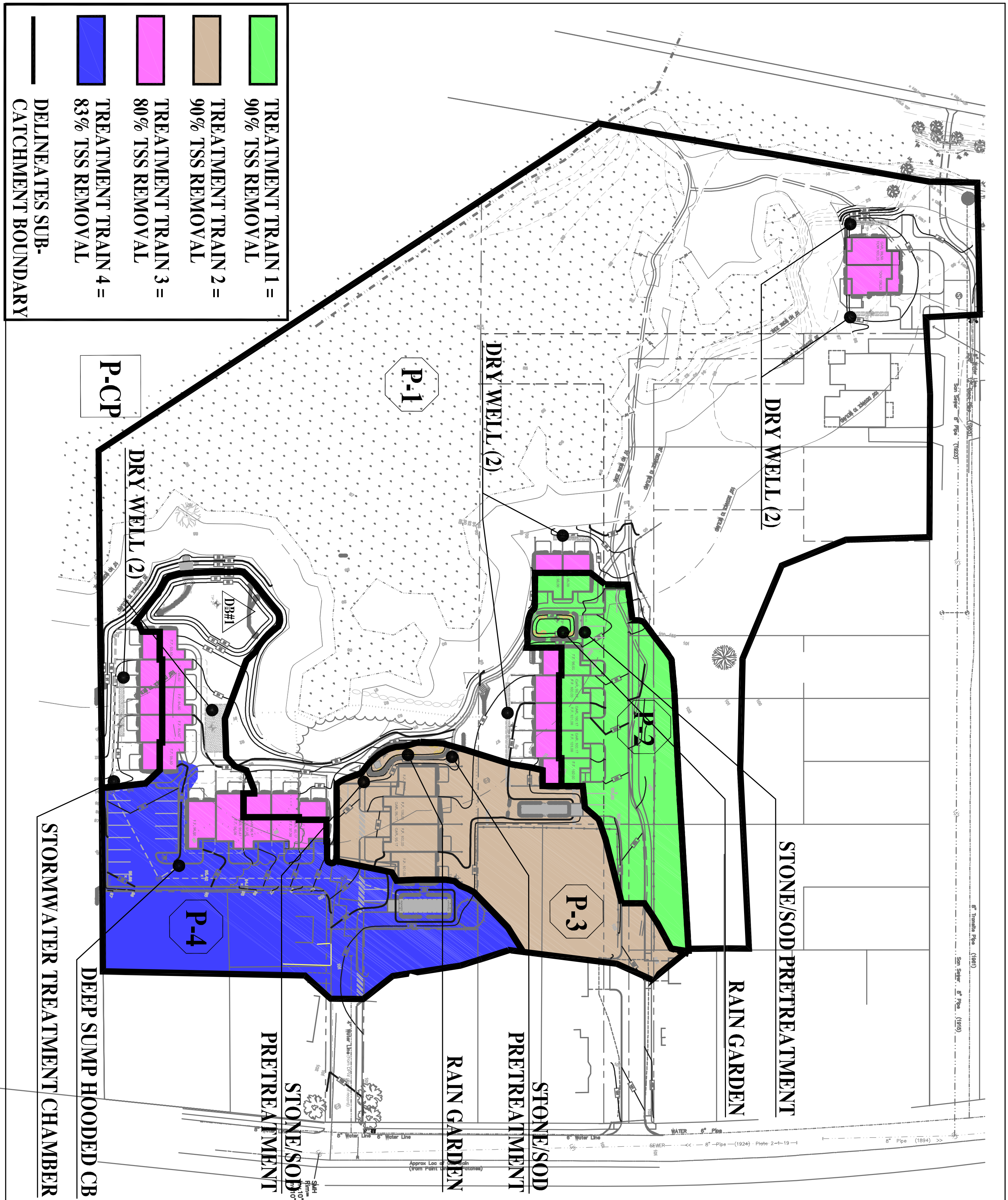
Appendix C – TSS Removal Summary



The Berkshire Design Group, Inc.
4 Allen Place Northampton, Massachusetts 01060
(413) 582-7000 • FAX (413) 582-7005

Figure Title:

Treatment Chain Area Map

North Street Condominiums

NORTHAMPTON MASSACHUSETTS

Reference:

Date: 04/14/09

Scale: 1"=100'

Appendix

C

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: Treatment Train 1 for P-2

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Rain Garden	**0.90**	**1.00**	**0.90**	**0.10**
	0.00	**0.10**	**0.00**	**0.10**
	0.00	**0.10**	**0.00**	**0.10**
	0.00	**0.10**	**0.00**	**0.10**
	0.00	**0.10**	**0.00**	**0.10**

