DEPARTMENT OF ENERGY & ENVIRONMENT

Carter Barron LID Retrofits

30 percent Design Report, August 2017

Carter Barron Amphitheater & Rock Creek Tennis Center, District of Columbia

Contract Number CW49533

Government of the District of Columbia
Department of Energy of Environment
Watershed Protection Division
1200 First Street, NE 5th Floor
Washington, DC 20002

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1 INTRODUCTION

The thirty (30)-acre Project Area is located in northern Washington, D.C. adjacent to the 16th Street Heights neighborhood. The Rock Creek Park Tennis Center sits at the headwaters of the Blagden Run watershed, a subwatershed of Rock Creek (Figure 1).

The Project Area was identified as a priority restoration area by FWS and NPS due to its impact on a portion of the three (3)-mile area where the known endemic population of *Stygobromus hayi* ("Hay's Spring amphipods") is found. During rain events, stormwater swiftly leaves the Project Area from five outfalls and is believed to compromise the endangered Hay's Spring amphipod population by washing the amphipod from its habitat, eroding the headwater spring areas where the amphipod is endemic, and lowering the groundwater table, which reduces habitat available for the species.

Four distinct gullies have been created by stormwater from outfalls draining the Project Area. Stormwater also leaves the Project Area through overland flow and a storm sewer that drains directly to Blagden Run. The targeted eleven (11)-acre impervious area has no stormwater controls because it was developed prior to the promulgation of the District's stormwater regulations.

The goal of the Project is to fully retrofit the targeted eleven (11)-acre impervious area with green infrastructure to restore natural hydrology, prevent erosion, reduce stormwater pollution and protect natural habitat for the federally listed endangered Hay's Spring amphipod.

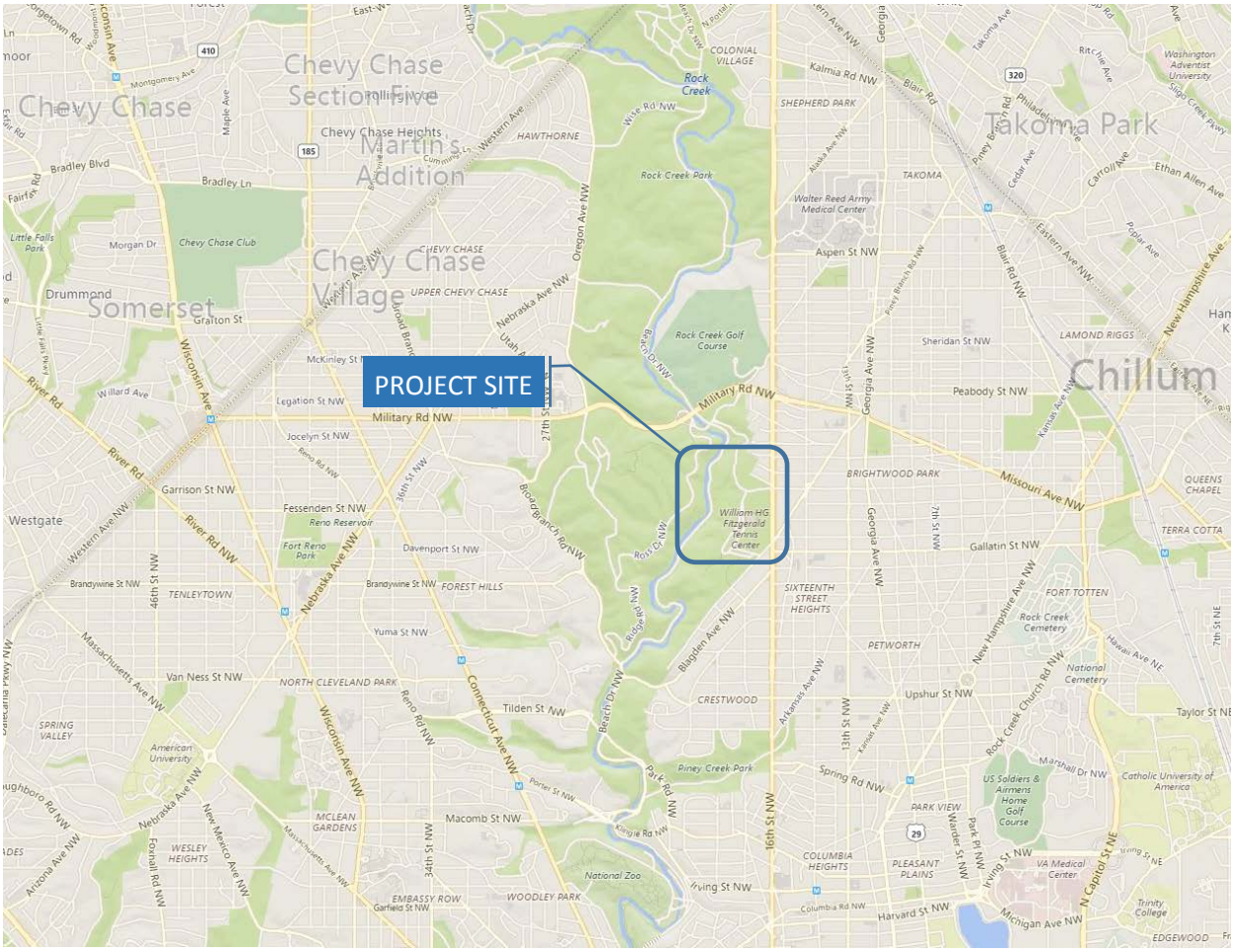


Figure 1: Project study area

2 EXISTING CONDITIONS AND DATA COLLECTION

Biohabitats assessed the existing conditions at the Rock Creek Tennis Center through a desktop review of available GIS data record drawings and multiple site visits. An existing conditions survey is currently in progress and will be completed prior to submission of a 60% design submittal.

2.1 GIS Data

Biohabitats compiled a base map of the existing conditions from available GIS data (LiDAR, Property Lines, impervious surface layers, etc.) to inform the 30% design submittals. Until a topographic survey is complete, a combination of GIS data and record drawings provides the best available data for design purposes. As needed for design purposes, specific components have been visually verified to ensure consistency of information (i.e. wet weather flow patterns across the parking lot).

2.2 Record Drawings

NPS provided Biohabitats with as-built plans for the parking lot and event layout drawings for the Citi Open Professional Tennis Tournament for review and consideration in developing the proposed 30% design submission. The record as-built plans identified for the project are listed below.

- Rock Creek Park Plans for Proposed Project PRA-ROCR 18(1): Reconstruction and Resurfacing of Parking Areas and Roadways serving the Carter Barron Amphiteater and the Tennis Pavillion and Stadium, Washington D.C. NPS No. 821/41918/

2.3 Topographic and Tree Survey

A topographic and tree survey of the project area is currently in progress and will be completed prior to the 60% submittal.

