AC.
PAVEMENT = 52,196 SF = 1.20 AC.

TOTAL AREA = 66,565 SF = 1.53 AC.

DESIGN INFILTRATION RATE = 10 IN/HR

SOIL TYPE = OUTWASH : CLASS A/B

WWHM3 SIZING = 15.33 FT W x 90 FT L x 3.75 FT H
= 5,174 CF

STORMTECH SIZING = MC-3500 CHAMBERS - 27
40% VOIDS IN STONE
= 5,049 CF

15445 53RD AVENUE SOUTH, SUITE 100 SEATTLE, WA 98188 FAX 206 388-1648 PHONE 425 251-8811 206 431-7970

PACIFIC ENGINEERING DESIGN LLC
CIVIL ENGINEERING AND PLANNING CONSULTANTS

JOB ____ #____
CALCULATED BY ____ DATE ____

ADDITIONAL TRENCH AREA = 4' x 7' x 5.5' = 154 CF
x 40% VOIDS
61 CF

STORAGE WITHIN PIPES & MANHOLES
2 - 48" DIA MANHOLE = 69 CF x2 = 138 CF
4 LF - 24" PIPE = 25 CF
10 LF - 8" PIPE = 21 CF
184 CF

TOTAL STORAGE:

REQUIRED (PER WWHM) = 5,174 CF

PROVIDED = STORMTECH TRENCH: 5049 CF
ADDITIONAL TRENCH: 61 CF
PIPES & MANHOLES: 184 CF
5,294 CF

15445 53RD AVENUE SOUTH, SUITE 100 SEATTLE, WA 98188 FAX 206 388-1648 PHONE 425 251-8811 206 431-7970

Western Washington Hydrology Model
PROJECT REPORT

Project Name: Tumwater UPS
Site Address: 7383 New Market Street
City : Tumwater
Report Date : 10/4/2012
Gage : Olympia
Data Start : 1955/10/01
Data End : 1999/09/30
Precip Scale: 1.11
WWHM3 Version:

PREDEVELOPED LAND USE

Name : UPS Tumwater Predev
Bypass: No

GroundWater: No

Pervious Land Use	Acres
A B, Forest, Flat	1.53

Impervious Land Use	Acres

Element Flows To:

Surface	Interflow	Groundwater

Name : UPS Tumwater Dev
Bypass: No

GroundWater: No

Pervious Land Use	Acres
A B, Lawn, Flat	.03

Impervious Land Use	Acres
ROOF TOPS FLAT	0.3
PARKING FLAT	1.2

Element Flows To:

Surface	Interflow	Groundwater
Infiltration Gallery,	Infiltration Gallery,	

Name : Infiltration Gallery
Width : 15.33 ft.
Length : 90 ft.
Depth: 3.75ft.
Infiltration On
Infiltration rate : 20
Infiltration saftey factor : 0.5
Wetted surface area On
Discharge Structure
Riser Height: 3.75 ft.
Riser Diameter: 12 in.

Element Flows To:
Outlet 1 Outlet 2

Vault Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
183.5	0.032	0.000	0.000	0.000
183.5	0.032	0.001	0.000	0.321
183.6	0.032	0.003	0.000	0.323
183.6	0.032	0.004	0.000	0.325
183.7	0.032	0.005	0.000	0.328
183.7	0.032	0.007	0.000	0.330
183.8	0.032	0.008	0.000	0.332
183.8	0.032	0.009	0.000	0.334
183.8	0.032	0.011	0.000	0.336
183.9	0.032	0.012	0.000	0.338
183.9	0.032	0.013	0.000	0.340
184.0	0.032	0.015	0.000	0.342
184.0	0.032	0.016	0.000	0.344
184.0	0.032	0.017	0.000	0.346
184.1	0.032	0.018	0.000	0.348
184.1	0.032	0.020	0.000	0.350
184.2	0.032	0.021	0.000	0.352
184.2	0.032	0.022	0.000	0.354
184.3	0.032	0.024	0.000	0.356
184.3	0.032	0.025	0.000	0.358
184.3	0.032	0.026	0.000	0.360
184.4	0.032	0.028	0.000	0.362
184.4	0.032	0.029	0.000	0.364
184.5	0.032	0.030	0.000	0.366
184.5	0.032	0.032	0.000	0.368
184.5	0.032	0.033	0.000	0.370
184.6	0.032	0.034	0.000	0.372
184.6	0.032	0.036	0.000	0.374
184.7	0.032	0.037	0.000	0.376
184.7	0.032	0.038	0.000	0.378
184.8	0.032	0.040	0.000	0.380
184.8	0.032	0.041	0.000	0.382
184.8	0.032	0.042	0.000	0.384
184.9	0.032	0.044	0.000	0.386
184.9	0.032	0.045	0.000	0.388
185.0	0.032	0.046	0.000	0.390
185.0	0.032	0.048	0.000	0.393
185.0	0.032	0.049	0.000	0.395
185.1	0.032	0.050	0.000	0.397
185.1	0.032	0.051	0.000	0.399
185.2	0.032	0.053	0.000	0.401
185.2	0.032	0.054	0.000	0.403
185.3	0.032	0.055	0.000	0.405
185.3	0.032	0.057	0.000	0.407
185.3	0.032	0.058	0.000	0.409
185.4	0.032	0.059	0.000	0.411
185.4	0.032	0.061	0.000	0.413
185.5	0.032	0.062	0.000	0.415
185.5	0.032	0.063	0.000	0.417
185.5	0.032	0.065	0.000	0.419
185.6	0.032	0.066	0.000	0.421
185.6	0.032	0.067	0.000	0.423
185.7	0.032	0.069	0.000	0.425
185.7	0.032	0.070	0.000	0.427
185.8	0.032	0.071	0.000	0.429
185.8	0.032	0.073	0.000	0.431
185.8	0.032	0.074	0.000	0.433
185.9	0.032	0.075	0.000	0.435
185.9	0.032	0.077	0.000	0.437
186.0	0.032	0.078	0.000	0.439
186.0	0.032	0.079	0.000	0.441
186.0	0.032	0.081	0.000	0.443

186.1	0.032	0.082	0.000	0.445
186.1	0.032	0.083	0.000	0.447
186.2	0.032	0.084	0.000	0.449
186.2	0.032	0.086	0.000	0.451
186.3	0.032	0.087	0.000	0.453
186.3	0.032	0.088	0.000	0.456
186.3	0.032	0.090	0.000	0.458
186.4	0.032	0.091	0.000	0.460
186.4	0.032	0.092	0.000	0.462
186.5	0.032	0.094	0.000	0.464
186.5	0.032	0.095	0.000	0.466
186.5	0.032	0.096	0.000	0.468
186.6	0.032	0.098	0.000	0.470
186.6	0.032	0.099	0.000	0.472
186.7	0.032	0.100	0.000	0.474
186.7	0.032	0.102	0.000	0.476
186.8	0.032	0.103	0.000	0.478
186.8	0.032	0.104	0.000	0.480
186.8	0.032	0.106	0.000	0.482
186.9	0.032	0.107	0.000	0.484
186.9	0.032	0.108	0.000	0.486
187.0	0.032	0.110	0.000	0.488
187.0	0.032	0.111	0.000	0.490
187.0	0.032	0.112	0.000	0.492
187.1	0.032	0.113	0.000	0.494
187.1	0.032	0.115	0.000	0.496
187.2	0.032	0.116	0.000	0.498
187.2	0.032	0.117	0.000	0.500
187.3	0.032	0.119	0.000	0.502
187.3	0.032	0.120	0.083	0.504
187.3	0.000	0.000	0.234	0.000

MITIGATED LAND USE

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.001928
5 year	0.007144
10 year	0.014372
25 year	0.030626
50 year	0.050234
100 year	0.078722

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.050038
5 year	0.075113
10 year	0.09582
25 year	0.127313
50 year	0.155091
100 year	0.186975

Yearly Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1957	0.015	0.000
1958	0.001	0.000
1959	0.001	0.000
1960	0.002	0.000
1961	0.004	0.000
1962	0.004	0.000
1963	0.000	0.000
1964	0.010	0.000
1965	0.005	0.000
1966	0.003	0.000
1967	0.000	0.000

1968	0.005	0.000
1969	0.001	0.000
1970	0.001	0.000
1971	0.000	0.000
1972	0.006	0.000
1973	0.033	0.000
1974	0.000	0.000
1975	0.007	0.000
1976	0.000	0.000
1977	0.005	0.000
1978	0.000	0.000
1979	0.004	0.000
1980	0.000	0.000
1981	0.002	0.000
1982	0.004	0.000
1983	0.005	0.000
1984	0.002	0.000
1985	0.002	0.000
1986	0.000	0.000
1987	0.004	0.000
1988	0.011	0.000
1989	0.000	0.000
1990	0.000	0.000
1991	0.005	0.000
1992	0.062	0.000
1993	0.000	0.000
1994	0.000	0.000
1995	0.000	0.000
1996	0.007	0.000
1997	0.015	0.000
1998	0.012	0.000
1999	0.000	0.000
2000	0.011	0.000

Ranked Yearly Peaks for Predeveloped and Mitigated. POC #1

Rank	**Predeveloped**	**Mitigated**
1	0.0618	0.0000
2	0.0331	0.0000
3	0.0154	0.0000
4	0.0148	0.0000
5	0.0118	0.0000
6	0.0113	0.0000
7	0.0107	0.0000
8	0.0102	0.0000
9	0.0073	0.0000
10	0.0067	0.0000
11	0.0059	0.0000
12	0.0053	0.0000
13	0.0050	0.0000
14	0.0050	0.0000
15	0.0049	0.0000
16	0.0047	0.0000
17	0.0043	0.0000
18	0.0039	0.0000
19	0.0039	0.0000
20	0.0037	0.0000
21	0.0035	0.0000
22	0.0029	0.0000
23	0.0022	0.0000
24	0.0019	0.0000
25	0.0018	0.0000
26	0.0015	0.0000
27	0.0015	0.0000
28	0.0011	0.0000
29	0.0007	0.0000
30	0.0006	0.0000
31	0.0004	0.0000
32	0.0004	0.0000
33	0.0003	0.0000
34	0.0003	0.0000
35	0.0003	0.0000

36	0.0003	0.0000
37	0.0003	0.0000
38	0.0003	0.0000
39	0.0003	0.0000
40	0.0003	0.0000
41	0.0003	0.0000
42	0.0003	0.0000
43	0.0003	0.0000
44	0.0003	0.0000

POC #1
The Facility PASSED

The Facility PASSED.

Flow(CFS)	Predev	Dev	Percentage	Pass/Fail
0.0010	497	0	0	Pass
0.0015	345	0	0	Pass
0.0020	268	0	0	Pass
0.0025	211	0	0	Pass
0.0030	161	0	0	Pass
0.0035	131	0	0	Pass
0.0040	102	0	0	Pass
0.0044	85	0	0	Pass
0.0049	72	0	0	Pass
0.0054	65	0	0	Pass
0.0059	63	0	0	Pass
0.0064	53	0	0	Pass
0.0069	46	0	0	Pass
0.0074	41	0	0	Pass
0.0079	37	0	0	Pass
0.0084	34	0	0	Pass
0.0089	28	0	0	Pass
0.0094	26	0	0	Pass
0.0099	25	0	0	Pass
0.0104	22	0	0	Pass
0.0109	19	0	0	Pass
0.0114	16	0	0	Pass
0.0119	14	0	0	Pass
0.0124	14	0	0	Pass
0.0129	13	0	0	Pass
0.0134	12	0	0	Pass
0.0139	12	0	0	Pass
0.0144	12	0	0	Pass
0.0149	11	0	0	Pass
0.0154	11	0	0	Pass
0.0159	10	0	0	Pass
0.0164	10	0	0	Pass
0.0169	10	0	0	Pass
0.0174	9	0	0	Pass
0.0179	9	0	0	Pass
0.0184	9	0	0	Pass
0.0189	8	0	0	Pass
0.0194	8	0	0	Pass
0.0199	8	0	0	Pass
0.0204	8	0	0	Pass
0.0209	7	0	0	Pass
0.0214	7	0	0	Pass
0.0219	7	0	0	Pass
0.0224	6	0	0	Pass
0.0229	6	0	0	Pass
0.0234	6	0	0	Pass
0.0239	6	0	0	Pass
0.0244	6	0	0	Pass
0.0249	6	0	0	Pass
0.0254	6	0	0	Pass
0.0258	5	0	0	Pass
0.0263	5	0	0	Pass
0.0268	5	0	0	Pass
0.0273	5	0	0	Pass

0.0278	4	0	0	Pass
0.0283	4	0	0	Pass
0.0288	4	0	0	Pass
0.0293	4	0	0	Pass
0.0298	4	0	0	Pass
0.0303	4	0	0	Pass
0.0308	3	0	0	Pass
0.0313	3	0	0	Pass
0.0318	3	0	0	Pass
0.0323	3	0	0	Pass
0.0328	3	0	0	Pass
0.0333	2	0	0	Pass
0.0338	2	0	0	Pass
0.0343	2	0	0	Pass
0.0348	2	0	0	Pass
0.0353	2	0	0	Pass
0.0358	2	0	0	Pass
0.0363	2	0	0	Pass
0.0368	2	0	0	Pass
0.0373	2	0	0	Pass
0.0378	2	0	0	Pass
0.0383	2	0	0	Pass
0.0388	2	0	0	Pass
0.0393	2	0	0	Pass
0.0398	2	0	0	Pass
0.0403	2	0	0	Pass
0.0408	2	0	0	Pass
0.0413	2	0	0	Pass
0.0418	2	0	0	Pass
0.0423	2	0	0	Pass
0.0428	2	0	0	Pass
0.0433	2	0	0	Pass
0.0438	2	0	0	Pass
0.0443	2	0	0	Pass
0.0448	2	0	0	Pass
0.0453	2	0	0	Pass
0.0458	1	0	0	Pass
0.0463	1	0	0	Pass
0.0468	1	0	0	Pass
0.0472	1	0	0	Pass
0.0477	1	0	0	Pass
0.0482	1	0	0	Pass
0.0487	1	0	0	Pass
0.0492	1	0	0	Pass
0.0497	1	0	0	Pass
0.0502	1	0	0	Pass

The Development Has an increase in flow durations for more than 50% of the flows for the range of the duration analysis.

Water Quality BMP Flow and Volume for POC 1.
On-line facility volume: 0.2685 acre-feet
On-line facility target flow: 0.01 **cfs.**
Adjusted for 15 min: 0.6505 **cfs.**
Off-line facility target flow: 0.1638 **cfs.**
Adjusted for 15 min: 0.3698 **cfs.**

Project:

StormTech®
Subsurface Stormwater Management℠

Chamber Model -	MC-3500	
Units -	Imperial	Click Here for Metric
Number of Chambers -	27	
Number of End Caps -	6	
Voids in the stone (porosity) -	40	%
Base of Stone Elevation -	183.50	ft
Amount of Stone Above Chambers -	12	in
Amount of Stone Below Chambers -	9	in

☐ Include Perimeter Stone in Calculations

Height of System (inches)	Incremental Single Chamber (cubic feet)	Incremental Single End Cap (cubic feet)	Incremental Chambers (cubic feet)	Incremental End Cap (cubic feet)	Incremental Stone (cubic feet)	Incremental Chamber, End (cubic feet)	Cumulative System (cubic feet)	Elevation (feet)
66	0.00	0.00	0.00	0.00	47.91	47.91	5049.43	189.00
65	0.00	0.00	0.00	0.00	47.91	47.91	5001.52	188.92
64	0.00	0.00	0.00	0.00	47.91	47.91	4953.61	188.83
63	0.00	0.00	0.00	0.00	47.91	47.91	4905.71	188.75
62	0.00	0.00	0.00	0.00	47.91	47.91	4857.80	188.67
61	0.00	0.00	0.00	0.00	47.91	47.91	4809.89	188.58
60	0.00	0.00	0.00	0.00	47.91	47.91	4761.98	188.50
59	0.00	0.00	0.00	0.00	47.91	47.91	4714.08	188.42
58	0.00	0.00	0.00	0.00	47.91	47.91	4666.17	188.33
57	0.00	0.00	0.00	0.00	47.91	47.91	4618.26	188.25
56	0.00	0.00	0.00	0.00	47.91	47.91	4570.35	188.17
55	0.00	0.00	0.00	0.00	47.91	47.91	4522.45	188.08
54	0.06	0.00	1.56	0.00	47.28	48.84	4474.54	188.00
53	0.20	0.01	5.32	0.06	45.76	51.13	4425.70	187.92
52	0.31	0.01	8.35	0.06	44.54	52.96	4374.56	187.83
51	0.61	0.02	16.48	0.12	41.27	57.87	4321.61	187.75
50	0.98	0.04	26.39	0.24	37.26	63.89	4263.74	187.67
49	1.20	0.05	32.51	0.30	34.78	67.60	4199.85	187.58
48	1.39	0.07	37.48	0.42	32.75	70.65	4132.26	187.50
47	1.54	0.09	41.70	0.54	31.01	73.25	4061.61	187.42
46	1.68	0.10	45.47	0.60	29.48	75.55	3988.35	187.33
45	1.81	0.12	48.83	0.72	28.09	77.64	3912.81	187.25
44	1.92	0.14	51.94	0.84	26.80	79.57	3835.17	187.17
43	2.03	0.16	54.75	0.96	25.62	81.33	3755.59	187.08
42	2.13	0.18	57.38	1.08	24.52	82.98	3674.26	187.00
41	2.21	0.20	59.80	1.20	23.51	84.51	3591.28	186.92
40	2.30	0.21	62.17	1.26	22.54	85.97	3506.77	186.83
39	2.38	0.24	64.30	1.44	21.61	87.35	3420.80	186.75
38	2.46	0.26	66.36	1.56	20.74	88.66	3333.45	186.67
37	2.53	0.27	68.27	1.62	19.95	89.84	3244.80	186.58
36	2.60	0.29	70.09	1.74	19.18	91.00	3154.95	186.50
35	2.66	0.32	71.82	1.92	18.41	92.15	3063.95	186.42
34	2.72	0.33	73.45	1.98	17.74	93.16	2971.80	186.33
33	2.78	0.35	74.98	2.10	17.08	94.16	2878.64	186.25
32	2.83	0.37	76.46	2.22	16.43	95.12	2784.48	186.17
31	2.88	0.39	77.85	2.34	15.83	96.02	2689.36	186.08
30	2.93	0.41	79.22	2.46	15.24	96.92	2593.34	186.00
29	2.98	0.43	80.45	2.58	14.70	97.72	2496.42	185.92
28	3.02	0.45	81.63	2.70	14.17	98.51	2398.70	185.83
27	3.07	0.46	82.77	2.76	13.69	99.23	2300.19	185.75
26	3.11	0.48	83.87	2.88	13.21	99.96	2200.97	185.67
25	3.14	0.49	84.90	2.94	12.77	100.61	2101.01	185.58
24	3.18	0.51	85.87	3.06	12.34	101.26	2000.39	185.50
23	3.21	0.52	86.76	3.12	11.96	101.84	1899.13	185.42
22	3.25	0.54	87.62	3.24	11.56	102.43	1797.30	185.33
21	3.28	0.54	88.45	3.24	11.23	102.92	1694.87	185.25
20	3.31	0.56	89.24	3.36	10.87	103.47	1591.95	185.17
19	3.33	0.57	89.97	3.42	10.55	103.94	1488.48	185.08
18	3.36	0.58	90.68	3.48	10.25	104.40	1384.54	185.00
17	3.38	0.58	91.35	3.48	9.98	104.80	1280.14	184.92
16	3.41	0.60	91.96	3.60	9.68	105.25	1175.33	184.83
15	3.43	0.60	92.55	3.60	9.45	105.60	1070.09	184.75
14	3.45	0.61	93.11	3.66	9.20	105.97	964.49	184.67
13	3.47	0.61	93.65	3.66	8.99	106.29	858.52	184.58
12	3.49	0.62	94.16	3.72	8.76	106.64	752.23	184.50
11	3.51	0.63	94.69	3.78	8.52	106.99	645.60	184.42
10	3.53	0.63	95.44	3.78	8.22	107.44	538.61	184.33
9	0.00	0.00	0.00	0.00	47.91	47.91	431.17	184.25
8	0.00	0.00	0.00	0.00	47.91	47.91	383.26	184.17
7	0.00	0.00	0.00	0.00	47.91	47.91	335.35	184.08
6	0.00	0.00	0.00	0.00	47.91	47.91	287.45	184.00
5	0.00	0.00	0.00	0.00	47.91	47.91	239.54	183.92
4	0.00	0.00	0.00	0.00	47.91	47.91	191.63	183.83
3	0.00	0.00	0.00	0.00	47.91	47.91	143.72	183.75
2	0.00	0.00	0.00	0.00	47.91	47.91	95.82	183.67
1	0.00	0.00	0.00	0.00	47.91	47.91	47.91	183.58

Design requirements for infiltration trenches used for flow control (soils not considered a treatment BMP)		
Requirements	Infiltration trenches located in **Western WA** (from SMMWW)	Infiltration trenches located in **Eastern WA** (from SMMEW, but does not include section 5.6)
Separation between ground water/ impermeable layer and base of trench	5 ft.	5 ft.
Soil type	None required	None required
Treatment required, must use Ecology approved BMP*	Solids removal; except for NPGIS** Oil control for high use sites, SMMWW, Vol 5, p. 2-3	Solids removal, except for NPGIS Oil control for high use and high ADT*** roads, see p. 2-22.
Short term Infiltration rate for treatment	No minimum	No minimum
Long term Infiltration rate	No minimum	No minimum
In ground water protection area? (well head or critical aquifer recharge area)	Check WA State DOH website GIS tool, http://www.doh.wa.gov/ehp/dw/swaphome.htm, to determine if trench is in a well head protection area. If yes, contact local DOH for local ordinances pertaining to stormwater.	Check WA State DOH website GIS tool, http://www.doh.wa.gov/ehp/dw/swaphome.htm If yes, contact local DOH for local ordinances pertaining to stormwater.
Operation and maintenance	Volume IV, SMMWW	Chapter 8 of SMMEW

*BMP – Best Management Practice, must be approved by Ecology. For approved BMPS go to http://www.ecy.wa.gov/programs/wq/grndwtr/uic/TreatmentOpts-EandWwa.pdf
**NPGIS – non pollutant generating impervious surface, see definition in either SMMEW or SMMWW, http://www.ecy.wa.gov/programs/wq/stormwater/tech.html
***ADT - Average Daily Traffic

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
TTY 711 or 800-833-6388 (For the Speech or Hearing Impaired)

December 1, 2004

Mr. Marvin Lock
District Environmental Coordinator
UPS, Plant Engineering
4455 7th Avenue South
Seattle, WA 98108

Dear Mr. Lock:

RE: Registration with the Underground Injection Control (UIC) Program, UPS-Kennewick, 6504 W. Okanogan Ave, Kennewick, WA

This letter is to acknowledge receipt of your registration forms to register the UPS Facilities listed below. All of the UIC wells are used to manage stormwater from the sites.

The goal of the UIC Program is to protect ground water by regulating discharges to UIC wells. UIC wells should not receive fluids that contain hazardous substances or from polluted source areas. Based on the information provided, the best management practices applied at the sites are presumed to protect ground water quality, and unless there is site specific information to indicate otherwise the non-endangerment requirements of the UIC program have been met.

The sites are registered as;

Site	UIC site number	Number of UIC wells at site
UPS Burlington	23311	1
UPS Kennewick	23312	5
UPS Moses Lake	23313	2
UPS Spokane Hub	23314	29
UPS Tumwater	23315	2
UPS Yakima	23316	7

The Yakima site states that the depth of the UIC wells are approximately 5 feet and the depth to ground water is approximately 3-10 feet. UIC wells need to have a separation between the bottom of the well and the top of the aquifer. If the well is located in the water table and water is in the well during the dry months of the year then the well needs to be retrofitted.

Please refer to the UIC site number for each location in all future correspondence. Also contact us if the wells are closed and describe the closure method.

Please call me at (360) 407-6143 or email me at maha461@ecy.wa.gov if you have any questions. Additional information on the UIC Program can also be found at our website http://www.ecy.wa.gov/programs/wq/grndwtr/uic/index.html.

Sincerely,

MHansen

Mary Shaleen-Hansen
Water Quality Program

Cc: Robin Sandell

For Department of Ecology Use									
UIC Site ID		WRIA		WQMA		Date Entered		Confirmation Mailed	

WASHINGTON STATE DEPARTMENT OF ECOLOGY

UNDERGROUND INJECTION CONTROL PROGRAM REGISTRATION FORM

Please send completed form to: UIC Coordinator, Water Quality Program, WA Department of Ecology, P.O. Box 47600, Olympia, WA 98504-7600

A. Facility/Site Information:

1. Facility Name: UPS – Tumwater
2. Address: 7383 New Market St SW
   City/State/Zip: Tumwater, WA 98501-6567 County: Thurston
   Telephone #: 360-357-6675
   Cross Streets: North/South _____ East/West _____
3. Latitude: 46° 58′ 50″ N Longitude: 122° 54′ 48″ W Meridian (E/W): _____
4. Township _____ Range: _____ Section: _____ ¼ Section _____ ¼ ¼ Section: _____
5. Nature of business and materials handled: Small parcel delivery service. Industrial activities performed at the facility include: Vehicle maintenance; vehicle washing; vehicle fueling; fuel storage (UST: gasoline); scrap metal storage; loading/unloading; and dumpster for trash storage.
6. Pollution prevention/treatment methods: Vehicle maintenance is primarily performed indoors; all vehicle wash water discharges to the sanitary sewer system; vehicle fuelers are trained in pollution prevention and spill response; ***Oil Spill Response Plan*** has been developed and implemented at the facility; spill response equipment is available; personnel trained in spill response are available during facility operating hours; trained UPS personnel attend fuel drops; fueling equipment is maintained in good condition; the fueling area is covered; storm water run-off from fueling area passes through an oil/water separator prior to discharging to the sanitary sewer system; storm water run-off from facility paved areas passes through an oil/water separator prior to discharging to a drain field; the storm water oil/water separators are periodically cleaned and inspected; scrap metal bin is covered; dumpster lids are kept closed; and good housekeeping practices are implemented.
7. Has a permit been issued for the site? No ☒ Yes, NPDES ☐ State Waste Discharge ☐
   Issued By:

B. Owner/Operator Information:

1. Owner Name: UPS (Attention: Plant Engineering)
   Owner Address: 4455 7th Avenue South
   City/State/Zip: Seattle, WA 98108
   Telephone #: 206-621-6261 (Marvin Lock, District Environmental Coordinator)
2. Operator/Contact Name: UPS – Plant Engineering
   Operator/Contact Address: 4455 7th Avenue South
   City/State/Zip: Seattle, WA 98108
   Telephone #: 206-621-6261 (Marvin Lock, District Environmental Coordinator)

C. UIC Well and Ground Water Information:

1. Number of UIC wells: Active 2 Under Construction 0 Temporarily Abandoned 0 Permanently Abandoned 0
2. Depth of UIC well (feet): 1 dry well: ~ 8 ft; 1 Drain Field: < 6 ft 3. Well Type(s) (see table below): 5D4: 2 wells
4. Depth to ground water (feet): Unknown Based on: Well Log ☐ Measurement ☐ Estimate ☐
   Date of Measurement: ______
5. Distance to nearest drinking water source (feet): Unknown (Note: no drinking water wells located on-site)
   Distance to nearest surface water source (feet): 7,000 – 8,000 feet: Percival Creek to the NW; Deschutes River to the NE.
6. Date well installation: Dry well: June 1972; Drain Field: June 1987
7. Date of well closure (if applicable): Not applicable
   Well closure method (if applicable): Not applicable
8. Injected fluid type, i.e., stormwater: Storm water

E. Remediation/ Clean up Sites (if applicable): <u>THIS SECTION IS NOT APPLICABLE TO FACILITY</u>

1. Type of remediation site CERCLA ☐ RCRA ☐ MTCA Independent ☐ MTCA Order ☐ Other ☐
2. Groundwater quality (including contaminant levels): N/A
3. Brief description of site geology: N/A
4. Injection process, including volume amounts (gals): N/A

EPA Well Types

5A19 Cooling Water Return	5R21 Aquifer Recharge	5W31 Septic System (well disposal)	5X28 Motor
5D2 Stormwater	5W9 Untreated Sewage	5W32 Septic System (drainfield)	Vehicle Waste
5D4 Industrial Storm Runoff	5W10 Cesspool	5A7 Closed Loop Heat Pump Ret.	
5G30 Special Drainage Water	5W11 Septic System (gen) 5W20 Industrial Process Water	5X26 Aquifer Remediation 5X27 Other Wells	
5A6 Geothermal Heat			

Completed by <u>Robin Sandell (Address: 6462 Quartz Circle, Arvada, CO 80007; Phone: 303-403-1098; Email: rmsandell@earthlink.net)</u>

Date <u>February 9, 2004</u>

To expedite the registration of your facility, please fill out this form in its entirety.

To receive this document in a different format, contact Mary Shaleen Hansen at (360) 407-6143 (Voice) or 711 or 1-800-833-6388 (TTY). E-mail can be sent to maha461@ecy.wa.gov.

UIC Well Assessment Special Protection Areas and Local Resource Evaluation Summary Table

Facility Name: UPS-Tumwater
Facility Address: 7383 New Market St SW, Tumwater, WA 98501
County: Thurston
Ecology UIC Site Number: 23315
Number of Registered UIC Wells: There are a total of one (1) stormwater drainage drywell and one (1) stormwater drainage drain field located at this facility. Both are registered as Class V UIC stormwater drainage wells and were built prior to February 2, 2006 (i.e., they are existing UIC wells).
Rev. Date: 2/23/11

	Evaluation Summary	Additional Requirements for Special Protection Areas:
Wellhead Protection Area (WHPZ)	The facility is located in a both a WHPZ. The WHPZs located in the vicinity of the facility are shown on the **Washington Department of Health – Wellhead Protection Zone Map** for this facility in Appendix C. The facility is also located in a WHPZ established by the City of Tumwater.	City of Tumwater Ordinance: Chapter 16.26 Wellhead Protection.
Surface Water Intake Protection Area (SWIPA)	The facility is not located in a SWIPA. The SWIPAs located in the vicinity of the facility are shown on the **Washington Department of Health – Surface Water Intake Protection Area Map** for this facility in Appendix C.	Not applicable. The facility is not in a SWIPA.
Critical Aquifer Recharge Area (CARA) and Local Requirements Summary	Mr. Andy Deffobis, Thurston County Associate Planner (360-786-5467, deffoba@co.thurston.wa.us), was contacted on 2/22/11 by Ms. Robin Sandell, ECTools, to determine if the facility was located in any special groundwater or surface water protection areas and if any Thurston County ordinances applied to the facility's UIC wells. Mr. Deffobis indicated that since the facility was located inside the Tumwater City Limits and was not in an Urban Growth Area there were no Thurston County Regulations that apply. Mr. Dan Smith, City of Tumwater, Water Resources Program Manager (360-754-4140; desmith@ci.tumwater.wa.us) was contacted on 2/22/11 by Ms. Robin Sandell, ECTools, to determine if the facility was located in any special groundwater or surface water protection areas and if any City of Tumwater ordinances applied to the facility's UIC wells. Mr. Smith indicated that the facility is located in one of the City's wellhead protection areas with either a 6-month or 1-year time of travel and is located in the City's aquifer protection overlay.	Mr. Dan Smith, Water Resources Program Manager, indicated that several ordinances did apply to operation of the UIC wells at the facility (Chapter 13.12.020 - Stormwater Management; Chapter 16.24 Aquifer Protection Standards; Chapter 16.26 Wellhead Protection). These codes were downloaded from the City's Web Site on 2/22/11 and any applicable requirements will be integrated into the Groundwater Protection Best Management Practices Plan.
Sole Source Aquifer (SSA)	The facility is not located in a Sole Source Aquifer as seen by the EPA Region 10 Sole Source Aquifer Regional Map in Appendix C.	Not applicable. The facility is not in a SSA.
Nearby Wells	The facility drinking water source is the public water supply system. Several public water supply wells, operated by the City of Tumwater, are located within 1,000 feet of the facility. Approximate distances from the facility to the City of Tumwater Water Supply Wells: Well #10 ~ 440 ft to the west; Well #15: ~ 640 ft directly east; Well #9: ~960 ft to the south.	City of Tumwater Ordinance: Chapter 16.24 Aquifer Protection Standards; Chapter 16.26 Wellhead Protection
Surface Water	The facility is not located within 1000 feet of any surface water body.	Not applicable. The UICs located at this facility are not within 1,000 feet of a surface water body.