Total TSS Removal = **90%**

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: **North Street Condominiums, Northampton, MA**
Prepared By: **Brian Darnold**
Date: **4/13/2009**

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

Mass. Dept. of Environmental Protection

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: Treatment Train 2 for P-3

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Rain Garden	0.90	1.00	0.90	0.10
	0.00	0.10	0.00	0.10
	0.00	0.10	0.00	0.10
	0.00	0.10	0.00	0.10
	0.00	0.10	0.00	0.10

Total TSS Removal = **90%**

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: **North Street Condominiums, Northampton, MA**
Prepared By: **Brian Darnold**
Date: **4/13/2009**

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

Mass. Dept. of Environmental Protection

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: Treatment Train 3 for P-1 and P-4 Roof Areas

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Dry Well	0.80	1.00	0.80	0.20
	0.00	0.20	0.00	0.20
	0.00	0.20	0.00	0.20
	0.00	0.20	0.00	0.20
	0.00	0.20	0.00	0.20

Total TSS Removal = 80%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: North Street Condominiums, Northampton, MA
Prepared By: Brian Darnold
Date: 4/13/2009

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

Mass. Dept. of Environmental Protection

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: Treatment Train 4 for P-4 Paved Areas

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**0.25**	**1.00**	**0.25**	**0.75**
Proprietary Treatment Practice	**0.77**	**0.75**	**0.58**	**0.17**
	0.00	**0.17**	**0.00**	**0.17**
	0.00	**0.17**	**0.00**	**0.17**
	0.00	**0.17**	**0.00**	**0.17**

Total TSS Removal = 83%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: **North Street Condominiums, Northampton, MA**
Prepared By: **Brian Darnold**
Date: **4/13/2009**

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

Mass. Dept. of Environmental Protection

The Berkshire Design Group, Inc.
4 Allen Place
Northampton, Massachusetts 01060

Landscape Architecture
Civil Engineering
Planning
Urban Design
Environmental Services

JOB North Street Condominiums
SHEET NUMBER 1 OF 2
CALCULATED BY BCD DATE 4/13/09
CHECKED BY ______ DATE ______
SCALE

Standard 4: Water Quality

System Sizing

R_{wqv} = Required water quality volume = $D_{wq} * A_{imp}$

$D_{wq} = 0.5in$ (Noncritical Area, land is not LUHPPL, no rapid infiltration rate)

Rain Garden 1: Impervious area to system = 11,109 sf

$R_{wqv} = (0.5in)(\frac{1'}{12''})(11{,}109 sf) = 463 cf$

Rain Garden volume = 706 cf* ✓ OKAY

*See Rain Garden 1 node on HydroCAD attachment @ Storage elevation 97.40' for volume calculation

Rain Garden 2: Impervious area to system = 6,722 sf

$R_{wqv} = (0.5in)(\frac{1'}{12''})(6{,}722 sf) = 280 cf$

Volume provided = 317 cf* ✓ OKAY

* See Rain Garden 2 node on HydroCAD attachment @ Storage elevation 97.60' for volume calculation

Dry Well 1: Imp Area = 660 sf

$R_{wqv} = (0.5in)(\frac{1'}{12''})(660 sf) = 28 cf$

Volume provided = 34 cf ✓ OKAY

Dry Well 2: Imp Area = 1935 sf

$R_{wqv} = (0.5in)(\frac{1'}{12''})(1935 sf) = 81 cf$

Volume provided = 98 cf ✓ OKAY

Dry Well 3: Imp area = 6173 sf

$R_{wqv} = (0.5in)(\frac{1'}{12''})(6173 sf) = 257 cf$

Volume provided = 258 cf ✓ OKAY

The Berkshire Design Group, Inc.
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Northampton, Massachusetts 01060

Landscape Architecture
Civil Engineering
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JOB North Street Condominiums
SHEET NUMBER 2 OF 2
CALCULATED BY BCD DATE 4/13/09
CHECKED BY ______ DATE ______
SCALE

Dry Well 4: Imp Area = 1833sf
Rwqv = (0.5in)(1'/12in)(1833 sf) = 76 cf
Volume provided = 81 cf ✓ OKAY

Dry Well 5 Imp Area = 815sF
Rwqv = (0.5in)(1'/12in)(815sf) = 34 cf
Volume provided = 40 cF ✓ OKAY