2.4 Soils

Biohabitats utilized the United States Department of Agricultures (USDA) Natural Resources Conservation Service's (NRCS) Web Soil Survey to perform a preliminary analysis of the existing on-site soils. Pending additional soil testing and the topographic survey, Biohabitats will also utilize the Web Soil Survey results to inform a more detailed hydrologic assessment. Table 1 below provides a list of the soils present at the site. A full printout of the Web Soil Survey has been attached in Appendix A.

Soil borings and Infiltration testing will be performed following the 30% design submittal.

Table 1: USDA NRCS Web Soil Survey Results

Map Unit Symbol	Map Unit Name
BdB	Beltsville silt loam, 0 to 8 percent slopes
CcB	Chillum silt loam, 0 to 8 percent slopes
CcC	Chillum silt loam, 8 to 15 percent slopes
CdB	Chillum-Urban land complex, 0 to 8 percent slopes
GgB	Glenelg loam, 0 to 8 percent slopes
GgC	Glenelg loam, 8 to 15 percent slopes
GgD	Glenelg loam, 15 to 25 percent slopes
KmB	Keyport-Urban land complex, 0 to 8 percent slopes
MbD	Manor loam, 15 to 40 percent slopes
ScC	Sassafras gravelly sandy loam, 8 to 15 percent slopes
Ub	Urban land

2.5 Site Visits

2.5.1 Project Kick-off (4/10/2017)

Staff from the District of Columbia's Department of Energy and Environment (DOEE), U.S. National Park Service (NPS), and Biohabitats (Bio) met on April 10th, 2017 at the project site to kick-off the design-build contract for the Carter Barron LID Retrofits project. The attendees walked the site, discussing the original concept drawing produced by Biohabitats, design concerns, and possible alternatives.

2.5.2 DOEE Wet Weather Site Visit (5/11/2017)

On May 11th, 2017 staff from DOEE (Steve Saari) conducted a site visit during a rain event in order to review the existing drainage patterns at the site. During the site visit, Mr. Saari captured numerous site photos (See Appendix C, photos C-5 to C-8 for sample photos) and took detailed field notes on the existing drainage patterns (See Appendix A).

3 HYDROLOGY and SWRv Computations

During the design process, Biohabitats delineated the drainage areas to each proposed BMP to calculate the required Stormwater Retention Volume (SWRv). Following the 30% submittal, Biohabitats will conduct a detailed Hydrologic Analysis of these drainage areas including the peak flow rates for the 15-year rainfall event (Q_{15}) as necessary to determine adequate sizing of BMP inlet and outlet structures.

3.1 SWRv

The required stormwater retention volumes (SWRv) for the project site were calculated following the methodology described in the DOEE Stormwater Management Guidebook (July 2013). Based on the project location, the proposed retrofit project has targeted a 1.2-inch rainfall event when calculating the SWRv for the site using Equation 2.1 from the guidebook.

The project site was split into thirteen contributing drainage areas (CDA) based on the possible locations of proposed BMPs. Table 2 below presents the breakout of drainage area characteristics and the Targeted SWRv for each CDA. Detailed calculations for the targeted SWRvs have been provided within Appendix B.

Table 2: SWRv Calculations

CDA ID	Contributing Drainage Area (CDA)				P	Stormwater Retention Volume (SWRv)
	Paved SF	Compacted SF	Natural SF	Total SF	IN	CF
1-1	24,700			24,700	1.2	2,347
1-2	13,160	7,025		20,185	1.2	1,426
1-3	59,560			59,560	1.2	5,658
1-4	78,520			78,520	1.2	7,459
1-5	65,140	20,275	170,565	255,980	1.2	6,695
1-6	18,380			18,380	1.2	1,746
1-7	16,970		13,490	30,460	1.2	1,612
1-8	9,530		2,140	11,670	1.2	905
2-1	22,780		35,200	57,980	1.2	2,164
3-1	10,360		32,840	43,200	1.2	984
4-1	6,060		5,560	11,620	1.2	576
5-1	10,920		19,270	30,190	1.2	1,037
6-1	4,310	2,420	4,780	11,510	1.2	470

4 PROPOSED DESIGN

The proposed design aims to meet the project goals through the installation of bioretention basins, sand seepage berms, riffle grade control structures and post and wattle structures. Additionally, the proposed design recommends utilizing a subsoiler to reduce soil compaction and improve infiltration within existing fields.

4.1 Bioretention

Bioretention Basins were located within numerous site locations based on their stormwater treatment and aesthetic values, versatility, and adaptability to site constraints. Due to the lack of infiltration testing results, Biohabitats has assumed that all bioretention features are considered to be “enhanced with an underdrain” design, as defined within the DOEE Stormwater Management Guidebook.

In addition to the standard bioretention design, Biohabitats has incorporated a shallow ponding shelf within multiple Bioretention areas. The intent of the ponding shelf is to allow a smaller footprint for the bioretention media by providing a large, shallow area that will be accessed by ponding during larger storm events. Because the ponding shelf is not intended to take credit for infiltration that may occur within its area, it can be sodded and receive heavy foot traffic. This has the added benefit of allowing park visitors and activities to utilize the ponding shelf area, outside of larger storm events.

4.2 Sand Seepage Berms

In the design plans, berms are graded perpendicular to concentrated flows to hold diverted storm flows in the adjacent floodplain. The berms are constructed of clean sand and wood chips to act as a filter bed. Berm dimensions are typically 1 foot in height with variable top widths, gradual side slopes (i.e. 10:1) and 6-inch sand lift of variable length. The wide top widths and gradual side slopes make the berms conducive to pedestrian traffic, where applicable. Following the topographic and tree surveys, placement of berms will be determined based on minimizing impacts to trees and pedestrian areas.

The berms are able to pond storm flows directed from the parking lots and to hold these diverted waters. This forces the water to take a longer flowpath, as well as create temporary ponding, infiltration,

transpiration, and seepage. In this manner, the berms will attenuate storm flows, increase time of concentration, and increase subsurface flows of the site by restoring the shallow groundwater table.

4.3 Riffle Grade Control Structures

Riffle Grade Controls consist of a series of riffles and/or cascades and shallow aquatic pools and native vegetation that safely attenuates and conveys storm flow, and converts stormwater to groundwater through infiltration and shallow groundwater seepage. The riffle grade controls may be constructed of logs and/or cobbles and may include a sand seepage layer to increase stormwater treatment. Selection of construction materials and inclusion of a sand seepage layer will be determined following topographic and tree surveys.