UIC Well Assessment High Threat to Groundwater Evaluation Summary Table

Facility Name: UPS-Tumwater
Facility Address: 7383 New Market St SW, Tumwater, WA 98501
County: Thurston
Ecology UIC Site Number: 23315
Number of Registered UIC Wells: There are a total of one (1) stormwater drainage drywell and one (1) stormwater drainage drain field located at this facility. Both are registered as Class V UIC stormwater drainage wells and were built prior to February 2, 2006 (i.e., they are existing UIC wells).
Rev. Date: 2/28/11

	DW1[1]	**DF1**[1]
Prohibited Discharges[2]	None	None
Pollutant Loading[3]	UIC does not receive a "high pollutant load". High-use assessment summary: • Trip count is <threshold. • No fueling • No petroleum storage • No outdoor hazardous material storage.	UIC may receive a "high pollutant load". High-use and potential pollutant sources assessment summary: • Trip count is <threshold. • Fuel storage in underground storage tank. Petroleum transfer is > 1,500 gal/yr. (High Use) • No outdoor hazardous material storage. • Vehicle Fueling: Vehicles are fueled in the drainage area to DF1. The fuel tanker truck may park in the drainage area to DF1. (High Use)
Vadose Zone Treatment Capacity[4]	Not applicable – UIC doesn't receive high pollutant load	Based on recent well logs (2008) in close proximity to the facility (across the street), the vadose zone in this area consists of fine to medium sand. Table 5.2 of the **Ecology Guidance for UIC Wells that Manage Stormwater** indicates that the vadose zone treatment capacity for this type of material is medium and a minimum thickness of 10 ft is needed for treatment. There is >10 ft of vadose zone between the bottom of the UIC wells at this facility and the water table during some periods of the year and there may be <10 ft during at other periods of the year.
UIC Inspection for Groundwater[5]	Date, Result: 9/18/08, Dry (ECTools[5])	Not applicable.
UIC Depth	~8 feet	< 6 feet
Depth to Groundwater[6]	Based on local well logs and information from Mr. Dan Smith, City of Tumwater, Water Resources Program Manager, depth to groundwater is approximately 14 - 20 feet depending on time of year and groundwater cycles.	Based on local well logs and information from Mr. Dan Smith, City of Tumwater, Water Resources Program Manager, depth to groundwater is approximately 14 - 20 feet depending on time of year and groundwater cycles.
BMPs Implemented[7]	BMPs #1 to #7	BMPs #1 to #5, #8, #9

Table Footnotes:

[1]DWx: Drywell with numerical designation. DFx: Drain field with numerical designator. CBx: Catch basin with numerical designator.

[2]Prohibited Discharges: Those discharges listed as prohibited in **the Ecology Guidance for UIC Wells that Manage Stormwater**, Section 2.2.

[3]High Pollutant Loading: The activities performed in the drainage area to the drywell were evaluated to determine if any of these activities were listed in Table 5.3 of the **Ecology Guidance for UIC Wells that Manage Stormwater** as contributing high pollutant loading. Only "High Use Sites" were investigated further, as none of the other activities/areas listed in Table 5.3 for high pollutant loading apply to this facility. Refer to the Site and Drainage Map for the activities performed in the drainage area for each drywell.

[4]Vadose Zone Treatment Capacity: Not applicable if the pollutant loading to the drywell is not high.

[5]ECTools: Environmental Compliance Tools, LLC. WSE: Western States Environmental.

[6]Depth to groundwater was determined using well logs in close proximity to the facility.

[7]BMPs implemented for each drywell, except as noted:

BMP #1: Development and implementation of a Groundwater Protection Best Management Practices Plan (GWP BMPP) that includes source control BMPs (e.g., exposure minimization, good housekeeping, preventative maintenance, spill control, employee training, routine inspections).

BMP #2: Semi-annual (spring and fall) surface sweeping using a high efficiency vacuum street sweeper.

BMP #3: Minimum of annual storm sewer system and drywell cleaning, including evacuating and cleaning the oil/water separator pre-treating runoff from CB1 and CB2 to DF1. (Note: additional cleaning will be done based on inspection findings).

BMP #4: Quarterly facility inspections to ensure source control BMPs are being properly implemented, to ensure treatment controls are in good condition and operating properly and to inspect the condition of the drywells.

BMP #5: The following BMP will be implemented by 6/30/11. Storm drain inserts will be installed in DW1 and CB1 and CB2, which both discharge to DF1. Note: The inserts will be inspected during the quarterly site inspections and cleaned as needed. The inserts will be, inspected, cleaned and replaced as needed during the semi-annual surface sweeping.

BMP #6: Vehicle Maintenance: Vehicle maintenance is performed inside the building. All vehicle maintenance materials are stored inside except scrap metal. Scrap metal is stored in a leak-free covered bin. The used oil aboveground storage tank (AST) is located inside the shop and is ~300 gallons. Transfers from the used oil AST generally only occur one to two times per year and the tanker truck parks inside the shop during the transfer. Spill cleanup material is available in the shop area (additional spill equipment is located nearby in the fueling area). Trained spill responders are available on-site to respond to spills. Mechanics are trained in spill prevention practices and spill response.

BMP #7: Vehicle Maintenance: The following BMPs will be implemented by 6/30/11. A storm drain cover will be added to the automotive shop spill kit and the automotive mechanics and spill responders will be trained to cover DW1 should a spill occur that could impact the drywell. The automotive mechanics will be trained to cover DW1 if a spill could impact the drywell during tanker truck transfers from the used oil tank. All drums must be placed on spill pallets, or in equivalent spill containment, if a spill from the drums could flow outdoors or into a floor drain.

BMP #8: Fueling Area BMPs: CB1 and CB2 are designed with sediment settling sumps and spill control separators to prevent pollutants from discharging from the fueling area to the drain field (DF1). An oil/water separator further treats stormwater discharging from CB2 to the drain field, DF1. A spill kit is available in the fueling area and trained spill responders are available on-site to respond to spills. Fuelers are trained in spill prevention practices and spill response. The fuel storage underground storage tank is compliant with all applicable regulations. The fuel dispensers are compliant with all applicable regulations and are inspected regularly to ensure proper function and to prevent spills and leaks.

UIC Well Assessment High Threat to Groundwater Evaluation Summary Table

BMP #9: Fueling Area BMPs: The following BMPs will be implemented by 6/30/11. Drain covers will be included in the fueling area spill kit and the UPS Certified Fuel Drop Receivers will be trained to place the drain covers over CB1 during all fuel drops. The tanker truck will be restricted from parking outside the drainage area of CB1 and/or the drainage area of CB3, which is in the fueling area and discharges to the municipal sanitary sewer system.

BMP #10: Description of Fueling System and Control Measures: The fuel storage tank is a double-walled fiberglass reinforced plastic underground storage tank with double-walled fiberglass reinforced plastic piping. The interstitial space of the piping drains back to the piping sump on top of the tank. The dispensers have secondary containment sumps underneath them that also drain back to the piping sump on the top of the tank. The monitoring consists of an Automatic Tank Gauge for primary leak detection from the tank, and the interstitial space between the inner and outer walls of the tank is filled with brine, and its level is monitored (both low and high) as a secondary leak detection method for the tank. The piping sump on top of the tank is also monitored to detect leaks in the piping or from the dispenser containment sump.

All sensors are tied into a Veeder Root TLS350 monitoring console with a dedicated phone line. The console sounds an audible alarm and dials out to a monitoring service in the event of there being a loss of volume from the tank, change in brine level of the tank interstitial space, liquid detected in the piping sump or an overfill of the tank (>95%). The monitoring service sends emailed alerts when any of the sensors are activated, and the console also sends a fax to the District UPS Plant Engineering Office any time one of the sensors are activated.

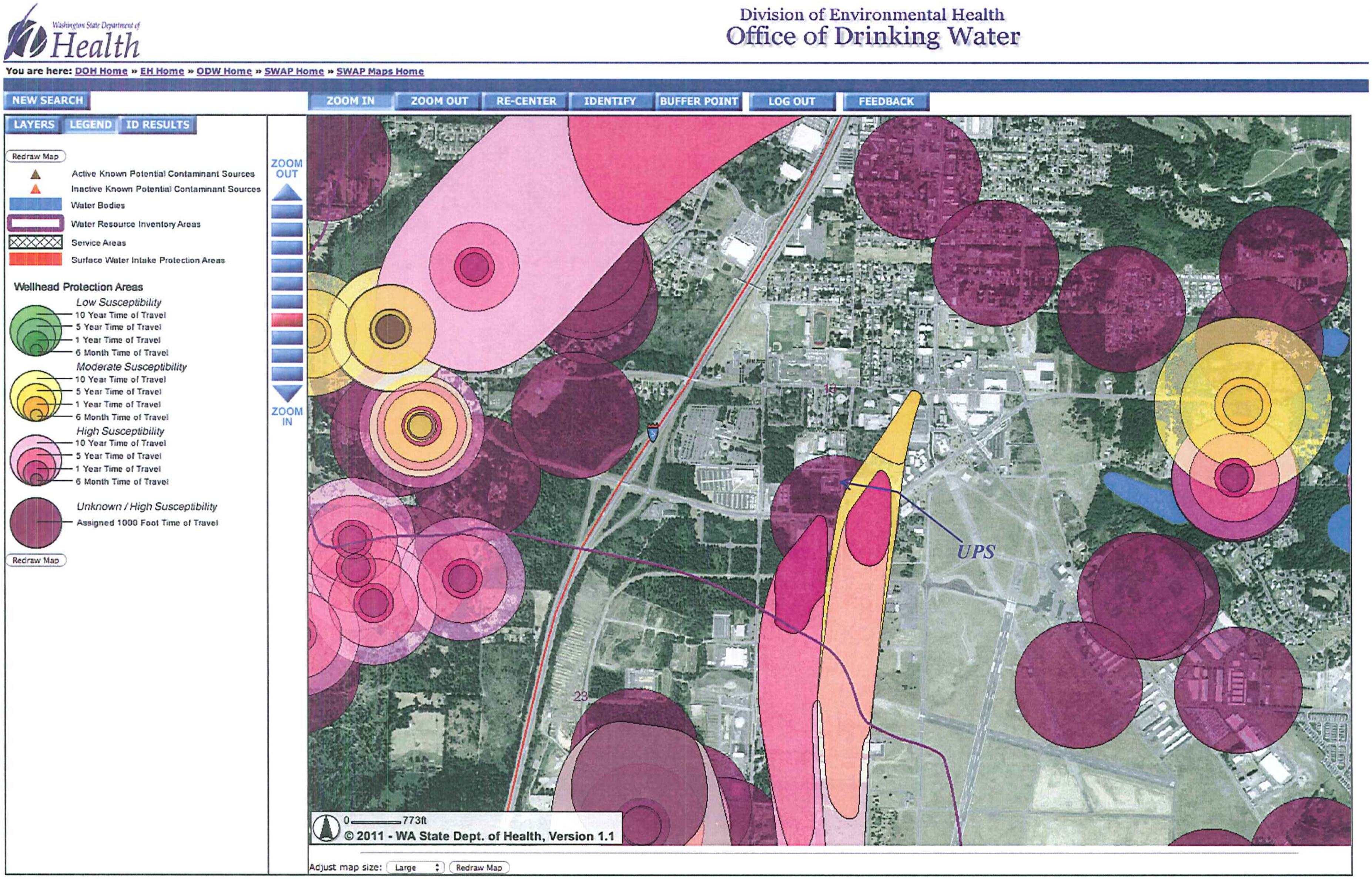
Overfill prevention consists of a ball valve in the vent pipe of the tank that closes at 90% restricting the escape of air from the tank - thereby limiting inflow of fuel. There is a secondary overfill protection in the form of a float valve on the tank's fill tube that closes off at 95% preventing any further filling of the tank. The tank monitoring console is also configured to alarm and send an email and a fax alert any time the tank is filled to the 95% capacity mark

The dispensers have a timer on them to limit the spill potential from a damaged hose. Gasoline timers are set to 3 minutes and diesel timers are set to 5 minutes. Dispensers also have shear valves to shut off fuel flow in case a dispenser is hit and sheared off its base.

The entire installation is inspected semi-annually and the annual inspection includes testing meter accuracy, flow rate, and leak detection.

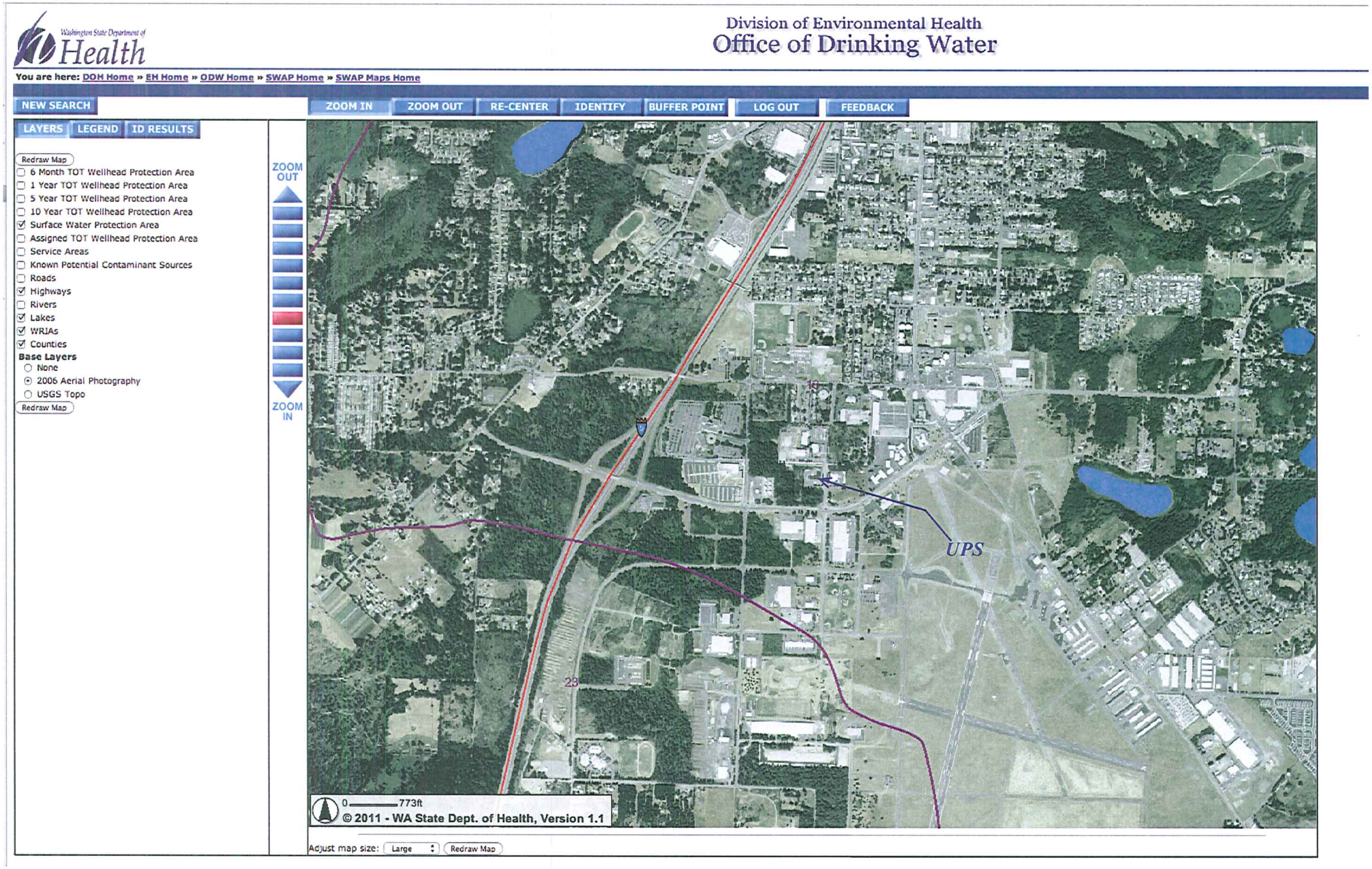
WASHINGTON STATE DEPARTMENT OF HEALTH – WELLHEAD PROTECTION ZONE MAP

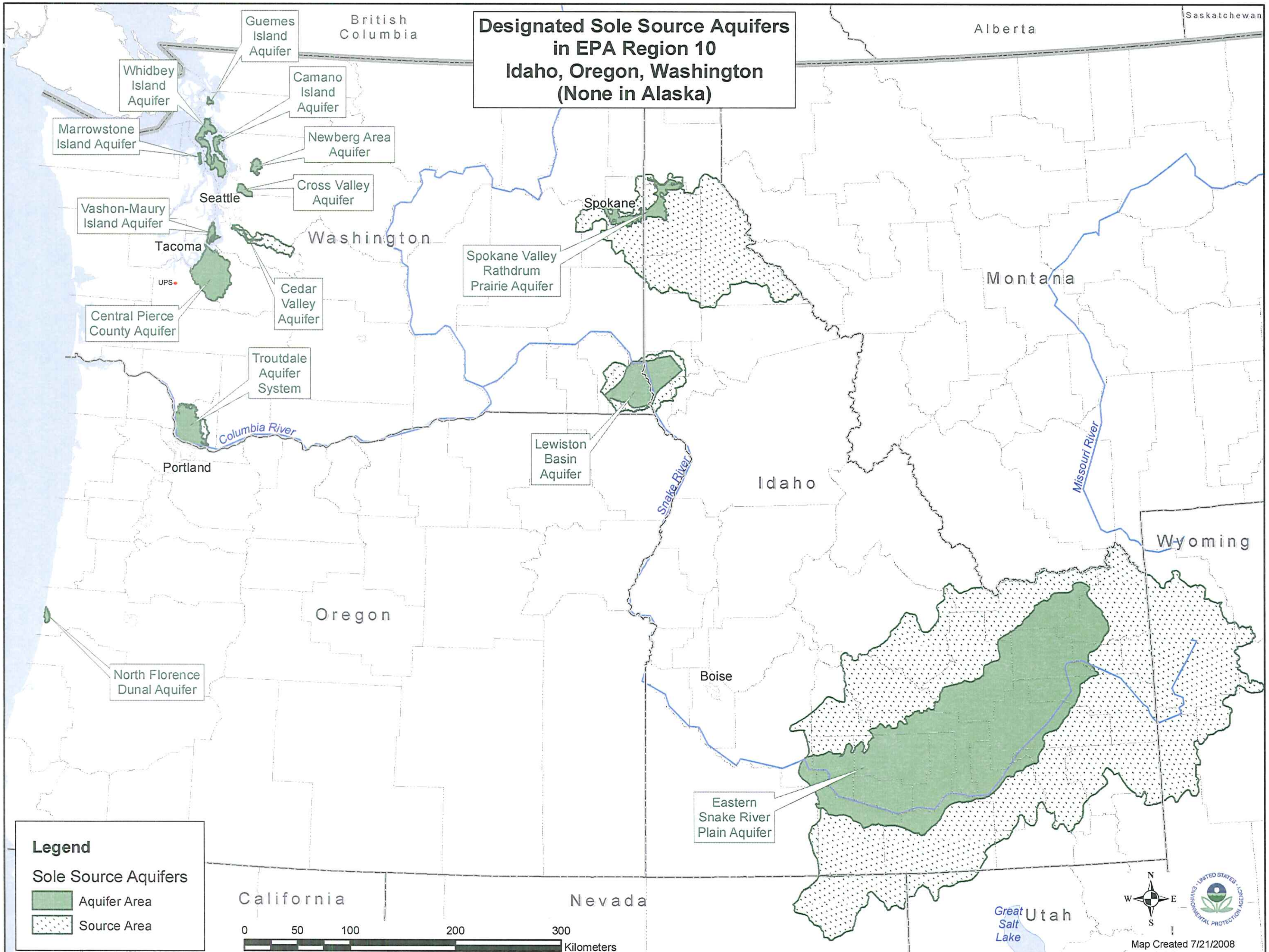
Facility: UPS – Tumwater
Address: 7383 New Market St SW, Tumwater, WA 98501
Rev. Date: 2/11/11
Conclusion: The facility's UIC wells are located in a wellhead protection zone.



WASHINGTON STATE DEPARTMENT OF HEALTH – SURFACE WATER INTAKE PROTECTION AREA MAP

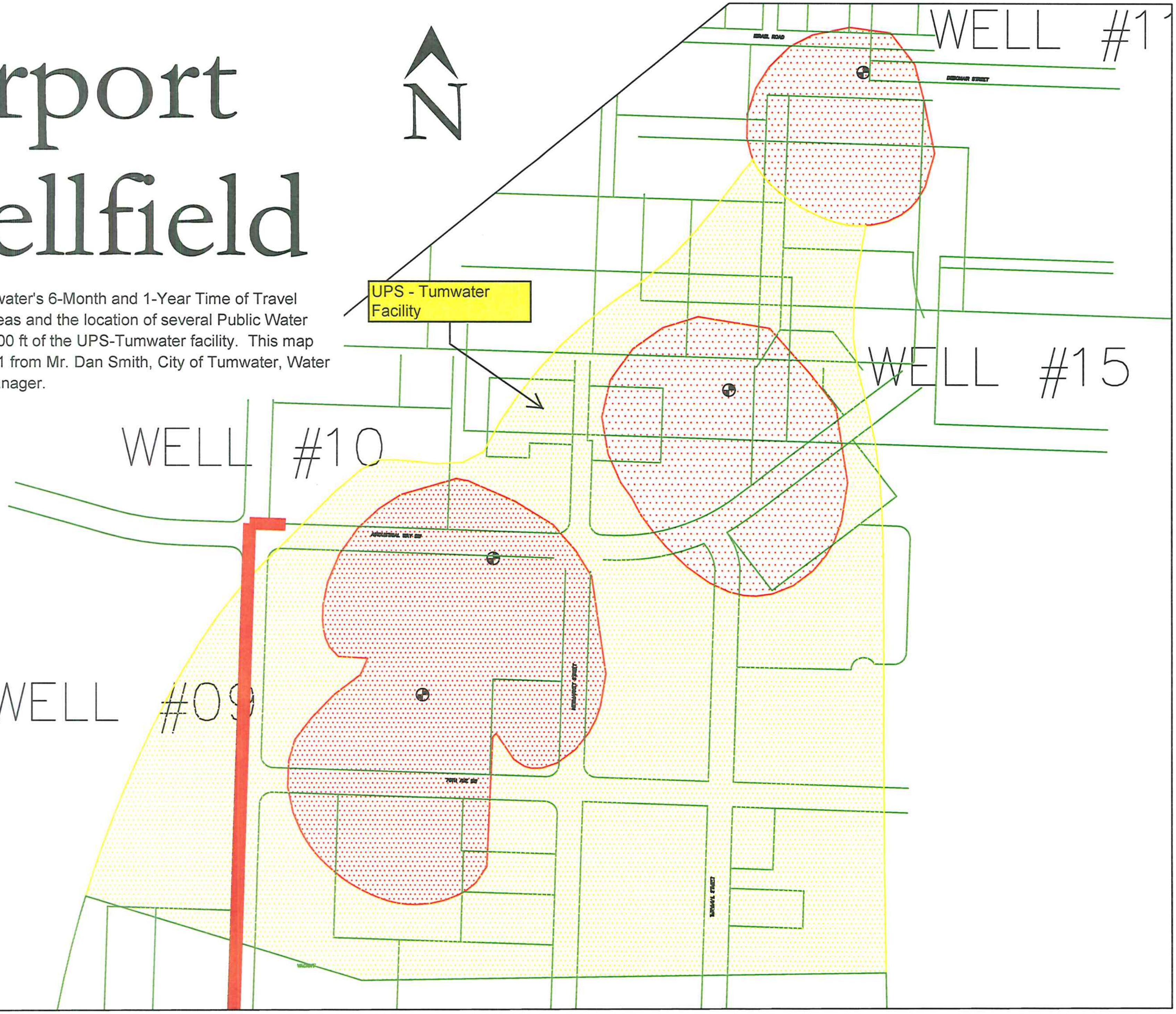
Facility: UPS – Tumwater
Address: 7383 New Market St SW, Tumwater, WA 98501
Rev. Date: 2/11/11
Conclusion: There are no surface water intake protection areas within 1000 feet of the facility.




Designated Sole Source Aquifers
in EPA Region 10
Idaho, Oregon, Washington
(None in Alaska)
British Columbia
Alberta
Saskatchewan
Guemes Island Aquifer
Whidbey Island Aquifer
Camano Island Aquifer
Marrowstone Island Aquifer
Newberg Area Aquifer
Cross Valley Aquifer
Seattle
Vashon-Maury Island Aquifer
Tacoma
UPS
Washington
Central Pierce County Aquifer
Cedar Valley Aquifer
Spokane
Spokane Valley Rathdrum Prairie Aquifer
Montana
Troutdale Aquifer System
Columbia River
Portland
Lewiston Basin Aquifer
Snake River
Idaho
Missouri River
Wyoming
Oregon
North Florence Dunal Aquifer
Boise
Eastern Snake River Plain Aquifer
Legend
Sole Source Aquifers
Aquifer Area
Source Area
California
Nevada
0
50
100
200
300
Kilometers
Great Salt Lake
Utah
N
W
E
S
Map Created 7/21/2008

Airport Wellfield

Map of the City of Tumwater's 6-Month and 1-Year Time of Travel Wellhead Protection Areas and the location of several Public Water Supply Wells within 1,000 ft of the UPS-Tumwater facility. This map was received on 2/23/11 from Mr. Dan Smith, City of Tumwater, Water Resources Program Manager.



StormTech®

Detention • Retention • Recharge

Subsurface Stormwater Management℠

MC-3500 Chamber

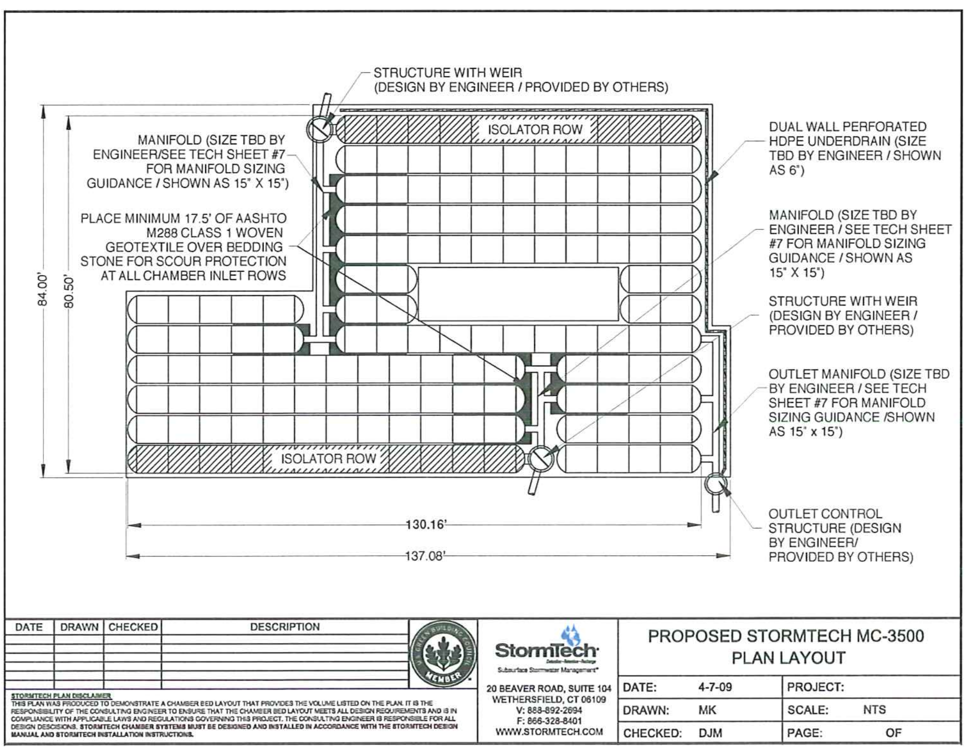
MC-3500 Design Manual

StormTech® Chamber Systems for Stormwater Management

U.S. GREEN BUILDING COUNCIL MEMBER

Table of Contents

StormTech Technical Services Department assists design professionals in specifying StormTech stormwater systems. This assistance includes the layout of chambers to meet the engineer's volume requirements and the connections to and from the chambers. The Technical Department can also assist converting and cost engineering projects currently specified with ponds, pipe, concrete vaults and other manufactured stormwater detention/retention products. Please note that it is the responsibility of the design engineer to ensure that the chamber bed layout meets all design requirements and is in compliance with applicable laws and regulations governing a project.



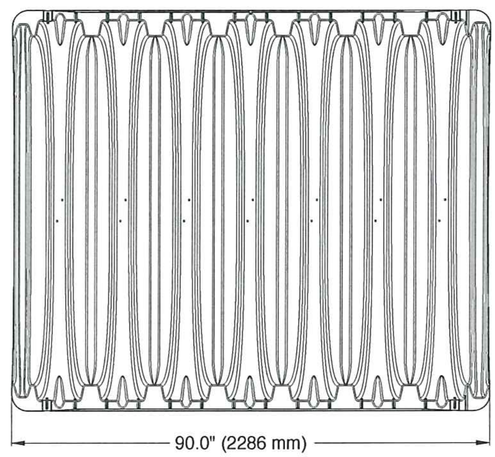
This manual is exclusively intended to assist engineers in the design of subsurface stormwater systems using StormTech chambers.

Figure 1

StormTech MC-3500 Chamber (not to scale)

Nominal Chamber Specifications

Size (L x W x H)	90" (2286 mm) x 77" (1956 mm) x 45" (1143 mm)
Chamber Storage	113.0 ft³ (3.20 m³)
Min. Installed Storage*	176.8 ft³ (5.01 m³)
Weight	124 lbs (56.2 kg)



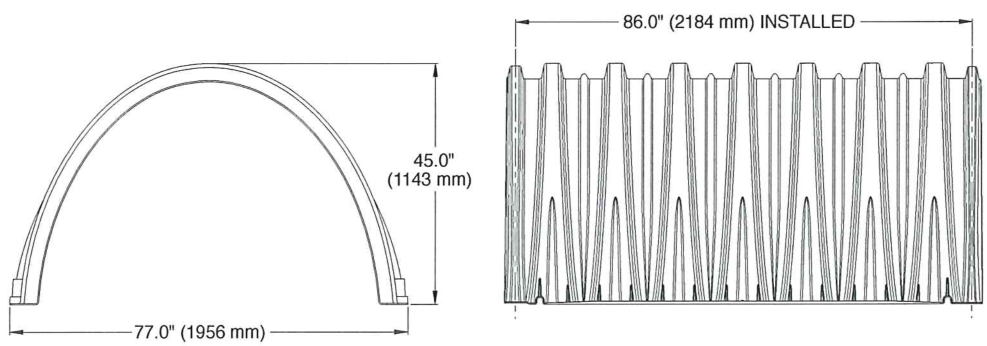
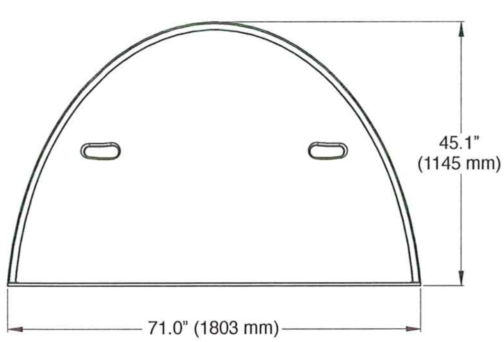


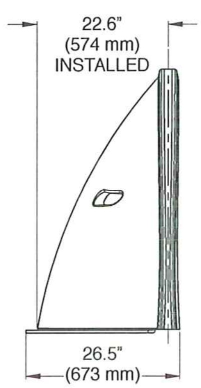
Figure 2

StormTech MC-3500 End Cap (not to scale)

Nominal End Cap Specifications

Size (L x W x H)	26.5" (673 mm) x 71" (1803 mm) x 45.1" (1145 mm)
End Cap Storage	15.6 ft³ (0.44 m³)
Min. Installed Storage*	45.6 ft³ (1.29 m³)
Weight	43 lbs (19.5 kg)





* This assumes a minimum of 12" (305 mm) of stone above, 9" (229 mm) of stone below and 6" (152 mm) of stone between the chambers/end caps and 40% stone porosity. The end cap minimum installed storage also includes the stone storage located in the 6" (152 mm) stone perimeter.

1.0 Product Information

1.1 PRODUCT DESIGN

StormTech's commitment to thorough product testing programs, materials evaluation and adherence to national standards has resulted in another superior product. Like other StormTech chambers, the MC-3500 is designed to meet the full scope of design requirements of Section 12.12 of the AASHTO LRFD Bridge Design Specifications and produced to the requirements of the American Society of Testing Materials (ASTM) International specification F 2418 "Standard Specification for Polypropylene (PP) Corrugated Stormwater Collection Chambers".

The StormTech MC-3500 chamber provides the full AASHTO safety factors for live loads and permanent earth loads. The ASTM F 2418 standard is linked to the AASHTO LRFD Bridge Design Specifications Section 12.12 design standard. ASTM F 2418 requires that the safety factors included in the AASHTO guidance are achieved as a prerequisite to meeting ASTM F 2418. StormTech chambers are also designed in accordance with ASTM F 2787 "Standard Practice for Structural Design of Thermoplastic Corrugated Wall Stormwater Collection Chambers" which provides specific guidance on how to design thermoplastic chambers in accordance with AASHTO Section 12.12. The three standards provide both the assurance of product quality and safe structural design.

The design of a larger chamber in the same tradition of our other chambers required the collaboration of experts in soil-structure interaction, plastics and manufacturing. Years of extensive research, including laboratory testing and field verification, were required to produce a chamber that is ready to meet both the rigors of installation and the longevity expected by engineers and owners.

This MC-3500 Design Manual provides the details and specifications necessary for consulting engineers to design stormwater management systems using the MC-3500 chamber. It provides specifications for storage capacities, layout dimensions as well as requirements for design to ensure a long service life. The basic design concepts for foundation and backfill materials, subgrade bearing capacities and row spacing remain equally as pertinent for the MC-3500 as the SC-740 and SC-310 chamber systems. However, since many design values and dimensional requirements are different for the MC-3500 than the SC-740 and SC-310 chambers, design manuals and installation instructions are not interchangeable.