Dry Well 6 Imp Area = 960 sf
Rwqv = (0.5in)(1'/12in)(960sf) = 40 cf
Volume provided = 40 cf ✓ OKAY

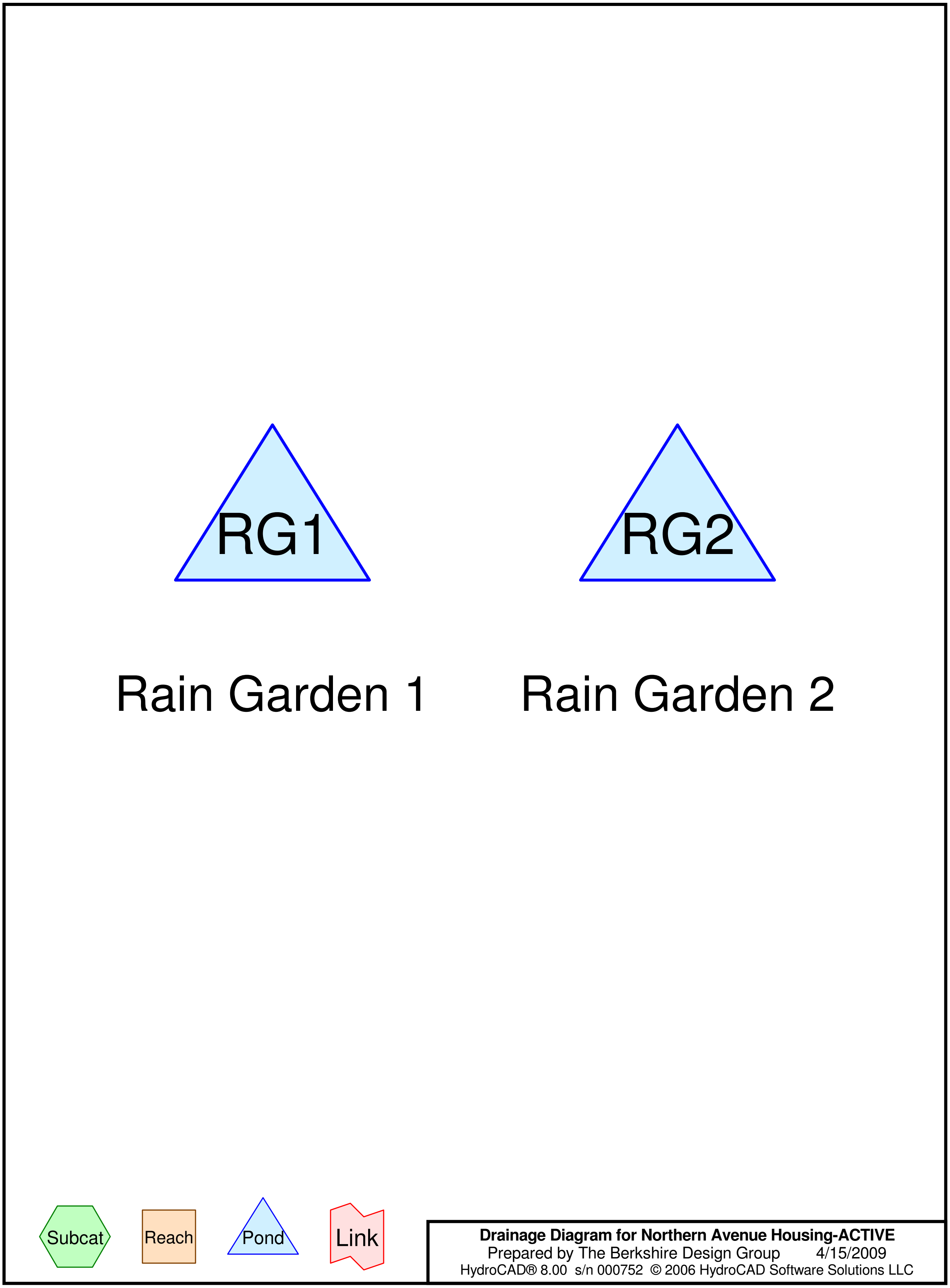
Dry well volume = 1ft (Typ. Depth) * Footprint (sf) (Area) * 0.40 (Void Ratio)