Sand Seepage Layer

Starting at a location of concentrated stormwater, the structures set water surface elevations at each pool and establish the hydraulic head necessary to drive the sand seepage system and support the vegetation. If utilized, the sand seepage bed is constructed by filling the existing eroded stream channel with clean sand and hardwood chips to function as a filtering bed. Structures (riffles or boulder cascades) provide grade control for the stable conveyance of storm flows.

These systems are effective at flow attenuation and can be designed to reduce runoff to mimic predevelopment, wooded condition in some situations, converting all surface flow inputs into shallow groundwater flows that discharge as seeps to the receiving stream or wetland. A full range of typical stormwater management criteria, including: groundwater recharge, volume reduction, water quality, channel protection, and flood control can be achieved by the systems, yet are also designed to be stable enough to convey flows associated with events up to and including the extreme floods (i.e. 100-year storm) in a non-erosive manner, which results in reduced channel erosion impacts commonly associated with stormwater practice outfalls and receiving waters. Because of the integration of vegetation and rock structures, the system is mostly self-maintaining. The expected benefits would include storm water quality and quantity control over a range of storm flows, enhanced habitat, and enhanced aesthetic appeal.

As of this concept submission, stormwater treatment has not be determined for proposed riffle grade control structures.

4.4 Post and Wattle Structures

Within the forested areas west of the parking lot, eroded gully's have begun to form due to concentrated flows originating at storm drain outfalls. The proposed restoration design calls for a low impact approach to minimize impacts to existing riparian forests and the groundwater seeps that are habitat for the federally endangered Hay's Spring Amphipod. Within these gullies a series of post and wattle structures will be placed to slow concentrated flows and spread the flow out of the eroded channels, promoting additional shallow subsurface interactions to benefit the Hay's Spring Amphipod habitat. The post and wattle structures consist of 2 rows of a series of approximately 7-foot-long 3" diameter wooden posts that are driven into the stream bed. Branches are woven in-between the posts to provide a matrix of material for trapping sediment and debris. In between the two rows of posts, branches will be placed. The specific locations of the post and wattle structures will determined when field topographic survey is completed.

4.5 Subsoiler

Soils in green spaces with heavy pedestrian and/or traffic, such as ball fields and overflow parking areas, can become deeply compacted over time. This compaction of green spaces results in reduced rainwater absorption and infiltration capacities and reduced the health of surrounding vegetation (eg. grass, shrubs, trees, etc.). Typical aeration practices intended to reduce compaction and restore the soil's hydraulic

characteristics only penetrate a few inches into the topsoil and do not address the compaction of soil layers that typically develop 12-22 inches below the surface.

The proposed application of a subsoiler to "fracture" these compacted layers that develop within the 12-22 inches below the surface have been found to dramatically increase the hydraulic characteristics (soil moisture, infiltration capacity, etc.) of the open green spaces. A recent study on the benefits of subsoiler application (Schwartz, 2016) estimated that the use of subsoiling reduced the Effective Curve Number (ECN) and Runoff Coefficient (Rv) of an urban athletic field from 87.4 and 0.52 to 43.7 and 0.016 respectively. A conversion of this magnitude in ECN and Rv values was determined to relate closest to the forested condition for pollutant loading rates, as identified in the Chesapeake Bay Watershed Model (v5.3.0), and therefore used as the post subsoiling rates.

Additionally, under the DOEE Stormwater Management Guidebook, these green spaces area considered “compacted” drainage areas. Based on this categorization, the total area of each athletic field is given a runoff coefficient of 0.25 and thus an equivalent required SWRv of 8,145 gallons per acre of athletic field. The runoff coefficient of 0.25 accounts for the compaction levels within these areas that greatly reduce the initial abstraction and infiltration of rainfall prior to developing runoff from the site. In comparison, “natural” areas are given a runoff coefficient value of 0.00 when calculating the required SWRv. Based on these definitions, conversion of athletic fields to a “natural” soil and rainfall capture capacity could yield an equivalent SWRv treated of 8,145 gallons per acre.

Pollutant Removals for the subsoiler are calculated by comparing the existing conditions nutrient loading rates for the athletic fields with the post-subsoiler application nutrient loading rates, assumed to have the hydrologic characteristics of a forested condition.

4.6 Stormwater Treatment

Biohabitats has calculated stormwater treatment (Retention Value and Pollutant Removals) for the bioretention basins, sand seepage berms, and subsoiler applications. Pending the topographic survey, Biohabitats may also present treatment credits for the riffle grade control structures. Table 3 below provides a summary of the treatment calculations, while Appendix B includes full calculations for the proposed BMPs. Table 3 presents of summary of the treatment credits.

4.6.1 Retention Value

Biohabitats calculated retention values for the bioretention basins and sand seepage berms based on the storage volumes provided within the ponding areas and media for each structure. Bioretention Basins were assumed to be “enhanced with an underdrain” until soil testing can be completed. For the storage calculations, Bioretention and Sand Seepage Media were given a porosity of 0.25 while stone within the bioretention reservoir was given a porosity of 0.4.

4.6.2 Pollutant Removals

Pollutant removal rates were calculated using the retrofit removal adjuster curves as defined in the "Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects" (Chesapeake Stormwater Network, 2015). In this methodology, the removal rates for Total Phosphorus (TP), Total Nitrogen (TN), and Total Suspended Solids (TSS) are calculated from a series of predefined "retrofit removal curves” for each BMP. For the District of Columbia, Biohabitats has calculated the runoff depth treated from the Stormwater Retention Volume (SWRv) and the BMPs Storage Volume using the following equation. The precipitation (P) used to calculate the SWRv throughout the project site equals 1.2 inches.

$$Runoff\ Treated\ (in) = \frac{SWRv(cf) * P\ (in)}{Sv\ (cf)}$$

Table 3: BMP Treatment Values

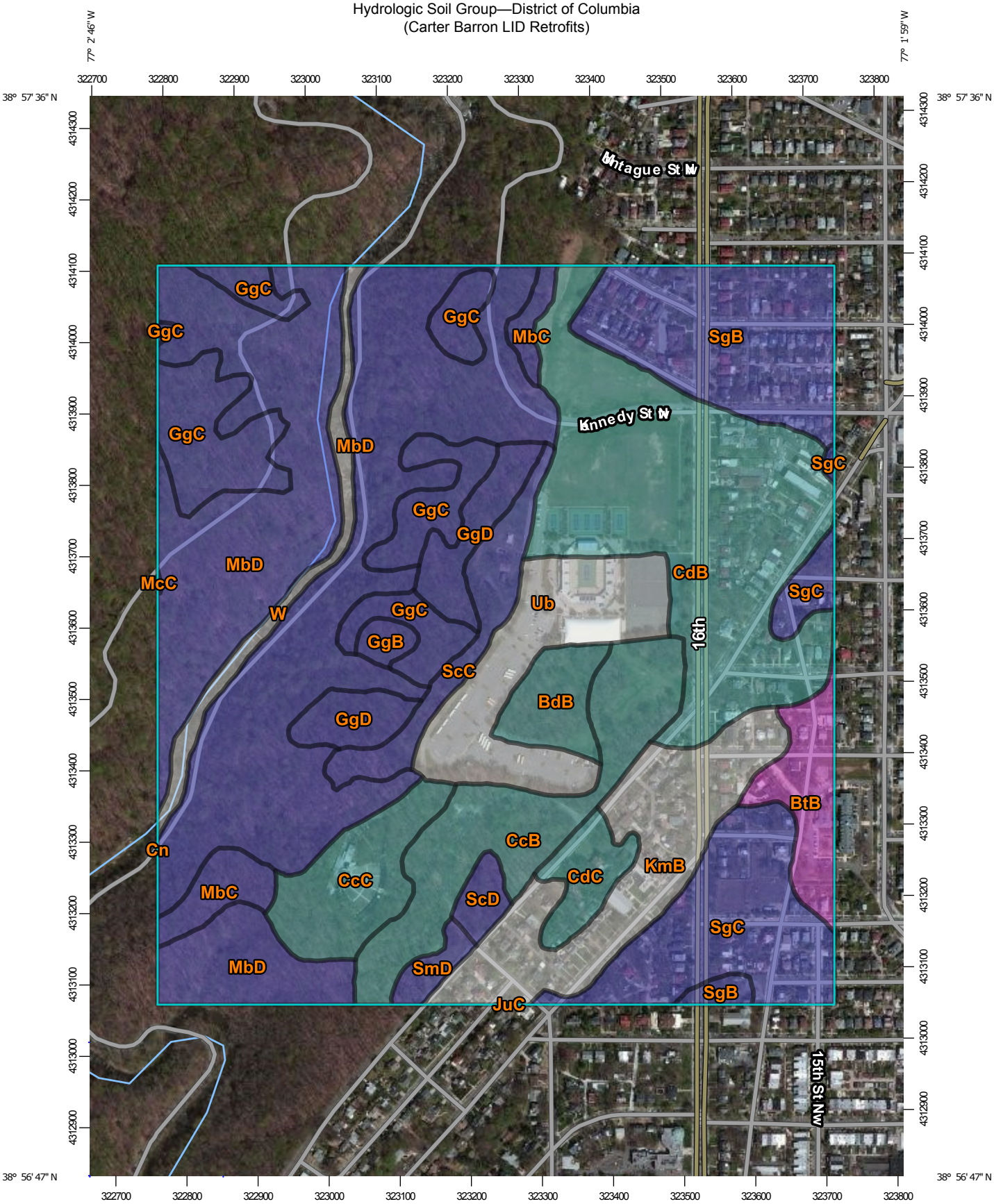
BMP	BMP Type	Type	SWRv cf	Sv cf	Runoff Treated in	TP Load Reduction lbs/yr	TN Load Reduction lbs/yr	TSS Load Reduction tons/yr
1-1	Bioretention	RR	2,347	2,381	1.22	0.85	3.85	0.20
1-2	Bioretention	RR	1,426	2,665	2.24	0.56	3.22	0.12
1-4	Bioretention	RR	7,459	10,639	1.71	2.84	12.93	0.66
1-5	Bioretention	RR	5,779	3,694	0.77	2.00	13.50	0.45
1-6	Bioretention	RR	1,746	1,844	1.27	0.64	2.89	0.15
1-7	Bioretention	RR	1,612	1,355	1.01	0.58	3.12	0.14
2-1	Bioretention	RR	2,164	2,562	1.42	0.88	5.30	0.21
3-1	Bioretention	RR	984	775	0.94	0.40	2.92	0.09
4-1	Bioretention	RR	576	541	1.13	0.22	1.18	0.05
5-1	Bioretention	RR	1,037	1,274	1.47	0.44	2.80	0.10
6-1	Bioretention	RR	470	705	1.80	0.18	1.06	0.04
7-1	Bioretention	RR	3,198	3,491	1.31	1.21	11.27	0.22
1-3	Sand Seepage	RR	5,658	5,500	1.17	2.03	9.21	0.47
7-2ss	Subsoiler		5,991	NA	NA	2.41	34.24	0.22
7-3ss	Subsoiler		3,754	NA	NA	1.51	21.45	0.14

APPENDIX A EXISTING CONDITIONS DATA

USDA NRCS Custom Soil Resource Report for District of Columbia, Rock Creek Park Tennis Center

Rock Creek Park Flow Patterns Redlines (Courtesy of Steve Saari of DOEE)

Hydrologic Soil Group—District of Columbia
(Carter Barron LID Retrofits)



Map Scale: 1:7,380 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 350 700 1400 2100

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: District of Columbia
Survey Area Data: Version 10, Sep 19, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — District of Columbia (DC001)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BdB	Beltsville silt loam, 0 to 8 percent slopes	C	4.2	1.7%
BtB	Brandywine-Urban land complex, 0 to 8 percent slopes	A	5.6	2.3%
CcB	Chillum silt loam, 0 to 8 percent slopes	C	14.6	6.0%
CcC	Chillum silt loam, 8 to 15 percent slopes	C	8.0	3.3%
CdB	Chillum-Urban land complex, 0 to 8 percent slopes	C	35.6	14.5%
CdC	Chillum-Urban land complex, 8 to 15 percent slopes	C	3.4	1.4%
Cn	Codorus-Urban land complex		0.0	0.0%
GgB	Glenelg loam, 0 to 8 percent slopes	B	1.1	0.4%
GgC	Glenelg loam, 8 to 15 percent slopes	B	16.8	6.9%
GgD	Glenelg loam, 15 to 25 percent slopes	B	6.7	2.7%
JuC	Joppa-Urban land complex, 8 to 15 percent slopes		0.0	0.0%
KmB	Keyport-Urban land complex, 0 to 8 percent slopes		16.0	6.5%
MbC	Manor loam, 8 to 15 percent slopes	B	4.0	1.6%
MbD	Manor loam, 15 to 40 percent slopes	B	69.0	28.2%
McC	Manor channery loam, 8 to 15 percent slopes	B	0.0	0.0%
ScC	Sassafras gravelly sandy loam, 8 to 15 percent slopes	B	5.8	2.4%
ScD	Sassafras gravelly sandy loam, 15 to 40 percent slopes	B	1.5	0.6%
SgB	Sassafras-Urban land complex, 0 to 8 percent slopes	B	17.1	7.0%