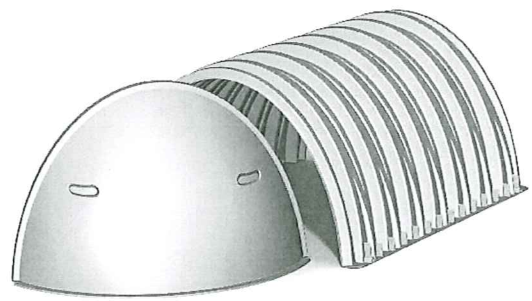
This manual includes only those details, dimensions, cover limits, etc for the MC-3500 and is intended to be a stand-alone design guide for the MC-3500 chamber. Installation Instructions specifically for the MC-3500 have also been published.

1.2 TECHNICAL SUPPORT

The StormTech Technical Services Department is available to assist the engineer with the layout of MC-3500 chamber systems and answer questions regarding all the StormTech chamber models. Call the Technical Services Department, email us at techinfo@stormtech.com or contact your local StormTech representative.

1.3 MC-3500 CHAMBER

All StormTech chambers are designed to the full scope of AASHTO requirements without repeating end walls or other structural reinforcing. StormTech's continuously curved, elliptical arch and the surrounding angular backfill are the key components of the structural system. With the addition of patent pending integral stiffening ribs **(Figure 3)**, the MC-3500 is assured to provide a long, safe service life. Like other StormTech chambers, the MC-3500 is produced from high quality, impact modified virgin polypropylene which is tested for short-term and long-term mechanical properties.



With the MC-3500, one chamber type is used for the start, middle and end of rows. Rows are formed by overlapping the *upper joint corrugation* of the next chamber over the *lower joint corrugation* of the previous chamber **(Figure 4)**.

The MC-3500 is designed with an optimized joining system. The height and width of the end corrugations have been designed to provide the required structural safety factors while providing an unobstructed flow path down each row.

To assist the contractor, StormTech chambers are molded with simple assembly instructions and arrows that indicate the direction in which to build rows. The corrugation valley immediately adjacent to the lower joint corrugation is marked "Overlap Here - Lower Joint." The corrugation valley immediately adjacent to the upper joint corrugation is marked "Build This Direction - Upper Joint."

Two people can safely and efficiently carry and place chambers without cumbersome connectors, special tools or heavy equipment. Each row of MC-3500 chambers must begin and end with a joint corrugation. Field cutting is not recommended. For system layout assistance contact StormTech.

1.4 MC-3500 END CAP

The MC-3500 end cap is very easy to install. The MC-3500 end cap is designed with a corrugation joint that fits over the top of either end of the chamber. The *end cap joint* is simply set over the top of either of the upper or lower chamber joint corrugations **(Figure 5)**. Three (3) screws fasten the end cap to the chamber to maintain a positive connection during backfilling. Handles are molded into the end cap to enable one person to carry and set the end cap in place.

1.5 MC-3500 PRE-CORED END CAPS

End caps with pre-cored 18" and 24" bottom connections and 15" top connections are standard parts. Other pre-cored end cap configurations are available by special order. See StormTech details.

Figure 3 – Chamber and End Cap Components

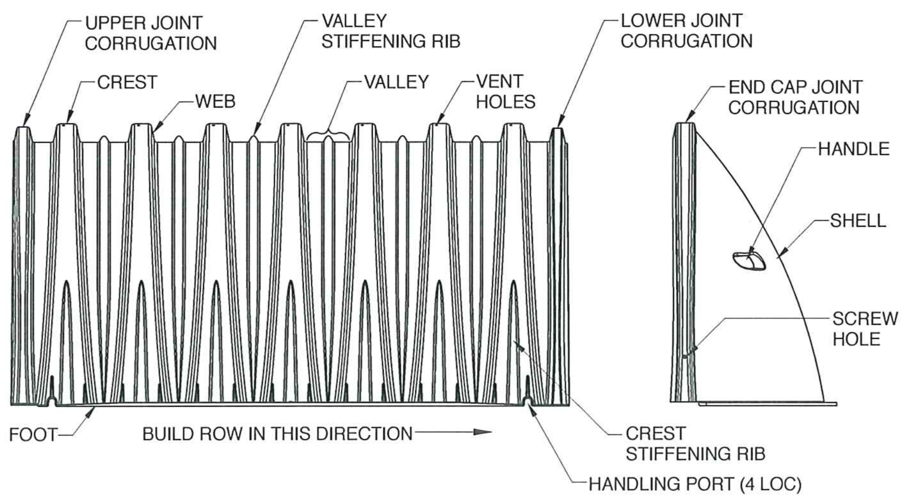


Figure 4 – Chamber Joint Overlap

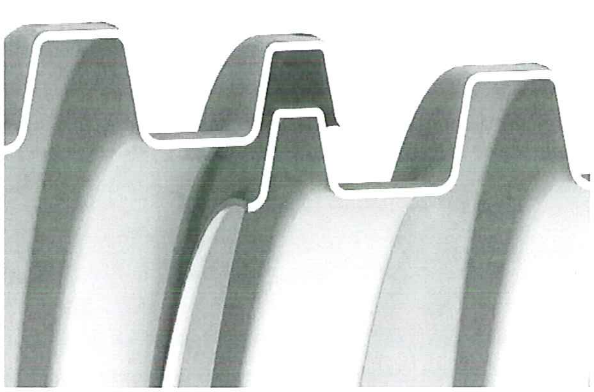
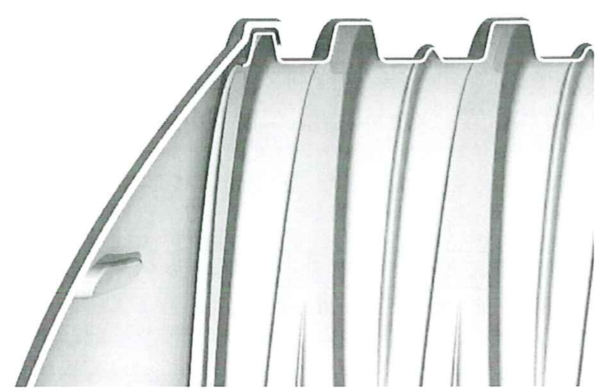


Figure 5 – End Cap Joint Overlap

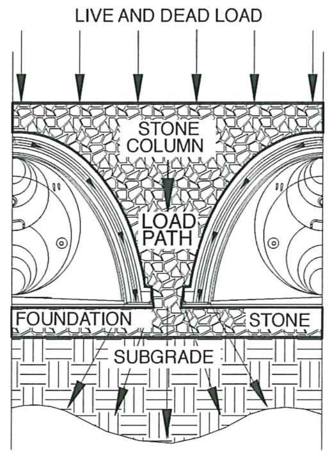


2.0 Foundations for Chambers

2.1 FOUNDATION REQUIREMENTS

StormTech MC-3500 chamber systems can be installed in various soil types. The subgrade bearing capacity and the cover height over the chambers determine the required depth of clean, crushed, angular foundation stone below the chambers. Foundation stone, also called bedding, is the stone between the subgrade soils and the feet of the chamber. Flexible structures are designed to transfer a significant portion of both live and dead loads through the surrounding soils. Chamber systems accomplish this by creating load paths through the columns of embedment stone between and around the rows of chambers. This creates load concentrations at the base of the columns between the rows. The foundation stone spreads out the concentrated loads to distributed loads that can be supported by the subgrade soils.

Since increasing the cover height (top of chamber to finished grade) causes increasing soil load, a greater depth of foundation stone is necessary to distribute the load to the subgrade soils. **Table 1** specifies the minimum required foundation depths for varying cover heights and allowable subgrade bearing capacities. The table is based on StormTech service loads and standard 6" (152 mm) row spacing for the MC-3500. The minimum required foundation depth is 9" (229 mm).



2.2 WEAKER SOILS

StormTech has not provided guidance for subgrade bearing capacities less than 2000 pounds per square foot [(2.0 ksf) (96 kPa)]. These soils are often highly variable, may contain organic materials and could be more sensitive to moisture. A geotechnical engineer must be consulted if soils with bearing capacities less than 2000 psf (96 kPa) are present.

Table 1 – Minimum Required Foundation Depth in Inches (mm)

Cover Hgt. ft (m)	Minimum Bearing Resistance for Service Loads ksf (kPa) 4.4 (211)	4.3 (206)	4.2 (201)	4.1 (196)	4.0 (192)	3.9 (187)	3.8 (182)	3.7 (177)	3.6 (172)	3.5 (168)	3.4 (163)	3.3 (158)	3.2 (153)	3.1 (148)	3.0 (144)	2.9 (139)	2.8 (134)	2.7 (129)	2.6 (124)	2.5 (120)	2.4 (115)	2.3 (110)	2.2 (105)	2.1 (101)	2.0 (96)
2.0 (0.61)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	12 (305)	12 (305)	12 (305)	12 (305)	15 (381)	15 (381)	15 (381)	18 (457)	18 (457)	24 (610)
2.5 (0.76)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	12 (305)	12 (305)	12 (305)	12 (305)	15 (381)	15 (381)	15 (381)	18 (457)	18 (457)	24 (610)	24 (610)
3.0 (0.91)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	12 (305)	12 (305)	12 (305)	12 (305)	15 (381)	15 (381)	15 (381)	18 (457)	18 (457)	18 (457)	24 (610)	24 (610)	24 (610)
3.5 (1.07)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	12 (305)	12 (305)	12 (305)	12 (305)	12 (305)	15 (381)	15 (381)	15 (381)	18 (457)	18 (457)	24 (610)	24 (610)	24 (610)	24 (610)	30 (762)
4.0 (1.22)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	12 (305)	12 (305)	12 (305)	12 (305)	12 (305)	15 (381)	15 (381)	15 (381)	18 (457)	18 (457)	18 (457)	24 (610)	24 (610)	24 (610)	24 (610)	30 (762)	30 (762)
4.5 (1.37)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	12 (305)	12 (305)	12 (305)	12 (305)	15 (381)	15 (381)	15 (381)	15 (381)	18 (457)	18 (457)	18 (457)	24 (610)	24 (610)	24 (610)	24 (610)	30 (762)	30 (762)	36 (914)
5.0 (1.52)	9 (229)	9 (229)	9 (229)	9 (229)	9 (229)	12 (305)	12 (305)	12 (305)	12 (305)	12 (305)	15 (381)	15 (381)	15 (381)	18 (457)	18 (457)	18 (457)	18 (457)	18 (457)	24 (610)	24 (610)	24 (610)	30 (762)	30 (762)	36 (914)	36 (914)
5.5 (1.68)	9 (229)	9 (229)	9 (229)	12 (305)	12 (305)	12 (305)	12 (305)	12 (305)	15 (381)	15 (381)	15 (381)	15 (381)	18 (457)	18 (457)	18 (457)	24 (610)	24 (610)	24 (610)	24 (610)	24 (610)	30 (762)	30 (762)	36 (914)	36 (914)	42 (1067)
6.0 (1.83)	9 (229)	9 (229)	12 (305)	12 (305)	12 (305)	12 (305)	15 (381)	15 (381)	15 (381)	15 (381)	18 (457)	18 (457)	18 (457)	18 (457)	24 (610)	24 (610)	24 (610)	24 (610)	24 (610)	30 (762)	30 (762)	36 (914)	36 (914)	42 (1067)	42 (1067)
6.5 (1.98)	9 (229)	12 (305)	12 (305)	12 (305)	12 (305)	12 (305)	15 (381)	15 (381)	15 (381)	15 (381)	18 (457)	18 (457)	18 (457)	24 (457)	24 (610)	24 (610)	24 (610)	24 (610)	30 (762)	30 (762)	30 (762)	36 (914)	36 (914)	42 (1067)	42 (1067)

NOTE: The design engineer is solely responsible for assessing the bearing resistance (allowable bearing capacity) of the subgrade soils and determining the depth of foundation stone. Subgrade bearing resistance should be assessed with consideration for the range of soil moisture conditions expected under a stormwater system.

3.1 FOUNDATION AND EMBEDMENT STONE

The stone surrounding the chambers consists of the *foundation* stone below the chambers and *embedment* stone surrounding the chambers. The foundation stone and embedment stone are important components of the structural system and also provide open void space for stormwater storage. **Table 2** provides the stone specifications that achieve both structural requirements and a porosity of 40% for stormwater storage. **Figure 6** specifies the extents of each backfill stone location.

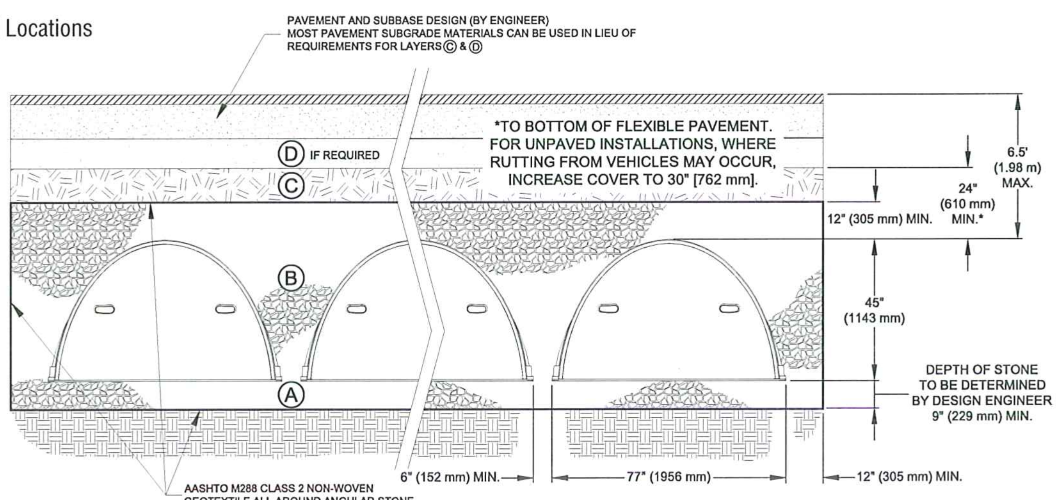
TABLE 2 – Acceptable Fill Materials

Material Location	Description	AASHTO M43 Designation[1]	Compaction/Density Requirement
Ⓓ Fill Material for layer 'D' starts from the top of the 'C' layer to the bottom of flexible pavement or unpaved finished grade above. Note that the pavement subbase may be part of the 'D' layer.	Any soil/rock materials, native soils or per engineer's plans. Check plans for pavement subgrade requirements.	N/A	Prepare per engineer's plans. Paved installations may have stringent material and preparation requirements.
Ⓒ Fill Material for layer 'C' starts from the top of the embedment stone ('B' layer) to 24" (610 mm) above the top of the chamber. Note that pavement subbase may be part of the 'C' layer.	Granular well-graded soil/aggregate mixtures, <35% fines. Most pavement subbase materials can be used in lieu of this layer. (AASHTO M145 A-1, A-2, A-3)	3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9, 10	Begin compaction after 24" (610 mm) of material over the chambers is reached. Compact additional layers in 12" (305 mm) max. lifts to a min. 95% Standard Proctor density. See MC-3500 Installation Instructions for acceptable compaction equipment loads.
Ⓑ Embedment Stone surrounding chambers from the foundation stone to the 'C' layer above.	Clean, crushed, angular stone, nominal size distribution 3/4 - 2" (19 mm - 51 mm)	3, 357, 4, 467, 5, 56, 57	No compaction required.
Ⓐ Foundation Stone below the chambers from the subgrade up to the foot (bottom) of the chamber.	Clean, crushed, angular stone, nominal size distribution 3/4 - 2" (19 mm - 51 mm)	3, 357, 4, 467, 5, 56, 57	Plate compact or roll to achieve a 95% Standard Proctor Density.[2]

PLEASE NOTE:

1. ***The listed AASHTO designations are for gradations only. The stone must also be clean, crushed, angular. For example, a specification for #4 stone would state: "clean, crushed, angular no. 4 (AASHTO M43) stone."***
2. ***As an alternate to Proctor Testing and field density measurements on open graded stone, StormTech compaction requirements are met for 'A' location materials when placed and compacted in 9" (229 mm) (max) lifts using two full passes with an appropriate compactor.***

FIGURE 6 – Fill Material Locations



Once layer 'C' is placed any soil/material can be placed in layer 'D' up to the finished grade. Most pavement subbase soils can be used to replace the materials requirements of layer 'C' or 'D' at the design engineer's discretion.

3.0 Required Materials/Row Separation

3.2 FILL ABOVE CHAMBERS

Refer to **Table 2** and **Figure 6** for acceptable fill material above the clean, crushed, angular stone. StormTech requires a minimum of 24" (610 mm) from the top of the chamber to the bottom of flexible pavement. For non-paved installations where rutting from vehicles may occur StormTech requires a minimum of 30" (762 mm) from top of chamber to finished grade.

3.3 GEOTEXTILE SEPARATION

A non-woven geotextile meeting AASHTO M288 Class 2 separation requirements must be installed to completely envelope the system and prevent soil intrusion into the crushed, angular stone. Overlap adjacent geotextile rolls per AASHTO M288 separation guidelines. See **Table 3** for a list of acceptable geotextiles.

TABLE 3 – Some Suitable Geotextiles

Manufacturer	AASHTO M288 Class 2 Non-Woven*	AASHTO M288 Class 1 Woven**
Belton Industries	———	Beltech 977
Carthage Mills	FX-60HS, FX-80HS	FX-66
GSE Lining Technology	NW6, NW8	——
Maccaferri	MacTex MX245, MacTex MX275	——
Pavco-Amanco	NT3000M, NT4000M	TR 4000
Propex	Geotex 651, Geotex 861, Geotex 601, Geotex 701, Geotex 801	Geotex 315ST, Geotex 2x2HF, Geotex 250ST
SKAPS Industries	GT 160NW, GT 180NW	W315
Tencate Mirafi	Mirafi 160N, Mirafi 180N	Mirafi 600X, Filterweave 403, Filterweave 404, Geolon HP570, Geolon HP665, Geolon HP770
TNS Advanced Tech.	R060, R070, R080, R100	——
US Fabrics	US 205NW, US 160NW	US 315

*AASHTO M288 Class 2 Non-Woven Geotextile Application: 1. Separation layer between angular stone and surrounding soils to prevent fines intrusion. 2. Filter layer over the chambers of the StormTech Isolator™ Row to prevent fines migration out of row while maintaining adequate hydraulic flows.

**AASHTO M288 Class 1 Woven Geotextile Application: 1. Filtration/stabilization layer for the angular stone foundation of the StormTech Isolator™ Row to prevent scouring of the stone base during the JetVac maintenance procedure, modest hydraulic flows maintained. 2. At each inlet row to prevent scouring of the foundation stone.

3.4 PARALLEL ROW SEPARATION/ PERPENDICULAR BED SEPARATION

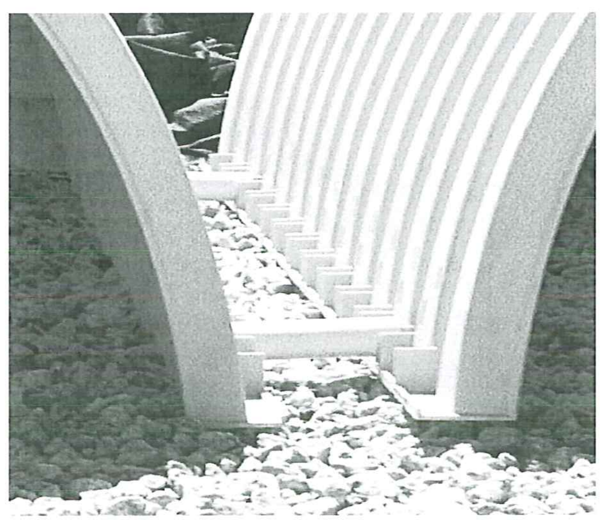
Parallel Row Separation

The minimum installed spacing between parallel rows after backfilling is 6" (152 mm) (measurement taken between the outside edges of the feet). Spacers may be used for layout convenience. Row spacing wider than the minimum 6" (152 mm) may be specified.

Increasing the spacing between chamber rows may allow the application of StormTech chambers with either less foundation stone or with weaker subgrade soils. This may be a good option where vertical restrictions on site prevent the use of a deeper foundation.

Perpendicular Bed Separation

When beds are laid perpendicular to each other, a minimum installed spacing of 36" (914 mm) between beds is required.



Spacers for row separation.

4.1 GENERAL

StormTech subsurface chamber systems offer the flexibility for a variety of inlet and outlet configurations. Contact the StormTech Technical Services Department or your local StormTech representative for assistance configuring inlet and outlet connections.

The open graded stone around and under the MC-3500 provides significant conveyance capacity ranging from approximately 0.8 cfs (23 l/s) to 13 cfs (368 l/s) per chamber. The actual conveyance capacity is dependent upon stone size, depth of foundation stone and head of water. Although the high conveyance capacity of the open graded stone is an important component of the flow network, StormTech recommends that a system of inlet and outlet manifolds be designed to distribute and convey the peak flow through the chamber system.

It is the responsibility of the design engineer to provide the design flow rates and storage volumes for the stormwater system and to ensure that the final design meets all conveyance and storage requirements. However, StormTech will work with the design engineer to assist with manifold and chamber layouts that meet the design objectives.

4.2 THE ISOLATOR™ ROW

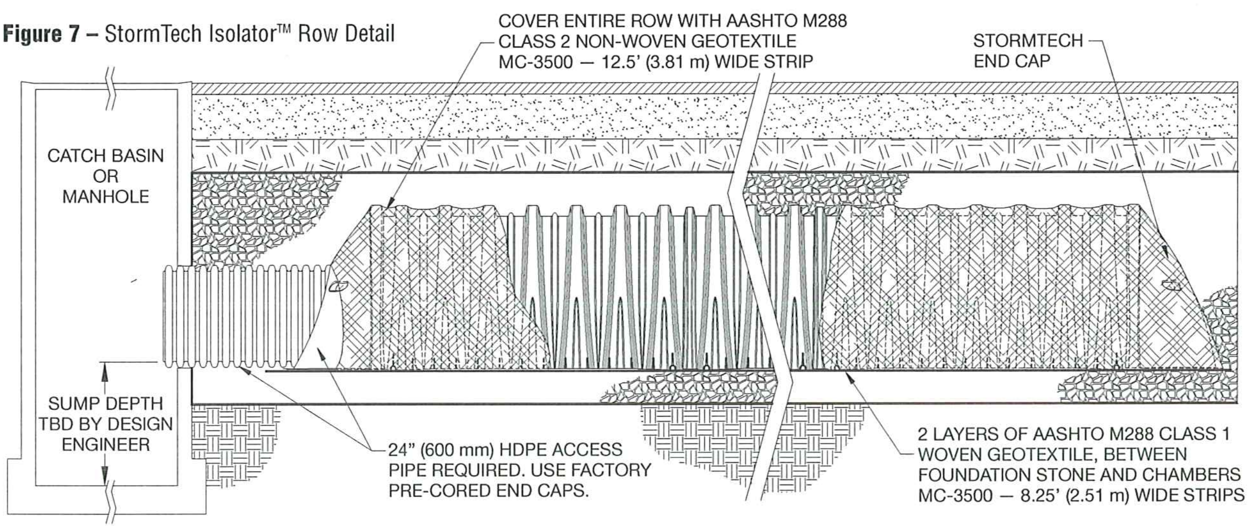
The Isolator Row is a patented system that inexpensively captures total suspended solids (TSS) and debris and provides easy access for inspection and maintenance. A double layer of woven geotextile between the bottom of the chambers and the foundation stone provides the filter media that satisfies most contaminant removal objectives. Each installed MC-3500 chamber and MC-3500 end cap provides 43.2 ft^2 (4.0 m^2) and 7.5 ft^2 (0.7 m^2) of bottom filter area respectively. Flow through Isolator Row chamber and end cap joints is filtered by a nonwoven geotextile that covers the chambers and end caps.

The Isolator Row can be configured for maintenance objectives or, in some regulatory jurisdictions, for water quality objectives. For water quality applications, Isolator Rows can be sized based on water quality volume or flow rate.

All Isolator Rows require: 1) a manhole for maintenance access, 2) a means of diversion of flows to the Isolator Row and 3) a high flow bypass. Flow diversion can be accomplished by either a weir in the upstream access manhole or simply by feeding the Isolator Row at a lower elevation than the high flow bypass. Contact StormTech for assistance sizing Isolator Rows.

When additional stormwater treatment is required, StormTech systems can be configured using a treatment train approach where other stormwater BMPs are located in series.

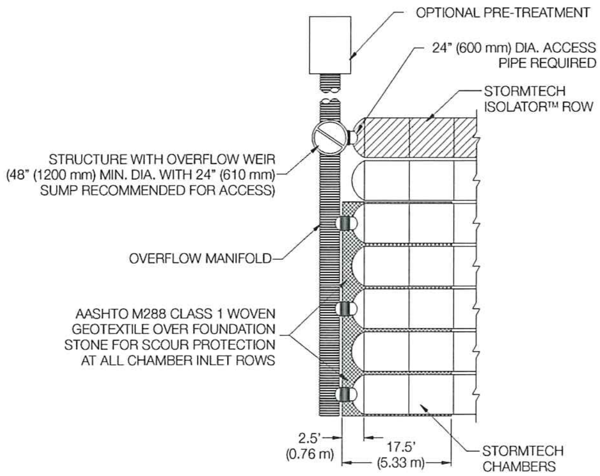
Figure 7 – StormTech Isolator™ Row Detail



NOTE: For many applications, the non-woven geotextile over the MC-3500 chambers can be eliminated or substituted with the AASHTO Class I woven geotextile. Contact your StormTech representative for assistance.

4.0 Hydraulics

Figure 8 – Typical Inlet Configuration With Isolator Row and Scour Protection



4.3 INLET MANIFOLDS

The primary function of the inlet manifold is to convey and distribute flows to a sufficient number of rows in the chamber bed such that there is ample conveyance capacity to pass the peak flows without creating an unacceptable backwater condition in upstream piping or scour the foundation stone under the chambers.

Manifolds are connected to MC-3500 end caps either at the top or bottom of the end cap. High inlet flow rates from either connection location produce a shear scour potential of the foundation stone. Inlet flows from top inlets also produce impingement scour potential. Scour potential is reduced when standing water is present over the foundation stone. However, for safe design across the wide range of applications, StormTech assumes minimal standing water at the time the design flow occurs.

To minimize scour potential, StormTech recommends the installation of woven scour protection fabric at each inlet row. This enables a protected transition zone from the concentrated flow coming out of the inlet pipe to a uniform flow across the entire width of the chamber for both top and bottom connections.

Allowable flow rates for design are dependent upon: the elevation of inlet pipe, foundation stone size and scour protection. With an appropriate scour protection geotextile installed from the end cap to at least 15' (4.57 m) in front of the inlet pipe, for both top and bottom feeds, the flow rates listed in **Table 4** can be used for all StormTech specified foundation stone gradations.

TABLE 4 – Allowable Inlet Flows With 15' (4.57 m) of Scour Protection for the MC-3500 Chamber

Inlet Pipe Diameter Inches (mm)	Allowable Maximum Flow Rate cfs (l/s)
12 (300)	2 (57)
15 (375)	3.5 (99)
18 (450)	5.5 (156)
24 (600)	8.5 (241)

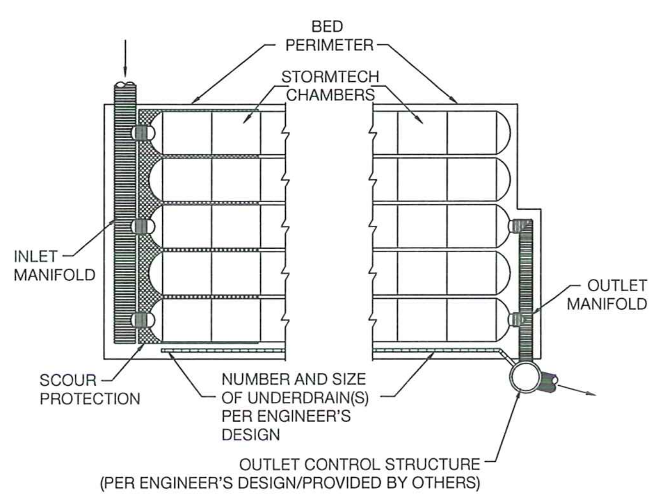
4.4 OUTLET MANIFOLDS

The primary function of the outlet manifold is to convey peak flows from the chamber system to the outlet control structure. Outlet manifolds are often sized for attenuated flows. They may be smaller in diameter and have fewer row connections than inlet manifolds. In some applications however, the intent of the outlet piping is to convey an unattenuated bypass flow rate and manifolds may be sized similar to inlet manifolds.

Since chambers are generally flowing at or near full at the time of the peak outlet flow rate, scour is generally not governing and outlet manifold sizing is based on pipe flow equations. In most cases, StormTech recommends that outlet manifolds connect the same rows that are connected to an inlet manifold. This provides a continuous flow path through open conduits to pass the peak flow without dependence on passing peak flows through stone.

The primary function of the underdrains is to draw down water stored in the stone below the invert of the manifold. Underdrains are generally not sized for conveyance of the peak flow.

Figure 9 – Typical Inlet, Outlet and Underdrain Configuration



5.0 Cumulative Storage Volumes

StormTech

Tables 5 and **6** provide cumulative storage volumes for the MC-3500 chamber and end cap. These tables can be used to calculate the stage–storage relationship for the retention or detention system. Digital spreadsheets in which the number of chambers and end caps can be input for quick cumulative storage calculations are available at www.stormtech.com. For assistance with site-specific calculations or input into routing software, contact the StormTech Technical Services Department.

TABLE 5 – MC-3500 Incremental Storage Volume Per Chamber

Assumes 40% stone porosity. Calculations are based upon a 9" (229 mm) stone base under the chambers, 12" (305 mm) of stone above chambers, and 6" (152 mm) spacing between chambers.

Depth of Water in System Inches (mm)	Cumulative Chamber Storage ft³ (m³)	Total System Cumulative Storage ft³ (m³)
66 (1676)	↑ 0	176.88 (5.009)
65 (1651)	0	175.22 (4.962)
64 (1626)	Stone 0	173.57 (4.915)
63 (1600)	Cover 0	171.92 (4.868)
62 (1575)	0	170.27 (4.821)
61 (1549)	0	168.61 (4.775)
60 (1524)	0	166.96 (4.728)
59 (1499)	0	165.31 (4.681)
58 (1473)	0	163.66 (4.634)
57 (1448)	0	162.01 (4.588)
56 (1422)	0	160.35 (4.541)
55 (1397)	↓ 0	158.70 (4.494)
54 (1372)	113.04 (3.201)	157.05 (4.447)
53 (1346)	112.98 (3.199)	155.36 (4.399)
52 (1321)	112.78 (3.194)	153.59 (4.349)
51 (1295)	112.47 (3.185)	151.75 (4.297)
50 (1270)	111.86 (3.168)	149.73 (4.240)
49 (1245)	110.89 (3.140)	147.50 (4.177)
48 (1219)	109.68 (3.106)	145.12 (4.109)
47 (1194)	108.29 (3.066)	142.64 (4.039)
46 (1168)	106.75 (3.023)	140.06 (3.966)
45 (1143)	105.07 (2.975)	137.39 (3.891)
44 (1118)	103.26 (2.924)	134.66 (3.813)
43 (1092)	101.33 (2.869)	131.85 (3.734)
42 (1067)	99.31 (2.812)	128.98 (3.652)
41 (1041)	97.18 (2.752)	126.05 (3.569)
40 (1016)	94.97 (2.689)	123.07 (3.485)
39 (991)	92.66 (2.624)	120.04 (3.399)
38 (965)	90.28 (2.556)	116.96 (3.312)
37 (940)	87.82 (2.487)	113.83 (3.223)
36 (914)	85.30 (2.415)	110.66 (3.134)
35 (889)	82.70 (2.342)	107.45 (3.043)
34 (864)	80.04 (2.267)	104.20 (2.951)
33 (838)	77.32 (2.189)	100.92 (2.858)
32 (813)	74.54 (2.111)	97.60 (2.764)
31 (787)	71.71 (2.031)	94.25 (2.669)
30 (762)	68.83 (1.949)	90.87 (2.573)
29 (737)	65.89 (1.866)	87.45 (2.476)
28 (711)	62.91 (1.782)	84.01 (2.379)
27 (686)	59.89 (1.696)	80.55 (2.281)
26 (660)	56.82 (1.609)	77.05 (2.182)
25 (635)	53.72 (1.521)	73.54 (2.082)
24 (610)	50.57 (1.432)	70.00 (1.982)
23 (584)	47.39 (1.342)	66.44 (1.881)
22 (559)	44.18 (1.251)	62.86 (1.780)
21 (533)	40.93 (1.159)	59.26 (1.678)
20 (508)	37.66 (1.066)	55.64 (1.576)
19 (483)	34.35 (0.973)	52.01 (1.473)
18 (457)	31.02 (0.878)	48.35 (1.369)
17 (432)	27.66 (0.783)	44.69 (1.265)
16 (406)	24.28 (0.688)	41.00 (1.161)
15 (381)	20.87 (0.591)	37.31 (1.056)
14 (356)	17.45 (0.494)	33.60 (0.951)
13 (330)	14.00 (0.396)	29.88 (0.846)
12 (305)	10.53 (0.298)	26.15 (0.740)
11 (279)	7.04 (0.199)	22.40 (0.634)
10 (254)	3.53 (0.100)	18.64 (0.528)
9 (229)	↑ 0	14.87 (0.421)
8 (203)	0	13.22 (0.374)
7 (178)	0	11.57 (0.328)
6 (152)	Stone 0	9.91 (0.281)
5 (127)	Foundation 0	8.26 (0.234)
4 (102)	0	6.61 (0.187)
3 (76)	0	4.96 (0.140)
2 (51)	0	3.30 (0.094)
1 (25)	↓ 0	1.65 (0.047)

NOTE: Add 1.65 ft³ (0.047 m³) of storage for each additional inch (25 mm) of stone foundation.

Contact StormTech for cumulative volume spreadsheets in digital format.

5.0 Cumulative Storage Volumes

TABLE 6 – MC-3500 Incremental Storage Volume Per End Cap

Assumes 40% stone porosity. Calculations are based upon a 9" (229 mm) stone base under the end caps, 12" (305 mm) of stone above end caps, 6" (152 mm) of spacing between end caps and 6" (152 mm) of stone perimeter.

Depth of Water in System Inches (mm)	Cumulative End Cap Storage ft³ (m³)	Total System Cumulative Storage ft³ (m³)
66 (1676)	0	45.65 (1.293)
65 (1651)	0	45.10 (1.277)
64 (1626)	Stone 0	44.55 (1.262)
63 (1600)	Cover 0	44.00 (1.246)
62 (1575)	0	43.45 (1.230)
61 (1549)	0	42.90 (1.215)
60 (1524)	0	42.35 (1.199)
59 (1499)	0	41.80 (1.184)
58 (1473)	0	41.25 (1.168)
57 (1448)	0	40.70 (1.153)
56 (1422)	0	40.15 (1.137)
55 (1397)	0	39.61 (1.122)
54 (1372)	15.64 (0.443)	39.06 (1.106)
53 (1346)	15.64 (0.443)	38.51 (1.090)
52 (1321)	15.63 (0.443)	37.95 (1.075)
51 (1295)	15.62 (0.442)	37.40 (1.059)
50 (1270)	15.60 (0.442)	36.84 (1.043)
49 (1245)	15.56 (0.441)	36.26 (1.027)
48 (1219)	15.51 (0.439)	35.68 (1.010)
47 (1194)	15.44 (0.437)	35.09 (0.994)
46 (1168)	15.35 (0.435)	34.49 (0.977)
45 (1143)	15.25 (0.432)	33.88 (0.959)
44 (1118)	15.13 (0.428)	33.26 (0.942)
43 (1092)	14.99 (0.424)	32.62 (0.924)
42 (1067)	14.83 (0.420)	31.98 (0.905)
41 (1041)	14.65 (0.415)	31.32 (0.887)
40 (1016)	14.45 (0.409)	30.65 (0.868)
39 (991)	14.24 (0.403)	29.97 (0.849)
38 (965)	14.00 (0.396)	29.28 (0.829)
37 (948)	13.74 (0.389)	28.58 (0.809)
36 (914)	13.47 (0.381)	27.86 (0.789)
35 (889)	13.18 (0.373)	27.14 (0.769)
34 (864)	12.86 (0.364)	26.40 (0.748)
33 (838)	12.53 (0.355)	25.65 (0.726)
32 (813)	12.18 (0.345)	24.89 (0.705)
31 (787)	11.81 (0.335)	24.12 (0.683)
30 (762)	11.42 (0.323)	23.34 (0.661)
29 (737)	11.01 (0.312)	22.54 (0.638)
28 (711)	10.58 (0.300)	21.73 (0.615)
27 (686)	10.13 (0.287)	20.92 (0.592)
26 (680)	9.67 (0.274)	20.09 (0.569)
25 (610)	9.19 (0.260)	19.25 (0.545)
24 (609)	8.70 (0.246)	18.41 (0.521)
23 (584)	8.19 (0.232)	17.55 (0.497)
22 (559)	7.67 (0.217)	16.69 (0.473)
21 (533)	7.13 (0.202)	15.82 (0.448)
20 (508)	6.59 (0.187)	14.94 (0.423)
19 (483)	6.03 (0.171)	14.06 (0.398)
18 (457)	5.46 (0.155)	13.17 (0.373)
17 (432)	4.88 (0.138)	12.27 (0.347)
16 (406)	4.30 (0.122)	11.37 (0.322)
15 (381)	3.70 (0.105)	10.46 (0.296)
14 (356)	3.10 (0.088)	9.55 (0.270)
13 (330)	2.49 (0.071)	8.64 (0.245)
12 (305)	1.88 (0.053)	7.72 (0.219)
11 (279)	1.26 (0.036)	6.80 (0.192)
10 (254)	0.63 (0.018)	5.87 (0.166)
9 (229)	0	4.95 (0.140)
8 (203)	0	4.40 (0.124)
7 (178)	0	3.85 (0.109)
6 (152)	0	3.30 (0.093)
5 (127)	Stone 0	2.75 (0.078)
4 (102)	Foundation 0	2.20 (0.062)
3 (76)	0	1.65 (0.047)
2 (51)	0	1.10 (0.031)
1 (25)	0	0.55 (0.016)

NOTE: Add 0.55 ft³ (0.016 m³) of storage for each additional inch (25 mm) of stone foundation.

Contact StormTech for cumulative volume spreadsheets in digital format.

6.0 MC-3500 Chamber System Sizing

StormTech

The following steps provide the calculations necessary for preliminary sizing of an MC-3500 chamber system. For custom bed configurations to fit specific sites, contact the StormTech Technical Services Department or your local StormTech representative.

1) Determine the amount of storage volume (V_S) required. It is the design engineer's sole responsibility to determine the storage volume required.

TABLE 7 – Storage Volume Per Chamber/End Cap ft³ (m³)

	Bare Unit Storage	Chamber/End Cap and Stone Volume — Stone Foundation Depth in. (mm)			
MC-3500	ft³ (m³)	9 (229)	12 (305)	15 (381)	18 (457)
Chamber	113 (3.20)	176.8 (5.01)	181.8 (5.15)	186.8 (5.29)	191.7 (5.43)
End Cap	15.6 (0.44)	45.6 (1.29)	47.3 (1.34)	48.9 (1.39)	50.6 (1.43)

NOTE: Assumes 40% porosity for the stone plus the chamber/end cap volume. End cap volume assumes 6" (152 mm) stone perimeter.

2) Determine the number of chambers (C) required. To calculate the number of chambers required for adequate storage, divide the storage volume (Vs) by the storage volume of the chamber (from **Table 7**), as follows: **C = Vs / Storage Volume per Chamber**

3) Determine the number of end caps required. The number of end caps (EC) required depends on the number of rows required by the project. Once the number of chamber rows is determined, multiply the number of chamber rows by 2 to determine the number of end caps required. **EC = No. of Chamber Rows x 2**

NOTE: Additional end caps may be required for systems having inlet locations within the chamber bed.

4) Determine additional storage provided by end caps. End Caps will provide additional storage to the project. Multiply the number of end caps (EC) by the storage volume per end cap (ECs) to determine the additional storage (As) provided by the end caps. **As = EC x ECs**

5) Adjust number of chambers (C) to account for additional end cap storage (As). The original number of chambers (C) can now be reduced due to the additional storage in the end caps. Divide the additional storage (As) by the storage volume per chamber to determine the number of chambers that can be removed. **Number of chambers to remove = As/ volume per chamber**

NOTE: Additional storage exists in the stone perimeter as well as in the inlet and outlet manifold systems. Contact StormTech's Technical Services Department for assistance with determining the number of chambers and end caps required for your project.

6) Determine the required bed size (S). The size of the bed will depend on the number of chambers and end caps required:
MC-3500 area per chamber = 49.6 ft² (4.6 m²)
MC-3500 area per end cap = 13.0 ft² (1.2 m²)

S = (C x area per chamber) + (EC x area per end cap)

NOTE: It is necessary to add 12" (305 mm) of stone perimeter parallel to the chamber rows and 6" (152 mm) of stone perimeter from the base of all end caps. The additional area due to perimeter stone is not included in the area numbers above.

7) Determine the amount of stone (V_{st}) required. To calculate the total amount of clean, crushed, angular stone required, multiply the number of chambers (C) and the number of end caps (EC) by the selected weight of stone from **Table 8.**

NOTE: Clean, crushed, angular stone is also required around the perimeter of the system.

TABLE 8 – Amount of Stone Per Chamber/End Cap

ENGLISH tons (yds³)	Stone Foundation Depth			
	9"	12"	15"	18"
MC-3500	8.4 (5.9 yd³)	9.0 (6.4 yd³)	9.7 (6.8 yd³)	10.3 (7.3 yd³)
End Cap	3.9 (2.8 yd³)	4.2 (2.9 yd³)	4.4 (3.1 yd³)	4.6 (3.2 yd³)
METRIC kg (m³)	229 mm	305 mm	381 mm	457 mm
MC-3500	7620 (4.5 m³)	8164 (4.9 m³)	8800 (5.2 m³)	9344 (5.6 m³)
End Cap	3538 (2.1 m³)	3810 (2.2 m³)	3992 (2.4 m³)	4173 (2.4 m³)

NOTE: Assumes 12" (305 mm) of stone above, 6" (152 mm) row spacing, and 6" (152 mm) of perimeter stone in front of end caps.

8) Determine the volume of excavation (Ex) required. Each additional foot of cover will add a volume of excavation of 1.8 yd³ (1.4 m³) per MC-3500 chamber and 0.6 yd³ (0.5 m³) per MC-3500 end cap.

TABLE 9 – Volume of Excavation Per Chamber/End Cap in yd³ (m³)

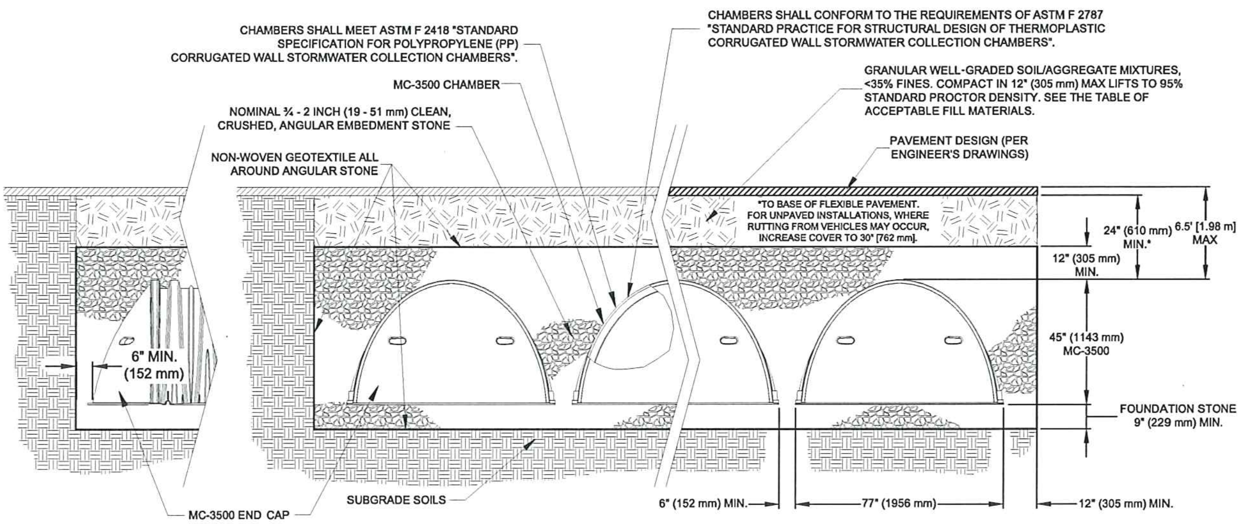
	Stone Foundation Depth			
	9" (229 mm)	12" (305 mm)	15" (381 mm)	18" (457 mm)
MC-3500	11.9 (9.1)	12.4 (9.5)	12.9 (9.9)	13.3 (10.2)
End Cap	4.0 (3.1)	4.1 (3.1)	4.3 (3.3)	4.4 (3.4)

NOTE: Assumes 6" (152 mm) of separation between chamber rows, 6" (152 mm) of perimeter in front of end caps, and 24" (610 mm) of cover. The volume of excavation will vary as the depth of cover increases.

9) Determine the area of geotextile (F) required. The bottom, top and sides of the bed must be covered with a non-woven geotextile (filter fabric) that meets AASHTO M288 Class 2 requirements. The area of the sidewalls must be calculated and a 24" (610 mm) overlap must be included for all seams. Geotextiles typically come in 15 foot (4.57 m) wide rolls.

7.0 Structural Cross Section and Specifications

Figure 10 – MC-3500 Structural Cross Section Detail – (not to scale)



THE INSTALLED CHAMBER SYSTEM SHALL PROVIDE THE LOAD FACTORS SPECIFIED IN THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS SECTION 12.12 FOR EARTH AND LIVE LOADS, WITH CONSIDERATION FOR IMPACT AND MULTIPLE VEHICLE PRESENCES.

MC-3500 STORMWATER CHAMBER SPECIFICATIONS:

1. Chambers shall be StormTech MC-3500 or approved equal.
2. Chambers shall be made from virgin, impact-modified polypropylene copolymers.
3. Chamber rows shall provide continuous, unobstructed internal space with no internal panels that would impede flow.
4. The structural design of the chambers, the structural backfill and the installation requirements shall ensure that the load factors specified in the AASHTO LRFD Bridge Design Specifications, Section 12.12 are met for: 1) long-duration dead loads and 2) short-duration live loads, based on the AASHTO Design Truck with consideration for impact and multiple vehicle presences.
5. Chambers shall conform to the requirements of ASTM F 2418, "Standard Specification for Polypropylene (PP) Corrugated Wall Stormwater Collection Chambers."
6. Chambers shall conform to the requirements of ASTM F 2787, "Standard Practice for Structural Design of Thermoplastic Corrugated Wall Stormwater Collection Chambers."
7. Only chambers that are approved by the engineer will be allowed. The contractor shall submit (3 sets) of the following to the engineer for approval before delivering chambers to the project site:
   - A structural evaluation by a registered structural engineer that demonstrates that the load factors specified in the AASHTO LRFD Bridge Design Specifications, Section 12.12 are met. The 50-year creep modulus data specified in ASTM F 2418 must be used as part of the AASHTO structural evaluation to verify long-term performance
   - Structural cross section detail on which the structural cross section is based.
8. The installation of chambers shall be in accordance with the manufacturer's latest Installation Instructions.

Detail drawings available in AutoCad Rev. 2000 format at www.stormtech.com.

8.0 General Notes

StormTech

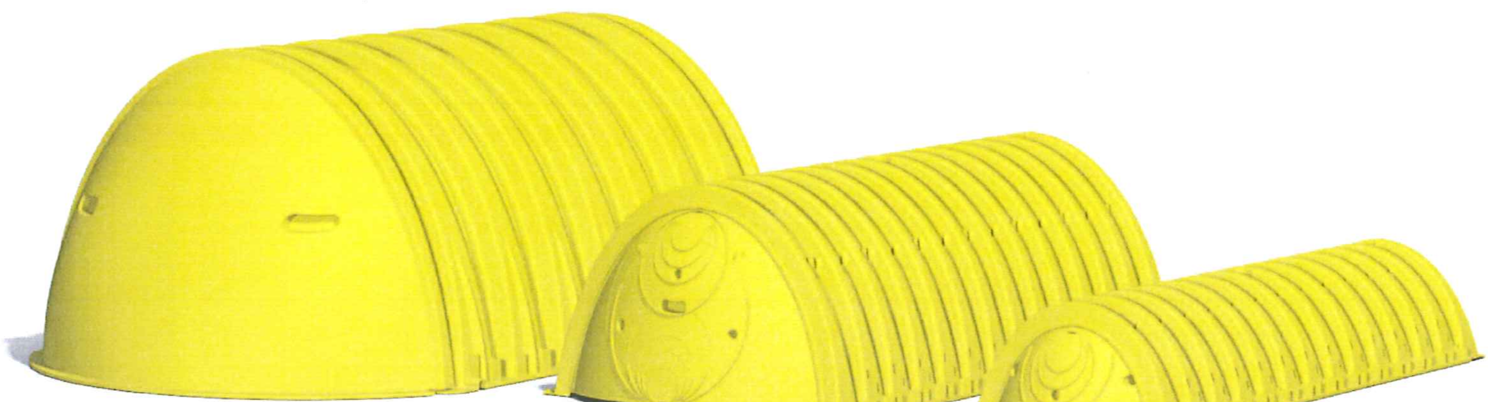
1. StormTech LLC ("StormTech") requires installing contractors to use and understand the latest **StormTech MC-3500 Installation Instructions** prior to beginning system installation.
2. StormTech offers installation consultations to installing contractors. Contact our Technical Service Department or local StormTech representative at least 30 days prior to system installation to arrange a pre-installation consultation. Our representatives can then answer questions or address comments on the StormTech chamber system and inform the Installing contractor of the minimum installation requirements before beginning the system's construction. Call 860-529-8188 to speak to a Technical Service Representative or visit www.stormtech.com to receive a copy of our Installation Instructions.
3. StormTech requirements for systems with pavement design (asphalt, concrete pavers, etc.): Minimum cover is 24" (610 mm) not including pavement; Maximum cover is 6.5' (1.98 m) including pavement. For installations that do not include pavement, where rutting from vehicles may occur, minimum required cover is 30" (762 mm), maximum cover is 6.5' (1.98 m).
4. The contractor must report any discrepancies with the bearing capacity of the subgrade materials to the design engineer.
5. AASHTO M288 Class 2 non-woven geotextile (filter fabric) must be used as indicated in the project plans.
6. Stone placement between chamber rows and around perimeter must follow instructions as indicated in the most current version of StormTech MC-3500 Installation Instructions.
7. Backfilling over the chambers must follow requirements as indicated in the most current version of StormTech MC-3500 Installation Instructions.
8. The contractor must refer to StormTech MC-3500 Installation Instructions for a Table of Acceptable Vehicle Loads at various depths of cover. This information is also available at the StormTech website: www.stormtech.com. The contractor is responsible for preventing vehicles that exceed StormTech requirements from traveling across or parking over the stormwater system. Temporary fencing, warning tape and appropriately located signs are commonly used to prevent unauthorized vehicles from entering sensitive construction areas.
9. The contractor must apply erosion and sediment control measures to protect the stormwater system during all phases of site construction per local codes and design engineer's specifications.
10. STORMTECH PRODUCT WARRANTY IS LIMITED. Contact StormTech for warranty information.

A Family of Products and Services for the Stormwater Industry:

- MC-3500 Chambers and End Caps
- SC-310 Chambers and End Caps
- SC-740 Chambers and End Caps
- SC and MC Fabricated End Caps
- Fabricated Manifold Fittings
- Patented Isolator Row for Maintenance and Water Quality
- Chamber Separation Spacers
- In-House System Layout Assistance
- On-Site Educational Seminars
- Worldwide Technical Sales Group
- Centralized Product Applications Department
- Research and Development Team
- Technical Literature, O&M Manuals and Detailed CAD drawings all downloadable via our Web Site

StormTech provides state of the art products and services that meet or exceed industry performance standards and expectations. We offer designers, regulators, owners and contractors the highest quality products and services for stormwater management that "Saves Valuable Land and Protects Water Resources."

Please contact one of our inside project application professionals or Regional Product Managers (RPMs) to discuss your particular application. A wide variety of technical support material is available in print, electronic media or from our website at www.stormtech.com. For any questions, please call StormTech at 888-892-2694.



MC-3500 SC-740 SC-310

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StormTech products are covered by one or more of the following patents: U.S. Patents: 5,401,459; 5,511,903; 5,716,163; 5,588,778; 5,839,844; Canadian Patents: 2,158,418 Other U.S. and Foreign Patents Pending

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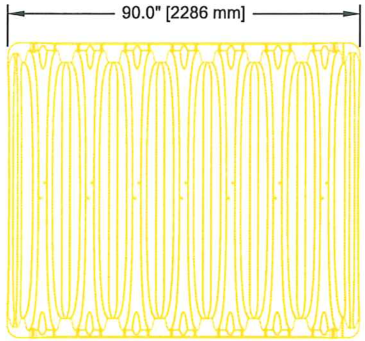
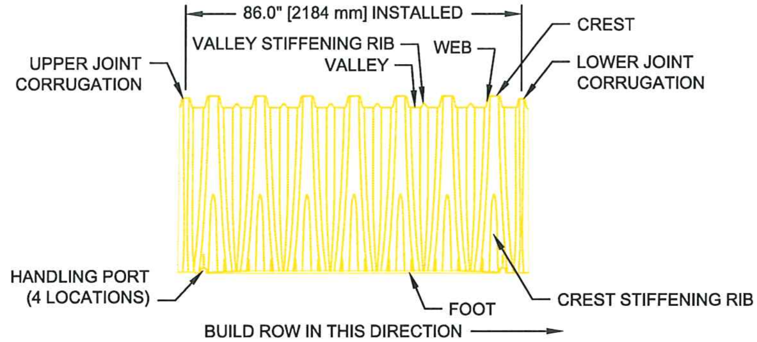


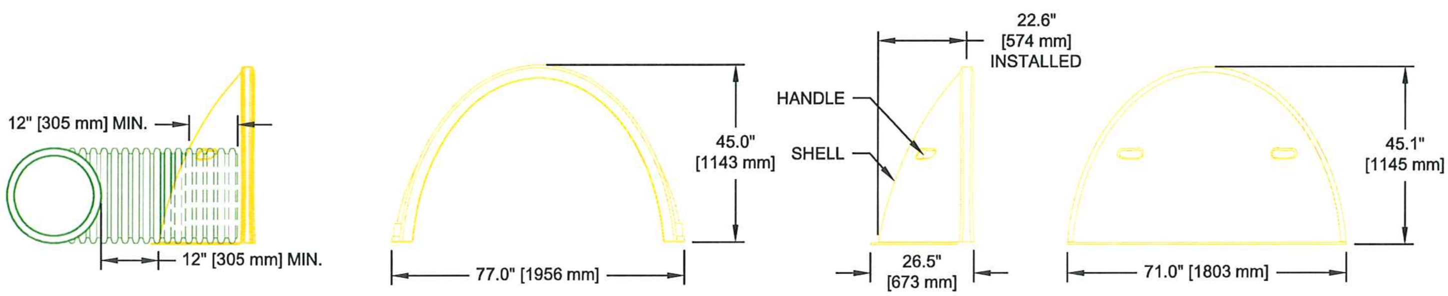


NOMINAL MC-3500 CHAMBER SPECIFICATIONS

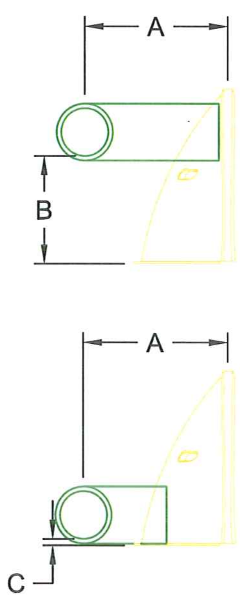
SIZE (L x W x H)	90" x 77" x 45" [2286 mm x 1956 mm x 1143 mm]
CHAMBER STORAGE	109.9 ft³ [3.11 m³]
MINIMUM INSTALLED STORAGE	178.9 ft³ [5.06 m³]
WEIGHT	134 lbs. [60.8 kg]

NOMINAL MC-3500 END CAP SPECIFICATIONS

SIZE (L x W x H)	26.5" x 71" x 45.1"[673 mm x 1803 mm x 1145 mm]
ENDCAP STORAGE	15.6 ft³ [0.44 m³]
MINIMUM INSTALLED STORAGE	46.9 ft³ [1.33 m³]
WEIGHT	43 lbs. [19.5 kg]



NOTE: MANIFOLD STUB MUST BE LAID HORIZONTAL FOR A PROPER FIT IN THE END CAP OPENING.



PART NUMBERS ENDING WITH "B" ARE FOR STUBS AT BOTTOM OF END CAP.
PART NUMBERS ENDING WITH "T" ARE FOR STUBS AT TOP OF END CAP.

PART#	STUB	B	C
MC3500TEPE12T	12" [300 mm]	26.36" (670 mm)	N/A
MC3500TEPE12B	12" [300 mm]	N/A	1.35" [34 mm]
MC3500TEPE15T	15" [375 mm]	23.39" [594 mm]	N/A
MC3500TEPE15B	15" [375 mm]	N/A	1.50" [38 mm]
MC3500TEPE18T	18" [450 mm]	20.03" [509 mm]	N/A
MC3500TEPE18B	18" [450 mm]	N/A	1.77" [45 mm]
MC3500TEPE24T	24" [600 mm]	14.48" [368 mm]	N/A
MC3500TEPE24B	24" [600 mm]	N/A	2.06" [52 mm]

NOTE: ALL DIMENSIONS ARE NOMINAL

CUSTOM PRECORED INVERTS ARE AVAILABLE UPON REQUEST.
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THE DESIGN ENGINEER SHALL REVIEW THIS DRAWING PRIOR TO CONSTRUCTION. IT IS THE ULTIMATE RESPONSIBILITY OF THE DESIGN ENGINEER TO ENSURE THAT THE PRODUCT(S) DEPICTED AND ALL ASSOCIATED DETAILS MEET ALL APPLICABLE LAWS, REGULATIONS, AND PROJECT REQUIREMENTS.

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MC-3500 TECHNICAL SPECIFICATIONS

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DATE:	04/25/12
DRAWN BY:	JLM
CHECKED:	

MC-3500/MC-4500

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StormTech Construction Guide

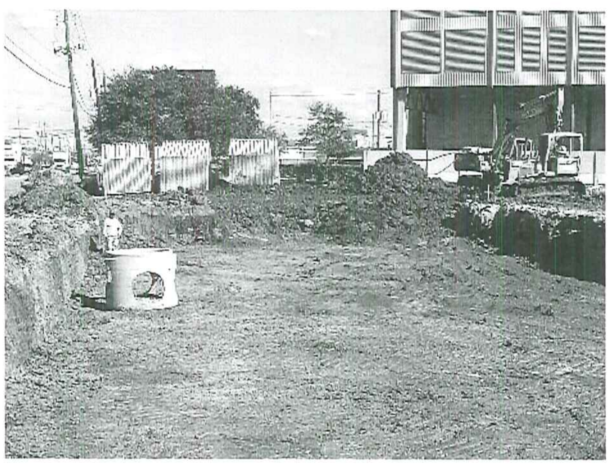
REQUIRED MATERIALS AND EQUIPMENT LIST

- Acceptable fill materials per **Table 1**
- Woven and non-woven geotextiles
- StormTech solid end caps and pre-cored end caps
- StormTech chambers
- MC-3500 end cap screws (2 ½" [64mm] coarse thread – 3 per end cap)
- MC-4500 chamber joint screws (Fastenal #12-11 x 1" slotted hex washer head sheet metal screw, type A, zinc/steel [SKU 1131123] - 6 per joint)
- StormTech manifolds and fittings

NOTE: MC-3500 chamber pallets are 77" x 90" (2.0 m x 2.3 m) and weigh about 2010 lbs. (912 kg) and MC-4500 pallets are 100" x 52" (2.5 m x 1.3 m) and weight about 840 lbs. (381 kg). Unloading chambers requires 72" (1.8 m) (min.) forks and/or tie downs (straps, chains, etc).

IMPORTANT: This installation guide provides the minimum requirements for proper installation of large chambers. Non-adherence to this guide may result in damage to chambers during installation. Replacement of damaged chambers during or after backfilling is costly and very time consuming. It is recommended that all installers are familiar with this guide, and that the contractor inspects the chambers for distortion, damage and joint integrity as work progresses.

Requirements for System Installation



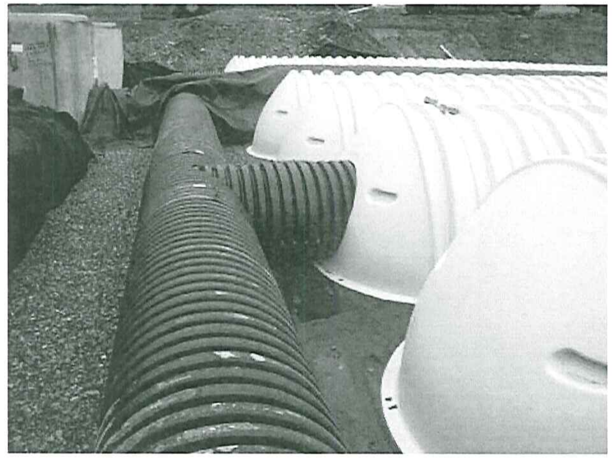
Excavate bed and prepare subgrade per engineer's plans.

Place non-woven geotextile over prepared soils and up excavation walls.

Place clean, crushed, angular stone foundation 9" (229 mm) min. Install underdrains if required. Compact to achieve a flat surface.

Manifold, Scour Fabric and Chamber Assembly

Install manifolds and lay out woven scour geotextile at inlet rows [min. 17.5 ft (5.33 m)] at each inlet end cap. Place a continuous piece (no seams) along entire length of Isolator® Row(s).

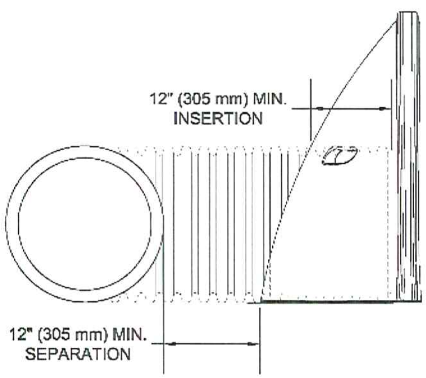


Align the first chamber and end cap of each row with inlet pipes. Each MC-3500 end cap must be fastened to chambers with three 2½" (64 mm) coarse thread screws before backfilling. Contractor may choose to postpone stone placement around end chambers and leave ends of rows open for easy inspection of chambers during the backfill process.

Continue installing chamber rows by overlapping chamber end corrugations. Chamber joints are labeled "Lower Joint— Overlap Here" and "Build This Direction—Upper Joint." Place non-woven geotextile over Isolator Row chambers (if specified).

Maintain minimum - 9" (229 mm) spacing between rows

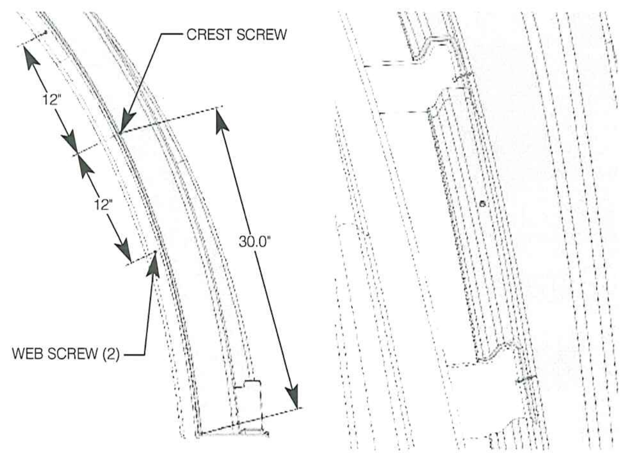
Manifold Insertion



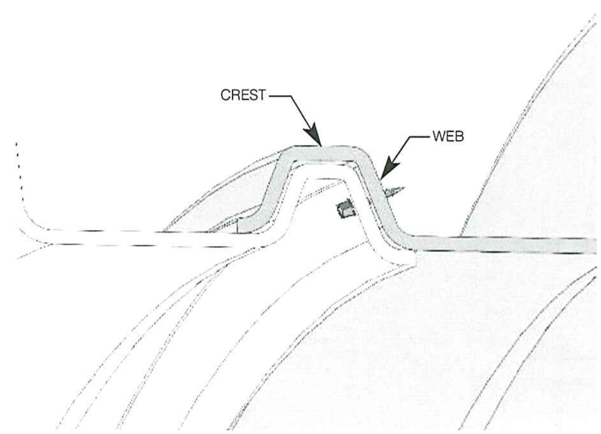
NOTE: MANIFOLD STUB MUST BE LAID HORIZONTAL FOR A PROPER FIT IN THE END CAP OPENING.

Insert inlet and outlet manifolds a minimum 12" (305 mm) into chamber end caps. Manifold header should be a minimum 12" (305 mm) from base of end cap.

MC-4500 Joint Assembly

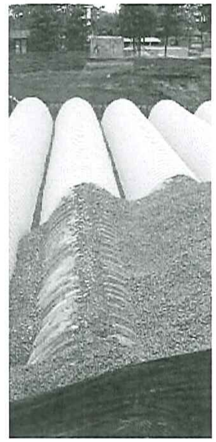


Install (6) screws (Fastenal #12-11x1") at each MC-4500 joint at locations shown. 3 screws on each side of joint. Care must be taken to avoid overtightening and/or "stripping" of screws.



Install the (2) web screws from the inside of the MC-4500 chamber 12" (305 mm) above and below the crest screw.

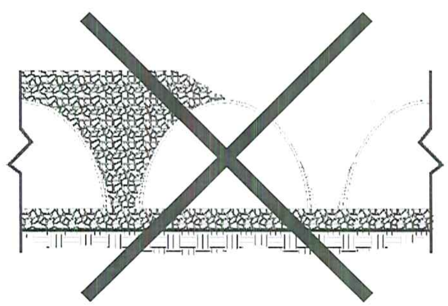
Initial Anchoring of Chambers – Embedment Stone

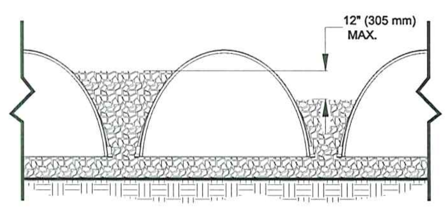
Initial embedment shall be spotted along the centerline of the chamber evenly anchoring the lower portion of the chamber. This is best accomplished with a stone conveyor or excavator reaching along the row.


No equipment shall be operated on the bed at this stage of the installation. Excavators must be located off the bed. Dump trucks shall not dump stone directly on to the bed. Dozers or loaders are not allowed on the bed at this time.

Backfill of Chambers – Embedment Stone

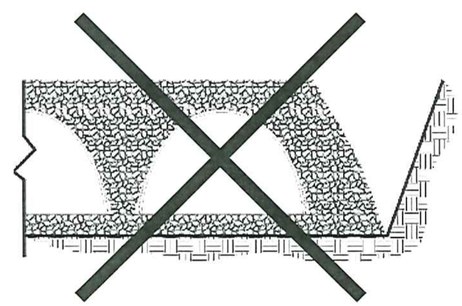


UNEVEN BACKFILL

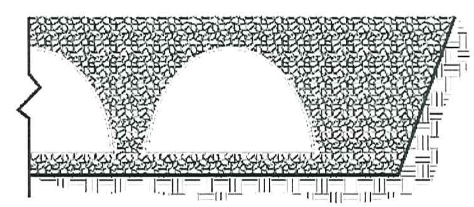


EVEN BACKFILL

Backfill chambers evenly. Stone column height should never differ by more than 12" (305 mm) between adjacent chamber rows or between chamber rows and perimeter.



PERIMETER NOT BACKFILLED



PERIMETER FULLY BACKFILLED

Perimeter stone must be brought up evenly with chamber rows. Perimeter must be fully backfilled, with stone extended horizontally to the excavation wall.

Backfill of Chambers – Embedment Stone and Cover Stone

Continue evenly backfilling between rows and around perimeter until embedment stone reaches tops of chambers. Perimeter stone must extend horizontally to the excavation wall for both straight or sloped sidewalls. **Only after chambers have been backfilled to top of chamber and with a minimum 12" (305 mm) of cover stone on top of chambers can small dozers be used over the chambers for backfilling remaining cover stone.**

Small dozers and skid loaders may be used for cover stone backfill in accordance with ground pressure limits in Table 2. Dozers must push material parallel to rows only. Never push perpendicular to rows. StormTech recommends that the contractor inspect chambers before placing final backfill. Any chambers damaged by construction shall be removed & replaced.

Final Backfill of Chambers – Fill Material

Install non-woven geotextile over stone. Geotextile must overlap 24" (610 mm) min. where edges meet. Compact at 24" (610 mm) of fill. Roller travel parallel with rows.

StormTech Isolator Row Detail

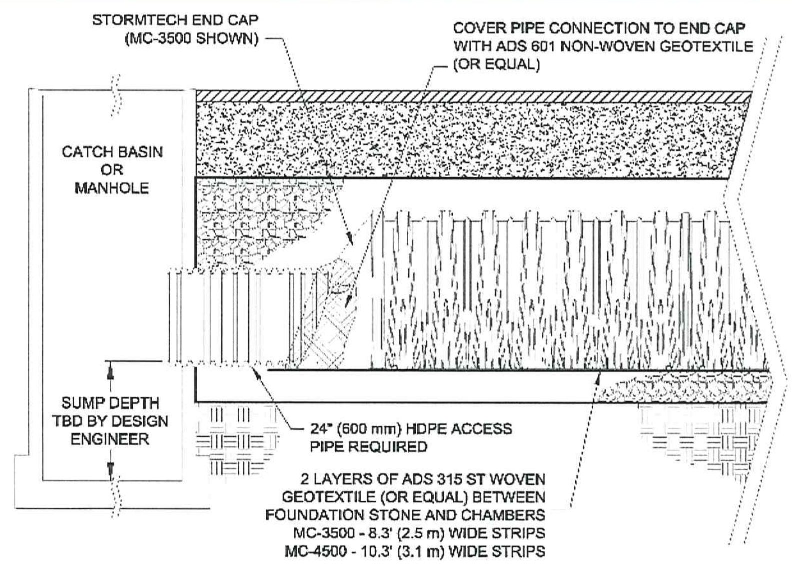


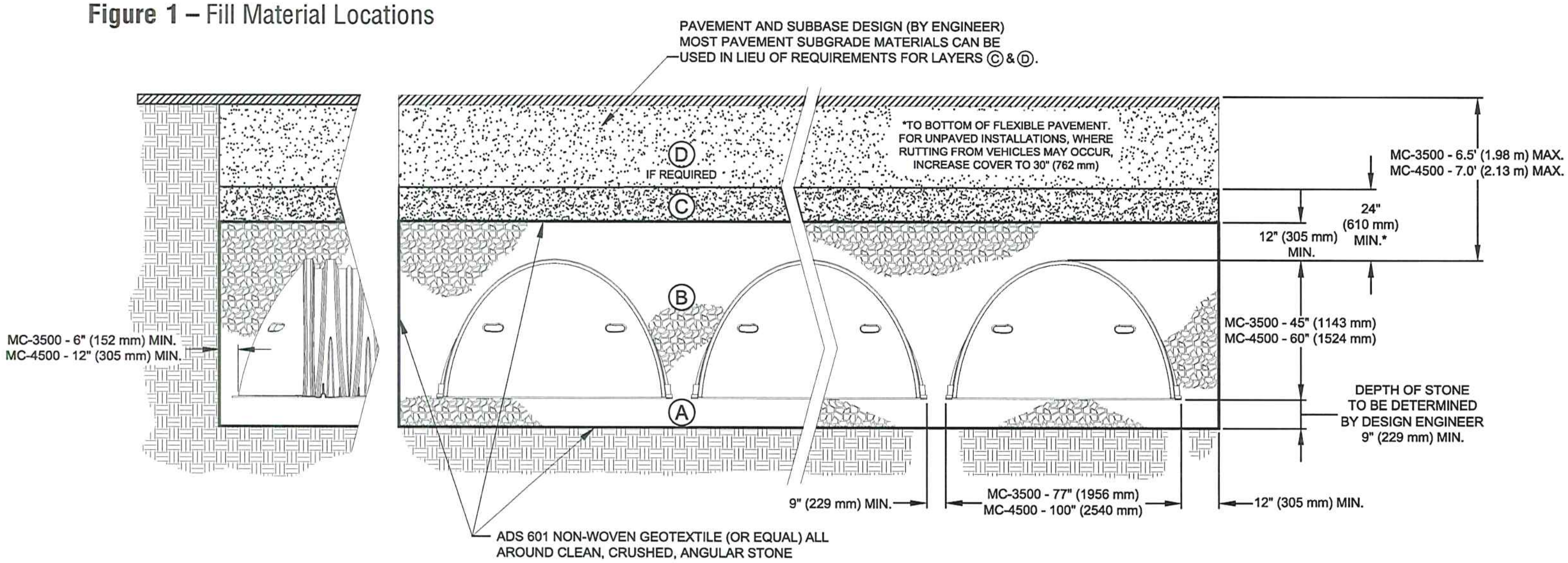
Table 1 – Acceptable Fill Materials

Material Location	Description	AASHTO M43 Designation[1]	Compaction/Density Requirement
Ⓓ Fill Material for layer 'D' starts from the top of the 'C' layer to the bottom of flexible pavement or unpaved finished grade above. Note that the pavement subbase may be part of the 'D' layer.	Any soil/rock materials, native soils or per engineer's plans. Check plans for pavement subgrade requirements.	N/A	Prepare per engineer's plans. Paved installations may have stringent material and preparation requirements.
Ⓒ Fill Material for layer 'C' starts from the top of the embedment stone ('B' layer) to 24" (610 mm) above the top of the chamber. Note that pavement subbase may be part of the 'C' layer.	Granular well-graded soil/aggregate mixtures, <35% fines. Most pavement subbase materials can be used in lieu of this layer. (AASHTO M145 A-1, A-2, A-3)	3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9, 10	Begin compaction after min. 24" (610 mm) of material over the chambers is reached. Compact additional layers in 12" (305 mm) max. lifts to a min. 95% Standard Proctor density. (See Tables 2 and 3 for maximum roller loads).
Ⓑ Embedment Stone surrounding chambers from the foundation stone to the 'C' layer above.	Clean, crushed, angular stone nominal particle size distribution 3/4 - 2" (19 mm - 51 mm)	3, 4	No compaction required.
Ⓐ Foundation Stone below the chambers from the subgrade up to the foot (bottom) of the chamber.	Clean, crushed, angular stone, nominal size distribution 3/4-2" (19 mm - 51 mm)	3, 4	Plate compact or roll to achieve a 95% Standard Proctor Density.[2]

PLEASE NOTE:

1. ***The listed AASHTO designations are for gradations only. The stone must also be clean, crushed, angular. For example, a specification for #4 stone would state: "clean, crushed, angular no. 4 (AASHTO M43) stone."***
2. ***As an alternate to Proctor Testing and field density measurements in the 'A' location, StormTech compaction requirements are met for 'A' location materials when placed and compacted in 9" (229 mm) (max.) lifts using two full passes with an appropriate compactor.***

Figure 1 – Fill Material Locations



Once layer 'C' is placed any soil/material can be placed in layer 'D' up to the finished grade. Most pavement subbase soils can be used to replace the materials requirements of layer 'C' or 'D' at the design engineer's discretion.

Table 2 – Maximum Allowable Construction Vehicle Loads[6]

Material Location	Fill Depth over Chambers in. [mm]	Maximum Allowable Wheel Loads: Max Axle Load for Trucks[1,2] lbs [kN]	Maximum Allowable Wheel Loads: Max Wheel Load for Loaders lbs [kN]	Maximum Allowable Track Loads: Track Width in. [mm]	Maximum Allowable Track Loads: Max Ground Pressure[3] psf [kPa]	Maximum Allowable Roller Loads: Max Drum Weight or Dynamic Force lbs [kN]
(D) Final Fill Material	36" [914] Compacted	32,000 [142]	16,000 [71]	12" [305] 18" [457] 24" [610] 30" [762] 36" [914]	3420 [164] 2350 [113] 1850 [89] 1510 [72] 1310 [63]	38,000 [169]
(C) Initial Fill Material	24" [610] Compacted	32,000 [142]	16,000 [71]	12" [305] 18" [457] 24" [610] 30" [762] 36" [914]	2480 [119] 1770 [85] 1430 [68] 1210 [58] 1070 [51]	20,000 [89]
	24" [610] Loose/Dumped	24,000 [107]	12,000 [53]	12" [305] 18" [457] 24" [610] 30" [762] 36" [914]	2245 [107] 1625 [78] 1325 [63] 1135 [54] 1010 [48]	16,000 [71]
	18" [457]	24,000 [107]	12,000 [53]	12" [305] 18" [457] 24" [610] 30" [762]	2010 [96] 1480 [71] 1220 [58] 1060 [51]	5,000 [22] (static loads only)[5]
(B) Embedment Stone	12" [305]	NOT ALLOWED	NOT ALLOWED	12" [305] 18" [457] 24" [610] 30" [762]	1100 [53] 715 [34] 660 [32] 580 [28]	NOT ALLOWED
	6" [152]	NOT ALLOWED	NOT ALLOWED	NOT ALLOWED	NOT ALLOWED	NOT ALLOWED

Table 3 – Placement Methods and Descriptions

Material Location	Placement Methods/ Restrictions	Wheel Load Restrictions	Track Load Restrictions	Roller Load Restrictions
		See Table 2 for Maximum Construction Loads		
(D) Final Fill Material	A variety of placement methods may be used. All construction loads must not exceed the maximum limits in Table 2.	36" (914 mm) minimum cover required for dump trucks to dump over chambers.		Roller travel parallel to rows only until 36" (914 mm) compacted cover is reached.
(C) Initial Fill Material	Excavator positioned off bed recommended. Small excavator allowed over chambers. Small dozer allowed.	Asphalt can be dumped into paver when compacted pavement subbase reaches 24" (610 mm) above top of chambers.	Dozers to push parallel to rows.[4]	Use dynamic force of roller only after compacted fill depth reaches 24" (610 mm) over chambers. Roller travel parallel to chamber rows only.
(B) Embedment Stone	No equipment allowed on bare chambers. Use excavator or stone conveyor positioned off bed or on foundation stone to evenly fill around all chambers to at least the top of chambers.	No wheel loads allowed. Material must be dumped outside the limits of the chamber bed.	Small LGP track dozers & skid loaders allowed to spread embedment stone with at least 12" (305 mm) stone under tracks at all times. Dozers to push parallel to rows only	No rollers allowed.
(A) Foundation Stone	No StormTech restrictions. Contractor responsible for any conditions or requirements by others relative to subgrade bearing capacity, dewatering or protection of subgrade.			

NOTES:

1. 36" (914 mm) of stabilized cover materials over the chambers is required for full dump truck travel and dumping.

2. During paving operations, dump truck axle loads on 24" (610 mm) of cover may be necessary. Precautions should be taken to avoid rutting of the road base layer, to ensure that compaction requirements have been met, and that a minimum of 24" (610 mm) of cover exists over the chambers. Contact StormTech for additional guidance on allowable axle loads during paving.

3. Ground pressure for track dozers is the vehicle operating weight divided by total ground contact area for both tracks. Excavators will exert higher ground pressures based on loaded bucket weight and boom extension. Excavators shall not operate on chamber beds until the total backfill reaches 3 feet (914 mm).

4. Mini-excavators can be used with at least 12" (305 mm) of stone over the chambers and are limited by the maximum ground pressures in Table 2 based on a full bucket at maximum boom extension.

5. StormTech does not require compaction of initial fill at 18" (457 mm) of cover. However, requirements by others for 6" (152 mm) lifts may necessitate the use of small compactors at 18" (457 mm) of cover.

6. Storage of materials such as construction materials, equipment, spoils, etc. should not be located over the StormTech system. The use of equipment over the StormTech system not covered in Table 2 (ex. soil mixing equipment, cranes, etc) is limited. Please contact StormTech for more information.

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Isolator™ Row O&M Manual

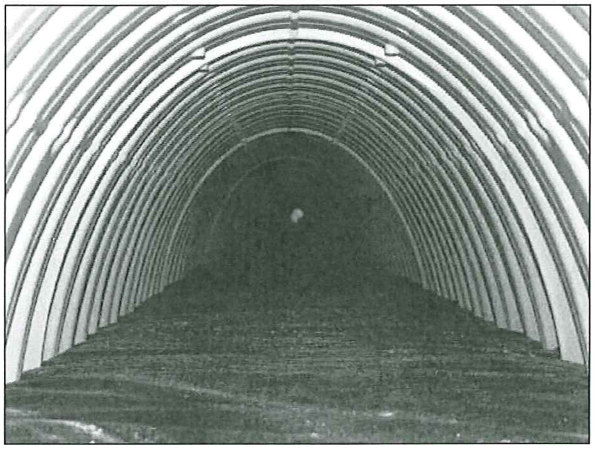
StormTech® Chamber System for Stormwater Management

U.S. GREEN BUILDING COUNCIL MEMBER

1.0 The Isolator™ Row

1.1 INTRODUCTION

An important component of any Stormwater Pollution Prevention Plan is inspection and maintenance. The StormTech Isolator Row is a patent pending technique to inexpensively enhance Total Suspended Solids (TSS) removal and provide easy access for inspection and maintenance.



Looking down the Isolator Row from the manhole opening, woven geotextile is shown between the chamber and stone base.

1.2 THE ISOLATOR™ ROW

The Isolator Row is a row of StormTech chambers, either SC-310, SC-740 or MC-3500 models, that is surrounded with filter fabric and connected to a closely located manhole for easy access. The fabric-wrapped chambers provide for settling and filtration of sediment as storm water rises in the Isolator Row and ultimately passes through the filter fabric. The open bottom chambers and perforated sidewalls allow storm water to flow both vertically and horizontally out of the chambers. Sediments are captured in the Isolator Row protecting the storage areas of the adjacent stone and chambers from sediment accumulation.

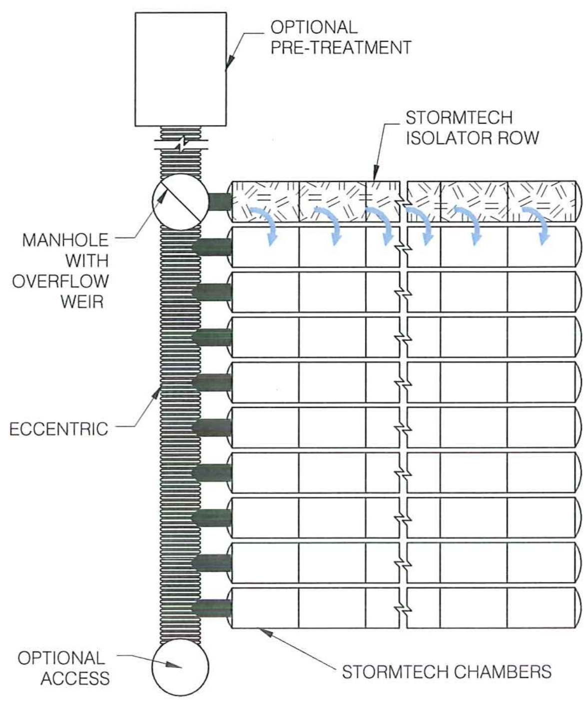
Two different fabrics are used for the Isolator Row. A woven geotextile fabric is placed between the stone and the Isolator Row chambers. The tough geotextile provides a media for storm water filtration and provides a durable surface for maintenance operations. It is also designed to prevent scour of the underlying stone and remain intact during high pressure jetting. A non-woven fabric is placed over the chambers to provide a filter media for flows passing through the perforations in the sidewall of the chamber.

The Isolator Row is typically designed to capture the "first flush" and offers the versatility to be sized on a volume basis or flow rate basis. An upstream manhole not only provides access to the Isolator Row but typically includes a high flow weir such that storm water flowrates or volumes that exceed the capacity of the Isolator Row overtop the over flow weir and discharge through a manifold to the other chambers.

The Isolator Row may also be part of a treatment train. By treating storm water prior to entry into the chamber system, the service life can be extended and pollutants such as hydrocarbons can be captured. Pre-treatment best management practices can be as simple as deep sump catch basins, oil-water separators or can be innovative storm water treatment devices. The design of the treatment train and selection of pretreatment devices by the design engineer is often driven by regulatory requirements. Whether pretreatment is used or not, the Isolator Row is recommended by StormTech as an effective means to minimize maintenance requirements and maintenance costs.

Note: See the StormTech Design Manual for detailed information on designing inlets for a StormTech system, including the Isolator Row.

StormTech Isolator Row with Overflow Spillway
(not to scale)



2.1 INSPECTION

The frequency of Inspection and Maintenance varies by location. A routine inspection schedule needs to be established for each individual location based upon site specific variables. The type of land use (i.e. industrial, commercial residential), anticipated pollutant load, percent imperviousness, climate, etc. all play a critical role in determining the actual frequency of inspection and maintenance practices.

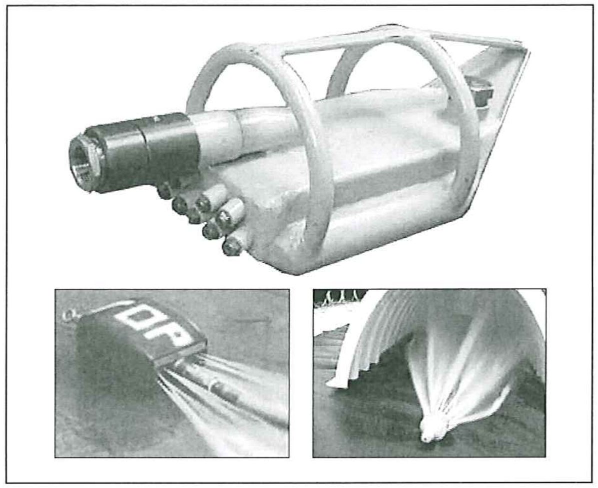
At a minimum, StormTech recommends annual inspections. Initially, the Isolator Row should be inspected every 6 months for the first year of operation. For subsequent years, the inspection should be adjusted based upon previous observation of sediment deposition.

The Isolator Row incorporates a combination of standard manhole(s) and strategically located inspection ports (as needed). The inspection ports allow for easy access to the system from the surface, eliminating the need to perform a confined space entry for inspection purposes.

If upon visual inspection it is found that sediment has accumulated, a stadia rod should be inserted to determine the depth of sediment. When the average depth of sediment exceeds 3 inches throughout the length of the Isolator Row, clean-out should be performed.

2.2 MAINTENANCE

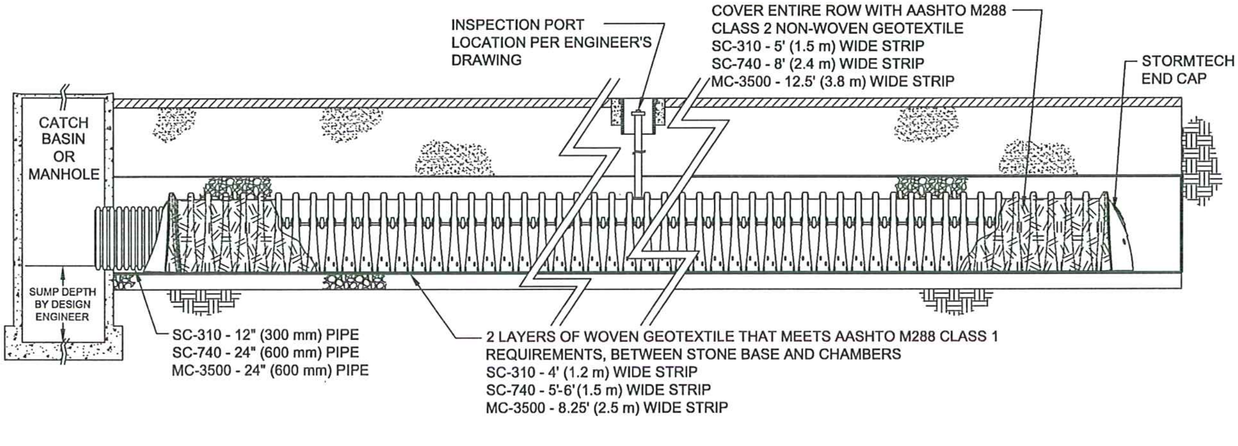
The Isolator Row was designed to reduce the cost of periodic maintenance. By "isolating" sediments to just one row, costs are dramatically reduced by eliminating the need to clean out each row of the entire storage bed. If inspection indicates the potential need for maintenance, access is provided via a manhole(s) located on the end(s) of the row for cleanout. If entry into the manhole is required, please follow local and OSHA rules for a confined space entries.



Examples of culvert cleaning nozzles appropriate for Isolator Row maintenance. (These are not StormTech products.)

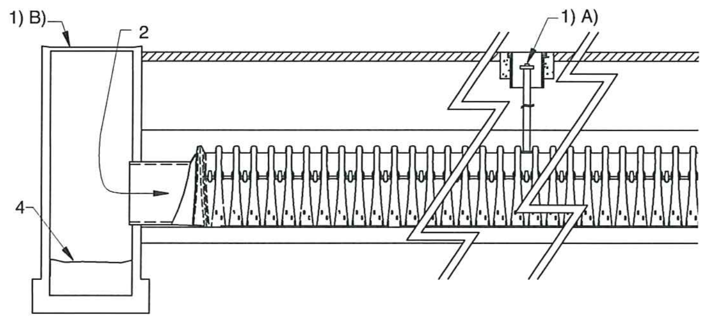
Maintenance is accomplished with the JetVac process. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row while scouring and suspending sediments. As the nozzle is retrieved, the captured pollutants are flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/JetVac combination vehicles. Selection of an appropriate JetVac nozzle will improve maintenance efficiency. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45" are best. Most JetVac reels have 400 feet of hose allowing maintenance of an Isolator Row up to 50 chambers long. **The JetVac process shall only be performed on StormTech Isolator Rows that have AASHTO class 1 woven geotextile (as specified by StormTech) over their angular base stone.**

StormTech Isolator Row (not to scale)



3.0 Isolator Row Step By Step Maintenance Procedures

StormTech Isolator Row (not to scale)



Step 1) Inspect Isolator Row for sediment

A) Inspection ports (if present)
  i. Remove lid from floor box frame
  ii. Remove cap from inspection riser
  iii. Using a flashlight and stadia rod, measure depth of sediment and record results on maintenance log.
  iv. If sediment is at, or above, 3 inch depth proceed to Step 2. If not proceed to step 3.

B) All Isolator Rows
  i. Remove cover from manhole at upstream end of Isolator Row
  ii. Using a flashlight, inspect down Isolator Row through outlet pipe
    1. Mirrors on poles or cameras may be used to avoid a confined space entry
    2. Follow OSHA regulations for confined space entry if entering manhole
  iii. If sediment is at or above the lower row of sidewall holes (approximately 3 inches) proceed to Step 2. If not proceed to Step 3.

Step 2) Clean out Isolator Row using the JetVac process

A) A fixed culvert cleaning nozzle with rear facing nozzle spread of 45 inches or more is preferable
B) Apply multiple passes of JetVac until backflush water is clean
C) Vacuum manhole sump as required

Step 3) Replace all caps, lids and covers, record observations and actions

Step 4) Inspect & clean catch basins and manholes upstream of the StormTech system

Sample Maintenance Log

Date	Stadia Rod Readings		Sediment Depth (1) - (2)	Observations/Actions	Inspector
	Fixed point to chamber bottom (1)	Fixed point to top of sediment (2)			
3/15/01	6.3 ft.	none		New installation. Fixed point is CI frame at grade	djm
9/24/01		6.2	0.1 ft.	Some grit felt	sm
6/20/03		5.8	0.5 ft.	Mucky feel, debris visible in manhole and in Isolator row, maintenance due	rv
7/7/03	6.3 ft.		0	System jetted and vacuumed	djm

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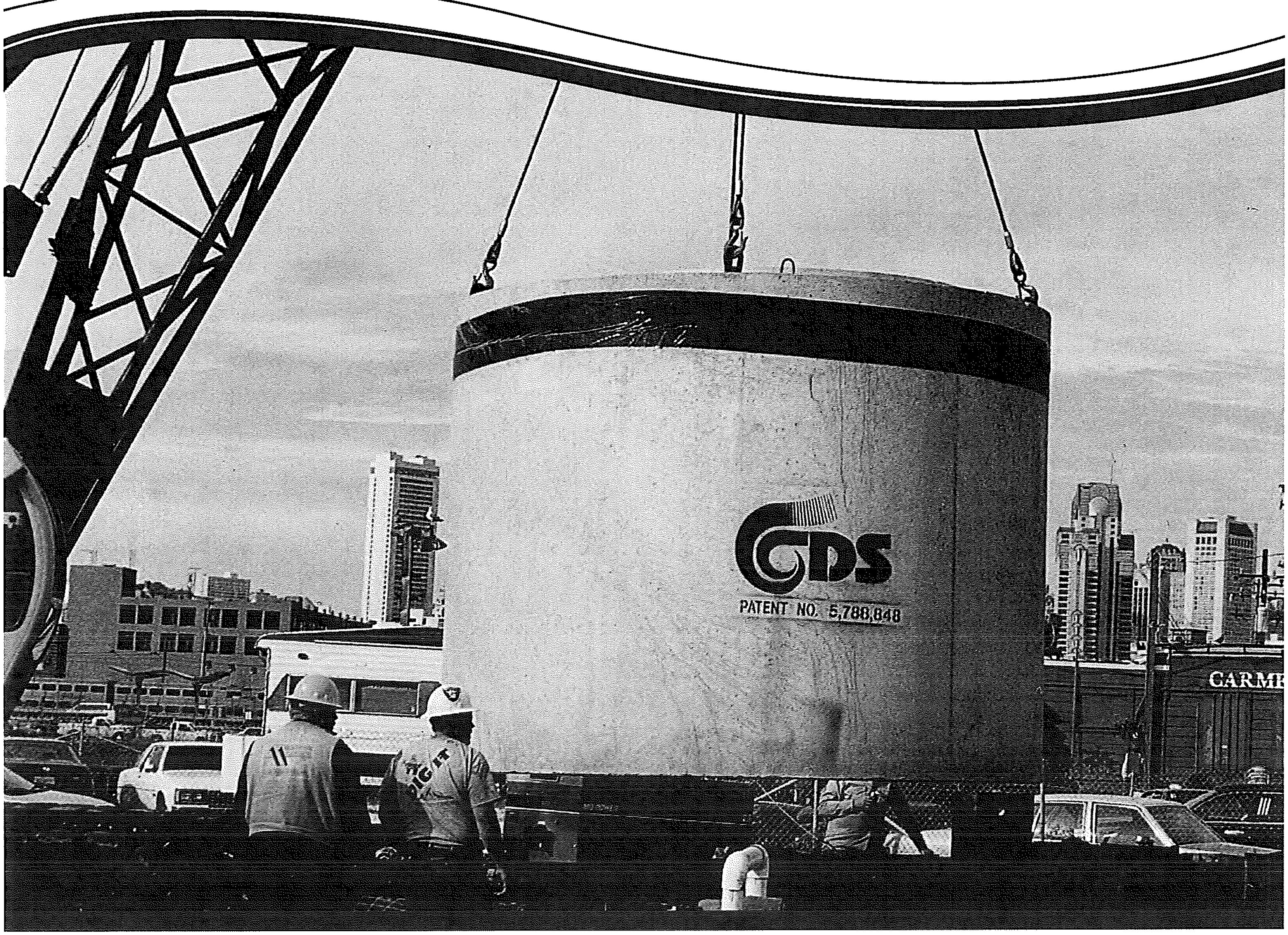
CDS Guide
Operation, Design, Performance and Maintenance



CDS®

Using patented continuous deflective separation technology, the CDS system screens, separates and traps debris, sediment, and oil and grease from stormwater runoff. The indirect screening capability of the system allows for 100% removal of floatables and neutrally buoyant material without blinding. Flow and screening controls physically separate captured solids, and minimize the re-suspension and release of previously trapped pollutants. Inline units can treat up to 6 cfs, and internally bypass flows in excess of 50 cfs. Available precast or cast-in-place, offline units can treat flows from 1 to 300 cfs. The pollutant removal capacity of the CDS system has been proven in lab and field testing.

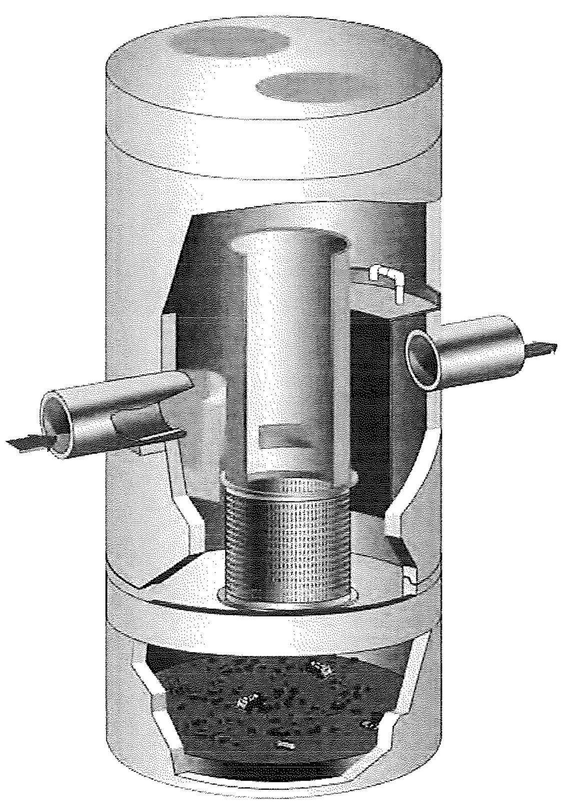
Operation Overview

Stormwater enters the diversion chamber where the diversion weir guides the flow into the unit's separation chamber and pollutants are removed from the flow. All flows up to the system's treatment design capacity enter the separation chamber and are treated.

Swirl concentration and screen deflection force floatables and solids to the center of the separation chamber where 100% of floatables and neutrally buoyant debris larger than the screen apertures are trapped.

Stormwater then moves through the separation screen, under the oil baffle and exits the system. The separation screen remains clog free due to continuous deflection.

During the flow events exceeding the design capacity, the diversion weir bypasses excessive flows around the separation chamber, so captured pollutants are retained in the separation cylinder.



Design Basics

There are three primary methods of sizing a CDS system. The Water Quality Flow Rate Method determines which model size provides the desired removal efficiency at a given flow rate for a defined particle size. The Rational Rainfall MethodTM and Probabalistic Method are used when a specific removal efficiency of the net annual sediment load is required.

Typically in the Unites States, CDS systems are designed to achieve an 80% annual solids load reduction based on lab generated performance curves for a gradation with an average particle size (d50) of 125-microns (μm). For some regulatory environments, CDS systems can also be designed to achieve an 80% annual solids load reduction based on an average particle size (d50) of 75-microns (μm).

Water Quality Flow Rate Method

In many cases, regulations require that a specific flow rate, often referred to as the water quality design flow (WQQ), be treated. This WQQ represents the peak flow rate from either an event with a specific recurrence interval (i.e. the six-month storm) or a water quality depth (i.e. 1/2-inch of rainfall).

The CDS is designed to treat all flows up to the WQQ. At influent rates higher than the WQQ, the diversion weir will direct most flow exceeding the treatment flow rate around the separation chamber. This allows removal efficiency to remain relatively constant in the separation chamber and reduces the risk of washout during bypass flows regardless of influent flow rates.