Site Net TSS Removal

Treatment chain 1 (Rain Garden 1) = 90% TSS Removal
Impervious Area = 11,109 sF
Treatment chain 2 (Rain Garden 2) = 90% TSS Removal
Impervious Area = 6,722 sf
Treatment chain 3 (6 Dry Wells) = 80% TSS Removal
Impervious (Roof) area = 12,376 sF
Treatment chain 4 (Deep sump Hooded CB + SWTC) = 83%
Impervious area = 12,540 sf
Total New impervious area = 45,440 sf

Net TSS Removed = $\frac{(11{,}109 * 0.90)_{TC1} + (6{,}722 sf * 0.90)_{TC2} + (12{,}376 sf * 0.80)_{TC3} + (12540 sf * 0.83)_{TC4}}{45{,}440 sf}$

= 0.80 ≥ 80% TSS Removed ✓ OKAY



Drainage Diagram for Northern Avenue Housing-ACTIVE
Prepared by The Berkshire Design Group 4/15/2009

Area Listing (selected nodes)

Area (acres)	CN	Description (subcats)
0.000		

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Pond RG1: Rain Garden 1 Peak Elev=0.00' Storage=0 cf
Primary=0.00 cfs 0.000 af

Pond RG2: Rain Garden 2 Peak Elev=0.00' Storage=0 cf
Primary=0.00 cfs 0.000 af

Pond RG1: Rain Garden 1

[43] Hint: Has no inflow (Outflow=Zero)

Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 0.00' @ 0.00 hrs Surf.Area= 0 sf Storage= 0 cf

Plug-Flow detention time= (not calculated)
Center-of-Mass det. time= (not calculated)

Volume	Invert	Avail.Storage	Storage Description
#1	95.85'	851 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
95.85	175	0	0
96.00	301	36	36
97.00	555	428	464
97.40	655	242	706
97.60	800	146	851

Device	Routing	Invert	Outlet Devices
#1	Primary	97.40'	**6.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' (Free Discharge)
└—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond RG2: Rain Garden 2

[43] Hint: Has no inflow (Outflow=Zero)

Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 0.00' @ 0.00 hrs Surf.Area= 0 sf Storage= 0 cf

Plug-Flow detention time= (not calculated)
Center-of-Mass det. time= (not calculated)

Volume	Invert	Avail.Storage	Storage Description
#1	97.10'	566 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
97.10	477	0	0
97.60	790	317	317
97.85	1,200	249	566

Device	Routing	Invert	Outlet Devices
#1	Primary	97.60'	**6.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Fact Sheet #4

Stormwater Technology: Stormceptor

(Hydro Conduit, formerly CSR New England Pipe)

Revised February 2003

*The **Stormceptor Fact Sheet** is one in a series of fact sheets for stormwater technologies and related performance evaluations, which are undertaken by the **Massachusetts STrategic Envirotechnology Partnership (STEP).***

A summary of the STEP evaluation entitled, *Technology Assessment, Stormceptor CSR New England Pipe*, January 1998 is provided in this fact sheet. When a more thorough understanding of a system is required, the full *Technology Assessment* should be reviewed. Copies are available for downloading from the STEP Web site (www.stepsite.org/progress/reports) or by contacting the STEP Program (Phone: 617/626/1197, FAX: 617/626/1180, email: linda.benevides@state.ma.us). The information in this fact sheet is subject to future updates as additional performance information becomes available.

Description/Definition

Stormceptor is a prefabricated, underground unit that separates oils, grease, and sediment from stormwater runoff when installed with an existing or new pipe conveyance system. The unit is divided into two chambers–a treatment and a flow bypass chamber. During typical storm events, runoff is directed by the inflow weir through a drop pipe into the lower treatment chamber where sediment, oil, and grease are separated from the flow by gravity. The bypass chamber is designed to convey excess stormwater, which overtops the inflow weir, through the system without treatment.

Equipment and Sizing

The on-line Stormceptor units are available in eight sizes ranging from six and twelve feet in diameter with capacities of 900 to 7200 gallons. Since issuing the STEP assessment in 1998, the manufacturer has expanded the Stormceptor product line to include a storm drain inlet (STC 450i) and three units (Models STC 11000, STC 13000, and STC16000). These systems are not included in the STEP evaluation. Users and decision-makers may require additional field test results and new data for these new systems in order to accept performance ratings, particularly if they are higher than those reported in the STEP technology assessment and this fact sheet.

Stormceptor units are available in either precast concrete or fiberglass for special applications. Concrete units are pre-engineered for HS-20 min. traffic loading at the surface. Fiberglass units can be used in areas where there is a potential for oil and chemical spills.