Hydrologic Soil Group— Summary by Map Unit — District of Columbia (DC001)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
SgC	Sassafras-Urban land complex, 8 to 15 percent slopes	B	16.2	6.6%
SmD	Sunnyside fine sandy loam, 15 to 40 percent slopes	B	1.5	0.6%
Ub	Urban land		13.4	5.5%
W	Water		4.1	1.7%
Totals for Area of Interest			**244.5**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

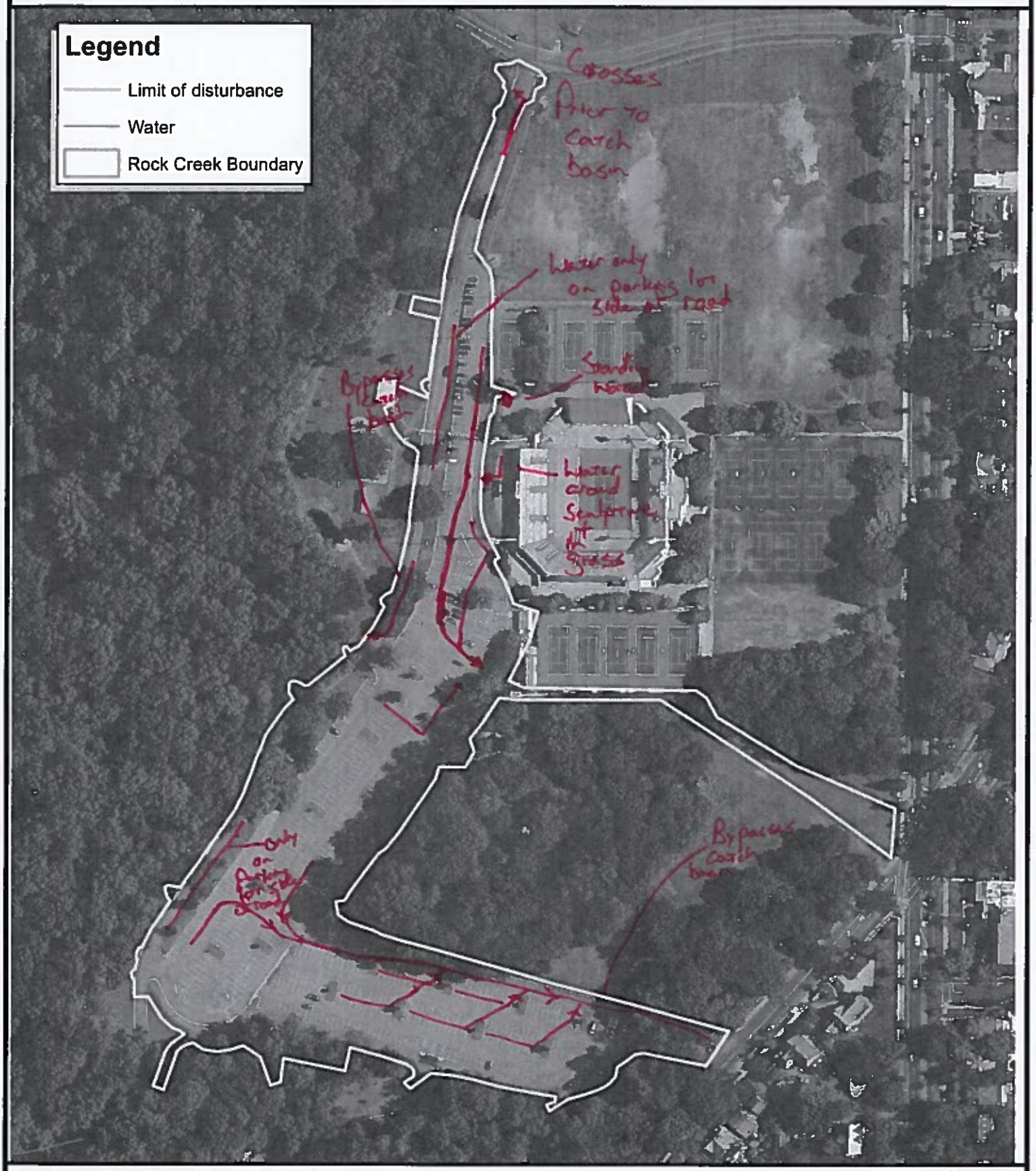
Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Rock Creek Park
Washington, D.C.

National Park Service
U.S. Department of the Interior

Assumed Boundaries of the Limit of Disturbanced



Produced by Rock Creek Park
October 2014

0 0.035 0.07 0.14 Miles

APPENDIX B TREATMENT CALCULATIONS

Stormwater Retention Volume Calculations
Bioretention Basin Design Calculations
Sand Seepage Berms Design Calculations
Pollutant Removal Calculations

Project Name Carter Barron LID Retrofits
Project No. 17010.01

Date: 8/10/2017

Completed By: GB
Checked By: BA

Subject: Stormwater Retention Volume Calculations

Stormwater Retention Volume (SWRv)

"Regulated sites that undergo a major land-disturbing activity or a major substantial improvement activity must employ BMPs and post-development land cover necessary to achieve the stormwater retention volume (SWRv) equal to the post-development runoff from the applicable rainfall event, as measured for a 24-hour storm with a 72-hour antecedent dry period. For a major substantial improvement activity located in the AWDZ, governed by the Anacostia Waterfront Environmental Standards Amendment Act of 2012, the applicable rainfall event is the 85th percentile rainfall event (1.0 inches). For all other major substantial improvement activities throughout the District, the applicable rainfall event is the 80th percentile rainfall event (0.8 inches)." (DDOE Stormwater Management Guidebook. July, 2013)

The SWRv is calculated as follows for the entire site and for each drainage area:

$$SWRv = P \times [(RvI*AI)+(RvC \times Ap) +(RvN \times AN)]/AT$$

where:

P = variable percentile rainfall event for the District dependent on regulatory trigger (1.2 inches)
Rv_I = 0.95 (runoff coefficient for impervious cover)
Rv_C = 0.25 (runoff coefficient for compacted cover)
Rv_N = 0.00 (runoff coefficient for natural cover)
A_I = Area of site in impervious cover (square feet)
A_C = Area of site in compacted cover (square feet)
A_N = Area of site in natural cover (square feet)
A_T = Total area of site (square feet)
12 = conversion factor, converting inches to feet

-DDOE Stormwater Management Guidebook (July, 2013)