Treatment flow rates are defined as the rate at which the CDS will remove a specific gradation of sediment at a specific removal efficiency. Therefore they are variable based on the gradation and removal efficiency specified by the design engineer.

Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydraulically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. The Rational Rainfall Method combines site-specific information with laboratory generated performance data, and local historical precipitation records to estimate removal efficiencies as accurately as possible.

Short duration rain gauge records from across the United States and Canada were analyzed to determine the percent of the total annual rainfall that fell at a range of intensities. US stations' depths were totaled every 15 minutes, or hourly, and recorded in 0.01-inch increments. Depths were recorded hourly with 1-mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and high intensity storms contributed relatively little to the total annual depth.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Rainfall Method. Since most sites are relatively small and highly impervious, the Rational Rainfall Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS system are determined. Performance efficiency curve determined from full scale laboratory tests on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Probabalistic Rational Method

The Probabalistic Rational Method is a sizing program CONTECH developed to estimate a net annual sediment load reduction for a particular CDS model based on site size, site runoff coefficient, regional rainfall intensity distribution, and anticipated pollutant characteristics.

The Probabilistic rational method is an extension of the rational method used to estimate peak discharge rates generated by storm events of varying statistical return frequencies (i.e.: 2-year storm event). Under this method, an adjustment factor is used to adjust the runoff coefficient estimated for the 10-year event, correlating a known hydrologic parameter with the target storm event. The rainfall intensities vary depending on the return frequency of the storm event under consideration. In general, these two frequency dependent parameters increase as the return frequency increases while the drainage area remains constant.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Method. Since most sites are relatively small and highly impervious, the Rational Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS are determined. Performance efficiency curve on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Treatment Flow Rate

The inlet throat area is sized to ensure that the WQQ passes through the separation chamber at a water surface elevation equal to the crest of the diversion weir. The diversion weir bypasses excessive flows around the separation chamber, thus helping to prevent re-suspension or re-entrainment of previously captured particles.

Hydraulic Capacity

CDS hydraulic capacity is determined by the length and height of the diversion weir and by the maximum allowable head in the system. Typical configurations allow hydraulic capacities of up to ten times the treatment flow rate. As needed, the crest of the diversion weir may be lowered and the inlet throat may be widened to increase the capacity of the system at a given water surface elevation. The unit is designed to meet project specific hydraulics.

Performance

Full-Scale Laboratory Test Results

A full-scale CDS unit (Model CDS2020-5B) was tested at the facility of University of Florida, Gainesville, FL. This full-scale CDS unit was evaluated under controlled laboratory conditions of pumped influent and the controlled addition of sediment.

Two different gradations of silica sand material (UF Sediment & OK-110) were used in the CDS performance evaluation. The particle size distributions (PSD) of the test materials were analyzed using standard method "Gradation ASTM D-422 with Hydrometer" by a certified laboratory. UF Sediment is a mixture of three different U.S. Silica Sand products referred as: "Sil-Co-Sil 106", "#1 DRY" and "20/40 Oil Frac". Particle size distribution analysis shows that the UF Sediment has a very fine gradation (d50 = 20 to 30 μm) covering a wide size range (uniform coefficient Cu averaged at 10.6). In comparison with the hypothetical TSS gradation specified in the NJDEP (New Jersey Department of Environmental Protection) and NJCAT (New Jersey Corporation for Advanced Technology) protocol for lab testing, the UF Sediment covers a similar range of particle size but with a finer d50 (d50 for NJDEP is approximately 50 μm) (NJDEP, 2003). The OK-110 silica sand is a commercial product of U.S. Silica Sand. The particle size distribution analysis of this material, also included in Figure 1, shows that 99.9% of the OK-110 sand is finer than 250 microns, with a mean particle size (d50) of 106 microns. The PSDs for the test material are shown in Figure 1.

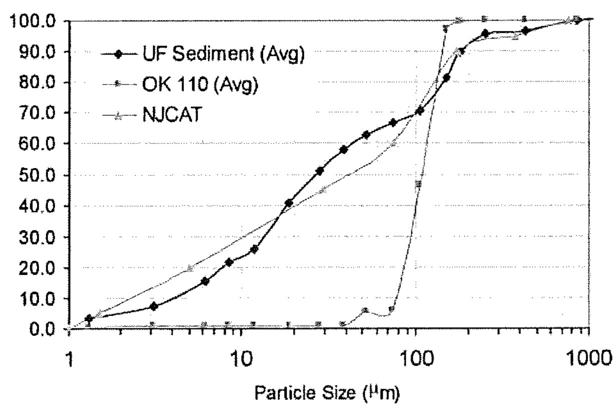


Figure 1. Particle size distributions for the test materials, as compared to the NJCAT/NJDEP theoretical distribution.

Tests were conducted to quantify the CDS unit (1.1 cfs (31.3-L/s) design capacity) performance at various flow rates, ranging from 1% up to 125% of the design capacity of the unit, using the 2400 micron screen. All tests were conducted with controlled influent concentrations approximately 200 mg/L. Effluent samples were taken at equal time intervals across the entire duration of each test run. These samples were then processed with a Dekaport Cone sample splitter to obtain representative sub-samples for Suspended Sediment Concentration (SSC – ASTM Standard Method D3977-97) and particle size distribution analysis.

Results and Modeling

Based on the testing data from the University of Florida, a performance model was developed for the CDS system. A regression analysis was used to develop a fitting curve for the scattered data points at various design flow rates. This model, which demonstrated good agreement with the laboratory data, can then be used to predict CDS system performance with respect to SSC removal for any particle size gradation assuming sandy-silt type of inorganic components of SSC. Figure 2 shows CDS predictive performance for two typical particle size gradations (NJCAT gradation and OK-110 sand).

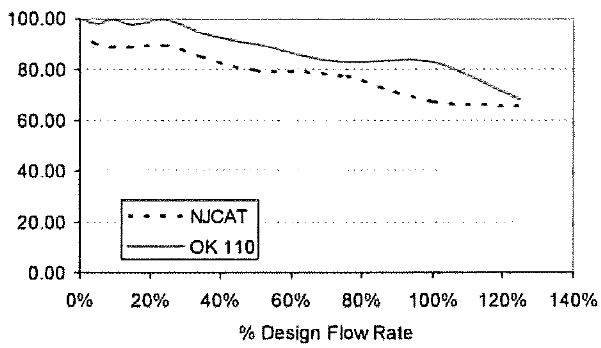


Figure 2. CDS stormwater treatment predictive performance for various particle gradations as a function of operating rate.

Many regulatory jurisdictions set a performance standard for hydrodynamic devices by stating that the devices shall be capable of achieving an 80% removal efficiency for particles having a mean particle size (d50) of 125 microns (WADOE, 2008). The model can be used to calculate the expected performance of such a PSD (shown in Figure 3). Supported by the laboratory data, the model indicates (Figure 4) that the CDS system with 2400 micron screen achieves approximately 80% removal at 100% of design flow rate, for this particle size distribution (d50 = 125 μm).

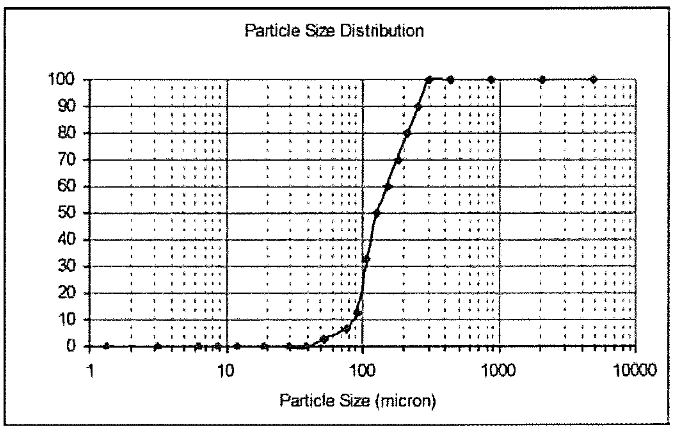


Figure 3. PSD with d50 = 125 microns, used to model performance for Ecology submittal.

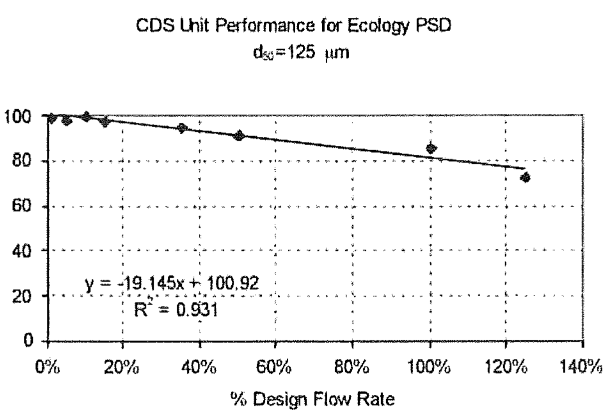


Figure 4. Modeled performance for CDS unit with 2400 microns screen, using Ecology PSD.

Maintenance

The CDS system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit, e.g., unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping of paved surfaces will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant deposition and transport may vary from year to year and regular inspections will help insure that the system is cleaned out at the appropriate time. At a minimum, inspections should be performed twice per year (i.e. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid accumulations, or in equipment washdown areas. Additionally, installations should be inspected more frequently where excessive amounts of trash are expected.

The visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions to inlet and/or separation screen. The inspection should also identify evidence of vector infestation and accumulations of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If sorbent material is used for enhanced removal of hydrocarbons then the level of discoloration of the sorbent material should also

be identified during inspection. It is useful and often required as part of a permit to keep a record of each inspection. A simple form for doing so is provided.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (screen/cylinder) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained behind the screen. For units possessing a sizable depth below grade (depth to pipe), a single manhole access point would allow both sump cleanout and access behind the screen.

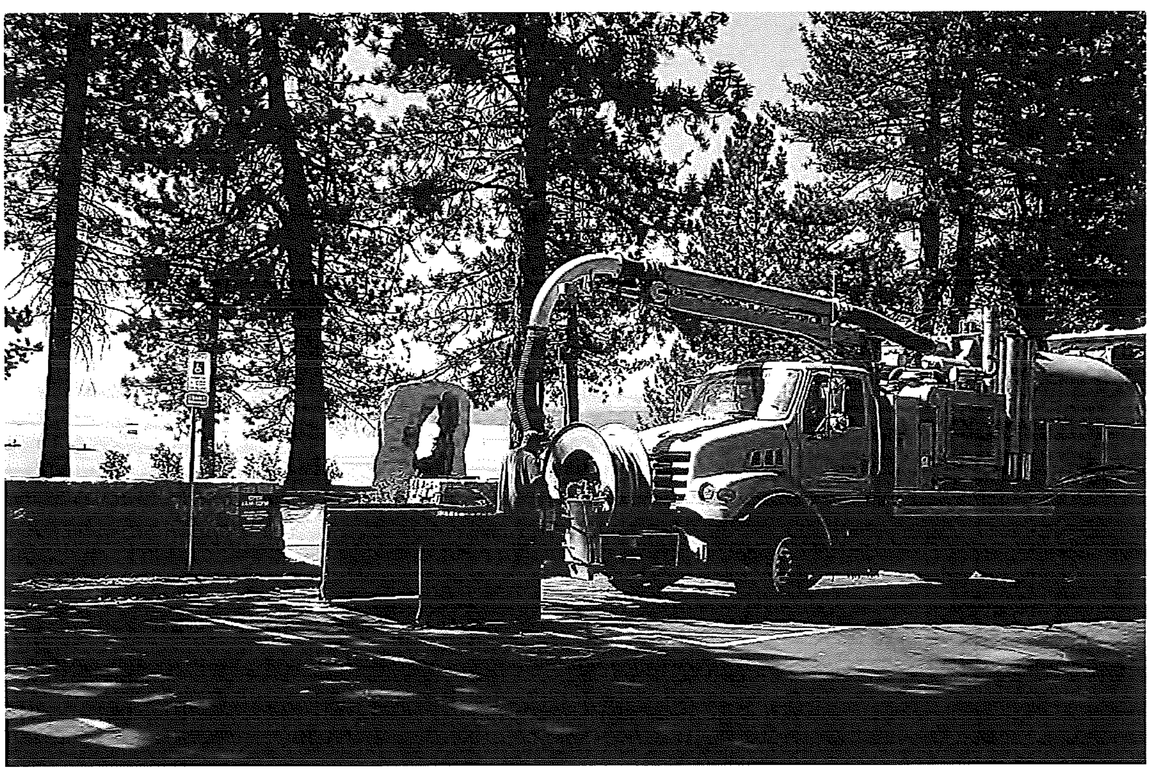
The CDS system should be cleaned when the level of sediment has reached 75% of capacity in the isolated sump and/or when an appreciable level of hydrocarbons and trash has accumulated. If sorbent material is used, it should be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded however it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine if the height of the sediment pile off the bottom of the sump floor exceeds 75% of the total height of isolated sump.

Cleaning

Cleaning of the CDS systems should be done during dry weather conditions when no flow is entering the system. Cleanout of the CDS with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should be pumped out also if pollutant build-up exists in this area.

In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually less expensive to dispose than the oil/water emulsion that may be created by vacuuming the oily layer. Trash can be netted out if you wish to separate it from the other pollutants. The screen should be power washed to ensure it is free of trash and debris.

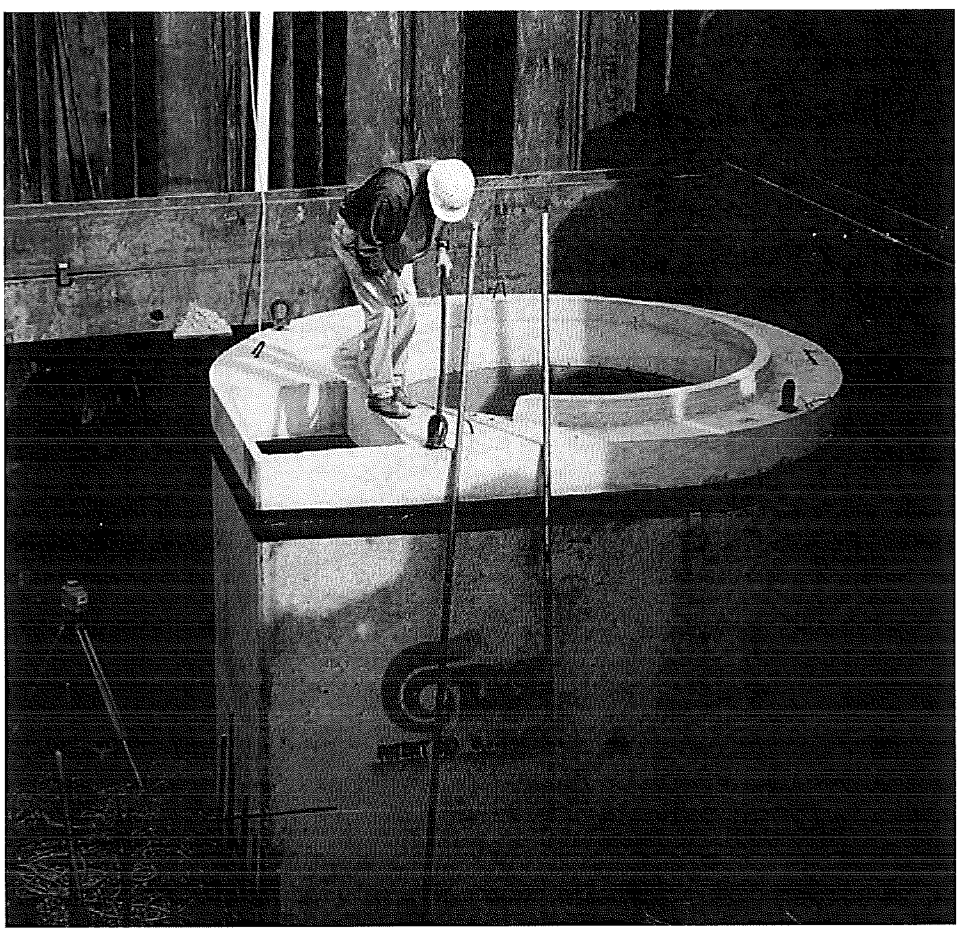
Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure proper safety precautions. Confined Space Entry procedures need to be followed. Disposal of all material removed from the CDS system should be done is accordance with local regulations. In many locations, disposal of evacuated sediments may be handled in the same manner as disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal.



CDS Model	Diameter ft	Diameter m	Distance from Water Surface to Top of Sediment Pile ft	Distance from Water Surface to Top of Sediment Pile m	Sediment Storage Capacity yd3	Sediment Storage Capacity m3
CDS2015-4	4	1.2	3.0	0.9	0.5	0.4
CDS2015	5	1.5	3.0	0.9	1.3	1.0
CDS2020	5	1.5	3.5	1.1	1.3	1.0
CDS2025	5	1.5	4.0	1.2	1.3	1.0
CDS3020	6	1.8	4.0	1.2	2.1	1.6
CDS3030	6	1.8	4.6	1.4	2.1	1.6
CDS3035	6	1.8	5.0	1.5	2.1	1.6
CDS4030	8	2.4	4.6	1.4	5.6	4.3
CDS4040	8	2.4	5.7	1.7	5.6	4.3
CDS4045	8	2.4	6.2	1.9	5.6	4.3

Table 1: CDS Maintenance Indicators and Sediment Storage Capacities

Note: To avoid underestimating the volume of sediment in the chamber, carefully lower the measuring device to the top of the sediment pile. Finer silty particles at the top of the pile may be more difficult to feel with a measuring stick. These finer particles typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile.



CDS Inspection & Maintenance Log

CDS Model: ____________________ Location: ____________________

Date	Water depth to sediment[1]	Floatable Layer Thickness[2]	Describe Maintenance Performed	Maintenance Personnel	Comments

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. If the difference between these measurements is less than eighteen inches the system should be cleaned out. **Note: To avoid underestimating the volume of sediment in the chamber, the measuring device must be carefully lowered to the top of the sediment pile.**

2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of an oil spill, the system should be cleaned immediately.

Support

- Drawings and specifications are available at www.contechstormwater.com.
- Site-specific design support is available from our engineers.

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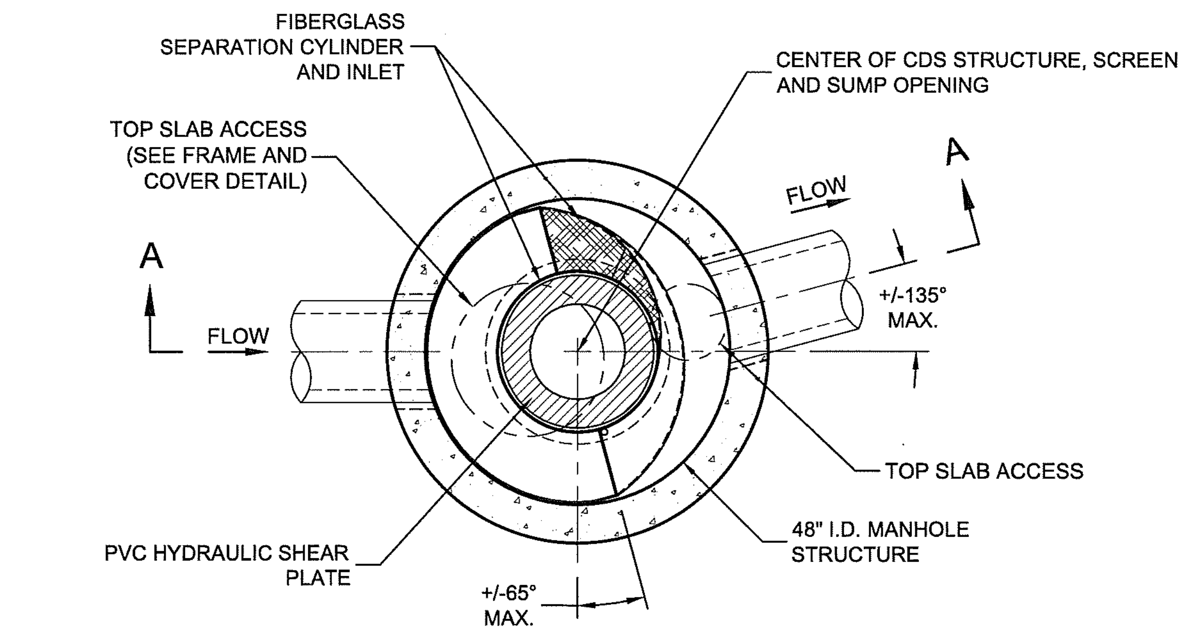
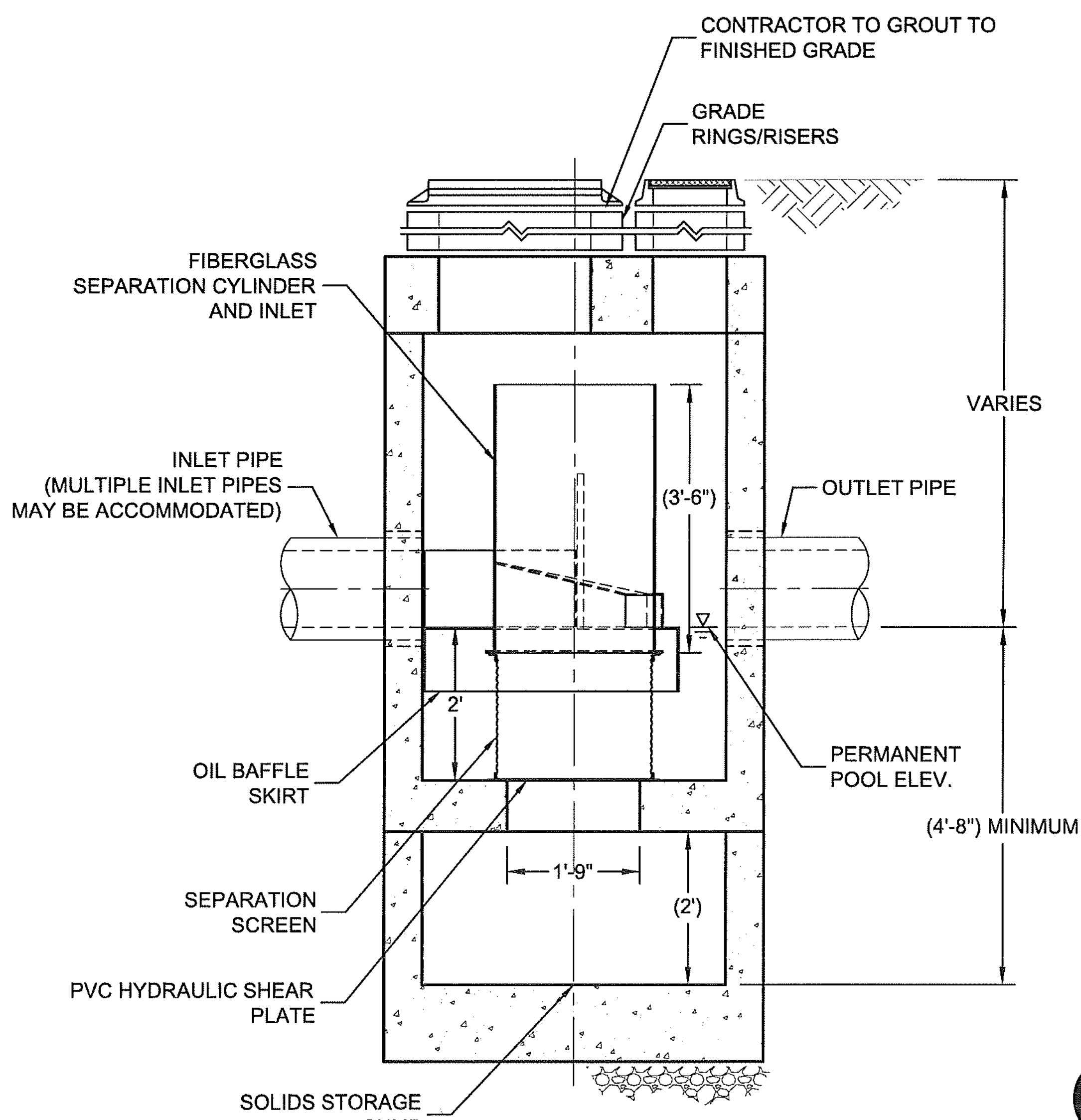


PLAN VIEW
N.T.S.



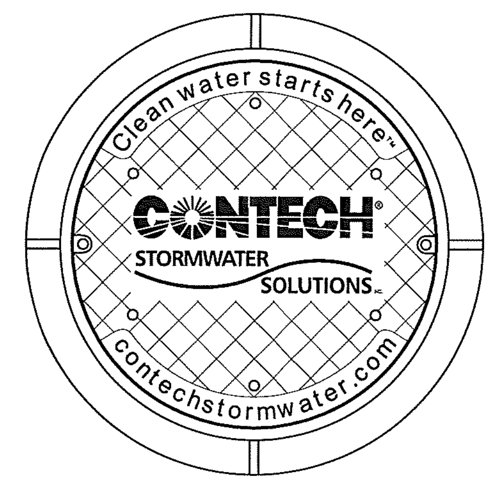
SECTION A-A
N.T.S.

CDS2015-4 DESIGN NOTES

CDS2015-4 RATED TREATMENT CAPACITY IS 0.7 CFS, OR PER LOCAL REGULATIONS. MAXIMUM HYDRAULIC INTERNAL BYPASS CAPACITY IS 10.0 CFS. IF THE SITE CONDITIONS EXCEED 10.0 CFS, AN UPSTREAM BYPASS STRUCTURE IS REQUIRED.

THE STANDARD CDS2015-4 CONFIGURATION IS SHOWN. ALTERNATE CONFIGURATIONS ARE AVAILABLE AND ARE LISTED BELOW. SOME CONFIGURATIONS MAY BE COMBINED TO SUIT SITE REQUIREMENTS.

DESIGNATION (MODEL SUFFIX)	CONFIGURATION DESCRIPTION
G	GRATED INLET ONLY (NO INLET PIPE)
GP	GRATED INLET WITH INLET PIPE OR PIPES
K	CURB INLET ONLY (NO INLET PIPE)
KP	CURB INLET WITH INLET PIPE OR PIPES



FRAME AND COVER
(DIAMETER VARIES)
N.T.S.

SITE SPECIFIC DATA REQUIREMENTS

STRUCTURE ID			
WATER QUALITY FLOW RATE (CFS)			*
PEAK FLOW RATE (CFS)			*
RETURN PERIOD OF PEAK FLOW (YRS)			*
SCREEN APERTURE (2400 OR 4700)			*
PIPE DATA:	I.E.	MATERIAL	DIAMETER
INLET PIPE 1	*	*	*
INLET PIPE 2	*	*	*
OUTLET PIPE	*	*	*
RIM ELEVATION			*
ANTI-FLOTATION BALLAST		WIDTH	HEIGHT
		*	*
NOTES/SPECIAL REQUIREMENTS:			
* PER ENGINEER OF RECORD			

GENERAL NOTES

1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. DIMENSIONS MARKED WITH ( ) ARE REFERENCE DIMENSIONS. ACTUAL DIMENSIONS MAY VARY.
3. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR CONTECH STORMWATER SOLUTIONS REPRESENTATIVE. www.contechstormwater.com
4. CDS WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
5. STRUCTURE AND CASTINGS SHALL MEET AASHTO HS20 LOAD RATING.
6. PVC HYDRAULIC SHEAR PLATE IS PLACED ON SHELF AT BOTTOM OF SCREEN CYLINDER. REMOVE AND REPLACE AS NECESSARY DURING MAINTENANCE CLEANING.

INSTALLATION NOTES

1. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
2. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE CDS MANHOLE STRUCTURE (LIFTING CLUTCHES PROVIDED).
3. CONTRACTOR TO ADD JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS, AND ASSEMBLE STRUCTURE.
4. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES. MATCH PIPE INVERTS WITH ELEVATIONS SHOWN.
5. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

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CDS2015-4
PRECAST CONCRETE WATER QUALITY SYSTEM
STANDARD DETAIL

I:\STORMWATER\DRAFTING\TEMPLATES\CAD STANDARDS\PRODUCT SUBMITTAL DRAWINGS (CURRENT)\CDS\CDS STD DETAIL\CDS2015-4-STD.DWG 7/21/2008 11:52 AM

CONTECH®
CONSTRUCTION PRODUCTS INC.

CDS® Inspection and Maintenance Guide

CDS TECHNOLOGIES

Maintenance

The CDS system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit. For example, unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping of paved surfaces will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant transport and deposition may vary from year to year and regular inspections will help ensure that the system is cleaned out at the appropriate time. At a minimum, inspections should be performed twice per year (e.g. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid accumulations, or in equipment washdown areas. Installations should also be inspected more frequently where excessive amounts of trash are expected.

The visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions in the inlet and separation screen. The inspection should also quantify the accumulation of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If absorbent material is used for enhanced removal of hydrocarbons, the level of discoloration of the sorbent material should also be identified during inspection. It is useful and often required as part of an operating permit to keep a record of each inspection. A simple form for doing so is provided.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (cylinder and screen) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained outside the screen. For deep units, a single manhole access point would allows both sump cleanout and access outside the screen.

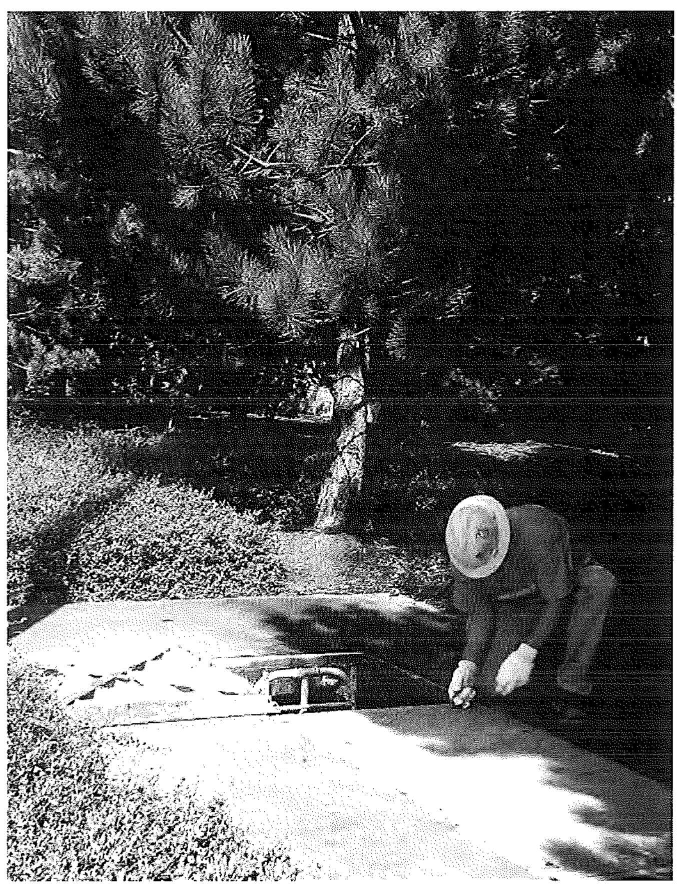
The CDS system should be cleaned when the level of sediment has reached 75% of capacity in the isolated sump or when an appreciable level of hydrocarbons and trash has accumulated. If absorbent material is used, it should be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded however it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Particles at the top of the pile typically offer less resistance to the end of the rod than consolidated particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine weather the height of the sediment pile off the bottom of the sump floor exceeds 75% of the total height of isolated sump.

Cleaning

Cleaning of a CDS systems should be done during dry weather conditions when no flow is entering the system. The use of a vacuum truck is generally the most effective and convenient method of removing pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should also be cleaned out if pollutant build-up exists in this area.

In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, the system should be cleaned out immediately in the event of an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use absorbent pads since they are usually less expensive to dispose than the oil/water emulsion that may be created by vacuuming the oily layer. Trash and debris can be netted out to separate it from the other pollutants. The screen should be power washed to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure that proper safety precautions have been followed. Confined space entry procedures need to be followed if physical access is required. Disposal of all material removed from the CDS system should be done in accordance with local regulations. In many jurisdictions, disposal of the sediments may be handled in the same manner as the disposal of sediments removed from catch basins or deep sump manholes.



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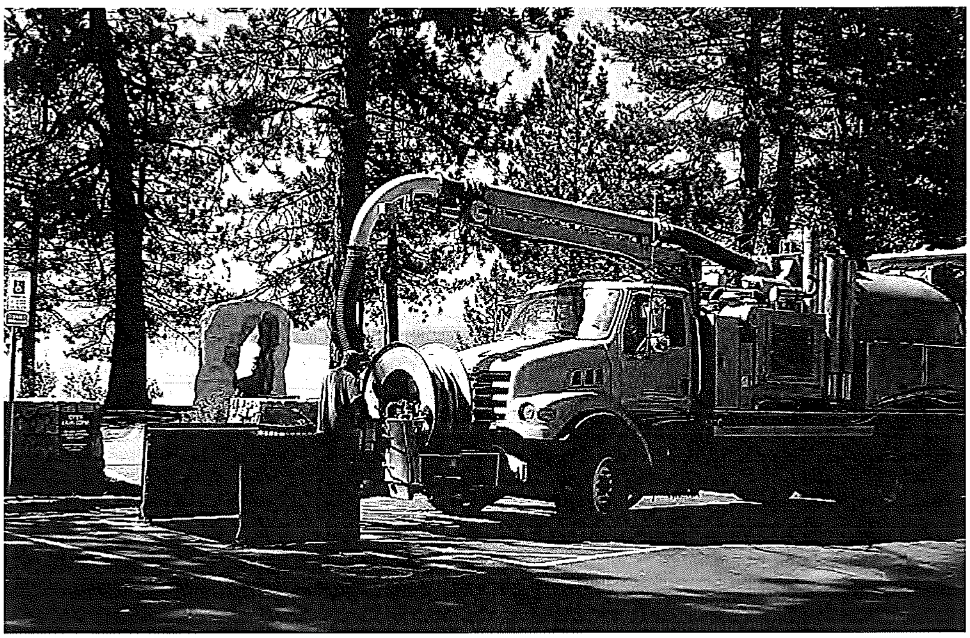
CDS2015	5	1.5	3.0	0.9	1.3	1.0
CDS2020	5	1.5	3.5	1.1	1.3	1.0
CDS2025	5	1.5	4.0	1.2	1.3	1.0
CDS3020	6	1.8	4.0	1.2	2.1	1.6
CDS3030	6	1.8	4.6	1.4	2.1	1.6
CDS3035	6	1.8	5.0	1.5	2.1	1.6
CDS4030	8	2.4	4.6	1.4	5.6	4.3
CDS4040	8	2.4	5.7	1.7	5.6	4.3
CDS4045	8	2.4	6.2	1.9	5.6	4.3

Table 1: CDS Maintenance Indicators and Sediment Storage Capacities



Support

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The product(s) described may be protected by one or more of the following US patents: 5,322,629; 5,624,576; 5,707,527; 5,759,415; 5,788,848; 5,985,157; 6,027,639; 6,350,374; 6,406,218; 6,641,720; 6,511,595; 6,649,048; 6,991,114; 6,998,038; 7,186,058; 7,296,692; 7,297,266; 7,517,450 related foreign patents or other patents pending.

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CDS Inspection & Maintenance Log

CDS Model: ______________________ Location: ______________________

Date	Water depth to sediment[1]	Floatable Layer Thickness[2]	Describe Maintenance Performed	Maintenance Personnel	Comments

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. If the difference between these measurements is less than eighteen inches the system should be cleaned out. **Note: To avoid underestimating the volume of sediment in the chamber, the measuring device must be carefully lowered to the top of the sediment pile.**

2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of an oil spill, the system should be cleaned immediately.

CONTECH STORMWATER SOLUTIONS INC.

SECTION [_____]

STORM WATER TREATMENT DEVICE

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope

The Contractor shall furnish all labor, equipment and materials necessary to install the storm water treatment device(s) (SWTD) and appurtenances specified in the Drawings and these specifications.

B. Related Sections

Section 02240: Dewatering
Section 02260: Excavation Support and Protection
Section 02315: Excavation and Fill
Section 02340: Soil Stabilization

1.2 QUALITY ASSURANCES

A. Inspection

All components shall be subject to inspection by the Engineer at the place of manufacture and/or installation. All components are subject to be rejected or identified for repair if the quality of materials and manufacturing do not comply with the requirements of this specification. Components which have been identified as defective may be subject for repair. Final acceptance of the component is contingent upon the discretion of the Engineer.

B. Warranty

The manufacturer shall guarantee the SWTD components against all manufacturer originated defects in materials or workmanship for a period of twelve (12) months from the date the components are delivered to the owner for installation. The manufacturer shall be notified of repair/replacement issues in writing within the referenced warranty period. The manufacturer shall, upon its determination of repair, correct or replace any manufacturer originated defects identified by written notice within the referenced warranty period. The use of SWTD components shall be limited to the application for which it was specifically designed.

C. Manufacturer's Performance Certificate

The SWTD manufacturer shall submit to the Engineer of Record a "Manufacturer's Performance Certification" certifying that each SWTD is capable of achieving the specified removal efficiencies as listed in these specifications. The certification shall be supported by independent third-party research.

1.3 SUBMITTALS

A. Shop Drawings

The contractor shall prepare and submit shop drawings in accordance with Section **[_____]** of the contract documents. The shop drawings shall detail horizontal and vertical dimensioning, reinforcement and joint type and locations.

PART 2 – PRODUCTS

2.1 MATERIALS AND DESIGN

A. Precast Concrete Components

Precast concrete components shall conform to applicable sections of ASTM C 478, ASTM C 857 and ASTM C 858 and the following:

1. Concrete shall achieve a minimum 28-day compressive strength of 4,000 pounds per square-inch (psi);
2. Unless otherwise noted, the precast concrete sections shall be designed to withstand lateral earth and AASHTO H-20 traffic loads;
3. Cement shall be Type III Portland Cement conforming to ASTM C 150;
4. Aggregates shall conform to ASTM C 33;
5. Reinforcing steel shall be deformed billet-steel bars, welded steel wire or deformed welded steel wire conforming to ASTM A 615, A 185 or A 497, respectively;
6. Joints shall be sealed with preformed joint sealing compound conforming to ASTM C 990 and
7. Shipping of components shall not be initiated until a minimum compressive strength of 4,000 psi is attained or five (5) calendar days after fabrication has expired, whichever occurs first.

B. Internal Components and Appurtenances

Internal Components and appurtenances shall conform to the following:

1. Screen and support structure shall be manufactured of Type 316 and 316L stainless steel conforming to ASTM F 1267-01;
2. Hardware shall be manufactured of Type 316 stainless steel conforming to ASTM A 320;
3. Fiberglass components shall conform to the National Bureau of Standards PS-15 and coated with an isophalic polyester gelcoat and
4. Access system(s) conform to the following:
   a. Manhole castings shall be designed to withstand AASHTO H-20 loadings and manufactured of cast-iron conforming to ASTM A 48 Class 30.
   b. Hatch systems shall be designed to withstand AASHTO H-20 loadings. Hatch systems not subject to direct traffic shall be manufactured of Grade 5086 aluminum. Hatch systems subject to

direct traffic loads shall be manufactured of steel conforming to ASTM A 36-93a, supplied with a hot-dip galvanized finish conforming to ASTM A 123 and access doors bolted to the frame.

2.2 PERFORMANCE

A. Removal Efficiencies

1. The SWTD shall be capable of achieving an 80 percent average annual reduction in the total suspended solid load.
2. The SWTD shall be capable of capturing and retaining 100 percent of pollutants greater than or equal to 2.4 millimeters (mm) regardless of the pollutant's specific gravity (i.e.: floatable and neutrally buoyant materials) for flows up to the device's rated-treatment capacity. The SWTD shall be designed to retain all previously captured pollutants addressed by this subsection under all flow conditions.
3. The SWTD shall be capable of capturing and retaining total petroleum hydrocarbons. The SWTD shall be capable of achieving a removal efficiency of 92 and 78 percent when the device is operating at 25 and 50 percent of its rated-treatment capacity. These removal efficiencies shall be based on independent third-party research for influent oil concentrations representative of storm water runoff (20 ± 5 mg/L). The SWTD shall be greater than 99 percent effective in controlling dry-weather accidental oil spills.

   The SWTD shall be capable of utilizing sorbent media to enhance removal and retention of petroleum based pollutants.

B. Hydraulic Capacity

4. The SWTD shall provide a rated-treatment capacity, which is consistent with governing water treatment regulations. At its rated-treatment capacity, the device shall be capable of achieving greater than 65 percent removal of particles typically found in roadside sediments. This removal efficiency shall be supported by independent third-party research utilizing samples consistent with the NURP gradation or finer.
5. The SWTD shall maintain the peak conveyance capacity of the drainage network as defined by the Engineer.

C. Storage Capacity

1. The SWTD shall be designed with a sump chamber for the storage of captured sediments and other negatively buoyant pollutants in between maintenance cycles. The minimum storage capacity provided by the sump chamber shall be in accordance with the volume listed in Table 1. The boundaries of the sump chamber shall be limited to that which do not degrade the SWTD's treatment efficiency as captured pollutants accumulate. The sump chamber shall be separate from the treatment processing portion(s) of the SWTD to minimize the probability of fine particle re-suspension. In order to not restrict the Owner's ability to maintain the SWTD, the minimum dimension providing access from the ground surface to the sump chamber shall be 20 inches in diameter.

2. The SWTD shall be designed to capture and retain Total Petroleum Hydrocarbons generated by wet-weather flow and dry-weather gross spills. The minimum storage capacity provided by the SWTD shall be in accordance with the volume listed in Table 1 below.

TABLE 1

CDS Model	Treatment Capacity (cfs)/(L/s)	Minimum Sump Storage Capacity (yd^3)/(m^3)	Minimum Oil Storage Capacity (gal)/(L)
CDS2015-G	0.7 (19.8)	0.5 (0.4)	70 (265)
CDS2015-4	0.7 (19.8)	0.5 (1.4)	70 (265)
CDS2015	0.7(19.8)	1.3 (1.0)	92 (348)
CDS2020	1.1 (31.2)	1.3 (1.0)	131 (496)
CDS2025	1.6 (45.3)	1.3 (1.0)	143 (541)
CDS3020	2.0 (56.6)	2.1 (1.6)	146 (552)
CDS3030	3.0 (85.0)	2.1 (1.6)	205 (776)
CDS3035	3.8 (106.2)	2.1 (1.6)	234 (885)
CDS4030	4.5 (127.4)	5.6 (4.3)	407 (1540)
CDS4040	6.0 (169.9)	5.6 (4.3)	492 (1862)
CDS4045	7.5 (212.4)	5.6 (4.3)	534 (2012)
CDS2020-D	1.1 (31.2)	1.3 (1.0)	131 (495)
CDS3020-D	2.0 (56.6)	2.1 (1.6)	146 (552)
CDS3030-D	3.0 (85.0)	2.1 (1.6)	205 (776)
CDS3035-D	3.8 (106.2)	2.1 (1.6)	234 (885)
CDS4030-D	4.5 (127.4)	4.3 (3.3)	328 (1241)
CDS4040-D	6.0 (169.9)	4.3 (3.3)	396 (1499)
CDS4045-D	7.5 (212.4)	4.3 (3.3)	430 (1627)
CDS5640-D	9.0 (254.9)	5.6 (4.3)	490 (1854)
CDS5653-D	14.0 (396.5)	5.6 (4.3)	599 (2267)
CDS5668-D	19.0 (538.1)	5.6 (4.3)	733 (2774)
CDS5678-D	25.0 (708.0)	5.6 (4.3)	814 (3081)
CDS3030-DV	3.0 (85.0)	2.1 (1.6)	205 (776)
CDS5042-DV	9.0 (254.9)	1.9 (1.5)	294 (1112)
CDS5050-DV	11.0 (311.5)	1.9 (1.5)	367 (1389)
CDS7070-DV	26.0 (736.3)	3.3 (2.5)	914 (3459)
CDS10060-DV	30.0 (849.6)	5.0 (3.8)	792 (2997)
CDS10080-DV	50.0 (1416.0)	5.0 (3.8)	1057 (4000)
CDS100100-DV	64.0 (1812.5)	5.0 (3.8)	1320 (4996)

D. Alternate Treatment Technologies and Sizing Criteria

The sizing criteria for treatment systems must conform to the recommended loading rate and 3rd party testing data requirements as mentioned below:

1. CDS Screening Systems – designed for full treatment of the runoff rate at a loading rate not to exceed the critical flow in the inlet, in order to achieve 80% TSS removal efficiency. (80% TSS removal based on a average particles size of 63 micron)
2. Vortex separation systems – designed for full treatment of the runoff rate at a loading rate not to exceeding 24 gpm/ft2, in order to achieve 80% TSS removal efficiency. The hydraulic capacity should not exceed a loading rate of 100 gpm/ft2 to prevent scouring of previously captured particles. 80% TSS removal based on a average particles size of 63 micron)
3. Gravity systems – designed for full treatment of the runoff rate at a loading rate not to exceeding 10 gpm/ft2, in order to achieve 80% TSS removal efficiency. The gravity units will not exceed luminar flow condition parameters in the treatment unit but will provide a bypass system to prevent turbulence from accruing in the system. (See "Stokes Law" for gravity settling requirements of particles. 80% TSS removal based on a average particles size of 63 micron)

Additionally, the performance of the unit must be evaluated by a third party and verified in a program that allows a more-or-less direct comparison to other technologies. Performance should be third party verified, and removal efficiencies across the spectrum of particle sizes reported, at a range of hydraulic loading rates varying over a range of at least 25 to 125% of the manufacturer's advertised 'water treatment' loading rate.

2.3 MANUFACTURER

The manufacturer of the SWTD shall be one that is regularly engaged in the engineering design and production of systems deployed for the treatment of storm water runoff for at least five (5) years and which have a history of successful production, acceptable to the Engineer. In accordance with the Drawings, the SWTD(s) shall be a CDS® device manufactured by:

CONTECH Stormwater Solutions
9025 Centre Pointe Dr., Suite 400
West Chester, OH 45069
(866) 551-8325 (toll free)

PART 3 – EXECUTION

3.1 HANDLING AND STORAGE

1. The contractor shall exercise care in the storage and handling of the SWTD components prior to and during installation. Any repair or replacement costs associated with events occurring after delivery is accepted and unloading has commenced shall be born by the contractor.

3.2 INSTALLATION

1. The SWTD shall be installed in accordance with the manufacturer's recommendations and related sections of the contract documents. The manufacturer shall provide the contractor installation instructions and offer on-site guidance during the important stages of the installation as identified by the manufacturer at no additional expense. A minimum of 72 hours notice shall be provided to the manufacturer prior to their performance of the services included under this subsection.
2. The contractor shall fill all voids associated with lifting provisions provided by the manufacturer. These voids shall be filled with non-shrinking grout providing a finished surface consistent with adjacent surfaces. The contractor shall trim all protruding lifting provisions flush with the adjacent concrete surface in a manner which leaves no sharp points or edges.

END OF SECTION

GEOTECH
CONSULTANTS, INC.

13256 Northeast 20th Street, Suite 16
Bellevue, Washington 98005
(425) 747-5618 FAX (425) 747-8561

October 18, 2012

JN 12276

United Parcel Service
C/o Pacific Engineering Design
15445 – 53rd Avenue South
Seattle, Washington

via email: jhopper@paceng.com

Attention: Joe Hopper

Subject: ***Stormwater Infiltration Considerations***
Existing UPS Facility
7383 New Market Street Southwest
Tumwater, Washington

Dear Mr. Hopper:

We are pleased to present this geotechnical engineering report in regards to stormwater infiltration on the property in Tumwater, Washington. The scope of our services consisted of exploring site surface and subsurface conditions, and then developing this report to provide recommendations for design and maintenance of on-site infiltration systems. This work was authorized by your acceptance of our proposal, P-8456, dated August 27, 2012.

We understand that the existing stormwater infiltration facility located in the undeveloped grass area north of the existing asphalt parking lot is no longer functioning properly, and the system backs up during periods of heavy precipitation causing minor flooding to occur in the northwestern parking lot. Thus, a new infiltration system is being considered for stormwater conveyance in the northern portion of the site.

If the scope of the project changes from what we have described above, we should be provided with revised plans in order to determine if modifications to the recommendations and conclusions of this report are warranted.

SITE CONDITIONS

SURFACE CONDITIONS

The attached Plate 1 illustrates the location of the site in Tumwater. The irregularly shaped property is located along the western side of New Market Street Southwest, just south of 73rd Avenue Southwest. The subject site is currently developed with a one-story, L-shaped commercial building located near the center of the site. Asphalt parking covers nearly the entire area surrounding the building. The property is currently being used as a United Parcel Service (UPS) distribution center and truck parking. The entire property is mostly level, with the parking lot sloped only slightly for drainage. The north side of the property is covered with low growing grass and a few sparse small trees. The areas to the west and south are covered with thick vegetation and sparse large trees.

We understand that the existing stormwater system on-site collects runoff from both the asphalt parking lot surrounding the building and the roof of the existing building. This water is then directed to an infiltration facility to the north of the existing parking lot, buried in the grass area just north of the parking lot. Before entering the infiltration system, the stomwater is directed through a series of three sediment tanks of various retention depths. During our site visit, we observed the condition inside the sediment tanks. The tanks each held water at a level a few feet beneath the outfall pipe. The water in each tank appeared murky, and was relatively viscous when extending a steel tape to the bottom of the tank. After exiting the last basin, the water enters an infiltration facility consisting of two parallel, 8-inch-diameter, perforated PVC pipes. Based on observations made in the field, the pipes appear to be surrounded in gravel, which in turn is wrapped in non-woven drainage fabric. Also, the infiltration trenches appear to be approximately 6 feet beneath the existing ground surface and about 50 to 70 feet in length, with two cleanouts extending above the ground surface at the eastern extent of the pipes. We also inspected the conditions of the cleanout pipes. Water staining was observed in both cleanout pipes, at the same elevation near the top of the pipes. These stains were also relatively dirty; indicating that unclean water was likely backed up in the cleanout pipes for an extended period.

SUBSURFACE CONDITIONS

The subsurface conditions were explored by excavating three test pits at the approximate locations shown on the Site Exploration Plan, Plate 2. Our exploration program was based on the proposed construction, anticipated subsurface conditions and those encountered during exploration, and the scope of work outlined in our proposal.

The test pits were excavated on September 14, 2012 with a rubber-tired backhoe. A geotechnical engineer from our staff observed the excavation process, logged the test pits, and obtained representative samples of the soil encountered. "Grab" samples of selected subsurface soil were collected from the backhoe bucket. The Test Pit Logs are attached to this report as Plates 3 through 5.

Soil Conditions

The soil revealed in the test pits at the surface of the site near the existing infiltration system consisted of native sand beneath a thin layer of topsoil. The native sand contained very small amounts of silt, was loose to medium dense beneath the surface, and became medium dense beneath about 5 feet. This medium dense native sand was encountered to the maximum depth reached by our explorations of 11 feet in Test Pit 1.

No obstructions were revealed by our explorations. However, debris, buried utilities, and old foundation and slab elements are commonly encountered on sites that have had previous development.

Groundwater Conditions

No groundwater seepage was observed in our test pits; for only a short time period. It should be noted that groundwater levels vary seasonally with rainfall and other factors. However, we did not observe clear evidence of groundwater at or above 11 feet in the test pits.

The stratification lines on the logs represent the approximate boundaries between soil types at the exploration locations. The actual transition between soil types may be gradual, and subsurface conditions can vary between exploration locations. The logs provide specific subsurface information only at the locations tested. The relative densities and moisture descriptions indicated on the test pit logs are interpretive descriptions based on the conditions observed during excavation.

The compaction of backfill was not in the scope of our services. Loose soil will therefore be found in the area of the test pits. If this presents a problem, the backfill will need to be removed and replaced with structural fill during construction.

PERCOLATION TESTING

As part of our study, we preformed two in-situ infiltration tests at the locations of Test Pits 2 and 3. These tests were performed in general accordance with the EPA falling head percolation test procedure as modified for Thurston County, as described in Appendix III-A of the City of Tumwater Drainage Design & Erosion Control Manual. These tests were conducted at elevations of approximately 6.0 and 6.5 feet beneath the existing surface of the site. A percolation rate was observed for a period of approximately 2 hours, following a pre-soak period. The lowest percolation rate recorded during this time period for either location was over 90 inches/hour. Several measured rates were higher than this.

INFILTRATION CONSIDERATIONS

The results of our percolation testing and observations of the soil conditions indicate that the on-site soils were relatively permeable. Based on our observations made during our site visit, it appears unlikely that the failure of the on-site infiltration system is not due to the on-site soils; it is more likely that the infiltration facility became clogged with silt, oils, and other debris over time, limiting the permeability of the infiltration trenches.

Based on the observations of the test pits and the results of our percolation tests, infiltration of stormwater collected throughout the site is a feasible method of stormwater disposal at the subject site. However, due to the nature of the use of the subject site as a parcel distribution center housing many large trucks and including a truck wash station, the stormwater system is likely subject to an excessive runoff of silt, oils, and other viscous material. Therefore, special measures should be implemented that help insure oils, silts, and other foreign materials are separated out from the stormwater prior to directing the water to an infiltration facility. Additionally, frequent maintenance and cleaning of the stormwater system will be necessary to remove built-up solids within the system. At a minimum, the system should include multiple cleanout locations to allow access for maintenance and cleaning. Additionally, it may be prudent to install an emergency overflow pipe that daylights to an appropriate off-site location or conveyance system to protect against flooding should the infiltration facility become clogged or backed-up.

Based on Appendix III-A of the City of Tumwater Drainage and & Erosion Control Manual, multiple methods are acceptable for estimating the infiltration rate to be used for design of infiltration facilities. These methods include one simple method based on field percolation testing and another based on the gradation of the on-site soils. As previously discussed, we performed multiple in-situ percolation tests near the location of the existing infiltration facility. The lowest recorded infiltration rate during testing was approximately 90 inches per hour. The City of Tumwater recommends applying the following correction factors to the measured rate during testing.

$I_{design} = I_{measured} \times F_{testing} \times F_{geometry} \times F_{plugging}$ where

$I_{measured}$ = infiltration rate measured during testing
$F_{testing}$ = 0.50 (for EPA method used)
$F_{geometry}$ = accounts for influence of facility geometry and depth to water table or impervious layer (assumed 1.0 for this calculation)
$F_{plugging}$ = 0.8 (for fine sands and loamy sands)

Based on this equation and the minimum design infiltration rate for the subject site would be 36.0 inches/hour. The City of Tumwater states that in no case may the design infiltration rate exceed 30 inches/hour.

Using Simple Method 2 outlined in the stormwater manual, the soil is classified using either the USDA Soil Texture Classification or ASTM Gradation Testing. We performed sieve testing on two representative samples obtained from the test pits conducted at the site. The results of these sieve tests are attached as Plate 5. Based on the USDA soil classification, the site soil would generally be classified as sand to loamy sand. The corresponding recommended design infiltration rate would be anywhere from 1 to 4 inches/hour if reduced correction factors are used. Based on the ASTM gradation, the recommended design infiltration rate would correspond to 2 inches/hour.

Recommended Design Infiltration Rate

We feel that the percolation rate measured by our on-site testing and the subsequent design infiltration rate is relatively fair representative of the actual infiltration rates of the site soils. However, based on the nature of the site and recommended values based on soil classification, we feel a reduced value is more appropriate. Therefore, for design of infiltration facilities on-site, we recommend using a design infiltration rate of 10 inches per hour.

LIMITATIONS

The conclusions and recommendations contained in this report are based on site conditions as they existed at the time of our site visit. If the subsurface conditions encountered during construction are significantly different from those anticipated, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. Unanticipated conditions are commonly encountered on construction sites. Such unexpected conditions frequently require making additional expenditures to attain a properly constructed project.

This report has been prepared for the exclusive use of United Parcel Service, its representatives for specific application to this project and site. Our recommendations and conclusions are based on the site materials observed and on previous experience with sites that have similar observed conditions. The conclusions and recommendations are professional opinions derived in accordance with current standards of practice within the limited scope of our services. No warranty is expressed or implied.

We trust that this report meets your immediate needs for the proposed development. Please contact us if we can be of further service.
The following plates are attached to complete this report:

Plate 1	Vicinity Map
Plate 2	Site Exploration Plan
Plates 3 - 4	Test Pit Logs
Plate 5	Grain-Size Analysis

Respectfully submitted,

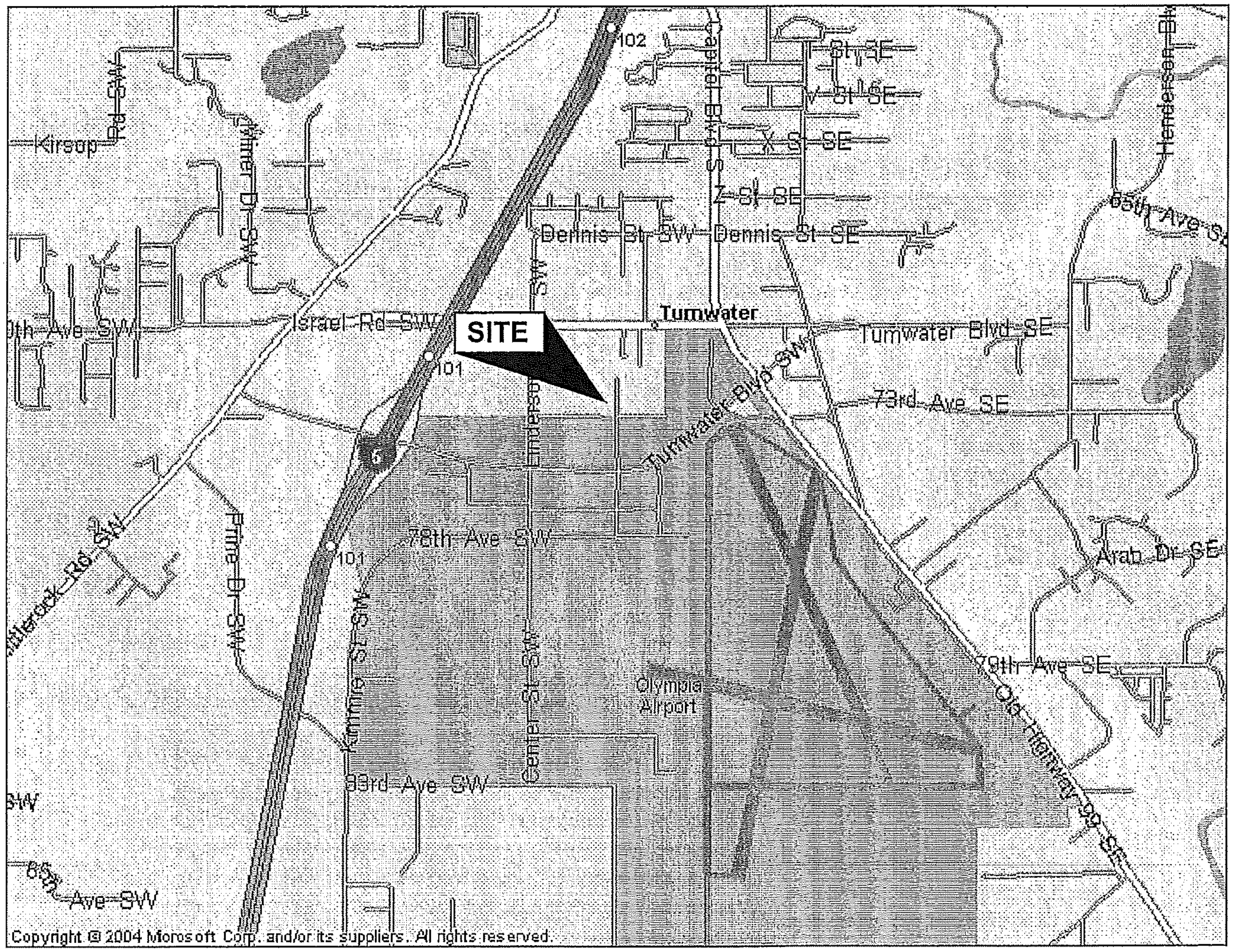
GEOTECH CONSULTANTS, INC.

Jason L. Hinds
Geotechnical Engineering

D. Robert Ward, P.E.
Principal

JLH/DRW: jyb

NORTH



(Source: Microsoft Streets and Trips, 2004)

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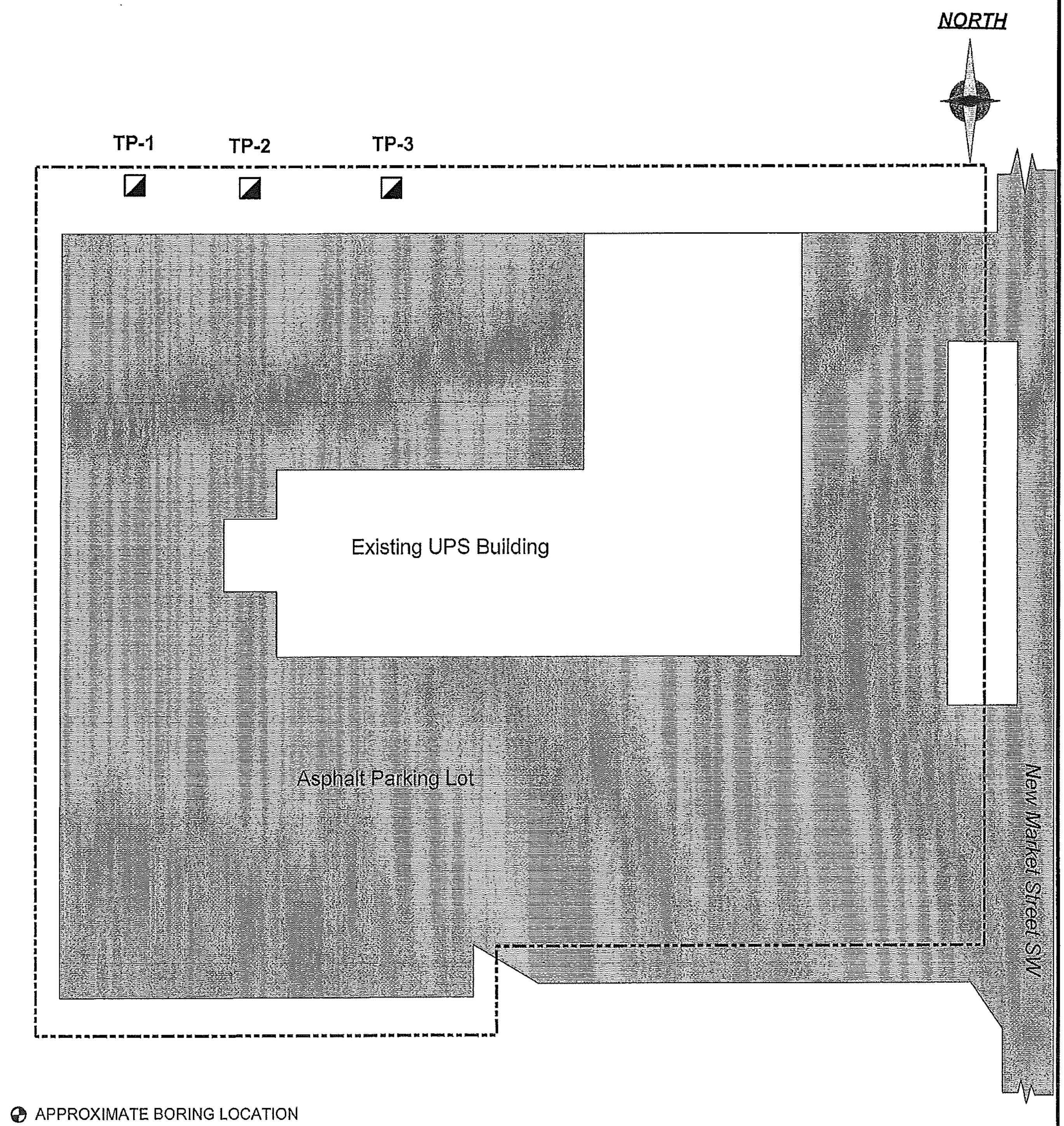
VICINITY MAP

7383 New Market Street Southwest
Tumwater, Washington

Job No:	Date:		Plate:
12276	Sept. 2012		1



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SITE EXPLORATION PLAN

7383 New Market Street Southwest
Tumwater, Washington

Job No:	Date:		Plate:
12276	Sept. 2012	No Scale	2

TEST PIT 1

Depth (ft.)	Moisture Content (%)	Water Table	USCS	Description
			FILL	Weeds and topsoil over;
			SP	Dark brown SAND with some roots, fine grained, moist, medium dense
				-becomes light brown to brown
5				
10				-some minor rusting
15				

* **Test Pit terminated at 11.5 feet on September 14, 2012.**
* **No groundwater observed during excavation.**
* **No caving observed during excavation.**

TEST PIT 2

Depth (ft.)	Moisture Content (%)	Water Table	USCS	Description
			FILL	Weeds and topsoil over;
			SP	Dark brown SAND with some roots, fine grained, moist, medium dense
				-becomes light brown to brown
5				
10				
15				

* **Test Pit terminated at 7.0 feet on Septmber 14, 2012.**
* **No groundwater observed during excavation.**
* **No caving observed during excavation.**

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TEST PIT LOG

7383 New Market Street Southwest
Tumwater, Washington

Job	*Date:*	*Logged by:*	*Plate:*
12276	Sept. 2012	JLH	3

TEST PIT 3

Depth (ft.)	Moisture Content (%)	Water Table	USCS	Description
			FILL	Weeds and topsoil over;
5			SP	Dark brown SAND, fine grained, moist, medium dense -light brown to tan
10				
15				

* **Test Pit terminated at 6 feet on September 14, 2012.**
* **No groundwater observed during excavation.**
* **No caving observed during excavation.**

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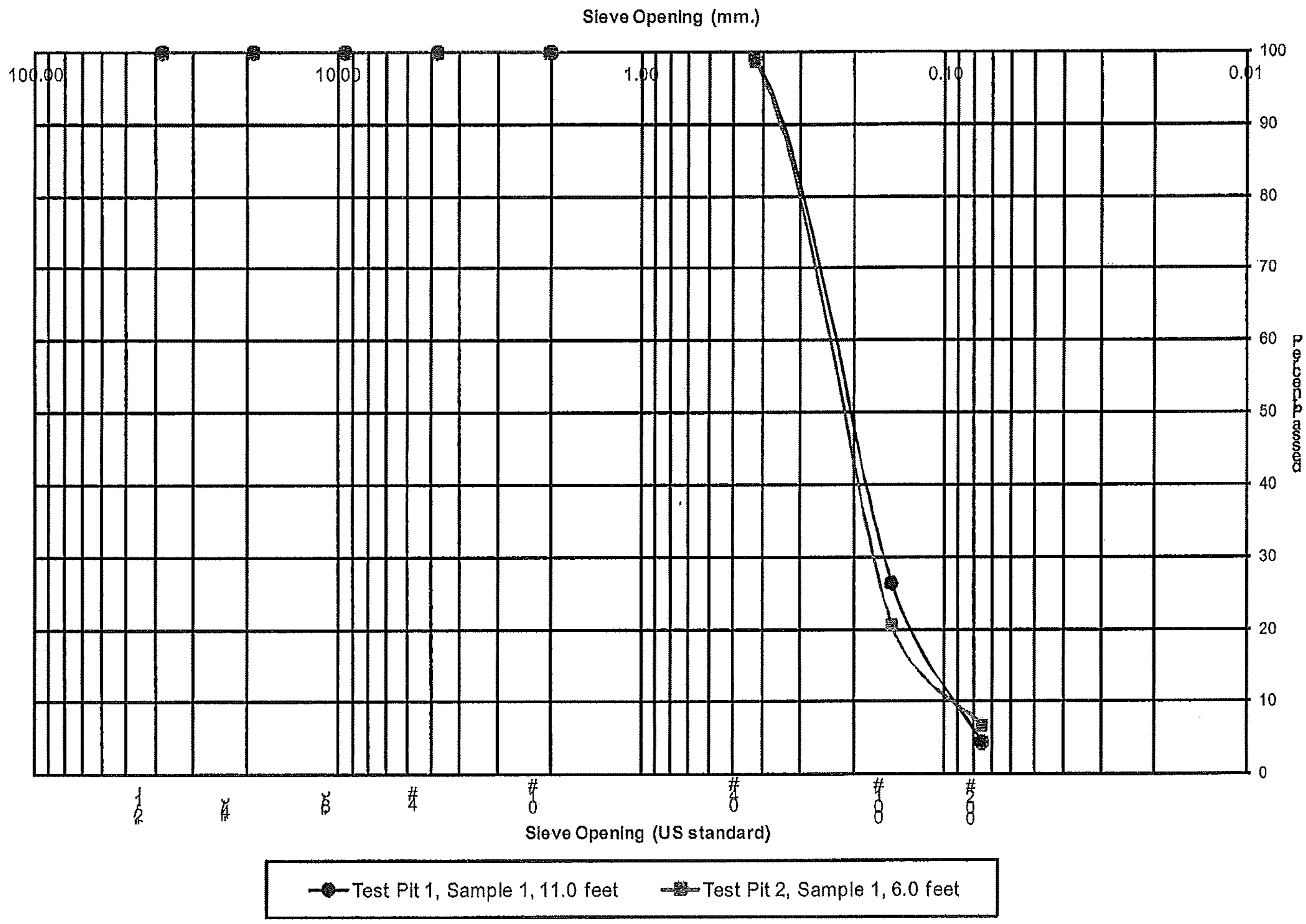
TEST PIT LOG

7383 New Market Street Southwest
Tumwater, Washington

Job	Date:	Logged by:	Plate:
12276	Sept. 2012	JLH	4



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SIEVE ANALYSIS

7383 New Market Street Southwest
Tumwater, Washington

Job No:	Date:		Plate:
12276	Sept. 2012		5

Appendix III-A
Methods for Determining Design Infiltration Rates

This appendix provides details on methods to estimate the design infiltration rate for infiltration facilities. The methods described include:

- Simple Method 1 – Field Testing Procedures
- Simple Method 2 – Soil Property Relationships
- Detailed Method – Based on Massmann (2003).

Simple Method 1 – Field Testing Procedures (In-Situ)

1. Excavate to the bottom elevation of the proposed infiltration facility.

2. Measure the infiltration rate of the underlying soil using either the EPA falling head percolation test procedure as modified for Thurston County (described below), the EPA falling head percolation test procedure as modified by Clark County (2008), the double ring infiltrometer test (ASTM D3385), or the Department of Ecology large scale Pilot Infiltration Test (PIT) described below and presented in the *Stormwater Management Manual for Western Washington* (Ecology 2005).

3. Fill test hole or apparatus with water and maintain at depths above the test elevation for saturation periods specific to the appropriate test.

4. Following the saturation period, the infiltration rate shall be determined in accordance with the specified test procedures.

5. Perform the minimum required number of infiltration tests at the proposed infiltration facility location as specified by the jurisdictions stormwater drainage manual and recommendations of the geotechnical professional.

6. Determine a representative infiltration rate.

For all field testing procedures, apply safety factor to obtain design infiltration rate (see next section).

Safety Factor for Field Measurements

The following equation incorporates safety factors to account for uncertainties related to testing, depth to the water table or impervious strata, infiltration receptor geometry, and long-term reductions in permeability due to biological activity and accumulation of fine sediment.

This equation estimates the maximum design infiltration rate, I_{design}. Depending on site conditions, additional reduction of the design infiltration rate may be appropriate. **In no case may the design infiltration rate exceed 30 inches/hour**.

$$I_{design} = I_{measured} \times F_{testing} \times F_{geometry} \times F_{plugging}$$

$F_{testing}$ accounts for uncertainties in the testing methods. For the EPA method, the SDI (ASTM D3385) method, or large-scale PIT testing, $F_{testing} = 0.50$.

$F_{geometry}$ accounts for the influence of facility geometry and depth to the water table or impervious strata on the actual infiltration rate. A shallow water table or impervious layer reduces the effective infiltration rate of a large pond, but this would not be reflected in a small scale test. $F_{geometry}$ must be between 0.25 and 1.0 as determined by the following equation: $F_{geometry} = 4\ D/W + 0.05$

Where: D = Depth from the bottom of the proposed facility to the maximum wet season water table or nearest impervious layer, whichever is less

W = Width of facility

$F_{plugging}$ accounts for reductions in infiltration rates over the long term due to plugging of soils. This factor is:

- 0.7 for loams and sandy loams
- 0.8 for fine sands and loamy sands
- 0.9 for medium sands
- 1.0 for coarse sands or cobbles, or any soil type in an infiltration facility preceded by a water quality facility (not including a pre-treatment unit or forebay for course sediment removal).

Falling Head Percolation Test Procedure (as Modified for Thurston County) (Source: EPA, *On-site Wastewater Treatment and Disposal Systems,* 1980)

1. **Number and Location of Tests**

   A minimum of three tests shall be performed within the area proposed for an infiltration facility. Tests shall be spaced uniformly throughout the area. For larger facilities or if soil conditions are highly variable, more tests may be required (see minimum testing requirements in Volume III).

2. **Preparation of Test Hole** (as modified for Thurston County)

   The diameter of each test hole is 8 inches, dug or bored to the proposed bottom elevation of the infiltration facility or to the most limiting soil horizon. To expose a natural soil surface, the bottom of the hole is scratched with a sharp pointed instrument and the loose material is removed from the test hole. A 6-inch-inner-diameter, 4-foot long, PVC pipe is set into the hole and pressed 6 inches into the soil, then 2 inches of 1/2- to 3/4-inch rock are placed in the pipe to protect the bottom from scouring when water is added.

3. **Soaking Period**

   The pipe is carefully filled with at least 12 inches of clear water. The depth of water must be maintained for at least 4 hours and preferably overnight if clay soils are present. A funnel with an attached hose or similar device may be used to prevent water from washing down the sides of the hole. Automatic siphons or float valves may be employed to automatically maintain the water level during the soaking period. It is extremely important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained.

   In sandy soils with little or no clay, soaking is not necessary. If, after filling the pipe twice with 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately.

4. Percolation Rate Measurement

   Except for sandy soils, percolation rate measurements are made at least 15 hours but no more than 30 hours after the soaking period began. The water level is adjusted to 6 inches above the gravel (or 8 inches above the bottom of the hole). At no time during the test is the water level allowed to rise more than 6 inches above the gravel. Immediately after adjustment, the water level is measured from a fixed reference point to the nearest 1/16th-inch, at 30 minute intervals. The test is continued until two successive water level drops do not vary by more than 1/16th-inch within a 90 minute period. At least three measurements are to be made.

   After each measurement, the water level is readjusted to the 6-inch level. The last water level drop is used to calculate the percolation rate.

   In sandy soils or soils in which the first 6 inches of water added after the soaking period seeps away in less than 30 minutes, water level measurements are made at 10-minute intervals for a 1-hour period. The last water level drop is used to calculate the percolation rate.

5. Percolation Rate Calculation

The percolation rate is calculated for each test site by dividing the time interval used between measurements by the magnitude of the last water level drop. This calculation results in a percolation rate in minutes/inch. To calculate the percolation rate for the area, average the rates obtained from each hole. (If tests in the area vary by more than 20 minutes/inch, variations in soil type are indicated. Under these circumstances, percolation rates should not be averaged.) The percolation rate in minutes/inch should be converted to infiltration rate in inches/hour and then to **compute the design infiltration rate (I_{design}), the final infiltration rates must then be adjusted by the appropriate correction factors outlined previously.**

Example: If the last measured drop in water level after 30 minutes is 5/8-inch, then:

percolation rate = (30 minutes)/(5/8 inch) = 48 minutes/inch. Convert this to inches per hour by inverting & multiplying by 60: infiltration rate – 1/48*60 = 1.25 inches/hour. (At a minimum, a safety factor "$F_{testing}$" of 0.5 is be applied to all field methods for determining infiltration rates.)

Washington Department of Ecology Infiltration Pit Method

The Pilot Infiltration Test (PIT) consists of a relatively large-scale infiltration test to better approximate infiltration rates for design of stormwater infiltration facilities. The PIT reduces some of the scale errors associated with relatively small-scale tests such as the Modified Falling Head Percolation Test, double ring infiltrometer or "stove-pipe" infiltration tests. It is not a standard test but rather a practical field procedure recommended by Ecology's Technical Advisory Committee. Following is a step-by-step description of the testing procedure.

Infiltration Test

1. Excavate the test pit to the depth of the bottom of the proposed infiltration facility. Lay back the slopes sufficiently to avoid caving and erosion during the test.

2. The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. For small drainages and where

water availability is a problem smaller areas may be considered as determined by the site professional.

3. Accurately document the size and geometry of the test pit.

4. Install a vertical measuring rod (minimum 5 feet long) marked in half-inch increments in the center of the pit bottom.

5. Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.

6. Add water to the pit at a rate that will maintain a water level between 3 and 4 feet above the bottom of the pit. A rotameter can be used to measure the flow rate into the pit.

Note: A water level of 3 to 4 feet provides for easier measurement and flow stabilization control. However, the depth must not exceed the proposed maximum depth of water expected in the completed facility.

7. Every 15 to 30 minutes, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point (between 3 and 4 feet) on the measuring rod.

8. Add water to the pit until 1 hour after the flow rate into the pit has stabilized (constant flow rate) while maintaining the same pond water level (usually 17 hours).

9. After the flow rate has stabilized, turn off the water and record the rate of infiltration in inches per hour from the measuring rod data, until the pit is empty.

Data Analysis

Calculate and record the infiltration rate in inches per hour in 30 minute or one-hour increments until 1 hour after the flow has stabilized.

Note: Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.

To compute the design infiltration rate (I_{design}), apply appropriate correction factors outlined previously.

Example:

The area of the bottom of the test pit is 8.5 feet by 11.5 feet.

Water flow rate was measured and recorded at intervals ranging from 15 to 30 minutes throughout the test. Between 400 minutes and 1,000 minutes, the flow rate stabilized between 10 and 12.5 gallons per minute or 600 to 750 gallons per hour. Divide the flow rate by the area of the test pit and convert to inches per hour to get an average of (9.8 + 12.3) / 2 = 11.1 inches per hour.

To compute the design infiltration rate (I_{design}), the infiltration rate must then be adjusted by the appropriate correction factors outlined previously.

Simple Method 2 – Soil Property Relationships

USDA Soil Textural Classification

Infiltration rates may be estimated from soil grain size distribution (gradation) data using the United States Department of Agriculture (USDA) textural analysis approach. Conduct the grain size distribution test in accordance with the USDA test procedure (Soil Survey Manual, USDA, October 1993, page 136). This manual only considers soil passing the #10 sieve (2 mm) (US Standard) to determine percentages of sand, silt, and clay for use in Figure A-1.

Short-term (field) infiltration rates, required correction factors, and design (long-term) infiltration rates based on gradations from soil samples and textural analysis are summarized in Table A.1. With prior approval by Tumwater, the correction factors may be reduced (to a minimum of 2.0) if there is little soil variability, there will be a high degree of long-term facility maintenance, and there is adequate pre-treatment to reduce total suspended solids in influent stormwater.

Table A.1. Recommended Infiltration Rates based on USDA Soil Textural Classification

	*Short-Term Infiltration Rate (in./hr)	Correction Factor, CF	Estimated Design (Long-term) Infiltration Rate (in./hr)
Clean sandy gravels and gravelly sands (i.e., 90% of the total soil sample is retained in the #10 sieve)	20	2	10
Sand	8	4	2
Loamy Sand	2	4	0.5
Sandy Loam	1	4	0.25
Loam	0.5	4	0.13

Source: *Stormwater Management Manual for Western Washington* (Ecology 2005).
*From WEF/ASCE, 1998.

ASTM Gradation Testing

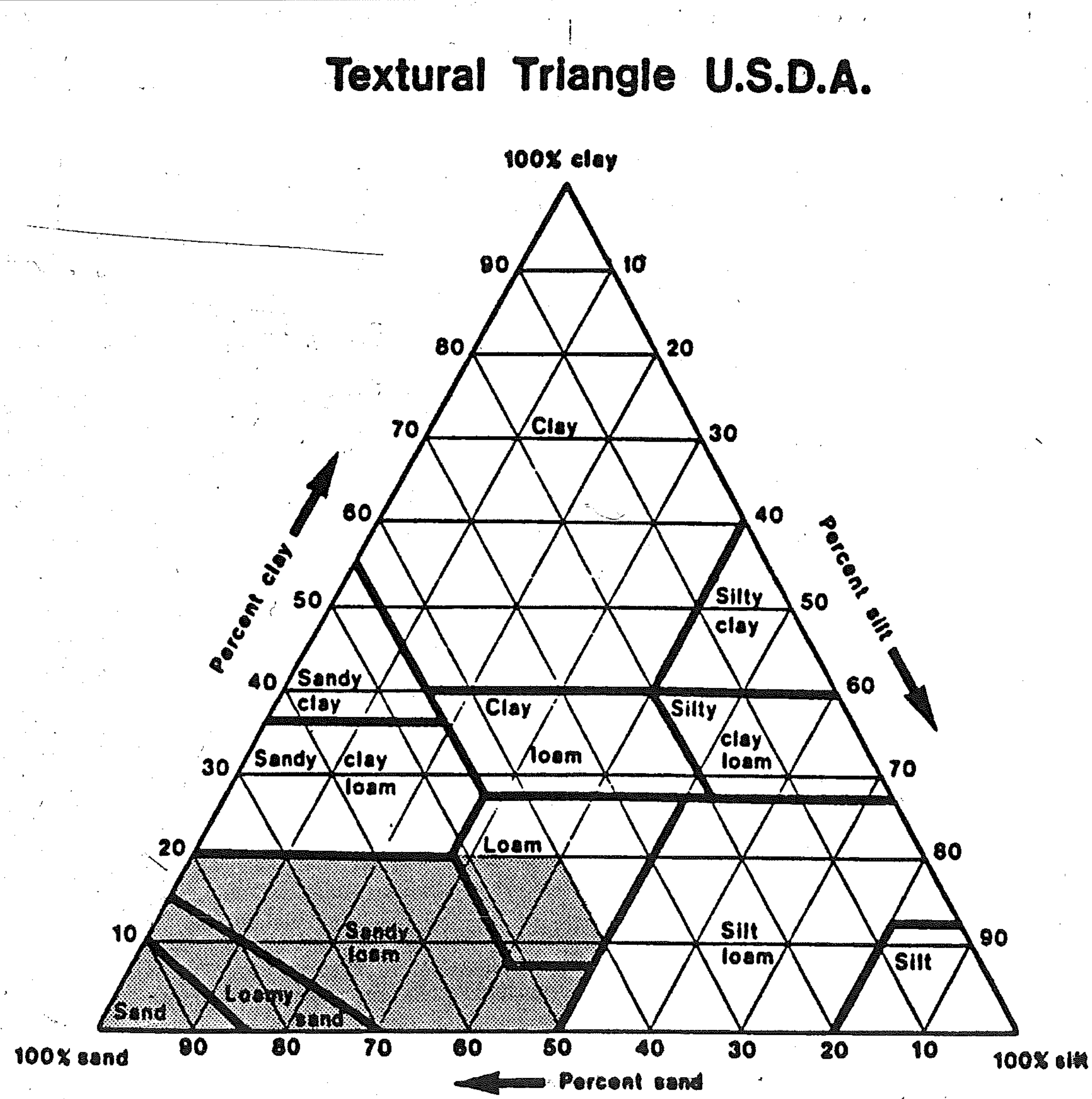
For sites with soils that would be classified as sands or sandy gravels ($D_{10} \geq 0.05$ mm, US Standard Sieve), Table A.2 may be used to estimate design infiltration rates. These rates may need to be reduced if the site is highly variable, or if maintenance and influent characteristics are not well controlled.

For finer soils ($D_{10} < 0.05$ mm, US Standard Sieve), consult Volume III of the *Stormwater Management Manual for Western Washington* (Ecology 2005).

Table A.2. Alternative Recommended Infiltration Rates based on ASTM Gradation Testing

D_{10} Size from ASTM D422 Soil Gradation Test (mm)	Estimated Design (Long-Term) Infiltration Rate (in./hr)
≥ 0.4	9
0.3	6.5
0.2	3.5
0.1	2.0
0.05	0.8

Source: *Stormwater Management Manual for Western Washington* (Ecology 2005).



Shaded area is applicable for design of infiltration BMPs
Source: U.S. Department of Agriculture

Figure A-1. USDA Textural Triangle.

Detailed Method

The detailed method described below is based on Massmann (2003)

Determine the Saturated Hydraulic Conductivity

For each defined layer below the pond to a depth below the pond bottom of 2.5 times the maximum depth of water in the pond, but not less than

6 feet, estimate the saturated hydraulic conductivity (K_{sat}) in centimeters per second (cm/s) using the following relationship (see Massmann 2003, and Massmann et al. 2003):

$$\log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines} \qquad (1)$$

Where, D_{10}, D_{60} and D_{90} are the grain sizes in millimeters (mm) for which 10 percent, 60 percent and 90 percent of the sample is more fine and f_{fines} is the fraction of the soil (by weight) that passes the number-200 sieve.

If the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the facility, soil layers at greater depths must be considered when assessing the site's hydraulic conductivity characteristics. Massmann (2003) indicates that where the water table is deep, soil or rock strata up to 100 feet below an infiltration facility can influence the rate of infiltration. Note that only the layers near and above the water table or low permeability zone (e.g., a clay, dense glacial till, or rock layer) need to be considered, as the layers below the ground water table or low permeability zone do not significantly influence the rate of infiltration.

Also note that this equation for estimating hydraulic conductivity assumes minimal compaction consistent with the use of tracked (i.e., low to moderate ground pressure) excavation equipment. If the soil layer being characterized has been exposed to heavy compaction, or is heavily over consolidated due to its geologic history (e.g., overridden by continental glaciers), the hydraulic conductivity for the layer could be approximately an order of magnitude less than what would be estimated based on grain size characteristics alone (Pitt 2003). In such cases, compaction effects must be taken into account when estimating hydraulic conductivity. For clean, uniformly graded sands and gravels, the reduction in K_{sat} due to compaction will be much less than an order of magnitude. For well-graded sands and gravels with moderate to high silt content, the reduction in K_{sat} will be close to an order of magnitude. For soils that contain clay, the reduction in K_{sat} could be greater than an order of magnitude.

For critical designs (facilities that pose a high risk of flooding and property damage in the event of clogging or other failure), the in-situ saturated conductivity of a specific layer can be obtained through field tests such as the packer permeability test (above or below the water table), the piezocone (below the water table), an air conductivity test (above the water table), or through the use of a pilot infiltration test (PIT) as described in Appendix III-A. Note that some field tests provide a direct estimate of infiltration rate, which is the product of hydraulic conductivity and hydraulic gradient (see Equation 5). In this case, the infiltration rate must be divided by the hydraulic gradient to calculate the hydraulic conductivity. This issue will need to be evaluated on a case-by-case basis when interpreting the results of field tests to ensure an accurate estimate of K_{sat}. It is important to recognize that the gradient in the test may not be the same as the gradient likely to occur in the full-scale infiltration facility in the long-term (i.e., when ground water mounding is fully developed).

Once the saturated hydraulic conductivity for each layer has been identified, determine the effective average saturated hydraulic conductivity below the pond. Hydraulic conductivity estimates from different layers can be combined into an equivalent hydraulic conductivity (K_{equiv}) using the harmonic mean:

$$K_{equiv} = \frac{d}{\sum \frac{d_i}{K_i}} \qquad (2)$$

Where:

d is the total depth of the soil column

d_i is the thickness of layer "i" in the soil column

K_i is the saturated hydraulic conductivity of layer "i" in the soil column.

The depth of the soil column, d, typically would include all layers between the pond bottom and the water table. However, for sites with very deep water tables (>100 feet) where ground water mounding to the base of the pond is not likely to occur, it is recommended that the total depth of the soil column in Equation 2 be limited to approximately 20 times the depth of pond. This is to ensure that the most important and relevant layers are included in the hydraulic conductivity calculations. Deep layers that are not likely to affect the infiltration rate near the pond bottom should not be included in Equation 2.

Equation 2 may over-estimate the effective hydraulic conductivity value at sites with low conductivity layers immediately beneath the infiltration pond. For sites where the lowest conductivity layer is within five feet of the base of the pond, it is suggested that this lowest hydraulic conductivity value be used as the equivalent hydraulic conductivity rather than the value from Equation 2.

The harmonic mean given by Equation 2 is the appropriate effective hydraulic conductivity for flow that is perpendicular to stratigraphic layers, and will produce conservative results when flow has a significant horizontal component such as could occur due to ground water mounding.

Calculate the Hydraulic Gradient

The steady state hydraulic gradient (i) is calculated as follows:

$$i = \frac{D_{wt} + D_{pond}}{138.62(K^{0.1})} \times CF_{size} \qquad (3)$$

Where:

D_{wt} is the depth from the base of the infiltration facility to the water table in feet

K is the saturated hydraulic conductivity in feet/day

D_{pond} is the depth of water in the facility in feet (see Massmann et al. 2003, for the development of this equation)

CF_{size}, is the correction for pond size. The correction factor was developed for ponds with bottom areas between 0.6 and 6 acres in size. For small ponds (ponds with area equal to 2/3 acre), the correction factor is equal to 1.0. For large ponds (ponds with area equal to 6 acres), the correction factor is 0.2, as shown in Equation 4.

$$CF_{size} = 0.73(A_{pond})^{-0.76} \qquad (4)$$

Where, A_{pond} is the area of pond bottom in acres.

This equation generally will result in a calculated gradient of less than 1.0 for moderate to shallow ground water depths (or to a low permeability layer) below the facility, and conservatively accounts for the development of a ground water mound.

A more detailed ground water mounding analysis using a program such as MODFLOW will usually result in a gradient that is equal to or greater than the gradient calculated using Equation 3. If the calculated gradient is greater than 1.0, the water table is considered to be deep, and a maximum gradient of 1.0 must be used. Typically, a depth to ground water of 100 feet or more is required to obtain a gradient of 1.0 or more using this equation.

Since the gradient is a function of depth of water in the facility, the gradient will vary as the pond fills during the season. The gradient could be calculated as part of the stage-discharge calculation used in the continuous runoff models. As of the date of this update, neither the WWHM or MGSFlood have that capability. However, updates to those models may soon incorporate the capability. Until that time, use a steady-state hydraulic gradient that corresponds with a ponded depth of ¼ of the maximum ponded depth – as measured from the basin floor to the overflow.

Calculate the Infiltration Rate using Darcy's Law

$$f = K\left(\frac{dh}{dz}\right) = Ki \qquad (5)$$

Where:

f is the specific discharge or infiltration rate of water through a unit cross-section of the infiltration facility (L/t)

K is the hydraulic conductivity (L/t)

dh/dz (= "i") is the hydraulic gradient (L/L)

Adjustments to Infiltration Rate

Adjustments to the infiltration rate calculated above are required to adjust for biofouling, siltation and pond aspect ratio.

To account for reductions in the rate resulting from long-term siltation and biofouling, take into consideration the degree of long-term maintenance and performance monitoring anticipated, the degree of influent control (e.g., pre-settling ponds biofiltration swales, etc.), and the potential for siltation, litterfall, moss buildup, etc. based on the surrounding environment.

It should be assumed that an average to high degree of maintenance will be performed on these facilities. A low degree of maintenance should be considered only when there is no other option (e.g., access problems). The infiltration rate estimated in the step above is multiplied by the reduction factors summarized in Table A.2.

Table A.2 Infiltration Rate Reduction Factors to Account for Biofouling and Siltation Effects for Ponds (Massmann, 2003)

Potential for Biofouling	Degree of Long-Term Maintenance/Performance Monitoring	Infiltration Rate Reduction Factor, $CF_{silt/bio}$
Low	Average to High	0.9
Low	Low	0.6

High	Average to High	0.5
High	Low	0.2

The values in this table assume that final excavation of the facility to the finished grade is deferred until all disturbed areas in the upgradient drainage area have been stabilized or protected (e.g., construction runoff is not allowed into the facility after final excavation of the facility).

Ponds located in shady areas where moss and litterfall from adjacent vegetation can build up on the pond bottom and sides, the upgradient drainage area will remain in a disturbed condition long-term, and no pretreatment (e.g., pre-settling ponds, biofiltration swales, etc.) is provided, are one example of a situation with a high potential for biofouling.

A low degree of longterm maintenance includes, for example, situations where access to the facility for maintenance is very difficult or limited, or where there is minimal control of the party responsible for enforcing the required maintenance. A low degree of maintenance should be considered only when there is no other option.

Adjustment for Pond Aspect Ratio

Adjust the infiltration rate for the effect of pond aspect ratio by multiplying the infiltration rate determined above by the aspect ratio correction factor CF_{aspect} as shown in the following equation:

$$CF_{aspect} = 0.02A_r + 0.98 \qquad (6)$$

Where, A_r is the aspect ratio for the pond (length/width). In no case shall CF_{aspect} be greater than 1.4. The final infiltration rate will therefore be as follows:

$$f = K \times i \times CF_{aspect} \times CF_{silt/bio} \qquad (7)$$

The rates calculated based on Equation 7 are long-term design rates. No additional reduction factor or factor of safety is needed.

Appendix V-C – Maintenance Guidelines

This appendix provides facility-specific maintenance standards. The standards are intended to provide conditions for determining, through inspection, if maintenance actions are required. Failure to meet these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, the inspection and maintenance schedules must be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

Instructions for Use of Maintenance Checklists

The following pages contain maintenance tables for most of the BMPs included in Volume V. Where private developers, rather than Tumwater staff, are responsible for facility maintenance, they should plan to complete a checklist for all system components on the following schedule:

(M) Monthly from October through April.

Annually, once in late summer (preferably September)

(S) Storm-based, after any major storm (use 1 inch in 24 hours as a guideline).

The tables contained in this appendix may be used as checklists. Maintenance personnel may use photocopies of these pages and check off items inspected and problems noted during each inspection. Actions taken and corrective action recommended should also be noted.

Table C-4. Maintenance Checklist for Infiltration Basins (BMP IN.01), Infiltration Trenches (BMP IN.02), and Bioinfiltration Swale (BMP IN.03)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M,S	General		Trash and Debris buildup in pond	Dumping of yard wastes such as grass clippings and branches into basin. Unsightly accumulation of non-degradable materials such as glass, plastic, metal, foam, and coated paper.	Remove trash and debris and dispose as prescribed by Tumwater Department of Water and Waste Management.
M			Poisonous Vegetation	Any poisonous vegetation which may constitute a hazard to the public. Examples of poisonous vegetation include: tansy ragwort, poison oak, stinging nettles, devilsclub.	Remove poisonous vegetation. Do not spray chemicals on vegetation without obtaining guidance from the City.
M,S			Fire Hazard or Pollution	Presence of chemicals such as natural gas, oil, and gasoline, obnoxious color, odor, or sludge noted.	Find sources of pollution and eliminate them. Water is free from noticeable color, odor, or contamination.
M			Vegetation not growing or is overgrown	Grass cover is sparse and weedy or is overgrown. Plants are sparse or invasive species are present.	Selectively thatch, aerate, and reseed ponds. Grass cutting unnecessary unless dictated by aesthetics. Contact the Cooperative Extension Service for direction on invasive species such as purple loosestrife and reed canary grass. Pond bottoms shall have uniform dense coverage of desired plant species.
M			Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents destroyed and dam or berm repaired. Contact the Tumwater Public Health and Social Services Department for guidance.
M			Insects	When insects such as wasps and hornets interfere with maintenance activities, or when mosquitoes become a nuisance.	Insects destroyed or removed from site. Contact Cooperative Extension Service for guidance.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A	Storage Area		Sediment buildup in system	A soil texture test indicates facility is not working at its designed capabilities or was incorrectly designed.	Sediment is removed and/or facility is cleaned so that infiltration system works according to design. A sediment trapping area is installed to reduce sediment transport into infiltration area.
A			Storage area drains slowly (more than 48 hours) or overflows	A soil texture test indicates facility is not working at its designed capabilities or was incorrectly designed.	Additional volume is added through excavation to provide needed storage. Soil is aerated and rototilled to improve drainage. Contact the City for information on its requirements regarding excavation.
M			Sediment trapping area	Any sediment and debris filling area to 10 percent of depth from sump bottom to bottom of outlet pipe or obstructing flow into the connector pipe.	Clean out sump to design depth.
One time			Sediment trapping area not present	Stormwater enters infiltration area directly without treatment.	Add a trapping area by constructing a sump for settling of solids. Segregate settling area from rest of facility. Contact City for more guidance.
M	Rock filters		Sediment and debris	By visual inspection little or no water flows through filter during heavy rain storms.	Replace gravel in rock filter.

If you are unsure whether a problem exists, please contact Tumwater and ask for technical assistance.

Key:
A = Annual (March or April preferred)
M = Monthly (see schedule)
S = After major storms

Table C-13. Maintenance Checklist for Catch Basins and Inlets

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M,S	General		Trash and Debris	Trash, debris, and sediment in or on basin	No trash or debris located immediately in front of catch basin opening. Grate is kept clean and allows water to enter.
M				Sediment or debris (in the basin) that exceeds 1/3 the depth from the bottom of basin to invert of the lowest pipe into or out of the basin.	No sediment or debris in the catch basin. Catch basin is dug out and clean.
M,S				Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
M			Structural Damage to Frame and/or Top Slab	Corner of frame extends more than 3/4 inch past curb face into the street (if applicable).	Frame is even with curb.
M				Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
M				Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached.	Frame is sitting flush on the riser rings or top slab and firmly attached.
A			Cracks in Basin Walls/ Bottom	Cracks wider than 1/2 inch and longer than 3 feet, any evidence of soil particles entering catch basin through cracks, or maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards. Contact a professional engineer for evaluation.
A				Cracks wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	No cracks more than 1/4 inch wide at the joint of inlet/outlet pipe.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A			Settlement/ Misalignment	Basin has settled more than 1 inch or has rotated more than 2 inches out of alignment.	Basin replaced or repaired to design standards. Contact a professional engineer for evaluation.
M			Vegetation	Vegetation growing across and blocking more than 10 percent of the basin opening.	No vegetation blocking opening to basin.
M			Vegetation	Vegetation growing in inlet/outlet pipe joints that is more than 6 inches tall and less than 6 inches apart.	No vegetation or root growth present.

If you are unsure whether a problem exists, please contact Tumwater and ask for technical assistance.

Key:
A = Annual (March or April preferred)
M = Monthly (see schedule)
S = After major storms

Table C-14. Maintenance Checklist for Energy Dissipators

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A	Rock pad		Missing or moved rock	Only one layer of rock exists above native soil in area 5 square feet or larger, or any exposure of native soil.	Replace rocks to design standard.
A	Rock-filled trench for discharge from pond		Missing or moved rock	Trench is not full of rock.	Add large rock (~30 lbs each) so that rock is visible above edge of trench.
M	Dispersion trench		Pipe plugged with sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed.
M			Perforations plugged	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Clean or replace perforated pipe.
M,S			Not discharging water properly	Visual evidence of water discharging at concentrated points along trench (under normal conditions, there should be a "sheet flow" of water along trench.) Intent is to prevent erosion damage.	Trench must be rebuilt or redesigned to standards. Pipe is provably plugged or damaged and needs replacement.
M,S			Water flows out top of "distributor" catch basin	Maintenance person observes water flowing out during any storm less than the design storm or it is causing or appears likely to cause damage.	Facility must be rebuilt or redesigned to standards. Pipe is probably plugged or damaged and needs replacement.
M,S			Receiving area over-saturated	Water in receiving area is causing or has potential of causing landslide.	Stabilize slope with grass or other vegetation, or rock if condition is severe.

If you are unsure whether a problem exists, please contact Tumwater and ask for technical assistance.

Key:
A = Annual (March or April preferred)
M = Monthly (see schedule)
S = After major storms