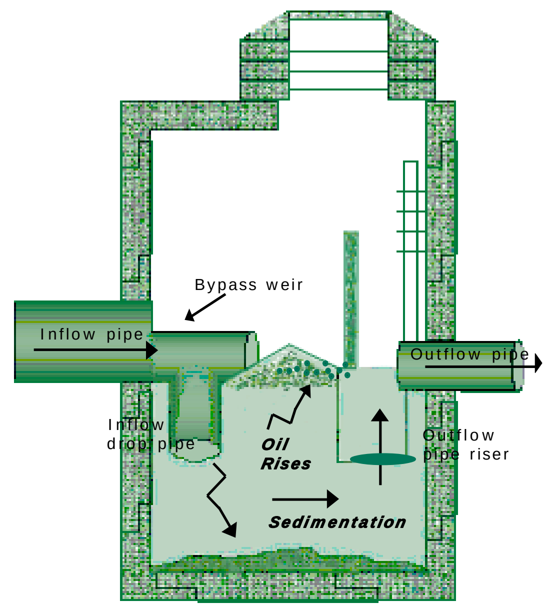


Figure 1. Stormceptor operation during average flow conditions.

Performance/Effectiveness

The system is designed to provide separation of sediment, oil, and grease from stormwater by routing runoff into a low-turbulence environment where solids settle and oils float out of solution. The system sizing is based on the drainage area, historical rainfall data, and the solids removal efficiency required. It is recommended that the system be used in combination with other stormwater controls to conform with the Massachusetts Stormwater Management Policy and standards.

An Imperial Model STC 2000 (equivalent to the Model STC 2400) in Edmonton, Canada treats flow from a 9.8 acre commercial parking lot. This system was monitored during four storm events in 1996 and shown to have an average total suspended solids (TSS) removal efficiency of 52 percent. In designing a system to achieve a comparable removal efficiency, the relationship between system size and impervious drainage area should be considered, as detailed in Table 1 and the Technology Assessment Report.

A Model STC 1200 in Westwood, Massachusetts treats flow from 0.65 acres consisting of a paved truck loading area at a manufacturing facility. The unit was monitored for six storm events in 1997, but only four events had measurable TSS influent concentrations. Of these four events, the average TSS removal efficiency was calculated to be 77 percent, which is less than the 80 percent removal targeted by the manufacturer.

Based on these field monitoring results, and when the unit sizing follows the guidance in Table 1, removal efficiencies between 52 percent and 77 percent may be achieved where installations have similar rainfall and land use characteristics as those reviewed for the STEP evaluation. It is recommended that additional field research and new data be evaluated to validate performance ratings higher than those verified by STEP.

Stormceptor Model Number	Maximum Impervious Area (acre	
	77% TSS removal	52% TSS remo
STC 900	0.45	0.9
STC 1200	0.7	1.45
STC 1800	1.25	2.55
STC 2400	1.65	3.35
STC 3600	2.6	5.3
STC 4800	3.6	7.25
STC 6000	4.6	9.25
STC 7200	5.55	11.25

Table 1: Adapted from the Stormceptor sizing for TSS removal in the STEP Technology Assessment. Notes: 1) On some sites, the maximum impervious area may need to be reduced to achieve these TSS removal rates. 2) The terms "critical area sizing" (to achieve 77 percent TSS removal) and "treatment train sizing" (for 52 percent removal) are no longer used by the manufacturer, but unit sizing is still applicable.

Specific performance claims for oil and grease were not evaluated by STEP. However, total petroleum hydrocarbons (TPH) were analyzed during the Westwood study. Results indicated that the unit was effective in capturing oils.

Technology Status

The Stormceptor system provides greater solids separation and higher TSS removal efficiencies than oil and grit separators. Stormceptor systems are among the category of hydrodynamic separators, which are flow-through devices with the capacity to settle or separate grit, oil, sediment, or other pollutants from stormwater. According to the U.S. Environmental Protection Agency, "Hydrodynamic separators are most effective where the materials to be removed from runoff are heavy particulates - which can be settled - or floatables - which can be captured, rather than solids with poor settleability or dissolved pollutants."

Although Stormceptor appears to remove sediment, grit, oil, and grease as claimed by the manufacturer, additional research is needed to determine how much sediment moves through the system untreated. The field studies evaluated for the STEP assessment predate the Stormwater Best Management Practice Demonstration Tier II Protocol (2001), which is applicable in Massachusetts and other states in the Technology Acceptance Reciprocity Partnership (TARP), to ensure quality controlled studies that can be shared among participating states. Therefore, interstate reciprocity is not available to the manufacturer, based on performance claims that were evaluated by STEP in 1998. If the TARP Protocol requirements are fulfilled in the future, the manufacturer could pursue reciprocal verification for Stormceptor systems in participating TARP states. More information on the TARP Protocol is available on the following Web site: www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp.

