FINAL DESIGN REPORT

FOR

HYBRID BMP PROJECT

INCLINE VILLAGE, NEVADA

July 2011

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1. INTRODUCTION

The Hybrid Best Management Practices (BMP) Project is a Low Impact Development (LID) retrofit for an existing stormwater treatment system within the Tahoe Basin, specifically Incline Village, Washoe County, Nevada. The proposed project seeks to install eight LID stormwater treatment areas within the Washoe County right-of-way along Village Blvd.

BACKGROUND

The shift from hydrologic and concentration-based regulatory requirements to new Total Maximum Daily Load (TMDL) regulations that are primarily concerned with reducing the mass of sub-16 micron (µm) particles should encourage BMP designs that are more efficient at fine sediment removal. Because the bulk of existing stormwater treatment systems are optimized to the old regulatory criteria, there may be a wide spread need to retrofit (or "enhance") existing Tahoe Regional Planning Agency (TRPA) Environmental Improvement Program (EIP) projects with treatment systems more effective at reducing the load of 16 micron particles.

The need for this project is justified from two perspectives: basin wide and project level.

Basin wide perspective: The Lake Tahoe TMDL technical research concluded 72 percent of sub-16 micron sediment originates from the urban landscape and 68 percent of the urban source is from primary and secondary roads (Lahontan and NDEP, 2009). To this point, the primary design criteria for urban BMPs has been hydrologic; that is, to treat the twenty year, one hour storm as determined by the TRPA, or one inch of precipitation in one hour. However, the Nevada Division of Environmental Protection (NDEP) will soon issue a Memorandum of Agreement (MOA) to all jurisdictions within the Nevada side of the Tahoe Basin that will call for a reduction of fine sediment load in their area of responsibility. This MOA will, in effect, shift pollutant control strategies from hydrologic and concentration criteria to one that primarily seeks to mitigate the *load* of sub-16 micron sediment. This shift in policy will likely result in a shift in the type of BMPs selected for EIP projects; that is, a new emphasis will be placed on BMPs most effective at sequestering fine sediment.

In 2002, the USGS compiled monitoring results from an extensive literature search and national databases to determine which BMP was the most efficient at removing suspended solids, lead, and total phosphorus (Zarrielo *et al*., 2002). The infiltration BMP was found to be the most efficient for all three constituents, and although the report did not look at sub-16 micron sediment, the fact that phosphorus and lead sorb to the finest particle sizes, their efficient removal implies similar performance for fine sediment. This, combined with conclusions from other peer reviewed literature (Roseen *et al*., 2006) and local anecdotal evidence that structural, flow-through BMPs do not significantly reduce sub 16-micron sediment (Dick Minto, pers. comm.; Sansalone, 2010), points to a need to shift from structural hydro-dynamic BMPs to infiltration systems in the TMDL era. However, project areas with significant residential or commercial development have space restrictions that prevent infiltration basins from being sized to accommodate the entire volume of a design storm. The Hybrid BMP Project seeks to validate the use of distributed, off-line infiltration basins in the county right-of-way as an alternative to current structural BMP systems and as a retrofit configuration for existing EIP projects.

Project level perspective: Observations made during the Incline Village Sweeper Study (NTCD, 2011) revealed that runoff from melting snow often occurred daily in the winter. The snowmelt flowed along the street gutter which contained the vast majority of road sediment. The resulting fine sediment concentration in the runoff water was relatively high and believed responsible for the surprisingly large mass of fine sediment found in the sump portion of the drop inlets (NTCD, 2011). Street sweeping immediately after a snow event is not possible because the road is typically snow covered and/or wet. Washoe County maintenance staff thinks that the structural hydrodynamic treatment vault at the terminal end of the EIP system is not effective at retaining fines (Dick Minto, pers. comm.). As a result, once the volume of melt water exceeds the volume capacity of the existing storm water system, the load of sub-16 micron sediment transported by stormwater into the existing conveyance system is discharged into Rosewood Creek and subsequently to Lake Tahoe.

The Minnesota city of Burnsville, faced with a requirement to reduce pollutants to a nearby lake, augmented an existing storm water conveyance system with 17 rain gardens or “bioretention” systems (City of Burnsville, 2006). The systems were installed primarily in the city right-of-way and filled with mulch and engineered soils with sufficient capacity to accommodate the runoff from a 0.9 inch storm (Figure 1). Stormwater entered the systems via a single cut in the roadside curb (Figure 2). If a bioretention system filled during a runoff event, subsequent runoff was hydraulically prevented from entering the system and continued to flow along the curb to the next bioretention system or to a drop inlet. Runoff captured within the bioretention system had no outlet except infiltration and reduced stormwater volume by 90% compared to the control catchment (Figure 3). Although the study did not report water quality, the authors believe the “off-line” design was very effective at permanently removing first flush pollutants from the stormwater (Mike Isensee, Burnsville, MN, pers. comm.). The residential property owners who participated in this study maintained the vegetation on the system (flowers and shrubs) while the city maintained the functionality.

Figure 1. Photo of “bioretention rain garden” constructed for the Burnsville, MN study.

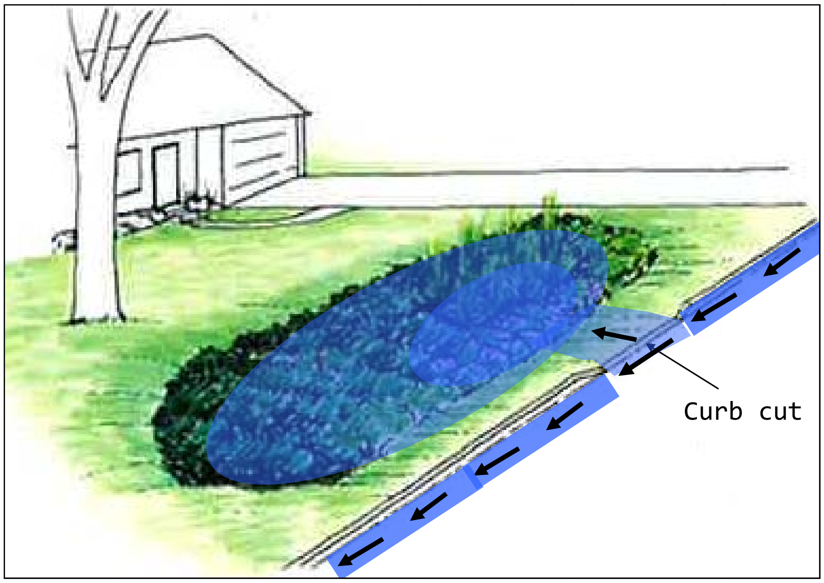


Figure 2. Conceptual schematic of a vegetated infiltration basin. Runoff remains in the road once the basin is full to capacity.

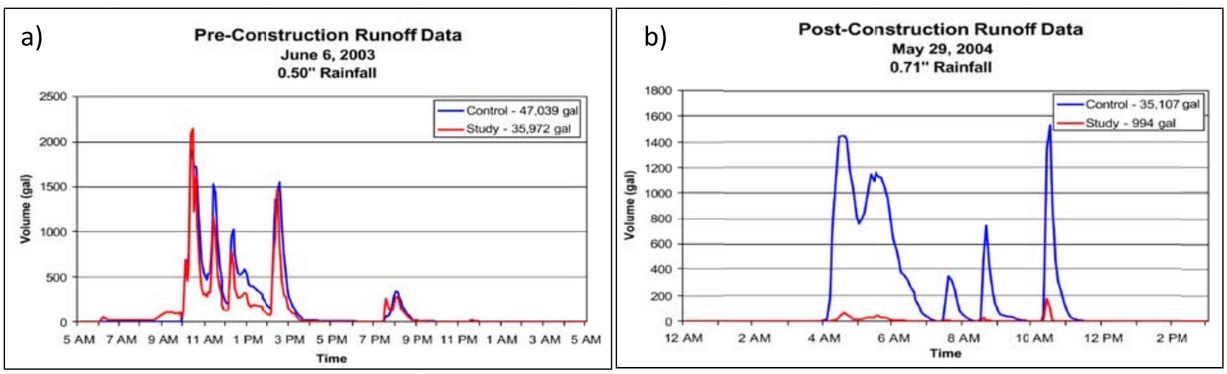


Figure 3. Hydrograph of two catchments before (a) and after (b) implementation of the "bioretention rain gardens" in Burnsville, MN. Overall, runoff was reduced 90 percent.

PROJECT LOCATION

The Hybrid BMP Project is located in Washoe County, in Incline Village, NV, along an approximately 1,000 foot length of Village Boulevard. The project area is the Washoe County right-of-way (ROW) along the southeastern side of Village Boulevard from just below Ace Court to just shy of Peepsight Circle (Figure 4). The project area is entirely within the Third Creek watershed, which is ranked by TRPA as a Priority 1 watershed. Adjacent developments include the Incline Village neighborhood along Village Boulevard and its side streets. Appendix A has a list of properties within 300' of the project.

Figure 4. Project area location.

DESCRIPTION

The Hybrid BMP Project will install multiple infiltration BMPs based on LID concepts in the Washoe County ROW along Village Boulevard. Because this is the first project to focus on LID BMPs in the county right-of-way, it was desirable to create a variety of system configurations to determine which features performed best. Most of the BMPs will not have an outlet except via infiltration or emergency overflow and most will be designed to become hydraulically isolated from additional inflow when full of water. After the runoff event, stormwater in the BMP will infiltrate and the sequestered fine sediment and other pollutants, unlike most stormwater treatment BMPs in the Tahoe Basin, will not be flushed out by a subsequent large flow event. In the event stormwater bypasses the Hybrid BMPs, excess stormwater will be treated in the existing conveyance stormwater system. BMPs were selected based on topography, runoff volume, engineering, and hydro-geologic considerations which will be discussed further later in this report.

Two paired catchments along Village Boulevard have been hydraulically matched as part of the sweeper study (NTCD, 2011) (Figure 5). This project will retrofit the upper sweeper area with LID treatments and measure the stormwater volume reduction of those BMPs on the upper catchment compared to the lower catchment to determine project effectiveness.

Figure 5. Sweeper Study project area upper and lower sweeper areas.

GOALS AND OBJECTIVES

The Hybrid BMP Project goals are as follows:

GOAL # 1: Reduce the runoff volume flowing from the County's impervious area in the altered (upper) catchment.

Objectives:

A. Treat 50 percent of the street stormwater runoff generated in the upper Village Boulevard sweeper study area with offline LID BMPs.

GOAL #2: Remove and sequester fine sediment mass from the catchment.

Objectives:

A. Employ infiltration or biofiltration LID BMPs to remove 50 percent of fine sediment particles from stormwater generated in the upper Village Boulevard sweeper study area.

GOAL #3: Sustain seasonal and longer term infiltration performance with minimal maintenance.

Objectives:

A. Install sediment stormwater pre-treatment systems such that Washoe County does not incur an additional maintenance load compared to current practices.

The bioinfiltration basins will be designed to accommodate stormwater runoff equivalent from at least a 0.86 inch, one hour storm (i.e., a 10 year event (Table 1)) from approximately 50% of the area of Village Boulevard between Ace Court and Peepsight Circle. Statistical analysis of 7 years of precipitation at Diamond Peak in Incline Village, NV reveals that 100% of daily water-equivalent precipitation was smaller than a 10 year, 24 hour precipitation event (i.e., 4.88 inches). Six of the eight proposed BMPs will bypass stormwater runoff that exceeds the basin treatment capacity. The bypassed stormwater will flow through the existing (unaltered) EIP conveyance and treatment system. The hydrologic source control realized by collecting and infiltrating the volume from the vast majority of runoff events will result in equally significant reductions in fine sediment load from the upper catchment of Village Boulevard.

PROJECT FUNDING

Table 1. Funding sources and amounts for the Hybrid BMP Project

Agency	Original Funding	Amend_1	Total Funds
United States Forest Service (USFS) Lake Tahoe Basin Management Unit (LTBMU) Erosion Control Grants Program (Round 10) grant	$94,860	$28,679	$123,539
Nevada Division of State Land (NDSL) Lake Tahoe License Plate (LTLP) grant	$86,100	$0	$86,100
Nevada Division of Environmental Protection (NDEP) 319(h) grant	$85,200	$0	$85,200
Washoe County/Tahoe Regional Planning Agency (TRPA) Water Quality Mitigation Funds	$80,738	$16,679	$97,417
In-kind equipment and labor	$13,222	$12,000	$25,222
TOTAL	**$360,120**	**$57,358**	**$417,478**

PROJECT PARTNERS

Nevada Tahoe Conservation District (NTCD) is the project sponsor and lead agency responsible for planning, designing, implementing and monitoring the Hybrid BMP Project. NTCD is working closely with Washoe County to ensure that the project suits their needs. In addition to NTCD and Washoe County, a number of other important partners will continue to participate in the process to ensure successful project delivery. Project partners include:

1. Nevada Tahoe Conservation District (NTCD)
2. Washoe County Public Works
3. United States Forest Service (USFS)
4. Nevada Division of State Lands (NDSL)
5. Nevada Division of Environmental Protection (NDEP)
6. Tahoe Regional Planning Agency (TRPA)
7. Natural Resources Conservation Service (NRCS)
8. Desert Research Institute (DRI)
9. Affected homeowners

2. DRAINAGE AND HYDROLOGY

EXISTING CONDITIONS

The existing site is a residential neighborhood with single family dwellings on ¼ acre or greater lots. Village Boulevard is approximately 30 feet wide and is paved with vertical curb and gutter on both sides. The street is crowned and originally had a 2 percent cross-slope, but has received numerous A/C overlays and the crown is no longer consistent. Depressions running the length of commonly traveled wheel paths are evident in some sections of the road, although this is slated to be corrected during the summer of 2011. The longitudinal slope varies from 4 to 8 percent. The existing topography is well within design guideline criteria published in various Rain Garden design manuals (i.e., Low Impact Development: Technical Guidance Manual For Puget Sound, Rain Gardens: A How-to Manual for Homeowners). Most manuals identify slopes over 12 percent as being the point at which slopes become too steep for the practical installation of rain gardens (Virginia Department of Forestry, 2010., Hinman, 2005., Bannermen and Considine 2003).

The slope of the ROW generally matches the slope of the street and the ground cover in the areas of proposed disturbance is mostly bare soil with scant pine needle mulch and native vegetation. One of the BMPs is in an area that is landscaped by a private homeowner with wood bark mulch and some ornamental plants.

The existing drainage and stormwater treatment for the site was installed in 2003 as part of the Village Boulevard and Mill Creek Water Quality Improvement Project (WQIP). This project installed curb and gutter, catch basins (i.e., drop inlets with sumps), and conveyance pipes within the Hybrid BMP project area. The stormwater is conveyed through a hydrodynamic separator to a dry basin at the southeast corner of Harold Drive and Village Boulevard

No areas within the project area are identified as special hazard areas in the most current FEMA 2009 Flood Insurance Rate Map (FIRM). Over 250 feet upslope of BMP1, near the intersection of Village Boulevard and a section of Rosewood Creek, there is an area identified Zone X in the FEMA FIRM which are areas of 0.2 percent annual chance of flood or areas of 1 percent annual chance flood with average depths of less than 1 foot.

LAND CAPABILITY

The U.S. Forest Service and TRPA developed the Bailey land capability system in the early 1970s based primarily on the official USDA soils maps for the Tahoe Region. Each soil type was assigned to a land capability class ranging from 1 to 7, with capability 1 being the most environmentally fragile and sensitive to development. Wherever land was found to be influenced by a stream or high groundwater, it was assigned to capability 1b, also known as "Stream Environment Zone" or SEZ.

The Hybrid BMP project is located entirely within TRPA land capability class 6.

EXISTING SOILS

NRCS soil survey indicates that all of the BMPs (except BMP 14) are within soil map unit 7141 Inville gravelly coarse sandy loam, 2 to 9 percent slopes, stony (Figure 6). BMP 14 is within soil map unit 7142 Inville gravelly coarse sandy loam, 9 to 15 percent slopes, stony. Both map unit descriptions indicate the area is well drained with more than 80” to the water table. Mapped infiltration rate for these units is listed at 4 inches per hour saturated conductivity (Ksat). Appendix B contains the map unit descriptions from the USDA Soil Survey for the Tahoe Basin Area, California and Nevada (USDA, NRCS 2007).

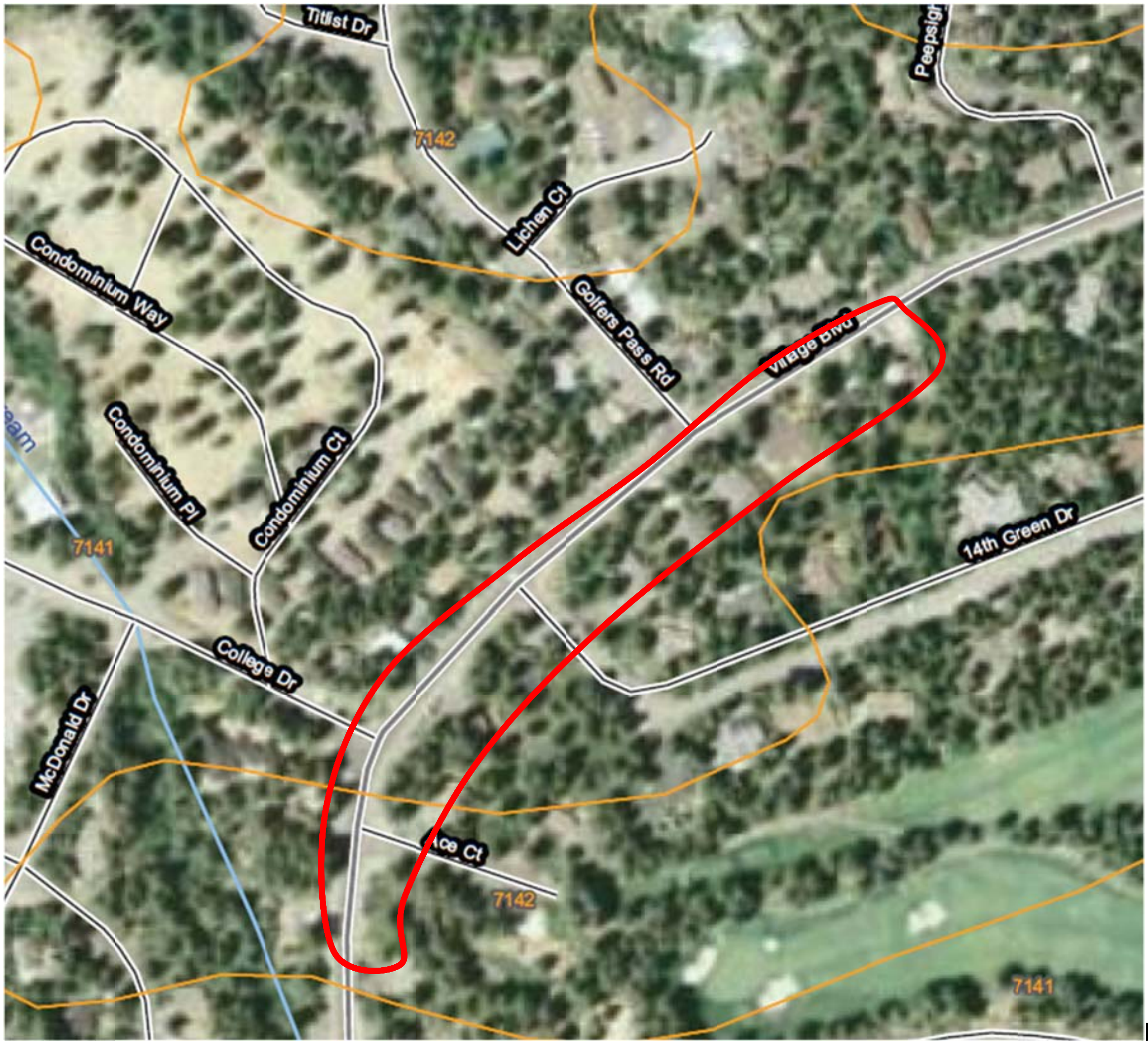


Figure 6. Project area NRCS soil map units. The project area is outlined in red.

Research has found that ideal bioinfiltration soil mixes should have between 2-5 percent fine particles (sub 200 sieve) for adequate infiltration. NTCD tested the soil found in the project area and found the sub 200 sieve mass is within this range, thus is adequate to use as a base for a bioinfiltration soil mix. Native on-site soil contains 3.2 percent fine particles by mass. Soil samples were dried completely, weighed and then sifted through a series of sieves. The weight of material passing the 200 sieve was divided by the weight of material sifted to determine the percent (by mass) passing the 200 sieve.

NTCD installed 6 piezometers on June 17, 2010 at two sites (BMP 11 and BMP 10) in the project area. These sites had the most vegetative indicators of a potential high water table. The piezometers were installed between 55 and 57 inches deep. Soil samples were collected during piezometer installation and later inspected by NRCS for mottling and gleying; none was found. NTCD encountered no high ground water or evidence of high ground water during piezometer installation; however, in the spring of 2011, groundwater tables were detectable at both BMP 10 and BMP 11. BMP 10 indicated groundwater levels at approximately 54 inches below existing grade, while BMP 11 indicated groundwater levels at approximately 36 inches below existing grade. The designs of BMP 10 and BMP 11 call for a maximum finished grade at 45 and 29 inches below existing grade respectively. It should also be noted that the precipitation received during the winter of 2010 was approximately 170 percent of normal and the sites were tested within days of the snow directly above them melting. Groundwater ponding within the rain gardens is not expected to occur even within the largest precipitation years.

Infiltration tests were performed at BMP 10 and BMP 11. Two constant head permeameter (CHP) tests were run for 10 minutes each at a depth of approximately 24 inches. BMP 10 yielded an average K_{Sat} of 1 inch per hour, while BMP 11 yielded an average K_{sat} of 2.55 inches per hour. The overall average K_{sat} was 1.75 inches per hour.

CATCHMENTS

A topographic survey was obtained from Nichols Consulting Engineers who is currently working on another stormwater treatment project in the area. The survey covered the project area in detail with the exception of some utilities and private improvements. By combining the topographic ground survey and the 2-foot contours from the Washoe County Geographic Information Systems (GIS) Department's database, NTCD was able to delineate both large scale and BMP scale catchments. Figure 7 shows the estimated extents of the upper "Ace" and lower "Harold" catchments. Figure 8 shows BMP scale catchments, separating impervious and pervious contributions. Table 2 breaks out the area of these BMP scale catchments.

PEAK AND DESIGN FLOW

Because of the small size of the contributing drainage areas, the rational method was used to evaluate the 5 year and 100 year flows being received by each BMP. The rational method calculates flow as ***Q = CiA*** where Q is flow in cubic feet, C is the unitless runoff coefficient based on the type of development, i is the precipitation intensity in inches per hour, and A is the contributing area in acres. All engineering calculations discussed below are available in Appendix D. The coefficient, C, was determined using methods available in the Truckee Meadows Regional Drainage Manual. The precipitation intensity, i, was determined using Figure 9 which was found using NOAA's Precipitation Frequency Data Server. Figure 10 shows the location of the NOAA precipitation data query. The results of the design and peak flow calculations are displayed in the Table 2.

One item to note is the short time of concentration (t_c) for all BMPs with the exception of BMP 14. Because each BMP receives predominately street runoff, travel time over a small paved area is short. Velocity estimates used to calculate t_c are from NRCS TR-55 (1986) or the equation: $V = 20.3282(S^{0.5})$. This equation overestimates the velocity for lengths under 200 feet (Lindberg, 2008), but is the best available method. The Truckee Meadows Regional Drainage Manual recommends a minimum t_c of 5 seconds, however, the more conservative approach of using the calculated t_c was utilized since slopes are steep in the area and sizing inlets to maximize interception is critical to the success of the LID features.

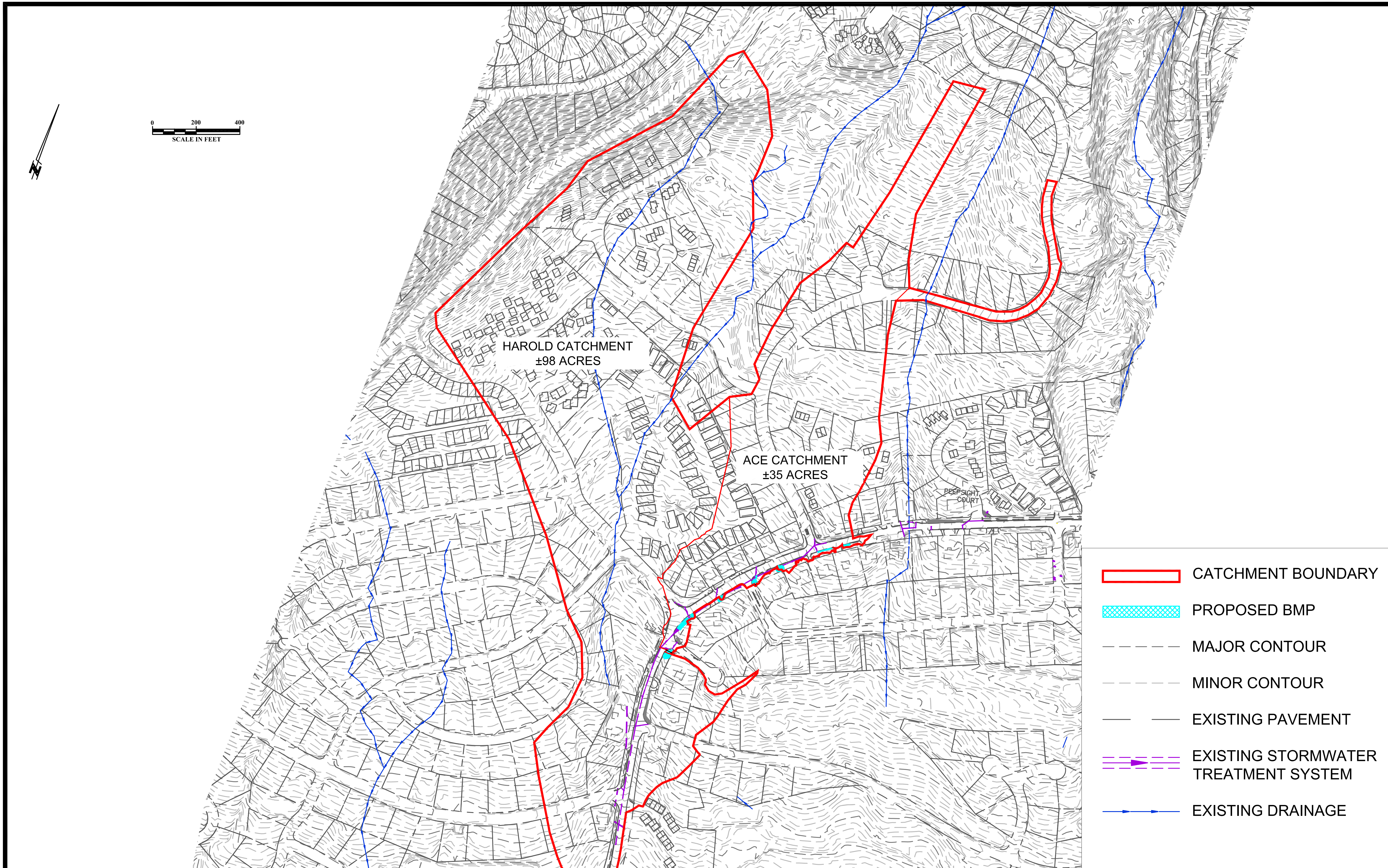
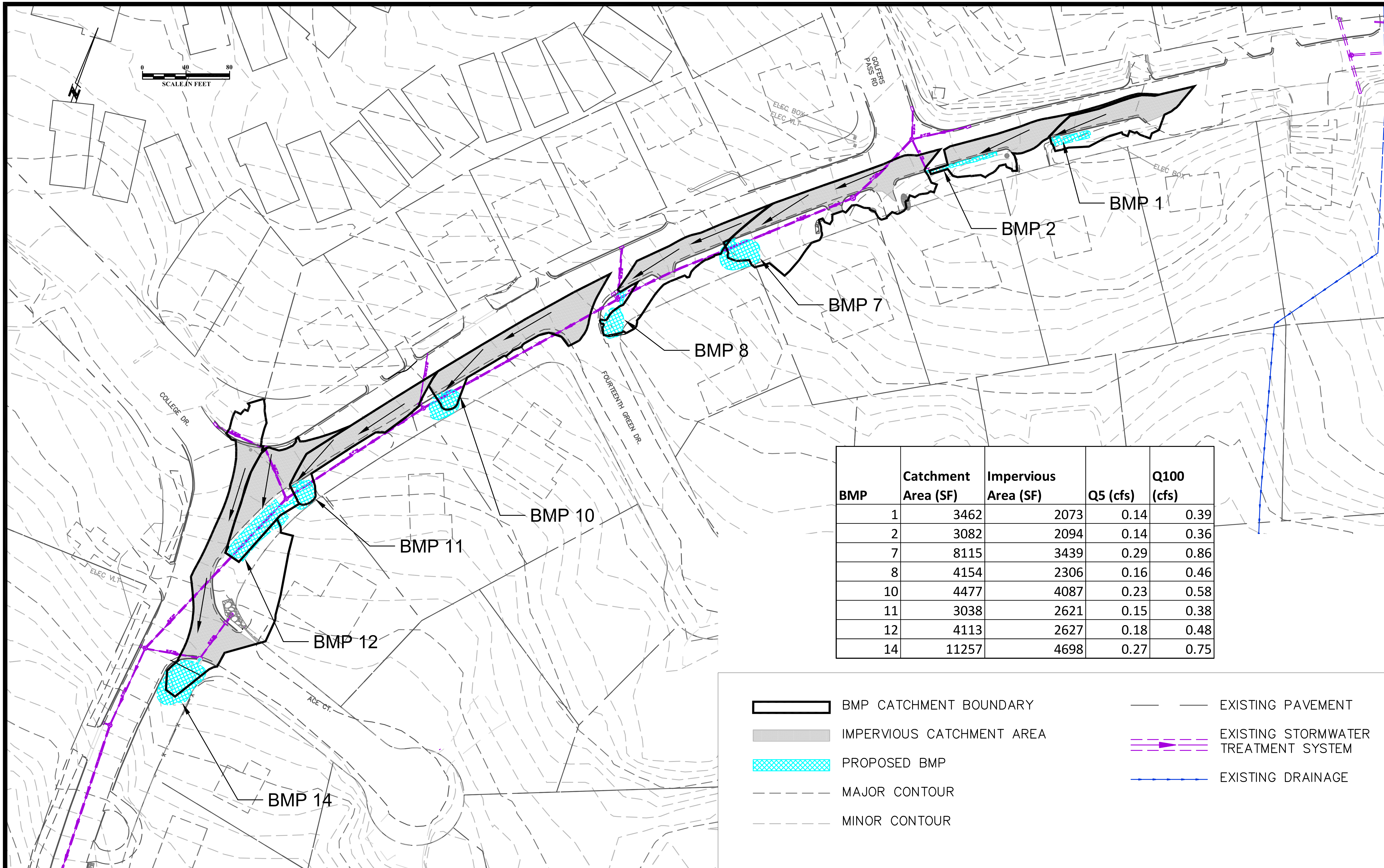


Figure 7. Location and extents of Ace and Harold Catchments based on 2-foot contours.



BMP	Catchment Area (SF)	Impervious Area (SF)	Q5 (cfs)	Q100 (cfs)
1	3462	2073	0.14	0.39
2	3082	2094	0.14	0.36
7	8115	3439	0.29	0.86
8	4154	2306	0.16	0.46
10	4477	4087	0.23	0.58
11	3038	2621	0.15	0.38
12	4113	2627	0.18	0.48
14	11257	4698	0.27	0.75

Figure 8. Extents of impervious and pervious contributing areas(catchments) to proposed BMPs.

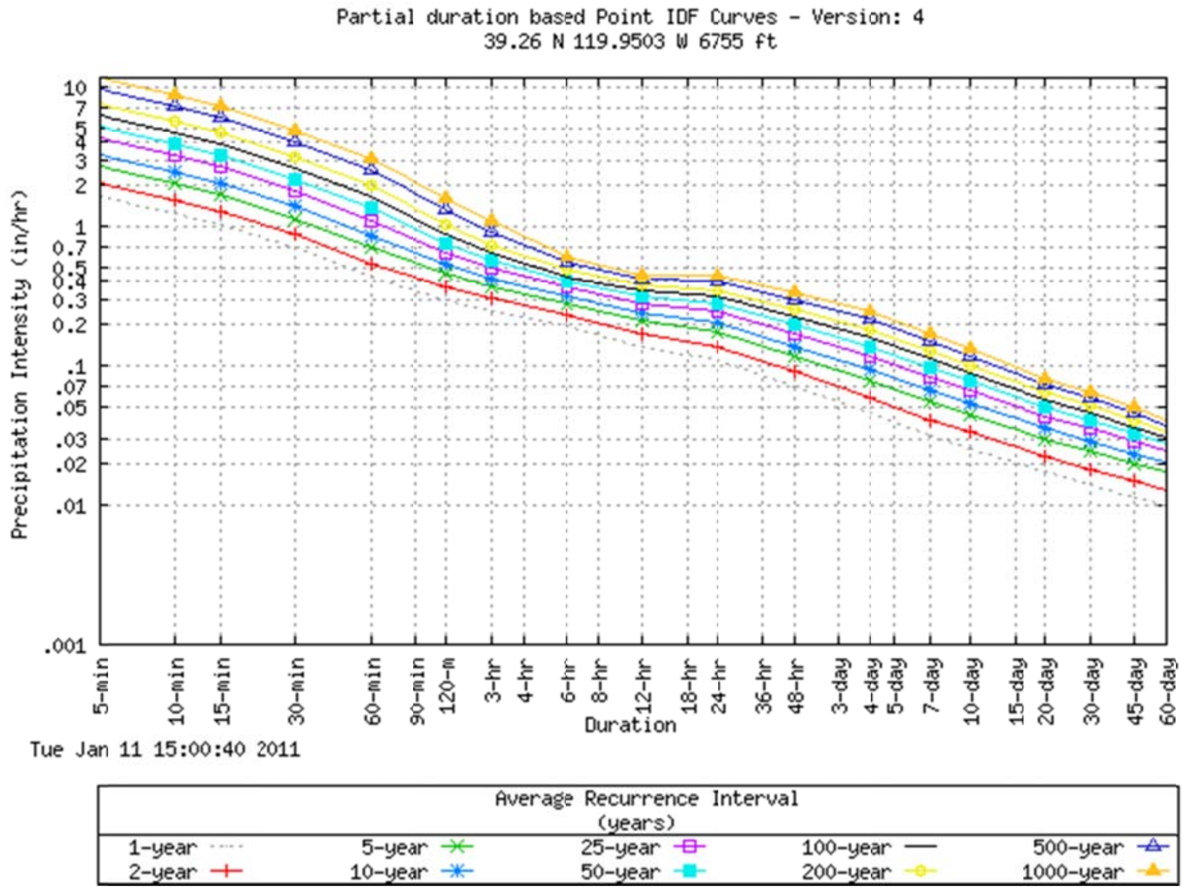


Figure 9. Precipitation intensity curves within project area. The 5-year and 100-year curves used to determine design and peak flows.

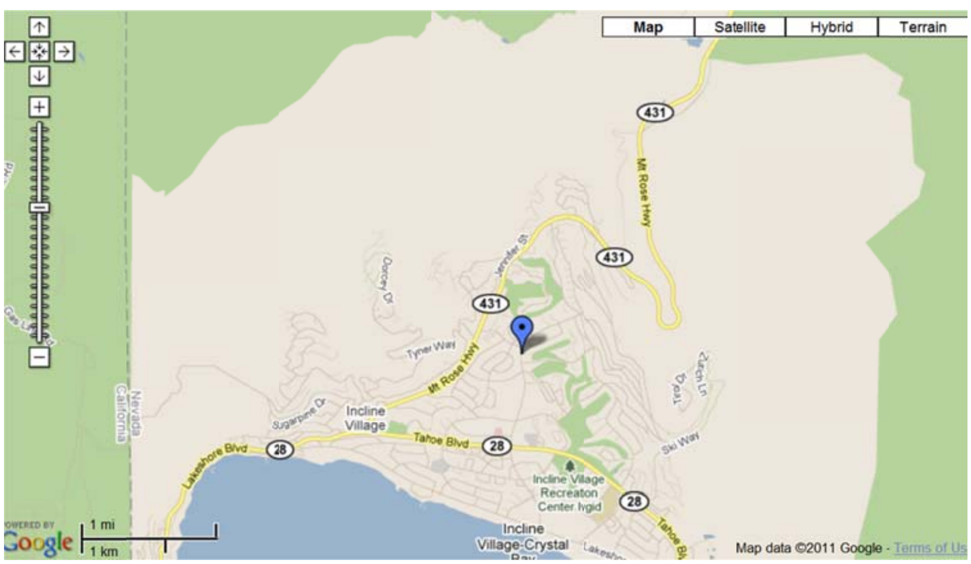


Figure 10. Location of precipitation data from NOAA.

Table 2. Results of Rational Method Calculations for each BMP (see Appendix D for detailed calculations).

BMP	Street A (sf)	SFD A (sf)	Total A (sf)	C_5	5 year t_i (min)	C_{100}	100 year t_i (min)	5 year t_c (min)	100 year t_c (min)	I_5 (in/hr)	I_{100} (in/hr)	Q_5 (cfs)	Q_{100} (cfs)
1	2073	1389	3462	0.71	3.7	0.80	2.9	4.29	3.44	2.5	6.22	0.14	0.39
2	2094	988	3082	0.74	1.7	0.82	1.3	2.54	2.14	2.7	6.22	0.14	0.36
7	3439	4676	8115	0.63	4.3	0.74	3.3	4.88	3.89	2.5	6.22	0.29	0.86
8	2306	1848	4154	0.69	4.0	0.78	3.1	4.40	3.49	2.5	6.22	0.16	0.46
10	4087	390	4477	0.83	0.0	0.89	0.0	0.53	0.53	2.7	6.22	0.19	0.46
11	2621	417	3038	0.82	0.0	0.88	0.0	0.52	0.52	2.7	6.22	0.15	0.38
12	2627	1486	4113	0.72	0.0	0.81	0.0	0.27	0.27	2.7	6.22	0.18	0.48
14	4698	6559	11257	0.63	4.3	0.74	3.3	5.21	4.22	1.69	3.95	0.27	0.75

3. DESIGN

GUIDING PRINCIPLES

LID design principles, low maintenance needs, and a focus on capturing sub-16 micron sediment were used to guide the design of the project. Working within the confines of the existing stormwater collection system forced the design to capture and treat the stormwater runoff before it was “lost” to the existing conveyance system. These constraints coupled with the LID philosophy and the focus on infiltration steered the project toward distributed small scale BMPs. The project gave preference to BMPs with low maintenance requirements, which are expected to integrate into the County’s current maintenance schedule. Economical and easily maintained BMPs were chosen over more highly engineered solutions requiring frequent maintenance at a higher cost. Rain gardens and bio-swales were designed to be self-maintaining by utilizing native plants to maintain infiltration rate through biological activity and annual growth and senescence of plant roots. Dense vegetation and direct-fall of pine needle will eliminate the need for mulch replenishment. The underground infiltration system (BMP 1) was designed to allow inspection and cleaning with existing County equipment unlike many previously installed underground systems.

SITE SELECTION

NTCD, along with Kris Klein and Dick Minto from Washoe County and Chuck Taylor, NRCS, walked the site along Village Boulevard and identified potential sites based on visual appearance of space and utility locations. The potential sites were added to LiDAR and topographic information. Sizes of sites were further evaluated based on mapped utility locations. Next, the square footage of the area draining to the curb at each site was modeled using hydrologic modeling tools in AutoCAD Civil 3D. The CAD tools use the TIN surface created from the LiDAR to determine the path of water along the surface and then associated boundaries of catchments. The LiDAR included the elevations of the curbs and gutters, but did not include microtopography or storm drain infrastructure and therefore these were manually adjusted with available survey information. The results of this analysis resulted in the BMP catchments discussed previously (Table 2). Sites were eliminated if the existing topographic data indicated no water would reach that area. Sites were also prioritized by the amounts of potential runoff that could reach them.

The site was visited again by NTCD staff as well as Michael Hogan from Integrated Environmental Restoration Services and feasibility of remaining sites were discussed. Washoe County Roads has pointed out wheel rutting in the roads that caused topography changes undetected in surveys. NTCD staff conducted a water pour exercise to test the accuracy of the CAD hydraulic model for each potential BMP site and to account for this microtopography due to asphalt overlays and wheel ruts. Because of the wheel rut issue and excessive physical constraints, the west side of Village was eliminated from the project area. Some sites located on the east side of Village were eliminated while others were added or relocated.

BMP TYPES

While the goal of this project was to test mainly offline, infiltration type LID treatments, the characteristics of some sites made them better candidates for flow-through treatments once a certain storm intensity was reached. Both BMPs 1 and 2 were originally designed as stormwater planters, however, the slopes in the area made safe curb heights hard to achieve without considerable construction cost. Because of the topography and width available, BMP 1 became an underground infiltration gallery with a double sediment trap. BMP 2 became a linear bio-swale because of the slope in the area and the narrow width and long length available. BMP 12 is designed to replace the existing Washoe County Public Works snow storage area, existing valley gutter and unimproved swale that drains to a small detention basin. Its unique design as a linear infiltration feature that receives overflow from BMP 11 is based on its existing conditions and available space. Appendix C contains the BMP Summary Table, which summarizes each BMP Type and its inlets type. Inlets are discussed in more detail later in this report.

TREATMENT CAPACITY

The BMPs in this project were designed to treat the largest storm possible given site constraints. Once the contributing areas and locations of the BMPs were determined, the BMP was sized within the allowable area. Factors such as property lines, slopes, trees, existing fences, and existing utilities often placed limitations on the extents of the BMP. For rain gardens, the bio-swale (BMP 2), and the linear infiltration feature (BMP 12), an Excel based BMP calculator based on the Type 2 hydrograph (Figure 11), Darcy's Law, and the Rational Method was used to determine the BMP's treatment capacity. For Darcy's Law, a conservative soil infiltration rate of 2"/hr was used even though engineering the soil will produce higher infiltration rates. Engineered soils are expected to have an infiltration rate between 4"/hr and 12"/hr. The 2"/hr figure was estimated from site-specific Constant Head Permeameter (CHP) measurements in the area that averaged 1.75"/hr as well as NRCS soil surveys for the area that predict rates of 4"/hr. Methods for establishing the properties of the existing soils are discussed in further detail earlier in this report under EXISTING SOILS.

For the underground infiltration BMPs (BMP 1), a target design storm of the 20 year, 1 hour Tahoe Basin storm was selected and the BMP was designed using the BMP Calculation Spreadsheet with Version 8 Soil Data developed by NRCS and available for download at http://www.tahoebmp.org/Documents.aspx and also available in Appendix D.

If rain gardens were found to treat storms in excess of the 100 year storm, they were reduced in size to reduce cost. Some BMPs were re-designed to accommodate a larger flow. BMP 10 and BMP 11 only treat the 5 and 1 year storms respectively; however, all of their excess runoff flows to BMP 12 and can be treated there. Calculations reveal that the combination of BMPs 11 and 12 treat the 25 year storm. Table 3 lists the Precipitation Depth (inches) for the designated storm frequency (Average Recurrence Interval). Treatment capacity for each BMP can be found in Table 4. Since BMP 2 and BMP 12 are flow-through BMPs and treat stormwater though filtration in addition to infiltration, their capacity may be larger than calculated because these equations only account for infiltration.

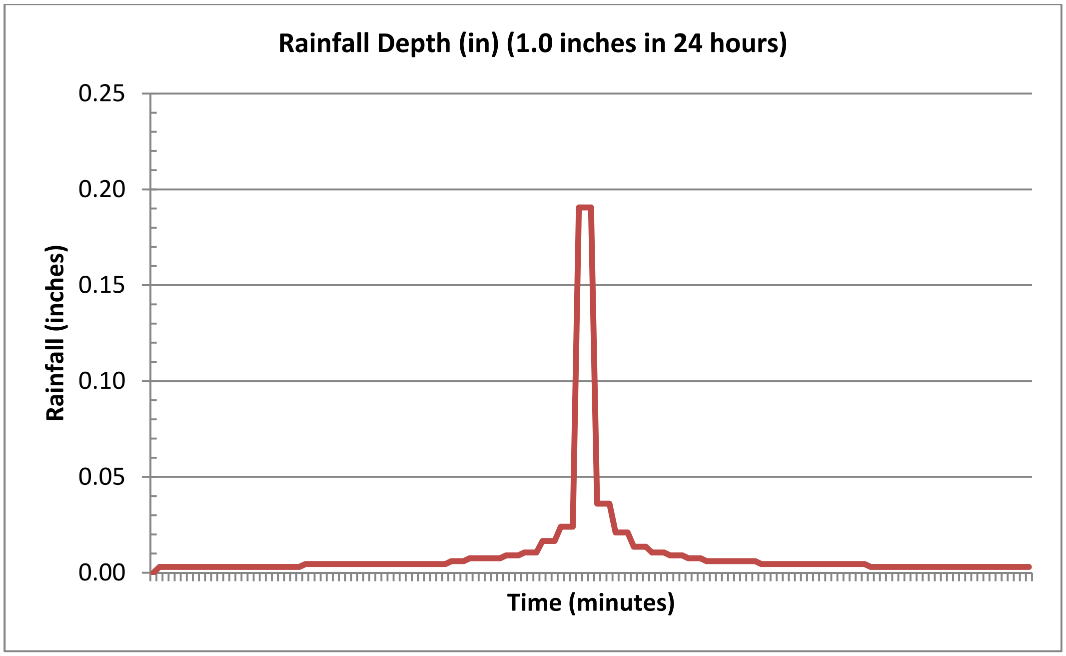


Figure 11. SCS Type II Unit Hydrograph used to calculate BMP capacity.

Table 3. Precipitation depth from NOAA Atlas 14 for 1 hour and 24 hour storms based on average recurrence interval.

Average Recurrence Interval	1 hr Storm Depth (in)	24 hr Storm Depth (in)
1	0.43	2.62
2	0.54	3.29
5	0.7	4.16
10	0.86	4.88
25	1.11	5.88
50	1.35	6.67
100	1.63	7.52
200	1.97	8.4
500	2.53	9.62
1000	3.06	10.6

Table 4. Capacity estimates for 1 hour storm based on calculated capture efficiency of inlet. (See Appendix D for calculations)

BMP	Treated 1 hr Storm Depth (in)	Approximate Average Recurrence Interval
1	1.00	20
2	1.12	27
7	1.38	56
8	1.38	57
10	0.80	8
11	0.41	1
12	2.26	324
11 and 12	1.34	50
14	1.79	141

PLRM RESULTS

The Pollutant Load Reduction Model (PLRM) was used to compare the pre-project and post-project effects on sub-16 micron sediment. Two catchments (Figure 12) were created within the large scale catchment of the project and these were combined into one outfall below BMP 14 at Ace Court. The lower catchment in the model has the LID features added. The PLRM showed that 42 percent (1.4 acres) of the primary road (Village Blvd.) drains to the LID features and predicted a 16 percent reduction in fine sediment particle load annually.

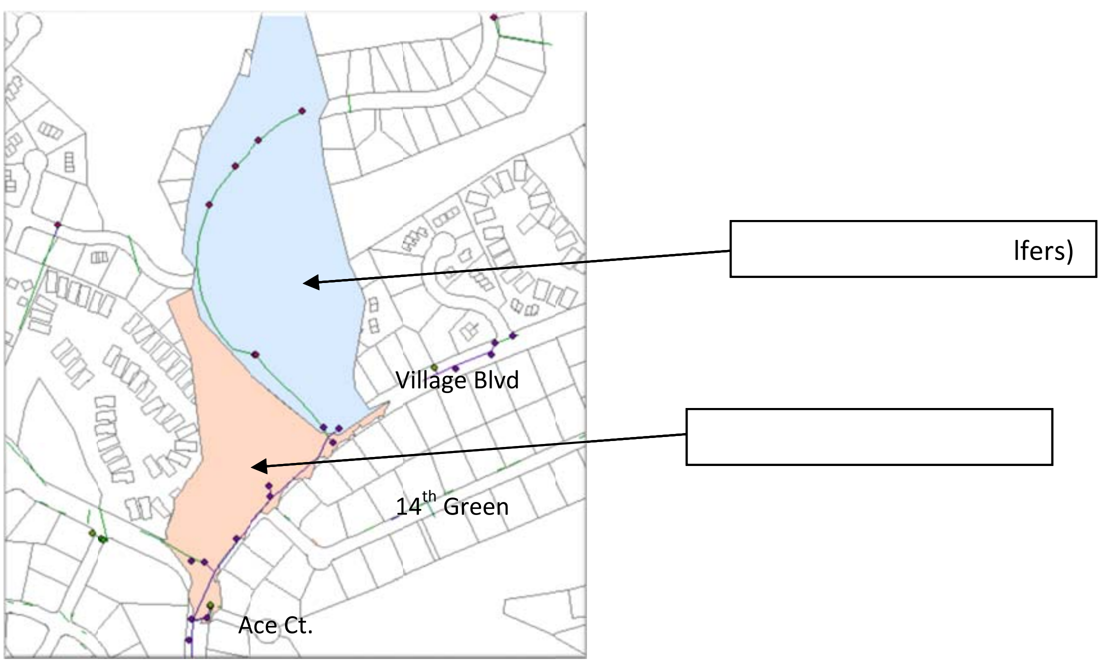


Figure 12. Upper and Lower (Ace) Catchments used for PLRM.

UNDERGROUND INFILTRATION DESIGN

An extensive literature review was conducted to choose the StormTech® SC-310 Chambers for the underground infiltration features – BMPs 1. The SC-310 units were chosen because they can be designed to be cleaned with existing Washoe County equipment including a vactor and/or water truck unlike other available underground units. BMP 1 receives runoff from over 2,000 square feet of runoff from pavement and so a double sediment trap was specified in order to reduce maintenance to the underground system. The first sediment trap is part of the curb inlet to the system. The curb inlet is located at the downhill end of the system so that the BMP will stop accepting water when it has reached its capacity (20 year, 1 hour storm). The second sediment trap is a cost effective circular pipe and will be retrofit with a filter sock as designed by Chuck Taylor from NRCS. This system filters out particles larger than 50 micron and larger. NTCD will install and maintain the filter sock with guidance from NRCS in order to test the effectiveness, maintenance requirements, and lifespan of the filter bag system in a public use. If after the two year monitoring period, the county is unwilling to accept maintenance of the filter sock, the sock will be removed; the BMP will still be fully functional. Appendix E has additional information about the NRCS filter bag system.

The SC-310 will be installed per the manufacturer's specifications with some modifications to the surrounding material to improve maintenance. Tenax Tendrain Triplanar Geonet is a filter fabric specified to be installed below each unit to withstand the pressures of either a vactor or pressurized water during cleaning. It will also be less susceptible to clogging since the voids are much larger than standard filter fabric.

RAIN GARDEN DESIGN

BMPs 7, 8, 10, 11, and 14 were ideal locations for rain gardens since the areas are relatively flat and wide with few trees and existing utility conflicts. The general design criterion for the rain garden berm height was 9 inches of freeboard from the maximum ponding height. With the exception of BMP 11, whose maximum ponding depth is 6 inches, maximum ponding depths are 12 inches for each rain garden. Even with a low infiltration rate of 1" per hour, BMPs would drain completely in 12 hours once full because the maximum ponding depth is only 12 inches (12 inches of ponded water infiltrating at 1" per hour takes a maximum of 12 hours). Nine inches of freeboard provides more than double the capacity if the overflow or inlet of any rain garden were to fail.

Berms are specified to have a 12 inch minimum top width and 3:1 inside slopes and 4:1 outside fill slopes. At the maximum ponding height, berms are 6.25 feet wide. The top width of 12 inches is wide enough to resist breaching, but narrow enough to discourage walking on. The native soils are currently compacted road shoulders and are ideal for achieving 90 percent compaction for the rain garden berms.

The bottoms of all rain gardens are flat. Bottom elevations were chosen to balance cut and fill as much as possible and work with the existing gutter elevation hydraulically. For BMPs where the engineer could not assure that flow would not enter once the BMP was at capacity, an emergency outlet was added. Emergency outlets are specified for BMPs 8, 11, and 14. Emergency outlets at BMPs 8 and 11 return the overflow to the original flow path. The emergency outlet at BMP 14 will likely never be activated since the BMP hydraulically isolates itself when the 12 inch ponding depth is met, however, if it were to be activated, it would return the stormwater to its original path 370 feet down the street, at the intersection of Village Blvd. and Driver Way. The Type 4R catch basin at Driver Way and the subsequent pipes have the capacity to handle this excess flow and surcharge calculations are available in Appendix D. Since emergency outlets will only be activated during the highest flows, eco-block swales were chosen to provide extra armoring. All overflow swales were designed using the 100 year flows (Table 2) combined with Manning's equation for flow in open channels. A conservative Manning's roughness coefficient (n) of 0.02 for eco-blocks was used. Inlet and outlet flow, velocity, and depth calculations are displayed in Table 5.

BMP 7 and BMP 10 are rain gardens that hydraulically isolate themselves once the maximum ponding depth of 12 inches is reached. When the rain gardens are at their maximum ponding depths and the sediment traps are full, water can no longer enter the curb inlet and will bypass to the next BMP or existing drainage inlet. These BMPs have no emergency overflow. Both BMPs 7 and 10 have curb inlets with single sediment traps and are fed runoff via vegetated swales.

BMP 8 receives flow from a curb inlet with a sediment trap via an 8 inch HDPE pipe. Runoff exits the HDPE pipe onto a flared end section (FES) and then across a rock dissipater to dissipate velocity. The bottom of the pipe is kept off the bottom of the BMP to reduce clogging and the associated maintenance. Because of the grade differential between the curb inlet and bottom elevation of BMP 8, it was impossible to design a hydraulically-isolating rain garden. Therefore an eco-block swale outlet is specified for BMP 8. The overflow would be utilized at storms above the volume of stormwater generated by a 20 year, 1 hour storm.

BMP 11 receives flow from a curb inlet with a sediment trap and an 8 inch HDPE pipe because of the steep slope from the road to the basin. Like BMP 8, flow from the HDPE pipe hits an FES and rock dissipater before entering the basin to avoid erosion. The size of BMP 11 was restricted due to existing utilities, trees, and the steep slope coming off the road. In addition, the required cut was too great to make a ponding depth of 12 inches, so BMP 11 is the only rain garden that has a ponding depth of 6 inches. Once this ponding depth is reached, BMP 11 overflows through a eco-block swale to BMP 12, a linear infiltration feature.

BMP 14 is the final BMP and rain garden at the southeast corner of Ace Ct. and Village Blvd. Tying into the existing drainage inlet (DI) presented a unique opportunity to capture additional flow from BMP 12's overflow as well as a large amount of street flow from the intersection of Village Blvd., Ace Ct., and College Blvd. Tying into the existing DI also saves money since it avoids the need to install a separate pre-treatment asset. The 8 inch HDPE pipe is placed 4 inches below the existing outlet pipe from the DI. When water in the DI ponds to the invert of the existing pipe (i.e., when the new pipe is half full), it will bypass BMP 14, therefore hydraulically isolating the BMP when its maximum ponding depth is reached. An eco-block swale overflow is included in the BMP 14 design in the event that large flows overwhelm both the new pipe and the existing pipe and continue to the fill the BMP because of head pressure. It is not expected that the overflow swale will be use unless there is clogging in the existing pipe or some other extreme event. Surcharge in the existing catch basin is not an issue at the 100 year flow rates and supporting calculations are available in Appendix D.

Table 5. Inlet and Outlet Calculations for Rain Gardens.

			Flow (cfs)		Velocity (ft/s)		Depth (ft)	
BMP	**Inlet or Outlet**	**Swale/Pipe Material (n)**	**5 year**	**100 year**	**5 year**	**100 year**	**5 year**	**100 year**
7	Inlet	Vegetated (0.03)	0.29	0.86	1.44	1.91	0.09	0.18
8	Inlet	HDPE Pipe (0.01)	0.16	0.46	6.64	9.08	0.08	0.14
8	Outlet	Eco-Block Swale (0.02)	N/A	0.46	N/A	1.71	N/A	0.16
10	Inlet	Vegetated Swale (0.03)	0.23	0.58	1.35	1.73	0.08	0.14
11	Inlet	HDPE Pipe (0.01)	0.15	0.38	6.22	8.20	0.08	0.13
11	Outlet	Eco-Block Swale (0.02)	N/A	0.38	N/A	2.35	N/A	0.11
14	Inlet	HDPE Pipe (0.01)	0.27	0.75	4.38	5.85	0.16	0.26
14	Outlet	Eco-Block Swale (0.02)	N/A	0.75	N/A	2.15	N/A	0.20

LINEAR LID FEATURE DESIGN

Linear LID features were determined to be a best fit for the sites of BMPs 2 and 12. BMP 2 is narrow and long with an existing slope of 4.4 percent. BMP 12 is wider and steeper (7 percent average slope) with an existing unimproved swale and the need to accommodate snow storage.

BMP 2 is a bio-swale with a 9 inch bottom width and 3:1 side slopes. The site is set within a road cut and the east side has an existing steep slope that will act as a berm and so no berm is necessary. The bio-swale provides 60 feet of treatment because the engineered soil readily promotes the infiltration along the flow path of the bio-swale. To prevent establishing locally high ground water, the final 17 feet of the bio-swale has a buried perforated pipe which is connected to the existing DI 8 inches above the invert of the existing conveyance. All water should be treated through either infiltration or filtration. Filtered stormwater would be runoff flowing through the plant roots and engineered soils into the perforated pipe. The perforated pipe enters DI without sharp angles so that it can be cleaned by the Washoe County Roads Department if necessary. If the perforated pipe were to clog or fail, water would flow out of the bio-swale through an emergency outlet, which is simply a curb cut above the existing DI. Results from flow, velocity, and depth calculations using Manning's equation are shown in Table 6 and Appendix D.

The site where BMP 12 is proposed presented a unique opportunity because there is an existing degraded swale entering a rock lined basin. This area is currently used for snow storage in the winter. A linear infiltration feature with rock weirs to create small ponding areas is proposed. The overflow will be to the existing rock lined basin which currently overflows to a stand pipe tied into the existing stormwater treatment system. Because the existing swale to the rock lined basin is unimproved, eco-blocks will be installed to line the swale between the proposed BMP 12 and the beginning of the rock lined basin.

Because the County currently uses BMP 12 for snow storage, the effects of snow load on the linear infiltration feature were considered. NTCD staff consulted with rain garden practitioners throughout the US and the consensus was that large quantities of snow did not degrade the infiltration capacity of the rain gardens. One practitioner from Nebraska noted that his rain gardens withstood six feet of snow piled on them throughout the winter and he has seen no decline in performance (Holm, 2010). Another expert from Villanova Center for the Advancement of Sustainability in Engineering noted that rain gardens used for snow storage actually treat the snow as it melts (Traver, 2010). An extensive study was conducted at the University of New Hampshire Center for Stormwater Treatment concluded that LID designs have a higher level of functionality during winter months than traditional BMPs (Roseen *et al.* 2009). Finally, a Minnesota study concluded that rain gardens maintain a high level of functionality throughout the winter months (Davidson *et al.*, 2008).