SUMMARY TABLE

	CONTRIBUTING DRAINAGE AREA (CDA)					
CDA ID	Paved SF	Compacted SF	Natural SF	Total SF	P IN	Stormwater Retention Volume (SWRv) CF
1-1	24,700			24,700	1.2	2,347
1-2	13,160	7,025		20,185	1.2	1,426
1-3	59,560			59,560	1.2	5,658
1-4	78,520			78,520	1.2	7,459
1-5	55,500	20,275	88,450	164,225	1.2	5,779
1-6	18,380			18,380	1.2	1,746
1-7	16,970		13,490	30,460	1.2	1,612
2-1	22,780		35,200	57,980	1.2	2,164
3-1	10,360		32,840	43,200	1.2	984
4-1	6,060		5,560	11,620	1.2	576
5-1	10,920		22,050	32,970	1.2	1,037
6-1	4,310	2,420		6,730	1.2	470
7-1	17,380	61,880		79,260	1.2	3,198
7-2ss		239,650		239,650	1.2	5,991
7-3ss		150,146		150,146	1.2	3,754

Calculations

DA 1-1

Step 1: Calculate SWRv

SWRv = P x [(Rv_I*A_I)+(Rv_C x A_p) +(Rv_N x A_N)] / A_T / 12

SWRv = 1.2 x [(24700 x 0.95) + (0 x 0.25) + (0 x 0) / 24700

SWRv = **2,347 cubic feet**

DA 1-2

Step 1: Calculate SWRv

SWRv = P x [(Rv_I*A_I)+(Rv_C x A_p) +(Rv_N x A_N)] / A_T / 12

SWRv = 1.2 x [(13160 x 0.95) + (7025 x 0.25) + (0 x 0) / 20185

SWRv = **1,426 cubic feet**

DA 1-3

Step 1: Calculate SWRv

SWRv = P x [(Rv_I*A_I)+(Rv_C x A_p) +(Rv_N x A_N)] / A_T / 12

SWRv = 1.2 x [(59560 x 0.95) + (0 x 0.25) + (0 x 0) / 59560

SWRv = **5,658 cubic feet**

DA 1-4

Step 1: Calculate SWRv

SWRv = P x [(Rv_I*A_I)+(Rv_C x A_p) +(Rv_N x A_N)] / A_T / 12

SWRv = 1.2 x [(78520 x 0.95) + (0 x 0.25) + (0 x 0) / 78520

SWRv = **7,459 cubic feet**

DA 1-5

Step 1: Calculate SWRv

SWRv = P x [(Rv_I*A_I)+(Rv_C x A_p) +(Rv_N x A_N)] / A_T / 12

SWRv = 1.2 x [(55500 x 0.95) + (20275 x 0.25) + (88450 x 0) / 164225

SWRv = **5,779 cubic feet**

DA 1-6

Step 1: Calculate SWRv

SWRv = P x [(Rv_I*A_I)+(Rv_C x A_p) +(Rv_N x A_N)] / A_T / 12

SWRv = 1.2 x [(18380 x 0.95) + (0 x 0.25) + (0 x 0) / 18380

SWRv = **1,746 cubic feet**

DA 1-7

Step 1: Calculate SWRv

SWRv = P x [(Rv_I*A_I)+(Rv_C x A_p) +(Rv_N x A_N)] / A_T / 12

SWRv = 1.2 x [(16970 x 0.95) + (0 x 0.25) + (13490 x 0) / 30460

SWRv = **1,612 cubic feet**

DA 2-1

Step 1: Calculate SWRv

SWRv = P x [(Rv_I*A_I)+(Rv_C x A_p) +(Rv_N x A_N)] / A_T / 12

SWRv = 1.2 x [(22780 x 0.95) + (0 x 0.25) + (35200 x 0) / 57980

SWRv = **2,164 cubic feet**

DA 3-1

Step 1: Calculate SWRv

SWRv = P x $[(Rv_I*A_I)+(Rv_C \times A_p) +(Rv_N \times A_N)] / A_T / 12$
SWRv = 1.2 x [(10360 x 0.95) + (0 x 0.25) + (32840 x 0) / 43200
SWRv = **984 cubic feet**

DA 4-1

Step 1: Calculate SWRv

SWRv = P x $[(Rv_I*A_I)+(Rv_C \times A_p) +(Rv_N \times A_N)] / A_T / 12$
SWRv = 1.2 x [(6060 x 0.95) + (0 x 0.25) + (5560 x 0) / 11620
SWRv = **576 cubic feet**

DA 5-1

Step 1: Calculate SWRv

SWRv = P x $[(Rv_I*A_I)+(Rv_C \times A_p) +(Rv_N \times A_N)] / A_T / 12$
SWRv = 1.2 x [(10920 x 0.95) + (0 x 0.25) + (22050 x 0) / 32970
SWRv = **1,037 cubic feet**

DA 6-1

Step 1: Calculate SWRv

SWRv = P x $[(Rv_I*A_I)+(Rv_C \times A_p) +(Rv_N \times A_N)] / A_T / 12$
SWRv = 1.2 x [(4310 x 0.95) + (2420 x 0.25) + (0 x 0) / 6730
SWRv = **470 cubic feet**

DA 7-1

Step 1: Calculate SWRv

SWRv = P x $[(Rv_I*A_I)+(Rv_C \times A_p) +(Rv_N \times A_N)] / A_T / 12$
SWRv = 1.2 x [(17380 x 0.95) + (61880 x 0.25) + (0 x 0) / 79260
SWRv = **3,198 cubic feet**

DA 7-2ss

Step 1: Calculate SWRv

SWRv = P x $[(Rv_I*A_I)+(Rv_C \times A_p) +(Rv_N \times A_N)] / A_T / 12$
SWRv = 1.2 x [(0 x 0.95) + (239650 x 0.25) + (0 x 0) / 239650
SWRv = **5,991 cubic feet**

Bioretention Basins

Bioretention Basins capture and store stormwater runoff and pass it through a filter bed of engineered soil media composed of sand, soil, and organic matter. Filtered runoff may be collected and returned to the conveyance system, or allowed to infiltrate into the soil. There are two different types of bioretention design configurations:

- Standard Designs. Practices with a standard underdrain design and less than 24 inches of filter media depth. If trees are planted using this design, the filter media depth must be at least 24 inches to support the trees.
- Enhanced Designs. Practices with underdrains that contain at least 24 inches of filter media depth and an infiltration sump/storage layer or practices that can infiltrate the design storm volume in 72 hours.

