
ATTACHMENT I
STORMWATER DRAINAGE CALCULATIONS

Stormwater Report



1900 Crown Colony Drive
Suite 402
Quincy, MA 02169
Tel: 617 657 0200
Fax: 617 657 0201
www.envpartners.com

To: Town of Acton Conservation Commission
From: Stephen C. Olson, P.E.
Cc: NOI CC list
Date: November 18, 2015
Subject: Nagog Pond Water Treatment Plant
WPA Form 3 - Notice of Intent
Stormwater Report

Environmental Partners Group, Inc. has prepared this stormwater report on behalf of the Town of Concord for the Wetlands Protection Act Notice of Intent for the Nagog Pond Water Treatment Plant project. This report has been prepared in accordance with the requirements of 310 CMR 10.00 and 310 CMR 21.00, and the guidelines of the Massachusetts Stormwater Handbook (MSH).

Project Applicant: Town of Concord Water Department
135 Keyes Road
Concord, MA 01742
Alan Cathcart, Water/Sewer Superintendent
(978) 318-3250

Preparer: Environmental Partners Group, Inc.
Stephen C. Olson, P.E.

Project Name: Nagog Pond Water Treatment Plant

Project Address: 180/182 Skyline Drive, Acton, MA 01720

The following materials are referenced as part of Stormwater Report:

- Stormwater Checklist
- Site Locus
- Demolition and Erosion Control Plan
- Site Plan and Yard Piping Plan
- Civil Details
- Stormwater Report
- Boring Logs and Sieve Analyses
- NCRS Soil Types and Soil Survey Map
- Source Control and Pollution Prevention Plan
- Stormwater Operation and Maintenance Plan

Project Type: Mix of New Development and Redevelopment

Project Narrative: The existing site is developed and includes a water treatment facility, chain link fencing, various yard piping, and an asphalt paved driveway. The site is bound to the north by Nagog Pond, to the east by wetlands and Nagog Brook, to the west by wetlands, and to the south by woods. Nagog Pond has an intake pipe, dam, and gatehouse associated with the existing water treatment plant.

The project includes the construction of a new water treatment plant, a new intake pipe, and a photovoltaic (PV) array. The new 1.5 million gallon per day drinking water treatment plant will replace the existing water treatment facility. The existing treatment facility is only operated seasonally in order to maintain an existing filtration waiver. The Town of Concord would like to construct a treatment plant capable of meeting all current drinking water regulations so that they may operate the facility on a continuous basis to meet current and future water demands. Construction activities will include architectural, structural, civil, process, HVAC, plumbing and electrical work, and the demolition of the existing treatment plant and appurtenant structures.

The new water treatment plant will be constructed over the existing water treatment facility on site, while also extending further to the west and south. Construction will begin with the installation of the PV array and all site work that will not require the treatment plant to be shut down. Since the existing facility is only operated seasonally, construction of the new water treatment plant will occur when the existing facility is not in use. The site grading will largely remain unchanged with only minor modifications to accommodate the new facilities. The paved area around the treatment plant will be sloped away from the building to direct stormwater away.

Existing Stormwater
Conditions:

The existing site has minimal stormwater management controls. Stormwater flows via sheet flow from the paved areas and roofs onto the surrounding grass, paved, rip-rap, and wooded areas. Ultimately, all stormwater is infiltrated into the ground or runs off towards Nagog Brook and through the culvert under Skyline Drive.

A rip-rap channel to the east of the existing driveway diverts driveway runoff towards a new catch basin near the intersection with Skyline Drive.

Proposed Stormwater
Conditions:

Cover type and grading will generally mimic existing conditions, with the exception of the PV array area being converted from a wooded area to an open space. The entire ground surface of the PV array area will receive a seed mix to encourage the development of a meadow.

In the vicinity of the new water treatment facility, stormwater runoff will be directed into a series of underground recharge chambers via deep sump catch basins with hoods, a drywell, and underground piping. The proposed stormwater facilities provide recharge, attenuate the peak discharge, and provide TSS removal. The overflow from this system will be equipped with a flared end section and rip-rap to provide additional velocity control and scour protection.

Runoff from the driveway will be directed towards the existing swale.

Existing and
Proposed Site Plans:

A set of full-size 22"x 34" design plans are provided as an attachment to the Notice of Intent. Existing conditions; the wetland boundary; 25-, 50-, 75- and 100-foot wetland buffer zones, and the existing water treatment facility are

shown on Sheet C-7. The proposed grading and drainage plan is shown on sheet C-11. Various civil details are shown on Sheets CD-1 through CD-7.

LID Measures: The project does not propose any disturbances to bordering vegetated wetlands.

Stormwater Standard 1: The project does not propose any new untreated discharges.

Stormwater Standard 2: The existing and proposed site conditions were analyzed for the 2, 10, and 100-year 24-hour storm events using HydroCAD Version 10. Based on these results, there is no increase in peak discharge rates for all storm events. Please refer to Table 1 below for a summary of peak rates. Please refer to the HydroCAD report in Attachment B for full details.

Table 1
Summary of Peak Discharge Rates

Storm Event	Existing Conditions	Developed Conditions
2-year	0.08 cfs	0.06 cfs
10-year	1.41 cfs	1.35 cfs
100-year	10.24 cfs	10.04 cfs

Soil type was determined using Natural Resource Conservation Service (NRCS) Soil Survey data. There are two Hydrologic Soil Groups (HSGs) on this site: HSG A and HSG D. Soil borings were conducted in the vicinity of the proposed recharge facilities to verify in situ soil conditions. Based on the sieve analyses from these soil borings, the HSG A soil in the vicinity of chamber C-2, chamber C-3, and the drywell has an infiltration rate of 5.1 inches/hour. This is consistent with the range of HSG A soil Rawls Rates listed in the MSH. The HSG D soil in the vicinity of C-1 was conservatively assumed to provide no infiltration in the HydroCAD model even though the current use of the area around C-1 for a leaching pit suggests that the soil in this location has a high infiltration rate. Soil borings and sieve analyses are provided in Attachment C.

Stormwater Standard 3: Stormwater will be recharged using underground chambers and a drywell. Recharge calculations are provided in Attachment D. Chambers C-2 and C-3 provide the *Required Recharge Volume* for this project, and the chambers will drain within the required 72 hours. Groundwater is not expected to affect recharge as there was no sign of any groundwater in any of the borings.

Stormwater Standard 4: The proposed best management practices (BMPs) treat the *Required Water Quality Volume* and provide 80% TSS removal. Based on one inch of runoff times the impervious area, the *Required Water Quality Volume* is 2,471 cf. The 2-year storm generates 2,573 cfs of runoff directed towards the BMPs around the proposed building. This is greater than the *Required Water Quality Volume*. The 2-year storm HydroCAD calculations provided in Attachment E show that proposed BMPs are sized appropriately to treat this volume. Therefore, this project meets the *Required Water Quality Volume* requirements.

Volume 2, Chapter 2 of the MSH states that subsurface structures, including underground plastic chambers, provide 80% TSS removal. Consequently, this project meets the TSS removal requirements as well.

A Long-Term Pollution Prevention Plan is combined with the Operation and Maintenance Plan (Standard 9) and is included in Attachment F.

Stormwater
Standard 5:

The water treatment process uses and will accept deliveries of various chemicals. There will be secondary containment within the delivery area to keep any spillage from migrating offsite.

Stormwater
Standard 6:

Standard 6 is applicable due to this project's proximity to Nagog Brook (a Division of Fisheries and Wildlife cold-water fishery) and Nagog Pond (Outstanding Resource Water).

As discussed above, the proposed BMPs treat the *Required Water Quality Volume* calculated using the "one-inch rule" (one-inch times the impervious area).

The project includes the use of subsurface structures, which are recommended BMPs for compliance with Standard 6. Deep sump catch basins with hoods are proposed to help provide additional TSS removal.

Stormwater
Standard 7:

"Maintenance and improvement of existing roadways" qualifies as a redevelopment project according to the MSH. In that sense, the improvement of the driveway to the facility counts as a redevelopment project. However, the entire project leads to an increase in impervious area. The increase in impervious area is generally a result of the enlarged building and the new pavement around the building. Consequently, the project proposes to meet all the Standards, and there is a particular focus on improving the stormwater management system near the proposed facility.

Stormwater
Standard 8:

A Construction Period Stormwater Pollution Prevention and Erosion and Sedimentation Control Plan (SWPPP) has not been included in this Stormwater Report. The project Contractor(s) will be required to submit a SWPPP for review and approval prior to any land disturbance.

Stormwater
Standard 9:

The Post Construction Operation and Maintenance (O&M) Plan is attached to this Stormwater Report. The O&M Plan includes the name of the stormwater management system owners, the party responsible for operation and maintenance, a schedule for implementation of routine and non-routine maintenance tasks, and a maintenance log form.

Stormwater

Standard 10: The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges. An Illicit Discharge Compliance Statement is not attached to this Stormwater Report but will be submitted prior to the discharge of any stormwater to post-construction BMPs.

Attachments:

Attachment A – Checklist for Stormwater Report

Attachment B – Standard 2 HydroCAD Calculations

Attachment C – Soil Information

Attachment D – Standard 3 Recharge Calculations

Attachment E – Standard 4 Water Quality Calculations

Attachment F – Long Term Pollution Prevention Plan and Operations & Maintenance Plan

Attachment G – Stormwater Figures

ATTACHMENT A
CHECKLIST FOR STORMWATER REPORT



Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.



A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the [Massachusetts Stormwater Handbook](#). The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.¹ This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8²
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

¹ The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

² For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.



Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature



Adam S. Kran 11/18/15
Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

- New development
- Redevelopment
- Mix of New Development and Redevelopment



Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

- No disturbance to any Wetland Resource Areas
- Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- Reduced Impervious Area (Redevelopment Only)
- Minimizing disturbance to existing trees and shrubs
- LID Site Design Credit Requested:
 - Credit 1
 - Credit 2
 - Credit 3
- Use of "country drainage" versus curb and gutter conveyance and pipe
- Bioretention Cells (includes Rain Gardens)
- Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- Treebox Filter
- Water Quality Swale
- Grass Channel
- Green Roof
- Other (describe): _____

Standard 1: No New Untreated Discharges

- No new untreated discharges
- Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.



Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

- Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.
- Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.
- Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

- Soil Analysis provided.
- Required Recharge Volume calculation provided.
- Required Recharge volume reduced through use of the LID site Design Credits.
- Sizing the infiltration, BMPs is based on the following method: Check the method used.
 - Static
 - Simple Dynamic
 - Dynamic Field¹
- Runoff from all impervious areas at the site discharging to the infiltration BMP.
- Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.
- Recharge BMPs have been sized to infiltrate the Required Recharge Volume.
- Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:
 - Site is comprised solely of C and D soils and/or bedrock at the land surface
 - M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
 - Solid Waste Landfill pursuant to 310 CMR 19.000
 - Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.
- Calculations showing that the infiltration BMPs will drain in 72 hours are provided.
- Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

¹ 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.



Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

- The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.
- Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
 - Provisions for storing materials and waste products inside or under cover;
 - Vehicle washing controls;
 - Requirements for routine inspections and maintenance of stormwater BMPs;
 - Spill prevention and response plans;
 - Provisions for maintenance of lawns, gardens, and other landscaped areas;
 - Requirements for storage and use of fertilizers, herbicides, and pesticides;
 - Pet waste management provisions;
 - Provisions for operation and management of septic systems;
 - Provisions for solid waste management;
 - Snow disposal and plowing plans relative to Wetland Resource Areas;
 - Winter Road Salt and/or Sand Use and Storage restrictions;
 - Street sweeping schedules;
 - Provisions for prevention of illicit discharges to the stormwater management system;
 - Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
 - Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
 - List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.
- A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.
 - Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:
 - is within the Zone II or Interim Wellhead Protection Area
 - is near or to other critical areas
 - is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
 - involves runoff from land uses with higher potential pollutant loads.
 - The Required Water Quality Volume is reduced through use of the LID site Design Credits.
 - Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.



Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

- The BMP is sized (and calculations provided) based on:
 - The ½" or 1" Water Quality Volume or
 - The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.
- The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.
- A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

- The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.
- The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted **prior to** the discharge of stormwater to the post-construction stormwater BMPs.
- The NPDES Multi-Sector General Permit does **not** cover the land use.
- LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.
- All exposure has been eliminated.
- All exposure has **not** been eliminated and all BMPs selected are on MassDEP LUHPPL list.
- The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

- The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.
- Critical areas and BMPs are identified in the Stormwater Report.



Checklist for Stormwater Report

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

- The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:
 - Limited Project
 - Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
 - Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
 - Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
 - Bike Path and/or Foot Path
 - Redevelopment Project
 - Redevelopment portion of mix of new and redevelopment.
- Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.
- The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
 - Construction Period Operation and Maintenance Plan;
 - Names of Persons or Entity Responsible for Plan Compliance;
 - Construction Period Pollution Prevention Measures;
 - Erosion and Sedimentation Control Plan Drawings;
 - Detail drawings and specifications for erosion control BMPs, including sizing calculations;
 - Vegetation Planning;
 - Site Development Plan;
 - Construction Sequencing Plan;
 - Sequencing of Erosion and Sedimentation Controls;
 - Operation and Maintenance of Erosion and Sedimentation Controls;
 - Inspection Schedule;
 - Maintenance Schedule;
 - Inspection and Maintenance Log Form.
- A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.



Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

- The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has **not** been included in the Stormwater Report but will be submitted **before** land disturbance begins.
- The project is **not** covered by a NPDES Construction General Permit.
- The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.
- The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

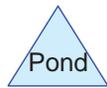
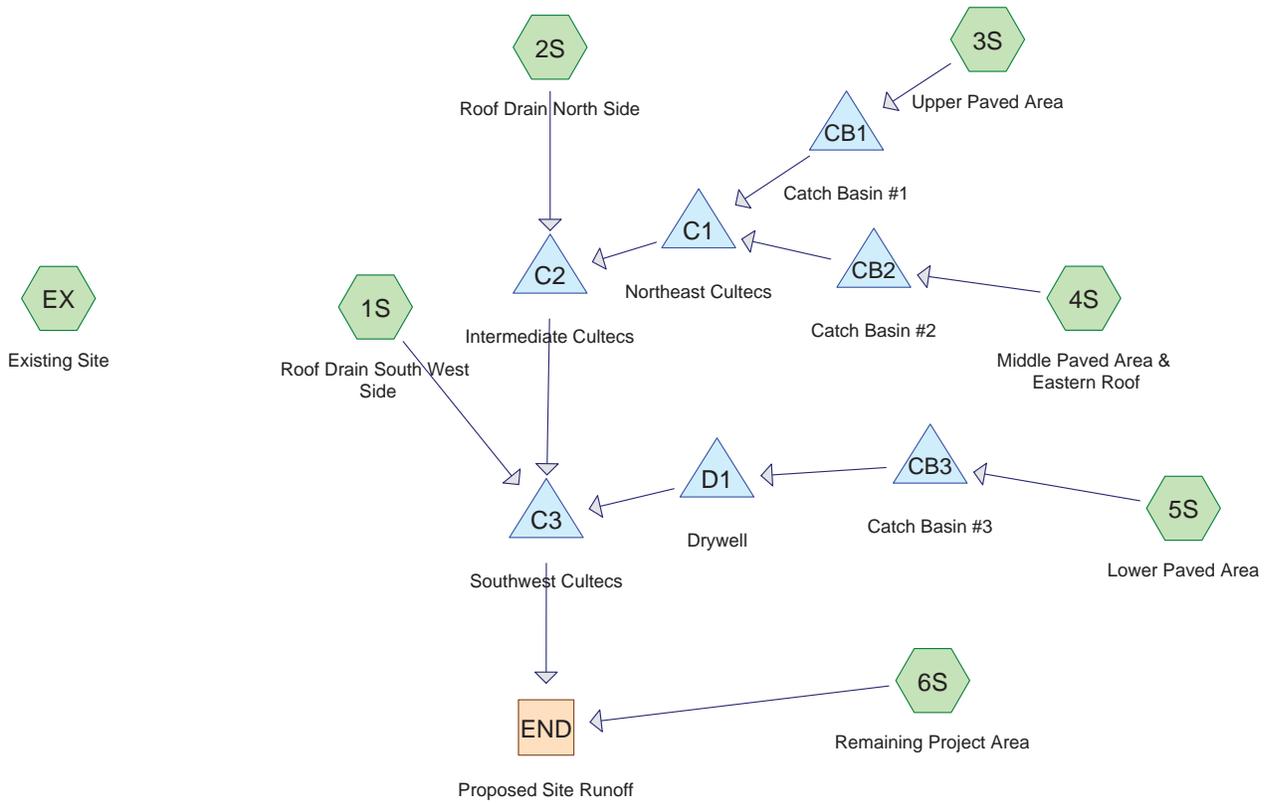
Standard 9: Operation and Maintenance Plan

- The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:
 - Name of the stormwater management system owners;
 - Party responsible for operation and maintenance;
 - Schedule for implementation of routine and non-routine maintenance tasks;
 - Plan showing the location of all stormwater BMPs maintenance access areas;
 - Description and delineation of public safety features;
 - Estimated operation and maintenance budget; and
 - Operation and Maintenance Log Form.
- The responsible party is **not** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:
 - A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
 - A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

- The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;
- An Illicit Discharge Compliance Statement is attached;
- NO Illicit Discharge Compliance Statement is attached but will be submitted **prior to** the discharge of any stormwater to post-construction BMPs.

ATTACHMENT B
STANDARD 2 HYDROCAD CALCULATIONS



Nagog HydroCAD - 2015-11-16

Prepared by Environmental Partners Group

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Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
37,532	49	50-75% Grass cover, Fair, HSG A (3S, 6S, EX)
12,778	76	Gravel roads, HSG A (6S, EX)
6,262	76	Gravel roads, HSG A (RIP RAP) (6S, EX)
698	76	Gravel roads, HSG A (rip rap) (3S)
39,143	30	Meadow, non-grazed, HSG A (6S)
27,757	78	Meadow, non-grazed, HSG D (6S)
39,344	98	Paved parking, HSG A (3S, 4S, 5S, 6S, EX)
7,639	98	Roofs, HSG A (1S, 2S, 4S)
224,763	30	Woods, Good, HSG A (6S, EX)
88,351	77	Woods, Good, HSG D (6S, EX)
484,267	51	TOTAL AREA

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Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
368,159	HSG A	1S, 2S, 3S, 4S, 5S, 6S, EX
0	HSG B	
0	HSG C	
116,108	HSG D	6S, EX
0	Other	
484,267		TOTAL AREA

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Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover	Sub Nun
37,532	0	0	0	0	37,532	50-75% Grass cover, Fair	
19,738	0	0	0	0	19,738	Gravel roads	
39,143	0	0	27,757	0	66,900	Meadow, non-grazed	
39,344	0	0	0	0	39,344	Paved parking	
7,639	0	0	0	0	7,639	Roofs	
224,763	0	0	88,351	0	313,114	Woods, Good	
368,159	0	0	116,108	0	484,267	TOTAL AREA	

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Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	C1	231.67	230.95	145.0	0.0050	0.012	4.0	0.0	0.0
2	C1	232.33	231.44	145.0	0.0061	0.012	8.0	0.0	0.0
3	C2	230.00	230.00	10.0	0.0000	0.012	8.0	0.0	0.0
4	C3	230.68	230.48	20.0	0.0100	0.012	8.0	0.0	0.0
5	CB1	232.95	231.75	20.0	0.0600	0.012	6.0	0.0	0.0
6	CB2	232.95	231.75	75.0	0.0160	0.012	6.0	0.0	0.0
7	CB3	232.95	232.38	115.0	0.0050	0.012	6.0	0.0	0.0
8	D1	231.25	231.00	5.0	0.0500	0.012	6.0	0.0	0.0

Time span=0.10-24.00 hrs, dt=0.02 hrs, 1196 points x 3
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
 Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Roof Drain South West Runoff Area=2,749 sf 100.00% Impervious Runoff Depth>2.83"
 Flow Length=50' Slope=0.1300 '/' Tc=6.0 min CN=98 Runoff=0.19 cfs 647 cf

Subcatchment 2S: Roof Drain North Side Runoff Area=3,230 sf 100.00% Impervious Runoff Depth>2.83"
 Flow Length=50' Slope=0.1300 '/' Tc=6.0 min CN=98 Runoff=0.22 cfs 761 cf

Subcatchment 3S: Upper Paved Area Runoff Area=10,259 sf 69.83% Impervious Runoff Depth>1.64"
 Tc=6.0 min CN=85 Runoff=0.45 cfs 1,399 cf

Subcatchment 4S: Middle Paved Area & Runoff Area=4,232 sf 100.00% Impervious Runoff Depth>2.83"
 Tc=6.0 min CN=98 Runoff=0.29 cfs 997 cf

Subcatchment 5S: Lower Paved Area Runoff Area=3,960 sf 100.00% Impervious Runoff Depth>2.83"
 Tc=6.0 min CN=98 Runoff=0.27 cfs 933 cf

Subcatchment 6S: Remaining Project Area Runoff Area=217,642 sf 3.80% Impervious Runoff Depth>0.08"
 Flow Length=562' Tc=15.9 min CN=49 Runoff=0.06 cfs 1,506 cf

Subcatchment EX: Existing Site Runoff Area=242,195 sf 7.17% Impervious Runoff Depth>0.10"
 Flow Length=562' Tc=15.9 min CN=50 Runoff=0.08 cfs 2,027 cf

Reach END: Proposed Site Runoff Inflow=0.06 cfs 1,506 cf
 Outflow=0.06 cfs 1,506 cf

Pond C1: Northeast Cultecs Peak Elev=232.17' Storage=0.025 af Inflow=0.74 cfs 2,357 cf
 Discarded=0.00 cfs 0 cf Primary=0.16 cfs 1,884 cf Outflow=0.16 cfs 1,884 cf

Pond C2: Intermediate Cultecs Peak Elev=230.35' Storage=313 cf Inflow=0.33 cfs 2,645 cf
 Discarded=0.06 cfs 1,899 cf Primary=0.14 cfs 746 cf Outflow=0.20 cfs 2,644 cf

Pond C3: Southwest Cultecs Peak Elev=230.33' Storage=0.012 af Inflow=0.45 cfs 1,934 cf
 Discarded=0.12 cfs 1,934 cf Primary=0.00 cfs 0 cf Outflow=0.12 cfs 1,934 cf

Pond CB1: Catch Basin #1 Peak Elev=233.56' Storage=27 cf Inflow=0.45 cfs 1,399 cf
 6.0" Round Culvert n=0.012 L=20.0' S=0.0600 '/' Outflow=0.45 cfs 1,380 cf

Pond CB2: Catch Basin #2 Peak Elev=233.35' Storage=24 cf Inflow=0.29 cfs 997 cf
 6.0" Round Culvert n=0.012 L=75.0' S=0.0160 '/' Outflow=0.29 cfs 977 cf

Pond CB3: Catch Basin #3 Peak Elev=233.34' Storage=24 cf Inflow=0.27 cfs 933 cf
 6.0" Round Culvert n=0.012 L=115.0' S=0.0050 '/' Outflow=0.27 cfs 913 cf

Pond D1: Drywell Peak Elev=231.63' Storage=35 cf Inflow=0.27 cfs 913 cf
 Discarded=0.01 cfs 372 cf Primary=0.26 cfs 541 cf Outflow=0.27 cfs 913 cf

Total Runoff Area = 484,267 sf Runoff Volume = 8,270 cf Average Runoff Depth = 0.20"
90.30% Pervious = 437,284 sf 9.70% Impervious = 46,983 sf

Summary for Subcatchment 1S: Roof Drain South West Side

Runoff = 0.19 cfs @ 12.08 hrs, Volume= 647 cf, Depth> 2.83"

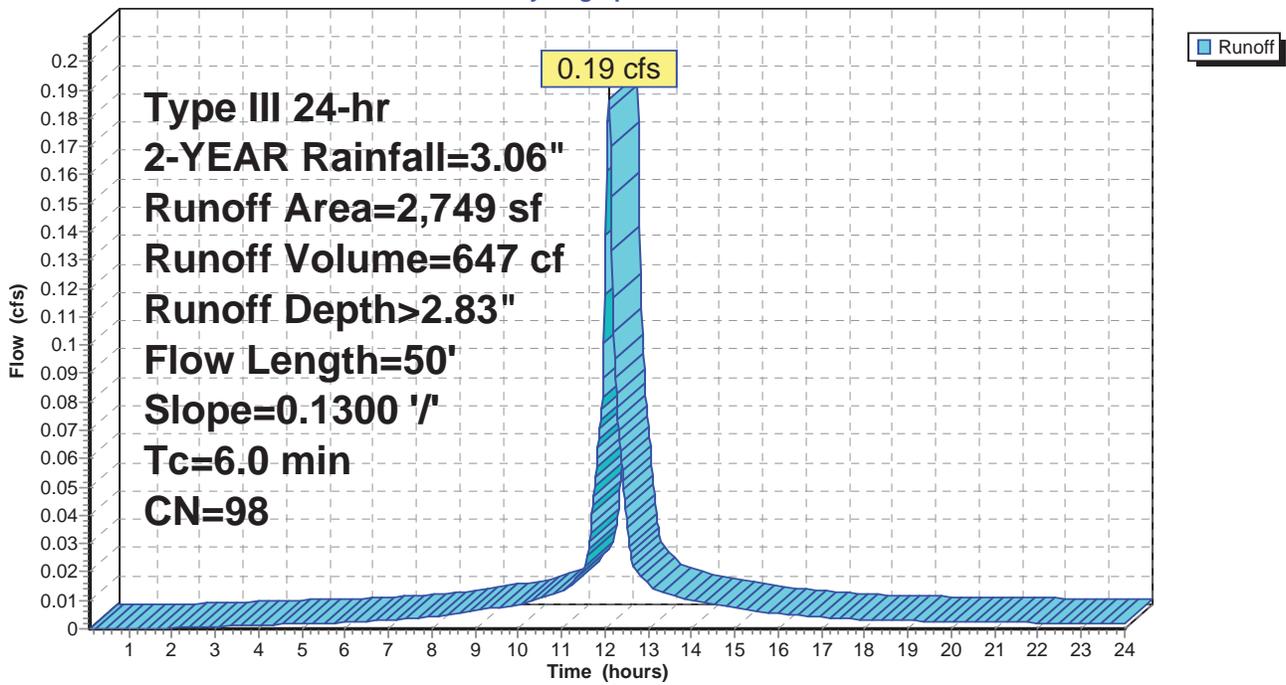
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
2,749	98	Roofs, HSG A
2,749		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.1300	0.14		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"

Subcatchment 1S: Roof Drain South West Side

Hydrograph



Summary for Subcatchment 2S: Roof Drain North Side

Runoff = 0.22 cfs @ 12.08 hrs, Volume= 761 cf, Depth> 2.83"

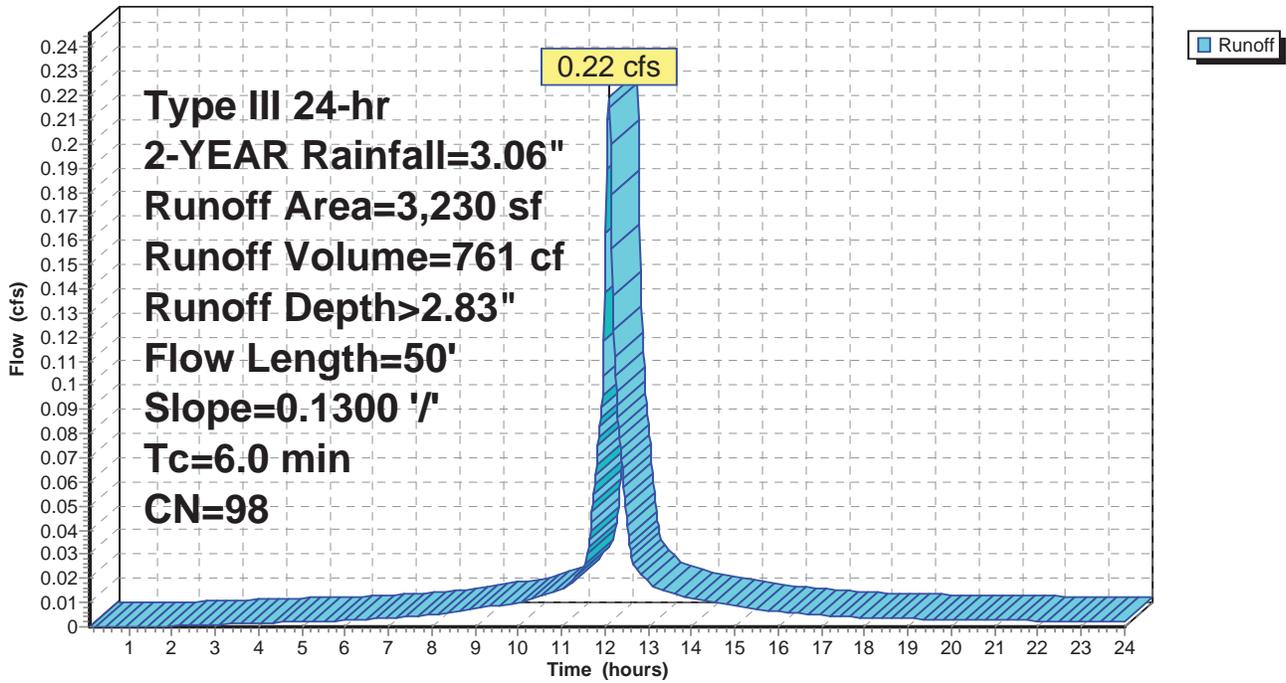
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
3,230	98	Roofs, HSG A
3,230		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.1300	0.14		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"

Subcatchment 2S: Roof Drain North Side

Hydrograph



Summary for Subcatchment 3S: Upper Paved Area

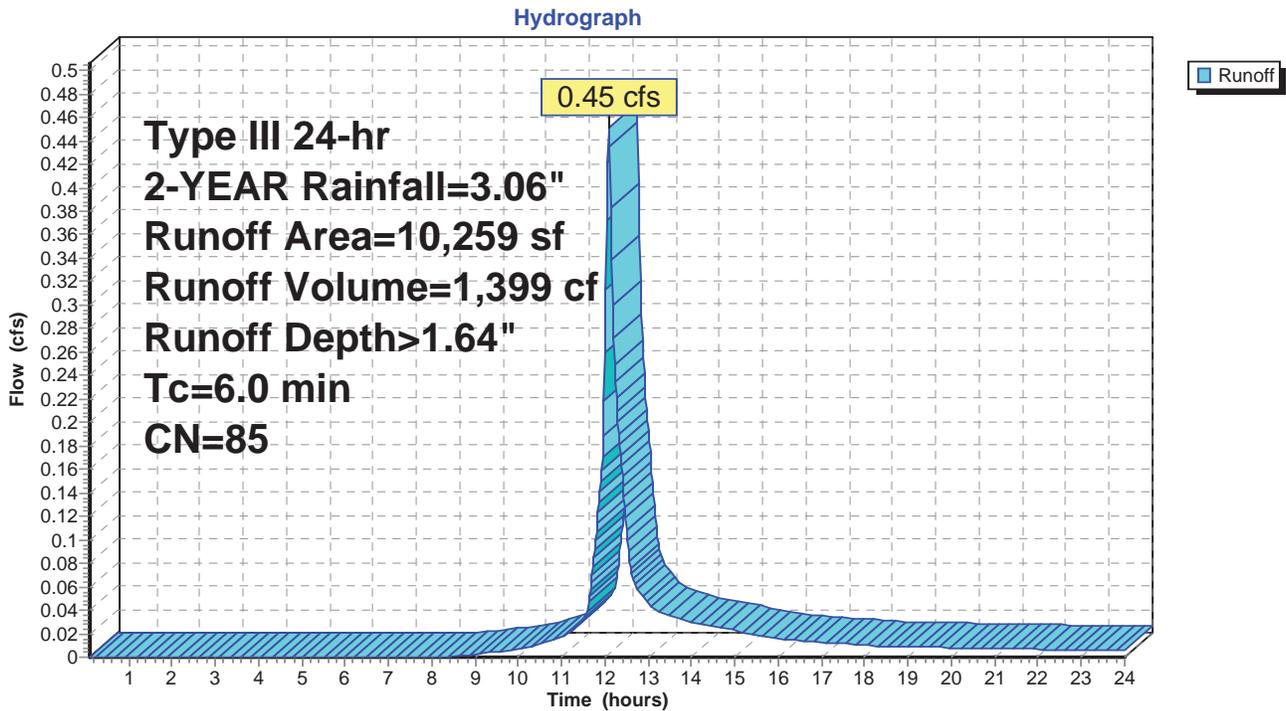
Runoff = 0.45 cfs @ 12.09 hrs, Volume= 1,399 cf, Depth> 1.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
7,164	98	Paved parking, HSG A
1,956	49	50-75% Grass cover, Fair, HSG A
441	49	50-75% Grass cover, Fair, HSG A
* 698	76	Gravel roads, HSG A (rip rap)
10,259	85	Weighted Average
3,095		30.17% Pervious Area
7,164		69.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 3S: Upper Paved Area



Summary for Subcatchment 4S: Middle Paved Area & Eastern Roof

Runoff = 0.29 cfs @ 12.08 hrs, Volume= 997 cf, Depth> 2.83"

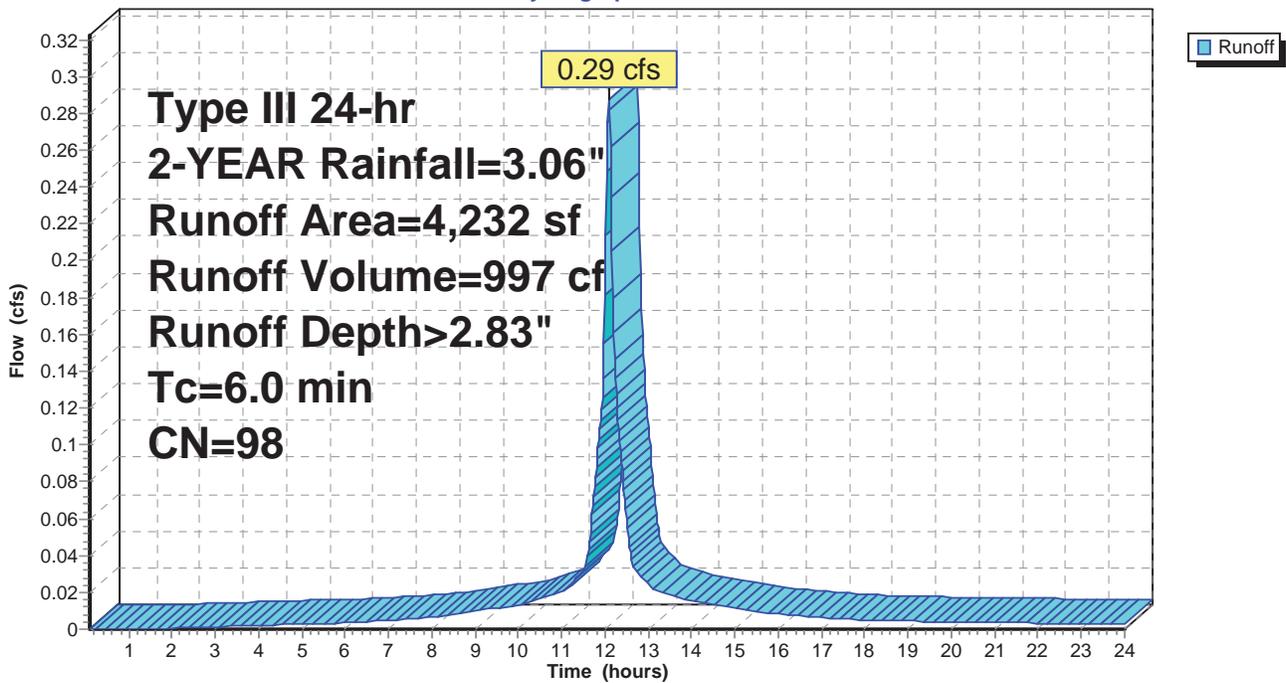
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
 Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
2,572	98	Paved parking, HSG A
1,660	98	Roofs, HSG A
4,232	98	Weighted Average
4,232		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 4S: Middle Paved Area & Eastern Roof

Hydrograph



Summary for Subcatchment 5S: Lower Paved Area

Runoff = 0.27 cfs @ 12.08 hrs, Volume= 933 cf, Depth> 2.83"

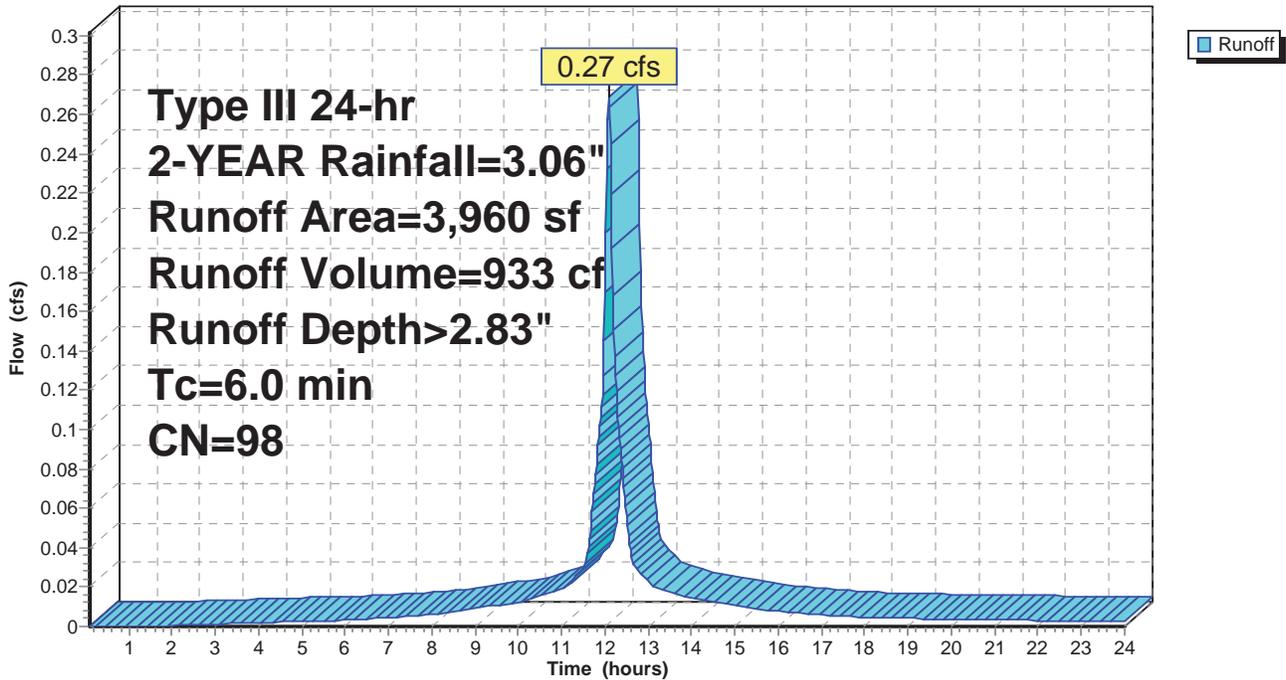
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
 Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
3,960	98	Paved parking, HSG A
3,960		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 5S: Lower Paved Area

Hydrograph



Summary for Subcatchment 6S: Remaining Project Area

Runoff = 0.06 cfs @ 14.72 hrs, Volume= 1,506 cf, Depth> 0.08"

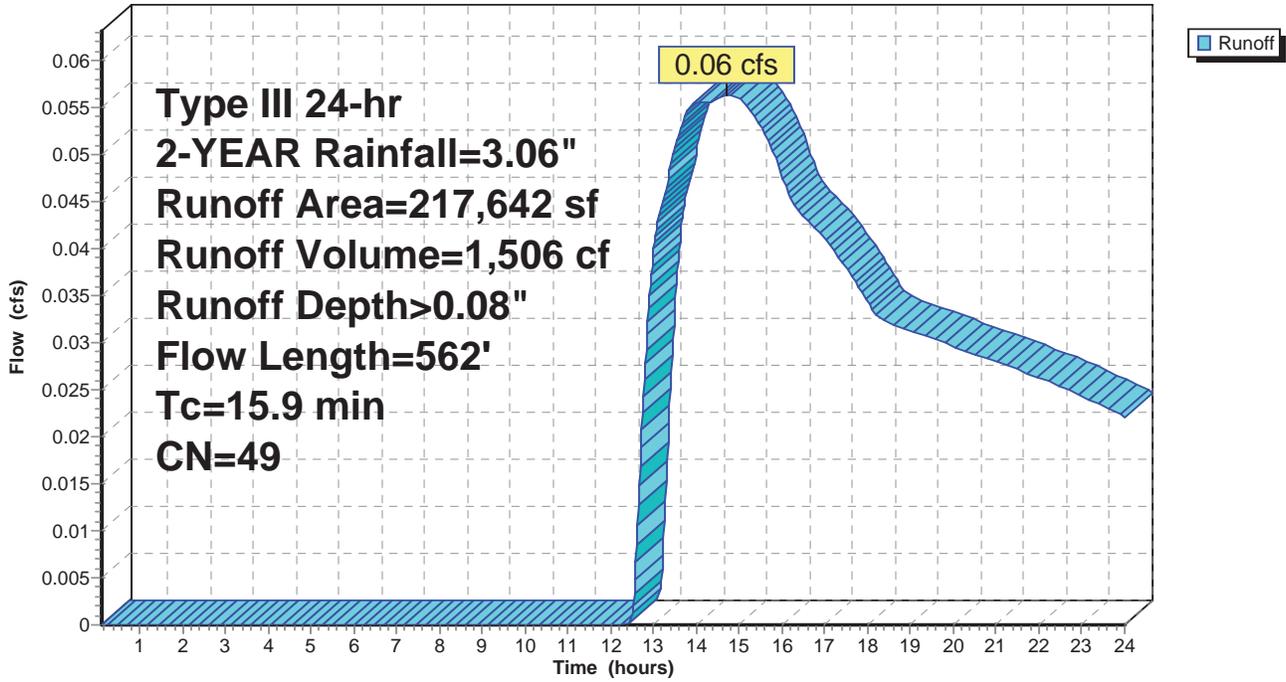
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
2,763	49	50-75% Grass cover, Fair, HSG A
9,597	76	Gravel roads, HSG A
8,274	98	Paved parking, HSG A
7,927	49	50-75% Grass cover, Fair, HSG A
27,757	78	Meadow, non-grazed, HSG D
28,946	77	Woods, Good, HSG D
78,485	30	Woods, Good, HSG A
39,143	30	Meadow, non-grazed, HSG A
11,968	30	Woods, Good, HSG A
* 2,782	76	Gravel roads, HSG A (RIP RAP)
217,642	49	Weighted Average
209,368		96.20% Pervious Area
8,274		3.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.7	50	0.0500	0.10		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"
0.3	36	0.1676	2.05		Shallow Concentrated Flow, woods pre grass strip Woodland Kv= 5.0 fps
0.1	10	0.1000	2.21		Shallow Concentrated Flow, grass strips (both) Short Grass Pasture Kv= 7.0 fps
0.0	12	0.0833	5.86		Shallow Concentrated Flow, pavement Paved Kv= 20.3 fps
6.7	440	0.0480	1.10		Shallow Concentrated Flow, rip rap Woodland Kv= 5.0 fps
0.1	14	0.1667	2.86		Shallow Concentrated Flow, grass strip Short Grass Pasture Kv= 7.0 fps
15.9	562	Total			

Subcatchment 6S: Remaining Project Area

Hydrograph



Summary for Subcatchment EX: Existing Site

Runoff = 0.08 cfs @ 13.84 hrs, Volume= 2,027 cf, Depth> 0.10"

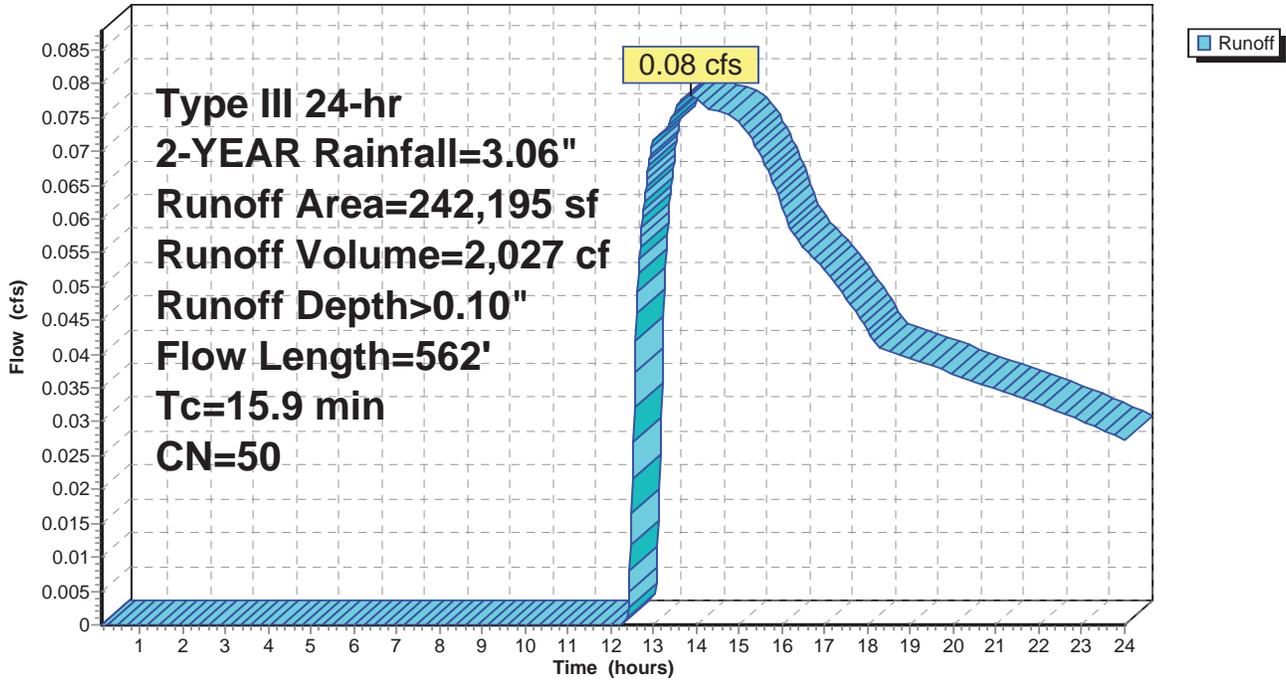
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
11,475	49	50-75% Grass cover, Fair, HSG A
3,181	76	Gravel roads, HSG A
17,374	98	Paved parking, HSG A
4,242	49	50-75% Grass cover, Fair, HSG A
8,728	49	50-75% Grass cover, Fair, HSG A
* 3,480	76	Gravel roads, HSG A (RIP RAP)
59,405	77	Woods, Good, HSG D
82,915	30	Woods, Good, HSG A
9,737	30	Woods, Good, HSG A
41,658	30	Woods, Good, HSG A
242,195	50	Weighted Average
224,821		92.83% Pervious Area
17,374		7.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.7	50	0.0500	0.10		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"
0.3	36	0.1676	2.05		Shallow Concentrated Flow, woods Woodland Kv= 5.0 fps
0.0	12	0.1000	6.42		Shallow Concentrated Flow, pavement Paved Kv= 20.3 fps
0.1	10	0.1000	2.21		Shallow Concentrated Flow, grass strip (both) Short Grass Pasture Kv= 7.0 fps
6.7	440	0.0480	1.10		Shallow Concentrated Flow, rip rap Woodland Kv= 5.0 fps
0.1	14	0.1667	2.86		Shallow Concentrated Flow, final grass strip Short Grass Pasture Kv= 7.0 fps
15.9	562	Total			

Subcatchment EX: Existing Site

Hydrograph



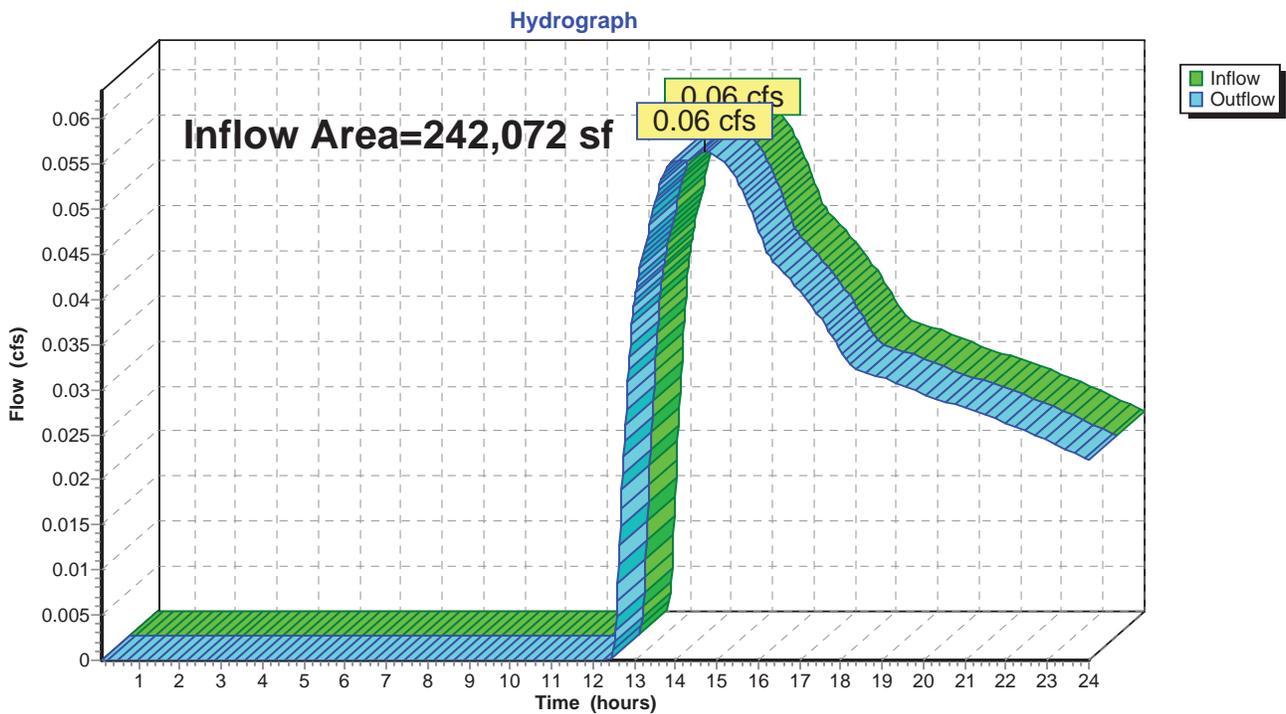
Summary for Reach END: Proposed Site Runoff

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 242,072 sf, 12.23% Impervious, Inflow Depth > 0.07" for 2-YEAR event
Inflow = 0.06 cfs @ 14.72 hrs, Volume= 1,506 cf
Outflow = 0.06 cfs @ 14.72 hrs, Volume= 1,506 cf, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3

Reach END: Proposed Site Runoff



Summary for Pond C1: Northeast Cultecs

Inflow Area = 14,491 sf, 78.64% Impervious, Inflow Depth > 1.95" for 2-YEAR event
 Inflow = 0.74 cfs @ 12.09 hrs, Volume= 2,357 cf
 Outflow = 0.16 cfs @ 13.05 hrs, Volume= 1,884 cf, Atten= 79%, Lag= 57.5 min
 Discarded = 0.00 cfs @ 0.10 hrs, Volume= 0 cf
 Primary = 0.16 cfs @ 13.05 hrs, Volume= 1,884 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 232.17' @ 12.53 hrs Surf.Area= 0.046 ac Storage= 0.025 af

Plug-Flow detention time= 171.0 min calculated for 1,884 cf (80% of inflow)
 Center-of-Mass det. time= 94.0 min (899.0 - 805.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	231.17'	0.018 af	14.50'W x 84.75'L x 2.54'H Field A 0.072 af Overall - 0.020 af Embedded = 0.052 af x 35.0% Voids
#2A	231.67'	0.020 af	Cultec R-150XLHD x 32 Inside #1 Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap Row Length Adjustment= +0.75' x 2.65 sf x 4 rows
#3B	231.17'	0.012 af	14.50'W x 54.00'L x 2.54'H Field B 0.046 af Overall - 0.013 af Embedded = 0.033 af x 35.0% Voids
#4B	231.67'	0.013 af	Cultec R-150XLHD x 20 Inside #3 Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap Row Length Adjustment= +0.75' x 2.65 sf x 4 rows
		0.062 af	Total Available Storage

Storage Group A created with Chamber Wizard
 Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	231.17'	0.090 in/hr Exfiltration X 0.00 over Surface area Phase-In= 0.01'
#2	Primary	231.67'	4.0" Round Culvert L= 145.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 231.67' / 230.95' S= 0.0050 '/' Cc= 0.900 n= 0.012, Flow Area= 0.09 sf
#3	Primary	232.33'	8.0" Round Culvert L= 145.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.33' / 231.44' S= 0.0061 '/' Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.00 cfs @ 0.10 hrs HW=231.17' (Free Discharge)
 ↳1=Exfiltration (Controls 0.00 cfs)

Primary OutFlow Max=0.16 cfs @ 13.05 hrs HW=232.09' TW=230.33' (Dynamic Tailwater)
 ↳2=Culvert (Barrel Controls 0.16 cfs @ 1.83 fps)
 ↳3=Culvert (Controls 0.00 cfs)

Pond C1: Northeast Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-150XLHD (Cultec Recharger® 150XLHD)

Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf

Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap

Row Length Adjustment= +0.75' x 2.65 sf x 4 rows

33.0" Wide + 6.0" Spacing = 39.0" C-C Row Spacing

8 Chambers/Row x 10.25' Long +0.75' Row Adjustment = 82.75' Row Length +12.0" End Stone x 2 = 84.75' Base Length

4 Rows x 33.0" Wide + 6.0" Spacing x 3 + 12.0" Side Stone x 2 = 14.50' Base Width

6.0" Base + 18.5" Chamber Height + 6.0" Cover = 2.54' Field Height

32 Chambers x 27.2 cf +0.75' Row Adjustment x 2.65 sf x 4 Rows = 876.8 cf Chamber Storage

3,123.4 cf Field - 876.8 cf Chambers = 2,246.6 cf Stone x 35.0% Voids = 786.3 cf Stone Storage

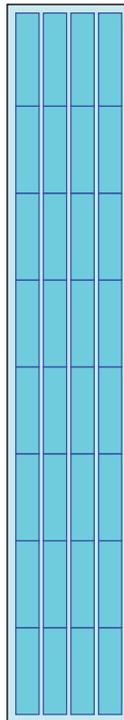
Chamber Storage + Stone Storage = 1,663.1 cf = 0.038 af

Overall Storage Efficiency = 53.2%

32 Chambers

115.7 cy Field

83.2 cy Stone



Pond C1: Northeast Cultecs - Chamber Wizard Field B

Chamber Model = Cultec R-150XLHD (Cultec Recharger® 150XLHD)

Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf

Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap

Row Length Adjustment= +0.75' x 2.65 sf x 4 rows

33.0" Wide + 6.0" Spacing = 39.0" C-C Row Spacing

5 Chambers/Row x 10.25' Long +0.75' Row Adjustment = 52.00' Row Length +12.0" End Stone x 2 = 54.00' Base Length

4 Rows x 33.0" Wide + 6.0" Spacing x 3 + 12.0" Side Stone x 2 = 14.50' Base Width

6.0" Base + 18.5" Chamber Height + 6.0" Cover = 2.54' Field Height

20 Chambers x 27.2 cf +0.75' Row Adjustment x 2.65 sf x 4 Rows = 551.0 cf Chamber Storage

1,990.1 cf Field - 551.0 cf Chambers = 1,439.1 cf Stone x 35.0% Voids = 503.7 cf Stone Storage

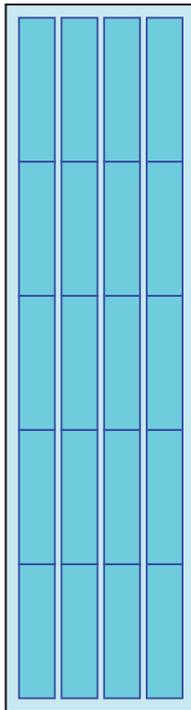
Chamber Storage + Stone Storage = 1,054.7 cf = 0.024 af

Overall Storage Efficiency = 53.0%

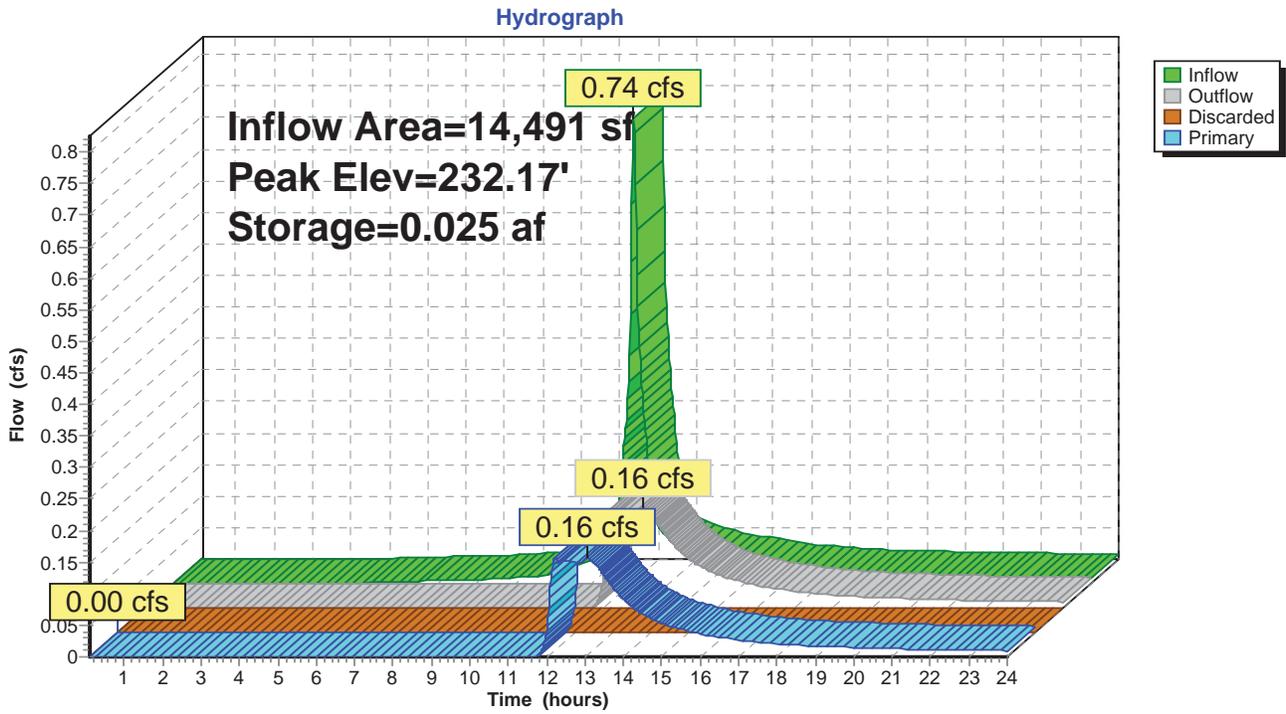
20 Chambers

73.7 cy Field

53.3 cy Stone



Pond C1: Northeast Cultecs



Summary for Pond C2: Intermediate Cultecs

Inflow Area = 17,721 sf, 82.53% Impervious, Inflow Depth > 1.79" for 2-YEAR event
 Inflow = 0.33 cfs @ 12.11 hrs, Volume= 2,645 cf
 Outflow = 0.20 cfs @ 12.48 hrs, Volume= 2,644 cf, Atten= 38%, Lag= 22.4 min
 Discarded = 0.06 cfs @ 13.35 hrs, Volume= 1,899 cf
 Primary = 0.14 cfs @ 12.48 hrs, Volume= 746 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 230.35' @ 13.35 hrs Surf.Area= 392 sf Storage= 313 cf
 Flood Elev= 233.94' Surf.Area= 392 sf Storage= 950 cf

Plug-Flow detention time= 29.6 min calculated for 2,644 cf (100% of inflow)
 Center-of-Mass det. time= 29.6 min (887.6 - 858.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	228.78'	447 cf	16.00'W x 24.50'L x 4.54'H Field A 1,780 cf Overall - 503 cf Embedded = 1,277 cf x 35.0% Voids
#2A	229.78'	503 cf	Cultec R-330XLHD x 9 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 3 rows
		950 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	228.78'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'
#2	Primary	230.00'	8.0" Round Culvert L= 10.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 230.00' / 230.00' S= 0.0000 1/ S= 0.0000 1/ Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.06 cfs @ 13.35 hrs HW=230.35' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.06 cfs)

Primary OutFlow Max=0.14 cfs @ 12.48 hrs HW=230.30' TW=230.15' (Dynamic Tailwater)

↑**2=Culvert** (Barrel Controls 0.14 cfs @ 1.37 fps)

Pond C2: Intermediate Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 3 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

3 Rows x 52.0" Wide + 6.0" Spacing x 2 + 12.0" Side Stone x 2 = 16.00' Base Width

12.0" Base + 30.5" Chamber Height + 12.0" Cover = 4.54' Field Height

9 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 3 Rows = 502.9 cf Chamber Storage

1,780.3 cf Field - 502.9 cf Chambers = 1,277.4 cf Stone x 35.0% Voids = 447.1 cf Stone Storage

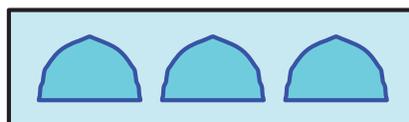
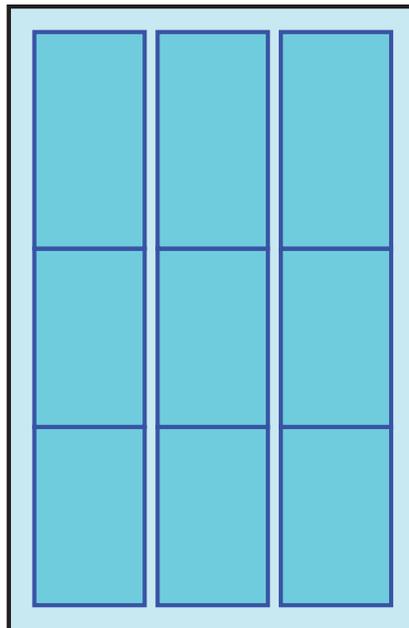
Chamber Storage + Stone Storage = 950.0 cf = 0.022 af

Overall Storage Efficiency = 53.4%

9 Chambers

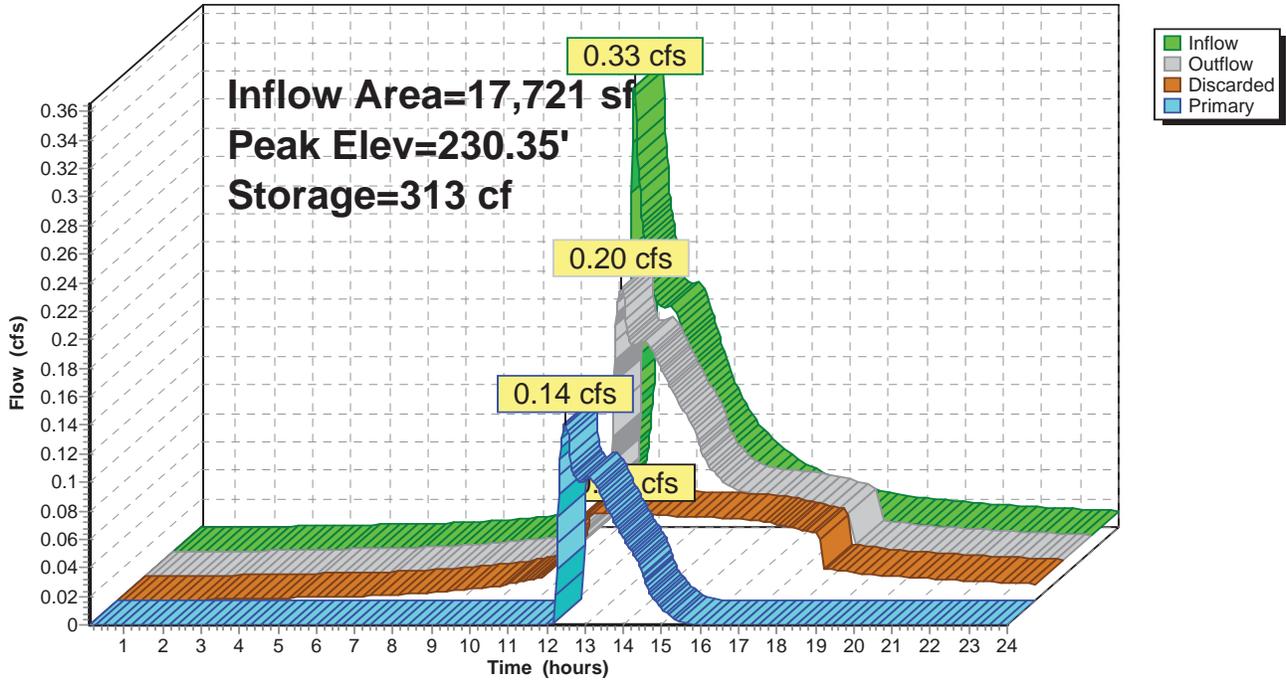
65.9 cy Field

47.3 cy Stone



Pond C2: Intermediate Cultecs

Hydrograph



Summary for Pond C3: Southwest Cultecs

Inflow Area = 24,430 sf, 87.33% Impervious, Inflow Depth > 0.95" for 2-YEAR event
 Inflow = 0.45 cfs @ 12.09 hrs, Volume= 1,934 cf
 Outflow = 0.12 cfs @ 13.41 hrs, Volume= 1,934 cf, Atten= 74%, Lag= 79.1 min
 Discarded = 0.12 cfs @ 13.41 hrs, Volume= 1,934 cf
 Primary = 0.00 cfs @ 0.10 hrs, Volume= 0 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 230.33' @ 13.41 hrs Surf.Area= 0.017 ac Storage= 0.012 af

Plug-Flow detention time= 42.3 min calculated for 1,932 cf (100% of inflow)
 Center-of-Mass det. time= 42.3 min (808.7 - 766.4)

Volume	Invert	Avail.Storage	Storage Description
#1A	229.07'	0.003 af	6.33'W x 24.50'L x 3.71'H Field A 0.013 af Overall - 0.004 af Embedded = 0.009 af x 35.0% Voids
#2A	229.74'	0.004 af	Cultec R-330XLHD x 3 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 1 rows
#3B	229.07'	0.011 af	11.17'W x 52.50'L x 3.71'H Field B 0.050 af Overall - 0.017 af Embedded = 0.033 af x 35.0% Voids
#4B	229.74'	0.017 af	Cultec R-330XLHD x 14 Inside #3 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 2 rows
		0.036 af	Total Available Storage

Storage Group A created with Chamber Wizard
 Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	229.07'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'
#2	Primary	230.68'	8.0" Round Culvert L= 20.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 230.68' / 230.48' S= 0.0100 1/ S= 0.0100 1/ Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.12 cfs @ 13.41 hrs HW=230.33' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.12 cfs)

Primary OutFlow Max=0.00 cfs @ 0.10 hrs HW=229.07' TW=0.00' (Dynamic Tailwater)

↑**2=Culvert** (Controls 0.00 cfs)

Pond C3: Southwest Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 1 rows

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

1 Rows x 52.0" Wide + 12.0" Side Stone x 2 = 6.33' Base Width

8.0" Base + 30.5" Chamber Height + 6.0" Cover = 3.71' Field Height

3 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 1 Rows = 167.6 cf Chamber Storage

575.4 cf Field - 167.6 cf Chambers = 407.8 cf Stone x 35.0% Voids = 142.7 cf Stone Storage

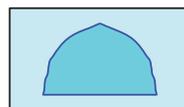
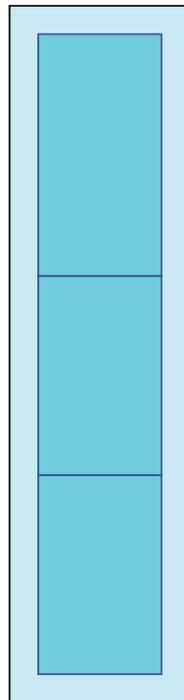
Chamber Storage + Stone Storage = 310.4 cf = 0.007 af

Overall Storage Efficiency = 53.9%

3 Chambers

21.3 cy Field

15.1 cy Stone



Pond C3: Southwest Cultecs - Chamber Wizard Field B

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 2 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

7 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 50.50' Row Length +12.0" End Stone x 2 = 52.50' Base Length

2 Rows x 52.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.17' Base Width

8.0" Base + 30.5" Chamber Height + 6.0" Cover = 3.71' Field Height

14 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 2 Rows = 752.6 cf Chamber Storage

2,174.0 cf Field - 752.6 cf Chambers = 1,421.5 cf Stone x 35.0% Voids = 497.5 cf Stone Storage

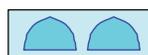
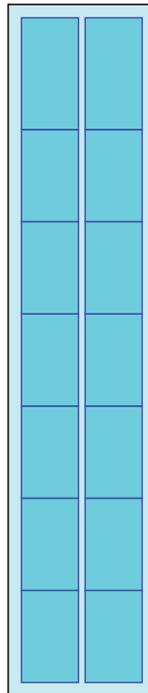
Chamber Storage + Stone Storage = 1,250.1 cf = 0.029 af

Overall Storage Efficiency = 57.5%

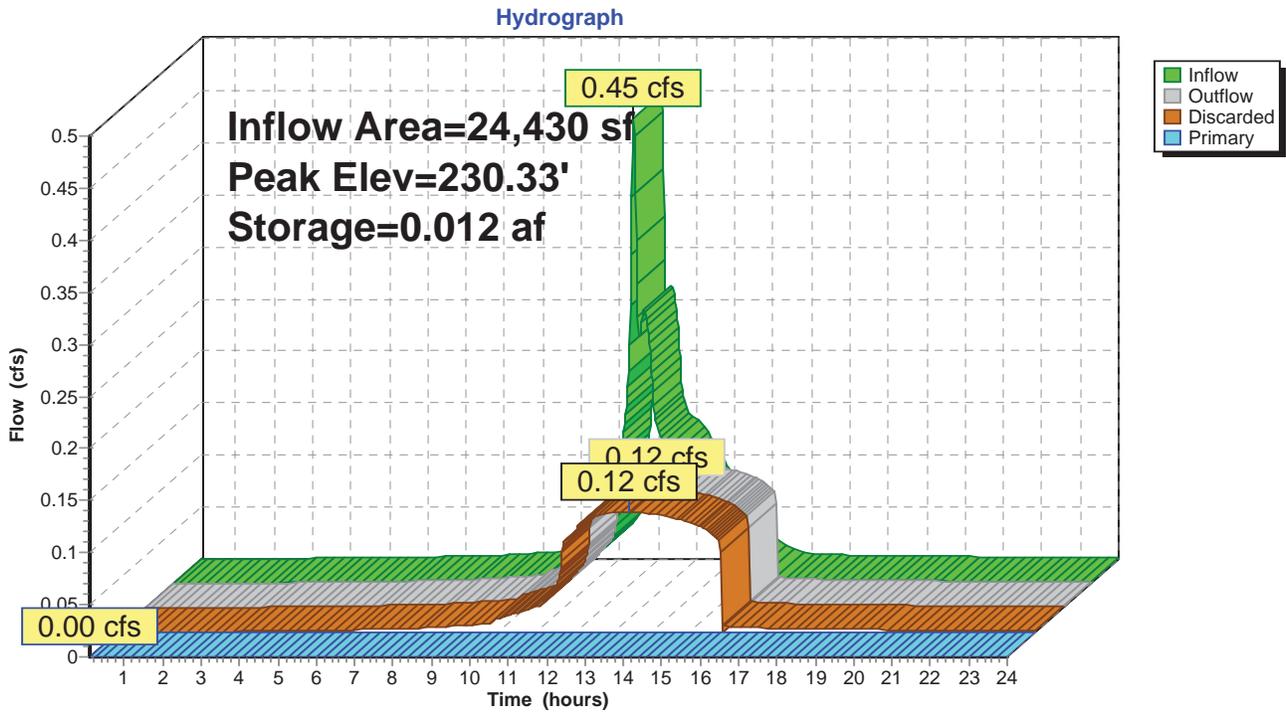
14 Chambers

80.5 cy Field

52.6 cy Stone



Pond C3: Southwest Cultecs



Summary for Pond CB1: Catch Basin #1

Inflow Area = 10,259 sf, 69.83% Impervious, Inflow Depth > 1.64" for 2-YEAR event
 Inflow = 0.45 cfs @ 12.09 hrs, Volume= 1,399 cf
 Outflow = 0.45 cfs @ 12.10 hrs, Volume= 1,380 cf, Atten= 0%, Lag= 0.4 min
 Primary = 0.45 cfs @ 12.10 hrs, Volume= 1,380 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 233.56' @ 12.10 hrs Surf.Area= 13 sf Storage= 27 cf

Plug-Flow detention time= 12.2 min calculated for 1,380 cf (99% of inflow)
 Center-of-Mass det. time= 4.0 min (831.5 - 827.4)

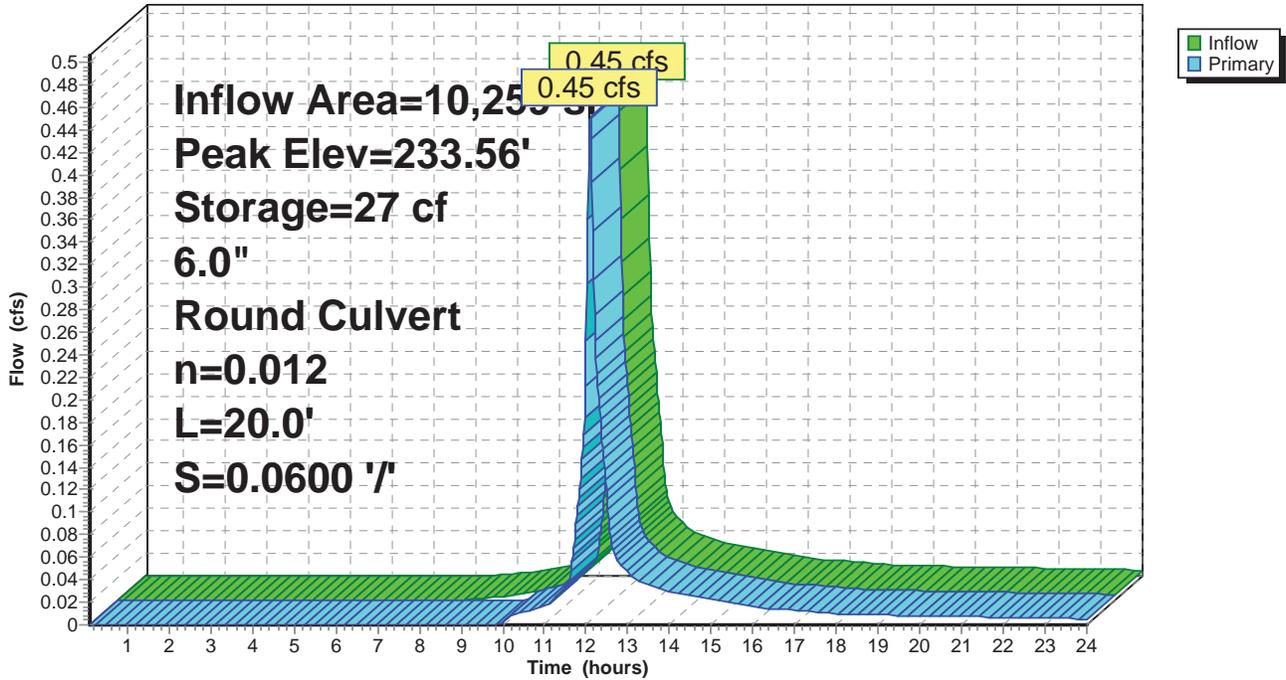
Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	464 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	3,335	419	464

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 20.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 231.75' S= 0.0600 '/ Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.45 cfs @ 12.10 hrs HW=233.56' TW=231.96' (Dynamic Tailwater)
 ↑1=Culvert (Inlet Controls 0.45 cfs @ 2.28 fps)

Pond CB1: Catch Basin #1

Hydrograph



Summary for Pond CB2: Catch Basin #2

Inflow Area = 4,232 sf, 100.00% Impervious, Inflow Depth > 2.83" for 2-YEAR event
 Inflow = 0.29 cfs @ 12.08 hrs, Volume= 997 cf
 Outflow = 0.29 cfs @ 12.09 hrs, Volume= 977 cf, Atten= 0%, Lag= 0.2 min
 Primary = 0.29 cfs @ 12.09 hrs, Volume= 977 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 233.35' @ 12.09 hrs Surf.Area= 13 sf Storage= 24 cf

Plug-Flow detention time= 23.0 min calculated for 977 cf (98% of inflow)
 Center-of-Mass det. time= 10.8 min (767.6 - 756.8)

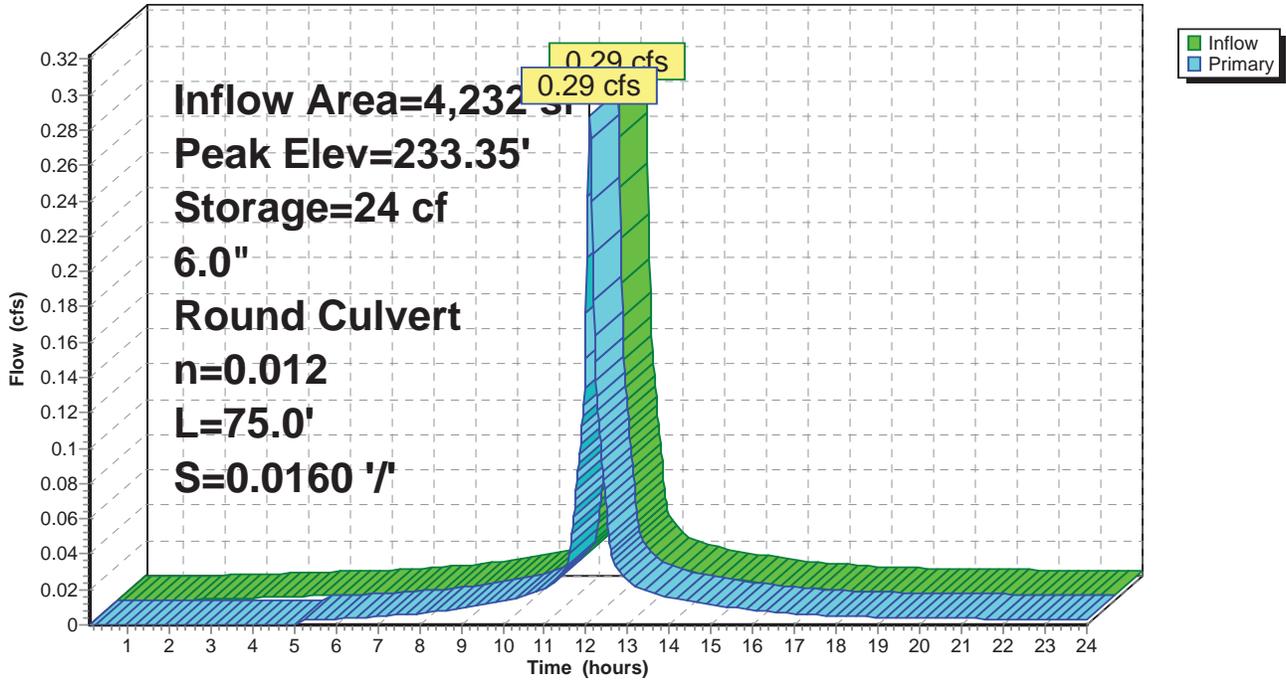
Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	258 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	1,690	213	258

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 75.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 231.75' S= 0.0160 '/ Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.29 cfs @ 12.09 hrs HW=233.35' TW=231.94' (Dynamic Tailwater)
 ↑**1=Culvert** (Inlet Controls 0.29 cfs @ 1.70 fps)

Pond CB2: Catch Basin #2

Hydrograph



Summary for Pond CB3: Catch Basin #3

Inflow Area = 3,960 sf, 100.00% Impervious, Inflow Depth > 2.83" for 2-YEAR event
 Inflow = 0.27 cfs @ 12.08 hrs, Volume= 933 cf
 Outflow = 0.27 cfs @ 12.09 hrs, Volume= 913 cf, Atten= 0%, Lag= 0.2 min
 Primary = 0.27 cfs @ 12.09 hrs, Volume= 913 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 233.34' @ 12.09 hrs Surf.Area= 13 sf Storage= 24 cf

Plug-Flow detention time= 24.4 min calculated for 912 cf (98% of inflow)
 Center-of-Mass det. time= 11.5 min (768.3 - 756.8)

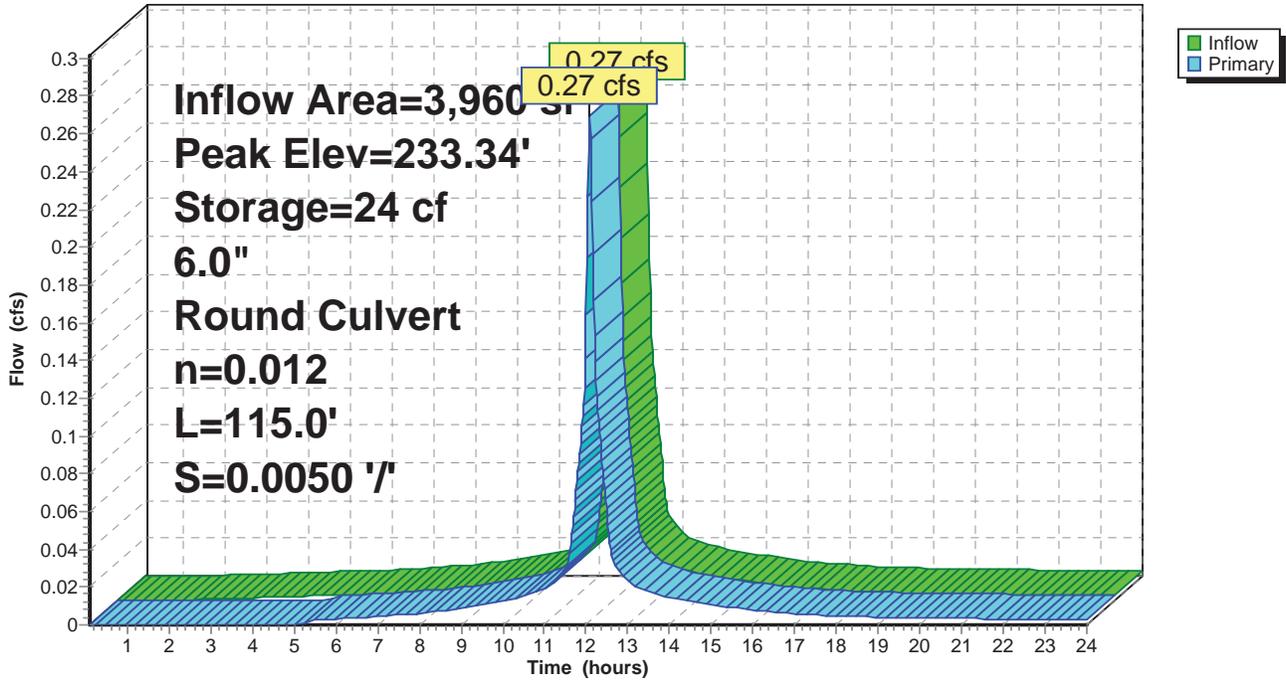
Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	293 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	1,963	247	293

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 115.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 232.38' S= 0.0050 '/ Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.27 cfs @ 12.09 hrs HW=233.34' TW=231.62' (Dynamic Tailwater)
 ↑1=Culvert (Barrel Controls 0.27 cfs @ 2.22 fps)

Pond CB3: Catch Basin #3

Hydrograph



Summary for Pond D1: Drywell

Inflow Area = 3,960 sf, 100.00% Impervious, Inflow Depth > 2.77" for 2-YEAR event
 Inflow = 0.27 cfs @ 12.09 hrs, Volume= 913 cf
 Outflow = 0.27 cfs @ 12.09 hrs, Volume= 913 cf, Atten= 0%, Lag= 0.4 min
 Discarded = 0.01 cfs @ 12.09 hrs, Volume= 372 cf
 Primary = 0.26 cfs @ 12.09 hrs, Volume= 541 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 231.63' @ 12.09 hrs Surf.Area= 33 sf Storage= 35 cf

Plug-Flow detention time= 19.4 min calculated for 912 cf (100% of inflow)
 Center-of-Mass det. time= 19.3 min (787.6 - 768.3)

Volume	Invert	Avail.Storage	Storage Description
#1	230.00'	98 cf	5.00'D x 5.00'H Vertical Cone/Cylinder Inside #2 141 cf Overall - 6.0" Wall Thickness = 98 cf
#2	230.00'	9 cf	6.50'D x 5.00'H Vertical Cone/Cylinder 166 cf Overall - 141 cf Embedded = 25 cf x 35.0% Voids
		107 cf	Total Available Storage

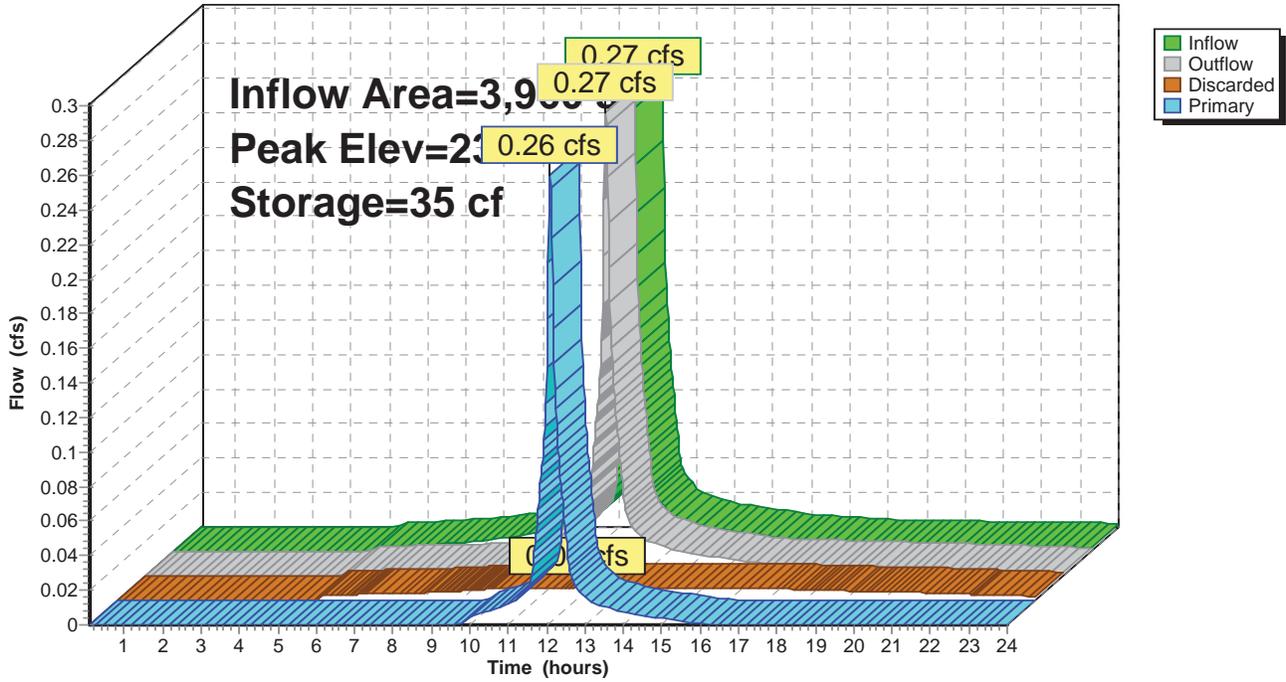
Device	Routing	Invert	Outlet Devices
#1	Primary	231.25'	6.0" Round Culvert L= 5.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 231.25' / 231.00' S= 0.0500 1' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf
#2	Discarded	230.00'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'

Discarded OutFlow Max=0.01 cfs @ 12.09 hrs HW=231.62' (Free Discharge)
 ↳ **2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.26 cfs @ 12.09 hrs HW=231.62' TW=229.71' (Dynamic Tailwater)
 ↳ **1=Culvert** (Inlet Controls 0.26 cfs @ 1.64 fps)

Pond D1: Drywell

Hydrograph



Time span=0.10-24.00 hrs, dt=0.02 hrs, 1196 points x 3
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
 Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Roof Drain South West Runoff Area=2,749 sf 100.00% Impervious Runoff Depth>4.33"
 Flow Length=50' Slope=0.1300 '/' Tc=6.0 min CN=98 Runoff=0.28 cfs 992 cf

Subcatchment 2S: Roof Drain North Side Runoff Area=3,230 sf 100.00% Impervious Runoff Depth>4.33"
 Flow Length=50' Slope=0.1300 '/' Tc=6.0 min CN=98 Runoff=0.33 cfs 1,166 cf

Subcatchment 3S: Upper Paved Area Runoff Area=10,259 sf 69.83% Impervious Runoff Depth>2.97"
 Tc=6.0 min CN=85 Runoff=0.81 cfs 2,539 cf

Subcatchment 4S: Middle Paved Area & Runoff Area=4,232 sf 100.00% Impervious Runoff Depth>4.33"
 Tc=6.0 min CN=98 Runoff=0.43 cfs 1,527 cf

Subcatchment 5S: Lower Paved Area Runoff Area=3,960 sf 100.00% Impervious Runoff Depth>4.33"
 Tc=6.0 min CN=98 Runoff=0.41 cfs 1,429 cf

Subcatchment 6S: Remaining Project Area Runoff Area=217,642 sf 3.80% Impervious Runoff Depth>0.48"
 Flow Length=562' Tc=15.9 min CN=49 Runoff=1.09 cfs 8,649 cf

Subcatchment EX: Existing Site Runoff Area=242,195 sf 7.17% Impervious Runoff Depth>0.52"
 Flow Length=562' Tc=15.9 min CN=50 Runoff=1.41 cfs 10,536 cf

Reach END: Proposed Site Runoff Inflow=1.35 cfs 9,549 cf
 Outflow=1.35 cfs 9,549 cf

Pond C1: Northeast Cultecs Peak Elev=232.61' Storage=0.040 af Inflow=1.24 cfs 4,027 cf
 Discarded=0.00 cfs 0 cf Primary=0.39 cfs 3,526 cf Outflow=0.39 cfs 3,526 cf

Pond C2: Intermediate Cultecs Peak Elev=231.11' Storage=536 cf Inflow=0.49 cfs 4,692 cf
 Discarded=0.07 cfs 2,506 cf Primary=0.34 cfs 2,185 cf Outflow=0.41 cfs 4,691 cf

Pond C3: Southwest Cultecs Peak Elev=231.04' Storage=0.021 af Inflow=0.94 cfs 4,127 cf
 Discarded=0.13 cfs 3,228 cf Primary=0.31 cfs 900 cf Outflow=0.44 cfs 4,127 cf

Pond CB1: Catch Basin #1 Peak Elev=234.37' Storage=37 cf Inflow=0.81 cfs 2,539 cf
 6.0" Round Culvert n=0.012 L=20.0' S=0.0600 '/' Outflow=0.81 cfs 2,519 cf

Pond CB2: Catch Basin #2 Peak Elev=233.54' Storage=26 cf Inflow=0.43 cfs 1,527 cf
 6.0" Round Culvert n=0.012 L=75.0' S=0.0160 '/' Outflow=0.43 cfs 1,508 cf

Pond CB3: Catch Basin #3 Peak Elev=233.49' Storage=26 cf Inflow=0.41 cfs 1,429 cf
 6.0" Round Culvert n=0.012 L=115.0' S=0.0050 '/' Outflow=0.40 cfs 1,410 cf

Pond D1: Drywell Peak Elev=231.78' Storage=38 cf Inflow=0.40 cfs 1,410 cf
 Discarded=0.01 cfs 453 cf Primary=0.39 cfs 949 cf Outflow=0.40 cfs 1,403 cf

Total Runoff Area = 484,267 sf Runoff Volume = 26,838 cf Average Runoff Depth = 0.67"
90.30% Pervious = 437,284 sf 9.70% Impervious = 46,983 sf

Summary for Subcatchment 1S: Roof Drain South West Side

Runoff = 0.28 cfs @ 12.08 hrs, Volume= 992 cf, Depth> 4.33"

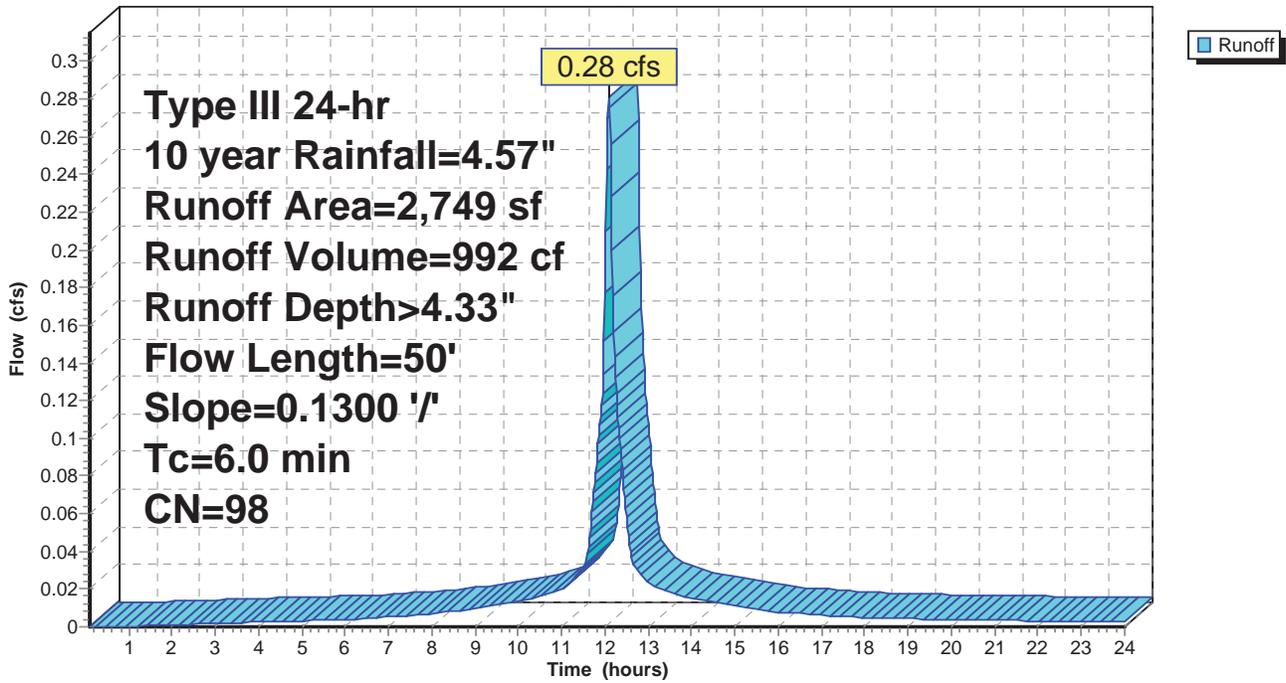
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10 year Rainfall=4.57"

Area (sf)	CN	Description
2,749	98	Roofs, HSG A
2,749		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.1300	0.14		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"

Subcatchment 1S: Roof Drain South West Side

Hydrograph



Summary for Subcatchment 2S: Roof Drain North Side

Runoff = 0.33 cfs @ 12.08 hrs, Volume= 1,166 cf, Depth> 4.33"

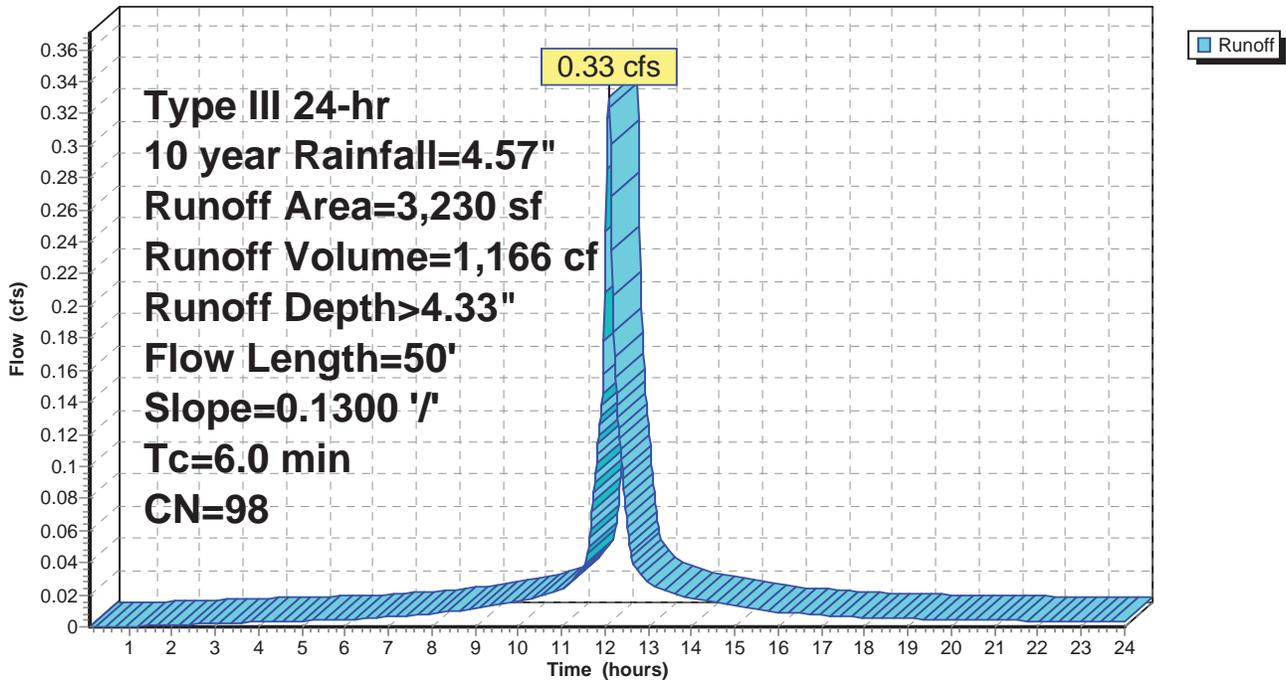
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
 Type III 24-hr 10 year Rainfall=4.57"

Area (sf)	CN	Description
3,230	98	Roofs, HSG A
3,230		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.1300	0.14		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"

Subcatchment 2S: Roof Drain North Side

Hydrograph



Summary for Subcatchment 3S: Upper Paved Area

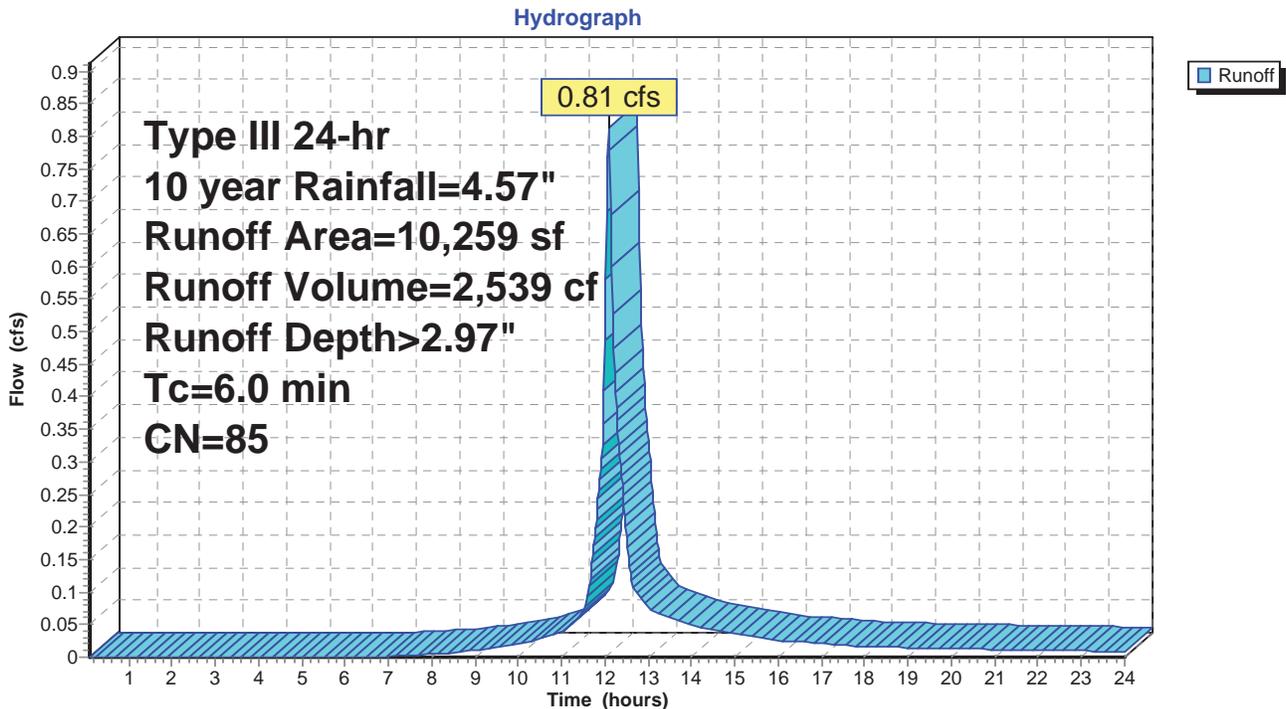
Runoff = 0.81 cfs @ 12.09 hrs, Volume= 2,539 cf, Depth> 2.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
 Type III 24-hr 10 year Rainfall=4.57"

Area (sf)	CN	Description
7,164	98	Paved parking, HSG A
1,956	49	50-75% Grass cover, Fair, HSG A
441	49	50-75% Grass cover, Fair, HSG A
* 698	76	Gravel roads, HSG A (rip rap)
10,259	85	Weighted Average
3,095		30.17% Pervious Area
7,164		69.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 3S: Upper Paved Area



Summary for Subcatchment 4S: Middle Paved Area & Eastern Roof

Runoff = 0.43 cfs @ 12.08 hrs, Volume= 1,527 cf, Depth> 4.33"

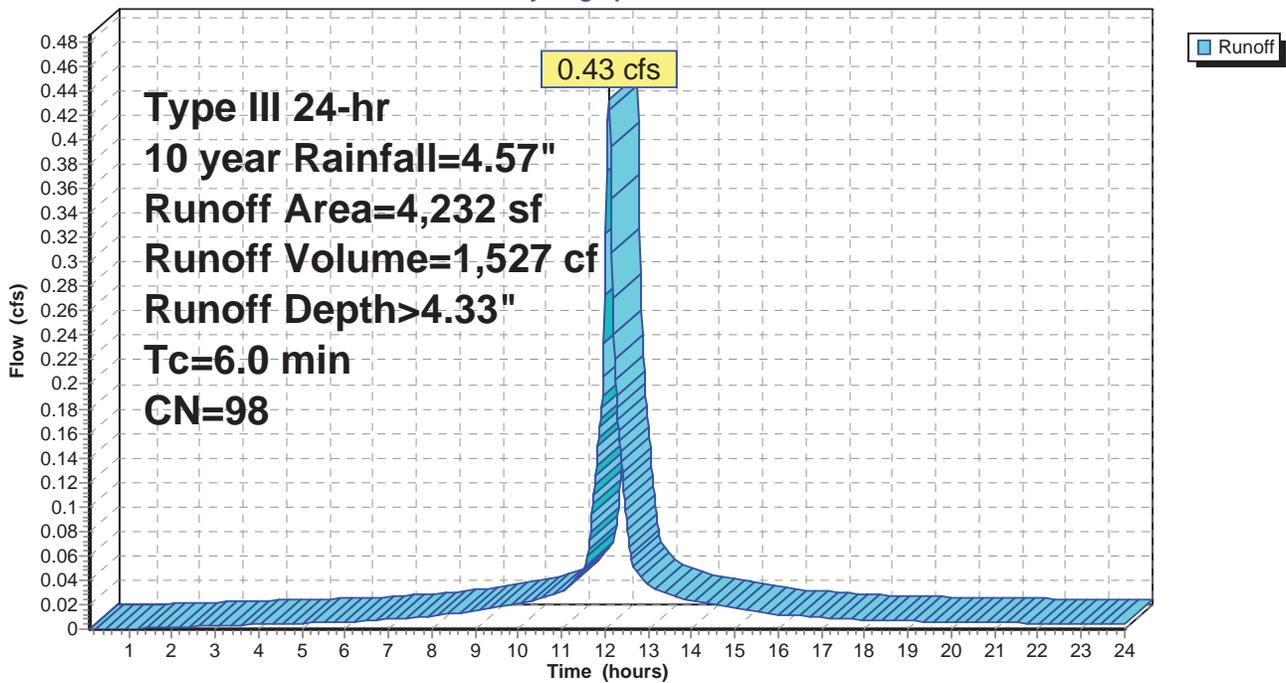
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10 year Rainfall=4.57"

Area (sf)	CN	Description
2,572	98	Paved parking, HSG A
1,660	98	Roofs, HSG A
4,232	98	Weighted Average
4,232		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 4S: Middle Paved Area & Eastern Roof

Hydrograph



Summary for Subcatchment 5S: Lower Paved Area

Runoff = 0.41 cfs @ 12.08 hrs, Volume= 1,429 cf, Depth> 4.33"

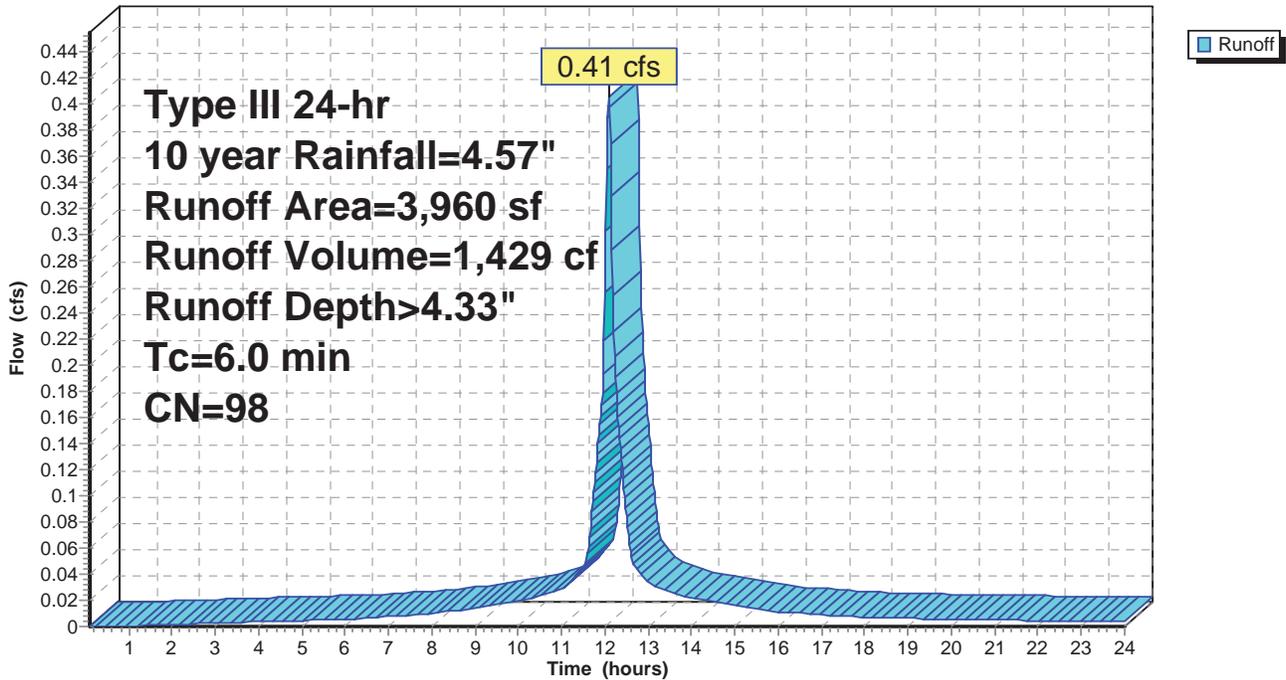
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
 Type III 24-hr 10 year Rainfall=4.57"

Area (sf)	CN	Description
3,960	98	Paved parking, HSG A
3,960		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 5S: Lower Paved Area

Hydrograph



Summary for Subcatchment 6S: Remaining Project Area

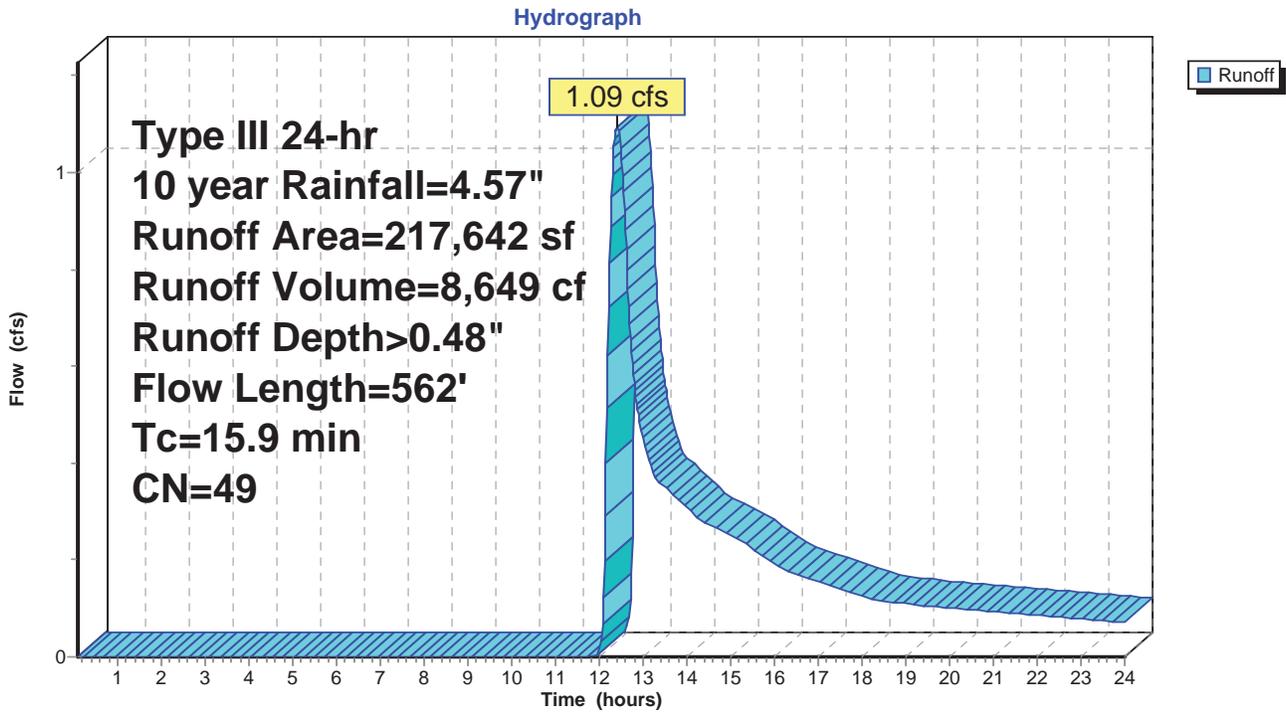
Runoff = 1.09 cfs @ 12.42 hrs, Volume= 8,649 cf, Depth> 0.48"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10 year Rainfall=4.57"

Area (sf)	CN	Description
2,763	49	50-75% Grass cover, Fair, HSG A
9,597	76	Gravel roads, HSG A
8,274	98	Paved parking, HSG A
7,927	49	50-75% Grass cover, Fair, HSG A
27,757	78	Meadow, non-grazed, HSG D
28,946	77	Woods, Good, HSG D
78,485	30	Woods, Good, HSG A
39,143	30	Meadow, non-grazed, HSG A
11,968	30	Woods, Good, HSG A
* 2,782	76	Gravel roads, HSG A (RIP RAP)
217,642	49	Weighted Average
209,368		96.20% Pervious Area
8,274		3.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.7	50	0.0500	0.10		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"
0.3	36	0.1676	2.05		Shallow Concentrated Flow, woods pre grass strip Woodland Kv= 5.0 fps
0.1	10	0.1000	2.21		Shallow Concentrated Flow, grass strips (both) Short Grass Pasture Kv= 7.0 fps
0.0	12	0.0833	5.86		Shallow Concentrated Flow, pavement Paved Kv= 20.3 fps
6.7	440	0.0480	1.10		Shallow Concentrated Flow, rip rap Woodland Kv= 5.0 fps
0.1	14	0.1667	2.86		Shallow Concentrated Flow, grass strip Short Grass Pasture Kv= 7.0 fps
15.9	562	Total			

Subcatchment 6S: Remaining Project Area



Summary for Subcatchment EX: Existing Site

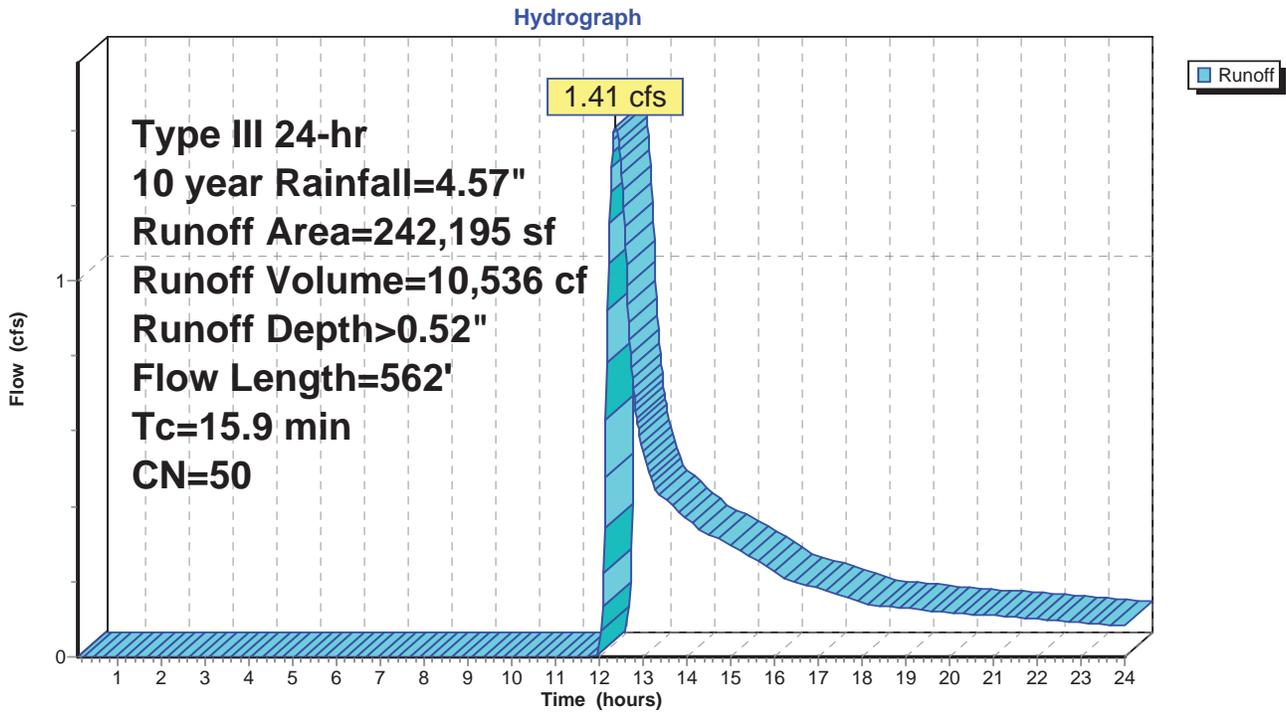
Runoff = 1.41 cfs @ 12.39 hrs, Volume= 10,536 cf, Depth> 0.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10 year Rainfall=4.57"

Area (sf)	CN	Description
11,475	49	50-75% Grass cover, Fair, HSG A
3,181	76	Gravel roads, HSG A
17,374	98	Paved parking, HSG A
4,242	49	50-75% Grass cover, Fair, HSG A
8,728	49	50-75% Grass cover, Fair, HSG A
* 3,480	76	Gravel roads, HSG A (RIP RAP)
59,405	77	Woods, Good, HSG D
82,915	30	Woods, Good, HSG A
9,737	30	Woods, Good, HSG A
41,658	30	Woods, Good, HSG A
242,195	50	Weighted Average
224,821		92.83% Pervious Area
17,374		7.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.7	50	0.0500	0.10		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"
0.3	36	0.1676	2.05		Shallow Concentrated Flow, woods Woodland Kv= 5.0 fps
0.0	12	0.1000	6.42		Shallow Concentrated Flow, pavement Paved Kv= 20.3 fps
0.1	10	0.1000	2.21		Shallow Concentrated Flow, grass strip (both) Short Grass Pasture Kv= 7.0 fps
6.7	440	0.0480	1.10		Shallow Concentrated Flow, rip rap Woodland Kv= 5.0 fps
0.1	14	0.1667	2.86		Shallow Concentrated Flow, final grass strip Short Grass Pasture Kv= 7.0 fps
15.9	562	Total			

Subcatchment EX: Existing Site



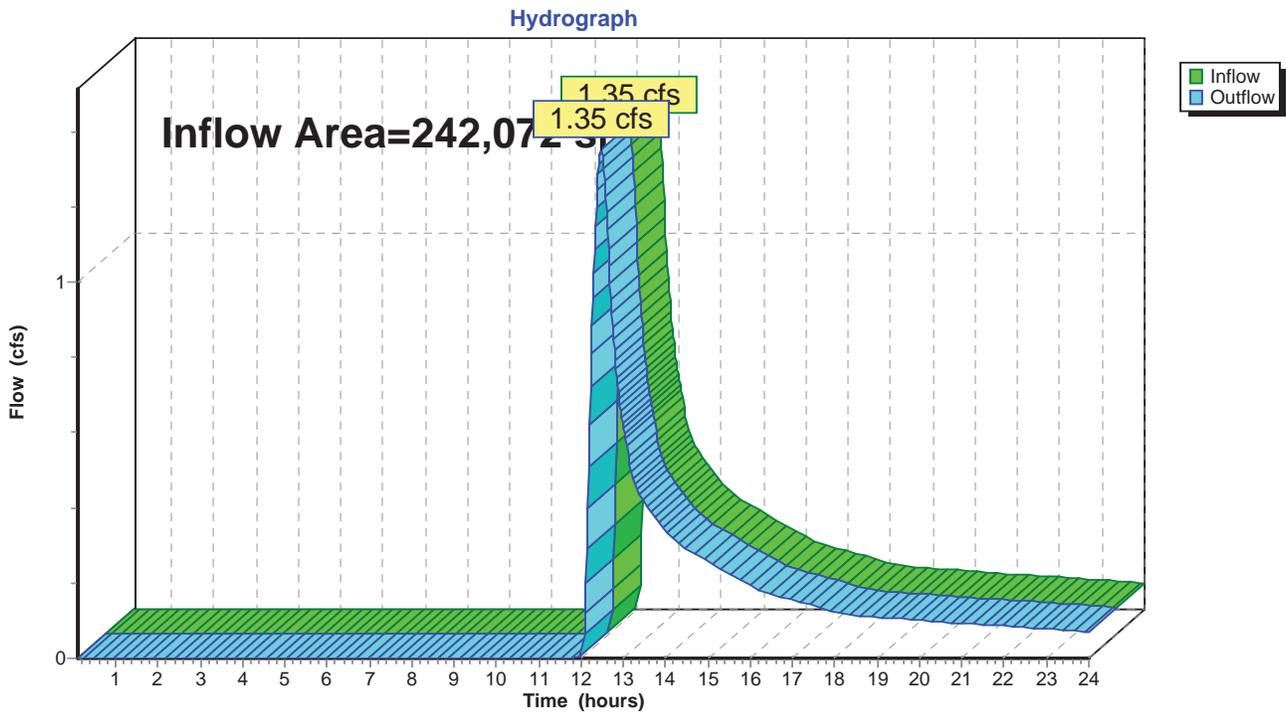
Summary for Reach END: Proposed Site Runoff

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 242,072 sf, 12.23% Impervious, Inflow Depth > 0.47" for 10 year event
Inflow = 1.35 cfs @ 12.47 hrs, Volume= 9,549 cf
Outflow = 1.35 cfs @ 12.47 hrs, Volume= 9,549 cf, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3

Reach END: Proposed Site Runoff



Summary for Pond C1: Northeast Cultecs

Inflow Area = 14,491 sf, 78.64% Impervious, Inflow Depth > 3.34" for 10 year event
 Inflow = 1.24 cfs @ 12.09 hrs, Volume= 4,027 cf
 Outflow = 0.39 cfs @ 12.41 hrs, Volume= 3,526 cf, Atten= 69%, Lag= 18.8 min
 Discarded = 0.00 cfs @ 0.10 hrs, Volume= 0 cf
 Primary = 0.39 cfs @ 12.41 hrs, Volume= 3,526 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 232.61' @ 12.41 hrs Surf.Area= 0.046 ac Storage= 0.040 af

Plug-Flow detention time= 146.4 min calculated for 3,526 cf (88% of inflow)
 Center-of-Mass det. time= 89.8 min (882.0 - 792.3)

Volume	Invert	Avail.Storage	Storage Description
#1A	231.17'	0.018 af	14.50'W x 84.75'L x 2.54'H Field A 0.072 af Overall - 0.020 af Embedded = 0.052 af x 35.0% Voids
#2A	231.67'	0.020 af	Cultec R-150XLHD x 32 Inside #1 Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap Row Length Adjustment= +0.75' x 2.65 sf x 4 rows
#3B	231.17'	0.012 af	14.50'W x 54.00'L x 2.54'H Field B 0.046 af Overall - 0.013 af Embedded = 0.033 af x 35.0% Voids
#4B	231.67'	0.013 af	Cultec R-150XLHD x 20 Inside #3 Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap Row Length Adjustment= +0.75' x 2.65 sf x 4 rows
		0.062 af	Total Available Storage

Storage Group A created with Chamber Wizard
 Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	231.17'	0.090 in/hr Exfiltration X 0.00 over Surface area Phase-In= 0.01'
#2	Primary	231.67'	4.0" Round Culvert L= 145.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 231.67' / 230.95' S= 0.0050 '/ Cc= 0.900 n= 0.012, Flow Area= 0.09 sf
#3	Primary	232.33'	8.0" Round Culvert L= 145.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.33' / 231.44' S= 0.0061 '/ Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.00 cfs @ 0.10 hrs HW=231.17' (Free Discharge)
 ↳1=Exfiltration (Controls 0.00 cfs)

Primary OutFlow Max=0.39 cfs @ 12.41 hrs HW=232.61' TW=231.02' (Dynamic Tailwater)
 ↳2=Culvert (Barrel Controls 0.19 cfs @ 2.14 fps)
 ↳3=Culvert (Inlet Controls 0.20 cfs @ 1.43 fps)

Pond C1: Northeast Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-150XLHD (Cultec Recharger® 150XLHD)

Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf

Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap

Row Length Adjustment= +0.75' x 2.65 sf x 4 rows

33.0" Wide + 6.0" Spacing = 39.0" C-C Row Spacing

8 Chambers/Row x 10.25' Long +0.75' Row Adjustment = 82.75' Row Length +12.0" End Stone x 2 = 84.75' Base Length

4 Rows x 33.0" Wide + 6.0" Spacing x 3 + 12.0" Side Stone x 2 = 14.50' Base Width

6.0" Base + 18.5" Chamber Height + 6.0" Cover = 2.54' Field Height

32 Chambers x 27.2 cf +0.75' Row Adjustment x 2.65 sf x 4 Rows = 876.8 cf Chamber Storage

3,123.4 cf Field - 876.8 cf Chambers = 2,246.6 cf Stone x 35.0% Voids = 786.3 cf Stone Storage

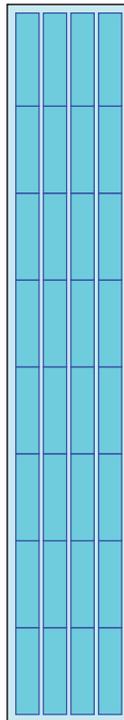
Chamber Storage + Stone Storage = 1,663.1 cf = 0.038 af

Overall Storage Efficiency = 53.2%

32 Chambers

115.7 cy Field

83.2 cy Stone



Pond C1: Northeast Cultecs - Chamber Wizard Field B

Chamber Model = Cultec R-150XLHD (Cultec Recharger® 150XLHD)

Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf

Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap

Row Length Adjustment= +0.75' x 2.65 sf x 4 rows

33.0" Wide + 6.0" Spacing = 39.0" C-C Row Spacing

5 Chambers/Row x 10.25' Long +0.75' Row Adjustment = 52.00' Row Length +12.0" End Stone x 2 = 54.00' Base Length

4 Rows x 33.0" Wide + 6.0" Spacing x 3 + 12.0" Side Stone x 2 = 14.50' Base Width

6.0" Base + 18.5" Chamber Height + 6.0" Cover = 2.54' Field Height

20 Chambers x 27.2 cf +0.75' Row Adjustment x 2.65 sf x 4 Rows = 551.0 cf Chamber Storage

1,990.1 cf Field - 551.0 cf Chambers = 1,439.1 cf Stone x 35.0% Voids = 503.7 cf Stone Storage

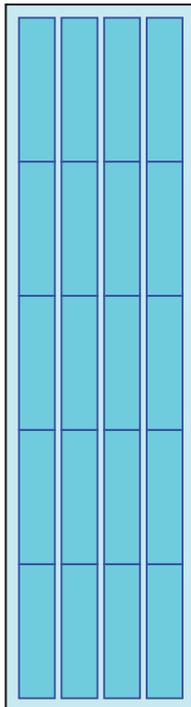
Chamber Storage + Stone Storage = 1,054.7 cf = 0.024 af

Overall Storage Efficiency = 53.0%

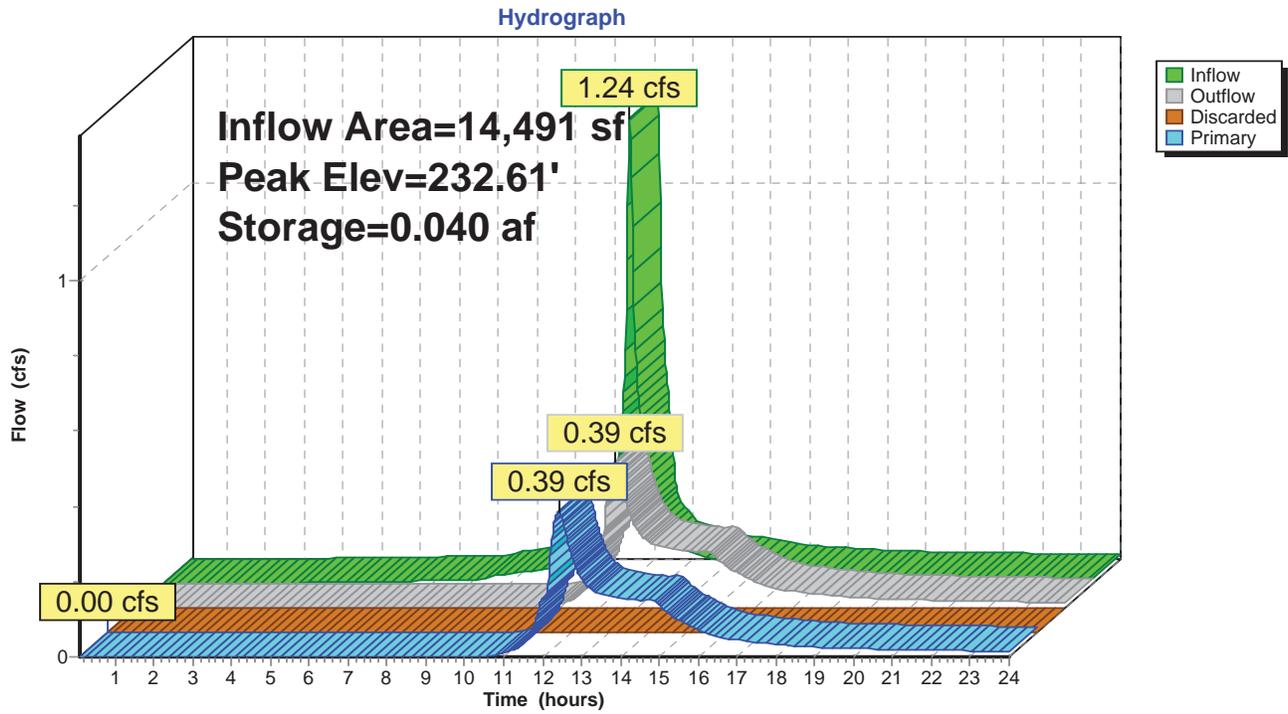
20 Chambers

73.7 cy Field

53.3 cy Stone



Pond C1: Northeast Cultecs



Summary for Pond C2: Intermediate Cultecs

Inflow Area = 17,721 sf, 82.53% Impervious, Inflow Depth > 3.18" for 10 year event
 Inflow = 0.49 cfs @ 12.34 hrs, Volume= 4,692 cf
 Outflow = 0.41 cfs @ 12.52 hrs, Volume= 4,691 cf, Atten= 17%, Lag= 10.4 min
 Discarded = 0.07 cfs @ 12.55 hrs, Volume= 2,506 cf
 Primary = 0.34 cfs @ 12.52 hrs, Volume= 2,185 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 231.11' @ 12.55 hrs Surf.Area= 392 sf Storage= 536 cf
 Flood Elev= 233.94' Surf.Area= 392 sf Storage= 950 cf

Plug-Flow detention time= 32.2 min calculated for 4,691 cf (100% of inflow)
 Center-of-Mass det. time= 32.1 min (881.1 - 849.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	228.78'	447 cf	16.00'W x 24.50'L x 4.54'H Field A 1,780 cf Overall - 503 cf Embedded = 1,277 cf x 35.0% Voids
#2A	229.78'	503 cf	Cultec R-330XLHD x 9 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 3 rows
		950 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	228.78'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'
#2	Primary	230.00'	8.0" Round Culvert L= 10.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 230.00' / 230.00' S= 0.0000 1' Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.07 cfs @ 12.55 hrs HW=231.11' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.07 cfs)

Primary OutFlow Max=0.34 cfs @ 12.52 hrs HW=231.10' TW=231.04' (Dynamic Tailwater)

↑**2=Culvert** (Inlet Controls 0.34 cfs @ 0.98 fps)

Pond C2: Intermediate Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 3 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

3 Rows x 52.0" Wide + 6.0" Spacing x 2 + 12.0" Side Stone x 2 = 16.00' Base Width

12.0" Base + 30.5" Chamber Height + 12.0" Cover = 4.54' Field Height

9 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 3 Rows = 502.9 cf Chamber Storage

1,780.3 cf Field - 502.9 cf Chambers = 1,277.4 cf Stone x 35.0% Voids = 447.1 cf Stone Storage

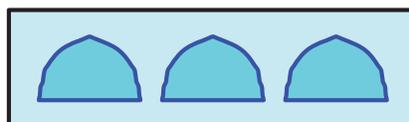
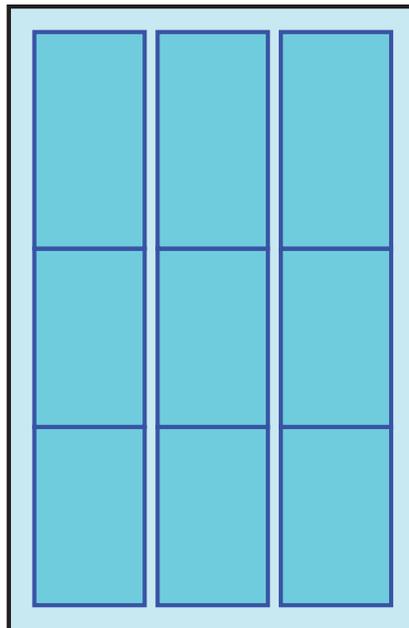
Chamber Storage + Stone Storage = 950.0 cf = 0.022 af

Overall Storage Efficiency = 53.4%

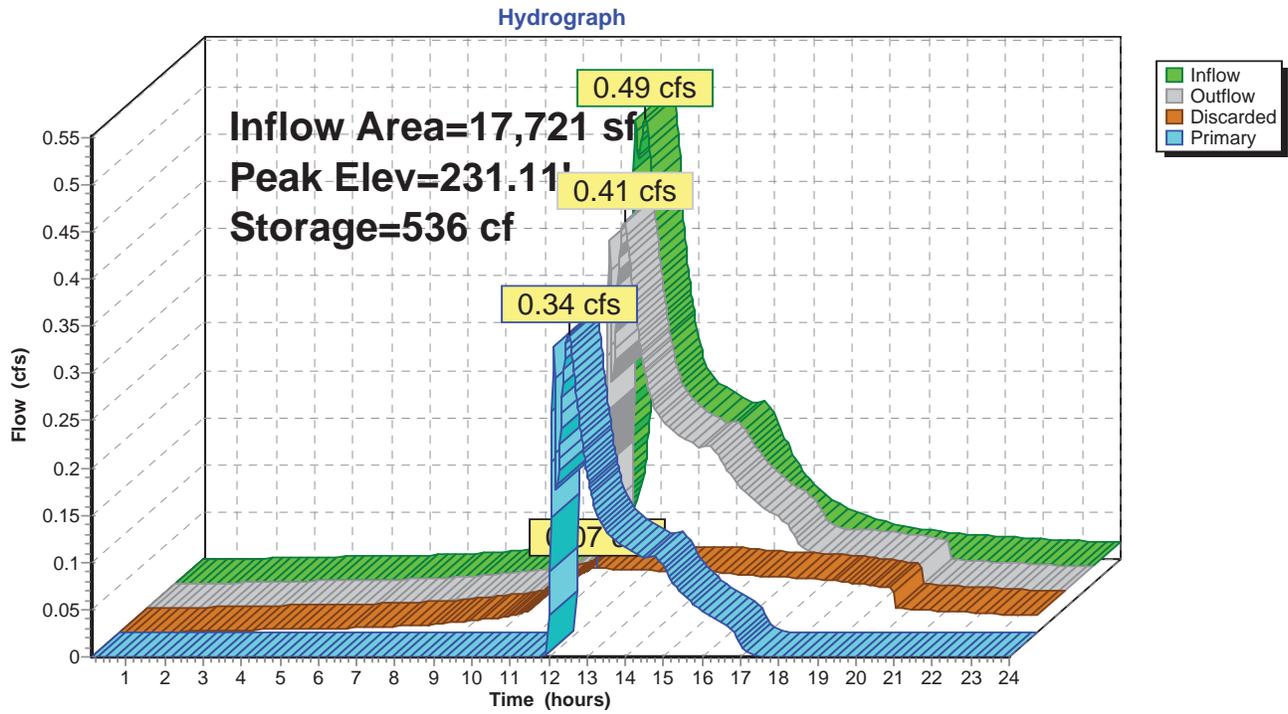
9 Chambers

65.9 cy Field

47.3 cy Stone



Pond C2: Intermediate Cultecs



Summary for Pond C3: Southwest Cultecs

Inflow Area = 24,430 sf, 87.33% Impervious, Inflow Depth > 2.03" for 10 year event
 Inflow = 0.94 cfs @ 12.11 hrs, Volume= 4,127 cf
 Outflow = 0.44 cfs @ 12.56 hrs, Volume= 4,127 cf, Atten= 53%, Lag= 26.6 min
 Discarded = 0.13 cfs @ 12.56 hrs, Volume= 3,228 cf
 Primary = 0.31 cfs @ 12.56 hrs, Volume= 900 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 231.04' @ 12.56 hrs Surf.Area= 0.017 ac Storage= 0.021 af

Plug-Flow detention time= (not calculated: outflow precedes inflow)
 Center-of-Mass det. time= 53.1 min (835.8 - 782.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	229.07'	0.003 af	6.33'W x 24.50'L x 3.71'H Field A 0.013 af Overall - 0.004 af Embedded = 0.009 af x 35.0% Voids
#2A	229.74'	0.004 af	Cultec R-330XLHD x 3 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 1 rows
#3B	229.07'	0.011 af	11.17'W x 52.50'L x 3.71'H Field B 0.050 af Overall - 0.017 af Embedded = 0.033 af x 35.0% Voids
#4B	229.74'	0.017 af	Cultec R-330XLHD x 14 Inside #3 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 2 rows
		0.036 af	Total Available Storage

Storage Group A created with Chamber Wizard
 Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	229.07'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'
#2	Primary	230.68'	8.0" Round Culvert L= 20.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 230.68' / 230.48' S= 0.0100 1/ S= 0.0100 1/ Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.13 cfs @ 12.56 hrs HW=231.04' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.13 cfs)

Primary OutFlow Max=0.31 cfs @ 12.56 hrs HW=231.04' TW=0.00' (Dynamic Tailwater)

↑**2=Culvert** (Inlet Controls 0.31 cfs @ 1.62 fps)

Pond C3: Southwest Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 1 rows

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

1 Rows x 52.0" Wide + 12.0" Side Stone x 2 = 6.33' Base Width

8.0" Base + 30.5" Chamber Height + 6.0" Cover = 3.71' Field Height

3 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 1 Rows = 167.6 cf Chamber Storage

575.4 cf Field - 167.6 cf Chambers = 407.8 cf Stone x 35.0% Voids = 142.7 cf Stone Storage

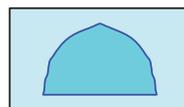
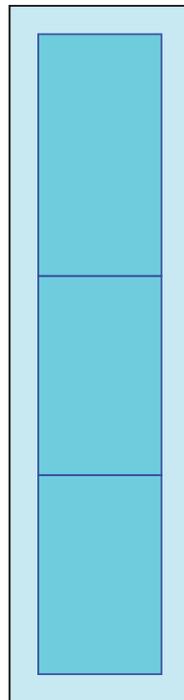
Chamber Storage + Stone Storage = 310.4 cf = 0.007 af

Overall Storage Efficiency = 53.9%

3 Chambers

21.3 cy Field

15.1 cy Stone



Pond C3: Southwest Cultecs - Chamber Wizard Field B

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 2 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

7 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 50.50' Row Length +12.0" End Stone x 2 = 52.50' Base Length

2 Rows x 52.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.17' Base Width

8.0" Base + 30.5" Chamber Height + 6.0" Cover = 3.71' Field Height

14 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 2 Rows = 752.6 cf Chamber Storage

2,174.0 cf Field - 752.6 cf Chambers = 1,421.5 cf Stone x 35.0% Voids = 497.5 cf Stone Storage

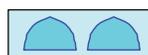
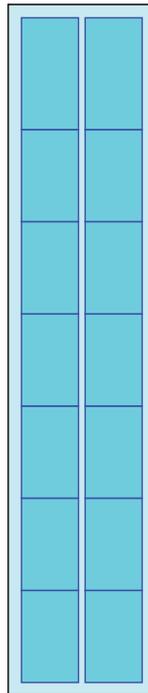
Chamber Storage + Stone Storage = 1,250.1 cf = 0.029 af

Overall Storage Efficiency = 57.5%

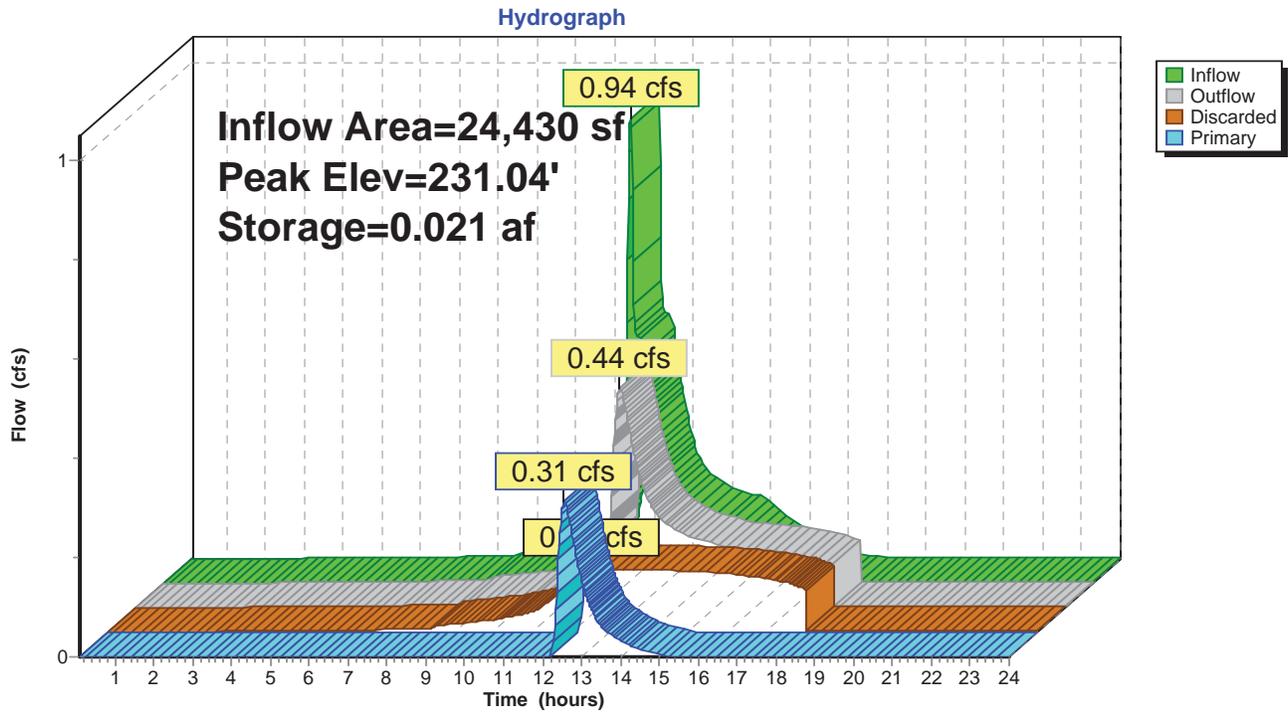
14 Chambers

80.5 cy Field

52.6 cy Stone



Pond C3: Southwest Cultecs



Summary for Pond CB1: Catch Basin #1

Inflow Area = 10,259 sf, 69.83% Impervious, Inflow Depth > 2.97" for 10 year event
 Inflow = 0.81 cfs @ 12.09 hrs, Volume= 2,539 cf
 Outflow = 0.81 cfs @ 12.10 hrs, Volume= 2,519 cf, Atten= 1%, Lag= 0.6 min
 Primary = 0.81 cfs @ 12.10 hrs, Volume= 2,519 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 234.37' @ 12.10 hrs Surf.Area= 13 sf Storage= 37 cf

Plug-Flow detention time= 7.7 min calculated for 2,517 cf (99% of inflow)
 Center-of-Mass det. time= 3.0 min (813.4 - 810.4)

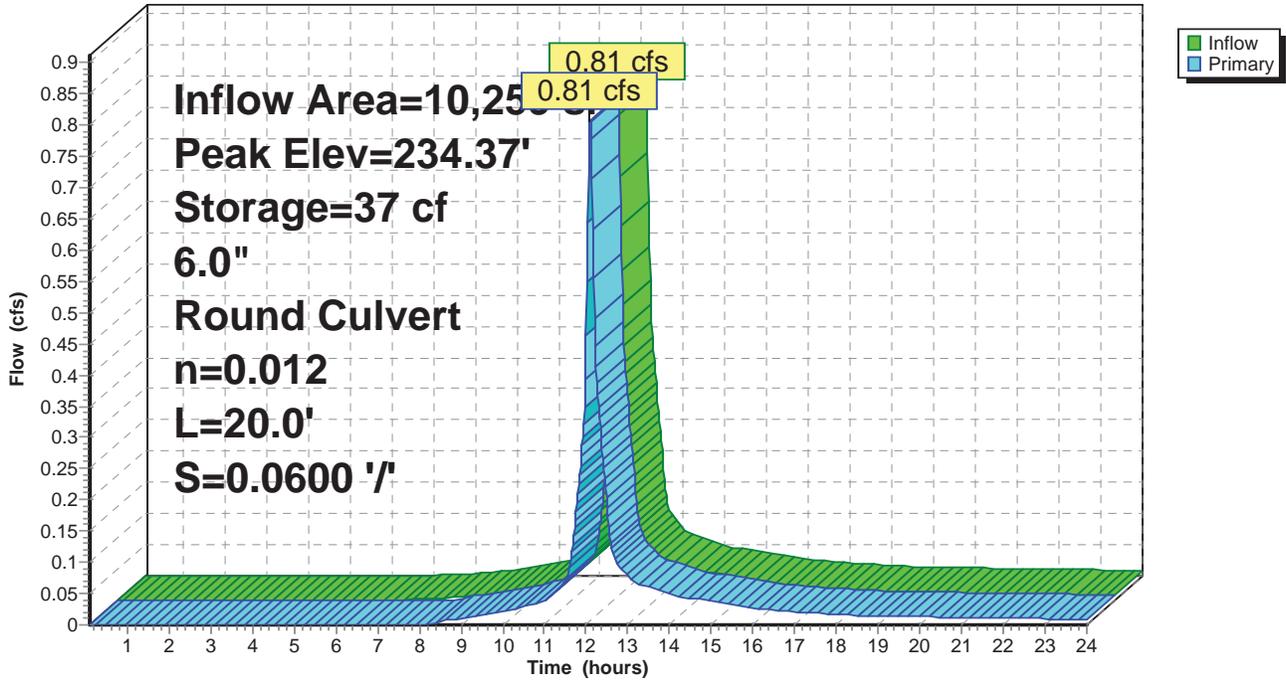
Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	464 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	3,335	419	464

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 20.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 231.75' S= 0.0600 '/ Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.81 cfs @ 12.10 hrs HW=234.36' TW=232.30' (Dynamic Tailwater)
 ↑**1=Culvert** (Inlet Controls 0.81 cfs @ 4.10 fps)

Pond CB1: Catch Basin #1

Hydrograph



Summary for Pond CB2: Catch Basin #2

Inflow Area = 4,232 sf, 100.00% Impervious, Inflow Depth > 4.33" for 10 year event
 Inflow = 0.43 cfs @ 12.08 hrs, Volume= 1,527 cf
 Outflow = 0.43 cfs @ 12.09 hrs, Volume= 1,508 cf, Atten= 0%, Lag= 0.3 min
 Primary = 0.43 cfs @ 12.09 hrs, Volume= 1,508 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 233.54' @ 12.09 hrs Surf.Area= 13 sf Storage= 26 cf

Plug-Flow detention time= 16.2 min calculated for 1,508 cf (99% of inflow)
 Center-of-Mass det. time= 7.9 min (756.9 - 749.0)

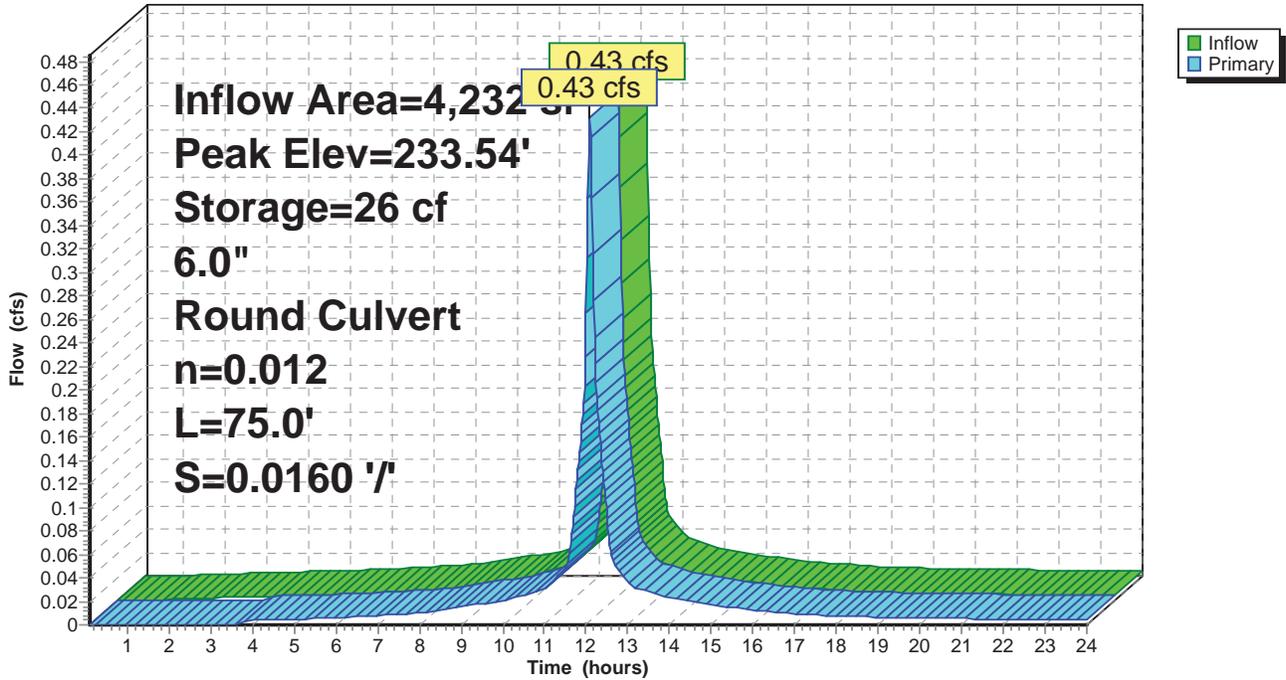
Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	258 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	1,690	213	258

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 75.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 231.75' S= 0.0160 '/ Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.43 cfs @ 12.09 hrs HW=233.53' TW=232.28' (Dynamic Tailwater)
 ↑**1=Culvert** (Inlet Controls 0.43 cfs @ 2.19 fps)

Pond CB2: Catch Basin #2

Hydrograph



Summary for Pond CB3: Catch Basin #3

Inflow Area = 3,960 sf, 100.00% Impervious, Inflow Depth > 4.33" for 10 year event
 Inflow = 0.41 cfs @ 12.08 hrs, Volume= 1,429 cf
 Outflow = 0.40 cfs @ 12.09 hrs, Volume= 1,410 cf, Atten= 0%, Lag= 0.3 min
 Primary = 0.40 cfs @ 12.09 hrs, Volume= 1,410 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 233.49' @ 12.09 hrs Surf.Area= 13 sf Storage= 26 cf

Plug-Flow detention time= 17.3 min calculated for 1,410 cf (99% of inflow)
 Center-of-Mass det. time= 8.4 min (757.4 - 749.0)

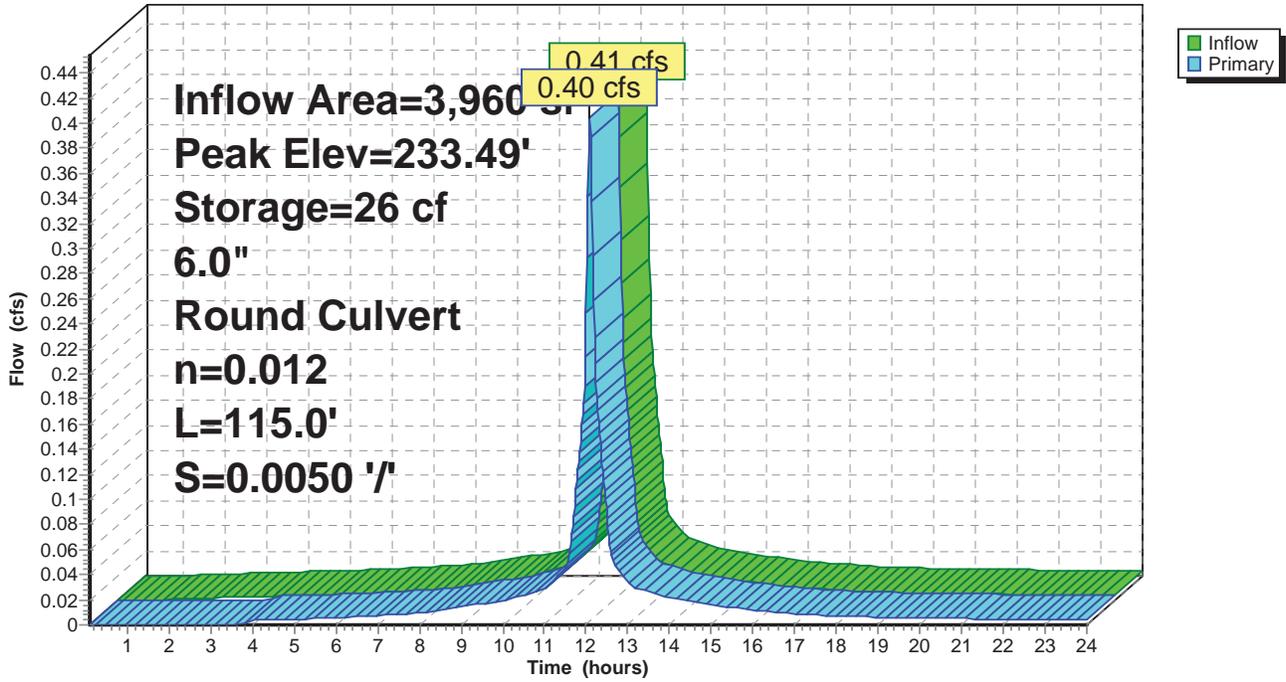
Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	293 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	1,963	247	293

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 115.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 232.38' S= 0.0050 ' / ' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.40 cfs @ 12.09 hrs HW=233.49' TW=231.77' (Dynamic Tailwater)
 ↑**1=Culvert** (Inlet Controls 0.40 cfs @ 2.04 fps)

Pond CB3: Catch Basin #3

Hydrograph



Summary for Pond D1: Drywell

Inflow Area = 3,960 sf, 100.00% Impervious, Inflow Depth > 4.27" for 10 year event
 Inflow = 0.40 cfs @ 12.09 hrs, Volume= 1,410 cf
 Outflow = 0.40 cfs @ 12.10 hrs, Volume= 1,403 cf, Atten= 0%, Lag= 0.5 min
 Discarded = 0.01 cfs @ 12.10 hrs, Volume= 453 cf
 Primary = 0.39 cfs @ 12.10 hrs, Volume= 949 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 231.78' @ 12.10 hrs Surf.Area= 33 sf Storage= 38 cf

Plug-Flow detention time= 17.8 min calculated for 1,401 cf (99% of inflow)
 Center-of-Mass det. time= 14.4 min (771.8 - 757.4)

Volume	Invert	Avail.Storage	Storage Description
#1	230.00'	98 cf	5.00'D x 5.00'H Vertical Cone/Cylinder Inside #2 141 cf Overall - 6.0" Wall Thickness = 98 cf
#2	230.00'	9 cf	6.50'D x 5.00'H Vertical Cone/Cylinder 166 cf Overall - 141 cf Embedded = 25 cf x 35.0% Voids
		107 cf	Total Available Storage

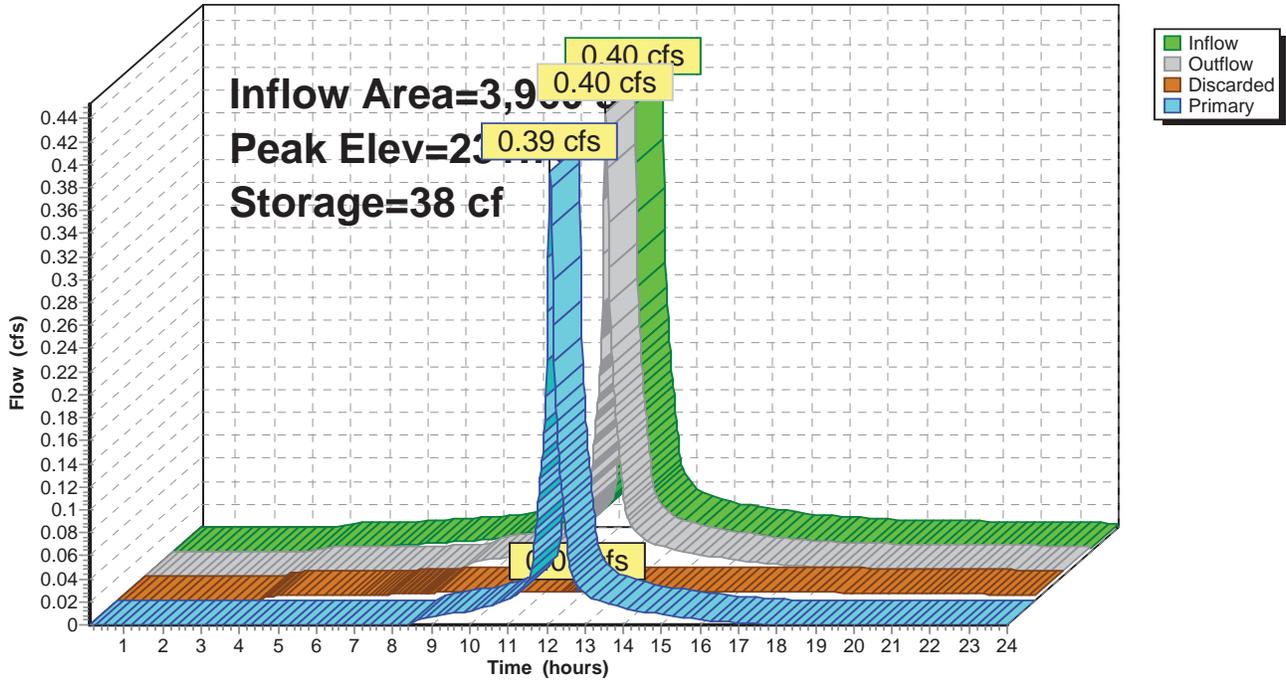
Device	Routing	Invert	Outlet Devices
#1	Primary	231.25'	6.0" Round Culvert L= 5.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 231.25' / 231.00' S= 0.0500 ' / ' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf
#2	Discarded	230.00'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'

Discarded OutFlow Max=0.01 cfs @ 12.10 hrs HW=231.78' (Free Discharge)
 ↑**2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.39 cfs @ 12.10 hrs HW=231.78' TW=230.09' (Dynamic Tailwater)
 ↑**1=Culvert** (Inlet Controls 0.39 cfs @ 2.00 fps)

Pond D1: Drywell

Hydrograph



Time span=0.10-24.00 hrs, dt=0.02 hrs, 1196 points x 3
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
 Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Roof Drain South West Runoff Area=2,749 sf 100.00% Impervious Runoff Depth>7.88"
 Flow Length=50' Slope=0.1300 '/ Tc=6.0 min CN=98 Runoff=0.50 cfs 1,806 cf

Subcatchment 2S: Roof Drain North Side Runoff Area=3,230 sf 100.00% Impervious Runoff Depth>7.88"
 Flow Length=50' Slope=0.1300 '/ Tc=6.0 min CN=98 Runoff=0.59 cfs 2,122 cf

Subcatchment 3S: Upper Paved Area Runoff Area=10,259 sf 69.83% Impervious Runoff Depth>6.33"
 Tc=6.0 min CN=85 Runoff=1.68 cfs 5,414 cf

Subcatchment 4S: Middle Paved Area & Runoff Area=4,232 sf 100.00% Impervious Runoff Depth>7.88"
 Tc=6.0 min CN=98 Runoff=0.77 cfs 2,781 cf

Subcatchment 5S: Lower Paved Area Runoff Area=3,960 sf 100.00% Impervious Runoff Depth>7.88"
 Tc=6.0 min CN=98 Runoff=0.72 cfs 2,602 cf

Subcatchment 6S: Remaining Project Area Runoff Area=217,642 sf 3.80% Impervious Runoff Depth>2.21"
 Flow Length=562' Tc=15.9 min CN=49 Runoff=8.66 cfs 40,137 cf

Subcatchment EX: Existing Site Runoff Area=242,195 sf 7.17% Impervious Runoff Depth>2.32"
 Flow Length=562' Tc=15.9 min CN=50 Runoff=10.24 cfs 46,812 cf

Reach END: Proposed Site Runoff Inflow=10.04 cfs 45,495 cf
 Outflow=10.04 cfs 45,495 cf

Pond C1: Northeast Cultecs Peak Elev=233.61' Storage=0.061 af Inflow=1.79 cfs 8,155 cf
 Discarded=0.00 cfs 0 cf Primary=1.03 cfs 7,604 cf Outflow=1.03 cfs 7,604 cf

Pond C2: Intermediate Cultecs Peak Elev=232.78' Storage=876 cf Inflow=1.46 cfs 9,726 cf
 Discarded=0.08 cfs 3,498 cf Primary=1.12 cfs 6,227 cf Outflow=1.20 cfs 9,725 cf

Pond C3: Southwest Cultecs Peak Elev=232.11' Storage=0.032 af Inflow=1.96 cfs 10,050 cf
 Discarded=0.16 cfs 4,692 cf Primary=1.39 cfs 5,358 cf Outflow=1.55 cfs 10,050 cf

Pond CB1: Catch Basin #1 Peak Elev=235.19' Storage=296 cf Inflow=1.68 cfs 5,414 cf
 6.0" Round Culvert n=0.012 L=20.0' S=0.0600 '/ Outflow=1.06 cfs 5,394 cf

Pond CB2: Catch Basin #2 Peak Elev=234.51' Storage=39 cf Inflow=0.77 cfs 2,781 cf
 6.0" Round Culvert n=0.012 L=75.0' S=0.0160 '/ Outflow=0.75 cfs 2,761 cf

Pond CB3: Catch Basin #3 Peak Elev=234.82' Storage=43 cf Inflow=0.72 cfs 2,602 cf
 6.0" Round Culvert n=0.012 L=115.0' S=0.0050 '/ Outflow=0.71 cfs 2,582 cf

Pond D1: Drywell Peak Elev=232.46' Storage=53 cf Inflow=0.71 cfs 2,582 cf
 Discarded=0.01 cfs 539 cf Primary=0.68 cfs 2,017 cf Outflow=0.69 cfs 2,556 cf

Total Runoff Area = 484,267 sf Runoff Volume = 101,675 cf Average Runoff Depth = 2.52"
90.30% Pervious = 437,284 sf 9.70% Impervious = 46,983 sf

Summary for Subcatchment 1S: Roof Drain South West Side

Runoff = 0.50 cfs @ 12.08 hrs, Volume= 1,806 cf, Depth> 7.88"

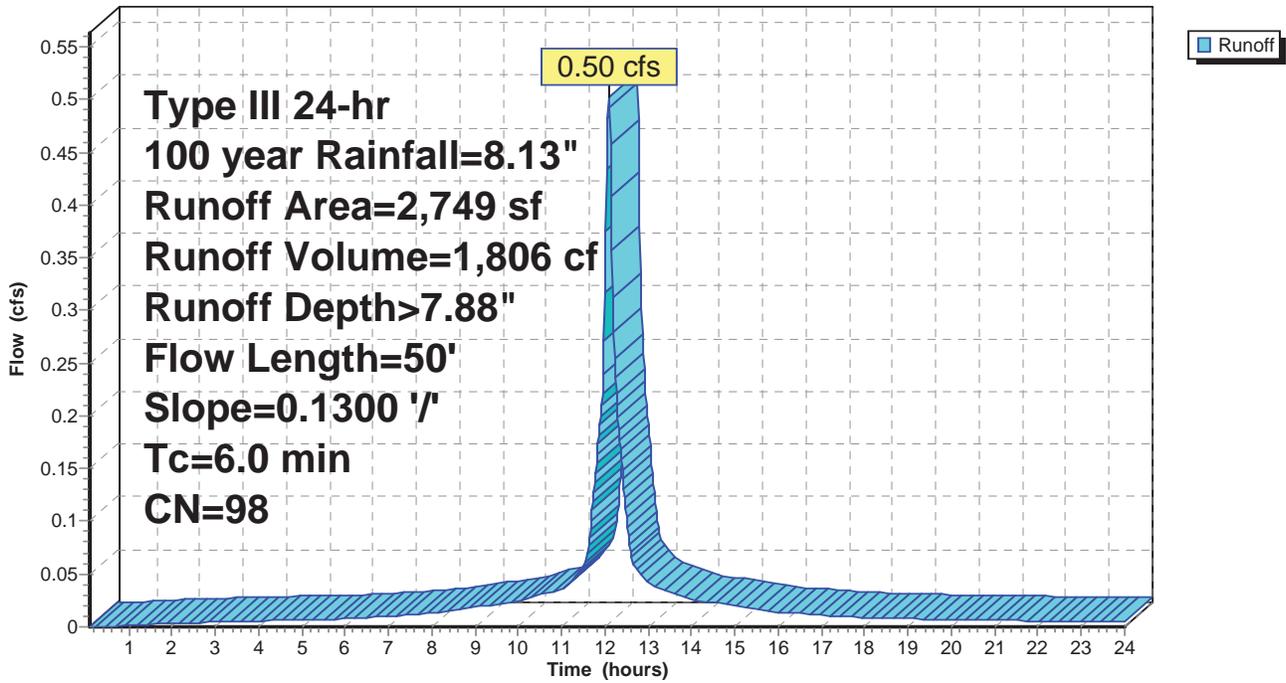
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100 year Rainfall=8.13"

Area (sf)	CN	Description
2,749	98	Roofs, HSG A
2,749		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.1300	0.14		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"

Subcatchment 1S: Roof Drain South West Side

Hydrograph



Summary for Subcatchment 2S: Roof Drain North Side

Runoff = 0.59 cfs @ 12.08 hrs, Volume= 2,122 cf, Depth> 7.88"

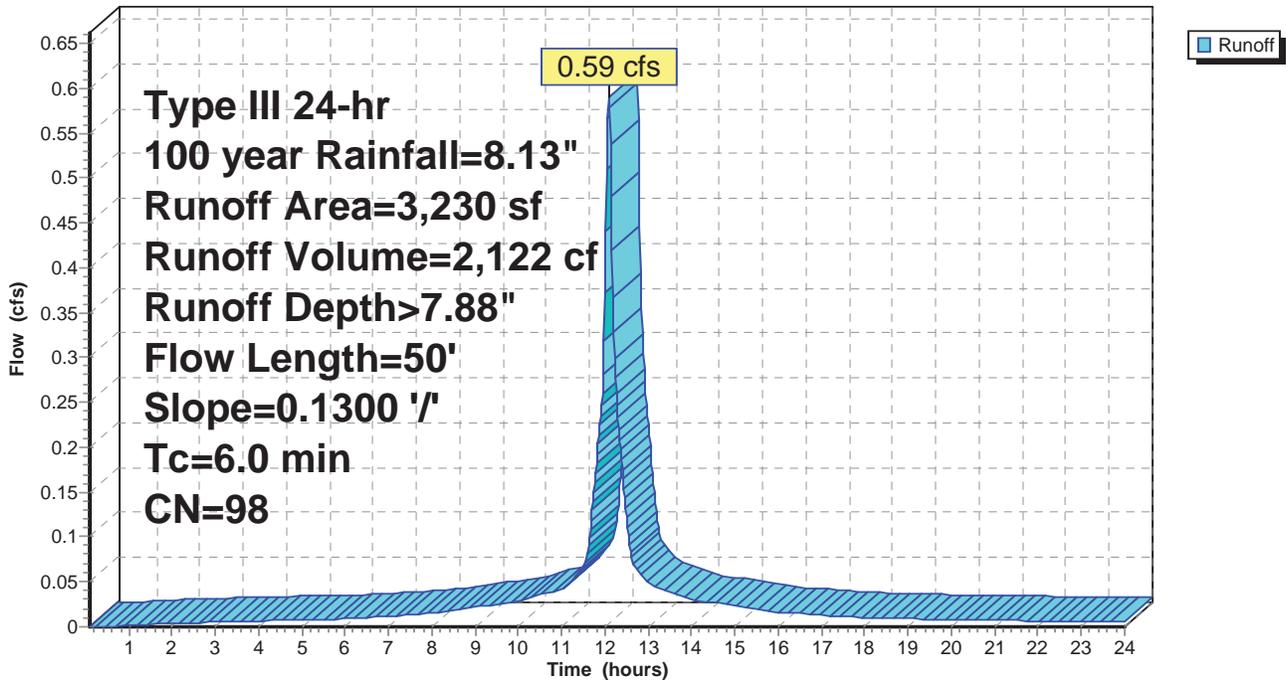
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
 Type III 24-hr 100 year Rainfall=8.13"

Area (sf)	CN	Description
3,230	98	Roofs, HSG A
3,230		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.1300	0.14		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"

Subcatchment 2S: Roof Drain North Side

Hydrograph



Summary for Subcatchment 3S: Upper Paved Area

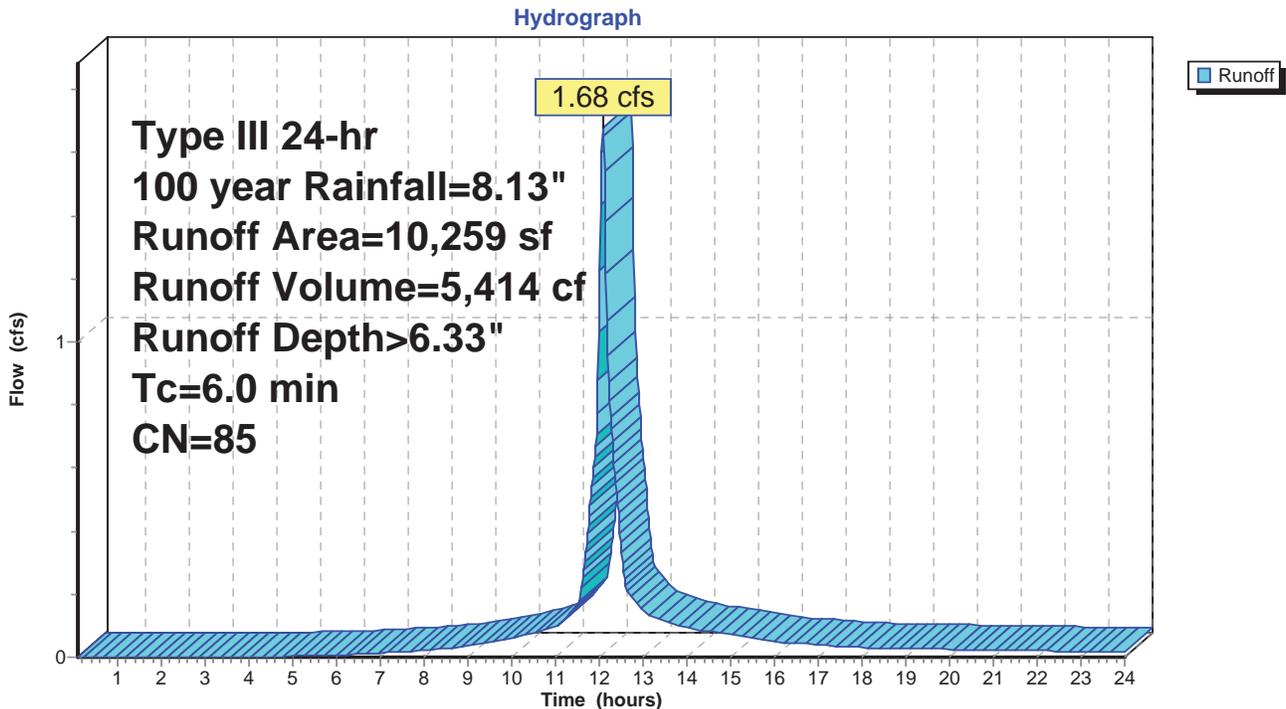
Runoff = 1.68 cfs @ 12.09 hrs, Volume= 5,414 cf, Depth> 6.33"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
 Type III 24-hr 100 year Rainfall=8.13"

Area (sf)	CN	Description
7,164	98	Paved parking, HSG A
1,956	49	50-75% Grass cover, Fair, HSG A
441	49	50-75% Grass cover, Fair, HSG A
* 698	76	Gravel roads, HSG A (rip rap)
10,259	85	Weighted Average
3,095		30.17% Pervious Area
7,164		69.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 3S: Upper Paved Area



Summary for Subcatchment 4S: Middle Paved Area & Eastern Roof

Runoff = 0.77 cfs @ 12.08 hrs, Volume= 2,781 cf, Depth> 7.88"

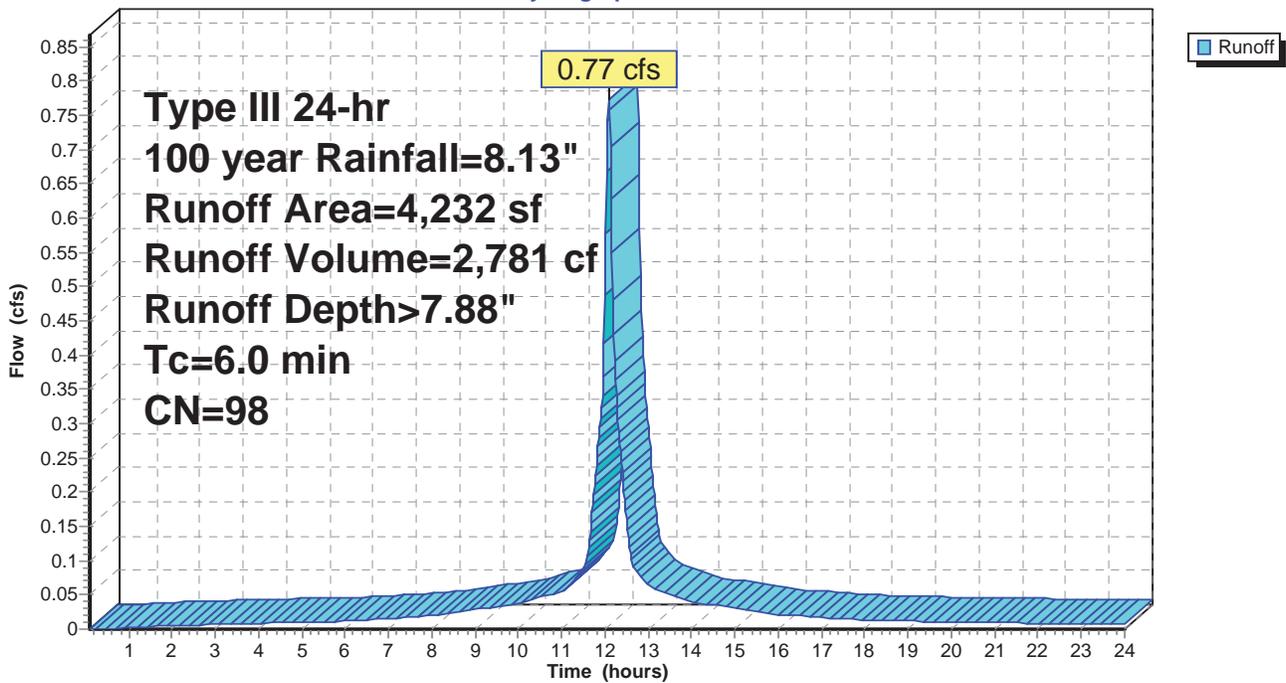
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
 Type III 24-hr 100 year Rainfall=8.13"

Area (sf)	CN	Description
2,572	98	Paved parking, HSG A
1,660	98	Roofs, HSG A
4,232	98	Weighted Average
4,232		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 4S: Middle Paved Area & Eastern Roof

Hydrograph



Summary for Subcatchment 5S: Lower Paved Area

Runoff = 0.72 cfs @ 12.08 hrs, Volume= 2,602 cf, Depth> 7.88"

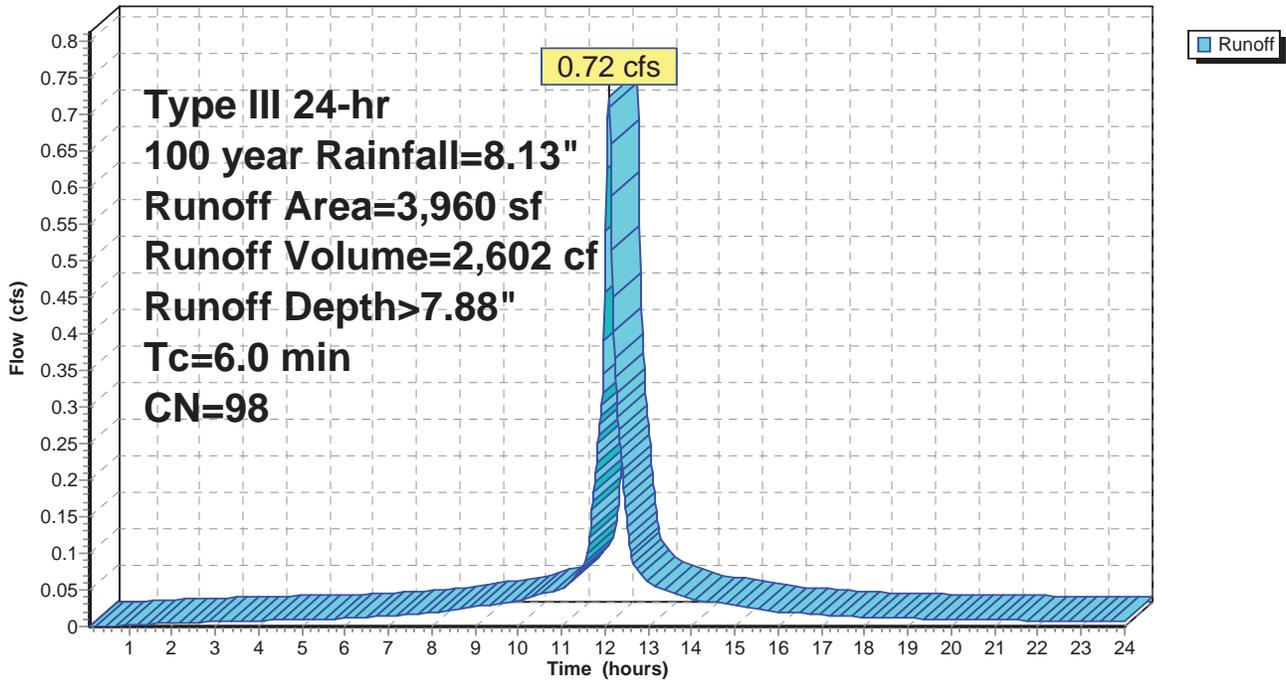
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
 Type III 24-hr 100 year Rainfall=8.13"

Area (sf)	CN	Description
3,960	98	Paved parking, HSG A
3,960		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 5S: Lower Paved Area

Hydrograph



Summary for Subcatchment 6S: Remaining Project Area

Runoff = 8.66 cfs @ 12.24 hrs, Volume= 40,137 cf, Depth> 2.21"

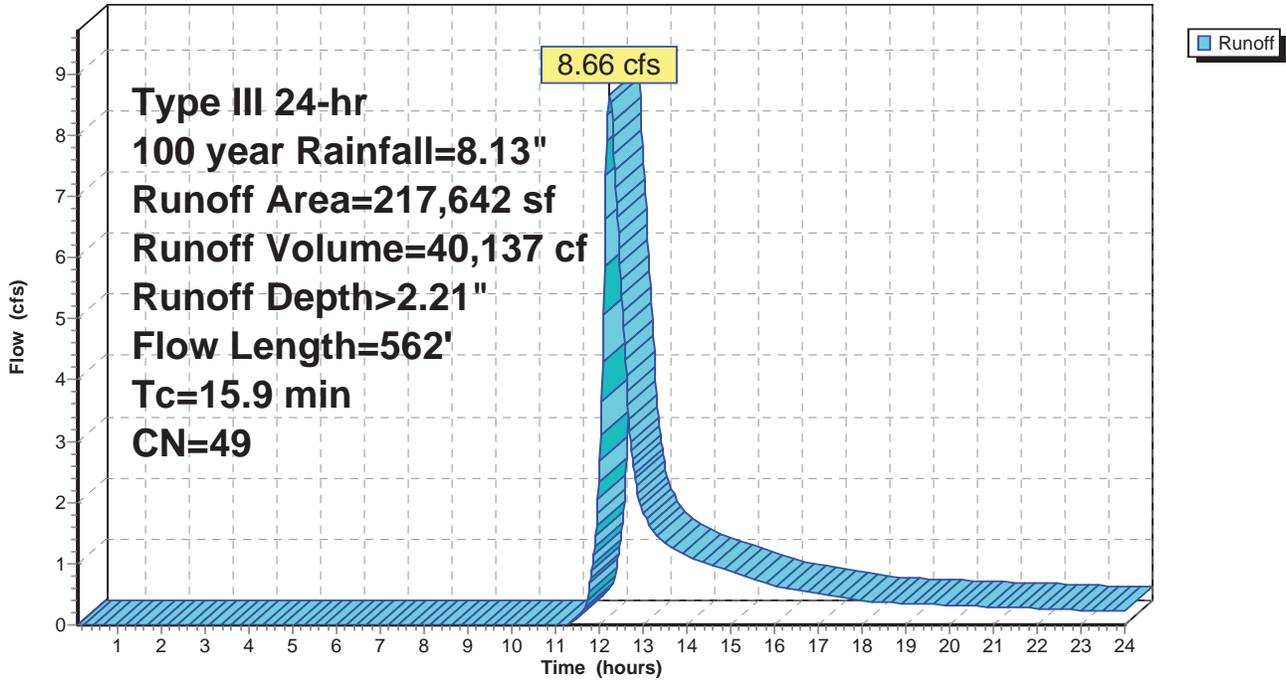
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100 year Rainfall=8.13"

Area (sf)	CN	Description
2,763	49	50-75% Grass cover, Fair, HSG A
9,597	76	Gravel roads, HSG A
8,274	98	Paved parking, HSG A
7,927	49	50-75% Grass cover, Fair, HSG A
27,757	78	Meadow, non-grazed, HSG D
28,946	77	Woods, Good, HSG D
78,485	30	Woods, Good, HSG A
39,143	30	Meadow, non-grazed, HSG A
11,968	30	Woods, Good, HSG A
* 2,782	76	Gravel roads, HSG A (RIP RAP)
217,642	49	Weighted Average
209,368		96.20% Pervious Area
8,274		3.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.7	50	0.0500	0.10		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"
0.3	36	0.1676	2.05		Shallow Concentrated Flow, woods pre grass strip Woodland Kv= 5.0 fps
0.1	10	0.1000	2.21		Shallow Concentrated Flow, grass strips (both) Short Grass Pasture Kv= 7.0 fps
0.0	12	0.0833	5.86		Shallow Concentrated Flow, pavement Paved Kv= 20.3 fps
6.7	440	0.0480	1.10		Shallow Concentrated Flow, rip rap Woodland Kv= 5.0 fps
0.1	14	0.1667	2.86		Shallow Concentrated Flow, grass strip Short Grass Pasture Kv= 7.0 fps
15.9	562	Total			

Subcatchment 6S: Remaining Project Area

Hydrograph



Summary for Subcatchment EX: Existing Site

Runoff = 10.24 cfs @ 12.24 hrs, Volume= 46,812 cf, Depth> 2.32"

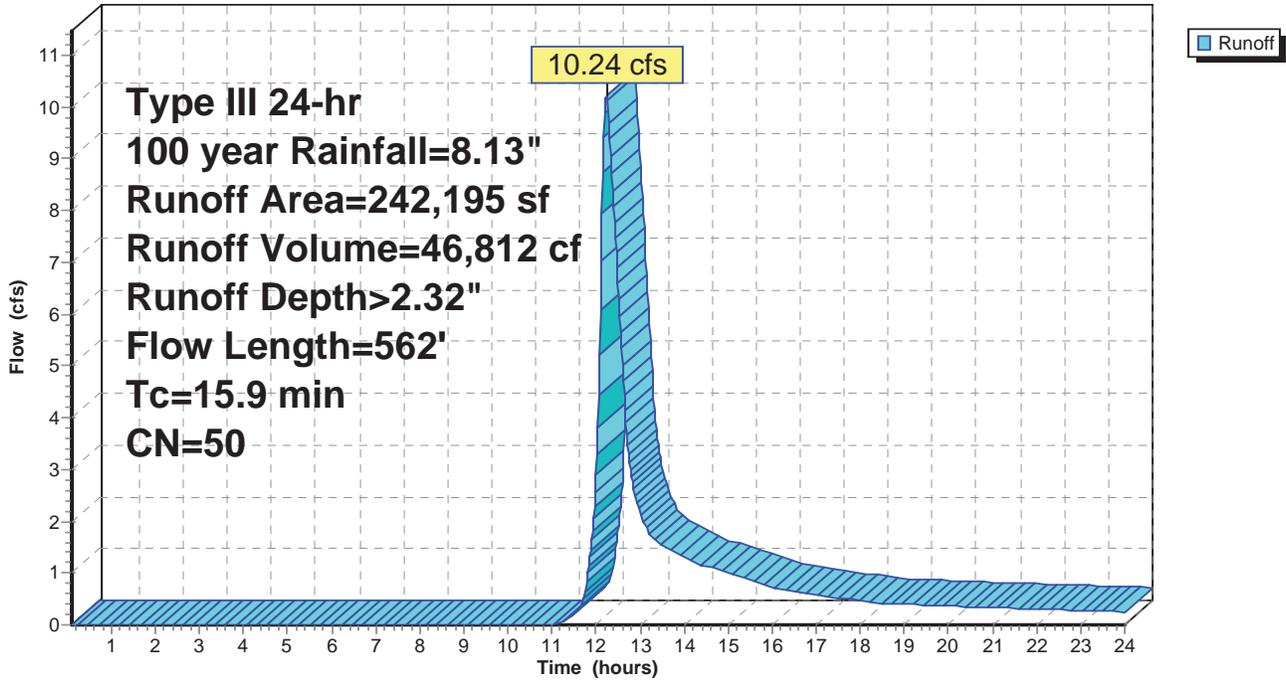
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
 Type III 24-hr 100 year Rainfall=8.13"

Area (sf)	CN	Description
11,475	49	50-75% Grass cover, Fair, HSG A
3,181	76	Gravel roads, HSG A
17,374	98	Paved parking, HSG A
4,242	49	50-75% Grass cover, Fair, HSG A
8,728	49	50-75% Grass cover, Fair, HSG A
* 3,480	76	Gravel roads, HSG A (RIP RAP)
59,405	77	Woods, Good, HSG D
82,915	30	Woods, Good, HSG A
9,737	30	Woods, Good, HSG A
41,658	30	Woods, Good, HSG A
242,195	50	Weighted Average
224,821		92.83% Pervious Area
17,374		7.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.7	50	0.0500	0.10		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"
0.3	36	0.1676	2.05		Shallow Concentrated Flow, woods Woodland Kv= 5.0 fps
0.0	12	0.1000	6.42		Shallow Concentrated Flow, pavement Paved Kv= 20.3 fps
0.1	10	0.1000	2.21		Shallow Concentrated Flow, grass strip (both) Short Grass Pasture Kv= 7.0 fps
6.7	440	0.0480	1.10		Shallow Concentrated Flow, rip rap Woodland Kv= 5.0 fps
0.1	14	0.1667	2.86		Shallow Concentrated Flow, final grass strip Short Grass Pasture Kv= 7.0 fps
15.9	562	Total			

Subcatchment EX: Existing Site

Hydrograph



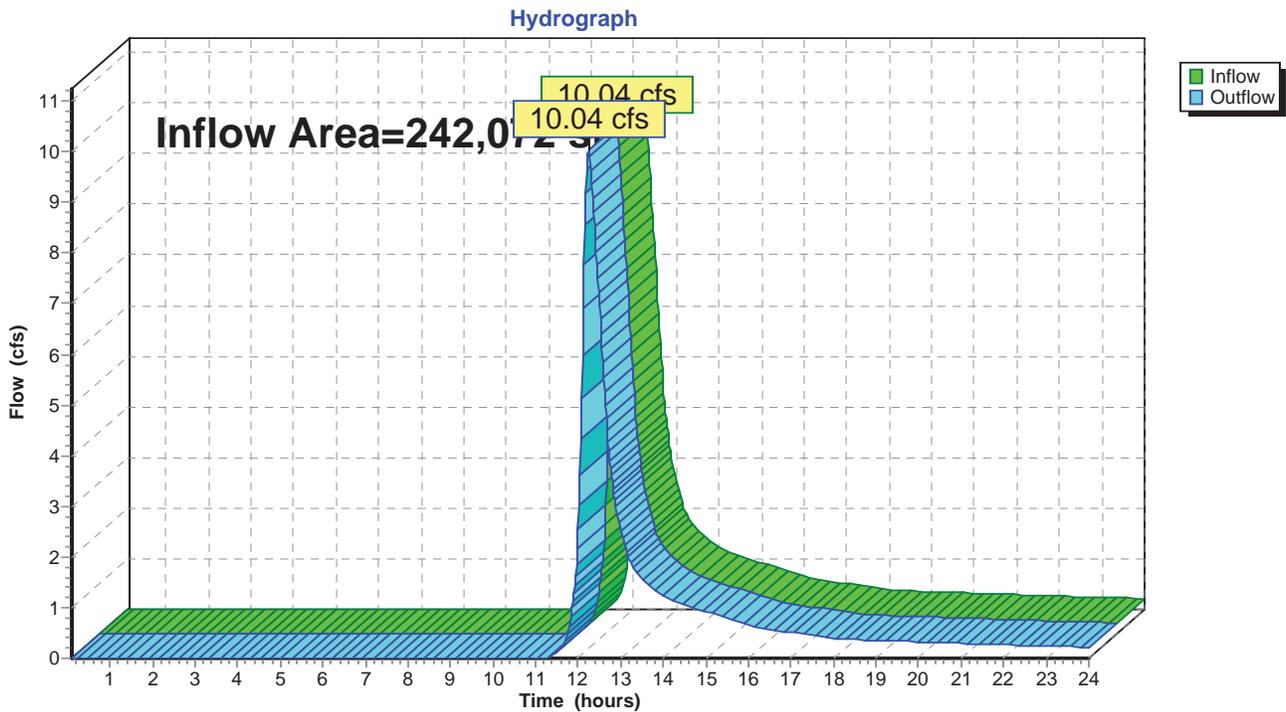
Summary for Reach END: Proposed Site Runoff

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 242,072 sf, 12.23% Impervious, Inflow Depth > 2.26" for 100 year event
Inflow = 10.04 cfs @ 12.24 hrs, Volume= 45,495 cf
Outflow = 10.04 cfs @ 12.24 hrs, Volume= 45,495 cf, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3

Reach END: Proposed Site Runoff



Summary for Pond C1: Northeast Cultecs

[87] Warning: Oscillations may require smaller dt or Finer Routing (severity=1)

Inflow Area = 14,491 sf, 78.64% Impervious, Inflow Depth > 6.75" for 100 year event
 Inflow = 1.79 cfs @ 12.10 hrs, Volume= 8,155 cf
 Outflow = 1.03 cfs @ 12.44 hrs, Volume= 7,604 cf, Atten= 43%, Lag= 20.5 min
 Discarded = 0.00 cfs @ 0.10 hrs, Volume= 0 cf
 Primary = 1.03 cfs @ 12.44 hrs, Volume= 7,604 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 233.61' @ 12.43 hrs Surf.Area= 0.046 ac Storage= 0.061 af

Plug-Flow detention time= 105.2 min calculated for 7,604 cf (93% of inflow)
 Center-of-Mass det. time= 69.0 min (845.3 - 776.3)

Volume	Invert	Avail.Storage	Storage Description
#1A	231.17'	0.018 af	14.50'W x 84.75'L x 2.54'H Field A 0.072 af Overall - 0.020 af Embedded = 0.052 af x 35.0% Voids
#2A	231.67'	0.020 af	Cultec R-150XLHD x 32 Inside #1 Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap Row Length Adjustment= +0.75' x 2.65 sf x 4 rows
#3B	231.17'	0.012 af	14.50'W x 54.00'L x 2.54'H Field B 0.046 af Overall - 0.013 af Embedded = 0.033 af x 35.0% Voids
#4B	231.67'	0.013 af	Cultec R-150XLHD x 20 Inside #3 Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap Row Length Adjustment= +0.75' x 2.65 sf x 4 rows
		0.062 af	Total Available Storage

Storage Group A created with Chamber Wizard
 Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	231.17'	0.090 in/hr Exfiltration X 0.00 over Surface area Phase-In= 0.01'
#2	Primary	231.67'	4.0" Round Culvert L= 145.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 231.67' / 230.95' S= 0.0050 '/' Cc= 0.900 n= 0.012, Flow Area= 0.09 sf
#3	Primary	232.33'	8.0" Round Culvert L= 145.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.33' / 231.44' S= 0.0061 '/' Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.00 cfs @ 0.10 hrs HW=231.17' (Free Discharge)
 ↳1=Exfiltration (Controls 0.00 cfs)

Primary OutFlow Max=1.03 cfs @ 12.44 hrs HW=233.61' TW=232.76' (Dynamic Tailwater)
 ↳2=Culvert (Outlet Controls 0.15 cfs @ 1.70 fps)
 ↳3=Culvert (Outlet Controls 0.88 cfs @ 2.52 fps)

Pond C1: Northeast Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-150XLHD (Cultec Recharger® 150XLHD)

Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf

Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap

Row Length Adjustment= +0.75' x 2.65 sf x 4 rows

33.0" Wide + 6.0" Spacing = 39.0" C-C Row Spacing

8 Chambers/Row x 10.25' Long +0.75' Row Adjustment = 82.75' Row Length +12.0" End Stone x 2 = 84.75' Base Length

4 Rows x 33.0" Wide + 6.0" Spacing x 3 + 12.0" Side Stone x 2 = 14.50' Base Width

6.0" Base + 18.5" Chamber Height + 6.0" Cover = 2.54' Field Height

32 Chambers x 27.2 cf +0.75' Row Adjustment x 2.65 sf x 4 Rows = 876.8 cf Chamber Storage

3,123.4 cf Field - 876.8 cf Chambers = 2,246.6 cf Stone x 35.0% Voids = 786.3 cf Stone Storage

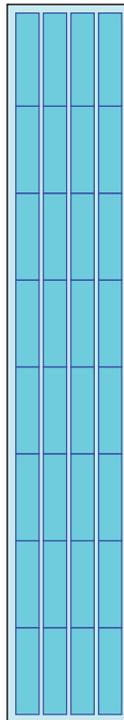
Chamber Storage + Stone Storage = 1,663.1 cf = 0.038 af

Overall Storage Efficiency = 53.2%

32 Chambers

115.7 cy Field

83.2 cy Stone



Pond C1: Northeast Cultecs - Chamber Wizard Field B

Chamber Model = Cultec R-150XLHD (Cultec Recharger® 150XLHD)

Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf

Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap

Row Length Adjustment= +0.75' x 2.65 sf x 4 rows

33.0" Wide + 6.0" Spacing = 39.0" C-C Row Spacing

5 Chambers/Row x 10.25' Long +0.75' Row Adjustment = 52.00' Row Length +12.0" End Stone x 2 = 54.00' Base Length

4 Rows x 33.0" Wide + 6.0" Spacing x 3 + 12.0" Side Stone x 2 = 14.50' Base Width

6.0" Base + 18.5" Chamber Height + 6.0" Cover = 2.54' Field Height

20 Chambers x 27.2 cf +0.75' Row Adjustment x 2.65 sf x 4 Rows = 551.0 cf Chamber Storage

1,990.1 cf Field - 551.0 cf Chambers = 1,439.1 cf Stone x 35.0% Voids = 503.7 cf Stone Storage

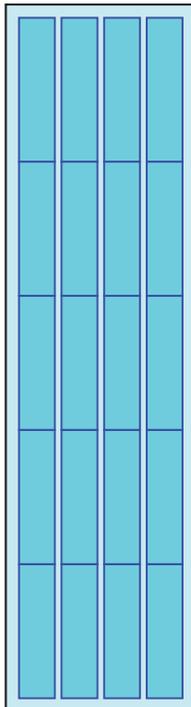
Chamber Storage + Stone Storage = 1,054.7 cf = 0.024 af

Overall Storage Efficiency = 53.0%

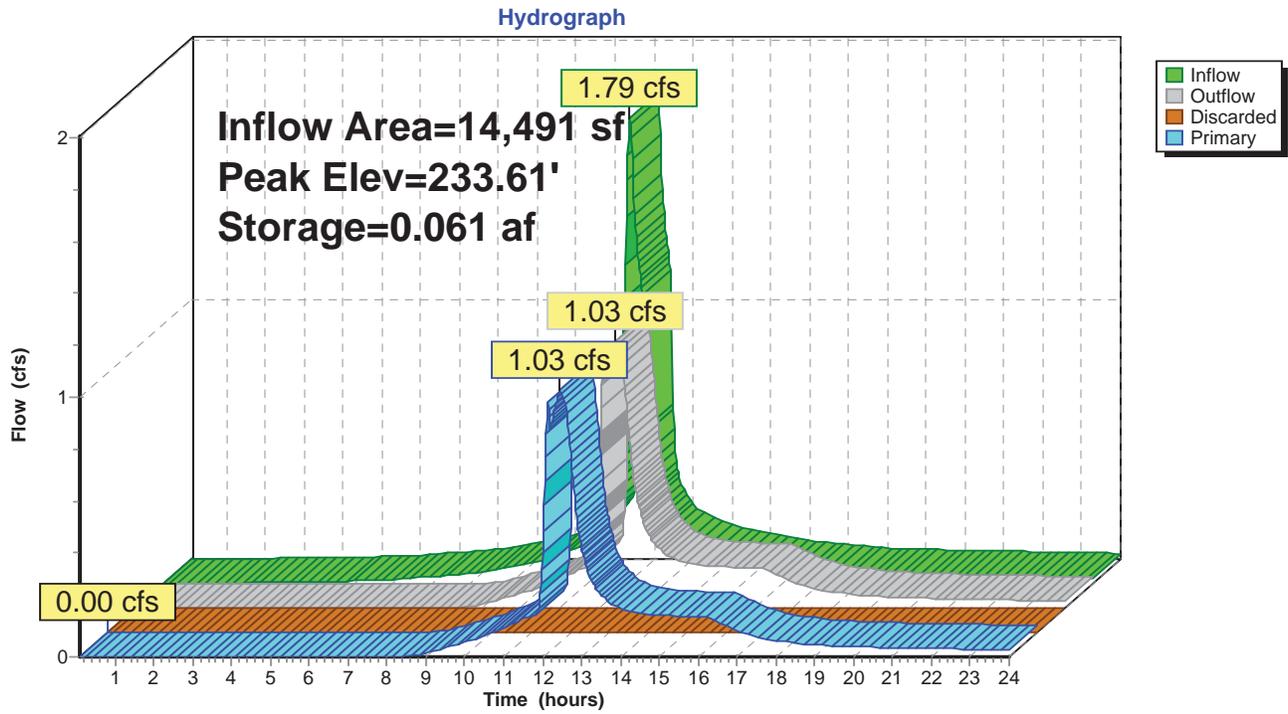
20 Chambers

73.7 cy Field

53.3 cy Stone



Pond C1: Northeast Cultecs



Summary for Pond C2: Intermediate Cultecs

Inflow Area = 17,721 sf, 82.53% Impervious, Inflow Depth > 6.59" for 100 year event
 Inflow = 1.46 cfs @ 12.13 hrs, Volume= 9,726 cf
 Outflow = 1.20 cfs @ 12.45 hrs, Volume= 9,725 cf, Atten= 18%, Lag= 19.4 min
 Discarded = 0.08 cfs @ 12.37 hrs, Volume= 3,498 cf
 Primary = 1.12 cfs @ 12.45 hrs, Volume= 6,227 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 232.78' @ 12.37 hrs Surf.Area= 392 sf Storage= 876 cf
 Flood Elev= 233.94' Surf.Area= 392 sf Storage= 950 cf

Plug-Flow detention time= 26.9 min calculated for 9,725 cf (100% of inflow)
 Center-of-Mass det. time= 26.8 min (849.3 - 822.4)

Volume	Invert	Avail.Storage	Storage Description
#1A	228.78'	447 cf	16.00'W x 24.50'L x 4.54'H Field A 1,780 cf Overall - 503 cf Embedded = 1,277 cf x 35.0% Voids
#2A	229.78'	503 cf	Cultec R-330XLHD x 9 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 3 rows
		950 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	228.78'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'
#2	Primary	230.00'	8.0" Round Culvert L= 10.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 230.00' / 230.00' S= 0.0000 1/ S= 0.0000 1/ Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.08 cfs @ 12.37 hrs HW=232.78' (Free Discharge)

↳ **1=Exfiltration** (Exfiltration Controls 0.08 cfs)

Primary OutFlow Max=1.12 cfs @ 12.45 hrs HW=232.76' TW=232.04' (Dynamic Tailwater)

↳ **2=Culvert** (Inlet Controls 1.12 cfs @ 3.21 fps)

Pond C2: Intermediate Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 3 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

3 Rows x 52.0" Wide + 6.0" Spacing x 2 + 12.0" Side Stone x 2 = 16.00' Base Width

12.0" Base + 30.5" Chamber Height + 12.0" Cover = 4.54' Field Height

9 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 3 Rows = 502.9 cf Chamber Storage

1,780.3 cf Field - 502.9 cf Chambers = 1,277.4 cf Stone x 35.0% Voids = 447.1 cf Stone Storage

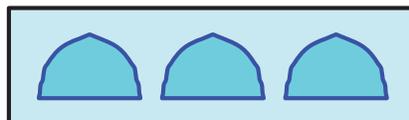
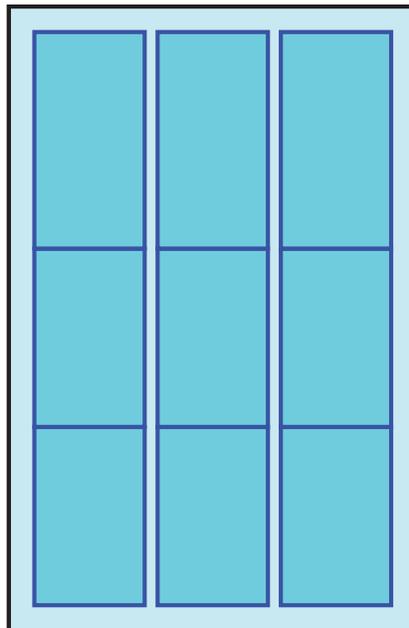
Chamber Storage + Stone Storage = 950.0 cf = 0.022 af

Overall Storage Efficiency = 53.4%

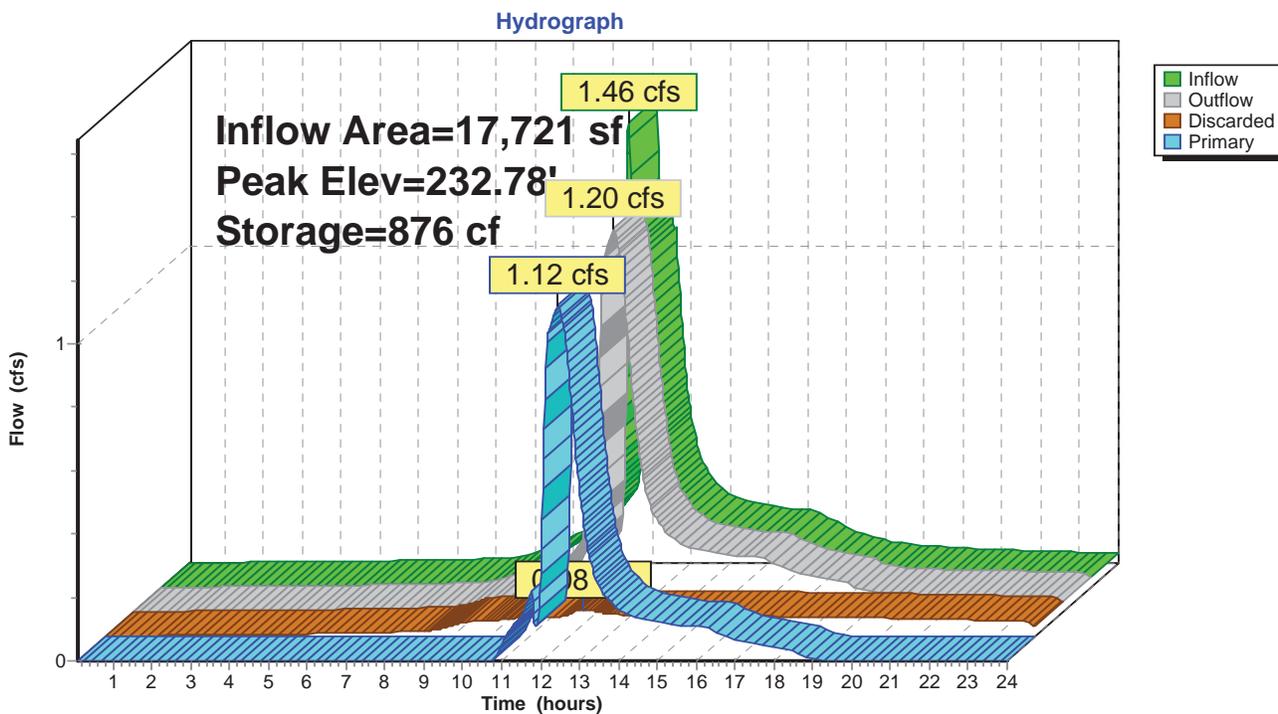
9 Chambers

65.9 cy Field

47.3 cy Stone



Pond C2: Intermediate Cultecs



Summary for Pond C3: Southwest Cultecs

Inflow Area = 24,430 sf, 87.33% Impervious, Inflow Depth > 4.94" for 100 year event
 Inflow = 1.96 cfs @ 12.14 hrs, Volume= 10,050 cf
 Outflow = 1.55 cfs @ 12.30 hrs, Volume= 10,050 cf, Atten= 21%, Lag= 9.9 min
 Discarded = 0.16 cfs @ 12.30 hrs, Volume= 4,692 cf
 Primary = 1.39 cfs @ 12.30 hrs, Volume= 5,358 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 232.11' @ 12.30 hrs Surf.Area= 0.017 ac Storage= 0.032 af

Plug-Flow detention time= 34.7 min calculated for 10,042 cf (100% of inflow)
 Center-of-Mass det. time= 34.6 min (812.7 - 778.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	229.07'	0.003 af	6.33'W x 24.50'L x 3.71'H Field A 0.013 af Overall - 0.004 af Embedded = 0.009 af x 35.0% Voids
#2A	229.74'	0.004 af	Cultec R-330XLHD x 3 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 1 rows
#3B	229.07'	0.011 af	11.17'W x 52.50'L x 3.71'H Field B 0.050 af Overall - 0.017 af Embedded = 0.033 af x 35.0% Voids
#4B	229.74'	0.017 af	Cultec R-330XLHD x 14 Inside #3 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 2 rows
		0.036 af	Total Available Storage

Storage Group A created with Chamber Wizard
 Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	229.07'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'
#2	Primary	230.68'	8.0" Round Culvert L= 20.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 230.68' / 230.48' S= 0.0100 1/ S= 0.0100 1/ Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.16 cfs @ 12.30 hrs HW=232.11' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.16 cfs)

Primary OutFlow Max=1.39 cfs @ 12.30 hrs HW=232.11' TW=0.00' (Dynamic Tailwater)

↑**2=Culvert** (Inlet Controls 1.39 cfs @ 3.99 fps)

Pond C3: Southwest Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 1 rows

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

1 Rows x 52.0" Wide + 12.0" Side Stone x 2 = 6.33' Base Width

8.0" Base + 30.5" Chamber Height + 6.0" Cover = 3.71' Field Height

3 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 1 Rows = 167.6 cf Chamber Storage

575.4 cf Field - 167.6 cf Chambers = 407.8 cf Stone x 35.0% Voids = 142.7 cf Stone Storage

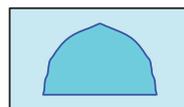
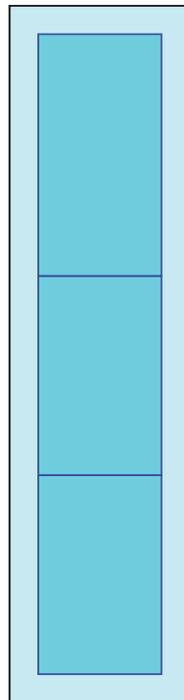
Chamber Storage + Stone Storage = 310.4 cf = 0.007 af

Overall Storage Efficiency = 53.9%

3 Chambers

21.3 cy Field

15.1 cy Stone



Pond C3: Southwest Cultecs - Chamber Wizard Field B

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 2 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

7 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 50.50' Row Length +12.0" End Stone x 2 = 52.50' Base Length

2 Rows x 52.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.17' Base Width

8.0" Base + 30.5" Chamber Height + 6.0" Cover = 3.71' Field Height

14 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 2 Rows = 752.6 cf Chamber Storage

2,174.0 cf Field - 752.6 cf Chambers = 1,421.5 cf Stone x 35.0% Voids = 497.5 cf Stone Storage

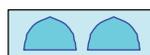
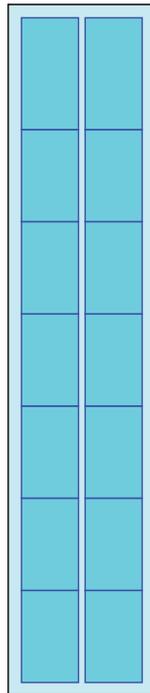
Chamber Storage + Stone Storage = 1,250.1 cf = 0.029 af

Overall Storage Efficiency = 57.5%

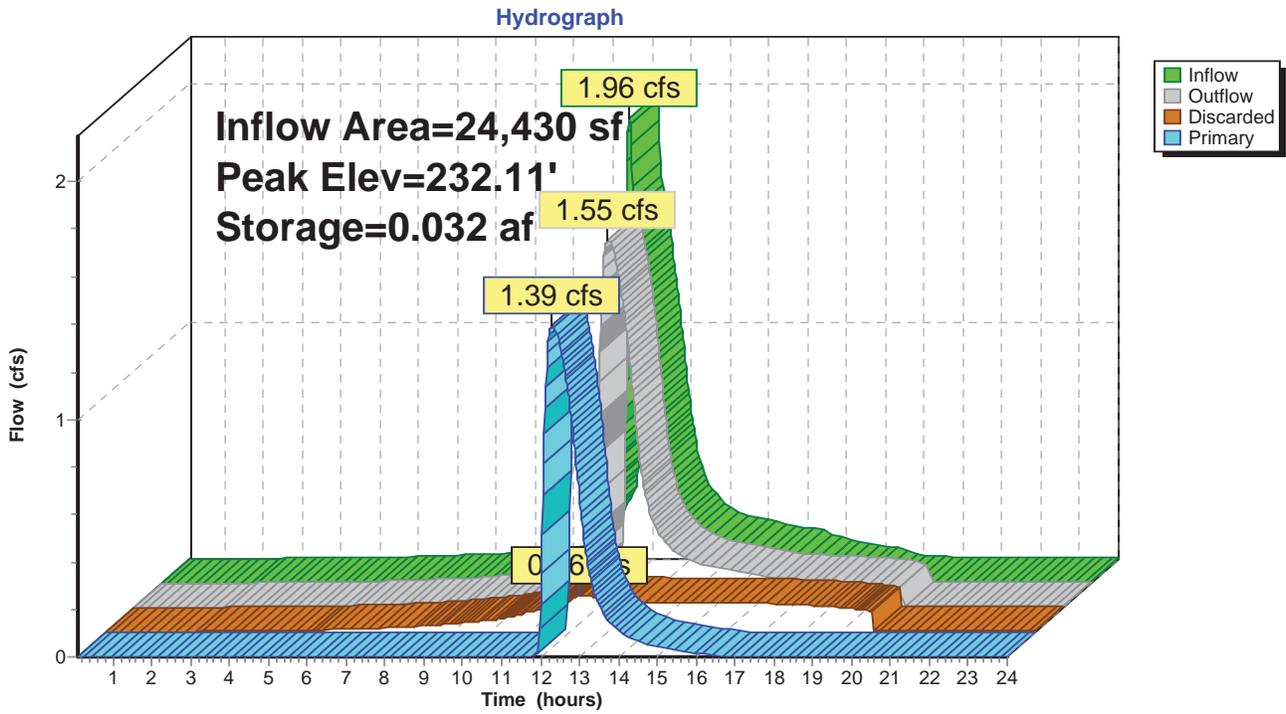
14 Chambers

80.5 cy Field

52.6 cy Stone



Pond C3: Southwest Cultecs



Summary for Pond CB1: Catch Basin #1

Inflow Area = 10,259 sf, 69.83% Impervious, Inflow Depth > 6.33" for 100 year event
 Inflow = 1.68 cfs @ 12.09 hrs, Volume= 5,414 cf
 Outflow = 1.06 cfs @ 12.17 hrs, Volume= 5,394 cf, Atten= 37%, Lag= 5.2 min
 Primary = 1.06 cfs @ 12.17 hrs, Volume= 5,394 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 235.19' @ 12.18 hrs Surf.Area= 2,578 sf Storage= 296 cf

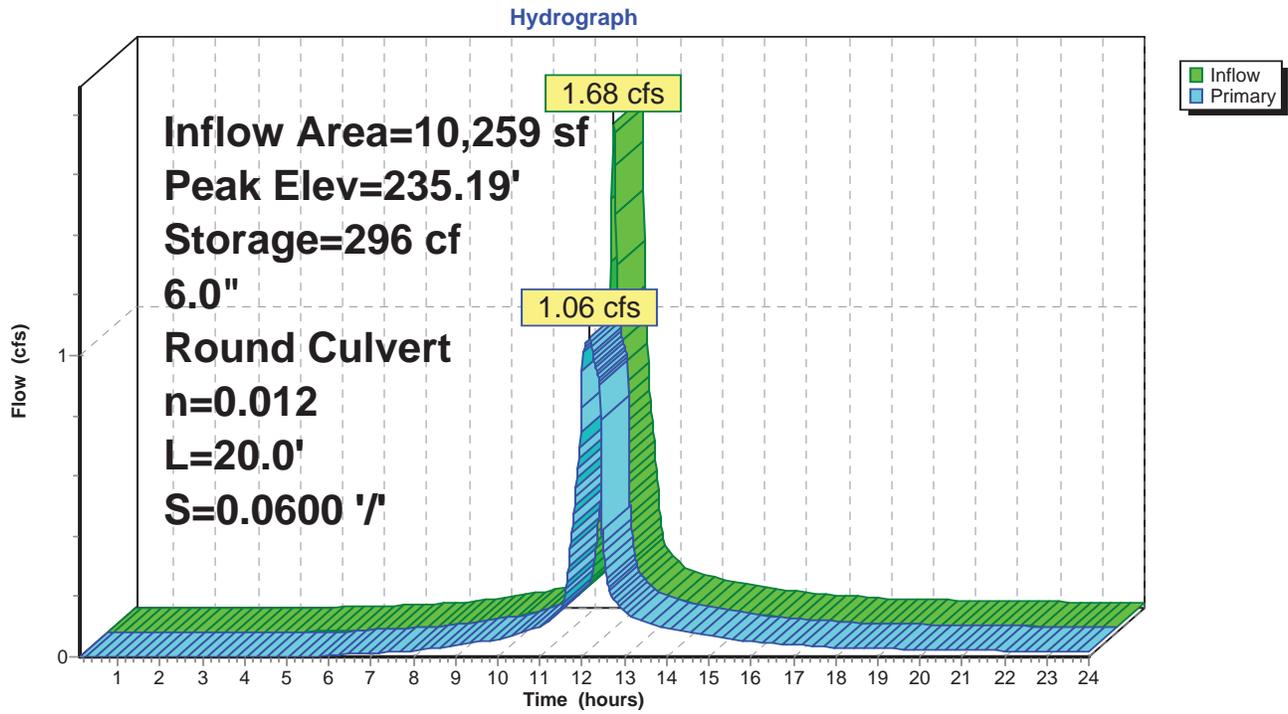
Plug-Flow detention time= 5.0 min calculated for 5,390 cf (100% of inflow)
 Center-of-Mass det. time= 2.7 min (792.1 - 789.4)

Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	464 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	3,335	419	464

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 20.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 231.75' S= 0.0600 '/' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=1.05 cfs @ 12.17 hrs HW=235.19' TW=233.15' (Dynamic Tailwater)
 ↑**1=Culvert** (Inlet Controls 1.05 cfs @ 5.36 fps)

Pond CB1: Catch Basin #1



Summary for Pond CB2: Catch Basin #2

Inflow Area = 4,232 sf, 100.00% Impervious, Inflow Depth > 7.88" for 100 year event
 Inflow = 0.77 cfs @ 12.08 hrs, Volume= 2,781 cf
 Outflow = 0.75 cfs @ 12.10 hrs, Volume= 2,761 cf, Atten= 3%, Lag= 0.8 min
 Primary = 0.75 cfs @ 12.10 hrs, Volume= 2,761 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 234.51' @ 12.11 hrs Surf.Area= 13 sf Storage= 39 cf

Plug-Flow detention time= 9.7 min calculated for 2,761 cf (99% of inflow)
 Center-of-Mass det. time= 4.9 min (745.4 - 740.5)

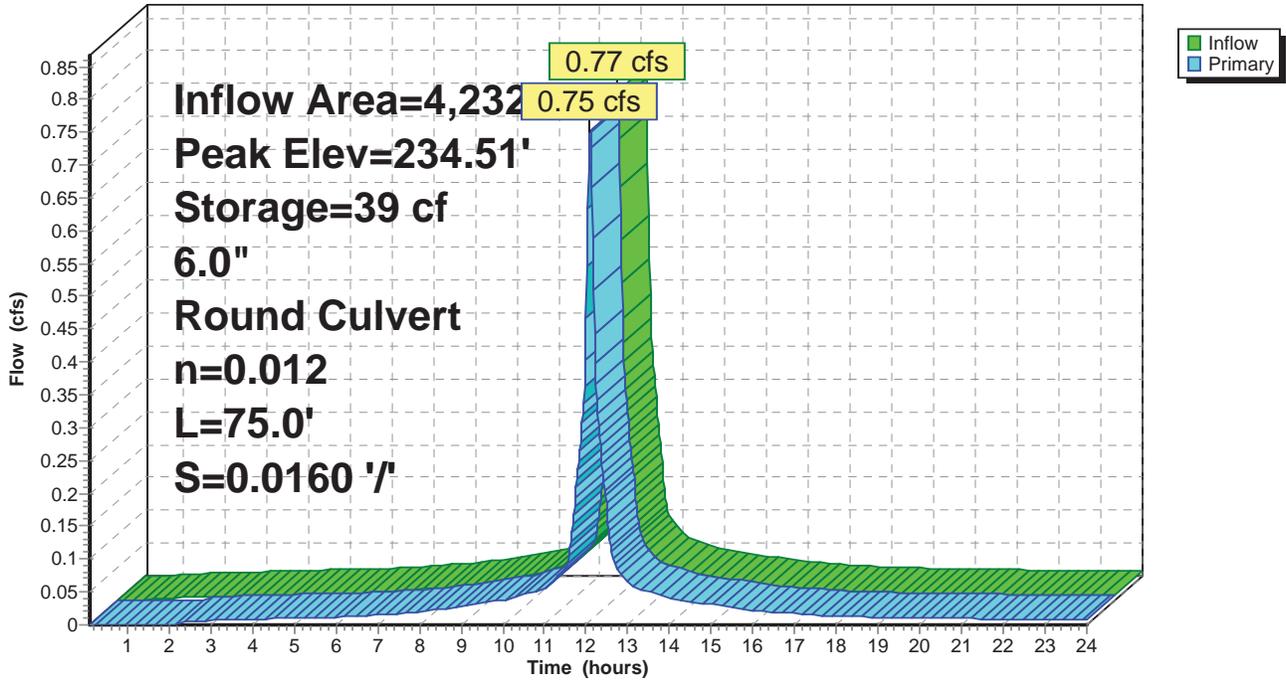
Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	258 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	1,690	213	258

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 75.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 231.75' S= 0.0160 '/' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.75 cfs @ 12.10 hrs HW=234.49' TW=232.92' (Dynamic Tailwater)
 ↑1=Culvert (Outlet Controls 0.75 cfs @ 3.81 fps)

Pond CB2: Catch Basin #2

Hydrograph



Summary for Pond CB3: Catch Basin #3

Inflow Area = 3,960 sf, 100.00% Impervious, Inflow Depth > 7.88" for 100 year event
 Inflow = 0.72 cfs @ 12.08 hrs, Volume= 2,602 cf
 Outflow = 0.71 cfs @ 12.10 hrs, Volume= 2,582 cf, Atten= 2%, Lag= 1.1 min
 Primary = 0.71 cfs @ 12.10 hrs, Volume= 2,582 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 234.82' @ 12.10 hrs Surf.Area= 13 sf Storage= 43 cf

Plug-Flow detention time= 10.3 min calculated for 2,582 cf (99% of inflow)
 Center-of-Mass det. time= 5.2 min (745.7 - 740.5)

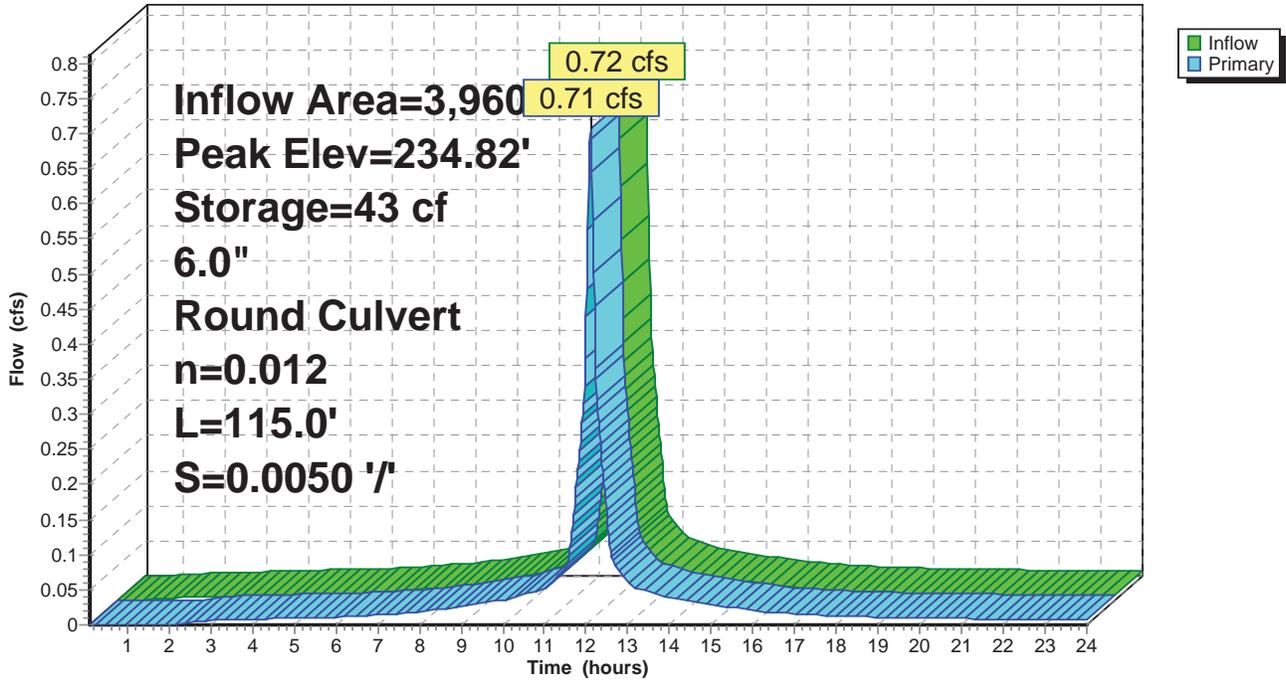
Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	293 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	1,963	247	293

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 115.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 232.38' S= 0.0050 '/ Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.71 cfs @ 12.10 hrs HW=234.82' TW=232.34' (Dynamic Tailwater)
 ↑1=Culvert (Barrel Controls 0.71 cfs @ 3.60 fps)

Pond CB3: Catch Basin #3

Hydrograph



Summary for Pond D1: Drywell

Inflow Area = 3,960 sf, 100.00% Impervious, Inflow Depth > 7.82" for 100 year event
 Inflow = 0.71 cfs @ 12.10 hrs, Volume= 2,582 cf
 Outflow = 0.69 cfs @ 12.10 hrs, Volume= 2,556 cf, Atten= 3%, Lag= 0.1 min
 Discarded = 0.01 cfs @ 12.15 hrs, Volume= 539 cf
 Primary = 0.68 cfs @ 12.10 hrs, Volume= 2,017 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs / 3
 Peak Elev= 232.46' @ 12.15 hrs Surf.Area= 33 sf Storage= 53 cf

Plug-Flow detention time= 13.2 min calculated for 2,556 cf (99% of inflow)
 Center-of-Mass det. time= 6.4 min (752.1 - 745.7)

Volume	Invert	Avail.Storage	Storage Description
#1	230.00'	98 cf	5.00'D x 5.00'H Vertical Cone/Cylinder Inside #2 141 cf Overall - 6.0" Wall Thickness = 98 cf
#2	230.00'	9 cf	6.50'D x 5.00'H Vertical Cone/Cylinder 166 cf Overall - 141 cf Embedded = 25 cf x 35.0% Voids
		107 cf	Total Available Storage

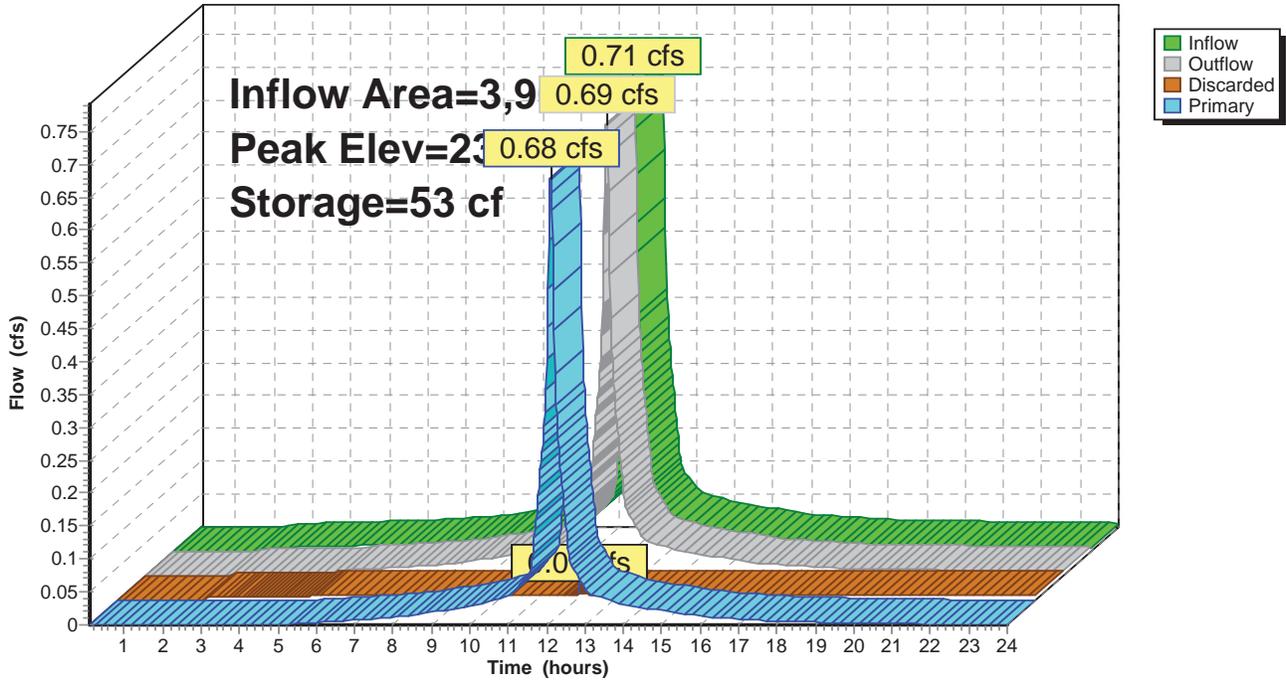
Device	Routing	Invert	Outlet Devices
#1	Primary	231.25'	6.0" Round Culvert L= 5.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 231.25' / 231.00' S= 0.0500 ' / ' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf
#2	Discarded	230.00'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'

Discarded OutFlow Max=0.01 cfs @ 12.15 hrs HW=232.46' (Free Discharge)
 ↳ **2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.67 cfs @ 12.10 hrs HW=232.35' TW=231.53' (Dynamic Tailwater)
 ↳ **1=Culvert** (Inlet Controls 0.67 cfs @ 3.43 fps)

Pond D1: Drywell

Hydrograph



***ATTACHMENT C
SOIL INFORMATION***

Boring Log B-1

Boring Log B-2

Boring Log B-1 Sieve Analysis

BORING LOG

Project: Nagog Water Treatment Plant Location: Concord, MA Client: Town of Concord Driller: Crawford Drilling Services, LLC Drilling Methods: Hollow Stem Auger, Drive and Wash Weather: 49 degrees, clear Performed By: LEU Date: 9/24/2015 Checked By: ZFK Time: 7:50 AM	Proposed Building Boring Locus Map	Boring: B-1 Location: See Plan Approx. Ground Elevation: Unknown Approx. Groundwater Elevation: Unknown Date/Time Datum: G.S. Project No. 200-1501
---	---	---

Depth (feet)	Sample No.	Blows per 6-inch	Pen./ Rec.	Soil Description		Stratum Change Depth (feet)	Note No.
1	S1	4-62-25-28	24/14	Fine SAND, brown, fragments of rock			
2							
3	S2	12-20-15-15	24/8.5	Fine SAND, brown and dark grey, fragments of rock			
4							
5							
6	S3	20-9-7-10	24/10.5	Coarse SAND with some gravel, dark brown. Isolated rock fragments			
7							
8	S4	5-6-7-7	24/10.5	Coarse SAND with some gravel, medium brown to dark grey. Isolated rock fragments			1
9							
10							
11							
12	C1	N/A	60/29	RQD = 91.4%			2
13							
14							
15							
16							
17	C2	N/A	60/23	Predominately fractured ledge. RQD = 21.7%			3
18							
19							
20				Boring terminated at BGF 19'			
21							
22							
23							
24							
25							

NOTES:

- 1 2" split spoon refusal at 9' BGS
- 2 Drive and wash 9' to 19' BGS
- 3 Lost 600 gallons of water

LEGEND

S - Split Spoon Sample	O/A - Sample Collected Off the Augers
UT - Undisturbed Tube Sample	
Trace - Approximately 0 to 10%	Some - Approximately 20 to 35%
Little - Approximately 10 to 20%	And - Approximately 35 to 50%
0-4 Coarse Soil N Value - Very Loose	11-30 Coarse Soil N Value - Medium Dense
5-10 Coarse Soil N Value - Loose	31-50 Coarse Soil N Value - Dense
0-2 Fine Soil N Value - Very Soft	4-8 Fine Soil N Value - Medium Stiff
2-4 Fine Soil N Value - Soft	8-15 Fine Soil N Value - Stiff

BORING LOG

Project: Nagog Water Treatment Plant Location: Concord, MA Client: Town of Concord Driller: Crawford Drilling Services, LLC Drilling Methods: Hollow Stem Auger Weather: 64 degrees, sunny and clear Performed By: LEU Date: 9/24/2015 Checked By: ZFK Time: 9:45 AM	Proposed Building Boring Locus Map	Boring: B-2 Location: See Plan Approx. Ground Elevation: Unknown Approx. Groundwater Elevation: Unknown Date/Time Datum: G.S. Project No. 200-1501
---	---	---

Depth (feet)	Sample No.	Blows per 6-inch	Pen./ Rec.	Soil Description	Stratum Change Depth (feet)	Note No.
1	S1	10-22-26-30	24/18	Fine SAND with some gravel, brown, medium brown to light grey, angular rock		
2						
3						
4						
5						
6						
7						
8	S2	40-80	12/10	Fine SAND, some gravel, some angular rock. Medium brown to light grey		
9						
10				Boring terminated at 9' due to split spoon refusal		Refusal
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

NOTES:

1 2" split spoon

LEGEND

S - Split Spoon Sample	O/A - Sample Collected Off the Augers
UT - Undisturbed Tube Sample	
Trace - Approximately 0 to 10%	Some - Approximately 20 to 35%
Little - Approximately 10 to 20%	And - Approximately 35 to 50%
0-4 Coarse Soil N Value - Very Loose	11-30 Coarse Soil N Value - Medium Dense
5-10 Coarse Soil N Value - Loose	31-50 Coarse Soil N Value - Dense
0-2 Fine Soil N Value - Very Soft	4-8 Fine Soil N Value - Medium Stiff
2-4 Fine Soil N Value - Soft	8-15 Fine Soil N Value - Stiff



Briggs Engineering & Testing

A DIVISION OF PK ASSOCIATES, INC.

Environmental Partners Group
1900 Crown Colony Drive
Suite 200
Quincy, MA 02169
Attn: Mr. Ziad Kary

Report Date: 11/2/15

Project: **E.P.G./Nagog Pond WWTP**
Briggs #: 24077

Tested: 10/30/15
Received: 10/22/15

1	<u>Sample No.</u> M-26570	<u>Description</u> Soil Boring	<u>Source of Material</u> B1, S3 5'-7'
---	------------------------------	-----------------------------------	---

2. Sieve Analysis {ASTM C 136, and ASTM C 117}

<u>Sieve Size</u>		<u>Results</u>	<u>Specifications</u>
<u>Standard</u>	<u>Alternate</u>	<u>{% Passing by Wt.}</u>	
100 mm	4"	100	
75 mm	3"	100	
63 mm	2-1/2"	100	
50 mm	2"	100	
37.5 mm	1-1/2"	100	
25 mm	1"	100	
19 mm	3/4"	73	
12.5 mm	1/2"	63	
9.5 mm	3/8"	57	
4.75 mm	#4	51	
2.36 mm	#8	45	
1.18 mm	#16	39	
0.600 mm	#30	31	
0.300 mm	#50	21	
0.150 mm	#100	19	
0.075 mm	#200	12.4	

BRIGGS ENGINEERING & TESTING

A Division of PK Associates, Inc.

Sean Skorohod
Director of Testing Services
Construction Technology Division

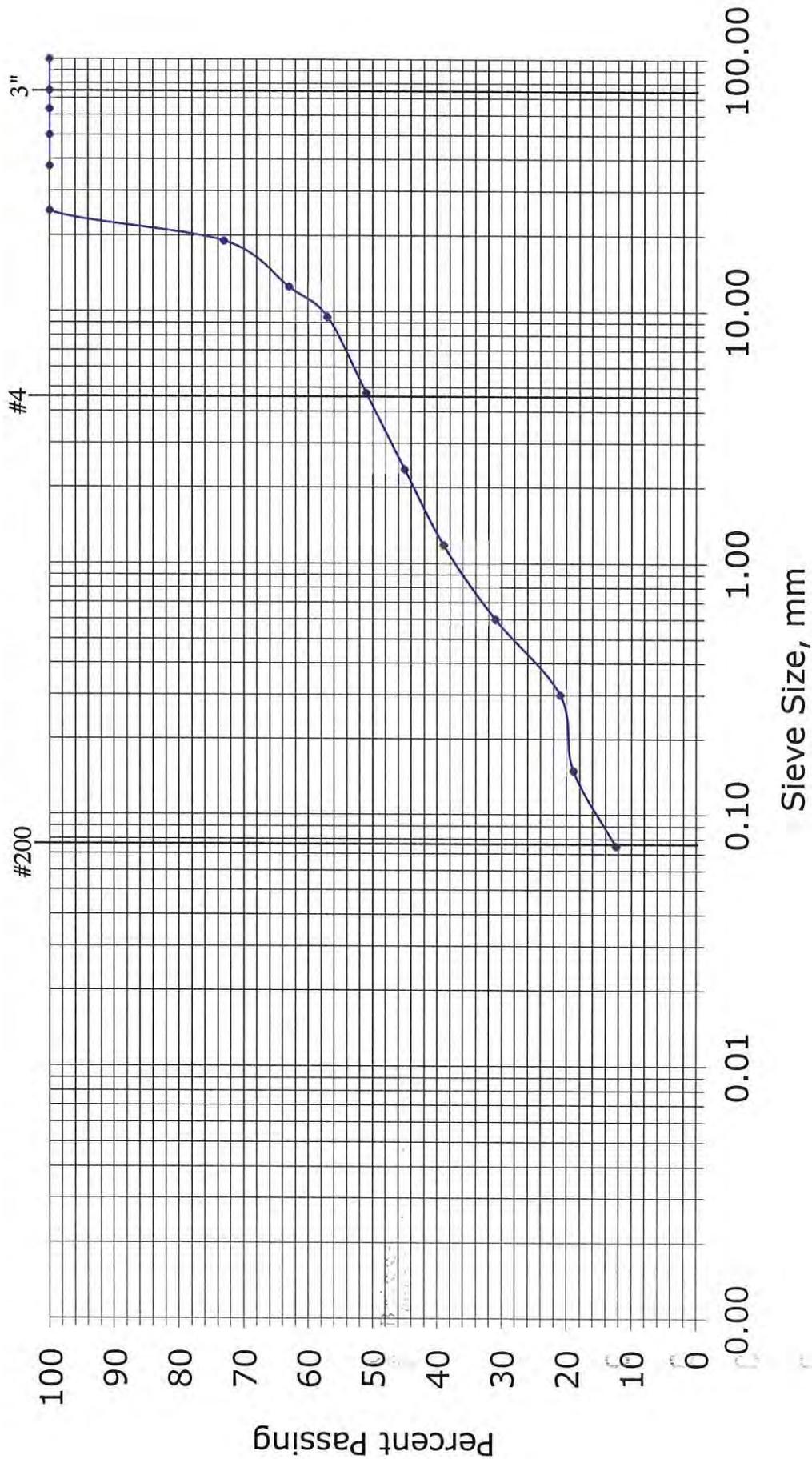
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A Division of PK Associates, Inc.

Project:	E.P.G./Nagog Pond WWTP
Date Tested:	10/30/15
Lab Ref. No.:	M-26570

Sieve Analysis



ATTACHMENT D
STANDARD 3 RECHARGE CALCULATIONS

Standard 3 Stormwater Calculations:

Required Recharge Volume:

Required Recharge Volume=Rv

Rv (cf) = F x Impervious Area (Post-Development)

NRCS HYDROLOGIC SOIL TYPE	APPROX SOIL TEXTURE	TARGET DEPTH FACTOR (F)
A	sand	0.6-inch
B	loam	0.35-inch
C	silty loam	0.25-inch
D	clay	0.1-inch

area (sf)	soil type	F (in)	F (ft)	Rv (cf)
19262.14	A	0.6	0.05	963.107
4343.524	A	0.6	0.05	217.1762
1437.48	D	0.1	0.008333	11.979
4613.726	D	0.1	0.008333	38.44772
29,656.87			Total:	1,230.71

Recharge Sizing Calcs

See HydroCAD Report of this attachment

Capture Area Adjustment:

(total site impervious area/site impervious area draining to recharge facilities)*Rv

Total Site Impervious Area (sf)= 29,656.87
 Impervious Area to Recharge (sf)= 20,730.90
 Ratio= 0.70 72%>65%, requirement satisfied
 1/Ratio= 1.43

Capture Area Adjustment (sf)=	1,760.61
--------------------------------------	-----------------

72 Hour Drawdown:

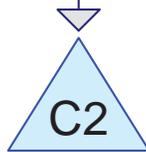
Tdrawdown=Rv/(K*bottom area)

Rv(cf)= 1,760.61	(Capture Area adjustment used)	330 XLHD Total Area	
K(in/hr)= 5.1	(Determined from sieve analysis	Area/Chamber (sf)	27.88
K(ft/hr)= 0.425	correlation using attached sieve analysis)	# of Chambers	26
A(sf)= 724.88	Surface Area of Cultec Chambers in A type soil	Total Area (sf)	724.88

Tdrawdown(hr)=	5.71
-----------------------	-------------



Required Recharge
Volume



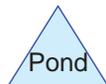
Intermediate Cultecs



Southwest Cultecs



Proposed Site Runoff



Simple Dynamic Calc

Prepared by Environmental Partners Group

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Page 2

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	C2	230.00	230.00	10.0	0.0000	0.012	8.0	0.0	0.0
2	C3	230.61	230.41	20.0	0.0100	0.012	8.0	0.0	0.0

Simple Dynamic Calc

Type III 24-hr 100 year Rainfall=8.13"

Prepared by Environmental Partners Group

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Time span=11.00-13.00 hrs, dt=0.02 hrs, 101 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 2S: Required Recharge Runoff Area=5,205 sf 100.00% Impervious Runoff Depth>4.06"
Flow Length=50' Slope=0.1300 '/' Tc=6.0 min CN=98 Runoff=0.95 cfs 1,761 cf

Reach END: Proposed Site Runoff Inflow=0.00 cfs 0 cf
Outflow=0.00 cfs 0 cf

Pond C2: Intermediate Cultecs Peak Elev=230.78' Storage=440 cf Inflow=0.95 cfs 1,761 cf
Discarded=0.07 cfs 420 cf Primary=0.76 cfs 1,011 cf Outflow=0.83 cfs 1,431 cf

Pond C3: Southwest Cultecs Peak Elev=230.55' Storage=0.015 af Inflow=0.76 cfs 1,011 cf
Discarded=0.12 cfs 463 cf Primary=0.00 cfs 0 cf Outflow=0.12 cfs 463 cf

Total Runoff Area = 5,205 sf Runoff Volume = 1,761 cf Average Runoff Depth = 4.06"
0.00% Pervious = 0 sf 100.00% Impervious = 5,205 sf

Simple Dynamic Calc

Prepared by Environmental Partners Group

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Type III 24-hr 100 year Rainfall=8.13"

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Summary for Subcatchment 2S: Required Recharge Volume

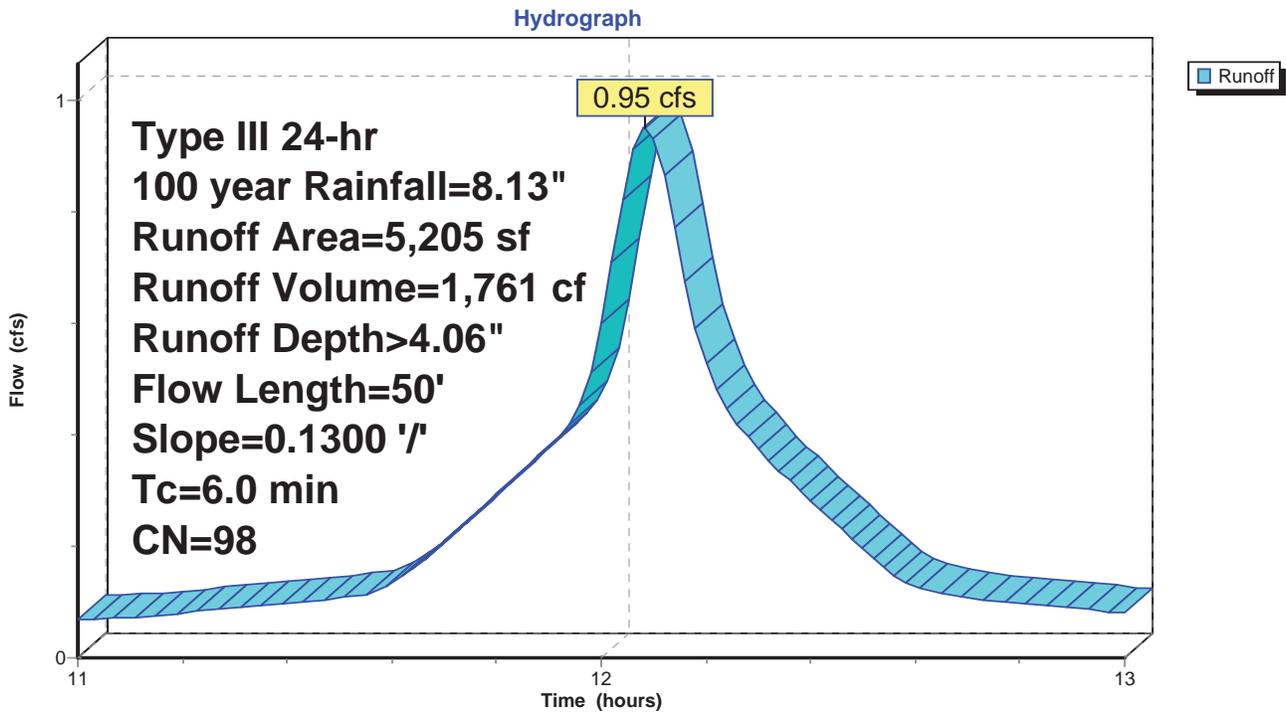
Runoff = 0.95 cfs @ 12.08 hrs, Volume= 1,761 cf, Depth> 4.06"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
Type III 24-hr 100 year Rainfall=8.13"

Area (sf)	CN	Description
5,205	98	Roofs, HSG A
5,205		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.1300	0.14		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"

Subcatchment 2S: Required Recharge Volume



Simple Dynamic Calc

Prepared by Environmental Partners Group

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Type III 24-hr 100 year Rainfall=8.13"

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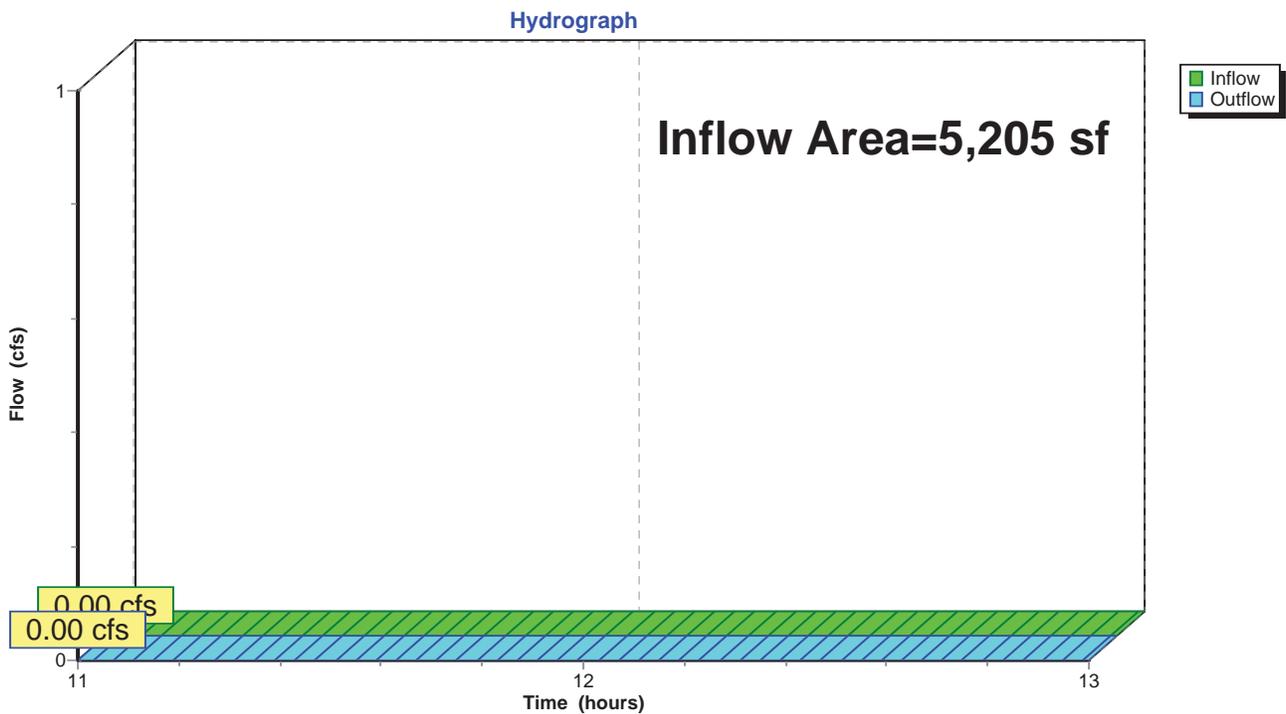
Summary for Reach END: Proposed Site Runoff

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 5,205 sf, 100.00% Impervious, Inflow Depth = 0.00" for 100 year event
Inflow = 0.00 cfs @ 11.00 hrs, Volume= 0 cf
Outflow = 0.00 cfs @ 11.00 hrs, Volume= 0 cf, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs

Reach END: Proposed Site Runoff



Simple Dynamic Calc

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Type III 24-hr 100 year Rainfall=8.13"

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Summary for Pond C2: Intermediate Cultecs

[82] Warning: Early inflow requires earlier time span

Inflow Area = 5,205 sf, 100.00% Impervious, Inflow Depth > 4.06" for 100 year event
 Inflow = 0.95 cfs @ 12.08 hrs, Volume= 1,761 cf
 Outflow = 0.83 cfs @ 12.13 hrs, Volume= 1,431 cf, Atten= 13%, Lag= 2.8 min
 Discarded = 0.07 cfs @ 12.13 hrs, Volume= 420 cf
 Primary = 0.76 cfs @ 12.13 hrs, Volume= 1,011 cf

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
 Peak Elev= 230.78' @ 12.13 hrs Surf.Area= 392 sf Storage= 440 cf
 Flood Elev= 233.94' Surf.Area= 392 sf Storage= 950 cf

Plug-Flow detention time= 14.6 min calculated for 1,416 cf (80% of inflow)
 Center-of-Mass det. time= 7.2 min (731.2 - 723.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	228.78'	447 cf	16.00'W x 24.50'L x 4.54'H Field A 1,780 cf Overall - 503 cf Embedded = 1,277 cf x 35.0% Voids
#2A	229.78'	503 cf	Cultec R-330XLHD x 9 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 3 rows
		950 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	228.78'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'
#2	Primary	230.00'	8.0" Round Culvert L= 10.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 230.00' / 230.00' S= 0.0000 1' Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.07 cfs @ 12.13 hrs HW=230.77' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.07 cfs)

Primary OutFlow Max=0.76 cfs @ 12.13 hrs HW=230.77' TW=229.92' (Dynamic Tailwater)

↑**2=Culvert** (Barrel Controls 0.76 cfs @ 2.35 fps)

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Type III 24-hr 100 year Rainfall=8.13"

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Pond C2: Intermediate Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 3 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

3 Rows x 52.0" Wide + 6.0" Spacing x 2 + 12.0" Side Stone x 2 = 16.00' Base Width

12.0" Base + 30.5" Chamber Height + 12.0" Cover = 4.54' Field Height

9 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 3 Rows = 502.9 cf Chamber Storage

1,780.3 cf Field - 502.9 cf Chambers = 1,277.4 cf Stone x 35.0% Voids = 447.1 cf Stone Storage

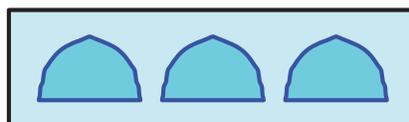
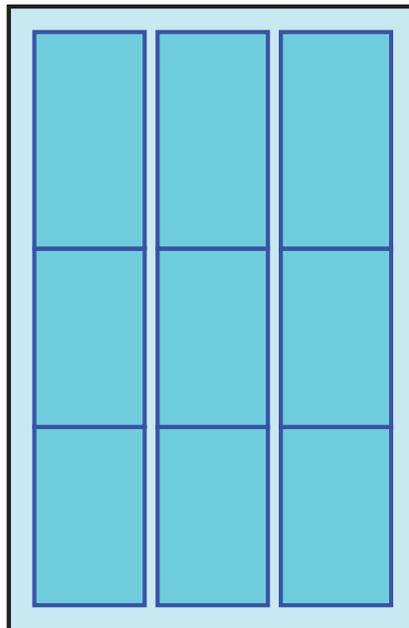
Chamber Storage + Stone Storage = 950.0 cf = 0.022 af

Overall Storage Efficiency = 53.4%

9 Chambers

65.9 cy Field

47.3 cy Stone



Simple Dynamic Calc

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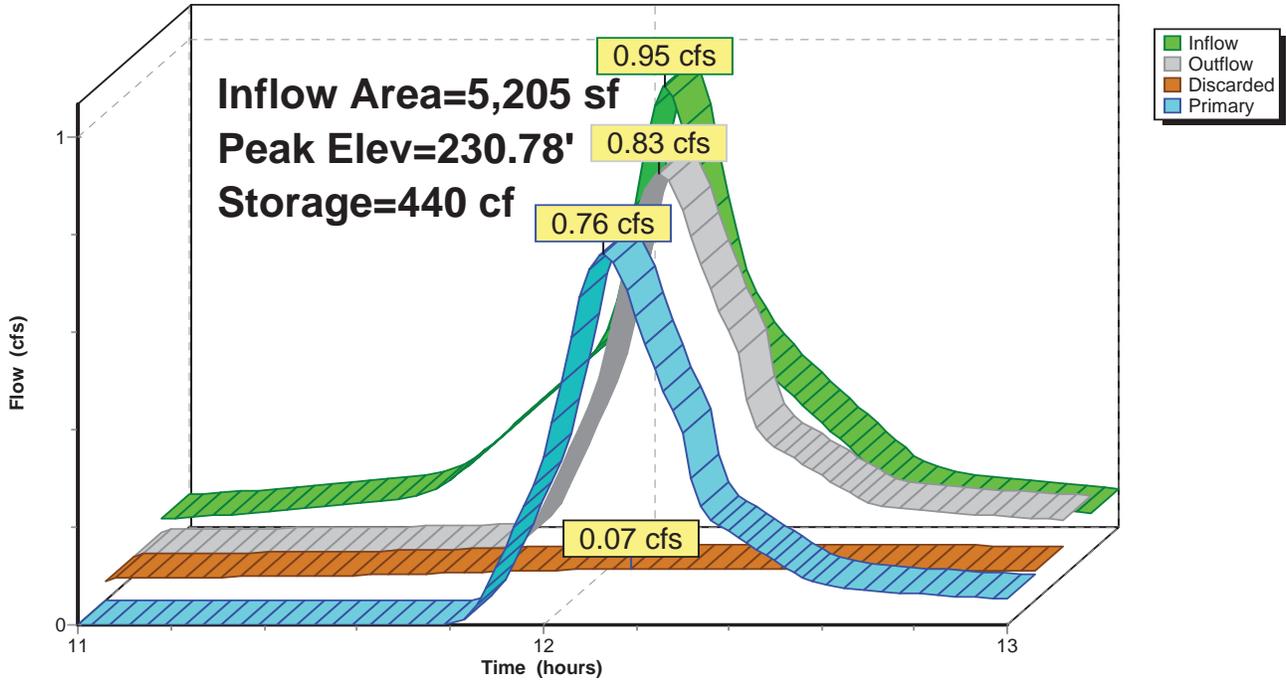
Type III 24-hr 100 year Rainfall=8.13"

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Pond C2: Intermediate Cultecs

Hydrograph



Simple Dynamic Calc

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Type III 24-hr 100 year Rainfall=8.13"

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Summary for Pond C3: Southwest Cultecs

Inflow Area = 5,205 sf, 100.00% Impervious, Inflow Depth > 2.33" for 100 year event
 Inflow = 0.76 cfs @ 12.13 hrs, Volume= 1,011 cf
 Outflow = 0.12 cfs @ 12.52 hrs, Volume= 463 cf, Atten= 84%, Lag= 23.2 min
 Discarded = 0.12 cfs @ 12.52 hrs, Volume= 463 cf
 Primary = 0.00 cfs @ 11.00 hrs, Volume= 0 cf

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
 Peak Elev= 230.55' @ 12.52 hrs Surf.Area= 0.017 ac Storage= 0.015 af

Plug-Flow detention time= 23.8 min calculated for 459 cf (45% of inflow)
 Center-of-Mass det. time= 13.4 min (747.8 - 734.3)

Volume	Invert	Avail.Storage	Storage Description
#1A	229.07'	0.003 af	6.33'W x 24.50'L x 3.71'H Field A 0.013 af Overall - 0.004 af Embedded = 0.009 af x 35.0% Voids
#2A	229.74'	0.004 af	Cultec R-330XLHD x 3 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 1 rows
#3B	229.07'	0.011 af	11.17'W x 52.50'L x 3.71'H Field B 0.050 af Overall - 0.017 af Embedded = 0.033 af x 35.0% Voids
#4B	229.74'	0.017 af	Cultec R-330XLHD x 14 Inside #3 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 2 rows
		0.036 af	Total Available Storage

Storage Group A created with Chamber Wizard
 Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	229.07'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'
#2	Primary	230.61'	8.0" Round Culvert L= 20.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 230.61' / 230.41' S= 0.0100 1/ Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.12 cfs @ 12.52 hrs HW=230.55' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.12 cfs)

Primary OutFlow Max=0.00 cfs @ 11.00 hrs HW=229.07' TW=0.00' (Dynamic Tailwater)

↑**2=Culvert** (Controls 0.00 cfs)

Simple Dynamic Calc

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Type III 24-hr 100 year Rainfall=8.13"

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Pond C3: Southwest Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 1 rows

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

1 Rows x 52.0" Wide + 12.0" Side Stone x 2 = 6.33' Base Width

8.0" Base + 30.5" Chamber Height + 6.0" Cover = 3.71' Field Height

3 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 1 Rows = 167.6 cf Chamber Storage

575.4 cf Field - 167.6 cf Chambers = 407.8 cf Stone x 35.0% Voids = 142.7 cf Stone Storage

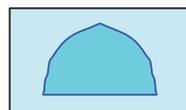
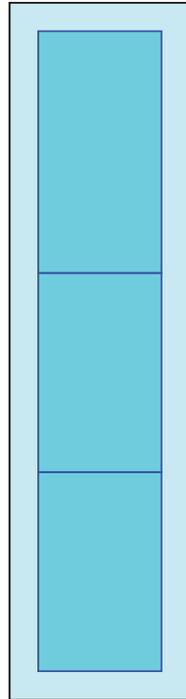
Chamber Storage + Stone Storage = 310.4 cf = 0.007 af

Overall Storage Efficiency = 53.9%

3 Chambers

21.3 cy Field

15.1 cy Stone



Simple Dynamic Calc

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Pond C3: Southwest Cultecs - Chamber Wizard Field B

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 2 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

7 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 50.50' Row Length +12.0" End Stone x 2 = 52.50' Base Length

2 Rows x 52.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.17' Base Width

8.0" Base + 30.5" Chamber Height + 6.0" Cover = 3.71' Field Height

14 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 2 Rows = 752.6 cf Chamber Storage

2,174.0 cf Field - 752.6 cf Chambers = 1,421.5 cf Stone x 35.0% Voids = 497.5 cf Stone Storage

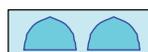
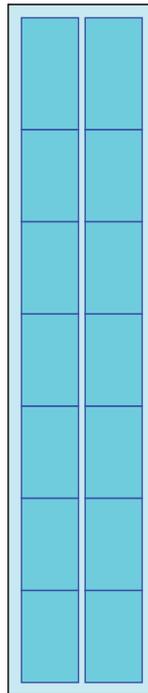
Chamber Storage + Stone Storage = 1,250.1 cf = 0.029 af

Overall Storage Efficiency = 57.5%

14 Chambers

80.5 cy Field

52.6 cy Stone



Simple Dynamic Calc

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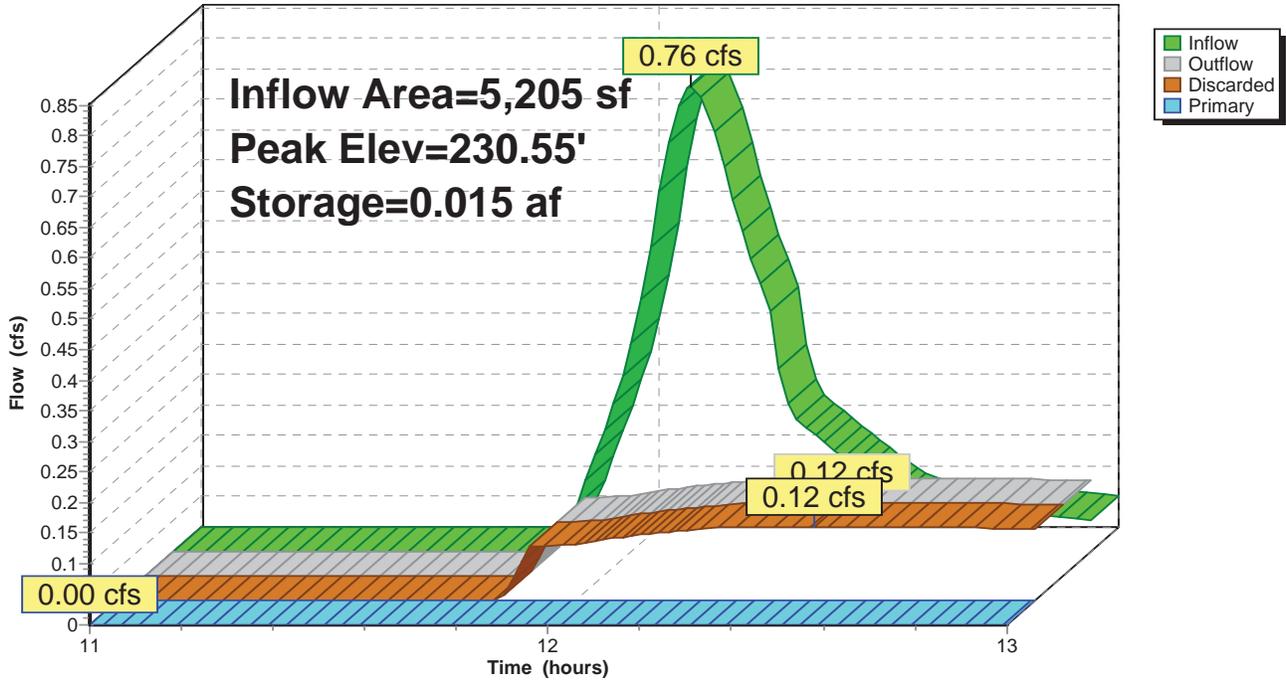
Type III 24-hr 100 year Rainfall=8.13"

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Pond C3: Southwest Cultecs

Hydrograph



ATTACHMENT E
STANDARD 4 WATER QUALITY CALCULATIONS

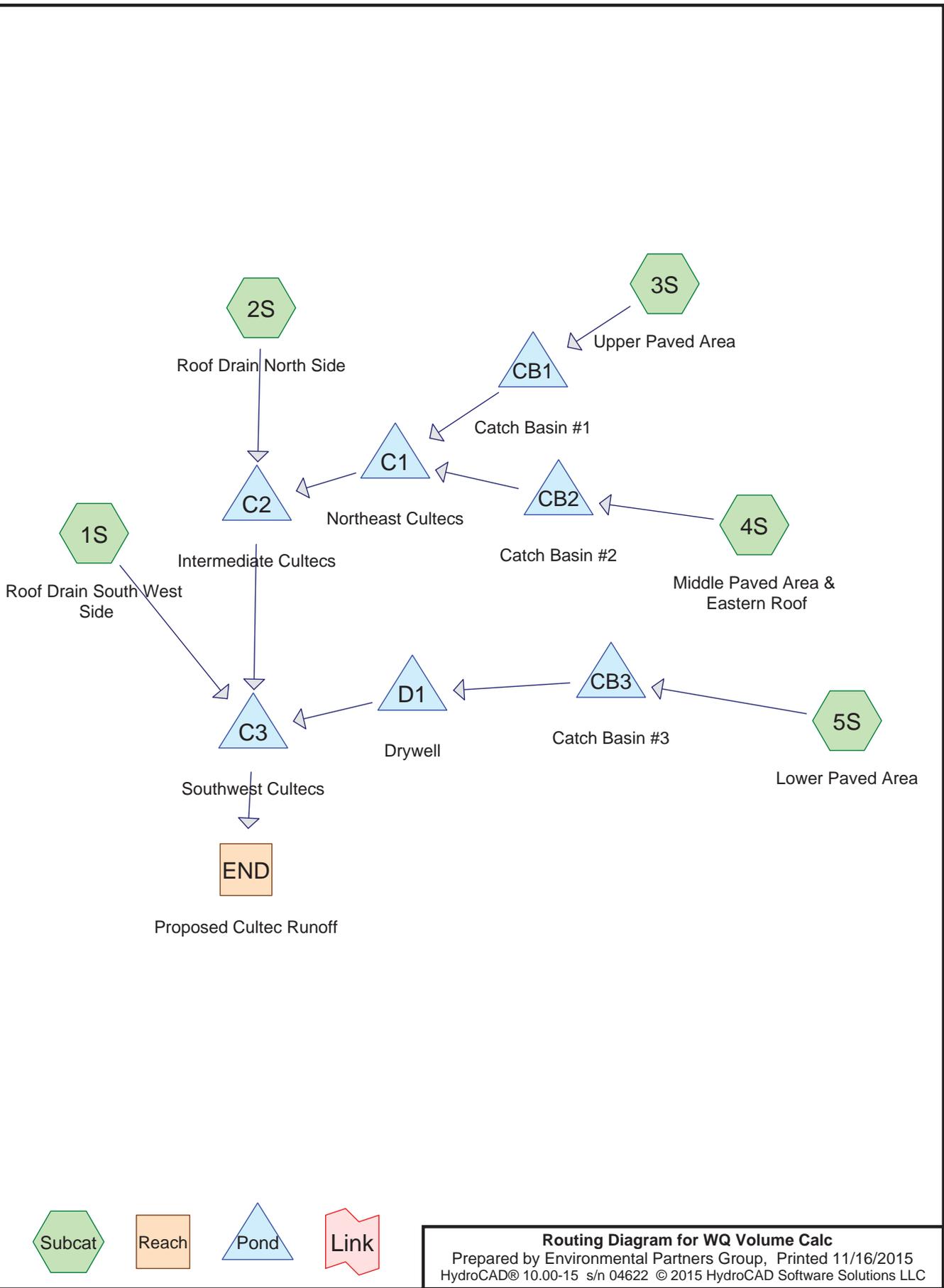
Standard 4 Stormwater Calculations:

Water Quality Treatment Volume

$V_{wq}(cf) = (1/12) * \text{impervious area}$

Imperv. Area (sf) = 29,656.87

Vwq(cf)=	2471.41
-----------------	----------------



WQ Volume Calc

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Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	C1	231.67	230.95	145.0	0.0050	0.012	4.0	0.0	0.0
2	C1	232.33	231.44	145.0	0.0061	0.012	8.0	0.0	0.0
3	C2	230.00	230.00	10.0	0.0000	0.012	8.0	0.0	0.0
4	C3	230.68	230.48	20.0	0.0100	0.012	8.0	0.0	0.0
5	CB1	232.95	231.75	20.0	0.0600	0.012	6.0	0.0	0.0
6	CB2	232.95	231.75	75.0	0.0160	0.012	6.0	0.0	0.0
7	CB3	232.95	232.38	115.0	0.0050	0.012	6.0	0.0	0.0
8	D1	231.25	231.00	5.0	0.0500	0.012	6.0	0.0	0.0

WQ Volume Calc

Type III 24-hr 2-YEAR Rainfall=3.06"

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Time span=11.00-13.00 hrs, dt=0.02 hrs, 101 points
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
 Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Roof Drain South West Runoff Area=2,749 sf 100.00% Impervious Runoff Depth>1.50"
 Flow Length=50' Slope=0.1300 '/' Tc=6.0 min CN=98 Runoff=0.19 cfs 345 cf

Subcatchment 2S: Roof Drain North Side Runoff Area=3,230 sf 100.00% Impervious Runoff Depth>1.50"
 Flow Length=50' Slope=0.1300 '/' Tc=6.0 min CN=98 Runoff=0.22 cfs 405 cf

Subcatchment 3S: Upper Paved Area Runoff Area=10,259 sf 69.83% Impervious Runoff Depth>0.93"
 Tc=6.0 min CN=85 Runoff=0.45 cfs 797 cf

Subcatchment 4S: Middle Paved Area & Runoff Area=4,232 sf 100.00% Impervious Runoff Depth>1.50"
 Tc=6.0 min CN=98 Runoff=0.29 cfs 530 cf

Subcatchment 5S: Lower Paved Area Runoff Area=3,960 sf 100.00% Impervious Runoff Depth>1.50"
 Tc=6.0 min CN=98 Runoff=0.27 cfs 496 cf

Reach END: Proposed Cultec Runoff Inflow=0.00 cfs 0 cf
 Outflow=0.00 cfs 0 cf

Pond C1: Northeast Cultecs Peak Elev=232.05' Storage=0.021 af Inflow=0.74 cfs 1,286 cf
 Discarded=0.00 cfs 0 cf Primary=0.15 cfs 433 cf Outflow=0.15 cfs 433 cf

Pond C2: Intermediate Cultecs Peak Elev=230.36' Storage=315 cf Inflow=0.25 cfs 838 cf
 Discarded=0.05 cfs 275 cf Primary=0.13 cfs 246 cf Outflow=0.18 cfs 522 cf

Pond C3: Southwest Cultecs Peak Elev=230.35' Storage=0.012 af Inflow=0.45 cfs 994 cf
 Discarded=0.09 cfs 472 cf Primary=0.00 cfs 0 cf Outflow=0.09 cfs 472 cf

Pond CB1: Catch Basin #1 Peak Elev=233.56' Storage=27 cf Inflow=0.45 cfs 797 cf
 6.0" Round Culvert n=0.012 L=20.0' S=0.0600 '/' Outflow=0.45 cfs 776 cf

Pond CB2: Catch Basin #2 Peak Elev=233.35' Storage=24 cf Inflow=0.29 cfs 530 cf
 6.0" Round Culvert n=0.012 L=75.0' S=0.0160 '/' Outflow=0.29 cfs 510 cf

Pond CB3: Catch Basin #3 Peak Elev=233.34' Storage=24 cf Inflow=0.27 cfs 496 cf
 6.0" Round Culvert n=0.012 L=115.0' S=0.0050 '/' Outflow=0.27 cfs 476 cf

Pond D1: Drywell Peak Elev=231.63' Storage=35 cf Inflow=0.27 cfs 476 cf
 Discarded=0.01 cfs 44 cf Primary=0.26 cfs 404 cf Outflow=0.27 cfs 448 cf

Total Runoff Area = 24,430 sf Runoff Volume = 2,573 cf Average Runoff Depth = 1.26"
12.67% Pervious = 3,095 sf 87.33% Impervious = 21,335 sf

WQ Volume Calc

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Type III 24-hr 2-YEAR Rainfall=3.06"

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Summary for Subcatchment 1S: Roof Drain South West Side

Runoff = 0.19 cfs @ 12.08 hrs, Volume= 345 cf, Depth> 1.50"

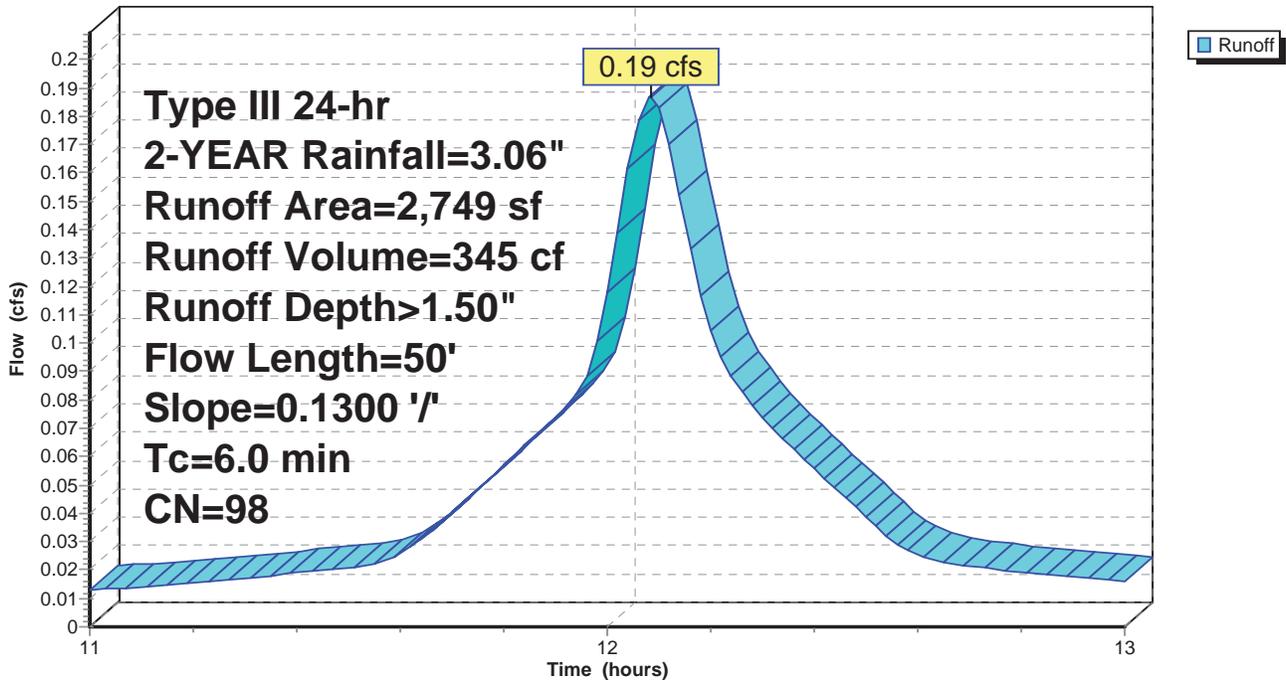
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
2,749	98	Roofs, HSG A
2,749		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.1300	0.14		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"

Subcatchment 1S: Roof Drain South West Side

Hydrograph



WQ Volume Calc

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Type III 24-hr 2-YEAR Rainfall=3.06"

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Summary for Subcatchment 2S: Roof Drain North Side

Runoff = 0.22 cfs @ 12.08 hrs, Volume= 405 cf, Depth> 1.50"

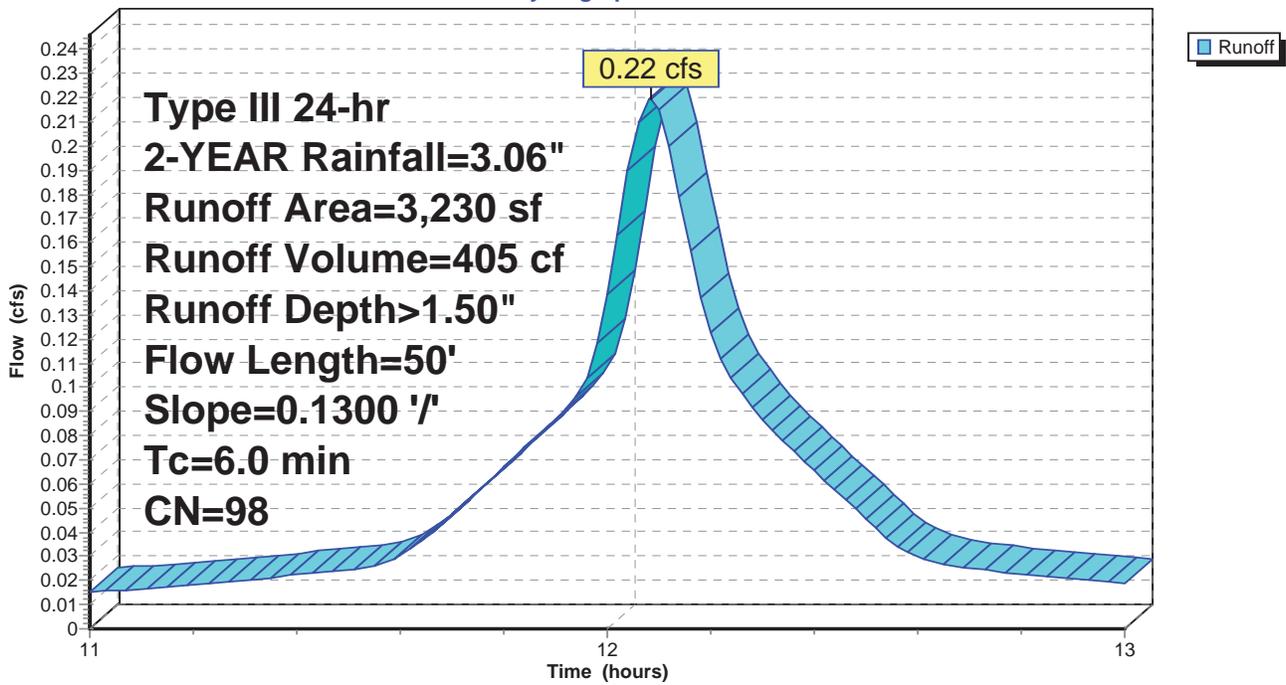
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
3,230	98	Roofs, HSG A
3,230		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	50	0.1300	0.14		Sheet Flow, sheet flow Woods: Light underbrush n= 0.400 P2= 3.06"

Subcatchment 2S: Roof Drain North Side

Hydrograph



WQ Volume Calc

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Type III 24-hr 2-YEAR Rainfall=3.06"

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Summary for Subcatchment 3S: Upper Paved Area

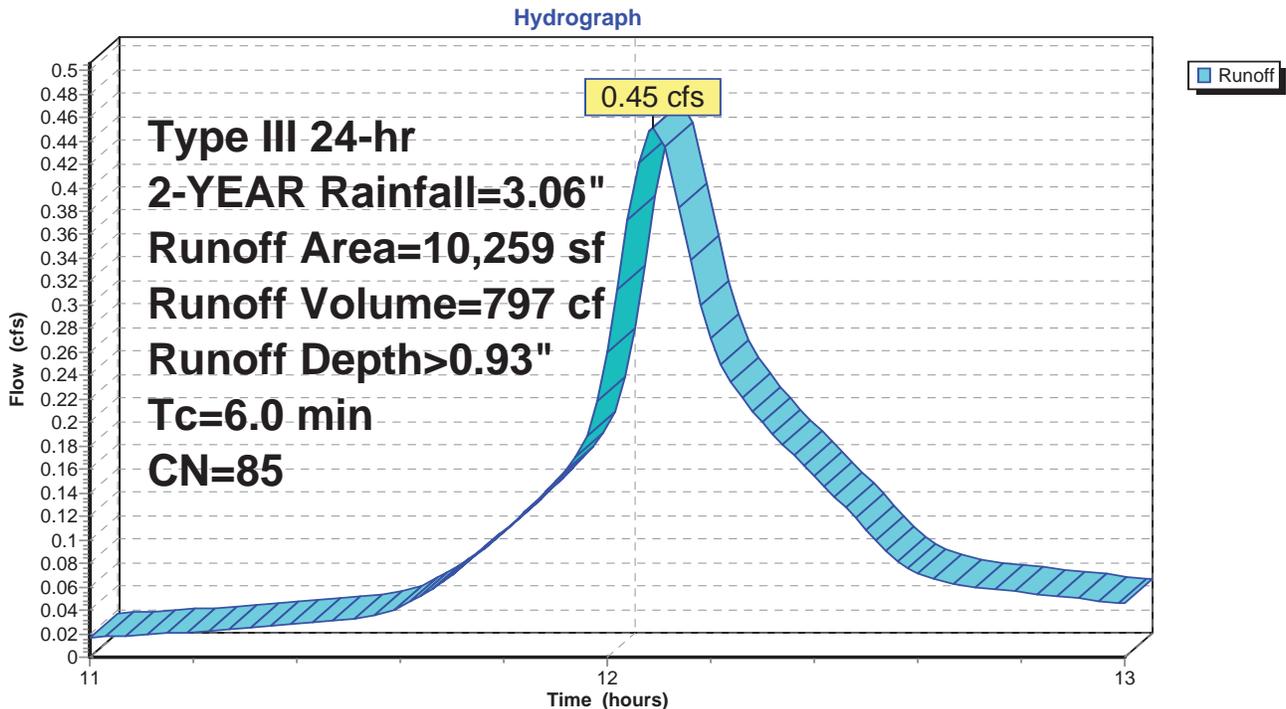
Runoff = 0.45 cfs @ 12.09 hrs, Volume= 797 cf, Depth> 0.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
7,164	98	Paved parking, HSG A
1,956	49	50-75% Grass cover, Fair, HSG A
441	49	50-75% Grass cover, Fair, HSG A
* 698	76	Gravel roads, HSG A (rip rap)
10,259	85	Weighted Average
3,095		30.17% Pervious Area
7,164		69.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 3S: Upper Paved Area



WQ Volume Calc

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Type III 24-hr 2-YEAR Rainfall=3.06"

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Summary for Subcatchment 4S: Middle Paved Area & Eastern Roof

Runoff = 0.29 cfs @ 12.08 hrs, Volume= 530 cf, Depth> 1.50"

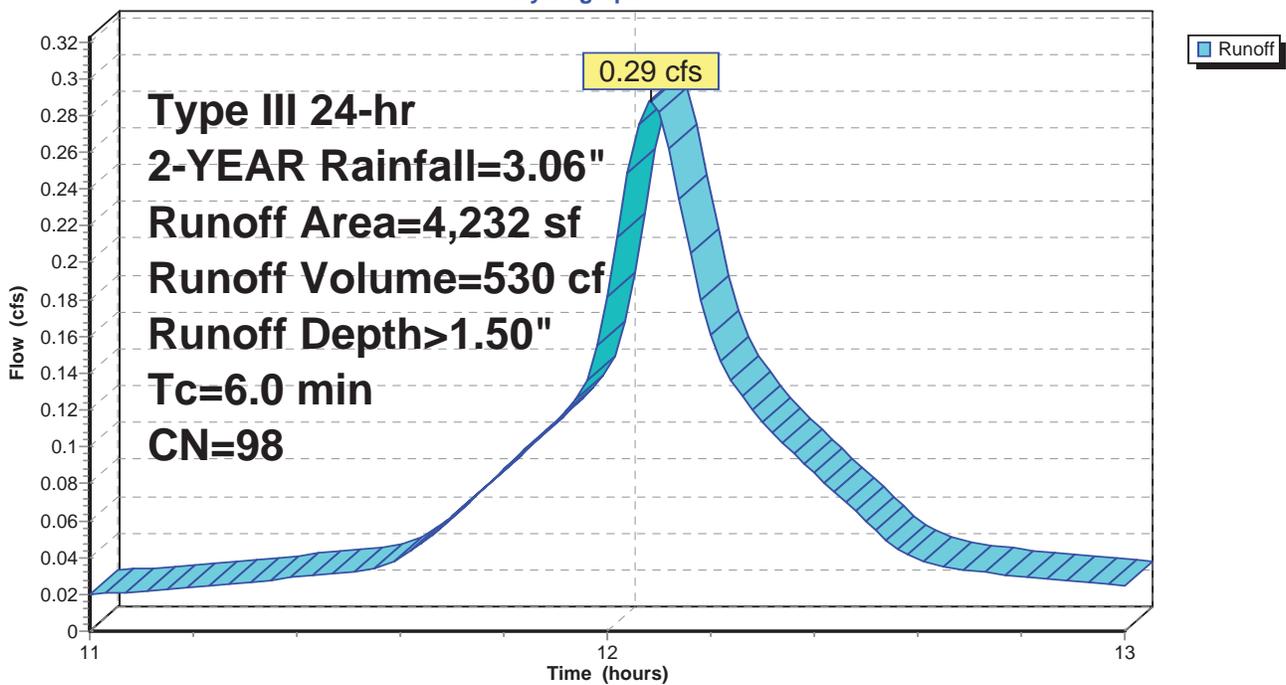
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
2,572	98	Paved parking, HSG A
1,660	98	Roofs, HSG A
4,232	98	Weighted Average
4,232		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 4S: Middle Paved Area & Eastern Roof

Hydrograph



WQ Volume Calc

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Type III 24-hr 2-YEAR Rainfall=3.06"

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Summary for Subcatchment 5S: Lower Paved Area

Runoff = 0.27 cfs @ 12.08 hrs, Volume= 496 cf, Depth> 1.50"

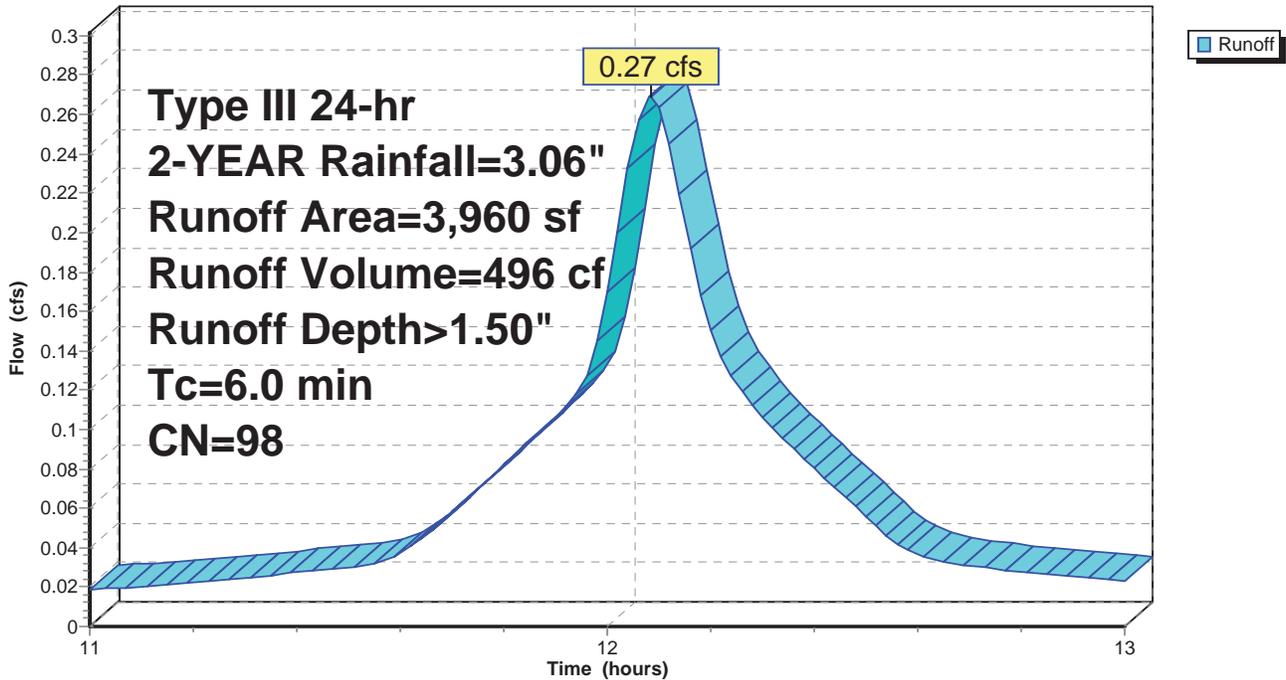
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-YEAR Rainfall=3.06"

Area (sf)	CN	Description
3,960	98	Paved parking, HSG A
3,960		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, pavement

Subcatchment 5S: Lower Paved Area

Hydrograph



WQ Volume Calc

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Type III 24-hr 2-YEAR Rainfall=3.06"

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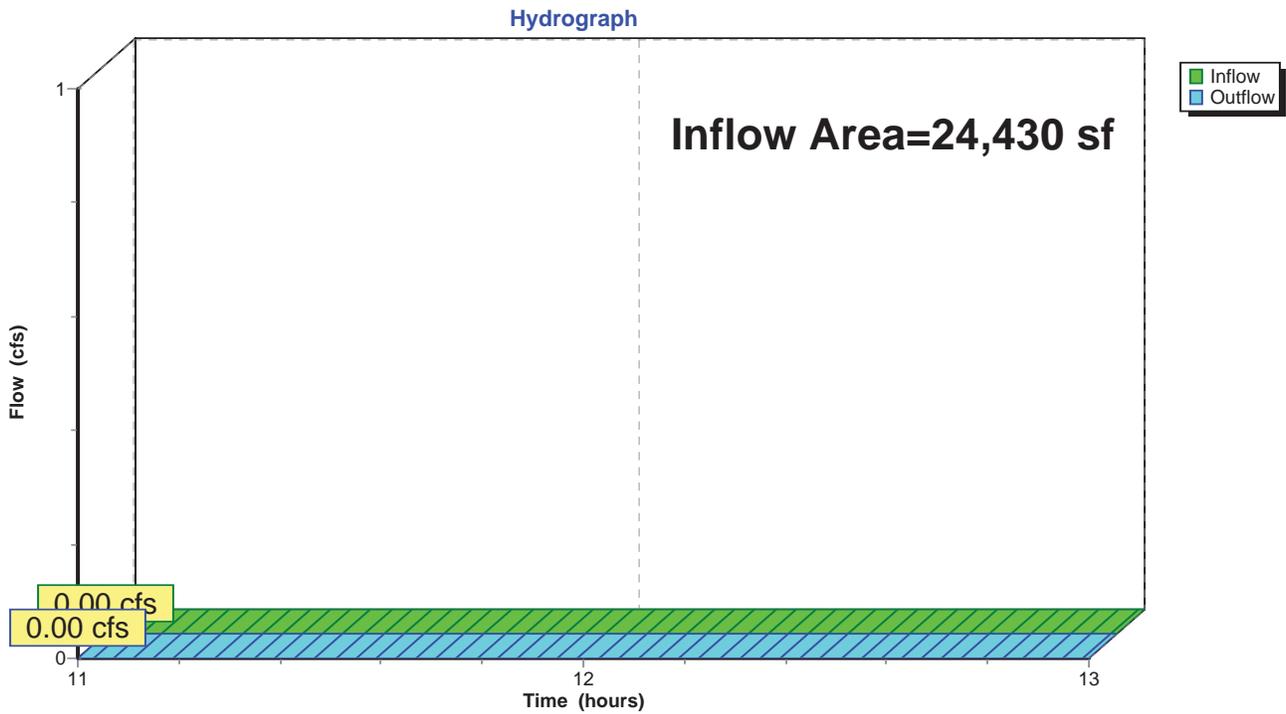
Summary for Reach END: Proposed Cultec Runoff

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 24,430 sf, 87.33% Impervious, Inflow Depth = 0.00" for 2-YEAR event
Inflow = 0.00 cfs @ 11.00 hrs, Volume= 0 cf
Outflow = 0.00 cfs @ 11.00 hrs, Volume= 0 cf, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs

Reach END: Proposed Cultec Runoff



WQ Volume Calc

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Type III 24-hr 2-YEAR Rainfall=3.06"

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Summary for Pond C1: Northeast Cultecs

Inflow Area = 14,491 sf, 78.64% Impervious, Inflow Depth > 1.07" for 2-YEAR event
 Inflow = 0.74 cfs @ 12.09 hrs, Volume= 1,286 cf
 Outflow = 0.15 cfs @ 12.53 hrs, Volume= 433 cf, Atten= 80%, Lag= 26.3 min
 Discarded = 0.00 cfs @ 11.00 hrs, Volume= 0 cf
 Primary = 0.15 cfs @ 12.53 hrs, Volume= 433 cf

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
 Peak Elev= 232.05' @ 12.53 hrs Surf.Area= 0.046 ac Storage= 0.021 af

Plug-Flow detention time= 45.9 min calculated for 429 cf (33% of inflow)
 Center-of-Mass det. time= 25.9 min (754.6 - 728.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	231.17'	0.018 af	14.50'W x 84.75'L x 2.54'H Field A 0.072 af Overall - 0.020 af Embedded = 0.052 af x 35.0% Voids
#2A	231.67'	0.020 af	Cultec R-150XLHD x 32 Inside #1 Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap Row Length Adjustment= +0.75' x 2.65 sf x 4 rows
#3B	231.17'	0.012 af	14.50'W x 54.00'L x 2.54'H Field B 0.046 af Overall - 0.013 af Embedded = 0.033 af x 35.0% Voids
#4B	231.67'	0.013 af	Cultec R-150XLHD x 20 Inside #3 Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap Row Length Adjustment= +0.75' x 2.65 sf x 4 rows
		0.062 af	Total Available Storage

Storage Group A created with Chamber Wizard
 Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	231.17'	0.090 in/hr Exfiltration X 0.00 over Surface area Phase-In= 0.01'
#2	Primary	231.67'	4.0" Round Culvert L= 145.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 231.67' / 230.95' S= 0.0050 1/' Cc= 0.900 n= 0.012, Flow Area= 0.09 sf
#3	Primary	232.33'	8.0" Round Culvert L= 145.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.33' / 231.44' S= 0.0061 1/' Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.00 cfs @ 11.00 hrs HW=231.17' (Free Discharge)
 ↳1=Exfiltration (Controls 0.00 cfs)

Primary OutFlow Max=0.15 cfs @ 12.53 hrs HW=232.05' TW=230.29' (Dynamic Tailwater)
 ↳2=Culvert (Barrel Controls 0.15 cfs @ 1.88 fps)
 ↳3=Culvert (Controls 0.00 cfs)

WQ Volume Calc

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Type III 24-hr 2-YEAR Rainfall=3.06"

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Pond C1: Northeast Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-150XLHD (Cultec Recharger® 150XLHD)

Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf

Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap

Row Length Adjustment= +0.75' x 2.65 sf x 4 rows

33.0" Wide + 6.0" Spacing = 39.0" C-C Row Spacing

8 Chambers/Row x 10.25' Long +0.75' Row Adjustment = 82.75' Row Length +12.0" End Stone x 2 = 84.75' Base Length

4 Rows x 33.0" Wide + 6.0" Spacing x 3 + 12.0" Side Stone x 2 = 14.50' Base Width

6.0" Base + 18.5" Chamber Height + 6.0" Cover = 2.54' Field Height

32 Chambers x 27.2 cf +0.75' Row Adjustment x 2.65 sf x 4 Rows = 876.8 cf Chamber Storage

3,123.4 cf Field - 876.8 cf Chambers = 2,246.6 cf Stone x 35.0% Voids = 786.3 cf Stone Storage

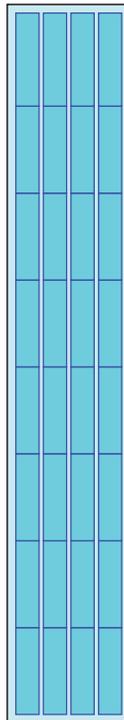
Chamber Storage + Stone Storage = 1,663.1 cf = 0.038 af

Overall Storage Efficiency = 53.2%

32 Chambers

115.7 cy Field

83.2 cy Stone



WQ Volume Calc

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Pond C1: Northeast Cultecs - Chamber Wizard Field B

Chamber Model = Cultec R-150XLHD (Cultec Recharger® 150XLHD)

Effective Size= 29.8"W x 18.0"H => 2.65 sf x 10.25'L = 27.2 cf

Overall Size= 33.0"W x 18.5"H x 11.00'L with 0.75' Overlap

Row Length Adjustment= +0.75' x 2.65 sf x 4 rows

33.0" Wide + 6.0" Spacing = 39.0" C-C Row Spacing

5 Chambers/Row x 10.25' Long +0.75' Row Adjustment = 52.00' Row Length +12.0" End Stone x 2 = 54.00' Base Length

4 Rows x 33.0" Wide + 6.0" Spacing x 3 + 12.0" Side Stone x 2 = 14.50' Base Width

6.0" Base + 18.5" Chamber Height + 6.0" Cover = 2.54' Field Height

20 Chambers x 27.2 cf +0.75' Row Adjustment x 2.65 sf x 4 Rows = 551.0 cf Chamber Storage

1,990.1 cf Field - 551.0 cf Chambers = 1,439.1 cf Stone x 35.0% Voids = 503.7 cf Stone Storage

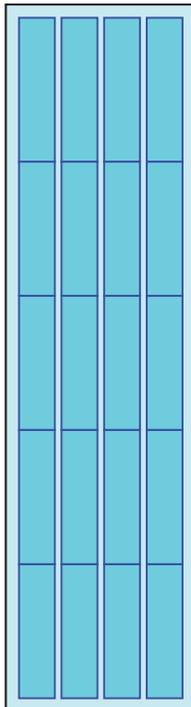
Chamber Storage + Stone Storage = 1,054.7 cf = 0.024 af

Overall Storage Efficiency = 53.0%

20 Chambers

73.7 cy Field

53.3 cy Stone



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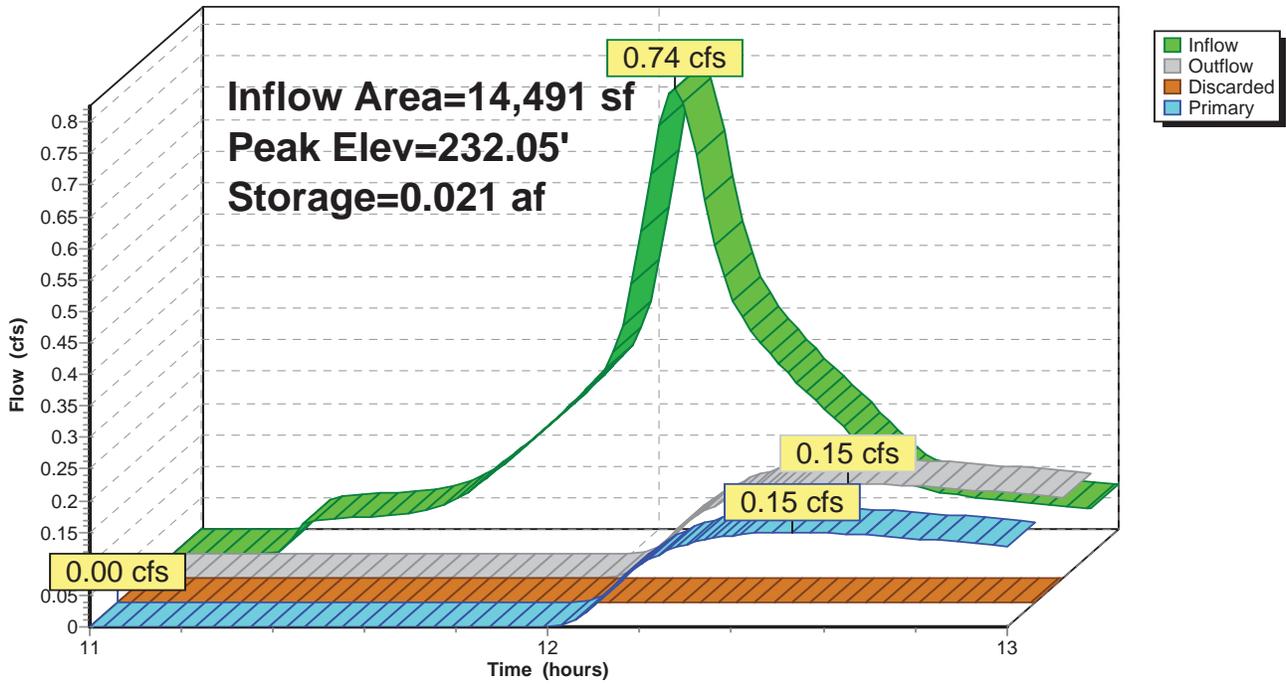
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Pond C1: Northeast Cultecs

Hydrograph



WQ Volume Calc

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Summary for Pond C2: Intermediate Cultecs

[82] Warning: Early inflow requires earlier time span

Inflow Area = 17,721 sf, 82.53% Impervious, Inflow Depth > 0.57" for 2-YEAR event
 Inflow = 0.25 cfs @ 12.11 hrs, Volume= 838 cf
 Outflow = 0.18 cfs @ 12.59 hrs, Volume= 522 cf, Atten= 28%, Lag= 28.7 min
 Discarded = 0.05 cfs @ 11.84 hrs, Volume= 275 cf
 Primary = 0.13 cfs @ 12.59 hrs, Volume= 246 cf

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
 Peak Elev= 230.36' @ 13.00 hrs Surf.Area= 392 sf Storage= 315 cf
 Flood Elev= 233.94' Surf.Area= 392 sf Storage= 950 cf

Plug-Flow detention time= 18.7 min calculated for 516 cf (62% of inflow)
 Center-of-Mass det. time= 4.1 min (744.0 - 739.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	228.78'	447 cf	16.00'W x 24.50'L x 4.54'H Field A 1,780 cf Overall - 503 cf Embedded = 1,277 cf x 35.0% Voids
#2A	229.78'	503 cf	Cultec R-330XLHD x 9 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 3 rows
		950 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	228.78'	5.100 in/hr Exfiltration over Surface area Phase-In= 0.01'
#2	Primary	230.00'	8.0" Round Culvert L= 10.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 230.00' / 230.00' S= 0.0000 1' Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.05 cfs @ 11.84 hrs HW=228.84' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=0.13 cfs @ 12.59 hrs HW=230.29' TW=230.20' (Dynamic Tailwater)

↑**2=Culvert** (Barrel Controls 0.13 cfs @ 1.34 fps)

WQ Volume Calc

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Type III 24-hr 2-YEAR Rainfall=3.06"

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Pond C2: Intermediate Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 3 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

3 Rows x 52.0" Wide + 6.0" Spacing x 2 + 12.0" Side Stone x 2 = 16.00' Base Width

12.0" Base + 30.5" Chamber Height + 12.0" Cover = 4.54' Field Height

9 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 3 Rows = 502.9 cf Chamber Storage

1,780.3 cf Field - 502.9 cf Chambers = 1,277.4 cf Stone x 35.0% Voids = 447.1 cf Stone Storage

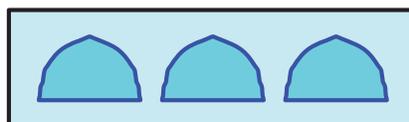
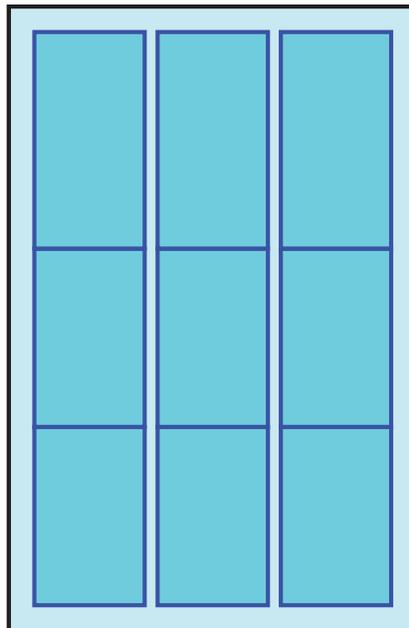
Chamber Storage + Stone Storage = 950.0 cf = 0.022 af

Overall Storage Efficiency = 53.4%

9 Chambers

65.9 cy Field

47.3 cy Stone



WQ Volume Calc

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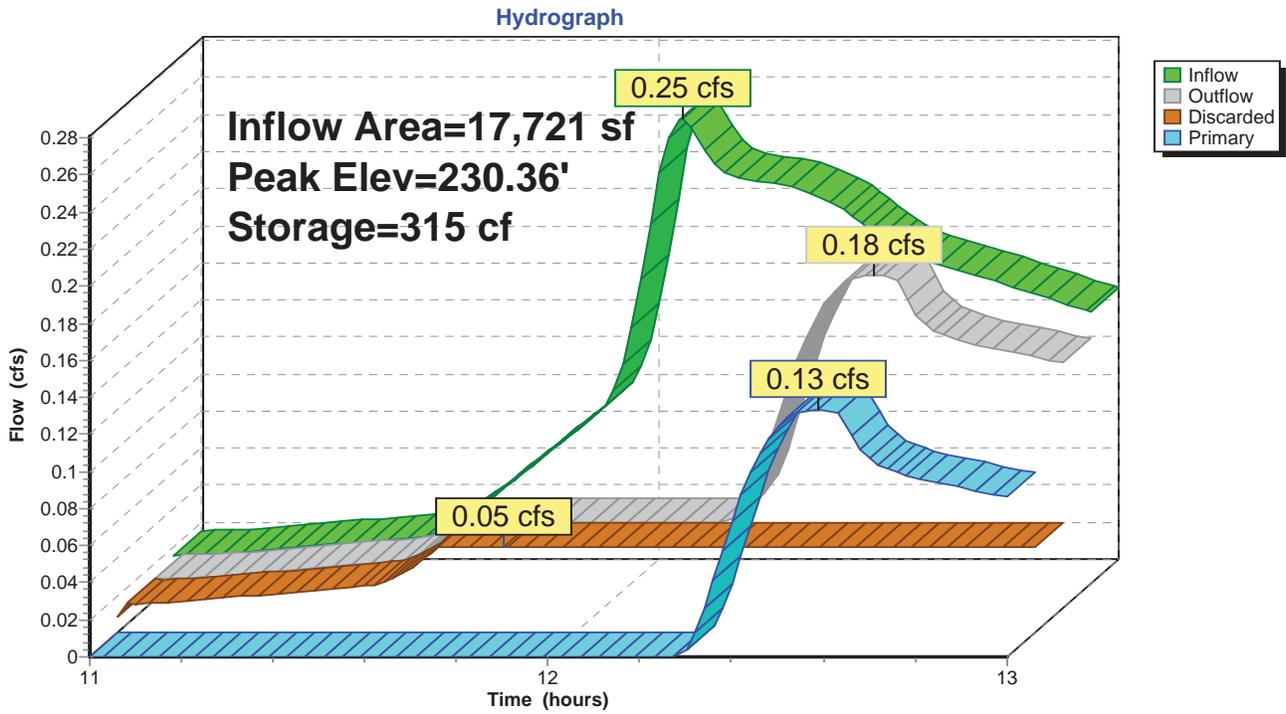
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Pond C2: Intermediate Cultecs



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Summary for Pond C3: Southwest Cultecs

When the time span is extended beyond 13 hours, the peak elevation during the 2-year storm is 230.39' at 13.5 hours. The elevation begins to decline at 13.70 hours. The peak elevation is below the culvert invert, so all water will be exfiltrated.

[82] Warning: Early inflow requires earlier time span

Inflow Area =	24,430 sf, 87.33% Impervious, Inflow Depth > 0.49" for 2-YEAR event
Inflow =	0.45 cfs @ 12.09 hrs, Volume= 994 cf
Outflow =	0.09 cfs @ 11.80 hrs, Volume= 472 cf, Atten= 80%, Lag= 0.0 min
Discarded =	0.09 cfs @ 11.80 hrs, Volume= 472 cf
Primary =	0.00 cfs @ 11.00 hrs, Volume= 0 cf

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
Peak Elev= 230.35' @ 13.00 hrs Surf.Area= 0.017 ac Storage= 0.012 af

Plug-Flow detention time= 18.4 min calculated for 467 cf (47% of inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

Volume	Invert	Avail.Storage	Storage Description
#1A	229.07'	0.003 af	6.33'W x 24.50'L x 3.71'H Field A 0.013 af Overall - 0.004 af Embedded = 0.009 af x 35.0% Voids
#2A	229.74'	0.004 af	Cultec R-330XLHD x 3 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 1 rows
#3B	229.07'	0.011 af	11.17'W x 52.50'L x 3.71'H Field B 0.050 af Overall - 0.017 af Embedded = 0.033 af x 35.0% Voids
#4B	229.74'	0.017 af	Cultec R-330XLHD x 14 Inside #3 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 2 rows
		0.036 af	Total Available Storage

Storage Group A created with Chamber Wizard

Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	229.07'	5.100 in/hr Exfiltration over Surface area Phase-In= 0.01'
#2	Primary	230.68'	8.0" Round Culvert L= 20.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 230.68' / 230.48' S= 0.0100 ' /' Cc= 0.900 n= 0.012, Flow Area= 0.35 sf

Discarded OutFlow Max=0.09 cfs @ 11.80 hrs HW=229.11' (Free Discharge)

↑1=Exfiltration (Exfiltration Controls 0.09 cfs)

Primary OutFlow Max=0.00 cfs @ 11.00 hrs HW=229.07' TW=0.00' (Dynamic Tailwater)

↑2=Culvert (Controls 0.00 cfs)

WQ Volume Calc

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Pond C3: Southwest Cultecs - Chamber Wizard Field A

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 1 rows

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

1 Rows x 52.0" Wide + 12.0" Side Stone x 2 = 6.33' Base Width

8.0" Base + 30.5" Chamber Height + 6.0" Cover = 3.71' Field Height

3 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 1 Rows = 167.6 cf Chamber Storage

575.4 cf Field - 167.6 cf Chambers = 407.8 cf Stone x 35.0% Voids = 142.7 cf Stone Storage

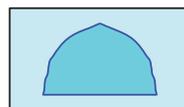
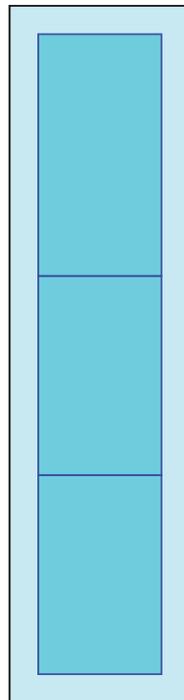
Chamber Storage + Stone Storage = 310.4 cf = 0.007 af

Overall Storage Efficiency = 53.9%

3 Chambers

21.3 cy Field

15.1 cy Stone



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Pond C3: Southwest Cultecs - Chamber Wizard Field B

Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 2 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

7 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 50.50' Row Length +12.0" End Stone x 2 = 52.50' Base Length

2 Rows x 52.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.17' Base Width

8.0" Base + 30.5" Chamber Height + 6.0" Cover = 3.71' Field Height

14 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 2 Rows = 752.6 cf Chamber Storage

2,174.0 cf Field - 752.6 cf Chambers = 1,421.5 cf Stone x 35.0% Voids = 497.5 cf Stone Storage

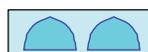
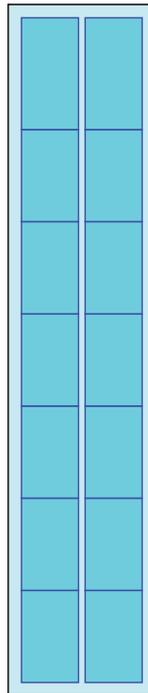
Chamber Storage + Stone Storage = 1,250.1 cf = 0.029 af

Overall Storage Efficiency = 57.5%

14 Chambers

80.5 cy Field

52.6 cy Stone



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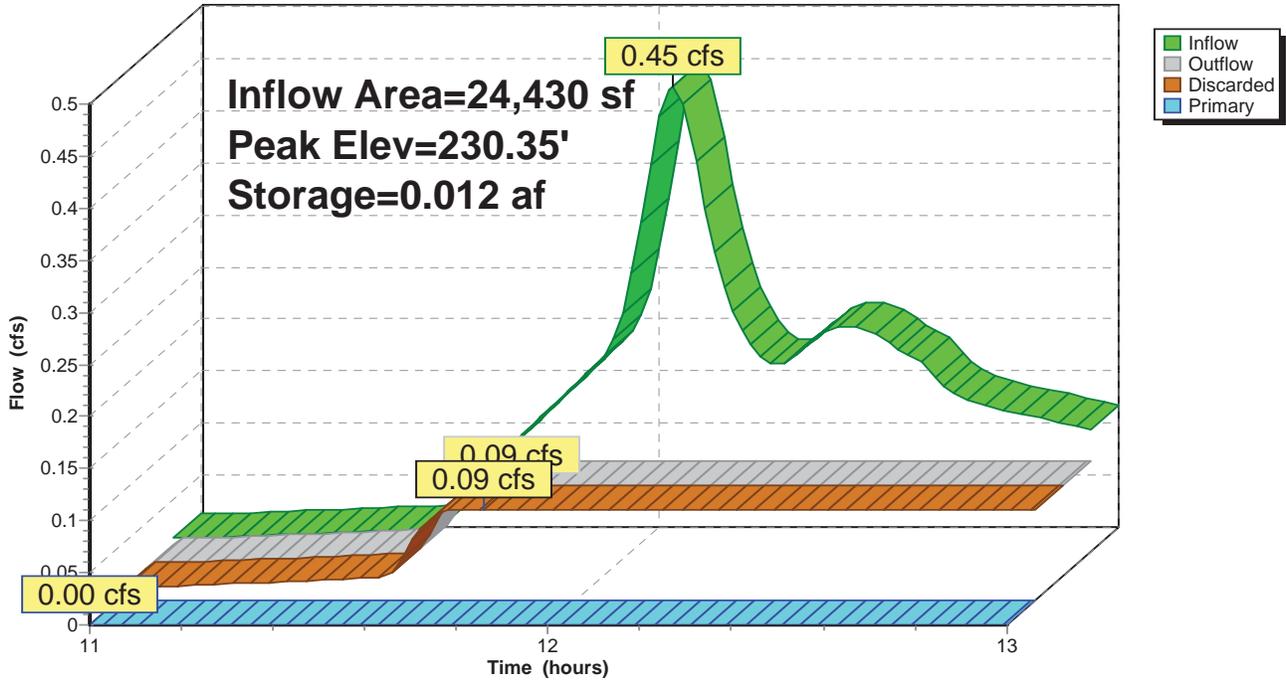
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Pond C3: Southwest Cultecs

Hydrograph



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Summary for Pond CB1: Catch Basin #1

[82] Warning: Early inflow requires earlier time span

Inflow Area = 10,259 sf, 69.83% Impervious, Inflow Depth > 0.93" for 2-YEAR event
 Inflow = 0.45 cfs @ 12.09 hrs, Volume= 797 cf
 Outflow = 0.45 cfs @ 12.10 hrs, Volume= 776 cf, Atten= 0%, Lag= 0.4 min
 Primary = 0.45 cfs @ 12.10 hrs, Volume= 776 cf

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
 Peak Elev= 233.56' @ 12.10 hrs Surf.Area= 13 sf Storage= 27 cf

Plug-Flow detention time= 3.1 min calculated for 768 cf (96% of inflow)
 Center-of-Mass det. time= 1.8 min (730.1 - 728.3)

Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	464 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	3,335	419	464

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 20.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 231.75' S= 0.0600 1' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.45 cfs @ 12.10 hrs HW=233.56' TW=231.81' (Dynamic Tailwater)
 ↑1=Culvert (Inlet Controls 0.45 cfs @ 2.28 fps)

WQ Volume Calc

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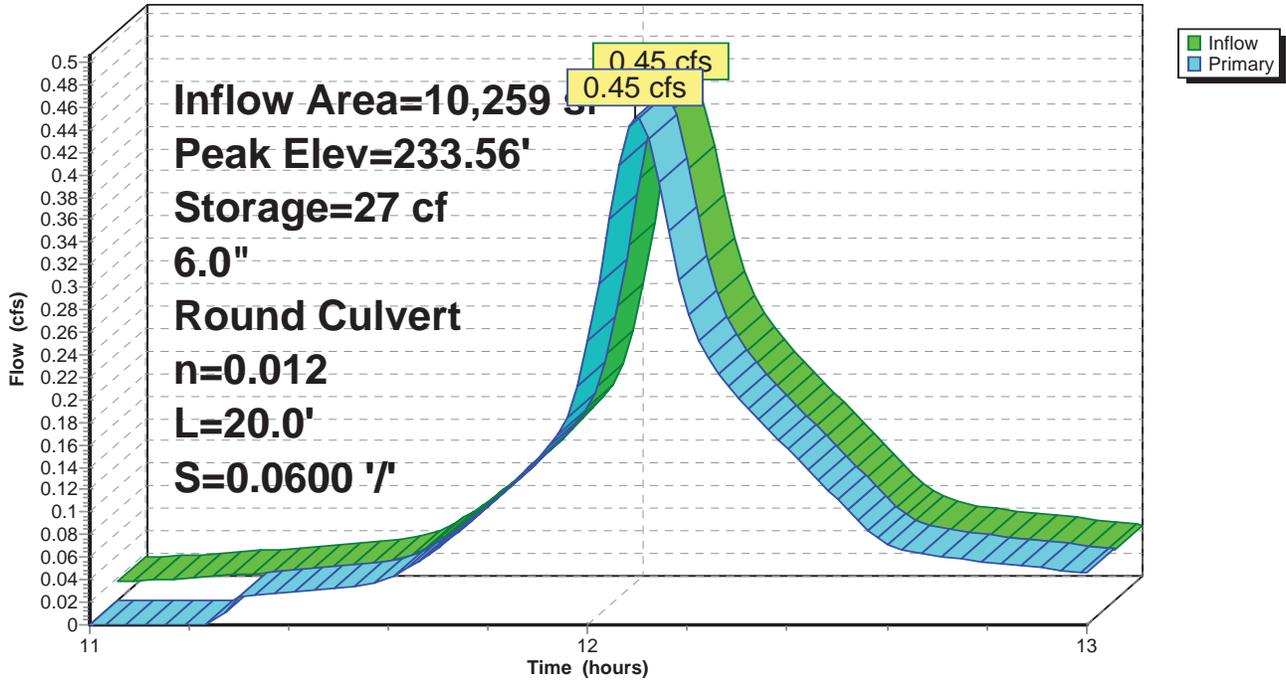
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Pond CB1: Catch Basin #1

Hydrograph



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Summary for Pond CB2: Catch Basin #2

[82] Warning: Early inflow requires earlier time span

Inflow Area = 4,232 sf, 100.00% Impervious, Inflow Depth > 1.50" for 2-YEAR event
 Inflow = 0.29 cfs @ 12.08 hrs, Volume= 530 cf
 Outflow = 0.29 cfs @ 12.09 hrs, Volume= 510 cf, Atten= 0%, Lag= 0.2 min
 Primary = 0.29 cfs @ 12.09 hrs, Volume= 510 cf

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
 Peak Elev= 233.35' @ 12.09 hrs Surf.Area= 13 sf Storage= 24 cf

Plug-Flow detention time= 4.6 min calculated for 509 cf (96% of inflow)
 Center-of-Mass det. time= 2.5 min (726.6 - 724.1)

Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	258 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	1,690	213	258

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 75.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 231.75' S= 0.0160 1' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.29 cfs @ 12.09 hrs HW=233.35' TW=231.80' (Dynamic Tailwater)
 ↑1=Culvert (Inlet Controls 0.29 cfs @ 1.70 fps)

WQ Volume Calc

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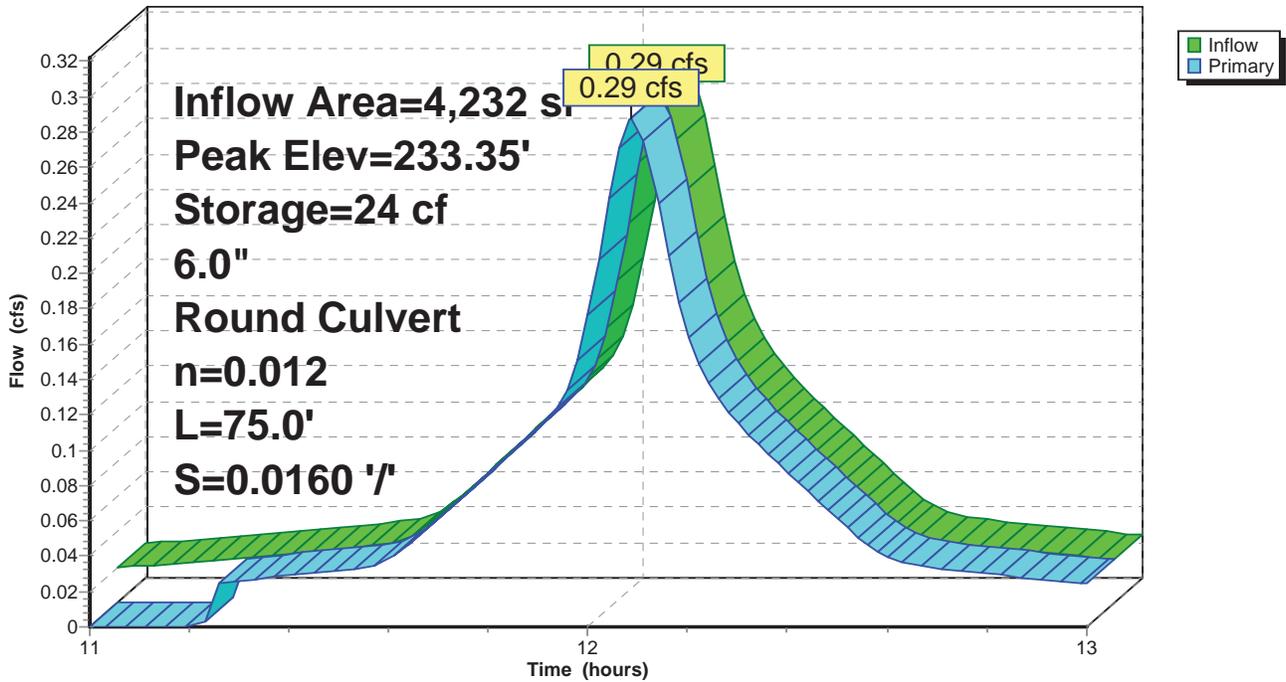
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Pond CB2: Catch Basin #2

Hydrograph



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Summary for Pond CB3: Catch Basin #3

[82] Warning: Early inflow requires earlier time span

Inflow Area = 3,960 sf, 100.00% Impervious, Inflow Depth > 1.50" for 2-YEAR event
 Inflow = 0.27 cfs @ 12.08 hrs, Volume= 496 cf
 Outflow = 0.27 cfs @ 12.09 hrs, Volume= 476 cf, Atten= 0%, Lag= 0.2 min
 Primary = 0.27 cfs @ 12.09 hrs, Volume= 476 cf

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
 Peak Elev= 233.34' @ 12.09 hrs Surf.Area= 13 sf Storage= 24 cf

Plug-Flow detention time= 4.8 min calculated for 471 cf (95% of inflow)
 Center-of-Mass det. time= 2.6 min (726.8 - 724.1)

Volume	Invert	Avail.Storage	Storage Description
#1	231.50'	293 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
231.50	13	0	0
235.00	13	46	46
235.25	1,963	247	293

Device	Routing	Invert	Outlet Devices
#1	Primary	232.95'	6.0" Round Culvert L= 115.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 232.95' / 232.38' S= 0.0050 1' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf

Primary OutFlow Max=0.27 cfs @ 12.09 hrs HW=233.34' TW=231.62' (Dynamic Tailwater)
 ↑1=Culvert (Barrel Controls 0.27 cfs @ 2.22 fps)

WQ Volume Calc

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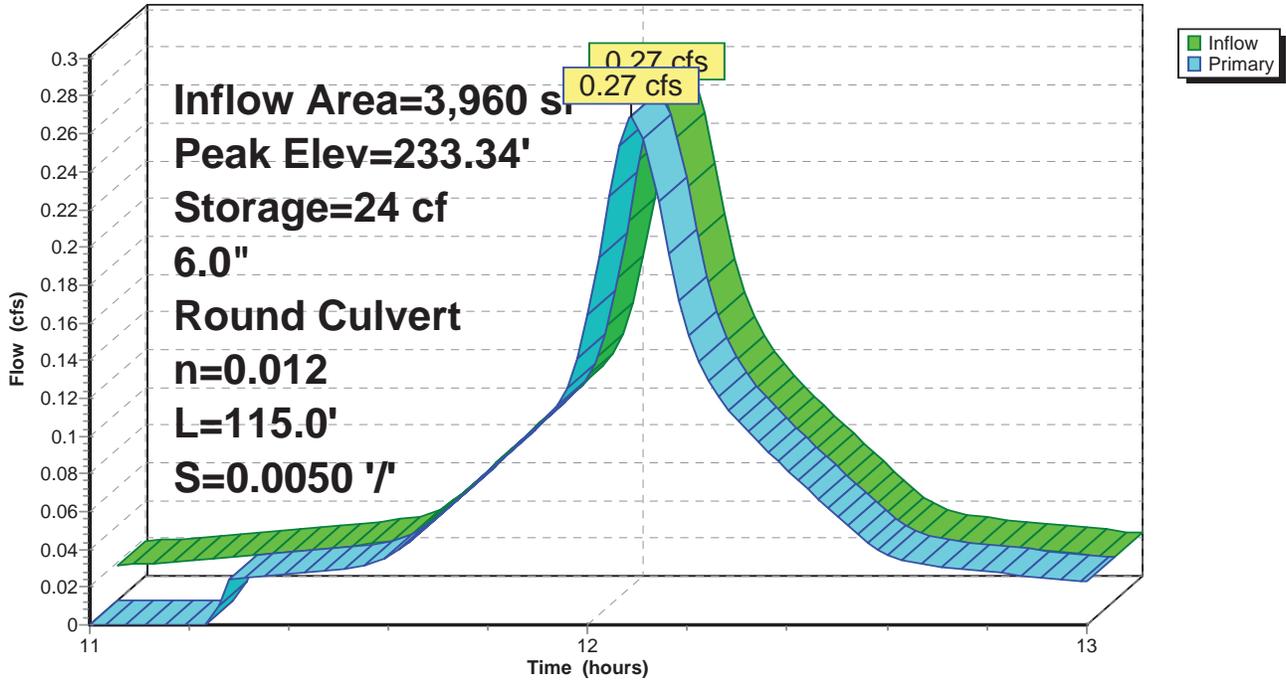
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Pond CB3: Catch Basin #3

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Type III 24-hr 2-YEAR Rainfall=3.06"

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Summary for Pond D1: Drywell

Inflow Area = 3,960 sf, 100.00% Impervious, Inflow Depth > 1.44" for 2-YEAR event
 Inflow = 0.27 cfs @ 12.09 hrs, Volume= 476 cf
 Outflow = 0.27 cfs @ 12.09 hrs, Volume= 448 cf, Atten= 0%, Lag= 0.4 min
 Discarded = 0.01 cfs @ 12.09 hrs, Volume= 44 cf
 Primary = 0.26 cfs @ 12.09 hrs, Volume= 404 cf

Routing by Dyn-Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.02 hrs
 Peak Elev= 231.63' @ 12.09 hrs Surf.Area= 33 sf Storage= 35 cf

Plug-Flow detention time= 5.7 min calculated for 448 cf (94% of inflow)
 Center-of-Mass det. time= 2.9 min (729.7 - 726.8)

Volume	Invert	Avail.Storage	Storage Description
#1	230.00'	98 cf	5.00'D x 5.00'H Vertical Cone/Cylinder Inside #2 141 cf Overall - 6.0" Wall Thickness = 98 cf
#2	230.00'	9 cf	6.50'D x 5.00'H Vertical Cone/Cylinder 166 cf Overall - 141 cf Embedded = 25 cf x 35.0% Voids
		107 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	231.25'	6.0" Round Culvert L= 5.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 231.25' / 231.00' S= 0.0500 1' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf
#2	Discarded	230.00'	5.100 in/hr Exfiltration over Wetted area Phase-In= 0.01'

Discarded OutFlow Max=0.01 cfs @ 12.09 hrs HW=231.62' (Free Discharge)
 ↳ **2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.26 cfs @ 12.09 hrs HW=231.62' TW=229.72' (Dynamic Tailwater)
 ↳ **1=Culvert** (Inlet Controls 0.26 cfs @ 1.64 fps)

WQ Volume Calc

Prepared by Environmental Partners Group

HydroCAD® 10.00-15 s/n 04622 © 2015 HydroCAD Software Solutions LLC

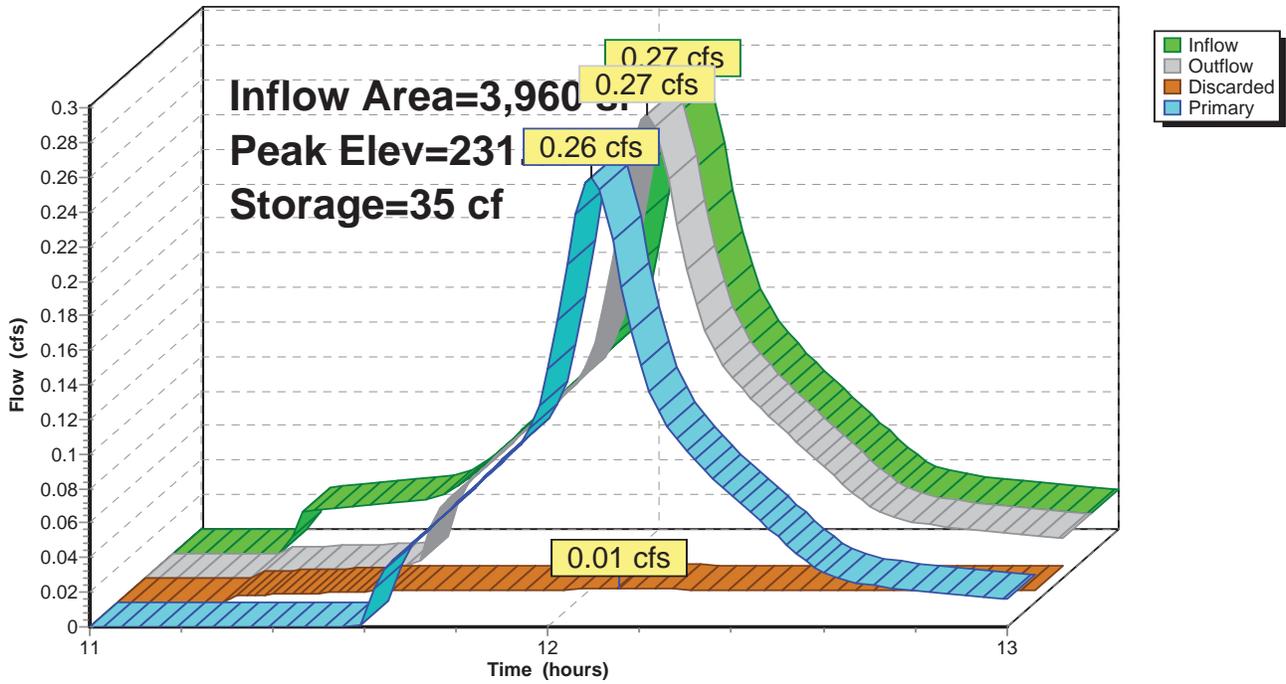
Type III 24-hr 2-YEAR Rainfall=3.06"

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Pond D1: Drywell

Hydrograph



ATTACHMENT F
LONG TERM POLLUTION PREVENTION PLAN AND
OPERATIONS AND MAINTENANCE PLAN

LONG TERM POLLUTION PREVENTION PLAN

1. Long Term Pollution Prevention Plan

This Long Term Pollution Prevention Plan (LTPPP) was prepared in accordance with Standard 4 of the Massachusetts Stormwater Management Handbook, the Massachusetts Department of Environmental Protection Stormwater Management Policy and the Massachusetts Wetlands Protection regulations (310 CMR 10.00). This LTPPP was prepared to address long term pollution prevention measures at the Nagog Pond Water Treatment Plant to be located at 180 Skyline Drive in Acton, Massachusetts (Site Locus, Attachment 1, Appendix B).

Good Housekeeping Practices

All chemicals will be stored inside. All treatment plant operators/employees will be instructed in the importance of not spilling fluids and chemicals onto the ground. All areas in the immediate vicinity of the treatment plant will be kept clean of excess debris.

Storing Materials and Waste Products

All chemicals and treatment process waste will be stored in adequately sized containers within the treatment plant. All treatment waste products will be disposed of in a legal manner at a state licensed recycling center or landfill. General trash generated by treatment plant personnel will be collected in standard trash barrels and disposed of at the public waste facility.

Vehicle Washing

Due to the nature of the site, very few vehicles will be accessing the site on a daily basis. Vehicle washing will not be allowed on the property to limit any potential contamination.

Routine Inspections and Maintenance of Stormwater BMPs

Refer to Stormwater Operation and Maintenance Plan within this Appendix.

Spill Prevention

The following measures will be taken at all loading/ unloading areas:

1. A significant amount of debris can accumulate outside uncovered loading/unloading areas. Sweep these surfaces frequently to remove material that could otherwise be washed off by stormwater. Sweep outside areas that are covered for a period of time by containers, logs, or other material after the areas are cleared.
2. Place drip pans, or other appropriate temporary containment device, at locations where leaks or spills may occur, such as hose connections, hose reels and filler

nozzles. Always use drip pans when making and breaking connections. Check loading and unloading equipment such as valves, pumps, flanges, and connections regularly for leaks and repair as needed.

Maintenance of Lawns, Gardens, and Other Landscaped Areas

A special wetland mix has been selected for the lawn area that will be under the PV array that will only require mowing on a biannual basis. The remaining landscaped area will be trimmed and maintained on an as needed basis. Any loose vegetation created from maintenance will be disposed of offsite.

Pet Waste Management

The proposed fencing is designed to limit pedestrian access to the site and surrounding areas, so pet waste is not expected to be a concern.

Proper Management of Deicing Chemicals

Any deicing chemicals, such as road salt, will be stored inside.

***STORMWATER MANAGEMENT
OPERATION AND MAINTENANCE PLAN***

1. Introduction

This Stormwater Management Operations and Maintenance Plan (O&M Plan) was prepared in accordance with Standard 9 of the Massachusetts Stormwater Management Handbook, the Massachusetts Department of Environmental Protection Stormwater Management Policy and the Massachusetts Wetlands Protection regulations (310 CMR 10.00). This O&M Plan was prepared for the stormwater management system proposed for the Nagog Pond Water Treatment Plant to be located at 180 Skyline Drive in Acton, Massachusetts (Site Locus, Attachment 1, Appendix B). This O&M plan addresses both construction and post-development stormwater management. The proposed construction stormwater management system is shown on the Erosion Control Plans (Sheets C-4 and C-8 of Appendix C). The proposed post-development stormwater management system is shown on the WTP and Solar Array Grading and Drainage Plan (Sheet C-11 of Appendix C). The construction details for typical construction and the proposed post-development stormwater management system are provided within Appendix C (Sheets CD-1 through CD-7).

This O&M Plan serves to identify the following:

- The Owner of the stormwater management system at the Nagog Pond Water Treatment Plant;
- The party responsible for the operation and maintenance of the stormwater management systems;
- The typical/proposed components of both systems;
- The construction details of both systems;
- The routine and non-routine maintenance tasks to be undertaken;
- A schedule for inspection and maintenance of both systems; and
- An inspection and maintenance log template.

2. Ownership and Operation/Maintenance

The Nagog Pond Water Treatment Plant and its stormwater management system will be located on the southeast portion of a 56 acre parcel owned by the Town of Concord. The parcel is partially developed with the existing Nagog Pond Water Treatment Plant and its ancillary facilities, and partially forested. The existing treatment facility and proposed treatment facility will be operated by the Town of Concord's Water Department, which is a division of the Concord Department of Public Works. Therefore, the Town of Concord is identified as the Owner of the proposed post-development stormwater management system for the Nagog Pond Water Treatment Plant. A General Contractor selected through the public bidding process will be responsible for the operation and maintenance of the construction stormwater management system throughout the construction of the new treatment facility, PV Array, and raw water intake. The Water Department will be charged with the operation and maintenance responsibilities for the proposed post-development stormwater management system.

3. Description of the Proposed Construction Stormwater Management System

The goal of the proposed construction stormwater management system is to prevent off-site (i.e. Nagog Pond, wetlands) migration of stormwater pollution and/or soil erosion. Generally, the means of accomplishing this goal are achieved through proper planning, soil stabilization, runoff control and sediment control.

Prior to the start of construction, a system of straw wattles will be installed between the limits of work and the sensitive resource areas (i.e., Nagog Pond and wetlands). During construction, efforts should be made to maximize the preservation of natural vegetation within the limits of work and to minimize the amount of disturbed area. Dust control activities should be implemented to prevent the aerial transport of dust off-site. During clearing, grading, and excavation operations, temporary stormwater runoff diversions should be constructed to divert flow away from sensitive receptors. The stormwater diversions should incorporate sediment traps/barriers and inlet/outlet protection. Stockpiled aggregate materials should be stabilized (poly-sheeting, temporary seeding, etc.) and protected with sediment trap/barriers. The proposed construction stormwater management system is shown on the Erosion Control Plans (Sheets C-4 and C-8 of Appendix C). Typical construction details are shown on the Sheets CD-1 through CD-7 of Appendix C.

The construction Stormwater Pollution Prevention Plan will be defined in greater detail in the Contractor's erosion and sediment control plan, which will also account for conditions detailed in the Town of Acton's Conservation Commission Order of Conditions.

4. Description of the Proposed Post-Development Stormwater Management System

The proposed post-development stormwater management system is comprised of storm drains with deep sump catch basins, HDPE drainage pipe, R-150XLHD and R-330XLHD Cultec chambers, a dry well, and improved use of an existing rip rap swale. The proposed post-development Stormwater Management system is shown on the WTP and Solar Array Grading and Drainage Plan (Sheet C-11 of Appendix C) and typical construction details are provided on the construction detail sheets of Appendix C.

Storm Drains and Deep Sump Catch Basins

Storm drains with deep sump catch basins will be installed for pretreatment of stormwater runoff. Storm drains will be installed in the paved driveways and parking areas of the new facility. Two storm drains will be located on the eastern side of the facility and one will be located on the southern side of the facility. The storm drains will receive storm water runoff from the paved areas, which will be sloped to convey sheet flow towards the drains. The drains will be comprised of removable grated covers overlying deep sump catch basins. The deep sump catch basins are designed to remove trash, debris, sediment, and oil and grease. Stormwater flow will enter the catch basin through the grated cover and then flow through the inverted opening of a drain pipe, which either connects to a drywell or Cultec structure.

Cultec Chambers

Model R-150 XLHD and R-330 XLHD Cultec Chambers, as manufactured by CULTEC, Inc., will be installed for infiltration and detention of stormwater runoff. Three sets of clusters will be installed, with one set installed to the east of the proposed treatment plant and two installed to the west of the proposed treatment plant. The cluster to the east will consist of 52 Cultec R-150XLHD chambers, the cluster to the northwest will consist of 9 Cultec R-330 XLHD chambers, and the cluster to the immediate west will consist of 17 Cultec R-330 XLHD chambers. All clusters will be interconnected, with the cluster to the east connecting to the cluster in the northwest with an 8" and 4" HDPE drain pipe, followed by the cluster to the northwest connecting to the cluster in the west with a 6" HDPE drain pipe. The final cluster located in the west will be equipped with an overflow directed towards the wetlands.

Drywell

A drywell will be installed to the southwest of the proposed facility to provide additional infiltration detention time for runoff flowing to the southernmost catch basin. The drywell will connect the southernmost catch basin to the cultec chamber cluster in the west, while also serving as a means to increase detention time and provide some pre-infiltration before the runoff reaches the cultec cluster.

Existing Rip Rap Swale

The existing rip rap swale runs parallel to the existing access road a few feet to the east. The eastern limits of the proposed access road will extend to the top of the existing swale to increase the amount of runoff that is diverted to the rip rap swale. The swale has a high point in the same location as the proposed access road, so all runoff from the swale that is north of the highpoint will be directed to the proposed deep sump catch basins, while the runoff from the swale on the south side of the high point will be directed to an existing catch basin at the bottom of the access road. In addition to increasing the runoff directed to the swale, the proposed maintenance and inspection activities aim to improve the existing swale to ensure that it functions as efficiently as possible at all times by means of continuous upkeep.

5. Maintenance and Inspection Activities

Construction Stormwater Management System

During the course of the construction phase of the project, the Town's General Contractor shall be responsible for the maintenance and inspection of the stormwater management system and erosion and sediment controls.

The Town's General Contractor shall conduct weekly inspections of the stormwater management system and erosion/sediment controls for stability and operation. In addition to the weekly inspections, the General Contractor shall inspect the stormwater system and controls within 24-hours of any runoff producing precipitation event. Any needed repairs will be made immediately to maintain barriers and controls.

Maintenance will include:

- Removing built up sediment at sediment traps and sediment barriers;
- Repairing straw wattle that become damaged or displaced;
- Remove built up sediment at truck tracking pads and wheel wash stations;
- Clean or replace gravel/stone when the sediment traps and/or truck pads/washes no longer drain properly;
- Maintain stormwater diversions to control stormwater flow and limit erosion;
- Identify and address locations of stormwater scouring or erosion;
- Practice good site housekeeping (i.e., trash collection, material staging areas, management of aggregate stockpiles);
- All seeded areas will be fertilized and reseeded, as necessary, and mulched according to contract specifications; and
- Comply with the conditions of Acton Conservation Commission's Order of Conditions.

Post-Development Stormwater Management System

After receiving a Certificate of Compliance from the Acton Conservation Commission and achieving “Substantial Completion” of construction, the Town (Concord Water Department) will take over all maintenance responsibilities for the post-development stormwater management system.

Storm Drains, Deep Sump Catch Basins, Drywell, Cultec Chambers, and Rip Rap Swale

Regular maintenance of the storm drains, deep sump catch basins, drywell, and Cultec chambers is essential to their proper operation. Therefore, regular maintenance and inspection activities include:

- Good housekeeping practices within driveways and parking areas (i.e., routine collection of trash from trash receptacles, keeping storm drain grates clear of obstructions, etc.);
- Monthly inspection of storm drains and deep sump catch basins;
- Quarterly cleaning of deep sump catch basins to remove built up sediments, debris, and oil and grease;
- Annual street sweeping of driveways and parking areas; and
- Disposal of removed catch basin cleanings in accordance with applicable state, local, and federal guidelines and regulations.

6. Maintenance Schedule

Construction Stormwater Management System

During the construction phase, the Town’s General Contractor should provide a maintenance and inspection schedule for the stormwater management system for the Town’s approval. A typical maintenance and inspection schedule is as follows:

<u>Daily:</u>	Repair stormwater, erosion, and sedimentation controls as necessary;
<u>Weekly:</u>	Inspect stormwater management system for effective and proper operation; repair as necessary.
<u>Run-off Events:</u>	Inspect stormwater management system within 24-hours of event; repair as necessary;

Post-Development Stormwater Management System

Following substantial completion of construction, the Town (Water Department) shall finalize a maintenance and inspection schedule for the stormwater management system

and have it on file at the treatment facility and at the Department of Public Works main office. The proposed maintenance and inspection schedule is as follows:

<u>Daily/Weekly:</u>	Repair stormwater, erosion, and sedimentation controls as necessary; Promote good housekeeping practices in driveways, parking areas, and stormwater management areas;
<u>Monthly:</u>	Inspect storm drains and deep sump catch basins for proper operation;
<u>Quarterly:</u>	Clean out sediments from deep sump catch basins;
<u>Semi-Annual:</u>	Inspect water quality swales for proper operation and condition;
<u>Annual:</u>	Removal of sediment from water quality swales;

7. Maintenance Log Form

The following is a typical maintenance and inspection form for the stormwater management system.

Date: _____
Name of Inspector: _____
Organization: _____

Type of Inspection
(Circle One): Daily / Weekly / Monthly / Quarterly / Semi-Annual / Annual

Reason for Inspection
(Circle All that Apply): Routine Maintenance / Routine Inspection / Run-Off Event / Emergency

Stormwater Control:
Condition (Circle One): Excellent / Good / Poor / Not Operational
Notes:
Action Items:

Stormwater Control:
Condition (Circle One): Excellent / Good / Poor / Not Operational
Notes:
Action Items:

Stormwater Control:
Condition (Circle One): Excellent / Good / Poor / Not Operational
Notes:
Action Items:

Stormwater Control:
Condition (Circle One): Excellent / Good / Poor / Not Operational
Notes:
Action Items:

Additional Notes:

Signature: _____ Date: _____

***CULTEC STORMWATER CHAMBERS
OPERATION AND MAINTENANCE GUIDELINES***

Contactor® & Recharger® Stormwater Chambers The Chamber With The Stripe®



Operation and Maintenance Guidelines

Operation & Maintenance

This manual contains guidelines recommended by CULTEC, Inc. and may be used in conjunction with, but not to supersede, local regulations or regulatory authorities. OSHA Guidelines must be followed when inspecting or cleaning any structure.

Introduction

The CULTEC Subsurface Stormwater Management System is a high-density polyethylene (HDPE) chamber system arranged in parallel rows surrounded by washed stone. The CULTEC chambers create arch-shaped voids within the washed stone to provide stormwater detention, retention, infiltration, and reclamation. Filter fabric is placed between the native soil and stone interface to prevent the intrusion of fines into the system. In order to minimize the amount of sediment which may enter the CULTEC system, a sediment collection device (stormwater pretreatment device) is recommended upstream from the CULTEC chamber system. Examples of pretreatment devices include, but are not limited to, an appropriately sized catch basin with sump, pretreatment catchment device, oil grit separator, or baffled distribution box. Manufactured pretreatment devices may also be used in accordance with CULTEC chambers. Installation, operation, and maintenance of these devices shall be in accordance with manufacturer's recommendations. Almost all of the sediment entering the stormwater management system will be collected within the pretreatment device.

Best Management Practices allow for the maintenance of the preliminary collection systems prior to feeding the CULTEC chambers. The pretreatment structures shall be inspected for any debris that will restrict inlet flow rates. Outfall structures, if any, such as outlet control must also be inspected for any obstructions that would restrict outlet flow rates. OSHA Guidelines must be followed when inspecting or cleaning any structure.

Operation and Maintenance Requirements

I. Operation

CULTEC stormwater management systems shall be operated to receive only stormwater run-off in accordance with applicable local regulations. CULTEC subsurface stormwater management chambers operate at peak performance when installed in series with pretreatment. Pretreatment of suspended solids is superior to treatment of solids once they have been introduced into the system. The use of pretreatment is adequate as long as the structure is maintained and the site remains stable with finished impervious surfaces such as parking lots, walkways, and pervious areas are properly maintained. If there is to be an unstable condition, such as improvements to buildings or parking areas, all proper silt control measures shall be implemented according to local regulations.

II. Inspection and Maintenance Options

- A. The CULTEC system may be equipped with an inspection port located on the inlet row. The inspection port is a circular cast box placed in a rectangular concrete collar. When the lid is removed, a 6-inch (150 mm) pipe with a screw-in plug will be exposed. Remove the plug. This will provide access to the CULTEC Chamber row below. From the surface, through this access, the sediment may be measured at this location. A stadia rod may be used to measure the depth of sediment if any in this row. If the depth of sediment is in excess of 3 inches (76 mm), then this row should be cleaned with high pressure water through a culvert cleaning nozzle. This would be carried out through an upstream manhole or through the CULTEC StormFilter Unit (or other pre-treatment device). CCTV inspection of this row can be deployed through this access port to determine if any sediment has accumulated in the inlet row.
- B. If the CULTEC bed is not equipped with an inspection port, then access to the inlet row will be through an upstream manhole or the CULTEC StormFilter.
 1. **Manhole Access**

This inspection should only be carried out by persons trained in confined space entry and sewer inspection services. After the manhole cover has been removed a gas detector must be lowered into the manhole to ensure that there are not high concentrations of toxic gases present. The inspector should be lowered into the manhole with the proper safety equipment as per OSHA requirements. The inspector may be able to observe sediment from this location. If this is not possible, the inspector will need to deploy a CCTV robot to permit viewing of the sediment.

2. StormFilter Access

Remove the manhole cover to allow access to the unit. Typically a 30-inch (750 mm) pipe is used as a riser from the StormFilter to the surface. As in the case with manhole access, this access point requires a technician trained in confined space entry with proper gas detection equipment. This individual must be equipped with the proper safety equipment for entry into the StormFilter. The technician will be lowered onto the StormFilter unit. The hatch on the unit must be removed. Inside the unit are two filters which may be removed according to StormFilter maintenance guidelines. Once these filters are removed the inspector can enter the StormFilter unit to launch the CCTV camera robot.

- C. The inlet row of the CULTEC system is placed on a polyethylene liner to prevent scouring of the washed stone beneath this row. This also facilitates the flushing of this row with high pressure water through a culvert cleaning nozzle. The nozzle is deployed through a manhole or the StormFilter and extended to the end of the row. The water is turned on and the inlet row is back-flushed into the manhole or StormFilter. This water is to be removed from the manhole or StormFilter using a vacuum truck.

III. Maintenance Guidelines

The following guidelines shall be adhered to for the operation and maintenance of the CULTEC stormwater management system:

- A. The owner shall keep a maintenance log which shall include details of any events which would have an effect on the system’s operational capacity.
- B. The operation and maintenance procedure shall be reviewed periodically and changed to meet site conditions.
- C. Maintenance of the stormwater management system shall be performed by qualified workers and shall follow applicable occupational health and safety requirements.
- D. Debris removed from the stormwater management system shall be disposed of in accordance with applicable laws and regulations.

IV. Suggested Maintenance Schedules

A. Minor Maintenance

The following suggested schedule shall be followed for routine maintenance during the regular operation of the stormwater system:

Frequency	Action
Monthly in first year	Check inlets and outlets for clogging and remove any debris as required.
Spring and Fall	Check inlets and outlets for clogging and remove any debris as required.
One year after commissioning and every third year following	Check inlets and outlets for clogging and remove any debris as required.

B. Major Maintenance

The following suggested maintenance schedule shall be followed to maintain the performance of the CULTEC stormwater management chambers. Additional work may be necessary due to insufficient performance and other issues that might be found during the inspection of the stormwater management chambers. (See table on next page)

Major Maintenance *(continued)*

	Frequency	Action
Inlets and Outlets	Every 3 years	<ul style="list-style-type: none"> Obtain documentation that the inlets, outlets and vents have been cleaned and will function as intended.
	Spring and Fall	<ul style="list-style-type: none"> Check inlet and outlets for clogging and remove any debris as required.
CULTEC Stormwater Chambers	2 years after commissioning	<ul style="list-style-type: none"> Inspect the interior of the stormwater management chambers through inspection port for deficiencies using CCTV or comparable technique. Obtain documentation that the stormwater management chambers and feed connectors will function as anticipated.
	9 years after commissioning every 9 years following	<ul style="list-style-type: none"> Clean stormwater management chambers and feed connectors of any debris. Inspect the interior of the stormwater management structures for deficiencies using CCTV or comparable technique. Obtain documentation that the stormwater management chambers and feed connectors have been cleaned and will function as intended.
	45 years after commissioning	<ul style="list-style-type: none"> Clean stormwater management chambers and feed connectors of any debris. Determine the remaining life expectancy of the stormwater management chambers and recommended schedule and actions to rehabilitate the stormwater management chambers as required. Inspect the interior of the stormwater management chambers for deficiencies using CCTV or comparable technique.
	45 to 50 years after commissioning	<ul style="list-style-type: none"> Replace or restore the stormwater management chambers in accordance with the schedule determined at the 45-year inspection. Attain the appropriate approvals as required. Establish a new operation and maintenance schedule.
Surrounding Site	Monthly in 1 st year	<ul style="list-style-type: none"> Check for depressions in areas over and surrounding the stormwater management system.
	Spring and Fall	<ul style="list-style-type: none"> Check for depressions in areas over and surrounding the stormwater management system.
	Yearly	<ul style="list-style-type: none"> Confirm that no unauthorized modifications have been performed to the site.

For additional information concerning the maintenance of CULTEC Subsurface Stormwater Management Chambers, please contact CULTEC, Inc. at 1-800-428-5832.



CULTEC

Chamber of Choice™

CULTEC, Inc.

878 Federal Road • P.O. Box 280 • Brookfield, CT 06804

Phone: 203-775-4416 • Toll Free: 800-4-CULTEC • Fax: 203-775-1462

Web: www.cultec.com • E-mail: custservice@cultec.com

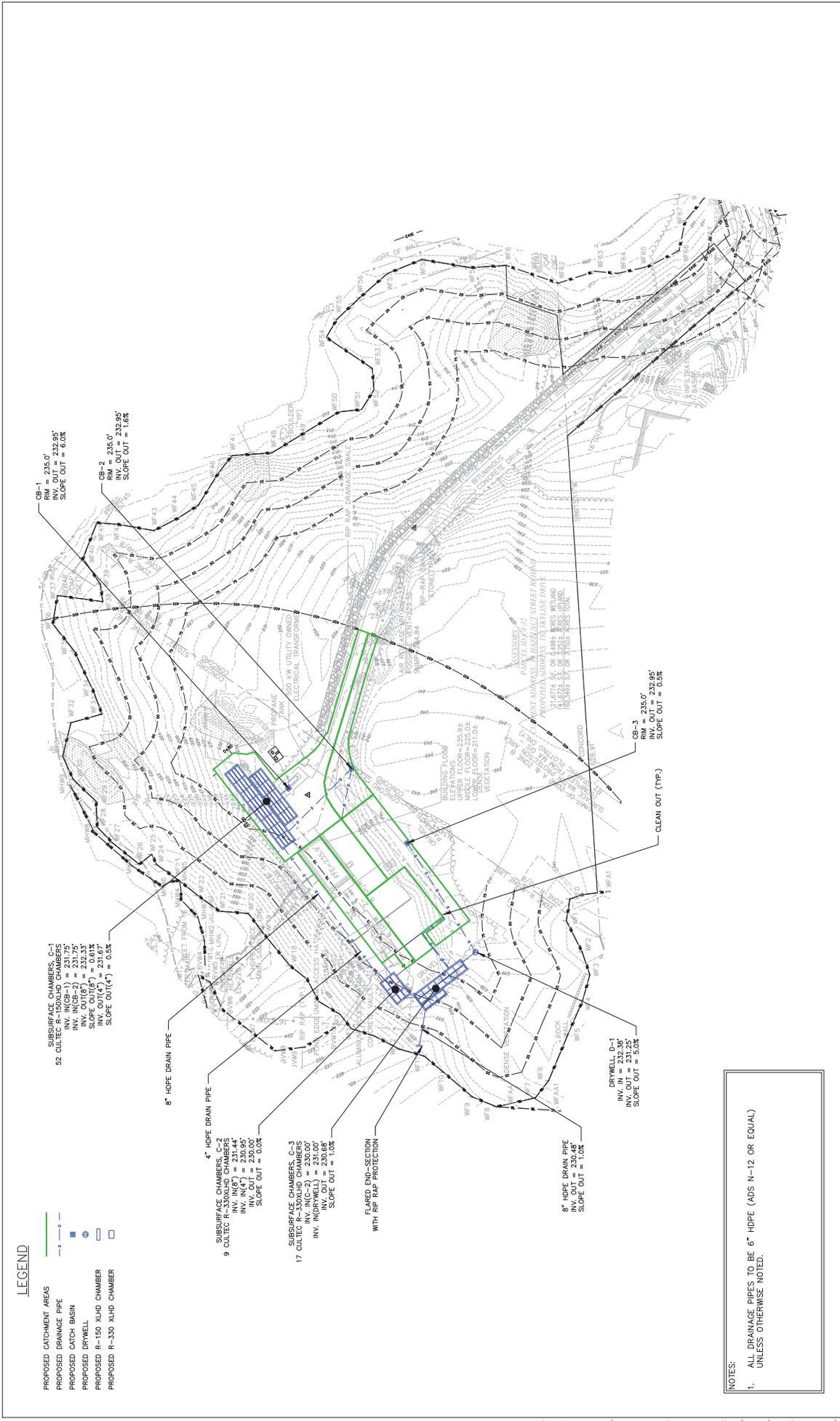
ATTACHMENT G
STORMWATER FIGURES

SW-1: Existing Soil Conditions and Boring Locations

SW-2: Existing Cover Type Areas and Tc Path

SW-3: Proposed Cover Type Areas

SW-4: Proposed BMP Structures and Catchment Areas



LEGEND

- PROPOSED CATCHMENT AREAS
- PROPOSED DRAINAGE PIPE
- PROPOSED CATCH BASIN
- PROPOSED DRYWELL
- PROPOSED R-150 XLHD CHAMBER
- PROPOSED R-330 XLHD CHAMBER

NOTES:
 1. ALL DRAINAGE PIPES TO BE 6" HDPE (ADS N-12 OR EQUAL) UNLESS OTHERWISE NOTED.

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A partnership for engineering solutions

DiMarini & Wolfe
ARCHITECTS • URBAN DESIGNERS
 BOSTON, MASSACHUSETTS

FOR PERMITTING
 Sheet No. **SW-4**

NAGOG POND WATER TREATMENT PLANT
 TOWN OF CONCORD, MASSACHUSETTS

**PROPOSED BMP STRUCTURES
 AND CATCHMENT AREAS**

Scale	Date	Job No.	Designed by	Drawn by	Checked by	Approved by
1"=40'	NOVEMBER 2015	200-1501	ASK/UB	JFB	DNRP	SCO

MARK	DATE	DESCRIPTION

THIS LINE IS ONE INCH LONG
 AT FULL SCALE ON A
 22" X 34" DRAWING