The existing valley gutter will be lowered to allow the stormwater to sheet flow off the road and enter the linear infiltration features. Through discussion with the Washoe County Roads Division Tahoe Supervisor, Dick Minto, it was decided that incorporating pre-treatment to this BMP inlet would be more maintenance than leaving it out. Therefore, BMP 12 is the only BMP without a dedicated sediment trap at the inlet. Instead, a 4-foot wide section of eco-blocks will form a ramp from the lowered valley gutter to the bottom of the BMP 12. A concrete cutoff wall will be installed at the base of the eco-blocks to prevent erosion and act as a level spreader to distribute the flow across the BMP. BMP 12 also receives overflow from BMP 11 via an eco-block swale.

Rock weirs delineate treatment areas in BMP 12 by allowing 9 inch drops between flat sections of engineered soil. The purpose of the first 4 weirs is simply as structure for these steep drops (not for impoundment) and therefore sedimentation of the weirs is not a problem and will not require additional maintenance. The slightly arced shape of the first 4 weirs is intended to keep water spread out, without putting added shear stresses on the side slopes of BMP 12. The final and fifth weir, at the tie-in with the existing swale, is designed to direct flow back to the center for conveyance, and therefore has a smaller arc radius.

The rocks in the rock weirs were sized using the US Army Corp of Engineers (USACE) guidelines for sizing rip rap in combination with the California Department of Transportation (CalTrans) guidelines for size rock weirs (see Appendix D for calculations). The USACE Stone Stability Design Chart provided the more conservative of the two results and was used to select a rock weight of ½ a ton. The D_{50} of granite this weight is 12 inches. The larger rock has the added benefit of easier maintenance as it will be easier to see when cleaning the linear infiltration feature. At the "downstream" end of the weirs, cobble is embedded to a 6 inches depth. Maximum scour depths were calculated as 1.5 inches based on CalTrans

Guidelines and using the equation $D = 1.14\,Dmnc\,(1.72 + (0.0084\,W/Dmnc)) - D_{mnc}$, where D_{mnc} is the maximum average depth above the weir, and so 6 inches of scour protection is conservative.

Because the slope falls away from the right-of-way towards an existing property, ample protection through a berm is prescribed for BMP 12's east side. The berm follows the same parameters as the rain garden berms, 12 inches minimum top width and 9 inches of freeboard above the maximum ponding depth.

Table 6. Flow, Velocity, and Depth Calculations for Linear LID Features (Appendix D).

			Flow (cfs)		Velocity (fps)		Depth (ft)	
BMP	**Manning's n**	**Slope (ft/ft)**	**5 year**	**100 year**	**5 year**	**100 year**	**5 year**	**100 year**
2	0.03	0.044	0.14	0.39	1.21	1.49	0.11	0.19
12	0.03	0.079	0.18	0.86	1.12	2.01	0.02	0.06
12 (outlet)	0.02	0.093	N/A	0.86	N/A	4.16	N/A	0.13

INLET DESIGN

Since this project was modeled after the Burnsville Minnesota Project, our initial design was for curb cut inlets to allow stormwater into the roadside LID features. Curb cuts are low impact, cost effective, and allow for hydraulic isolation once the feature has reached its treatment capacity. However, since the grade of Village Boulevard is somewhat steep in comparison to the site in Minnesota, Type 4R Catch Basins were considered. The HEC Urban Drainage Manual (HEC-22) states that typically grate inlets perform better on slopes steeper than 3 percent, however, they are highly susceptible to clogging which is documented along Tahoe Basin roads due to pine needle accumulation. HEC-22 also outlines the numerous advantages to curb-opening inlets, many of which would apply at Village Boulevard, including more efficiency with large amounts of floating debris. One way to increase the efficiency of a curb opening inlet is to add a depression or sump within the gutter. Adding a 2 inch depression to a curb inlet increases the flow interception efficiency to above many types of grate inlets (HEC-22) (see Figure 13).

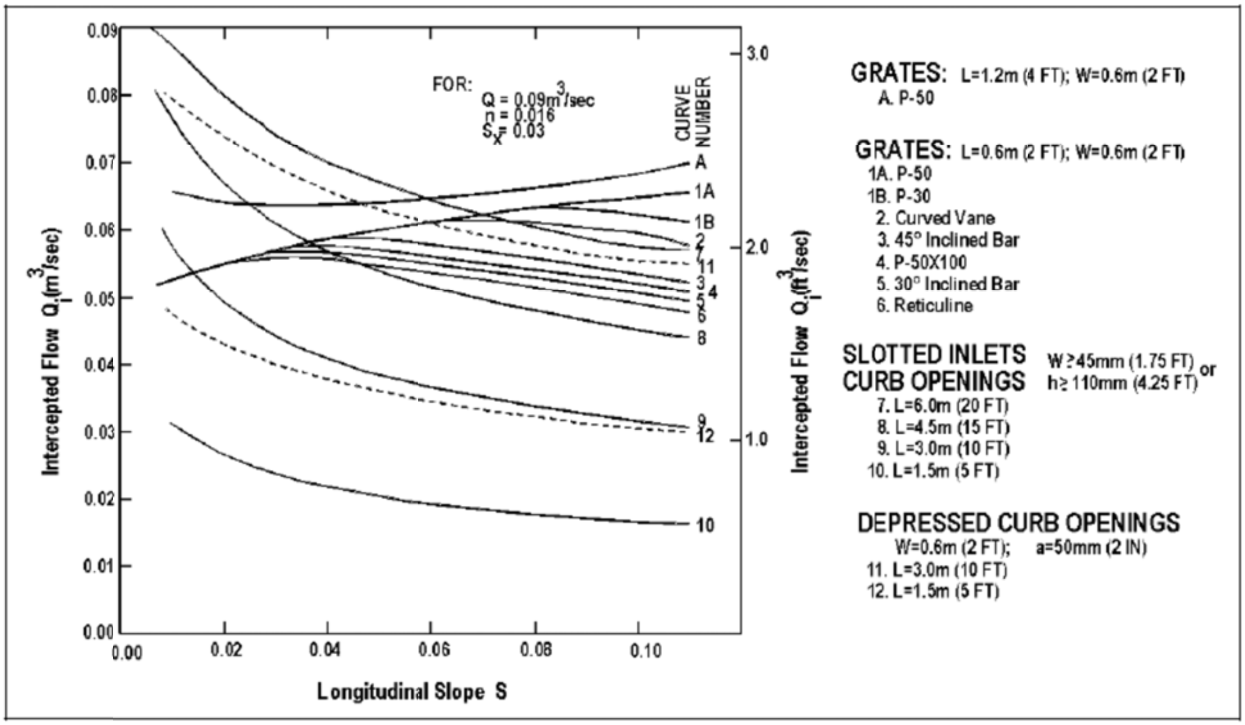


Figure 13. Comparison of inlet interception capacity on variable street grades (HEC-22 Figure 4-11).

Since the BMPs are located along areas of Village Boulevard with different grades and characteristics, a variety of inlets were designed (Table 7). BMPs 1, 2, 7, 8, and 10 have curb opening inlets with sumps. BMP 11 has a standard Type 4R Catch Basin inlet due to its steep roadside slope and vertical offset from the road to the basin that would make a vegetated swale too steep. BMP 12 has a single curb inlet because of its existing valley gutter and use as a snow storage area in the winter. Finally BMP 14 has an existing catch basin in an ideal location for an inlet and so a drain inlet splitter was utilized as the inlet.

To size curb inlet openings, the existing slopes and curb and gutter characteristics were input into the following equations:

$$Q = (0.56/n)S_x^{1.67}S_L^{0.5}T^{2.67}$$

Where Q is peak flow, n is a Manning's Roughness Coefficient (0.012 for concrete curb and gutter), S_x is the cross-slope of the flow area which is the gutter in this case, S_L is the longitudinal gutter slope, and T is the width of flow.

Once the flow within the gutter is calculated, the length for total interception (L_T) was calculated using the following equation from HEC-22:

$$L_T = 0.6Q^{0.42}S_L^{0.3}(1/nS_x)^{0.6}$$

Since this resulted in length much larger than safe or practical, reasonable shorter lengths were selected with the goal of capturing at least 70 percent of the stormwater flow – which is the efficiency of the existing Type 4R catch basins. To assess efficiency of these shorter lengths (L), efficiency of flow capture was calculated as:

$$E = 1 - (1 - L/L_T)^{1.8}$$

While the flow capture efficiencies within the 5 year storm were all above 80 percent, the flow capture efficiencies for the 100 year storm were not as high as desired. Adding a 3 inch depression to curb inlets increased the efficiency to a desired level. The new shorter L_T for each inlet resulted in an increased efficiency. Minimum curb inlet opening flow capture efficiency is 72.4 percent. The results of these calculations are summarized in Table 7.

Table 7. Summary of Inlet calculations. BMP 14 uses an existing drainage inlet and was not included in the calculation exercise.

BMP	S_L (ft/ft)	S_X (ft/ft)	Selected Length (L) (ft)	Without Sump		With 3" Sump	
				Efficiency at Q_5 (%)	Efficiency at Q_{100} (%)	Efficiency at Q_5 (%)	Efficiency at Q_{100} (%)
1	0.04	0.06	5	85.3%	63.1%	98.0%	78.5%
2	0.04	0.06	5	85.2%	64.8%	97.9%	80.3%
7	0.06	0.06	7	80.2%	57.5%	94.5%	72.4%
8	0.06	0.06	7	92.6%	70.7%	100.0%	86.2%
9	0.04	0.06	5	100%	88.6%	100%	99.5%
10	0.07	0.06	7	88.3%	68.8%	99.4%	84.3%
11	0.05	0.06	7	95.6%	77.3%	100%	92.2%
12	0.08	0.11	32	100%	100.0%	No depression required	

ENGINEERED SOILS

Rain garden design manuals recommend a bioinfiltration soil mix typically consisting of topsoil, sand and compost (Hinman, 2005., Prince George's, 2007.). The objective of a bioinfiltration soil mix is to balance the infiltration rate between adequate drawdown and pollutant removal while providing a healthy growing medium for long-term plant and soil health. Common guidelines for bioinfiltration soil mix are as follows:

1. Between 2 and 5 percent fine particles passing the #200 sieve.
2. Minimum organic matter content of 10 percent by dry weight.
3. Minimum 1 inch per hour K_{sat} and maximum of 12 inches per hour K_{sat}.
4. 24 inches minimum depth for nitrogen and phosphorus removal.

Existing in-situ soils do not exceed the recommended fine particle content, thus are acceptable for use as a component of a bioinfiltration soil mix. The average K_{sat} of existing soils exceeds 1 inch per hour. However, existing soils are very low in organic matter content as shown in Appendix D, thus will be amended with organic content. Consultations with Michael Hogan of Integrated Environmental Restoration Services cautioned against adding a high compost content (35-50% in a typical bioinfiltration soil mix (Hinman, 2005.)) to the bioinfiltration soil mix because it could lead to weed problems. Because native plants do not require a rich soil, acceptable organic matter content could be achieved through the addition of aged wood chips, which are readily available, will maintain soil structure, act as a moisture source during summer droughts, slowly degrade and build soils.

The existing soils in the project area do not currently support a population of invasive weeds, thus using the existing soils as a component of the bioinfiltration soil mix should pose no danger of future invasive weed infestation.

The existing in-situ soils will be amended to obtain a suitable bioinfiltration soil mix. Bioinfiltration soil mix will be created outside the rain garden using native soils from the excavated rain garden and soil amendments. The bioinfiltration soil mix shall consist of 50% native soil, 30% aged wood chips and 20% Full Circle Soil Essence Elite compost by volume.

Existing in-situ soils will be salvaged to be used for bioinfiltration soil mix and/or grading as specified in the plans and specifications and indicated in the field by the Engineer. The rain gardens will be excavated to allow for the placement of 36"of bioinfiltration soil mix as shown in the plans and as specified by the engineer. Side walls will be close to vertical to maximize the volume of infiltration media backfill and to simplify the calculations of needed materials. Sub-soils in the rain garden will be deeply and thoroughly scarified to a depth of eighteen (18) inches with a toothed backhoe to create a transition between existing soils and the bioinfiltration mix.

PLANT SELECTION

Vegetation helps to maintain the infiltration capacity of rain gardens thereby easing the expected maintenance (Clar *et al*., 2004). Maria Cahill (Green Girl Land Development Solutions, Portland, OR; www.greengirlpdx.com) suggested that at least one shrub, grass and groundcover species be planted in each rain garden. Native vegetation was given a preference over adapted vegetation due to easier maintenance of native vegetation concerning snow loading and anticipated summer drought. Herbaceous vegetation will be established in the project area from seed, while woody vegetation will be established from transplanted containerized plants.

Washoe County provided a sizing constraint of 18” on mature plant height due to sight distance considerations for right-of-way safety. The plants will likely see high snow loads from plowing the roads as well as high concentrations of stormwater pollutants. The selected plants must also be tolerant of periodic inundation of up to a foot of water for two days. Plants must also be drought tolerant to handle the long dry summers.

NTCD staff put together an initial list of candidate plants based off of the plant lists in the *Home Landscaping Guide for Lake Tahoe and Vicinity, Sierra Nevada Lawn and Garden* and *Native Plants for High-Elevation Western Gardens.* This initial list has been added to and refined as a result of conversations with: Michael Hogan from Integrated Environmental Restoration Services, who is currently installing two rain gardens in Nevada City, CA; John Cobourn of University of Nevada Cooperative Extension, Rachel Kozloski of NRCS and Ed Kleiner Jr. of Comstock Seed.

A seed mix of several native species was chosen due to cost constraints and a lack of data on which plant species would thrive in Tahoe rain gardens. Also, establishing a dense vegetative cover will obviate the need for future mulch replenishment, thereby lowering maintenance requirements.

Washoe County reviewed the proposed plant list and approved the seed mixes and woody plants in Appendix G for use in the project area.

4. PROJECT PERMITTING

The Hybrid BMP Project is approaching the permit process as if it were an EIP project spearheaded by Washoe County.

NEPA CATEGORICAL EXCLUSION

The National Environmental Policy Act (NEPA) Categorical Exclusion Document for the Hybrid BMP Project was submitted to the USFS for review on February 15, 2011. A Decision Memo indicating a Categorical Exclusion was issued May 10, 2011. The project utilized the Biological Evaluation, Wildlife Biological Assessment, Noxious Weed Risk Assessment and Cultural Resource Inventory Report from the Fairview/Fairway Phase III EIP project, since the projects overlap.

TRPA EIP PROJECT PERMIT

The TRPA EIP Project Review Application and Initial Environmental Checklist for the Hybrid BMP project were submitted to the TRPA on January 20, 2011. A review of the permit will occur once the TAC meets and reviews the 90% design plans.

WASHOE COUNTY ROAD CUT PERMIT

A Washoe County Road Cut Permit must be obtained by the Contractor prior to construction. The no-fee permit may be obtained at the Washoe County Roads Division Building, 625 Mount Rose Highway in Incline Village, NV.

STORMWATER POLLUTION PREVENTION PLAN (SWPPP)

The area of disturbance associated with the implementation of the project is expected to be less than an acre in size, therefore, does not trigger a Stormwater Pollution Prevention Plan.

WASHOE COUNTY DUST CONTROL PERMIT

The area of disturbance associated with the implementation of the project is expected to be less than an acre, therefore, does not trigger a Dust Control Permit.

5. PROJECT MAINTENANCE

NTCD staff produced a 'Rain Garden Maintenance Plan' (Appendix H) to outline anticipated inspection and maintenance activities of the rain gardens for Washoe County. The County currently does not maintain any rain gardens, thus this document was intended to be a primer on inspection and maintenance of rain gardens in the Tahoe Basin. The plan was produced from a review of the literature, experience regarding vegetation and infiltration basin maintenance in Tahoe and from conversations with Maria Cahill and Mike Isensee—two prominent experts in the field of rain garden design. As there are currently no rain gardens within the Tahoe Basin, exact maintenance is unknown. This maintenance plan will be refined and updated as actual rain garden inspection and maintenance are performed.

IRRIGATION

Irrigation will be provided to establish the vegetation in the project area by establishing an agreement with adjacent homeowners to access their water system. NTCD will maintain the irrigation for one to two growing seasons depending on plant establishment success and then remove temporary irrigation after plant establishment. Maintenance will include periodic checks to ensure proper functioning, coverage and water delivery of the irrigation system. More details are provided in the revegetation plan.

PRETREATMENT ASSETS

Each LID feature (except BMP 12) will include sediment traps at each inlet to capture coarse sediment before it enters the feature. The traps are designed to be cleaned with a Vactor truck. The traps will be located either in or just behind the curb so that regular street sweeping removes accumulated pine needles from their inlet grates and pans. Installation of the LID features is not expected to increase street sweeping or Vactoring frequency as the overall sediment load will be the same but more distributed with the additional assets. Sediment traps will reduce the amount of coarse sediment that enters each LID feature and therefore increase their lifespan by limiting surficial sediment accumulation.

VEGETATION

The LID features will be planted with low-maintenance, native vegetation approved by Washoe County for sight safety concerns. Regular irrigation is required for the first growing season and occasional irrigation the second year (performed by NTCD). Once vegetation is established, maintenance of the LID feature consists of periodic trash and debris removal. The LID features will also require removal of invasive weeds similar to other stormwater facilities and County right-of-ways. Thick vegetation in the LID features and a natural pine needle mulch supply from surrounding trees will obviate the need for mulch replenishment. BMP RAM protocols to determine vegetative cover should be followed annually as the LID features will be classified as 'infiltration features' according to BMP RAM. Desired percentage of vegetation differs from BMP RAM default values in that ideal vegetation percent cover in the LID features should be between 50 and 80 percent.

NTCD will maintain all revegetation areas following completion of work for 2 years, so that there is no evidence of erosion, such as rills or gullies. During the maintenance period, NTCD will identify and remove any noxious and invasive weeds (listed as Class One and Two weeds by the Lake Tahoe Basin Weed Coordinating Group) from the revegetation treatment areas.

After the 2 year maintenance period, Washoe County will assume maintenance responsibilities for the vegetation in accordance with their standard procedures. Properly designed and installed rain gardens require little maintenance once established. NTCD expects maintenance needs at the end of 2 years to be invasive weed and tree seedling removal.

INFILTRATION PERFORMANCE

Soils will be amended to increase infiltration and create a healthy growing medium. The City of Portland has experienced acceptable infiltration rates over the life of their rain gardens, some of which are 10 to 15 years old (Maria Cahill, Portland, OR, pers comm.). It is expected that once vegetation is established, the biological activity will maintain or even increase the infiltration rates of the soil. Other municipalities have experienced an *increase* in infiltration rates five years following construction, likely due to soil biological activity and the annual cycle of plant root growth and senescence (Mike Isensee, Burnsville, MN, pers. comm.). Thus, it is not expected that maintenance will include replacing the engineered soils of the rain gardens. However, since rain gardens have not been installed in the Tahoe basin, it's not known whether soil infiltration will be self-maintaining as in other regions.

The maintenance trigger for infiltration performance is ponding water for longer than 3 days or unsatisfactory infiltration performance using BMP RAM protocols for infiltration features. Loosening of the soil profile with a broadfork is the first step of soil reconditioning. If desired infiltration performance is not achieved, removal of the top inch of soil in late summer or aerating or tilling the top few inches of soil may restore desired infiltration. Revegetation is not necessary if care is taken not to destroy vegetation or remove the seed bank. If major soil reconditioning (soil replacement) is needed after years of proper function, then vegetation would have to be reestablished. In the event of early failure of the soil, Washoe County may elect to take the rain gardens off-line to avoid the maintenance burden associated with repeated, extensive soil reconditioning.

INSPECTION AND MAINTENANCE SCHEDULE

Maintenance of the rain gardens is required when inspections reveal the following:

- Trash, debris or sediment accumulation (determined visually, inspect twice annually)
    - Remove trash, debris and dispose of properly
    - Remove accumulated sediment and dispose of properly (ensure design depth of rain gardens is maintained)
- Weeds (use the same protocol and frequency for all county right of ways)
    - Remove invasive weeds and any tree seedlings to prevent their establishment
- Full sediment traps (inspect and maintain at the same frequency as existing catch basins along Village Blvd. using BMP RAM protocols)
    - Empty sediment traps and dispose of properly
- Pine needle obstruction of inlets
    - Remove pine needles from entry via regular street sweeping
- Ponding water for longer than 3 days or poor infiltration (using BMP RAM protocols for infiltration basins)
    - Loosen soil profile with broadfork **or** remove top inch of soil in gardens **or** aerate/till the top few inches of soil in late summer.

Refer to Table 8 Anticipated Rain Garden Inspection and Maintenance for a more detailed schedule.

Table 8. Anticipated Rain Garden Inspection and Maintenance Schedule.

Anticipated Rain Garden Inspection and Maintenance		
Task	Schedule	Responsibility
Irrigation	1" of water per week during the first growing season to establish vegetation. Possibly additional irrigation the second year.	NTCD (first 2 years)
Weeding	The LID features will be planted with native vegetation to improve infiltration and nutrient up take. Invasive weeds and tree seedlings are not desired in the LID features. Invasive weeds must be managed as in any stormwater treatment facility or County Right-of-Way.	NTCD (first 2 years) Washoe County thereafter
Street Sweeping	Four times a year and before and after major storm events. Removing pine needles from the drainage inlets is key for stormwater entry to the gardens.	Washoe County
Empty Sediment Traps	Follow the current schedule of twice a year. (Spring and Fall)	Washoe County
Remove Trash/Debris	Annually (same schedule as any other stormwater basin).	NTCD (first 2 years) Washoe County thereafter
BMP RAM	Use BMP RAM Field Observation Protocols for Infiltration Basins. Percent cover vegetation should be between 50 and 80 percent. Conduct annually, or as often as condition scores are desired	NTCD (first 2 years) Washoe County thereafter
Soil Reconditioning	Not Anticipated[1]. The experience of other municipalities is that reconditioning of bioretention basins is a very rare maintenance requirement. The vegetation is expected to maintain porosity and infiltration. Rain gardens often have a higher infiltration rate five years after construction, likely due to soil biological activity and the annual cycle of root growth and senescence[2]. In the unlikely event that desired infiltration is not maintained, loosening of the soil profile with a broad fork is recommended. Removal of the top inch of soil or aerating or tilling the top few inches of soil may in late summer also be performed to restore function.	Washoe County

[1] 7/20/10 Conversation with Maria Cahill of Green Girl Land Development Solutions.
[2] 7/22/10 Conversation with Mike Isensee of Dakota County Soil and Water Conservation District.

6. REFERENCES

Bannerman, R. and Considine, E. 2003. Rain Gardens: A How-to Manual for Homeowners. http://clean-water.uwex.edu/pubs/pdf/rgmanual.pdf

Busco, J. and Morin, N. R. 2003. Native Plants for High-Elevation Western Gardens.

Cahill, Maria. 2010. Vegetated Stormwater Facilities Technical Field Class (aka Rain Gardens 201). 19—22 July 2010.

California Regional Water Quality Control Board, Lahontan Region and Nevada Division of Environmental Protection (Lahontan and NDEP). 2010. Final Lake Tahoe Total Maximum Daily Load Report.

City of Burnsville. 2006. Burnsville Stormwater Retrofit Study. http://www.ci.burnsville.mn.us/DocumentView.aspx?DID=449

Clar, M., Barfield, B. J., and O'Connor, T. P. 2004. Stormwater Best Management Practices Design Guide Volume 2: Vegetative Biofilters. EPA-600-R04-121A.

Cobourn, J., Carlos, B., Christopherson, J., Donaldson, S., Johnson, W., Post, R., Skelly, J. and Smith, E. 2006. Home Landscaping Guide for Lake Tahoe and Vicinity. http://www.unce.unr.edu/publications/files/nr/2006/eb0601.pdf

Davidson, J. D., LeFevre, N. J., and Oberts, G. 2008. Hydrologic Bioretention Performance and Design Criteria for Cold Climates. Water Environment Research Foundation Project 04-DEC-13SG.

Environmental Services Division, Department of Environmental Resources, The Prince George's County, Maryland (Prince George's). Revised 2007. Bioretention Manual. http://www.princegeorgescountymd.gov/Government/AgencyIndex/DER/ESG/Bioretention/pdf/Bioretention%20Manual_2009%20Version.pdf Accessed August 23, 2010.

Hinman, Curtis. 2005. Low Impact Development: Technical Guidance Manual for Puget Sound.

Hinman, Curtis. 2009. Bioretention Soil Mix Review and Recommendations for Western Washington.

Holm, Kent. E-mail interview. 21 September 2010.

Isensee, Mikael. 2010. Telephone Conversation. 27 July 2010.

Lindberg, Michael. 2008. Civil Engineering Reference Manual for the PE Exam. 11th Edition.

Nevada Tahoe Conservation District. 2011. The Effectiveness of Street Sweeping in Incline Village, NV. (Draft).

NOAA's National Weather Service Hydrometeorological Design Studies Center Precipitation Frequency Data Server http://hdsc.nws.noaa.gov/hdsc/pfds/sa/nv_pfds.html

Roseen, R. M., Ballestero, T. P., Houle, J. J., Avelleneda, P., Wildey, R., & Briggs, J. 2006. Storm water low-impact development, conventional structural, and manufactured treatment strategies for parking lot runoff. *Transportation Research Record: Journal of the Transportation Research Board*. Vol. 1984 pp. 135-147.

Roseen, R. M., Ballestero, T. P., Houle, J. J., Avelleneda, P., Briggs, J., Fowler, G., & Wildey, R. 2009. Seasonal Performance Variations for Storm-Water Management Systems in Cold Climate Conditions. *Journal of Environmental Engineering.* Vol. March 2009 pp. 128—137. http://www.unh.edu/erg/cstev/pubs_specs_info/jee_3_09_unhsc_cold_climate.pdf

Sansalone, John. 2010. Myth, Modeling and Measurements of Urban Stormwater Treatment. Presentation to University of Nevada, Reno Hydrology Department, October 15, 2010, Reno, NV.

Sierra Nevada Alliance. 2010. Sierra Nevada Yard & Garden: A Homeowner's Guide to Landscaping in the Sierra Nevada. http://www.sierranevadaalliance.org/publications/SNLG/SNYG_lores.pdf

Traver, Robert. E-mail interview. 21 September 2010.

Truckee Meadows Regional Drainage Manual. April 30, 2009

United States Department of Agriculture, Natural Resources Conservation Service (USDA NRCS). 2007. Soil Survey of the Tahoe Basin Area, California and Nevada. Accessible online at: *http://soils.usda.gov/survey/printed_surveys/*. Accessed on June 14, 2010.

U.S. Soil Conservation Service. Technical Release 55: Urban Hydrology for Small Watersheds. USDA (U.S. Department of Agriculture). June 1986.

Virginia Department of Forestry. *Rain Gardens, A Landscape Tool to Improve Water Quality*. Publication VDOF 000127. http://www.dof.virginia.gov/ Accessed August 16, 2010.

Zarriello, Phillip J., Robert F. Breault, and Peter K. Weiskel, 2002, Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River, Massachusetts, USGS Water-Resources Investigations Report 02-4220

7. APPENDICES

APPENDIX A—Addresses within 300’ of Project

APN	NUM	DIR	STREET
12929001	0		PINION PINE WAY
12939004	895		PEEPSIGHT CT
12937007	854		LICHEN CT
12936004	856		LICHEN CT
12935000	0		GOLFERS PASS RD
12936002	856		LICHEN CT
12936003	856		LICHEN CT
12936001	856		LICHEN CT
12934004	880		GOLFERS PASS RD
12933001	900		GOLFERS PASS RD
12933003	900		GOLFERS PASS RD
12933002	900		GOLFERS PASS RD
12933004	900		GOLFERS PASS RD
12928023	0		ROSEWOOD CIR
12932000	0		GOLFERS PASS RD
12928024	0		ROSEWOOD CIR
13101316	628		VILLAGE BLVD
12932001	899		GOLFERS PASS RD
12932002	899		GOLFERS PASS RD
13101207	0		UNSPECIFIED
13101308	637		14TH GREEN DR
12929111	844		ROSEWOOD CIR
13101315	626		VILLAGE BLVD
12929110	848		ROSEWOOD CIR
12929109	852		ROSEWOOD CIR
12928013	609		VILLAGE BLVD
13101314	612		VILLAGE BLVD
12929108	856		ROSEWOOD CIR
12928014	607		VILLAGE BLVD
12929107	860		ROSEWOOD CIR
12937009	0		UNSPECIFIED
13101313	615		14TH GREEN DR
12928015	605		VILLAGE BLVD
12929102	882		ROSEWOOD CIR
12928016	603		VILLAGE BLVD
12939005	633		VILLAGE BLVD
13101231	604		14TH GREEN DR
12936000	0		LICHEN CT
13101230	600		VILLAGE BLVD
13101232	608		14TH GREEN DR
12939006	631		VILLAGE BLVD
13101229	900		ACE CT
12939007	629		VILLAGE BLVD
12408315	590		MC DONALD DR
12934000	0		GOLFERS PASS RD
12939008	627		VILLAGE BLVD
12408314	897	S	DYER CIR
13101319	646		VILLAGE BLVD
12934003	880		GOLFERS PASS RD
12933000	0		GOLFERS PASS RD
12928010	863		GOLFERS PASS RD
12934002	880		GOLFERS PASS RD
13101223	904		DRIVER WAY
12934001	880		GOLFERS PASS RD
13101318	634		VILLAGE BLVD
13101224	900		DRIVER WAY
12408330	575		VILLAGE BLVD
12928011	881		GOLFERS PASS RD
13101317	630		VILLAGE BLVD
12929114	826		ROSEWOOD CIR
12929113	832		ROSEWOOD CIR
12929112	838		ROSEWOOD CIR
12928012	611		VILLAGE BLVD
13101309	633		14TH GREEN DR
13101310	629		14TH GREEN DR
12929106	864		ROSEWOOD CIR
12929105	868		ROSEWOOD CIR
13101311	621		14TH GREEN DR
12929104	872		ROSEWOOD CIR
12929103	878		ROSEWOOD CIR
13101312	617		14TH GREEN DR
12928019	890		COLLEGE DR
12928018	898		COLLEGE DR
12928017	601		VILLAGE BLVD
12408334	591		VILLAGE BLVD
13101234	616		14TH GREEN DR
13101233	612		14TH GREEN DR
13101228	906		ACE CT
12408335	585		VILLAGE BLVD
13101226	901		ACE CT
13101227	905		ACE CT
12408313	893	S	DYER CIR
13101225	584		VILLAGE BLVD
12408312	891	S	DYER CIR

APPENDIX B—Soil Descriptions

7141 - Inville gravelly coarse sandy loam, 2 to 9 percent slopes, stony

Composition

°Inville and similar soils: 80 percent of the unit
°Christopher, Loamy coarse sand and similar soils: 10 percent of the unit
°Cassenai, gravelly loamy coarse sand and similar soils: 4 percent of the unit
°Jorge, very gravelly sandy loam and similar soils: 3 percent of the unit
°Kingsbeach and similar soils: 2 percent of the unit
°Aquic Xerorthents and similar soils: 1 percent of the unit

Setting

Landform(s) mountains, hillslopes on outwash terraces
Elevatio 6234 to 6955 feet
Precipitatio 19 to 33 inches

Slope 2 to 9 percent
Air temperature: 41 to 46 ºF
Frost-free 45 to 110 days

Characteristics of Inville and similar soils

Average total avail. water in top five feet 3.6
Available water capacity Low
Parent outwash derived from mixed
Restrictive none
Depth to Water none within the soil profile
Drainage well drained
Flooding none
Ponding none

Soil loss tolerance (T 5
Wind erodibility group 7
Wind erodibility index 38
Land capability class, irrigated:
Land capability class, non- 4e
Hydric soil: no
Hydrologic B
Runoff class: low
Potential frost moderate

Saturated hydraulic conductivity High

Representative soil profile:

Horizon --	Depth (inches)	Texture	Ksat	pH	Salinity (mmhos/cm)	SAR
Oi --	0 to 2	Slightly decomposed plant	56.7		0 - 0	0 - 0
A --	2 to 12	Gravelly coarse sandy loam	4.0	5.6 to 6.5	0 - 0	0 - 0
Bt --	12 to 37	Extremely cobbly sandy loam	4.0	5.6 to 6.5	0 - 0	0 - 0
C --	37 to 56	Extremely gravelly loamy coarse sand	21.3	5.6 to 6.5	0 - 0	0 - 0

Ecological class(es): NRCS Forestland Site - Pinus jeffreyi-Abies concolor/Ceanothus cordulatus-Ceanothus prostratus/Pedicularis semibarbata-Kelloggia

Tabular Data Version: 3
Tabular Data Version Date: 01/13/2007

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Brief Soil Descriptions (Tahoe)

Tahoe Basin Area, California and Nevada

[7142 - Inville gravelly coarse sandy loam, 9 to 15 percent slopes, stony]

7142 - Inville gravelly coarse sandy loam, 9 to 15 percent slopes, stony

Composition

- Inville and similar soils: 80 percent of the unit
- Cassenai, gravelly loamy coarse sand and similar soils: 10 percent of the unit
- Christopher, Gravelly Loamy Coarse Sand and similar soils: 4 percent of the unit
- Jorge, very gravelly sandy loam and similar soils: 3 percent of the unit
- Meeks, extremely bouldery and similar soils: 2 percent of the unit
- Aquic Xerorthents and similar soils: 1 percent of the unit

Setting

Landform(s) mountains, hillslopes on outwash terraces
Elevatio 6234 to 7251 feet
Precipitatio 21 to 37 inches

Slope 9 to 15 percent
Air temperature: 41 to 46 ºF
Frost-free 45 to 110 days

Characteristics of Inville and similar soils

Average total avail. water in top five feet 3.6
Available water capacity Low
Parent outwash derived from mixed
Restrictive none
Depth to Water none within the soil profile
Drainage well drained
Flooding none
Ponding none

Soil loss tolerance (T 5
Wind erodibility group 7
Wind erodibility index 38
Land capability class, irrigated:
Land capability class, non- 4e
Hydric soil: no
Hydrologic B
Runoff class: low
Potential frost moderate

Saturated hydraulic conductivity High

Representative soil profile:

Horizon --	Depth (inches)	Texture	Ksat	pH	Salinity (mmhos/cm)	SAR
Oi --	0 to 2	Slightly decomposed plant	56.7		0 - 0	0 - 0
A --	2 to 12	Gravelly coarse sandy loam	4.0	5.6 to 6.5	0 - 0	0 - 0
Bt --	12 to 37	Extremely cobbly sandy loam	4.0	5.6 to 6.5	0 - 0	0 - 0
C --	37 to 56	Extremely gravelly loamy coarse sand	21.3	5.6 to 6.5	0 - 0	0 - 0

Ecological class(es): NRCS Forestland Site - Pinus jeffreyi-Abies concolor/Ceanothus cordulatus-Ceanothus prostratus/Pedicularis semibarbata-Kelloggia

APPENDIX C—BMP Summary Table

BMP	Type	Total Area Treated in SF (Impervious Area)	Recurrence Interval of 1 hr Storm Treated	Features	Treatment Processes	Overflow
1	Subsurface Infiltration Units	3462 (2073)	20 yr	Curb inlet to NRCS sediment trap pre-treatment, Subsurface infiltration units, inspection ports	NRCS sediment trap settling and filtration (to 50 micron), 20 year storm void space storage allowing infiltration, hydraulically isolates when full	NO
2	Bioswale	3084 (2094)	27 yr	Curb inlet to sediment trap pre-treatment, shallow vegetated bioswale, 30" engineered soils, underdrain in last quarter (length) connected to existing DI, emergency overflow to road in the event that underdrain fails	Sediment trap settling, filtration through filter strip swale, infiltration through amended soils, excess runoff filtered through soil before exiting through underdrain to DI, overflow back to street in the event that underdrain fails	YES
7	Rain Garden	8115 (3439)	56 yr	Curb inlet to filter strip swale into vegetated rain garden with 30" engineered soils. Rain garden's maximum ponding depth is 12"	Catch basin settling, filtration along filter strip swale, infiltration through amended soils, hydraulically isolates itself when full	NO
8	Rain Garden	4154 (2306)	57 yr	Curb inlet to HDPE pipe with rock dissapater with 30" engineered soils. Curb cut overflow to street. Rain garden's maximum ponding depth is 12"	Catch basin settling, filtration within rock dissipater, infiltration through amended soils, overflow back to street through curb cut when ponding depth exceeds 12"	YES
10	Rain Garden	4477 (4087)	8 yr	Curb inlet to filter strip swale into vegetated rain garden with 30" engineered soils. Rain garden's maximum ponding depth is 12"	Catch basin settling, filtration along filter strip swale, infiltration through amended soils, hydraulically isolates itself when full	NO
11	Rain Garden	3038 (2621)	1 yr	Curb inlet to HDPE pipe with rock dissapater into vegetated rain garden with 30" engineered soils. Vegetated swale overflow to BMP 12. Rain garden's maximum ponding depth is 6"	Catch basin settling, filtration within rock dissipater, infiltration through amended soils, overflow to BMP 12 through vegetated swale when ponding depth exceeds 6"	YES
12	Linear Infiltration Feature	4113 (2627)	324 yr (50 yr w/ BMP 11 runoff)	Lowered valley gutter to eco-block ramp, filter strip swale, shallow vegetated bioswale with rock weirs to encourage infiltration, 30" engineered soils, emergency overflow to existing standpipe at Ace Ct.	Filtration through vegetated filter strip, infiltration through amended soils	YES
14	Rain Garden	11257 (4698)	141 yr	Existing type 4R catch basin to HDPE pipe into vegetated rain garden with 30" engineered soils. Curb cut overflow to street. Rain garden's maximum ponding depth is 12"	Catch basin settling, filtration within rock dissipater, infiltration through amended soils, overflow through curb cut to street when ponding depth exceeds 12"	YES

Appendix D: Engineering Calculations Contents

1. Rational Method
2. Inlet Efficiency Calculations
3. Manning's Calculations
4. BMP Capacity
    a. BMP 1
    b. BMP 2
    c. BMP 7
    d. BMP 10
    e. BMP 11
    f. BMP 12
    g. BMPs 11 and 12
    h. BMP 14
5. Surcharge Calculations
6. Weir Calculations
7. Average Recurrence Interval Estimation
8. NOAA Precipitation Charts

Rational Method Calculations

$V = 20.3282\sqrt{S}$

C5 = (0.45*A(sfd) + 0.88*A(paved))/A(total) — based on % of area

$ti5 = \frac{1.8(1.1 - C5)\sqrt{L}}{S^{1/3}}$

C100 = (0.6*A(sfd) + 0.93*A(paved))/A(total) — based of % of area

$ti100 = \frac{1.8(1.1 - C100)\sqrt{L}}{S^{1/3}}$

$Q = CiA$

BMP	Paved A (sf)	SFD (1/4 acre) A (sf)	Total A (sf)	Gutter Slope (S) (%)	Avg V (ft/s)*	Paved L (ft)	Travel time tt (min)	Land S (%)	Land L (Ft)	C5	ti5 (min)	C100	ti100 (min)	tc5 (min)	tc100 (min)	Total L (ft)	tc check (min)	Final tc5 (min)	i(5) (in/hr)	Final tc100 (min)	i(100) (in/hr)	Q5 (cfs)	Q100 (cfs)
ORIGIN	CAD	CAD	Sum	TIN Surface		CAD	tt = L/V	TIN Surface	CAD	C5 = (0.45*A(sfd) + 0.88*A(paved))/A(total)		C100 = (0.6*A(sfd) + 0.93*A(paved))/A(total)		=ti+tt	=ti+tt	Paved L + Land L	L/180+10	Min of tc check and tc5	from NOAA	Min of tc check and tc100	from NOAA		
1	2073	1389	3462	3.8	3.96	136	0.57	3.5	64	0.71	3.7	0.80	2.9	4.29	3.44	200	11.1	4.3	2.5	3.44	6.22	0.14	0.39
2	2094	988	3082	4	4.07	200	0.82	13.4	40	0.74	1.7	0.82	1.3	2.54	2.14	240	11.3	2.5	2.7	2.14	6.22	0.14	0.36
7	3439	4676	8115	7.2	5.45	190	0.58	7.4	99	0.63	4.3	0.74	3.3	4.88	3.89	289	11.6	4.9	2.5	3.89	6.22	0.29	0.86
8	2306	1848	4154	8.3	5.86	150	0.43	8.2	117	0.69	4.0	0.78	3.1	4.40	3.49	267	11.5	4.4	2.5	3.49	6.22	0.16	0.46
10	4087	390	4477	7.1	5.42	173	0.53	7.1	0	0.84	0.0	0.90	0.0	0.53	0.53	173	11.0	0.5	2.7	0.53	6.22	0.23	0.58
11	2621	417	3038	6.4	5.14	160	0.52	3.4	0	0.82	0.0	0.88	0.0	0.52	0.52	160	10.9	0.5	2.7	0.52	6.22	0.15	0.38
12	2627	1486	4113	7.8	5.68	93	0.27	7.2	0	0.72	0.0	0.81	0.0	0.27	0.27	93	10.5	0.3	2.7	0.27	6.22	0.18	0.48
14	4698	6559	11257	3.5	3.80	203	0.89	7.2	97	0.63	4.3	0.74	3.3	5.21	4.22	300	11.7	5.2	1.69	4.22	3.95	0.27	0.75

Variable	Description
A	Area
V	Velocity
S	Slope
L	Length
tt	travel time in gutter
tic	initial flow time
tc	time of concentration
C	runoff coefficient (based on land use and %)
tc check	this is a way to check tc calcs, use the minimum of the 2.

* C assumes 30% coverage (maximum allowed coverage in Tahoe basin)

**V calcs best suited for flow paths > 100ft

Inlet Calculations

$L_T = K_u Q^{0.42} S_L^{0.3} [1 / (n S_x)]^{0.6}$

$E = 1 - [1 - (L / L_T)]^{1.8}$

$V = \frac{K_u}{n} S_L^{0.5} S_X^{0.67} T^{0.67}$

$E_o = 1-(1-W/T)^{2.67}$

$Q = (K_u/n) S_x^{1.67} S_L^{0.5} T^{2.67}$

BMP	So	Sx (no sump)	Q5 (cfs)	Q100 (cfs)	T (constant - gutter never fills)	S(g)	V (fps)	L(t)5	L(t)100	Actual L	E5 (No Sump)	E100 (No Sump)	d w/ depr.	L open	a (in)	W	Eo	S(g) with depr.	Q in gutter	L5	L100	E5 (with Sump)	E100 (with Sump)
ORIGIN			rational method		std detail	std detail				selected by designer			add 3" depr		sump	see Fig 1				same as previous		same as previous	
1	0.042	0.028	0.14	0.39	1.4	0.0625	3.7406	7.62	11.75	5	0.85	0.631099932	0.43	4	0.25	3	0.9916375	0.10301	4.05	5.6493	8.712118	0.979637258	0.7847
2	0.042	0.005	0.14	0.36	1.4	0.0625	3.7406	7.65	11.35	5	0.85	0.648446831	0.43	4	0.25	3	0.9916375	0.10301	4.05	5.6696	8.412066	0.978615167	0.8029
7	0.064	0.025	0.29	0.86	1.4	0.0625	4.6175	11.80	18.48	7	0.80	0.575478477	0.43	4	0.25	3	0.9916375	0.10301	5	8.7447	13.69863	0.945049936	0.7241
8	0.062	0.039	0.16	0.46	1.4	0.0625	4.5448	9.14	14.15	7	0.93	0.70719149	0.43	4	0.25	3	0.9916375	0.10301	4.92	6.7775	10.49011	1	0.8621
10	0.071	0.03	0.23	0.58	1.4	0.0625	4.8635	11.05	16.14	7	0.84	0.640806005	0.43	4	0.25	3	0.9916375	0.10301	5.27	8.1885	11.95941	0.969010185	0.7949
11	0.053	0.026	0.15	0.38	1.4	0.0625	4.202	8.51	12.46	7	0.96	0.77343744	0.43	4	0.25	3	0.9916375	0.10301	4.55	6.3045	9.236483	1	0.9221
12	0.08	0.029	0.18	0.48	3	0.1111	12.645	7.35	10.93	60	1.00	1	0.43	4	3	3	0.9916375	0.11111	6.35		10.93395	1	1

*n = 0.012 for all calcs (Concrete gutter, troweled finish)

Variable	Description
So	Slope down street
Sx	Cross slope on street
Q5	five year flow (from rational method)
Q100	100 year flow (from rational method)
W	width of curb flow
S(g)	composite cross slope of gutter
V	velocity
L(t)	length required for total interception
d	depth
Actual L	length of recessed curb from curb
L open	length of opening

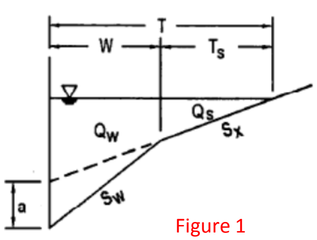


Figure 1

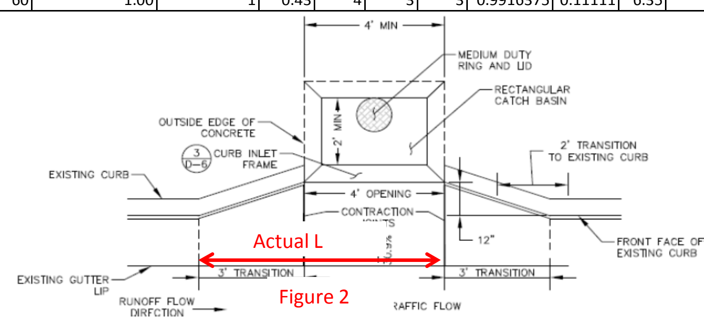


Figure 2

BMP	So (ft/ft)	Sx (ft/ft)	Selected Length (ft)	Without Sump		With 3" Sump	
				Efficiency at Q5 (%)	Efficiency at Q100 (%)	Efficiency at Q5 (%)	Efficiency at Q100 (%)
1	0.04	0.06	5	85.3%	63.1%	98.0%	78.5%
2	0.04	0.06	5	85.2%	64.8%	97.9%	80.3%
7	0.06	0.06	7	80.2%	57.5%	94.5%	72.4%
8	0.06	0.06	7	92.6%	70.7%	100.0%	86.2%
10	0.07	0.06	7	83.6%	64.1%	96.9%	79.5%
11	0.05	0.06	7	95.6%	77.3%	100.0%	92.2%
12	0.08	0.11	32	100.0%	100.0%	No sump	

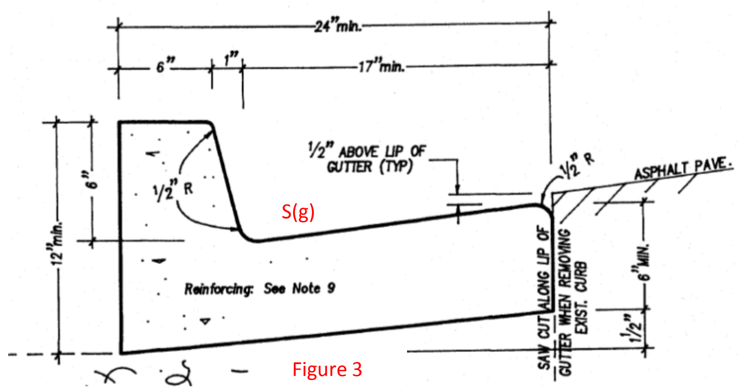


Figure 3

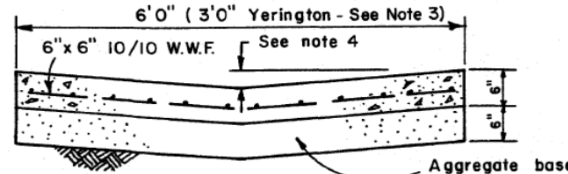


Figure 4

MANNINGS ROUGHNESS ASSUMPTIONS

n assumptions	Min	Norm	Max	
ACB	0.017	0.02	0.03	(max assumes mature grass)
Grass	0.03	0.04	0.05	
Rock	0.035			
Concrete	0.011	0.013	0.02	
HDPE		0.01		

LEGEND

(shaded)	calculated
(boxed)	input

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

BMP1 (5 year)

CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of water (y)	0.109	ft
DIA	0.66666667	ft
R	0.33333333	
cross sectional area (A_c)	0.03719551	ft2
wetted perimeter (P)	0.55502598	ft
channel slope (S)	0.024	ft/ft
hydraulic radius (R)	0.0670158	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.01	
mean velocity (v)	3.79818306	ft/s
channel flow (Q)	0.14127535	

BMP1 (100 yr)

CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of water (y)	0.181	ft
DIA	0.66667	ft
R	0.333335	
cross sectional area (A_c)	0.076633	ft2
wetted perimeter (P)	0.730786	ft
channel slope (S)	0.024	ft/ft
hydraulic radius (R)	0.104863	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.01	
mean velocity (v)	5.119249	ft/s
channel flow (Q)	0.392301	

USED TO CHECK OUTLETS OF SED CANS

Rectangular MANNINGS CALCULATOR

depth of water (y)	0.1	ft
base of trapezoid	6	ft
cross sectional area (A_c)	0.6	ft2
wetted perimeter (P)	6.2	ft
channel slope (S)	0.01	ft/ft
hydraulic radius (R)	0.096774194	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.03	
mean velocity (v)	1.044088379	ft/s
channel flow (Q)	0.626453027	

FROM RATIONAL METHOD

BMP	**Q5 (cfs)**	**Q100 (cfs)**
1	0.14	0.39
2	0.14	0.36
7	0.29	0.86
8	0.16	0.46
10	0.23	0.58
11	0.15	0.38
12	0.18	0.48
14	0.27	0.75

BMP2 (5 year)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	3	unitless
depth of water (y)	0.108	ft
base of trapezoid	0.75	ft
cross sectional area (A_c)	0.115992	ft2
wetted perimeter (P)	2.91	ft
channel slope (S)	0.044	ft/ft
hydraulic radius (R)	0.03985979	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.03	
mean velocity (v)	1.21240371	ft/s
channel flow (Q)	0.14062913	

BMP2 (100 yr)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	3	unitless
depth of water (y)	0.1852	ft
base of trapezoid	0.75	ft
cross sectional area (A_c)	0.241797	ft2
wetted perimeter (P)	4.454	ft
channel slope (S)	0.044	ft/ft
hydraulic radius (R)	0.054288	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.03	
mean velocity (v)	1.489674	ft/s
channel flow (Q)	0.360199	

BMP7 (5 yr)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	3	unitless
depth of water (D)	0.089	ft
base of trapezoid	2	ft
cross sectional area (A_c)	0.201763	ft2
wetted perimeter (P)	3.78	ft
channel slope (S)	0.042	ft/ft
hydraulic radius (R)	0.05337646	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.03	
mean velocity (v)	1.43909242	ft/s
channel flow (Q)	0.2903556	

BMP7 (100 yr)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	3	unitless
depth of water (D)	0.179	ft
base of trapezoid	2	ft
cross sectional area (A_c)	0.454123	ft2
wetted perimeter (P)	5.58	ft
channel slope (S)	0.042	ft/ft
hydraulic radius (R)	0.081384	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.03	
mean velocity (v)	1.906405	ft/s
channel flow (Q)	0.865742	

BMP8 (5 yr)

CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of water (y)	0.081	ft
DIA	0.66667	ft
R	0.333335	
cross sectional area (A_c)	0.02416137	ft2
wetted perimeter (P)	0.47472565	ft
channel slope (S)	0.106	ft/ft
hydraulic radius (R)	0.05089543	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.01	
mean velocity (v)	6.64442803	ft/s
channel flow (Q)	0.16053846	

BMP8 (100 yr)

CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of water (y)	0.1351	ft
DIA	0.66667	ft
R	0.333335	
cross sectional area (A_c)	0.050644	ft2
wetted perimeter (P)	0.622604	ft
channel slope (S)	0.106	ft/ft
hydraulic radius (R)	0.081342	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.01	
mean velocity (v)	9.082737	ft/s
channel flow (Q)	0.459988	

BMP8 outlet (100 yr)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	2	unitless
depth of water (D)	0.164	ft
base of trapezoid	1.3125	ft
cross sectional area (A_c)	0.269042	ft2
wetted perimeter (P)	2.9525	ft
channel slope (S)	0.013	ft/ft
hydraulic radius (R)	0.091123455	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.02	
mean velocity (v)	1.715460046	ft/s
channel flow (Q)	0.461530802	

BMP10 (5 yr)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	3	unitless
depth of water (D)	0.077	ft
base of trapezoid	2	ft
cross sectional area (A_c)	0.171787	ft2
wetted perimeter (P)	3.54	ft
channel slope (S)	0.042	ft/ft
hydraulic radius (R)	0.0485274	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.03	
mean velocity (v)	1.35055898	ft/s
channel flow (Q)	0.23200848	

BMP10 (100 yr)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	3	unitless
depth of water (D)	0.139	ft
base of trapezoid	2	ft
cross sectional area (A_c)	0.335963	ft2
wetted perimeter (P)	4.78	ft
channel slope (S)	0.042	ft/ft
hydraulic radius (R)	0.070285	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.03	
mean velocity (v)	1.728879	ft/s
channel flow (Q)	0.580839	

BMP11 (5 yr)

CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of water (y)	0.081	ft
DIA	0.66667	ft
R	0.333335	
cross sectional area (A_c)	0.02416137	ft2
wetted perimeter (P)	0.47472565	ft
channel slope (S)	0.093	ft/ft
hydraulic radius (R)	0.05089543	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.01	
mean velocity (v)	6.22366407	ft/s
channel flow (Q)	0.15037223	

BMP11 (100 yr)

CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of water (y)	0.127	ft
DIA	0.66667	ft
R	0.333335	
cross sectional area (A_c)	0.046352	ft2
wetted perimeter (P)	0.60222	ft
channel slope (S)	0.093	ft/ft
hydraulic radius (R)	0.076969	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.01	
mean velocity (v)	8.199836	ft/s
channel flow (Q)	0.380082	

BMP11 outlet (100 yr)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	2	unitless
depth of water (D)	0.106	ft
base of trapezoid	1.3125	ft
cross sectional area (A_c)	0.161597	ft2
wetted perimeter (P)	2.3725	ft
channel slope (S)	0.036	ft/ft
hydraulic radius (R)	0.06811254	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.02	
mean velocity (v)	2.35121014	ft/s
channel flow (Q)	0.379948505	

BMP12 (5 year)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	3	unitless
depth of water (y)	0.0244	ft
base of trapezoid	6.5	ft
cross sectional area (A_c)	0.16038608	ft2
wetted perimeter (P)	6.988	ft
channel slope (S)	0.079	ft/ft
hydraulic radius (R)	0.02295164	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.03	
mean velocity (v)	1.12439857	ft/s
channel flow (Q)	0.18033788	

BMP12 (100 yr)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	3	unitless
depth of water (y)	0.064	ft
base of trapezoid	6.5	ft
cross sectional area (A_c)	0.428288	ft2
wetted perimeter (P)	7.78	ft
channel slope (S)	0.079	ft/ft
hydraulic radius (R)	0.05505	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.03	
mean velocity (v)	2.014723	ft/s
channel flow (Q)	0.862882	

BMP12 OUTLET (100 year)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	2	unitless
depth of water (y)	0.131	ft
base of trapezoid	1.32	ft
cross sectional area (A_c)	0.207242	ft2
wetted perimeter (P)	2.63	ft
channel slope (S)	0.093	ft/ft
hydraulic radius (R)	0.07879924	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.02	
mean velocity (v)	4.164648051	ft/s
channel flow (Q)	0.863089991	

BMP14 (5 yr)

CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of water (y)	0.155	ft
DIA	0.66667	ft
R	0.333335	
cross sectional area (A_c)	0.06158826	ft2
wetted perimeter (P)	0.67086057	ft
channel slope (S)	0.021	ft/ft
hydraulic radius (R)	0.09180486	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.01	
mean velocity (v)	4.38233495	ft/s
channel flow (Q)	0.26990039	

BMP14 (100 yr)

CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of water (y)	0.264	ft
DIA	0.66667	ft
R	0.333335	
cross sectional area (A_c)	0.128647	ft2
wetted perimeter (P)	0.907513	ft
channel slope (S)	0.021	ft/ft
hydraulic radius (R)	0.141757	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.01	
mean velocity (v)	5.854532	ft/s
channel flow (Q)	0.753166	

BMP14 outlet (100 yr)

Trapezoid MANNINGS CALCULATOR

input	value	units
trapezoidal side slope (s)	2	unitless
depth of water (D)	0.203	ft
base of trapezoid	1.3125	ft
cross sectional area (A_c)	0.3488555	ft2
wetted perimeter (P)	3.3425	ft
channel slope (S)	0.017	ft/ft
hydraulic radius (R)	0.104369634	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.02	
mean velocity (v)	2.147481247	ft/s
channel flow (Q)	0.749160644	

BMP Calculation Spreadsheet with Version 8 Soil Data

Property Address:	628 VILLAGE BLVD	**570 Job class**	II
APN:	131-013-16 (APN lookup)	**558 Job Class**	I
Date:	6/10/11	**Total Drain Rock Quantity (yd^3)**	5.0
Designed By:	Meghan Kelly	**Total Runoff Calculated (ft^3)**	172.8
		Total Excavation (yd^3)	9.4

	MAP DATA	ON-SITE DEPTHS
Water Table:	>5ft	
Restriction:	None noted	
Max. Depth of Install:	67 in.	
Map Unit:	7141	

Contributing Surface	Other						
# of Stories	0						
Length (ft.)	1						
Width (ft.)	2073						
Area (ft^2)	2073	0	0	0	0	0	0
Runoff (ft^3)	**172.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Treatment Label:	**BMP1**						
Length (ft.)	28.5						
Width (in.)	46						
Depth (in.)	28						
On-Site Ksat ($^{in}/_{hr}$)	2.0						
mapped Ksat ($^{in}/_{hr}$)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Prefab Void Space (%)	100%						
Average Void Space (%)	69%						
Effective Volume (yd^3)	9.4	0.0	0.0	0.0	0.0	0.0	0.0
Treatment Capacity (ft^3)	**200.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Drain Rock Quantity (yd^3)	5.0	0.0	0.0	0.0	0.0	0.0	0.0
Excess Runoff (ft^3)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Excess Capacity (ft^3)	**27.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	0	0	0	0	0	0	0

			Total
Contributing Surface			
# of Stories			
Length (ft.)			
Width (ft.)			
Area (ft^2)	0	0	
Runoff (ft^3)	0.0	0.0	**0.0**
Treatment Label:			
Length (ft.)			
Width (in.)			
Depth (in.)			
On-Site Ksat ($^{in}/_{hr}$)			
mapped Ksat ($^{in}/_{hr}$)	4.0	4.0	
Prefab Void Space (%)			
Average Void Space (%)			
Effective Volume (yd^3)	0.0	0.0	
Treatment Capacity (ft^3)	0.0	0.0	**0.0**
Drain Rock Quantity (yd^3)	0.0	0.0	**0.0**
Excess Runoff (ft^3)			**0.0**
Excess Capacity (ft^3)			**0.0**
	0	0	

			Total
Contributing Surface			
# of Stories			
Length (ft.)			
Width (ft.)			
Area (ft^2)	0	0	
Runoff (ft^3)	0.0	0.0	**0.0**
Treatment Label:			
Length (ft.)			
Width (in.)			
Depth (in.)			
On-Site Ksat ($^{in}/_{hr}$)			
mapped Ksat ($^{in}/_{hr}$)	4.0	4.0	
Prefab Void Space (%)			
Average Void Space (%)			
Effective Volume (yd^3)	0.0	0.0	
Treatment Capacity (ft^3)	0.0	0.0	**0.0**
Drain Rock Quantity (yd^3)	0.0	0.0	**0.0**
Excess Runoff (ft^3)			**0.0**
Excess Capacity (ft^3)			**0.0**
	0	0	

			Total
Contributing Surface			
# of Stories			
Length (ft.)			
Width (ft.)			
Area (ft^2)	0	0	
Runoff (ft^3)	0.0	0.0	**0.0**
Treatment Label:			
Length (ft.)			
Width (in.)			
Depth (in.)			
On-Site Ksat ($^{in}/_{hr}$)			
mapped Ksat ($^{in}/_{hr}$)	4.0	4.0	
Prefab Void Space (%)			
Average Void Space (%)			
Effective Volume (yd^3)	0.0	0.0	
Treatment Capacity (ft^3)	0.0	0.0	**0.0**
Drain Rock Quantity (yd^3)	0.0	0.0	**0.0**
Excess Runoff (ft^3)			**0.0**
Excess Capacity (ft^3)			**0.0**
	0	0	

Contributing Surface			Total
# of Stories			
Length (ft.)			
Width (ft.)			
Area (ft^2)	0	0	
Runoff (ft^3)	0.0	0.0	**0.0**
Treatment Label:			
Length (ft.)			
Width (in.)			
Depth (in.)			
On-Site Ksat ($^{in}/_{hr}$)			
mapped Ksat ($^{in}/_{hr}$)	4.0	4.0	
Prefab Void Space (%)			
Average Void Space (%)			
Effective Volume (yd^3)	0.0	0.0	
Treatment Capacity (ft^3)	0.0	0.0	**0.0**
Drain Rock Quantity (yd^3)	0.0	0.0	**0.0**
Excess Runoff (ft^3)			**0.0**
Excess Capacity (ft^3)			**0.0**
	0	0	

				Total
Contributing Surface				
# of Stories				
Length (ft.)				
Width (ft.)				
Area (ft^2)	0	0	0	
Runoff (ft^3)	0.0	0.0	0.0	**0.0**
Treatment Label:				
Length (ft.)				
Width (in.)				
Depth (in.)				
On-Site Ksat ($^{in}/_{hr}$)				
mapped Ksat ($^{in}/_{hr}$)	4.0	4.0	4.0	
Prefab Void Space (%)				
Average Void Space (%)				
Effective Volume (yd^3)	0.0	0.0	0.0	
Treatment Capacity (ft^3)	0.0	0.0	0.0	**0.0**
Drain Rock Quantity (yd^3)	0.0	0.0	0.0	**0.0**
Excess Runoff (ft^3)				**0.0**
Excess Capacity (ft^3)				**0.0**
	0	0	0	

				Total
Contributing Surface				
# of Stories				
Length (ft.)				
Width (ft.)				
Area (ft^2)	0	0	0	
Runoff (ft^3)	0.0	0.0	0.0	**0.0**
Treatment Label:				
Length (ft.)				
Width (in.)				
Depth (in.)				
On-Site Ksat ($^{in}/_{hr}$)				
mapped Ksat ($^{in}/_{hr}$)	4.0	4.0	4.0	
Prefab Void Space (%)				
Average Void Space (%)				
Effective Volume (yd^3)	0.0	0.0	0.0	
Treatment Capacity (ft^3)	0.0	0.0	0.0	**0.0**
Drain Rock Quantity (yd^3)	0.0	0.0	0.0	**0.0**
Excess Runoff (ft^3)				**0.0**
Excess Capacity (ft^3)				**0.0**
	0	0	0	

					Total
Contributing Surface					
# of Stories					
Length (ft.)					
Width (ft.)					
Area (ft^2)	0	0	0	0	
Runoff (ft^3)	0.0	0.0	0.0	0.0	**0.0**
Treatment Label:					
Length (ft.)					
Width (in.)					
Depth (in.)					
On-Site Ksat ($^{in}/_{hr}$)					
mapped Ksat ($^{in}/_{hr}$)	4.0	4.0	4.0	4.0	
Prefab Void Space (%)					
Average Void Space (%)					
Effective Volume (yd^3)	0.0	0.0	0.0	0.0	
Treatment Capacity (ft^3)	0.0	0.0	0.0	0.0	**0.0**
Drain Rock Quantity (yd^3)	0.0	0.0	0.0	0.0	**0.0**
Excess Runoff (ft^3)					**0.0**
Excess Capacity (ft^3)					**0.0**
	0	0	0	0	

Basin

	2:1 (rock lined)				5:1 (mowable)			
Contributing Surface								
Length (ft.)								
Width (ft.)								
Area (ft^2)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Runoff (ft^3)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Treatment Label:								
Top Length (ft.)								
Top Width (ft.)								
Depth (in.)								
Bottom Length (ft.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Width (ft.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Volume (yd^3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
On-Site Ksat								
Mapped Ksat	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**
Treatment Capacity (ft^3)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Excess Runoff (ft^3)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Excess Capacity (ft^3)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Notes:

Deck Treatments

Contributing Surface				
Deck Length (ft.)				
Deck Width (ft.)				
Access Length (ft.)				
Access Width (ft.)				
Additional Treatment See				
Drain Rock Quantity (yd^3)				

Sheet:	**1**
of:	**1**

worksheet template date: 6/30/2010

United States Department of Agriculture
NRCS Natural Resources Conservation Service

This worksheet is intended to provide an estimate of proper dimensions of infiltration structures and represents no guarantee of the adequacy of overall system design.

Spreadsheet Illustrating Rain Garden Sizing
24 Hour Storms, NRCS Type 2 Rainfall Distribution

BMP 2

1 Hour Rainfall Depth =	1.173	in	Enter
Peak Rainfall Intensity =	2.00	in/hr	Calculated from distribution
Impervious Surface Square-Footage =	2094		Enter
Runoff Coefficient =	0.9		0.9 - 0.98 for imp surface
Rain Garden Square-Footage =	153.5		
Ratio of Rain Garden to Impervious Surface =	0.073		Calculated
Soil Infiltration Rate =	3	in/hr	Enter
Maximum Ponding Depth in Rain Garden =	4.00	in	
Depth of bioinfiltration soil below Rain Garden =	30.00	inches	
Void ratio for bioinfiltration soil =	27%	25% for eng soil, 40% for rock (1/8th roc	
Storage capacity of bioinfiltration soil=	103.23	cf	

(1) Time (min)	(2) Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Maximum Infiltration Rate (cfs)	(8) Inflow - Infiltration Rate (cfs)	(9) Inflow - Infiltration Volume (cf)	(10) Cumulative Inflow - Outflow (cf)	(11) Rock trench Ponding Depth (in)
0	0.0000	0.00	0.00	0	0	0.0106597	-0.01066	-0.2665	0.00	0.00
0.4167	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	0.10	0.03
0.8333	0.0012	0.17	0.01	0.18422	0.00106	0.0106597	-0.00329	-0.0823	0.02	0.01
1.25	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	0.12	0.04
1.6667	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	0.22	0.06
2.0833	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	0.33	0.09
2.5	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	0.43	0.12
2.9167	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	0.53	0.15
3.3333	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	0.63	0.18
3.75	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	0.73	0.21
4.1667	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	0.84	0.24
4.5833	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	0.94	0.27
5	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	1.04	0.30
5.4167	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	1.14	0.33
5.8333	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	1.24	0.36
6.25	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	1.34	0.39
6.6667	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	1.45	0.42
7.0833	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	1.55	0.45
7.5	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	1.65	0.48
7.9167	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	1.75	0.51
8.3333	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	1.85	0.54
8.75	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	1.96	0.57
9.1667	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	2.06	0.60
9.5833	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	2.34	0.68
10	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	2.45	0.71
10.417	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	2.73	0.79
10.833	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	2.83	0.82
11.25	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	3.12	0.91
11.667	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	3.41	0.99
12.083	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	3.51	1.02
12.5	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	3.80	1.10
12.917	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	4.08	1.19
13.333	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	4.18	1.22
13.75	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	4.47	1.30
14.167	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	4.76	1.38
14.583	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	4.86	1.41
15	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	5.14	1.49

15.417	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	5.43	1.58
15.833	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	5.90	1.71
16.25	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	6.19	1.80
16.667	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	6.47	1.88
17.083	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	6.94	2.02
17.5	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	7.23	2.10
17.917	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	7.52	2.18
18.333	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	7.99	2.32
18.75	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	8.27	2.40
19.167	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	8.56	2.49
19.583	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	9.03	2.62
20	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	9.31	2.71
20.417	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	9.79	2.84
20.833	0.0059	0.84	0.04	0.9211	0.00528	0.0106597	0.02618	0.6546	10.44	3.03
21.25	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	10.91	3.17
21.667	0.0059	0.84	0.04	0.9211	0.00528	0.0106597	0.02618	0.6546	11.56	3.36
22.083	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	12.04	3.50
22.5	0.0059	0.84	0.04	0.9211	0.00528	0.0106597	0.02618	0.6546	12.69	3.69
22.917	0.0059	0.84	0.04	0.9211	0.00528	0.0106597	0.02618	0.6546	13.34	3.88
23.333	0.0070	1.01	0.04	1.10532	0.00633	0.0106597	0.03355	0.8388	14.18	4.12
23.75	0.0059	0.84	0.04	0.9211	0.00528	0.0106597	0.02618	0.6546	14.84	4.31
24.167	0.0070	1.01	0.04	1.10532	0.00633	0.0106597	0.03355	0.8388	15.68	4.56
24.583	0.0070	1.01	0.04	1.10532	0.00633	0.0106597	0.03355	0.8388	16.52	4.80
25	0.0070	1.01	0.04	1.10532	0.00633	0.0106597	0.03355	0.8388	17.35	5.04
25.417	0.0082	1.18	0.05	1.28954	0.00739	0.0106597	0.04092	1.0230	18.38	5.34
25.833	0.0094	1.35	0.06	1.47376	0.00845	0.0106597	0.04829	1.2073	19.58	5.69
26.25	0.0082	1.18	0.05	1.28954	0.00739	0.0106597	0.04092	1.0230	20.61	5.99
26.667	0.0129	1.86	0.08	2.02642	0.01161	0.0106597	0.07040	1.7599	22.37	6.50
27.083	0.0129	1.86	0.08	2.02642	0.01161	0.0106597	0.07040	1.7599	24.13	7.01
27.5	0.0129	1.86	0.08	2.02642	0.01161	0.0106597	0.07040	1.7599	25.89	7.52
27.917	0.0188	2.70	0.12	2.94751	0.01689	0.0106597	0.10724	2.6810	28.57	8.30
28.333	0.0176	2.53	0.11	2.76329	0.01584	0.0106597	0.09987	2.4968	31.07	9.03
28.75	0.0188	2.70	0.12	2.94751	0.01689	0.0106597	0.10724	2.6810	33.75	9.81
29.167	0.1490	21.45	0.94	23.3959	0.13407	0.0106597	0.92518	23.1294	56.88	16.53
29.583	0.1478	21.28	0.93	23.2117	0.13302	0.0106597	0.91781	22.9452	79.82	23.20
30	0.1490	21.45	0.94	23.3959	0.13407	0.0106597	0.92518	23.1294	102.95	29.92
30.417	0.0282	4.05	0.18	4.42127	0.02534	0.0106597	0.16619	4.1548	107.10	30.00
30.833	0.0282	4.05	0.18	4.42127	0.02534	0.0106597	0.16619	4.1548	111.26	30.00
31.25	0.0282	4.05	0.18	4.42127	0.02534	0.0106597	0.16619	4.1548	115.41	30.00
31.667	0.0164	2.36	0.10	2.57908	0.01478	0.0106597	0.09250	2.3126	117.73	30.00
32.083	0.0152	2.20	0.10	2.39486	0.01372	0.0106597	0.08513	2.1284	119.86	30.00
32.5	0.0164	2.36	0.10	2.57908	0.01478	0.0106597	0.09250	2.3126	122.17	30.00
32.917	0.0106	1.52	0.07	1.65798	0.0095	0.0106597	0.05566	1.3915	123.56	30.00
33.333	0.0117	1.69	0.07	1.8422	0.01056	0.0106597	0.06303	1.5757	125.14	30.00
33.75	0.0106	1.52	0.07	1.65798	0.0095	0.0106597	0.05566	1.3915	126.53	30.00
34.167	0.0082	1.18	0.05	1.28954	0.00739	0.0106597	0.04092	1.0230	127.55	30.00
34.583	0.0082	1.18	0.05	1.28954	0.00739	0.0106597	0.04092	1.0230	128.57	30.00
35	0.0082	1.18	0.05	1.28954	0.00739	0.0106597	0.04092	1.0230	129.60	30.00
35.417	0.0070	1.01	0.04	1.10532	0.00633	0.0106597	0.03355	0.8388	130.43	30.00
35.833	0.0059	0.84	0.04	0.9211	0.00528	0.0106597	0.02618	0.6546	131.09	30.00
36.25	0.0070	1.01	0.04	1.10532	0.00633	0.0106597	0.03355	0.8388	131.93	30.00
36.667	0.0059	0.84	0.04	0.9211	0.00528	0.0106597	0.02618	0.6546	132.58	30.00
37.083	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	133.05	30.00
37.5	0.0059	0.84	0.04	0.9211	0.00528	0.0106597	0.02618	0.6546	133.71	30.00
37.917	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	134.18	30.00
38.333	0.0059	0.84	0.04	0.9211	0.00528	0.0106597	0.02618	0.6546	134.83	30.00
38.75	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	135.30	30.00
39.167	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	135.77	30.00

39.583	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	136.24	30.00
40	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	136.71	30.00
40.417	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	137.18	30.00
40.833	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	137.65	30.00
41.25	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	138.13	30.00
41.667	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	138.41	30.00
42.083	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	138.88	30.00
42.5	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	139.17	30.00
42.917	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	139.45	30.00
43.333	0.0047	0.68	0.03	0.73688	0.00422	0.0106597	0.01882	0.4704	139.92	30.00
43.75	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	140.21	30.00
44.167	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	140.50	30.00
44.583	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	140.78	30.00
45	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	141.07	30.00
45.417	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	141.36	30.00
45.833	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	141.46	30.00
46.25	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	141.74	30.00
46.667	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	142.03	30.00
47.083	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	142.13	30.00
47.5	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	142.42	30.00
47.917	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	142.70	30.00
48.333	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	142.81	30.00
48.75	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	143.09	30.00
49.167	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	143.19	30.00
49.583	0.0035	0.51	0.02	0.55266	0.00317	0.0106597	0.01145	0.2862	143.48	30.00
50	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	143.58	30.00
50.417	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	143.68	30.00
50.833	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	143.79	30.00
51.25	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	143.89	30.00
51.667	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	143.99	30.00
52.083	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	144.09	30.00
52.5	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	144.19	30.00
52.917	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	144.30	30.00
53.333	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	144.40	30.00
53.75	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	144.50	30.00
54.167	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	144.60	30.00
54.583	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	144.70	30.00
55	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	144.81	30.00
55.417	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	144.91	30.00
55.833	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	145.01	30.00
56.25	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	145.11	30.00
56.667	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	145.21	30.00
57.083	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	145.32	30.00
57.5	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	145.42	30.00
57.917	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	145.52	30.00
58.333	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	145.62	30.00
58.75	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	145.72	30.00
59.167	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	145.82	30.00
59.583	0.0012	0.17	0.01	0.18422	0.00106	0.0106597	-0.00329	-0.0823	145.74	30.00
60	0.0023	0.34	0.01	0.36844	0.00211	0.0106597	0.00408	0.1019	145.84	30.00
60.417	0.0000	0.00	0.00	0	0	0.0106597	-0.01066	-0.2665	145.58	30.00
60.833	0.0000	0.00	0.00	0	0	0.0106597	-0.01066	-0.2665	145.31	30.00
	1.17			0	**1.06**					

Spreadsheet Illustrating Rain Garden Sizing
24 Hour Storms, NRCS Type 2 Rainfall Distribution

BMP 7

1 Hour Rainfall Depth =	1.788	in	Enter
Peak Rainfall Intensity =	2.00	in/hr	Calculated from distribution
Impervious Surface Square-Footage =	3439		Enter
Runoff Coefficient =	0.9		0.9 - 0.98 for imp surface
Rain Garden Square-Footage =	270		
Ratio of Rain Garden to Impervious Surface =	0.079		Calculated
Soil Infiltration Rate =	3	in/hr	Enter
Maximum Ponding Depth in Rain Garden =	12.00	in	Calculated
Depth of bioinfiltration soil below Rain Garden =	30.00	inches	
Void ratio for bioinfiltration soil =	25%	25% for bioinf soil	
Storage capacity of bioinfiltration soil=	168.75	cf	

(1) Time (min)	(2) Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Maximum Infiltration Rate (cfs)	(8) Inflow - Infiltration Rate (cfs)	(9) Inflow - Infiltration Volume (cf)	(10) Cumulative Inflow - Outflow (cf)	(11) Rock trench Ponding Depth (in)
0	0.0000	0.00	0.00	0	0	0.01875	-0.01875	-0.4688	0.00	0.00
0.4167	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	0.45	0.08
0.8333	0.0018	0.26	0.02	0.46117	0.00161	0.01875	-0.00030	-0.0076	0.45	0.08
1.25	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	0.90	0.16
1.6667	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	1.35	0.24
2.0833	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	1.81	0.32
2.5	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	2.26	0.40
2.9167	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	2.71	0.48
3.3333	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	3.17	0.56
3.75	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	3.62	0.64
4.1667	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	4.07	0.72
4.5833	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	4.53	0.81
5	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	4.98	0.89
5.4167	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	5.44	0.97
5.8333	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	5.89	1.05
6.25	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	6.34	1.13
6.6667	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	6.80	1.21
7.0833	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	7.25	1.29
7.5	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	7.70	1.37
7.9167	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	8.16	1.45
8.3333	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	8.61	1.53
8.75	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	9.06	1.61
9.1667	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	9.52	1.69
9.5833	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	10.43	1.85
10	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	10.89	1.94
10.417	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	11.80	2.10
10.833	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	12.25	2.18
11.25	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	13.17	2.34
11.667	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	14.08	2.50
12.083	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	14.54	2.58
12.5	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	15.45	2.75
12.917	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	16.37	2.91
13.333	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	16.82	2.99
13.75	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	17.74	3.15
14.167	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	18.65	3.32
14.583	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	19.10	3.40
15	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	20.02	3.56
15.417	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	20.93	3.72

15.833	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	22.31	3.97
16.25	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	23.22	4.13
16.667	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	24.14	4.29
17.083	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	25.51	4.54
17.5	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	26.43	4.70
17.917	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	27.34	4.86
18.333	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	28.72	5.11
18.75	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	29.63	5.27
19.167	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	30.55	5.43
19.583	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	31.93	5.68
20	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	32.84	5.84
20.417	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	34.22	6.08
20.833	0.0089	1.29	0.09	2.30585	0.00805	0.01875	0.07348	1.8371	36.05	6.41
21.25	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	37.43	6.65
21.667	0.0089	1.29	0.09	2.30585	0.00805	0.01875	0.07348	1.8371	39.27	6.98
22.083	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	40.64	7.23
22.5	0.0089	1.29	0.09	2.30585	0.00805	0.01875	0.07348	1.8371	42.48	7.55
22.917	0.0089	1.29	0.09	2.30585	0.00805	0.01875	0.07348	1.8371	44.32	7.88
23.333	0.0107	1.54	0.11	2.76702	0.00966	0.01875	0.09193	2.2983	46.61	8.29
23.75	0.0089	1.29	0.09	2.30585	0.00805	0.01875	0.07348	1.8371	48.45	8.61
24.167	0.0107	1.54	0.11	2.76702	0.00966	0.01875	0.09193	2.2983	50.75	9.02
24.583	0.0107	1.54	0.11	2.76702	0.00966	0.01875	0.09193	2.2983	53.05	9.43
25	0.0107	1.54	0.11	2.76702	0.00966	0.01875	0.09193	2.2983	55.35	9.84
25.417	0.0125	1.80	0.13	3.22819	0.01126	0.01875	0.11038	2.7594	58.11	10.33
25.833	0.0143	2.06	0.15	3.68936	0.01287	0.01875	0.12882	3.2206	61.33	10.90
26.25	0.0125	1.80	0.13	3.22819	0.01126	0.01875	0.11038	2.7594	64.09	11.39
26.667	0.0197	2.83	0.20	5.07287	0.0177	0.01875	0.18416	4.6041	68.69	12.21
27.083	0.0197	2.83	0.20	5.07287	0.0177	0.01875	0.18416	4.6041	73.29	13.03
27.5	0.0197	2.83	0.20	5.07287	0.0177	0.01875	0.18416	4.6041	77.90	13.85
27.917	0.0286	4.12	0.30	7.37872	0.02575	0.01875	0.27640	6.9100	84.81	15.08
28.333	0.0268	3.86	0.28	6.91755	0.02414	0.01875	0.25795	6.4488	91.26	16.22
28.75	0.0286	4.12	0.30	7.37872	0.02575	0.01875	0.27640	6.9100	98.17	17.45
29.167	0.2271	32.70	2.34	58.5686	0.20437	0.01875	2.32399	58.0998	156.27	27.78
29.583	0.2253	32.44	2.32	58.1074	0.20276	0.01875	2.30555	57.6387	213.91	30.00
30	0.2271	32.70	2.34	58.5686	0.20437	0.01875	2.32399	58.0998	272.01	30.00
30.417	0.0429	6.18	0.44	11.0681	0.03862	0.01875	0.42397	10.5993	282.60	30.00
30.833	0.0429	6.18	0.44	11.0681	0.03862	0.01875	0.42397	10.5993	293.20	30.00
31.25	0.0429	6.18	0.44	11.0681	0.03862	0.01875	0.42397	10.5993	303.80	30.00
31.667	0.0250	3.60	0.26	6.45638	0.02253	0.01875	0.23951	5.9876	309.79	30.00
32.083	0.0232	3.35	0.24	5.99521	0.02092	0.01875	0.22106	5.5265	315.32	30.00
32.5	0.0250	3.60	0.26	6.45638	0.02253	0.01875	0.23951	5.9876	321.31	30.00
32.917	0.0161	2.32	0.17	4.15053	0.01448	0.01875	0.14727	3.6818	324.99	30.00
33.333	0.0179	2.57	0.18	4.6117	0.01609	0.01875	0.16572	4.1429	329.13	30.00
33.75	0.0161	2.32	0.17	4.15053	0.01448	0.01875	0.14727	3.6818	332.81	30.00
34.167	0.0125	1.80	0.13	3.22819	0.01126	0.01875	0.11038	2.7594	335.57	30.00
34.583	0.0125	1.80	0.13	3.22819	0.01126	0.01875	0.11038	2.7594	338.33	30.00
35	0.0125	1.80	0.13	3.22819	0.01126	0.01875	0.11038	2.7594	341.09	30.00
35.417	0.0107	1.54	0.11	2.76702	0.00966	0.01875	0.09193	2.2983	343.39	30.00
35.833	0.0089	1.29	0.09	2.30585	0.00805	0.01875	0.07348	1.8371	345.23	30.00
36.25	0.0107	1.54	0.11	2.76702	0.00966	0.01875	0.09193	2.2983	347.52	30.00
36.667	0.0089	1.29	0.09	2.30585	0.00805	0.01875	0.07348	1.8371	349.36	30.00
37.083	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	350.74	30.00
37.5	0.0089	1.29	0.09	2.30585	0.00805	0.01875	0.07348	1.8371	352.57	30.00
37.917	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	353.95	30.00
38.333	0.0089	1.29	0.09	2.30585	0.00805	0.01875	0.07348	1.8371	355.79	30.00
38.75	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	357.16	30.00
39.167	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	358.54	30.00
39.583	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	359.91	30.00
40	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	361.29	30.00

40.417	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	362.67	30.00
40.833	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	364.04	30.00
41.25	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	365.42	30.00
41.667	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	366.33	30.00
42.083	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	367.71	30.00
42.5	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	368.62	30.00
42.917	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	369.54	30.00
43.333	0.0072	1.03	0.07	1.84468	0.00644	0.01875	0.05504	1.3759	370.91	30.00
43.75	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	371.83	30.00
44.167	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	372.74	30.00
44.583	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	373.66	30.00
45	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	374.57	30.00
45.417	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	375.49	30.00
45.833	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	375.94	30.00
46.25	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	376.86	30.00
46.667	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	377.77	30.00
47.083	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	378.23	30.00
47.5	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	379.14	30.00
47.917	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	380.05	30.00
48.333	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	380.51	30.00
48.75	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	381.42	30.00
49.167	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	381.88	30.00
49.583	0.0054	0.77	0.06	1.38351	0.00483	0.01875	0.03659	0.9148	382.79	30.00
50	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	383.24	30.00
50.417	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	383.70	30.00
50.833	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	384.15	30.00
51.25	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	384.61	30.00
51.667	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	385.06	30.00
52.083	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	385.51	30.00
52.5	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	385.97	30.00
52.917	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	386.42	30.00
53.333	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	386.87	30.00
53.75	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	387.33	30.00
54.167	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	387.78	30.00
54.583	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	388.23	30.00
55	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	388.69	30.00
55.417	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	389.14	30.00
55.833	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	389.60	30.00
56.25	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	390.05	30.00
56.667	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	390.50	30.00
57.083	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	390.96	30.00
57.5	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	391.41	30.00
57.917	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	391.86	30.00
58.333	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	392.32	30.00
58.75	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	392.77	30.00
59.167	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	393.22	30.00
59.583	0.0018	0.26	0.02	0.46117	0.00161	0.01875	-0.00030	-0.0076	393.22	30.00
60	0.0036	0.51	0.04	0.92234	0.00322	0.01875	0.01814	0.4536	393.67	30.00
60.417	0.0000	0.00	0.00	0	0	0.01875	-0.01875	-0.4688	393.20	30.00
60.833	0.0000	0.00	0.00	0	0	0.01875	-0.01875	-0.4688	392.73	30.00
	1.79			0	**1.61**					

Spreadsheet Illustrating Rain Garden Sizing
24 Hour Storms, NRCS Type 2 Rainfall Distribution

BMP 11

1 Hour Rainfall Depth =	0.412	in	Enter
Peak Rainfall Intensity =	2.00	in/hr	Calculated from distribution
Impervious Surface Square-Footage =	2621		Enter
Runoff Coefficient =	0.9		0.9 - 0.98 for imp surface
Rain Garden Square-Footage =	67		
Ratio of Rain Garden to Impervious Surface =	0.026		Calculated
Soil Infiltration Rate =	2	in/hr	Enter
Maximum Ponding Depth in Rain Garden =	6.01	in	Calculated
Depth of bioinfiltration soil below Rain Garden =	30.00	inches	
Void ratio for bioinfiltration soil =	25%	25% for bioinf soil	
Storage capacity of bioinfiltration soil=	41.88	cf	

(1) Time (min)	(2) Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Maximum Infiltration Rate (cfs)	(8) Inflow - Infiltration Rate (cfs)	(9) Inflow - Infiltration Volume (cf)	(10) Cumulative Inflow - Outflow (cf)	(11) Rock trench Ponding Depth (in)
0	0.0000	0.00	0.00	0	0	0.0031019	-0.00310	-0.0775	0.00	0.00
0.4167	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.08	0.06
0.8333	0.0004	0.06	0.00	0.08099	0.00037	0.0031019	0.00014	0.0034	0.09	0.06
1.25	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.17	0.12
1.6667	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.26	0.18
2.0833	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.34	0.24
2.5	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.43	0.30
2.9167	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.51	0.37
3.3333	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.59	0.43
3.75	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.68	0.49
4.1667	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.76	0.55
4.5833	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.85	0.61
5	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	0.93	0.67
5.4167	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	1.02	0.73
5.8333	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	1.10	0.79
6.25	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	1.19	0.85
6.6667	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	1.27	0.91
7.0833	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	1.35	0.97
7.5	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	1.44	1.03
7.9167	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	1.52	1.09
8.3333	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	1.61	1.15
8.75	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	1.69	1.21
9.1667	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	1.78	1.27
9.5833	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	1.94	1.39
10	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	2.03	1.45
10.417	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	2.19	1.57
10.833	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	2.28	1.63
11.25	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	2.44	1.75
11.667	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	2.61	1.87
12.083	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	2.69	1.93
12.5	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	2.86	2.05
12.917	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	3.02	2.17
13.333	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	3.11	2.23
13.75	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	3.27	2.34
14.167	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	3.44	2.46
14.583	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	3.52	2.52
15	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	3.69	2.64

15.417	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	3.85	2.76
15.833	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	4.10	2.94
16.25	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	4.26	3.06
16.667	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	4.43	3.17
17.083	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	4.68	3.35
17.5	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	4.84	3.47
17.917	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	5.01	3.59
18.333	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	5.25	3.76
18.75	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	5.42	3.88
19.167	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	5.58	4.00
19.583	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	5.83	4.18
20	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	6.00	4.30
20.417	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	6.24	4.47
20.833	0.0021	0.30	0.02	0.40494	0.00185	0.0031019	0.01310	0.3274	6.57	4.71
21.25	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	6.82	4.88
21.667	0.0021	0.30	0.02	0.40494	0.00185	0.0031019	0.01310	0.3274	7.14	5.12
22.083	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	7.39	5.29
22.5	0.0021	0.30	0.02	0.40494	0.00185	0.0031019	0.01310	0.3274	7.72	5.53
22.917	0.0021	0.30	0.02	0.40494	0.00185	0.0031019	0.01310	0.3274	8.05	5.76
23.333	0.0025	0.36	0.02	0.48593	0.00222	0.0031019	0.01634	0.4084	8.45	6.06
23.75	0.0021	0.30	0.02	0.40494	0.00185	0.0031019	0.01310	0.3274	8.78	6.29
24.167	0.0025	0.36	0.02	0.48593	0.00222	0.0031019	0.01634	0.4084	9.19	6.58
24.583	0.0025	0.36	0.02	0.48593	0.00222	0.0031019	0.01634	0.4084	9.60	6.88
25	0.0025	0.36	0.02	0.48593	0.00222	0.0031019	0.01634	0.4084	10.01	7.17
25.417	0.0029	0.42	0.02	0.56692	0.0026	0.0031019	0.01958	0.4894	10.50	7.52
25.833	0.0033	0.47	0.03	0.64791	0.00297	0.0031019	0.02281	0.5704	11.07	7.93
26.25	0.0029	0.42	0.02	0.56692	0.0026	0.0031019	0.01958	0.4894	11.56	8.28
26.667	0.0045	0.65	0.04	0.89088	0.00408	0.0031019	0.03253	0.8133	12.37	8.86
27.083	0.0045	0.65	0.04	0.89088	0.00408	0.0031019	0.03253	0.8133	13.18	9.44
27.5	0.0045	0.65	0.04	0.89088	0.00408	0.0031019	0.03253	0.8133	14.00	10.03
27.917	0.0066	0.95	0.05	1.29582	0.00593	0.0031019	0.04873	1.2183	15.21	10.90
28.333	0.0062	0.89	0.05	1.21483	0.00556	0.0031019	0.04549	1.1373	16.35	11.71
28.75	0.0066	0.95	0.05	1.29582	0.00593	0.0031019	0.04873	1.2183	17.57	12.59
29.167	0.0523	7.53	0.41	10.2856	0.04709	0.0031019	0.40832	10.2080	27.78	19.90
29.583	0.0519	7.48	0.41	10.2046	0.04672	0.0031019	0.40508	10.1271	37.90	27.16
30	0.0523	7.53	0.41	10.2856	0.04709	0.0031019	0.40832	10.2080	48.11	30.00
30.417	0.0099	1.42	0.08	1.94373	0.0089	0.0031019	0.07465	1.8662	49.98	30.00
30.833	0.0099	1.42	0.08	1.94373	0.0089	0.0031019	0.07465	1.8662	51.84	30.00
31.25	0.0099	1.42	0.08	1.94373	0.0089	0.0031019	0.07465	1.8662	53.71	30.00
31.667	0.0058	0.83	0.05	1.13384	0.00519	0.0031019	0.04225	1.0563	54.77	30.00
32.083	0.0054	0.77	0.04	1.05286	0.00482	0.0031019	0.03901	0.9753	55.74	30.00
32.5	0.0058	0.83	0.05	1.13384	0.00519	0.0031019	0.04225	1.0563	56.80	30.00
32.917	0.0037	0.53	0.03	0.7289	0.00334	0.0031019	0.02605	0.6514	57.45	30.00
33.333	0.0041	0.59	0.03	0.80989	0.00371	0.0031019	0.02929	0.7323	58.18	30.00
33.75	0.0037	0.53	0.03	0.7289	0.00334	0.0031019	0.02605	0.6514	58.83	30.00
34.167	0.0029	0.42	0.02	0.56692	0.0026	0.0031019	0.01958	0.4894	59.32	30.00
34.583	0.0029	0.42	0.02	0.56692	0.0026	0.0031019	0.01958	0.4894	59.81	30.00
35	0.0029	0.42	0.02	0.56692	0.0026	0.0031019	0.01958	0.4894	60.30	30.00
35.417	0.0025	0.36	0.02	0.48593	0.00222	0.0031019	0.01634	0.4084	60.71	30.00
35.833	0.0021	0.30	0.02	0.40494	0.00185	0.0031019	0.01310	0.3274	61.04	30.00
36.25	0.0025	0.36	0.02	0.48593	0.00222	0.0031019	0.01634	0.4084	61.45	30.00
36.667	0.0021	0.30	0.02	0.40494	0.00185	0.0031019	0.01310	0.3274	61.77	30.00
37.083	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	62.02	30.00
37.5	0.0021	0.30	0.02	0.40494	0.00185	0.0031019	0.01310	0.3274	62.35	30.00
37.917	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	62.59	30.00
38.333	0.0021	0.30	0.02	0.40494	0.00185	0.0031019	0.01310	0.3274	62.92	30.00
38.75	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	63.17	30.00

39.167	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	63.41	30.00
39.583	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	63.66	30.00
40	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	63.91	30.00
40.417	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	64.15	30.00
40.833	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	64.40	30.00
41.25	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	64.65	30.00
41.667	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	64.81	30.00
42.083	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	65.06	30.00
42.5	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	65.22	30.00
42.917	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	65.39	30.00
43.333	0.0016	0.24	0.01	0.32396	0.00148	0.0031019	0.00986	0.2464	65.64	30.00
43.75	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	65.80	30.00
44.167	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	65.97	30.00
44.583	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	66.13	30.00
45	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	66.30	30.00
45.417	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	66.46	30.00
45.833	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	66.55	30.00
46.25	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	66.71	30.00
46.667	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	66.88	30.00
47.083	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	66.96	30.00
47.5	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	67.13	30.00
47.917	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	67.29	30.00
48.333	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	67.38	30.00
48.75	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	67.54	30.00
49.167	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	67.63	30.00
49.583	0.0012	0.18	0.01	0.24297	0.00111	0.0031019	0.00662	0.1654	67.79	30.00
50	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	67.88	30.00
50.417	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	67.96	30.00
50.833	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.05	30.00
51.25	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.13	30.00
51.667	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.21	30.00
52.083	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.30	30.00
52.5	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.38	30.00
52.917	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.47	30.00
53.333	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.55	30.00
53.75	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.64	30.00
54.167	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.72	30.00
54.583	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.81	30.00
55	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.89	30.00
55.417	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	68.97	30.00
55.833	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	69.06	30.00
56.25	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	69.14	30.00
56.667	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	69.23	30.00
57.083	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	69.31	30.00
57.5	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	69.40	30.00
57.917	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	69.48	30.00
58.333	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	69.57	30.00
58.75	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	69.65	30.00
59.167	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	69.73	30.00
59.583	0.0004	0.06	0.00	0.08099	0.00037	0.0031019	0.00014	0.0034	69.74	30.00
60	0.0008	0.12	0.01	0.16198	0.00074	0.0031019	0.00338	0.0844	69.82	30.00
60.417	0.0000	0.00	0.00	0	0	0.0031019	-0.00310	-0.0775	69.74	30.00
60.833	0.0000	0.00	0.00	0	0	0.0031019	-0.00310	-0.0775	69.67	30.00
	0.41			0	**0.37**					

Spreadsheet Illustrating Rain Garden Sizing
24 Hour Storms, NRCS Type 2 Rainfall Distribution

BMP 12

1 Hour Rainfall Depth =	2.26	in	Enter
Peak Rainfall Intensity =	2.00	in/hr	Calculated from distribution
Impervious Surface Square-Footage =	2627		Enter
Runoff Coefficient =	0.9		0.9 - 0.98 for imp surface
Rain Garden Square-Footage =	497		
Ratio of Rain Garden to Impervious Surface =	0.189		Calculated
Soil Infiltration Rate =	2	in/hr	Enter
Maximum Ponding Depth in Rain Garden =	1.50	in	1.5" on avg (triangle based o
Depth of bioinfiltration soil below Rain Garden =	30.00	inches	
Void ratio for bioinfiltration soil =	25%	25% for bioinf soil	
Storage capacity of bioinfiltration soil=	310.63	cf	

(1) Time (min)	(2) Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Maximum Infiltration Rate (cfs)	(8) Inflow - Infiltration Rate (cfs)	(9) Inflow - Infiltration Volume (cf)	(10) Cumulative Inflow - Outflow (cf)	(11) Rock trench Ponding Depth (in)
0	0.0000	0.00	0.00	0	0	0.0230093	-0.02301	-0.5752	0.00	0.00
0.4167	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	0.32	0.03
0.8333	0.0023	0.33	0.02	0.44528	0.00203	0.0230093	-0.00520	-0.1300	0.19	0.02
1.25	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	0.50	0.05
1.6667	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	0.82	0.08
2.0833	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	1.13	0.11
2.5	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	1.45	0.14
2.9167	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	1.76	0.17
3.3333	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	2.08	0.20
3.75	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	2.39	0.23
4.1667	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	2.71	0.26
4.5833	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	3.02	0.29
5	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	3.34	0.32
5.4167	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	3.65	0.35
5.8333	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	3.97	0.38
6.25	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	4.28	0.41
6.6667	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	4.60	0.44
7.0833	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	4.92	0.47
7.5	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	5.23	0.51
7.9167	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	5.55	0.54
8.3333	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	5.86	0.57
8.75	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	6.18	0.60
9.1667	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	6.49	0.63
9.5833	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	7.25	0.70
10	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	7.57	0.73
10.417	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	8.33	0.80
10.833	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	8.64	0.83
11.25	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	9.40	0.91
11.667	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	10.16	0.98
12.083	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	10.48	1.01
12.5	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	11.24	1.09
12.917	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	12.00	1.16
13.333	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	12.32	1.19
13.75	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	13.08	1.26
14.167	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	13.84	1.34
14.583	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	14.15	1.37
15	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	14.91	1.44

15.417	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	15.67	1.51
15.833	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	16.88	1.63
16.25	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	17.64	1.70
16.667	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	18.40	1.78
17.083	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	19.61	1.89
17.5	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	20.37	1.97
17.917	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	21.13	2.04
18.333	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	22.33	2.16
18.75	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	23.09	2.23
19.167	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	23.86	2.30
19.583	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	25.06	2.42
20	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	25.82	2.49
20.417	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	27.03	2.61
20.833	0.0113	1.63	0.09	2.22638	0.01017	0.0230093	0.06605	1.6512	28.68	2.77
21.25	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	29.88	2.89
21.667	0.0113	1.63	0.09	2.22638	0.01017	0.0230093	0.06605	1.6512	31.54	3.05
22.083	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	32.74	3.16
22.5	0.0113	1.63	0.09	2.22638	0.01017	0.0230093	0.06605	1.6512	34.39	3.32
22.917	0.0113	1.63	0.09	2.22638	0.01017	0.0230093	0.06605	1.6512	36.04	3.48
23.333	0.0136	1.95	0.11	2.67166	0.0122	0.0230093	0.08386	2.0964	38.14	3.68
23.75	0.0113	1.63	0.09	2.22638	0.01017	0.0230093	0.06605	1.6512	39.79	3.84
24.167	0.0136	1.95	0.11	2.67166	0.0122	0.0230093	0.08386	2.0964	41.89	4.05
24.583	0.0136	1.95	0.11	2.67166	0.0122	0.0230093	0.08386	2.0964	43.98	4.25
25	0.0136	1.95	0.11	2.67166	0.0122	0.0230093	0.08386	2.0964	46.08	4.45
25.417	0.0158	2.28	0.12	3.11694	0.01424	0.0230093	0.10167	2.5417	48.62	4.70
25.833	0.0181	2.60	0.14	3.56221	0.01627	0.0230093	0.11948	2.9870	51.61	4.98
26.25	0.0158	2.28	0.12	3.11694	0.01424	0.0230093	0.10167	2.5417	54.15	5.23
26.667	0.0249	3.58	0.20	4.89804	0.02237	0.0230093	0.17291	4.3228	58.47	5.65
27.083	0.0249	3.58	0.20	4.89804	0.02237	0.0230093	0.17291	4.3228	62.80	6.06
27.5	0.0249	3.58	0.20	4.89804	0.02237	0.0230093	0.17291	4.3228	67.12	6.48
27.917	0.0362	5.21	0.28	7.12442	0.03254	0.0230093	0.26197	6.5492	73.67	7.11
28.333	0.0339	4.88	0.27	6.67915	0.03051	0.0230093	0.24416	6.1039	79.77	7.70
28.75	0.0362	5.21	0.28	7.12442	0.03254	0.0230093	0.26197	6.5492	86.32	8.34
29.167	0.2870	41.33	2.26	56.5501	0.25832	0.0230093	2.23900	55.9749	142.30	13.74
29.583	0.2848	41.01	2.24	56.1048	0.25628	0.0230093	2.22118	55.5296	197.83	19.11
30	0.2870	41.33	2.26	56.5501	0.25832	0.0230093	2.23900	55.9749	253.80	24.51
30.417	0.0542	7.81	0.43	10.6866	0.04882	0.0230093	0.40446	10.1114	263.91	25.49
30.833	0.0542	7.81	0.43	10.6866	0.04882	0.0230093	0.40446	10.1114	274.02	26.47
31.25	0.0542	7.81	0.43	10.6866	0.04882	0.0230093	0.40446	10.1114	284.14	27.44
31.667	0.0316	4.56	0.25	6.23387	0.02848	0.0230093	0.22635	5.6586	289.79	27.99
32.083	0.0294	4.23	0.23	5.78859	0.02644	0.0230093	0.20853	5.2134	295.01	28.49
32.5	0.0316	4.56	0.25	6.23387	0.02848	0.0230093	0.22635	5.6586	300.67	29.04
32.917	0.0203	2.93	0.16	4.00749	0.01831	0.0230093	0.13729	3.4323	304.10	29.37
33.333	0.0226	3.25	0.18	4.45277	0.02034	0.0230093	0.15510	3.8775	307.98	29.74
33.75	0.0203	2.93	0.16	4.00749	0.01831	0.0230093	0.13729	3.4323	311.41	30.00
34.167	0.0158	2.28	0.12	3.11694	0.01424	0.0230093	0.10167	2.5417	313.95	30.00
34.583	0.0158	2.28	0.12	3.11694	0.01424	0.0230093	0.10167	2.5417	316.49	30.00
35	0.0158	2.28	0.12	3.11694	0.01424	0.0230093	0.10167	2.5417	319.03	30.00
35.417	0.0136	1.95	0.11	2.67166	0.0122	0.0230093	0.08386	2.0964	321.13	30.00
35.833	0.0113	1.63	0.09	2.22638	0.01017	0.0230093	0.06605	1.6512	322.78	30.00
36.25	0.0136	1.95	0.11	2.67166	0.0122	0.0230093	0.08386	2.0964	324.88	30.00
36.667	0.0113	1.63	0.09	2.22638	0.01017	0.0230093	0.06605	1.6512	326.53	30.00
37.083	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	327.73	30.00
37.5	0.0113	1.63	0.09	2.22638	0.01017	0.0230093	0.06605	1.6512	329.39	30.00
37.917	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	330.59	30.00
38.333	0.0113	1.63	0.09	2.22638	0.01017	0.0230093	0.06605	1.6512	332.24	30.00
38.75	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	333.45	30.00

39.167	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	334.65	30.00
39.583	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	335.86	30.00
40	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	337.07	30.00
40.417	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	338.27	30.00
40.833	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	339.48	30.00
41.25	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	340.68	30.00
41.667	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	341.44	30.00
42.083	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	342.65	30.00
42.5	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	343.41	30.00
42.917	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	344.17	30.00
43.333	0.0090	1.30	0.07	1.78111	0.00814	0.0230093	0.04823	1.2059	345.38	30.00
43.75	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	346.14	30.00
44.167	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	346.90	30.00
44.583	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	347.66	30.00
45	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	348.42	30.00
45.417	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	349.18	30.00
45.833	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	349.50	30.00
46.25	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	350.26	30.00
46.667	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	351.02	30.00
47.083	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	351.33	30.00
47.5	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	352.09	30.00
47.917	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	352.85	30.00
48.333	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	353.17	30.00
48.75	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	353.93	30.00
49.167	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	354.24	30.00
49.583	0.0068	0.98	0.05	1.33583	0.0061	0.0230093	0.03042	0.7606	355.01	30.00
50	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	355.32	30.00
50.417	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	355.64	30.00
50.833	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	355.95	30.00
51.25	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	356.27	30.00
51.667	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	356.58	30.00
52.083	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	356.90	30.00
52.5	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	357.21	30.00
52.917	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	357.53	30.00
53.333	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	357.84	30.00
53.75	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	358.16	30.00
54.167	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	358.47	30.00
54.583	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	358.79	30.00
55	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	359.10	30.00
55.417	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	359.42	30.00
55.833	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	359.74	30.00
56.25	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	360.05	30.00
56.667	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	360.37	30.00
57.083	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	360.68	30.00
57.5	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	361.00	30.00
57.917	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	361.31	30.00
58.333	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	361.63	30.00
58.75	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	361.94	30.00
59.167	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	362.26	30.00
59.583	0.0023	0.33	0.02	0.44528	0.00203	0.0230093	-0.00520	-0.1300	362.13	30.00
60	0.0045	0.65	0.04	0.89055	0.00407	0.0230093	0.01261	0.3153	362.44	30.00
60.417	0.0000	0.00	0.00	0	0	0.0230093	-0.02301	-0.5752	361.87	30.00
60.833	0.0000	0.00	0.00	0	0	0.0230093	-0.02301	-0.5752	361.29	30.00
	2.26			0	**2.03**					

Spreadsheet Illustrating Rain Garden Sizing
24 Hour Storms, NRCS Type 2 Rainfall Distribution

BMP 11 & 12

1 Hour Rainfall Depth =	1.336	in	Enter
Peak Rainfall Intensity =	2.00	in/hr	Calculated from distribution
Impervious Surface Square-Footage =	5248		Enter
Runoff Coefficient =	0.9		0.9 - 0.98 for imp surface
Rain Garden Square-Footage =	564		
Ratio of Rain Garden to Impervious Surface =	0.107		Calculated
Soil Infiltration Rate =	2	in/hr	Enter
Maximum Ponding Depth in Rain Garden =	2.03	in	weighted avg = (1.5" x 497+ (
Depth of bioinfiltration soil below Rain Garden =	30.00	inches	
Void ratio for bioinfiltration soil =	25%	25% for bioinf soil	
Storage capacity of bioinfiltration soil=	352.50	cf	

(1) Time (min)	(2) Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Maximum Infiltration Rate (cfs)	(8) Inflow - Infiltration Rate (cfs)	(9) Inflow - Infiltration Volume (cf)	(10) Cumulative Inflow - Outflow (cf)	(11) Rock trench Ponding Depth (in)
0	0.0000	0.00	0.00	0	0	0.0261111	-0.02611	-0.6528	0.00	0.00
0.4167	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	0.40	0.03
0.8333	0.0013	0.19	0.02	0.52585	0.0012	0.0261111	-0.00508	-0.1269	0.27	0.02
1.25	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	0.67	0.06
1.6667	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	1.07	0.09
2.0833	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	1.47	0.13
2.5	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	1.87	0.16
2.9167	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	2.27	0.19
3.3333	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	2.67	0.23
3.75	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	3.06	0.26
4.1667	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	3.46	0.29
4.5833	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	3.86	0.33
5	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	4.26	0.36
5.4167	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	4.66	0.40
5.8333	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	5.06	0.43
6.25	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	5.46	0.46
6.6667	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	5.86	0.50
7.0833	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	6.26	0.53
7.5	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	6.65	0.57
7.9167	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	7.05	0.60
8.3333	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	7.45	0.63
8.75	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	7.85	0.67
9.1667	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	8.25	0.70
9.5833	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	9.18	0.78
10	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	9.57	0.81
10.417	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	10.50	0.89
10.833	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	10.90	0.93
11.25	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	11.82	1.01
11.667	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	12.75	1.08
12.083	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	13.15	1.12
12.5	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	14.07	1.20
12.917	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	15.00	1.28
13.333	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	15.39	1.31
13.75	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	16.32	1.39
14.167	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	17.24	1.47
14.583	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989	17.64	1.50
15	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	18.57	1.58

15.417	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	19.49	1.66
15.833	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506	20.94	1.78
16.25	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	21.87	1.86
16.667	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	22.79	1.94
17.083	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506	24.24	2.06
17.5	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	25.17	2.14
17.917	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	26.09	2.22
18.333	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506	27.54	2.34
18.75	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	28.47	2.42
19.167	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	29.39	2.50
19.583	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506	30.84	2.63
20	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248	31.77	2.70
20.417	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506	33.22	2.83
20.833	0.0067	0.96	0.11	2.62925	0.00601	0.0261111	0.07906	1.9765	35.20	3.00
21.25	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506	36.65	3.12
21.667	0.0067	0.96	0.11	2.62925	0.00601	0.0261111	0.07906	1.9765	38.62	3.29
22.083	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506	40.07	3.41
22.5	0.0067	0.96	0.11	2.62925	0.00601	0.0261111	0.07906	1.9765	42.05	3.58
22.917	0.0067	0.96	0.11	2.62925	0.00601	0.0261111	0.07906	1.9765	44.03	3.75
23.333	0.0080	1.15	0.13	3.1551	0.00721	0.0261111	0.10009	2.5023	46.53	3.96
23.75	0.0067	0.96	0.11	2.62925	0.00601	0.0261111	0.07906	1.9765	48.51	4.13
24.167	0.0080	1.15	0.13	3.1551	0.00721	0.0261111	0.10009	2.5023	51.01	4.34
24.583	0.0080	1.15	0.13	3.1551	0.00721	0.0261111	0.10009	2.5023	53.51	4.55
25	0.0080	1.15	0.13	3.1551	0.00721	0.0261111	0.10009	2.5023	56.01	4.77
25.417	0.0094	1.35	0.15	3.68095	0.00842	0.0261111	0.12113	3.0282	59.04	5.02
25.833	0.0107	1.54	0.17	4.2068	0.00962	0.0261111	0.14216	3.5540	62.59	5.33
26.25	0.0094	1.35	0.15	3.68095	0.00842	0.0261111	0.12113	3.0282	65.62	5.58
26.667	0.0147	2.12	0.23	5.78435	0.01323	0.0261111	0.20526	5.1316	70.75	6.02
27.083	0.0147	2.12	0.23	5.78435	0.01323	0.0261111	0.20526	5.1316	75.89	6.46
27.5	0.0147	2.12	0.23	5.78435	0.01323	0.0261111	0.20526	5.1316	81.02	6.90
27.917	0.0214	3.08	0.34	8.41359	0.01924	0.0261111	0.31043	7.7608	88.78	7.56
28.333	0.0200	2.89	0.32	7.88774	0.01804	0.0261111	0.28940	7.2350	96.01	8.17
28.75	0.0214	3.08	0.34	8.41359	0.01924	0.0261111	0.31043	7.7608	103.77	8.83
29.167	0.1697	24.43	2.67	66.7829	0.1527	0.0261111	2.64520	66.1301	169.90	14.46
29.583	0.1683	24.24	2.65	66.257	0.1515	0.0261111	2.62417	65.6043	235.51	20.04
30	0.1697	24.43	2.67	66.7829	0.1527	0.0261111	2.64520	66.1301	301.64	25.67
30.417	0.0321	4.62	0.50	12.6204	0.02886	0.0261111	0.47870	11.9676	313.61	26.69
30.833	0.0321	4.62	0.50	12.6204	0.02886	0.0261111	0.47870	11.9676	325.57	27.71
31.25	0.0321	4.62	0.50	12.6204	0.02886	0.0261111	0.47870	11.9676	337.54	28.73
31.667	0.0187	2.69	0.29	7.36189	0.01683	0.0261111	0.26836	6.7091	344.25	29.30
32.083	0.0174	2.50	0.27	6.83604	0.01563	0.0261111	0.24733	6.1833	350.43	29.82
32.5	0.0187	2.69	0.29	7.36189	0.01683	0.0261111	0.26836	6.7091	357.14	30.00
32.917	0.0120	1.73	0.19	4.73265	0.01082	0.0261111	0.16319	4.0799	361.22	30.00
33.333	0.0134	1.92	0.21	5.2585	0.01202	0.0261111	0.18423	4.6057	365.83	30.00
33.75	0.0120	1.73	0.19	4.73265	0.01082	0.0261111	0.16319	4.0799	369.91	30.00
34.167	0.0094	1.35	0.15	3.68095	0.00842	0.0261111	0.12113	3.0282	372.94	30.00
34.583	0.0094	1.35	0.15	3.68095	0.00842	0.0261111	0.12113	3.0282	375.96	30.00
35	0.0094	1.35	0.15	3.68095	0.00842	0.0261111	0.12113	3.0282	378.99	30.00
35.417	0.0080	1.15	0.13	3.1551	0.00721	0.0261111	0.10009	2.5023	381.49	30.00
35.833	0.0067	0.96	0.11	2.62925	0.00601	0.0261111	0.07906	1.9765	383.47	30.00
36.25	0.0080	1.15	0.13	3.1551	0.00721	0.0261111	0.10009	2.5023	385.97	30.00
36.667	0.0067	0.96	0.11	2.62925	0.00601	0.0261111	0.07906	1.9765	387.95	30.00
37.083	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506	389.40	30.00
37.5	0.0067	0.96	0.11	2.62925	0.00601	0.0261111	0.07906	1.9765	391.38	30.00
37.917	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506	392.83	30.00
38.333	0.0067	0.96	0.11	2.62925	0.00601	0.0261111	0.07906	1.9765	394.80	30.00
38.75	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506	396.25	30.00

39.167	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506		397.71	30.00
39.583	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506		399.16	30.00
40	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506		400.61	30.00
40.417	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506		402.06	30.00
40.833	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506		403.51	30.00
41.25	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506		404.96	30.00
41.667	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		405.88	30.00
42.083	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506		407.33	30.00
42.5	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		408.26	30.00
42.917	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		409.18	30.00
43.333	0.0053	0.77	0.08	2.1034	0.00481	0.0261111	0.05802	1.4506		410.63	30.00
43.75	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		411.56	30.00
44.167	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		412.48	30.00
44.583	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		413.41	30.00
45	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		414.33	30.00
45.417	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		415.26	30.00
45.833	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		415.66	30.00
46.25	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		416.58	30.00
46.667	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		417.51	30.00
47.083	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		417.91	30.00
47.5	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		418.83	30.00
47.917	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		419.76	30.00
48.333	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		420.15	30.00
48.75	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		421.08	30.00
49.167	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		421.48	30.00
49.583	0.0040	0.58	0.06	1.57755	0.00361	0.0261111	0.03699	0.9248		422.40	30.00
50	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		422.80	30.00
50.417	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		423.20	30.00
50.833	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		423.60	30.00
51.25	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		424.00	30.00
51.667	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		424.40	30.00
52.083	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		424.80	30.00
52.5	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		425.19	30.00
52.917	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		425.59	30.00
53.333	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		425.99	30.00
53.75	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		426.39	30.00
54.167	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		426.79	30.00
54.583	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		427.19	30.00
55	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		427.59	30.00
55.417	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		427.99	30.00
55.833	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		428.39	30.00
56.25	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		428.79	30.00
56.667	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		429.18	30.00
57.083	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		429.58	30.00
57.5	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		429.98	30.00
57.917	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		430.38	30.00
58.333	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		430.78	30.00
58.75	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		431.18	30.00
59.167	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		431.58	30.00
59.583	0.0013	0.19	0.02	0.52585	0.0012	0.0261111	-0.00508	-0.1269		431.45	30.00
60	0.0027	0.38	0.04	1.0517	0.0024	0.0261111	0.01596	0.3989		431.85	30.00
60.417	0.0000	0.00	0.00	0	0	0.0261111	-0.02611	-0.6528		431.20	30.00
60.833	0.0000	0.00	0.00	0	0	0.0261111	-0.02611	-0.6528		430.54	30.00
	1.34			0	**1.20**						

Spreadsheet Illustrating Rain Garden Sizing
24 Hour Storms, NRCS Type 2 Rainfall Distribution

BMP 14

1 Hour Rainfall Depth =	1.785	in	Enter
Peak Rainfall Intensity =	2.00	in/hr	Calculated from distribution
Impervious Surface Square-Footage =	4698		Enter
Runoff Coefficient =	0.9		0.9 - 0.98 for imp surface
Rain Garden Square-Footage =	387		
Ratio of Rain Garden to Impervious Surface =	0.082		Calculated
Soil Infiltration Rate =	2	in/hr	Enter
Maximum Ponding Depth in Rain Garden =	12.00	in	weighted avg = (1.5" x 497+ (
Depth of bioinfiltration soil below Rain Garden =	30.00	inches	
Void ratio for bioinfiltration soil =	25%	25% for bioinf soil	
Storage capacity of bioinfiltration soil=	241.88	cf	

(1) Time (min)	(2) Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Maximum Infiltration Rate (cfs)	(8) Inflow - Infiltration Rate (cfs)	(9) Inflow - Infiltration Volume (cf)	(10) Cumulative Inflow - Outflow (cf)	(11) Rock trench Ponding Depth (in)
0	0.0000	0.00	0.00	0	0	0.0179167	-0.01792	-0.4479	0.00	0.00
0.4167	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	0.81	0.10
0.8333	0.0018	0.26	0.03	0.62894	0.00161	0.0179167	0.00724	0.1810	0.99	0.12
1.25	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	1.80	0.22
1.6667	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	2.61	0.32
2.0833	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	3.42	0.42
2.5	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	4.23	0.52
2.9167	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	5.04	0.63
3.3333	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	5.85	0.73
3.75	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	6.66	0.83
4.1667	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	7.47	0.93
4.5833	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	8.28	1.03
5	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	9.09	1.13
5.4167	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	9.90	1.23
5.8333	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	10.71	1.33
6.25	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	11.52	1.43
6.6667	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	12.33	1.53
7.0833	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	13.14	1.63
7.5	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	13.95	1.73
7.9167	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	14.76	1.83
8.3333	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	15.57	1.93
8.75	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	16.38	2.03
9.1667	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	17.19	2.13
9.5833	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	18.63	2.31
10	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	19.44	2.41
10.417	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	20.88	2.59
10.833	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	21.69	2.69
11.25	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	23.13	2.87
11.667	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	24.57	3.05
12.083	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	25.38	3.15
12.5	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	26.81	3.33
12.917	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	28.25	3.50
13.333	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	29.06	3.60
13.75	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	30.50	3.78
14.167	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	31.94	3.96
14.583	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	32.75	4.06
15	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	34.19	4.24

15.417	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	35.63	4.42
15.833	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	37.70	4.68
16.25	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	39.14	4.85
16.667	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	40.58	5.03
17.083	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	42.64	5.29
17.5	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	44.08	5.47
17.917	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	45.52	5.65
18.333	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	47.59	5.90
18.75	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	49.03	6.08
19.167	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	50.47	6.26
19.583	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	52.53	6.52
20	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	53.97	6.69
20.417	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	56.04	6.95
20.833	0.0089	1.29	0.13	3.14472	0.00803	0.0179167	0.10787	2.6968	58.74	7.29
21.25	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	60.81	7.54
21.667	0.0089	1.29	0.13	3.14472	0.00803	0.0179167	0.10787	2.6968	63.50	7.88
22.083	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	65.57	8.13
22.5	0.0089	1.29	0.13	3.14472	0.00803	0.0179167	0.10787	2.6968	68.27	8.47
22.917	0.0089	1.29	0.13	3.14472	0.00803	0.0179167	0.10787	2.6968	70.96	8.80
23.333	0.0107	1.54	0.15	3.77367	0.00964	0.0179167	0.13303	3.3258	74.29	9.21
23.75	0.0089	1.29	0.13	3.14472	0.00803	0.0179167	0.10787	2.6968	76.99	9.55
24.167	0.0107	1.54	0.15	3.77367	0.00964	0.0179167	0.13303	3.3258	80.31	9.96
24.583	0.0107	1.54	0.15	3.77367	0.00964	0.0179167	0.13303	3.3258	83.64	10.37
25	0.0107	1.54	0.15	3.77367	0.00964	0.0179167	0.13303	3.3258	86.96	10.79
25.417	0.0125	1.80	0.18	4.40261	0.01125	0.0179167	0.15819	3.9547	90.92	11.28
25.833	0.0143	2.06	0.20	5.03156	0.01285	0.0179167	0.18335	4.5836	95.50	11.85
26.25	0.0125	1.80	0.18	4.40261	0.01125	0.0179167	0.15819	3.9547	99.46	12.34
26.667	0.0196	2.83	0.28	6.91839	0.01767	0.0179167	0.25882	6.4705	105.93	13.14
27.083	0.0196	2.83	0.28	6.91839	0.01767	0.0179167	0.25882	6.4705	112.40	13.94
27.5	0.0196	2.83	0.28	6.91839	0.01767	0.0179167	0.25882	6.4705	118.87	14.74
27.917	0.0286	4.11	0.40	10.0631	0.0257	0.0179167	0.38461	9.6152	128.48	15.94
28.333	0.0268	3.86	0.38	9.43417	0.0241	0.0179167	0.35945	8.9863	137.47	17.05
28.75	0.0286	4.11	0.40	10.0631	0.0257	0.0179167	0.38461	9.6152	147.09	18.24
29.167	0.2267	32.64	3.20	79.876	0.20403	0.0179167	3.17712	79.4281	226.51	28.09
29.583	0.2249	32.39	3.17	79.247	0.20242	0.0179167	3.15196	78.7991	305.31	30.00
30	0.2267	32.64	3.20	79.876	0.20403	0.0179167	3.17712	79.4281	384.74	30.00
30.417	0.0428	6.17	0.60	15.0947	0.03856	0.0179167	0.58587	14.6468	399.39	30.00
30.833	0.0428	6.17	0.60	15.0947	0.03856	0.0179167	0.58587	14.6468	414.03	30.00
31.25	0.0428	6.17	0.60	15.0947	0.03856	0.0179167	0.58587	14.6468	428.68	30.00
31.667	0.0250	3.60	0.35	8.80523	0.02249	0.0179167	0.33429	8.3573	437.04	30.00
32.083	0.0232	3.34	0.33	8.17628	0.02088	0.0179167	0.30913	7.7284	444.77	30.00
32.5	0.0250	3.60	0.35	8.80523	0.02249	0.0179167	0.33429	8.3573	453.12	30.00
32.917	0.0161	2.31	0.23	5.6605	0.01446	0.0179167	0.20850	5.2126	458.34	30.00
33.333	0.0179	2.57	0.25	6.28945	0.01607	0.0179167	0.23366	5.8415	464.18	30.00
33.75	0.0161	2.31	0.23	5.6605	0.01446	0.0179167	0.20850	5.2126	469.39	30.00
34.167	0.0125	1.80	0.18	4.40261	0.01125	0.0179167	0.15819	3.9547	473.35	30.00
34.583	0.0125	1.80	0.18	4.40261	0.01125	0.0179167	0.15819	3.9547	477.30	30.00
35	0.0125	1.80	0.18	4.40261	0.01125	0.0179167	0.15819	3.9547	481.25	30.00
35.417	0.0107	1.54	0.15	3.77367	0.00964	0.0179167	0.13303	3.3258	484.58	30.00
35.833	0.0089	1.29	0.13	3.14472	0.00803	0.0179167	0.10787	2.6968	487.28	30.00
36.25	0.0107	1.54	0.15	3.77367	0.00964	0.0179167	0.13303	3.3258	490.60	30.00
36.667	0.0089	1.29	0.13	3.14472	0.00803	0.0179167	0.10787	2.6968	493.30	30.00
37.083	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	495.37	30.00
37.5	0.0089	1.29	0.13	3.14472	0.00803	0.0179167	0.10787	2.6968	498.06	30.00
37.917	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	500.13	30.00
38.333	0.0089	1.29	0.13	3.14472	0.00803	0.0179167	0.10787	2.6968	502.83	30.00
38.75	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	504.90	30.00

39.167	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	506.96	30.00
39.583	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	509.03	30.00
40	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	511.10	30.00
40.417	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	513.17	30.00
40.833	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	515.24	30.00
41.25	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	517.30	30.00
41.667	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	518.74	30.00
42.083	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	520.81	30.00
42.5	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	522.25	30.00
42.917	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	523.69	30.00
43.333	0.0071	1.03	0.10	2.51578	0.00643	0.0179167	0.08271	2.0679	525.76	30.00
43.75	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	527.20	30.00
44.167	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	528.63	30.00
44.583	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	530.07	30.00
45	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	531.51	30.00
45.417	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	532.95	30.00
45.833	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	533.76	30.00
46.25	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	535.20	30.00
46.667	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	536.64	30.00
47.083	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	537.45	30.00
47.5	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	538.89	30.00
47.917	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	540.33	30.00
48.333	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	541.14	30.00
48.75	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	542.58	30.00
49.167	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	543.39	30.00
49.583	0.0054	0.77	0.08	1.88683	0.00482	0.0179167	0.05756	1.4389	544.82	30.00
50	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	545.63	30.00
50.417	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	546.44	30.00
50.833	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	547.25	30.00
51.25	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	548.06	30.00
51.667	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	548.87	30.00
52.083	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	549.68	30.00
52.5	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	550.49	30.00
52.917	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	551.30	30.00
53.333	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	552.11	30.00
53.75	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	552.92	30.00
54.167	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	553.73	30.00
54.583	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	554.54	30.00
55	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	555.35	30.00
55.417	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	556.16	30.00
55.833	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	556.97	30.00
56.25	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	557.78	30.00
56.667	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	558.59	30.00
57.083	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	559.40	30.00
57.5	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	560.21	30.00
57.917	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	561.02	30.00
58.333	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	561.83	30.00
58.75	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	562.64	30.00
59.167	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	563.45	30.00
59.583	0.0018	0.26	0.03	0.62894	0.00161	0.0179167	0.00724	0.1810	563.63	30.00
60	0.0036	0.51	0.05	1.25789	0.00321	0.0179167	0.03240	0.8100	564.44	30.00
60.417	0.0000	0.00	0.00	0	0	0.0179167	-0.01792	-0.4479	564.00	30.00
60.833	0.0000	0.00	0.00	0	0	0.0179167	-0.01792	-0.4479	563.55	30.00
	1.79			0	**1.61**					

Flow for DI Surcharge at Village and Driver

ORIGIN	CAD	CAD	Sum	TIN Surface	$V = 20.3282\sqrt{S}$	CAD	tt = L/V	TIN Surface	CAD	C5 = (0.45*A(sfd) + 0.88*A(paved))/A(total) (based on % of area)	$ti5 = \frac{1.8(1.1-C5)\sqrt{L}}{S^{1/3}}$	C100 = (0.6*A(sfd) + 0.93*A(paved))/A(total) (based of % of area)	$ti100 = \frac{1.8(1.1-C100)\sqrt{L}}{S^{1/3}}$	=ti+tt	=ti+tt	Paved L + Land L	L/180+10	Min of tc check and tc5	from NOAA	Min of tc check and tc100	from NOAA	$Q = CiA$	
BMP	**Paved A (sf)**	**SFD (1/4 acre) A (sf)**	**Total A (sf)**	**Gutter Slope (S) (%)**	**Avg V (ft/s)***	**Paved L (ft)**	**Travel time tt (min)**	**Land S (%)**	**Land L (Ft)**	**C5**	**ti5 (min)**	**C100**	**ti100 (min)**	**tc5 (min)**	**tc100 (min)**	**Total L (ft)**	**tc check (min)**	**Final tc5 (min)**	**i(5) (in/hr)**	**Final tc100 (min)**	**i(100) (in/hr)**	**Q5 (cfs)**	**Q100 (cfs)**
11	2621	417	3038	6.4	5.14	160	0.52	3.4	0	0.82	0.0	0.88	0.0	0.52	0.52	160	10.9	0.5	2.7	0.52	6.22	0.15	0.38
12	2627	1486	4113	7.8	5.68	93	0.27	7.2	0	0.72	0.0	0.81	0.0	0.27	0.27	93	10.5	0.3	2.7	0.27	6.22	0.18	0.48
14	4698	6559	11257	3.5	3.80	203	0.89	7.2	97	0.63	4.3	0.74	3.3	5.21	4.22	300	11.7	5.2	1.69	4.22	3.95	0.27	0.75
Below 14	4504	9572	14076	10.5	6.59	365	0.92	10.5	413	0.59	8.6	0.71	6.6	9.48	7.51	365	12.0	9.5	1.69	7.51	3.95	0.32	0.90

Variable	Description
A	Area
V	Velocity
S	Slope
L	Length
tt	travel time in gutter
tic	initial flow time
tc	time of concentration
C	runoff coefficient (based on land use and %)
tc check	this is a way to check tc calcs, use the minimum of the 2.

* C assumes 30% coverage (maximum allowed coverage in Tahoe basin)
**V calcs best suited for flow paths > 100ft

Q5 is sum of BMP14 and below since it would only bypass due to catastrophic failure (unlikely)
Q100 is the sum of all - in the event flows from BMP11, 12, 14 and below must be intercepted by DI at Driver Way

Type 4 R Catch Basin at Driver

L	W	H	Volume (CF)	V with 30% se	Q5 (INPUT)	Q100 (INPUT)	Q5 (OUTPUT)	Q100 (OUTPUT)
3	2	5	30	21	0.60	2.51		9.26

Type 4 R Catch Basin at Ace

L	W	H	Volume (CF)	V with 30% se	Q5 (INPUT)	Q100 (INPUT)	Q5 (OUTPUT)	Q100 (OUTPUT)
3	2	5	30	21	0.61	1.61		9.26

OUTLET capacity is much greater than additional input - therefore no increase in surcharge due to bypass of one Catch Basin

Driver
Q5 Pipe outlet
CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of	0.1725	ft
DIA	1	ft
R	0.5	
cross sec	0.0904	ft2
wetted p	0.8566	ft
channel	0.04	ft/ft
hydrauli	0.1056	ft
conversi	1.486	
Manning	0.01	
mean ve	6.6379	ft/s
channel	0.6002	cfs

Driver
Q100 pipe outlet
CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of water (y	0.356	ft
DIA	1	ft
R	0.5	
cross sectional ar	0.250715269	ft2
wetted perimeter	1.278658635	ft
channel slope (S)	0.04	ft/ft
hydraulic radius (	0.196076781	ft
conversion (C_1)	1.486	
Mannings roughn	0.01	
mean velocity (v)	10.03073871	ft/s
channel flow (Q)	2.514859357	cfs

Driver and Ace (12" outlet pipe)
CIRCULAR MANNINGS CALCULATOR (FULL PIPE)

input	value	units	
depth	1	ft	
DIA	1	ft	
R	0.5		
cross s	0.785	ft2	
wetted	3.142	ft	
channe	0.04	ft/ft	slope from as builts
hydrau	0.25	ft	
conver	1.486		
Mannir	0.01		
mean v	11.79	ft/s	
channe	9.263	cfs	

Weir Calculations for BMP12

Variable	Description
W	minumum rock mass in pounds
SG	rock specific gravity

$$W = (0.00002\ V^6\ SG) / ((SG-1)^3\ (0.207))$$

$$*V = 1.33\ V_{AVG}\ (ft/s)$$

Rock sizing

Vavg	2.014723 fps	
V	2.679581 fps	
SG(granite)	2.6	
W	0.022703 lbs	--> really small rock

size at 1/2 ton to ease maintenance

$$SCOUR\ DEPTH = D_{mxb} - D_{mnc}$$

$$D_{mxb} = 1.14\ D_{mnc}\ (1.72 + (0.0084\ W/D_{mnc}))$$

Rock Embedment

Dmxb	maximum water depth at weir (ft)	
Dmnc	mean channel depth upstream of weir (ft)	
Dmnb	0.166667 ft	
Dmnb	0.327017	
Scour	0.160351 ft	embedment depth chosen at 1 boulder = 12"

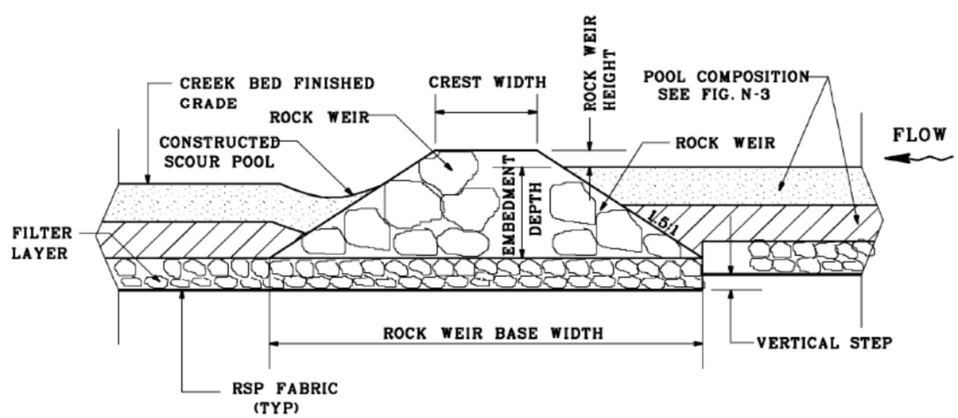
Crest width

Crest width = 2 (rock weir D50) --> also really small - going with top width of 1/2 ton boulder = 9"

$$R = (L^2/8\ m) + (m/2)$$

Vortex Arc

R	rock weir radius
L	chord length (6.5')
m	mid chord offset = 3*D50 = 3 x 12" = 3'
R =	3.260417



Rock weir spacing

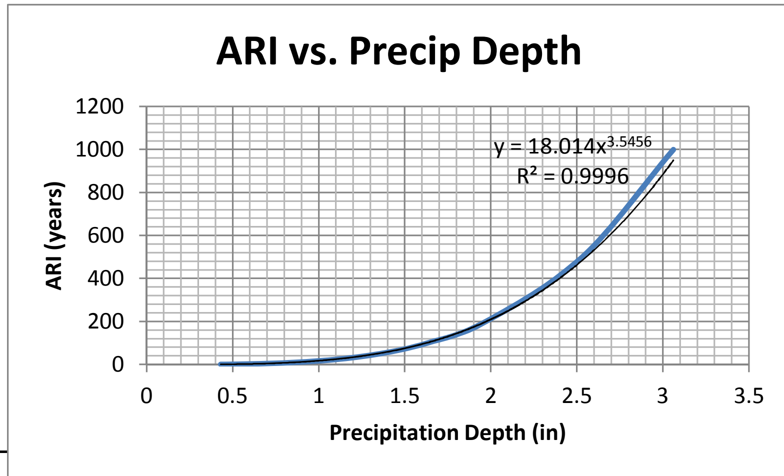
Max = 25'

Drop between weirs = 1'

choose drop of 9" between weirs

From NOAA

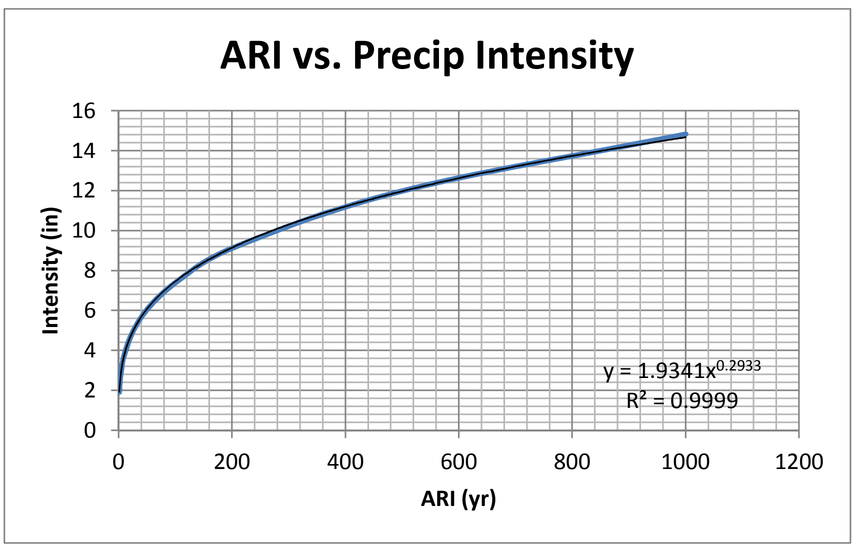
ARI* (years)	60 min	24 hr
1	0.43	2.62
2	0.54	3.29
5	0.7	4.16
10	0.86	4.88
25	1.11	5.88
50	1.35	6.67
100	1.63	7.52
200	1.97	8.4
500	2.53	9.62
1000	3.06	10.6



BMP	1 hr storm depth (in)	ARI	I(ARI)	A	Q (ARI)	Slope	L(ARI)	E (ARI)	1 hr storm (intcpt)	ARI considering E
2	1.17	32	5.33	2094	0.18	0.042	8.482046	0.956724	1.12	27
7	1.79	141	8.26	3439	0.46	0.042	12.55888	0.769397	1.38	56
8	1.73	126	7.99	2306	0.30	0.064	11.87611	0.798572	1.38	57
10	1.00	18	4.53	4087	0.30	0.062	11.79028	0.802346	0.80	8
11	0.41	1	1.80	2621	0.08	0.071	6.908463	1	0.41	1
12	2.26	324	10.54	2627	0.45	0.053	13.32195	1	2.26	324
11&12	1.34	50	6.10	5248	0.52		not effected by efficiency			50
14	1.79	141	8.25	4698	0.63		not effected by efficiency			141

Intensity from NOAA

ARI** (years)	5 min
1	1.92
2	2.4
5	3.12
10	3.8
25	4.96
50	6.05
100	7.39
200	9.12
500	11.99
1000	14.83



POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Nevada 39.25983 N 119.95103 W 6755 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Thu Jun 23 2011

Confidence Limits | Seasonality | Related Info | GIS data | Maps | Docs | Return to State Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.21	0.26	0.35	0.43	0.59	0.74	1.14	1.65	2.62	3.40	4.36	5.32	6.18	8.32	10.15	12.38	14.34
2	0.17	0.26	0.32	0.44	0.54	0.73	0.91	1.40	2.05	3.29	4.31	5.58	6.87	8.00	10.75	13.11	16.03	18.68
5	0.22	0.34	0.42	0.57	0.70	0.91	1.11	1.69	2.52	4.16	5.58	7.44	9.28	10.81	14.36	17.51	21.34	24.91
10	0.27	0.42	0.52	0.69	0.86	1.06	1.27	1.91	2.90	4.88	6.64	9.00	11.25	13.05	17.17	20.92	25.36	29.38
25	0.35	0.54	0.67	0.90	1.11	1.30	1.50	2.20	3.39	5.88	8.17	11.26	14.08	16.20	21.03	25.59	30.75	35.20
50	0.43	0.65	0.81	1.09	1.35	1.51	1.70	2.41	3.77	6.67	9.43	13.14	16.40	18.74	24.08	29.26	34.91	39.55
100	0.52	0.79	0.98	1.32	1.63	1.76	1.92	2.62	4.15	7.52	10.78	15.20	18.92	21.45	27.27	33.08	39.21	43.89
200	0.63	0.95	1.18	1.59	1.97	2.07	2.23	2.88	4.53	8.40	12.23	17.44	21.62	24.32	30.57	37.03	43.59	48.20
500	0.81	1.23	1.52	2.04	2.53	2.63	2.75	3.28	5.03	9.62	14.31	20.70	25.52	28.39	35.16	42.48	49.53	53.85
1000	0.97	1.48	1.84	2.47	3.06	3.16	3.26	3.63	5.40	10.60	16.02	23.41	28.73	31.68	38.79	46.78	54.18	58.12

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

*** Upper bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.16	0.24	0.30	0.41	0.50	0.66	0.81	1.24	1.83	2.98	3.94	5.05	6.16	7.14	9.52	11.63	14.03	16.35
2	0.20	0.30	0.38	0.51	0.63	0.81	1.00	1.54	2.28	3.74	4.99	6.48	7.95	9.24	12.29	15.00	18.13	21.27
5	0.26	0.40	0.49	0.66	0.82	1.01	1.22	1.85	2.80	4.72	6.47	8.63	10.74	12.47	16.40	20.04	24.14	28.36
10	0.32	0.48	0.60	0.81	1.00	1.19	1.40	2.10	3.21	5.53	7.71	10.42	13.01	15.05	19.60	23.90	28.70	33.43
25	0.41	0.63	0.78	1.05	1.30	1.46	1.66	2.43	3.79	6.67	9.51	13.05	16.32	18.71	24.05	29.29	34.90	40.11
50	0.50	0.77	0.95	1.28	1.58	1.72	1.90	2.68	4.23	7.58	11.00	15.26	19.03	21.67	27.61	33.54	39.74	45.22
100	0.62	0.94	1.16	1.57	1.94	2.02	2.17	2.95	4.71	8.58	12.65	17.70	22.04	24.90	31.43	38.11	44.77	50.35
200	0.76	1.16	1.43	1.93	2.39	2.42	2.56	3.27	5.21	9.64	14.44	20.39	25.34	28.38	35.48	42.88	50.03	55.49
500	1.00	1.52	1.88	2.54	3.14	3.15	3.22	3.77	5.89	11.13	17.08	24.48	30.23	33.51	41.21	49.67	57.30	62.38
1000	1.24	1.88	2.33	3.14	3.89	3.92	3.96	4.24	6.42	12.38	19.37	27.97	34.32	37.72	45.91	55.16	63.15	67.73

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are greater than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

*** Lower bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

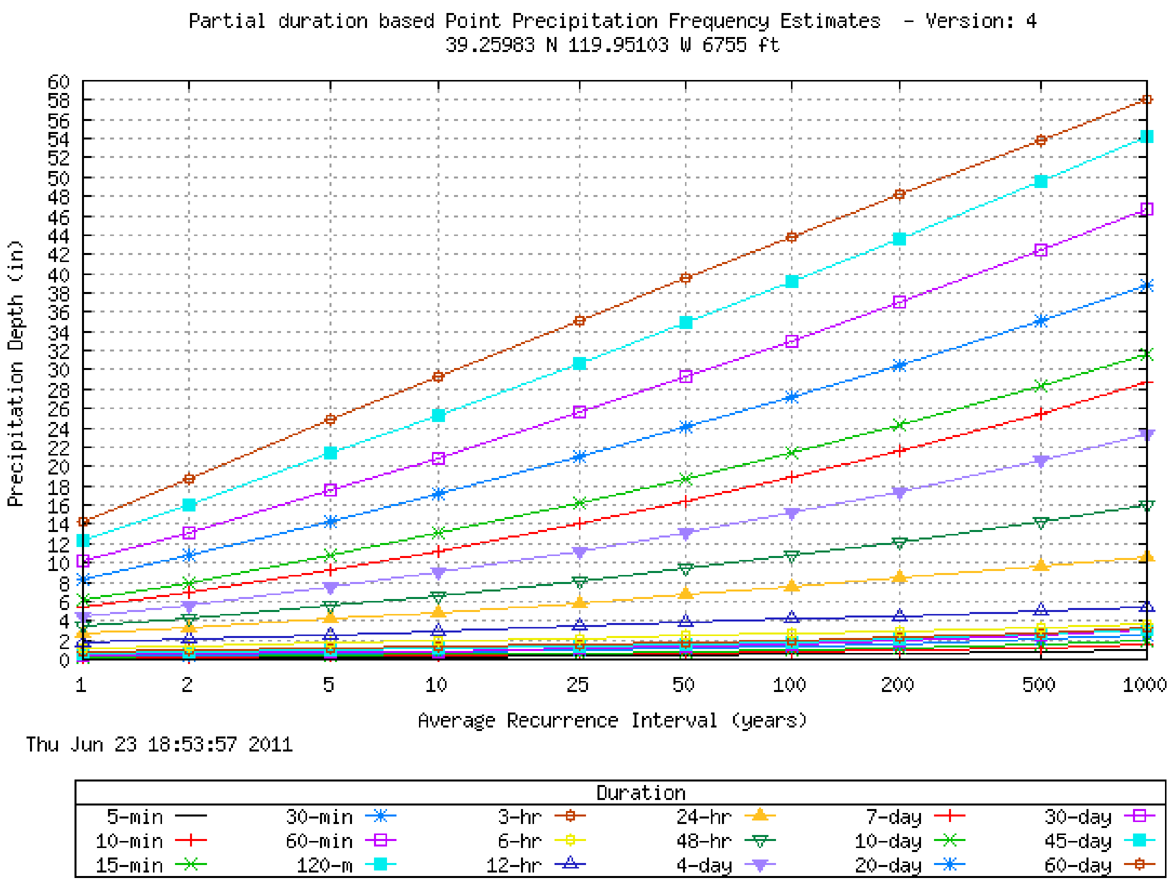
ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.12	0.18	0.23	0.31	0.38	0.54	0.67	1.03	1.49	2.33	2.98	3.79	4.62	5.36	7.28	8.88	10.85	12.44
2	0.15	0.23	0.28	0.38	0.47	0.66	0.84	1.28	1.86	2.93	3.77	4.86	5.96	6.94	9.41	11.49	14.05	16.22
5	0.20	0.30	0.37	0.49	0.61	0.82	1.01	1.53	2.27	3.69	4.86	6.46	8.04	9.35	12.54	15.30	18.68	21.58
10	0.24	0.36	0.45	0.60	0.74	0.95	1.15	1.73	2.59	4.30	5.75	7.79	9.71	11.24	14.94	18.22	22.14	25.45
25	0.30	0.45	0.56	0.76	0.94	1.13	1.34	1.97	3.00	5.14	7.01	9.65	12.06	13.85	18.19	22.16	26.70	30.36

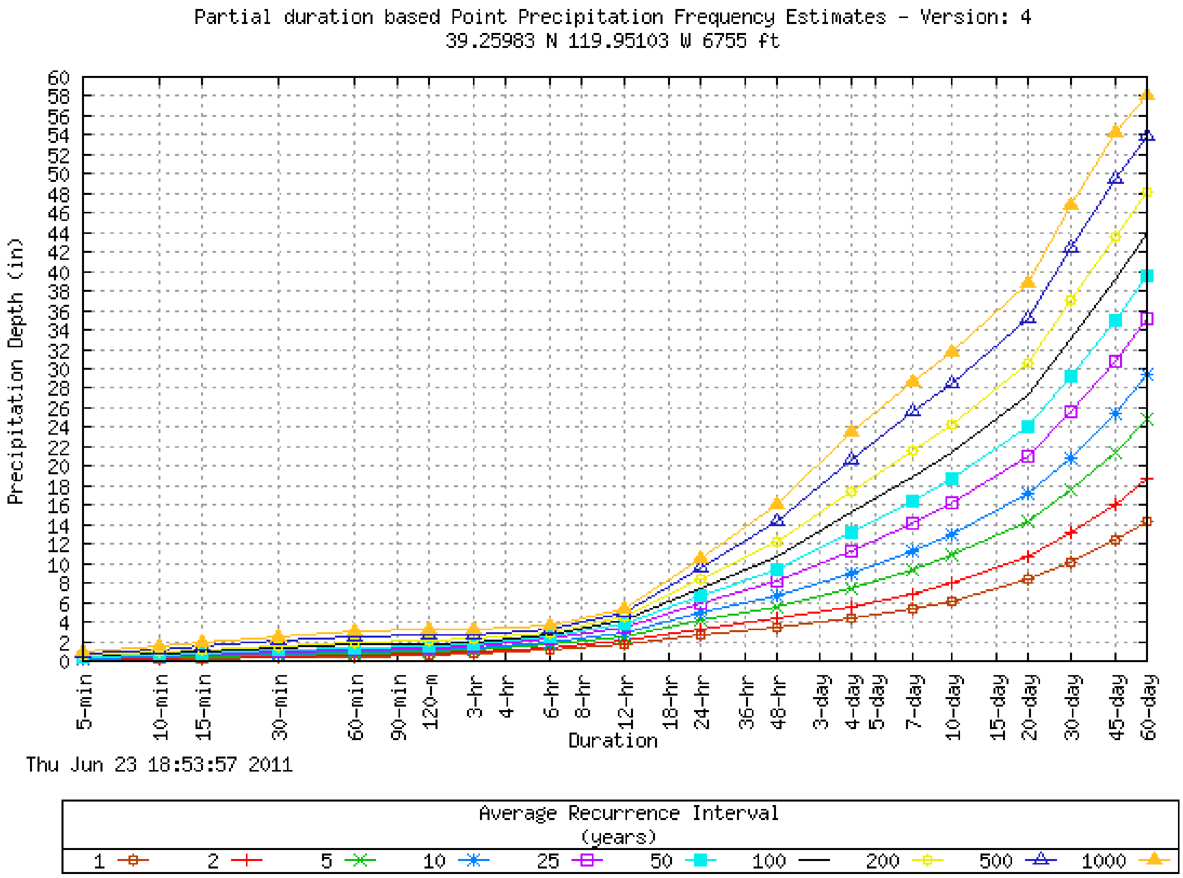
50	0.35	0.53	0.66	0.89	1.10	1.29	1.50	2.14	3.30	5.80	8.02	11.18	13.93	15.92	20.69	25.17	30.16	33.93
100	0.41	0.62	0.77	1.03	1.28	1.46	1.67	2.29	3.58	6.47	9.07	12.79	15.90	18.07	23.21	28.25	33.61	37.45
200	0.47	0.72	0.89	1.20	1.49	1.67	1.90	2.48	3.85	7.15	10.17	14.48	17.99	20.27	25.81	31.32	37.09	40.88
500	0.57	0.87	1.07	1.45	1.79	2.03	2.27	2.77	4.17	8.06	11.66	16.83	20.83	23.28	29.23	35.46	41.57	45.25
1000	0.65	1.00	1.23	1.66	2.06	2.36	2.63	3.03	4.40	8.75	12.82	18.72	23.11	25.66	31.85	38.62	44.98	48.45

* The **lower** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **less** than.
** These precipitation frequency estimates are based on a partial duration maxima series. ARI is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

Text version of tables





Related Information

Maps & Aerials

Click here to see topographic maps and aerial photographs available for this location from Microsoft Research Maps

Watershed/Streamflow Information

Click here to see watershed and streamflow information available for this location from the U.S. Environmental Protection Agency's site

Climate Data Sources

National Climatic Data Center (NCDC) database

Locate NCDC climate stations within:

+/-30 minutes or +/-1 degree of this location. Digital ASCII data can be obtained directly from **NCDC**.

Note: Precipitation frequency results are based on analysis of precipitation data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to the matching documentation available at the PF Document page

Natural Resources Conservation Service's (NRCS) SNOTEL dataset

At present, there are more than 700 SNOTEL sites typically located in the mountainous regions of the Western U.S. that report daily and/or hourly precipitation, air temperture, snow water equivalent and snow depth data.

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Nevada 39.25983 N 119.95103 W 6755 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Thu Jun 23 2011

Confidence Limits | Seasonality | Related Info | GIS data | Maps | Docs | Return to State Map

Precipitation Intensity Estimates (in/hr)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	1.66	1.26	1.04	0.70	0.43	0.30	0.25	0.19	0.14	0.11	0.07	0.05	0.03	0.03	0.02	0.01	0.01	0.01
2	2.05	1.57	1.29	0.87	0.54	0.37	0.30	0.23	0.17	0.14	0.09	0.06	0.04	0.03	0.02	0.02	0.01	0.01
5	2.69	2.05	1.69	1.14	0.70	0.45	0.37	0.28	0.21	0.17	0.12	0.08	0.06	0.05	0.03	0.02	0.02	0.02
10	3.28	2.50	2.06	1.39	0.86	0.53	0.42	0.32	0.24	0.20	0.14	0.09	0.07	0.05	0.04	0.03	0.02	0.02
25	4.25	3.23	2.67	1.80	1.11	0.65	0.50	0.37	0.28	0.24	0.17	0.12	0.08	0.07	0.04	0.04	0.03	0.02
50	5.15	3.91	3.24	2.18	1.35	0.76	0.57	0.40	0.31	0.28	0.20	0.14	0.10	0.08	0.05	0.04	0.03	0.03
100	6.22	4.73	3.91	2.63	1.63	0.88	0.64	0.44	0.34	0.31	0.22	0.16	0.11	0.09	0.06	0.05	0.04	0.03
200	7.51	5.72	4.73	3.18	1.97	1.04	0.74	0.48	0.38	0.35	0.25	0.18	0.13	0.10	0.06	0.05	0.04	0.03
500	9.66	7.35	6.07	4.09	2.53	1.31	0.92	0.55	0.42	0.40	0.30	0.22	0.15	0.12	0.07	0.06	0.05	0.04
1000	11.68	8.89	7.34	4.94	3.06	1.58	1.09	0.61	0.45	0.44	0.33	0.24	0.17	0.13	0.08	0.06	0.05	0.04

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

*** Upper bound of the 90% confidence interval**
Precipitation Intensity Estimates (in/hr)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	1.92	1.46	1.21	0.81	0.50	0.33	0.27	0.21	0.15	0.12	0.08	0.05	0.04	0.03	0.02	0.02	0.01	0.01
2	2.40	1.82	1.51	1.01	0.63	0.41	0.33	0.26	0.19	0.16	0.10	0.07	0.05	0.04	0.03	0.02	0.02	0.01
5	3.12	2.38	1.96	1.32	0.82	0.51	0.41	0.31	0.23	0.20	0.13	0.09	0.06	0.05	0.03	0.03	0.02	0.02
10	3.80	2.90	2.40	1.61	1.00	0.59	0.46	0.35	0.27	0.23	0.16	0.11	0.08	0.06	0.04	0.03	0.03	0.02
25	4.96	3.77	3.12	2.10	1.30	0.73	0.55	0.41	0.31	0.28	0.20	0.14	0.10	0.08	0.05	0.04	0.03	0.03
50	6.05	4.60	3.80	2.56	1.58	0.86	0.63	0.45	0.35	0.32	0.23	0.16	0.11	0.09	0.06	0.05	0.04	0.03
100	7.39	5.63	4.65	3.13	1.94	1.01	0.72	0.49	0.39	0.36	0.26	0.18	0.13	0.10	0.07	0.05	0.04	0.03
200	9.12	6.94	5.73	3.86	2.39	1.21	0.85	0.55	0.43	0.40	0.30	0.21	0.15	0.12	0.07	0.06	0.05	0.04
500	11.99	9.12	7.54	5.07	3.14	1.58	1.07	0.63	0.49	0.46	0.36	0.25	0.18	0.14	0.09	0.07	0.05	0.04
1000	14.83	11.29	9.33	6.28	3.89	1.96	1.32	0.71	0.53	0.52	0.40	0.29	0.20	0.16	0.10	0.08	0.06	0.05

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are greater than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

*** Lower bound of the 90% confidence interval**
Precipitation Intensity Estimates (in/hr)

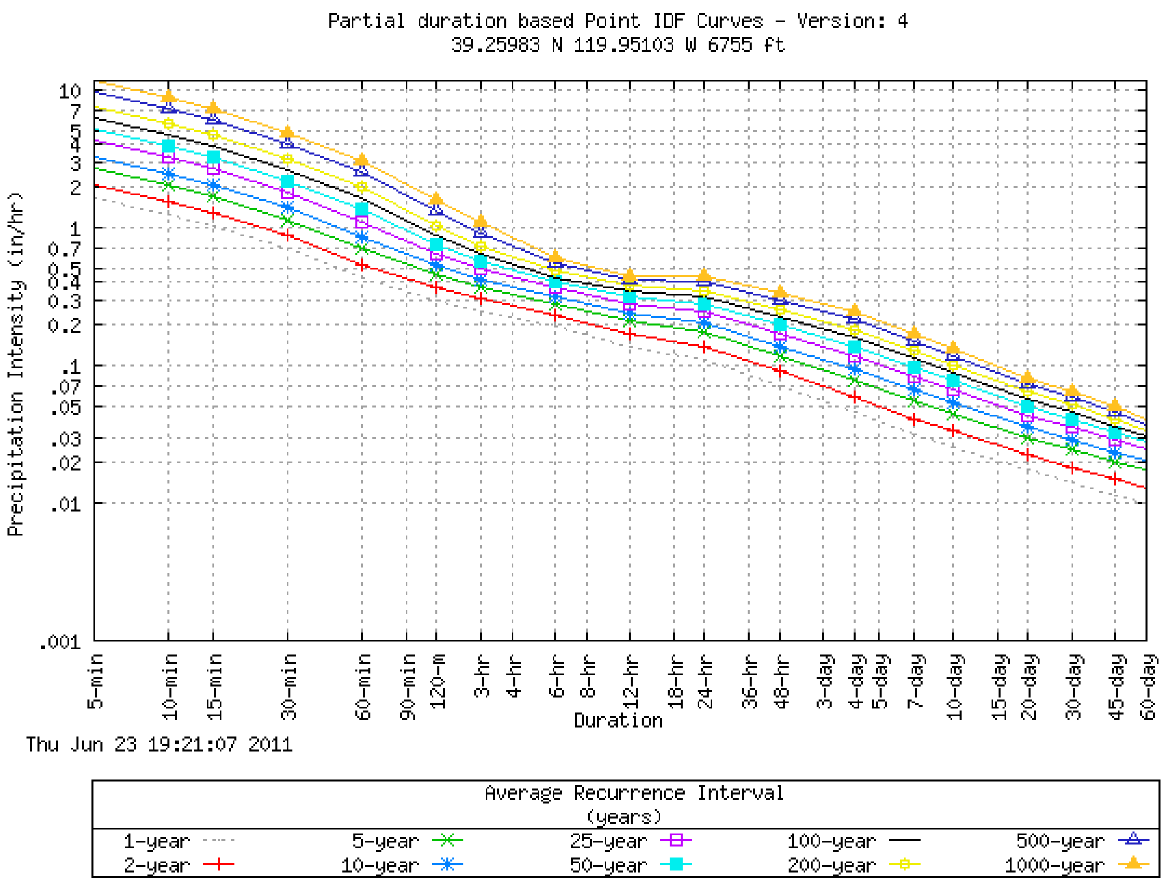
ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	1.45	1.10	0.92	0.62	0.38	0.27	0.22	0.17	0.12	0.10	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01
2	1.81	1.38	1.14	0.77	0.47	0.33	0.28	0.21	0.15	0.12	0.08	0.05	0.04	0.03	0.02	0.02	0.01	0.01
5	2.34	1.78	1.47	0.99	0.61	0.41	0.34	0.26	0.19	0.15	0.10	0.07	0.05	0.04	0.03	0.02	0.02	0.01
10	2.83	2.15	1.78	1.20	0.74	0.47	0.38	0.29	0.22	0.18	0.12	0.08	0.06	0.05	0.03	0.03	0.02	0.02
25	3.58	2.72	2.25	1.51	0.94	0.57	0.45	0.33	0.25	0.21	0.15	0.10	0.07	0.06	0.04	0.03	0.02	0.02

50	4.20	3.19	2.64	1.78	1.10	0.65	0.50	0.36	0.27	0.24	0.17	0.12	0.08	0.07	0.04	0.03	0.03	0.02
100	4.88	3.72	3.08	2.07	1.28	0.73	0.55	0.38	0.30	0.27	0.19	0.13	0.09	0.08	0.05	0.04	0.03	0.03
200	5.66	4.31	3.56	2.40	1.49	0.84	0.63	0.41	0.32	0.30	0.21	0.15	0.11	0.08	0.05	0.04	0.03	0.03
500	6.84	5.20	4.30	2.90	1.79	1.02	0.76	0.46	0.35	0.34	0.24	0.18	0.12	0.10	0.06	0.05	0.04	0.03
1000	7.85	5.98	4.94	3.32	2.06	1.18	0.88	0.51	0.37	0.36	0.27	0.19	0.14	0.11	0.07	0.05	0.04	0.03

* The lower bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are less than.
** These precipitation frequency estimates are based on a partial duration maxima series. ARI is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

Text version of tables



Related Information

Maps & Aerials

Click here to see topographic maps and aerial photographs available for this location from Microsoft Research Maps

Watershed/Streamflow Information

Click here to see watershed and streamflow information available for this location from the U.S. Environmental Protection Agency's site

Climate Data Sources

National Climatic Data Center (NCDC) database

Locate NCDC climate stations within:

+/-30 minutes or +/-1 degree of this location. Digital ASCII data can be obtained directly from **NCDC**.

Note: Precipitation frequency results are based on analysis of precipitation data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to the matching documentation available at the PF Document page

Natural Resources Conservation Service's (NRCS) SNOTEL dataset

At present, there are more than 700 SNOTEL sites typically located in the mountainous regions of the Western U.S. that report daily and/or hourly precipitation, air temperture, snow water equivalent and snow depth data.

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

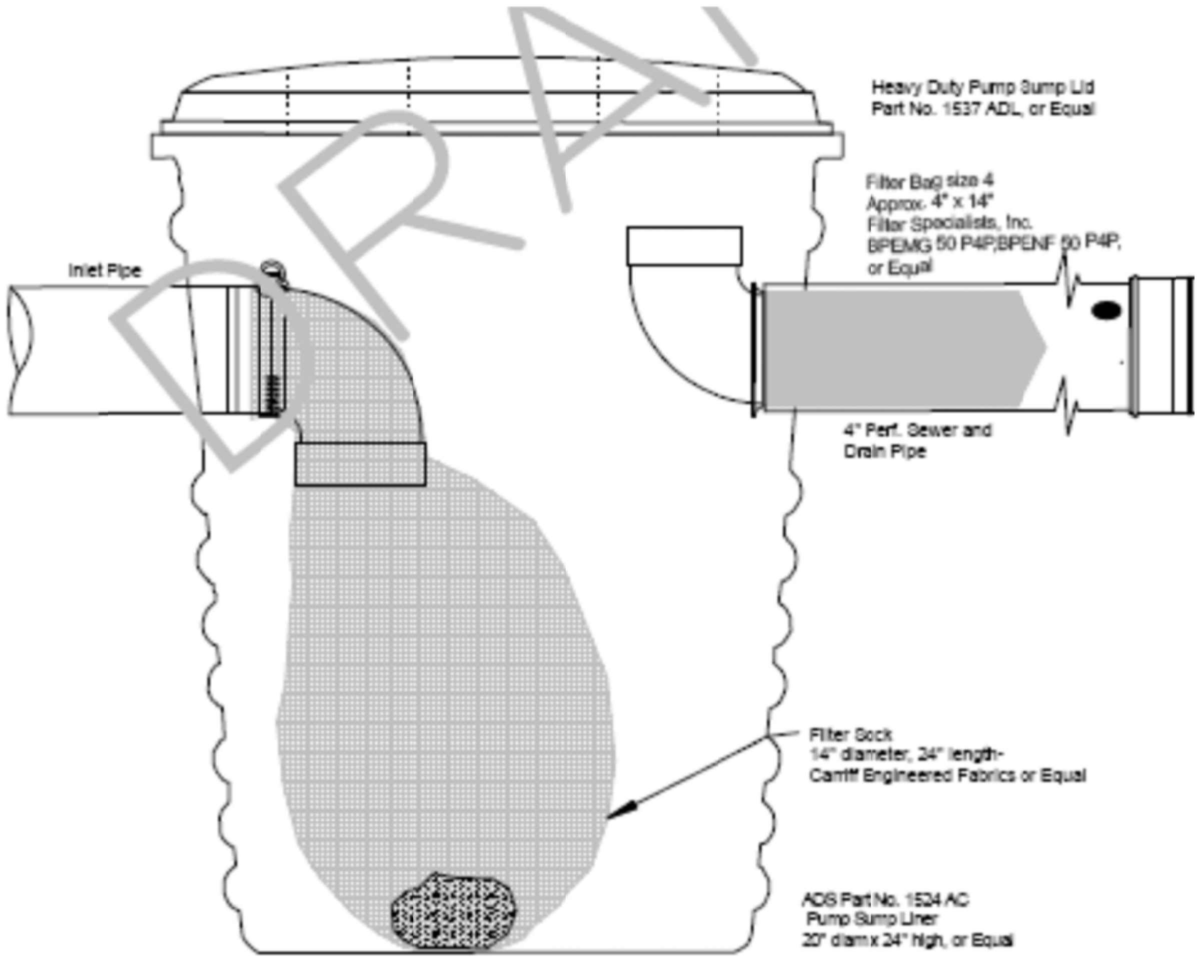
APPENDIX E—Filter Sock

Filter Socks – Zodiac/Carriff Engineering or equivalent

Zodiac's durable knit construction is seamless and can be used as a filter envelope to cover various types of perforated drainage materials including Corrugated HDPE, steel, aluminum and PVC drain pipes. Protect your subsurface drainage system from clogging by insisting on the use of Zodiac's tubular knit SOCK™ geotextile fabric.

Our "DRAINSLEEVE"™ product line is popular with the do it yourselfer and is available in pre-cut lengths of 10´ (3 metre) and 100´ (30 metre) rolls and is available from most major plumbing and building supply outlets throughout North America .It's easy to install, and now comes pre applied to its own integrated applicator to make installation easier. Just pull the fabric over the perforated pipe, like pulling on your socks. Zodiac manufactures their tubular knit fabrics for application on perforated pipes ranging in diameter from 2" (50 mm) to 48" (1200 mm). Zodiac's knit "SOCK"™ and "DRAINSLEEVE"™ geotextiles conform to the new ASTM D6707–06 "Standard Specification for Circular Knit Geotextile for Use in Subsurface Drainage Applications", for both Type "A" and Type "H" fabrics. Custom fabrics are available with specific filtration characteristics in mind.

The figure below demonstrates the use of the filter sock in this project. The filter sock will be attached to the inlet pipe using a 8" hose clamp. The elbows and filter bag in the diagram are not applicable to this project.



APPENDIX F—Tahoe Native Soil Analysis

TAHOE NATIVE SOILS

Nutrient	Measure	Desired Ration	Desired Level		Tahoe Screened D.G.	Tahoe Screened Fill	Tahoe Beach Soil	Native Soil Incline	AVERAGE	Desired Level
Humus			**30-40**		3	8	5	5	5.25	**30-40**
Nitrates	lbs./Acre		**40**		6	8	8	2	6	**40**
Ammonia	lbs./Acre		**40**		4	0	0	2	1.5	**40**
Phosphorus	lbs./Acre	1P:K	**174**		32	13	36	11	23	**174**
Potassium	lbs./Acre		**167**		215	80	37	222	138.5	**167**
Calcium	lbs./Acre	7Ca:1Mg	**3,000**		410	532	205	659	451.5	**3,000**
Magnesium	lbs./Acre		**429**		41	40	33	87	72	**429**
Sodium	PPM		**<35**		2	18	2	14	9	**<35**
ERGS	µS/CM.		**200**		75	137	22	68	75.5	**200**
ORP			**28**		28	28	27	25	27	**28**
pH			**6.5**		7.8	6.9	6.3	6.7	6.92	**6.5**
Copper	PPM		**0.8-2.5**		1	0.5	0.6	1.3	.85	**0.8-2.5**
Iron	PPM		**10-25**		18.8	9.6	14.6	79.1	30.52	**10-25**
Zinc	PPM		**1-6**		0.8	1	6.4	3.1	2.8	**1-6**
Manganese	PPM		**8-30**		3.4	2.7	3.8	12.8	5.6	**8-30**
Boron	PPM		**0.8-1.2**		0	0	0.0	0.2	.05	**0.8-1.2**
Phosphorus										
Bray 1	(ppm)				37	46	8	10		
Olsen	(ppm)				19.6	16.4	8.3	12		
Potassium	(ppm)				52.8	34.4	8.6	98		
Calcium					824.58	936.31	227.09	1014.53		
Magnesium					135.45	67.2	52.36	221.5		
Sodium					2	18	2	14		
Organic Matter	%				0.401	1.241	0.303	1.187		
pH					7.8	6.9	6.3	6.7		
K	%		**2-5%**		2.5	1.4	0.3	2.4	1.65	**2-5%**
Ca	%		**60-70%**		76.4	75.4	13.4	47.7	53.2	**60-70%**
Mg	%		**10-20%**		20.9	9.0	5.1	17.4	13.1	**10-20%**
Na	%		**0.5-3%**		0.2	1.3	0.1	0.6	.55	**0.5-3%**
C.E.C.	meq/100g				5.4	5.4	1.6	7.2	4.9	
Acidity	meq/100g				0.0	0.8	6.9	3.4	2.7	

APPENDIX G—Seed Mixes and Woody Plants

Seed Mix 1 Rain Gardens				
Common Name	**Species**	**Lbs/Acre**	**Acres**	**Total**
WILDRYE BLUE HIGH ELEVATION	*Elymus glaucus*	5.00		5.00
FESCUE SHEEP COVAR	*Festuca ovina*	4.00		4.00
FESCUE HARD DURAR	*Festuca trachyphylla*	4.00		4.00
RUSH BALTIC	*Juncus balticus*	0.15		0.15
WILDRYE CREEPING	*Elymus triticoides*	6.00		6.00
SEDGE NEBRASKENSIS	*Carex nebrascensis*	0.35		0.35
WHEATGRASS SLENDER REVENU	*Elymus trachycaulus*	1.00		1.00
SIERRA WILDFLOWER MIX		1.00		1.00
Arnica Mollis	*Arnica mollis*			
Black-eyed Susan	*Rudbeckia hirta*			
Buckwheat Sulphur	*Eriogonum umbellatum*			
Candytuft	*Iberis sempervirens*			
Catchfly	*Silene armeria*			
Cinquefoil	*Potentilla gracilis*			
Columbine, red	*Aquilegia formosa*			
Coreopsis Lanceleaf	*Coreopsis lanceolata*			
Coreopsis Plains	*Coreopsis tinctoria*			
Flax, blue	*Linum perenne*			
Flax, scarlet	*Linum grandiflorum*			
Geum	*Geum macrophyllum*			
Gilia, golden	*Linanthus aureus*			
Gilia, scarlet	*Ipomopsis aggregata*			
Indian Blanketflower	*Gaillardia aristata*			
Iris missouriensis	*Iris missouriensis*			
Keckellia	*Keckiella breviflora*			
Lupine, argentus	*Lupinus argenteus*			
Lupine, perennis	*Lupinus perennis*			
Monkeyflower, yellow	*Mimulus guttatus*			
Monkeyflower, Lewis	*Mimulus lewisii*			
Penstemon, rydbergii	*Penstemon rydbergii*			
Penstemon, strictus	*Penstemon strictus*			
Poppy, California	*Eschscholzia californica*			
Poppy, Flanders	*Papaver rhoeas*			
Shasta Daisy	*Leucanthemum x superbum*			
Showy Goldeneye	*Viguiera multiflora*			
Snow in Summer	*Cerastium tomentosum*			
Wallflower	*Erysimum asperum*			
TOTALS		21.5		21.5

Seed Mix 2 Grass Filter Strip				
Common Name	**Species**	**Lbs/Acre**	**Acres**	**Total**
WILDRYE BLUE HIGH ELEVATION	*Elymus glaucus*	7.71		7.71
FESCUE SHEEP COVAR	*Festuca ovina*	4		4
WILDRYE CREEPING	*Elymus triticoides*	2		2
WHEATGRASS STREAMBANK SO	*Elymus lanceolatus ssp. Psammophilus*	2		2
WHEATGRASS SLENDER REVENU	*Elymus trachycaulus*	8.5		10
TOTALS		24.21		25.71

Seed Mix 3 Upland Areas				
Common Name	**Species**	**Lbs/Acre**	**Acres**	**Total**
FESCUE SHEEP COVAR	*Festuca ovina*	4		4
WHEATGRASS STREAMBANK SO	*Elymus lanceolatus ssp. Psammophilus*	6		6
PENSTEMON SPECIOSUS	*Penstemon speciousus*	0.5		0.5
BUCKWHEAT SULFUR	*Eriogonum umbellatum*	0.5		0.5
YARROW WHITE	*Achillea millefolium*	0.25		0.25
FLAX BLUE	*Linum perenne*	2		2
POPPY CALIFORNIA	*Eschscholzia californica*	3		3
WHEATGRASS SLENDER REVENU	*Elymus trachycaulus*	6		6
TOTALS		22.25		22.25

Woody Species				
Common Name	**Species**	**Height**	**Number**	**Size**
Mountain Pride Penstemon	*Penstemon newberryi*	1'	16	Supercell
Pinemat Manzanita	*Arctostaphylos nevadensis*	1'	12	Supercell
Mahala Mat	*Ceanothus prostratus*	6"	12	Supercell
Shrubby Cinquefoil	*Potentilla fruticosa*	2.5'	16	1 Gallon
Mountain Spirea	*Spiraea densiflora*	2'	16	Supercell
Creeping Snowberry	*Symphoricarpos mollis*	2'	12	Supercell

APPENDIX H—Anticipated Rain Garden Inspection and Maintenance

Rain Garden Maintenance Plan

Properly designed and installed rain gardens require little maintenance once established.

Sediment Traps: Each LID feature will include sediment traps at each inlet to capture coarse sediment before it enters the feature. The traps are designed to be cleaned with a Vactor truck. The traps will be located either in or just behind the curb so that regular street sweeping removes accumulated pine needles from their inlet grates and pans. Installation of the LID features is not expected to increase street sweeping or Vactoring frequency as the overall sediment load will be the same but more distributed with the additional assets. Sediment traps will reduce the amount of coarse sediment that enters each LID feature and therefore increase their lifespan by limiting surficial sediment accumulation.

Vegetation: The LID features will be planted with low-maintenance, native vegetation approved by Washoe County for sight safety concerns. Regular irrigation is required for the first growing season and occasional irrigation the second year (performed by NTCD). Once vegetation is established, maintenance of the LID feature consists of periodic trash and debris removal. The LID features will also require removal of invasive weeds similar to other stormwater facilities and County right-of-ways. Thick vegetation in the LID features and a natural pine needle mulch supply from surrounding trees will obviate the need for mulch replenishment. BMP RAM protocols to determine vegetative cover should be followed annually as the LID features will be classified as 'infiltration basins' according to BMP RAM. Desired percentage of vegetation differs from BMP RAM default values in that ideal vegetation percent cover in the LID features should be between 50 and 80 percent.

Infiltration Performance: The City of Portland has experienced acceptable infiltration rates over the life of their rain gardens, some of which are 10 to 15 years old[1]. Once vegetation is established, it is expected that biological activity will maintain or even increase infiltration rates of the soil. Other municipalities have experienced increased infiltration rates five years following construction, likely due to soil biological activity and the annual cycle of plant root growth and senescence[2]. Thus, replacement of the amended soils in the LID features is not anticipated.

The maintenance trigger for infiltration performance is ponding water for longer than 3 days or unsatisfactory infiltration performance using BMP RAM protocols for infiltration basins. Loosening of the soil profile with a broadfork is the first step of soil reconditioning. If desired infiltration performance is not achieved, removal of the top inch of soil in late summer or aerating or tilling the top few inches of soil may restore desired infiltration. Revegetation is not necessary if care is taken not to destroy vegetation or remove the seed bank. If major soil reconditioning is performed (soil replacement), then vegetation would have to be reestablished.

<u>Inspection and Maintenance:</u> Maintenance of the rain gardens is required when inspections reveal the following:

- Trash, debris or sediment accumulation (determined visually, inspect twice annually)
  - Remove trash, debris and dispose of properly
  - Remove accumulated sediment and dispose of properly (ensure design depth of rain gardens is maintained)
- Weeds (use the same protocol and frequency for all county right-of-ways)
  - Remove invasive weeds and any tree seedlings to prevent their establishment
- Full sediment traps (inspect and maintain at the same frequency as existing catch basins using BMP RAM protocols)
  - Empty sediment traps and dispose of properly
- Pine needle obstruction of inlets
  - Remove pine needles from entry via regular street sweeping
- Ponding water for longer than 3 days or poor infiltration (using BMP RAM protocols for infiltration basins)
  - Loosen soil profile with broadfork **or** remove top inch of soil in gardens **or** aerate/till the top few inches of soil in late summer.

Anticipated Rain Garden Inspection and Maintenance		
Task	Schedule	Responsibility
Irrigation	1" of water per week during the first growing season to establish vegetation. Possibly additional irrigation the second year.	NTCD (first 2 years)
Weeding	The LID features will be planted with native vegetation to improve infiltration and nutrient up take. Invasive weeds and tree seedlings are not desired in the LID features. Invasive weeds must be managed as in any stormwater treatment facility or County Right-of-Way.	NTCD (first 2 years) Washoe County thereafter
Street Sweeping	Four times a year and before and after major storm events. Removing pine needles from the drainage inlets is key for stormwater entry to the gardens.	Washoe County
Empty Sediment Traps	Follow the current schedule of twice a year. (Spring and Fall)	Washoe County
Remove Trash/Debris	Annually (same schedule as any other stormwater basin).	NTCD (first 2 years) Washoe County thereafter
BMP RAM	Use BMP RAM Field Observation Protocols for Infiltration Basins. Percent cover vegetation should be between 50 and 80 percent. Conduct annually, or as often as condition scores are desired	NTCD (first 2 years) Washoe County thereafter
Soil Reconditioning	Not Anticipated[3]. The experience of other municipalities is that reconditioning of bioretention basins is a very rare maintenance requirement. The vegetation is expected to maintain porosity and infiltration. Rain gardens often have a higher infiltration rate five years after construction, likely due to soil biological activity and the annual cycle of root growth and senescence[4]. In the unlikely event that desired infiltration is not maintained, loosening of the soil profile with a broad fork is recommended. Removal of the top inch of soil or aerating or tilling the top few inches of soil may in late summer also be performed to restore function.	Washoe County

[3] 7/20/10 Conversation with Maria Cahill of Green Girl Land Development Solutions.
[4] 7/22/10 Conversation with Mike Isensee of Dakota County Soil and Water Conservation District.