Storage Volumes within a Bioretention Basin have been calculated using the following equation from the DDOE Stormwater Management Guidebook (July, 2013)

$$Sv = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{gravel} \times \eta_{gravel})] + (SA_{average} \times d_{ponding})$$

where:

Sv	=	total storage volume of bioretention (ft^3)
SA_{bottom}	=	bottom surface area of bioretention (ft^2)
d_{media}	=	depth of the filter media (ft)
η_{media}	=	effective porosity of the filter media (typically 0.25)
d_{gravel}	=	depth of the underdrain and underground storage gravel layer (ft)
η_{gravel}	=	effective porosity of the gravel layer (typically 0.4)
$SA_{average}$	=	average surface area of bioretention (ft^2) typically, where SA_{top} is the top surface area of bioretention, $SA_{average} = \frac{SA_{bottom} + SA_{top}}{2}$
$d_{ponding}$	=	maximum ponding depth of bioretention (ft)

SUMMARY TABLE

					Areas		Depths				
BMP	Bioretention Version	Contributing Drainage Area ID	SWRv (1.2") CF	Infiltration Rate CF	Ponded Shelf Area SF	Bioretention Area SF	Ponding (Over Shelf) IN	Ponding (Over Bio) IN	Bioretention Soil Media Depth IN	11" Reservoir + Stone Sump Depth IN	Storage Volume CF
1-1	Enhanced w/out UD	1-1	2,347	0.200		1,095	0	12	18	24	2,381
1-2	Enhanced w/out UD	1-2	1,426	0.200	1,430	1,061	3	12	18	24	2,665
1-4	Enhanced w/out UD	1-4	7,459	0.200	-	4,892	0	12	18	24	10,639
1-5	Enhanced w/out UD	1-5	5,779	0.200	4,650	1,164	3	12	18	24	3,694
1-6	Enhanced w/out UD	1-6	1,746	0.200		716	0	12	18	36	1,844
1-7	Enhanced w/out UD	1-7	1,612	0.200		589		12	24	24	1,355
2-1	Enhanced w/out UD	2-1	2,164	0.200		1,178		12	18	24	2,562
3-1	Enhanced w/out UD	3-1	984	0.200		287		12	24	36	775
4-1	Enhanced w/out UD	4-1	576	0.200		235		12	24	24	541
5-1	Enhanced w/out UD	5-1	1,037	0.200		411		12	24	48	1,274
6-1	Enhanced w/out UD	6-1	470	0.200	744	226	3	12	24	24	705
7-1	Enhanced w/out UD	7-1	3,198	0.200	3,378	1,217	3	12	18	24	3,491

Calculations

BMP 1-1

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 1095:24700
SA:CDA = ***4.4%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.95**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **54** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 18.0 inches
d_{stone} = 24.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 1095 * [(1.5 x 0.25)+(2 x 0.4)] + (1095 x 1 + 0 x 0)
S_v = **2,381 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 2381:2347
S_V***:SWRv =*** 101%

BMP 1-2

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 1061:20185
SA:CDA = ***5.3%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.71**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **36** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 18.0 inches
d_{stone} = 24.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 1061 * [(1.5 x 0.25)+(2 x 0.4)] + (1061 x 1 + 1430 x 0.25)
S_v = **2,665 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 2665:1426
S_V***:SWRv =*** 187%

BMP 1-4

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 4892:78520
SA:CDA = ***6.2%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.95**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **42** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 18.0 inches
d_{stone} = 24.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 4892 * [(1.5 x 0.25)+(2 x 0.4)] + (4892 x 1 + 0 x 0)
S_v = **10,639 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 10639:7459
S_V***:SWRv =*** 143%

BMP 1-5

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 1164:164225
SA:CDA = ***0.7%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.35**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **72** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 18.0 inches
d_{stone} = 24.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 1164 * [(1.5 x 0.25)+(2 x 0.4)] + (1164 x 1 + 4650 x 0.25)
S_v = **3,694 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 3694:5779
S_V***:SWRv =*** 64%

BMP 1-6

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 716:18380
SA:CDA = ***3.9%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.95**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **60** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 18.0 inches
d_{stone} = 36.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 716 * [(1.5 x 0.25)+(3 x 0.4)] + (716 x 1 + 0 x 0)
S_v = **1,844 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 1844:1746
S_V***:SWRv =*** 106%

BMP 1-7

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 589:30460
SA:CDA = ***1.9%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.53**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **72** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 24.0 inches
d_{stone} = 24.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 589 * [(2 x 0.25)+(2 x 0.4)] + (589 x 1 + 0 x 0)
S_v = **1,355 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 1355:1612
S_V***:SWRv =*** 84%

BMP 2-1

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 1178:57980
SA:CDA = ***2.0%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.37**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **36** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 18.0 inches
d_{stone} = 24.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 1178 * [(1.5 x 0.25)+(2 x 0.4)] + (1178 x 1 + 0 x 0)
S_v = **2,562 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 2562:2164
S_V***:SWRv =*** 118%

BMP 3-1

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 287:43200
SA:CDA = ***0.7%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.23**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **#N/A** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 24.0 inches
d_{stone} = 36.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 287 * [(2 x 0.25)+(3 x 0.4)] + (287 x 1 + 0 x 0)
S_v = **775 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 775:984
S_V***:SWRv =*** 79%

BMP 4-1

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 235:11620
SA:CDA = ***2.0%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.50**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **48** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 24.0 inches
d_{stone} = 24.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 235 * [(2 x 0.25)+(2 x 0.4)] + (235 x 1 + 0 x 0)
S_v = **541 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 541:576
S_V***:SWRv =*** 94%

BMP 5-1

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 411:32970
SA:CDA = ***1.2%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.31**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **66** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 24.0 inches
d_{stone} = 48.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 411 * [(2 x 0.25)+(4 x 0.4)] + (411 x 1 + 0 x 0)
S_v = **1,274 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 1274:1037
S_V***:SWRv =*** 123%

BMP 6-1

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 226:6730
SA:CDA = ***3.4%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.70**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **48** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 24.0 inches
d_{stone} = 24.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 226 * [(2 x 0.25)+(2 x 0.4)] + (226 x 1 + 744 x 0.25)
S_v = **705 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 705:470
S_V***:SWRv =*** 150%

BMP 7-1

Step 1: Determine Max. Filter Depth from SA:CDA & RvCDA (Table 3.21)

SA:CDA = 1217:79260
SA:CDA = ***1.5%***

R_v *CDA=* Value from DDOT Summary Data Spreadsheet
R_v ***CDA=*** **0.40**

From DDOE Table 3.21 for SA:CDA & RvCDA Above
Max. Filter Media Depth = **60** **inches**

Step 2: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 18.0 inches
d_{stone} = 24.0 inches

Step 3: Calculate Storage Volume

$S_v = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{stone} \times \eta_{stone})] + (SA_{bottom} \times d_{ponding\text{-}bio} + SA_{shelf} \times d_{ponding\text{-}shelf})$
S_v = 1217 * [(1.5 x 0.25)+(2 x 0.4)] + (1217 x 1 + 3378 x 0.25)
S_v = **3,491 cubic feet**

Step 4: Check Sv vs SWRv of Drainage Area

S_V*:SWRv =* 3491:3198
S_V***:SWRv =*** 109%

Sand Seepage Berms

Sand seepage berms are constructed of clean sand and wood chips to act as a filter bed. Berm dimensions are typically 1 foot in height with variable top widths, gradual side slopes (i.e. 10:1) and 6-inch sand lift of variable length. The wide top widths and gradual side slopes make the berms conducive to pedestrian traffic, where applicable. The berms will provide microtopography throughout the landscape. Grading in the vicinity of the berms will be roughened to provide additional microtopography variations. Following the topographic and tree surveys, placement of berms will be determined based on minimizing impacts to trees and pedestrian areas.

The berms are able to pond storm flows directed from the parking lots and to hold these diverted waters. This forces the water to take a longer flow path, as well as create temporary ponding, infiltration, transpiration, and seepage. In this manner, the berms will attenuate storm flows, increase time of concentration, and increase subsurface flows of the site by restoring the shallow groundwater table.

Storage volumes for stormwater treatment are calculated by assuming a 0.25 porosity of the filter media.

SUMMARY TABLE

BMP	Drainage Area ID	SWRv (1.2")	Infiltration Rate	Areas		Depths		Storage Volume
				Ponding	Berm	Ponding	Sand Seepage Media	
		CF	CF	SF	SF	IN	IN	CF
1-3	1-3	5,658	0.200	3,000	20,000	12	6	5,500

Calculations

BMP 1-3

Step 1: Select Ponding & Media Depths+ based on Site Constraints

$d_{p\text{-}ponding}$ = 12.0 inches
d_{media} = 6.0 inches

Step 2: Calculate Storage Volume

$S_v = (SA_{media} \times d_{media} \times \eta_{media}) + (SA_{ponding} \times d_{ponding})$

S_v = [(20000 x 6 x 0.25) + (3000 x 12)] / 12

S_v = 5,500 cubic feet

Pollutant Removals - Bioretention, Sand Seepage

Pollutant removal rates are calculated using the retrofit removal adjuster curves as defined in the "Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects" (Chesapeake Stormwater Network, 2015). In this methodology, the removal rates for Total Phosphorus (TP), Total Nitrogen (TN), and Total Suspended Solids (TSS) are calculated from a series of predefined "retrofit removal within each BMP. For the District of Columbia, Biohabitats has calculated the runoff depth treated from the Stormwater Retention Volume (SWRv) and the BMPs Storage Volume using the following equation. The precipitation (P) used to calculate the SWRv throughout the project site equals 1.2 inches.

$$Runoff\ Treated\ (in) = \frac{SWRv(cf) * P\ (in)}{Sv\ (cf)}$$

Pollutant Removals - Subsoiler

Pollutant Removals for the subsoiler are calculated by comparing the existing condtions nutrient loading rates for the athletic fields with the post-subsoiler application nutrient loading rates, assumed to have the hydrologic characteristics of a forested condition. A recent study on the benefits of subsoiler application (Schwartz, 2016) estimated that the use of subsoiling reduced the Effective Curve Number (ECN) and Runoff Coefficient (Rv) of an urban athletic field from 87.4 and 0.52 to 43.7 and 0.016 respectively. A conversion of this magnitude in ECN and Rv values was determined to relate closest to the forested condition for pollutant loading rates, as identified in the Chesapeake Bay Watershed Model (v5.3.0), and therefore used as the post subsoiling rates.

Pollutant Loading Rates

	Urban Impervious lbs/ac/yr	Pervious Urban lbs/ac/yr	Forested lbs/ac/yr
TN	10.85	9.43	3.16
TP	2.04	0.57	0.13
TSS	0.44	0.07	0.03

SUMMARY TABLE

BMP	BMP Type	TOP	CDA ID	SWRv CF	Sv CF	Runoff Treated IN	TP Load lbs/yr	TN Load lbs/yr	TSS Load tons/yr	TP Removal %	TN Removal %	TSS Removal %	TP Load Reduction lbs/yr	TN Load Reduction lbs/yr	TSS Load Reduction tons/yr
1-1	Bioretention	RR	1-1	2,347	2,381	1.22	1.16	6.15	0.25	73%	63%	79%	0.85	3.85	0.20
1-2	Bioretention	RR	1-2	1,426	2,665	2.24	0.71	4.80	0.14	78%	67%	84%	0.56	3.22	0.12
1-4	Bioretention	RR	1-4	7,459	10,639	1.71	3.68	19.56	0.79	77%	66%	83%	2.84	12.93	0.66
1-5	Bioretention	RR	1-5	5,779	3,694	0.77	3.13	24.63	0.65	64%	55%	69%	2.00	13.50	0.45
1-6	Bioretention	RR	1-6	1,746	1,844	1.27	0.86	4.58	0.19	74%	63%	79%	0.64	2.89	0.15
1-7	Bioretention	RR	1-7	1,612	1,355	1.01	0.83	5.21	0.18	70%	60%	75%	0.58	3.12	0.14
2-1	Bioretention	RR	2-1	2,164	2,562	1.42	1.17	8.23	0.25	75%	64%	81%	0.88	5.30	0.21
3-1	Bioretention	RR	3-1	984	775	0.94	0.58	4.96	0.13	69%	59%	74%	0.40	2.92	0.09
4-1	Bioretention	RR	4-1	576	541	1.13	0.30	1.91	0.07	72%	62%	77%	0.22	1.18	0.05
5-1	Bioretention	RR	5-1	1,037	1,274	1.47	0.58	4.32	0.13	76%	65%	81%	0.44	2.80	0.10
6-1	Bioretention	RR	6-1	470	705	1.80	0.23	1.60	0.05	78%	66%	83%	0.18	1.06	0.04
7-1	Bioretention	RR	7-1	3,198	3,491	1.31	1.62	17.73	0.27	74%	64%	80%	1.21	11.27	0.22
1-3	Sand Seepage	RR	1-3	5,658	5,500	1.17	2.79	14.84	0.60	73%	62%	78%	2.03	9.21	0.47
7-2ss	Subsoiler		7-2ss	5,991	NA	NA	3.14	51.88	0.39	77%	66%	57%	2.41	34.24	0.22
7-3ss	Subsoiler		7-3ss	3,754	NA	NA	1.96	32.50	0.24	77%	66%	57%	1.51	21.45	0.14

APPENDIX C PHOTO LOG

Image C-1: Eroding Gully (4/10/2017)

Image C-2: Location of BMP 1-2 (4/10/2017)

Image C-3: Location of BMP 1-3 (4/10/2017)

Image C-4: Location of BMP 7-1 (4/10/2017)

Image C-5: BMP 7-1 Flow Patterns

(5/11/2017, Courtesy of DOEE)

Image C-6: BMP 1-2 Flow Patterns

(5/11/2017, Courtesy of DOEE

Image C-7: BMP 1-1 Flow Patterns

(5/11/2017, Courtesy of DOEE)

Image C-8: BMP 1-3 Flow Patterns

(4/15/11/2017, Courtesy of DOEE)