Applications/Advantages

- Stormceptor systems identified in Table 1 should be used in combination with other BMPs to remove 80 percent of the average annual load of TSS (DEP Stormwater Policy Standard 4). Systems may be well suited for pretreatment in a mixed component system designed for stormwater recharge.
- Performance data show that Stormceptor may provide TSS removal rates in the range of 52 percent to 77 percent when sized according to Table 1. Higher TSS removal rates were achieved during low flow, low intensity storms with less than one third of an inch of runoff. Also, by reducing the impervious drainage area,

relative to the system size, the STEP Technology Assessment Report indicated that higher removal efficiencies may be achievable. However, STEP recommends collection of additional data "representing a varied set of operating conditions over a realistic maintenance cycle to verify TSS removal rates greater than 80 percent."

- The Stormceptor system is suitable for new and retrofit applications. For retrofit applications, it should not take the place of a catch basin for the systems that have been verified. Also, for retrofit applications, it should be installed in lateral lines and not main trunk lines.
- The system is particularly well suited in constricted areas and where space is limited.
- It also is suitable for use in areas of high potential pollutant loads (DEP Stormwater Policy Standard 5), where it may be used effectively in capturing and containing oil and chemical spills. *Web site:* www.state.ma.us/dep/brp/stormwtr/stormpub.htm.

Considerations/Limitations

- Systems are not expected to provide significant nutrient (nitrogen and phosphorus) or fecal coliform removal.
- The systems are not recommended for use in critical areas, such as public drinking water supplies, certified vernal pools, public swimming beaches, shellfish growing areas, cold water fisheries, and some Areas of Critical Environmental Concern (ACECs), except as a pretreatment device for BMPs that have been approved by DEP for use in critical areas. The structural BMPs approved for use in critical areas are described in Standard 6 of the Stormwater Management Policy, www.state.ma.us/dep/brp/stormwtr/stormpub.htm.
- There is a limited set of useful data for predicting the relationship between treatment efficiency and loading rates. Removal efficiencies have not been demonstrated for all unit sizes.
- Further research is needed to determine how much TSS bypasses the treatment chamber during certain, higher velocity storm events which recur less frequently.
- Systems require regular maintenance to minimize the potential for washout of the accumulated sediments.

Reliability/Maintenance

All BMPs require scheduled, routine maintenance to ensure that they operate as efficiently as possible. Although maintenance requirements are site specific, a general relationship between cleaning needs and depths of sediment has been established by the manufacturer. Inspection of the Stormceptor interior should be done after major storm events, particularly in the first year of operation. It is recommended that material in the treatment chamber be pumped out by a vacuum truck semiannually, or when the sediment and pollutant loads reach about 15 percent of the total storage. If the unit is used for spill containment, it should be pumped after the event is contained. Typical cleaning costs were estimated by the manufacturer in 1998 to be $250, with disposal costs averaging $300 to $500. The expected life of a system has been estimated to be 50 to 100 years.

Sediment Depths Indicating Required Maintenan	
Model Number	Sediment Depth (feet)
STC 900	0.5
STC 1200	0.75
STC 1800	1
STC 2400	1
STC 3600	1.25
STC 4800	1
STC 6000	1.5
STC 7200	1.25

Table 2: The Stormceptor system clean out is based on 15 percent of the sediment storage volume in the unit.

References

Winkler, E.S. 1998. "Technology Assessment, Stormceptor." University of Massachusetts, Amherst, MA.
STEP Web site: www.stepsite.org/progress/reports

Massachusetts Department of Environmental Protection and Office of Coastal Zone Management. 1997. "Stormwater Management Handbooks, Volumes One and Two." Boston, MA. *Handbooks Web site:* www.state.ma.us/dep/brp/stormwtr/stormpub.htm.

"Performance of a Proprietary Stormwater Treatment Device: The Stormceptor. The Practice of Watershed Protection: Article 120. Thomas. R. Schueler and Heather K. Holland editors. 2000. Ellicott City, MD.

United States Environmental Protection Agency. "Storm Water Technology Fact Sheet Hydrodynamic Separators." EPA 832-F-99-017.

Stormceptor Web sites: www.rinkermaterials.com/stormceptor

TARP Web site: www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp.