Hydrologic & Hydraulic Analysis

for

The Village at Sudbury Station

Hudson Road & Concord Road
Sudbury, Massachusetts

June 10, 2016
Revised July 14, 2016

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1.0 Introduction

The proposed project includes a 250 unit apartment complex under the Massachusetts General Laws, Chapter 40B, and is located with access off both Concord Road and Hudson Road in Sudbury, Massachusetts. This Hydrologic & Hydraulic Report has been prepared to support a set of plans prepared by this office entitled "Preliminary Site Plan for The Village at Sudbury Station, Sudbury, Mass," which was submitted as part of the application package. The report provides detailed information and calculations to verify the proposed Stormwater Management System design conforms to Massachusetts Stormwater Management Standard No. 2, which requires that post-development peak discharge rates do not exceed pre-development peak discharge rates. Further, this analysis was undertaken to verify that the stormwater management system as designed will not result in off-site flooding, or increase either flood heights or flood volumes in Mineway Brook.

The proposed stormwater management system has the benefit of a Superseding Negative Determination of Applicability from MassDEP dated April 20, 2016. As such, compliance with the Massachusetts Stormwater Management Standards is not required, as there will be no discharge into Waters of the Commonwealth or of the United States, nor into the buffer zone of any wetland, or into any wetland resource area. Nevertheless, the stormwater management system has been carefully designed to ensure that pre-construction and post-construction peak rates of runoff remain the same or lower, and so that no off-site post development impacts will occur; TSS Removal will achieve standards required by the Massachusetts Stormwater Standards; recharge will be provided as per the Massachusetts Stormwater Standards; and no discharge into any wetland or waterbody will occur, as required by the Massachusetts Stormwater Standards. In short, though compliance with the Massachusetts Stormwater Standards is not legally required, the Stormwater Management System has been designed to comply with these Standards, and therefore Section 8.0 of the Town of Sudbury Stormwater By-law regulations with the significant exception that, pursuant to MassDEP Technical Guidance, (see Appendix D and Section 2.6 below) the annual rainfall intensities are calculated in accordance with "United States Department of Commerce, Weather Bureau, Technical Paper 40, *Rainfall frequency Atlas of the United States.*"

1.1 Project Overview

The proposed development includes construction of five 3- or 4-story apartment buildings, five multi-unit townhouse buildings, a maintenance building, clubhouse, surface and garage parking, access driveways, landscaping, and required utility infrastructure, all as shown on the Preliminary Site Plans filed with the Zoning Board of Appeals and attached hereto. The site will be serviced by an on-site wastewater treatment plant, and utility connections for gas, electric, and CATV off of Hudson Road. The proposed water line will be looped from Concord Road through the site to Hudson Road.

1.2 Existing Site Conditions

The subject site consists of several parcels of land including Peter's Way and Peter's Way Extension, plus an easement over #30 Hudson Road. The total land area encompasses approximately 41 acres. The site is located within the Single Residence C and Single Residence A zoning districts. The site is essentially divided with the northerly portion being presently under an agricultural preservation restriction (APR) and the southerly half being the development area.

The site is largely undeveloped and wooded except for a gravel access road over Peter's Way and the single family dwelling at #30 Hudson Road. Topography is moderate to steep, sloping down from east to west toward the abutting railroad bed and wetland resource areas.

1.3 Soils

The Natural Resource Conservation Service has mapped the soils on site as the following:

51A—Swansea muck, 0 to 1 percent slopes
254A—Merrimac fine sandy loam, 0 to 3 percent slopes
255A—Windsor loamy sand, 0 to 3 percent slopes
255B—Windsor loamy sand, 3 to 8 percent slopes
256A—Deerfield loamy sand, 0 to 3 percent slopes
260B—Sudbury fine sandy loam, 3 to 8 percent slopes
300B—Montauk fine sandy loam, 3 to 8 percent slopes
307B—Paxton fine sandy loam, 0 to 8 percent slopes, extremely stony
420B—Canton fine sandy loam, 3 to 8 percent slopes

The predominant soils within the development area include Paxton Fine Sandy Loam and Sudbury Fine Sandy Loam. The Paxton soils are located on the sloping hillside portions of the site. This soil is a typical glacial till classified as Hydrologic Soil Group (HSG) C and has shallow depth to groundwater with a dense substratum. Sudbury soils are located along the toe of slope and are classified as HSG B. These soils have a highly permeable gravelly sand substratum with typical depth to groundwater greater than 80 inches.

Extensive soil testing has been performed on-site by Provencher Engineering, for design of the waste water treatment plant and disposal area; and by Northeast Geotechnical for design of foundations and geotechnical studies. The testing results generally agree with the soil mapping with coarser grained highly permeable material located along the toe of slope and denser glacial till material located along the hillside. Permeability testing was also performed by Sullivan Connors & Associates for design of the stormwater recharge system.

The NRCS soil mapping, soil evaluation forms, and permeability testing results have been attached as Appendix A and B.

1.4 Wetland Resources Areas

Wetland resource areas existing on-site approximately 250 feet from any proposed construction, with the exception of the Peter's Way access road, for which the applicant has received a Superseding Negative Determination of Applicability following the Sudbury Conservation Commission's no action. The resources include Bordering Vegetated Wetlands, Bordering Land Subject to Flooding (BLSF), and Bank associated with a stream/river (Mineway Brook). The delineation was confirmed by the Sudbury Conservation Commission through and Order of Resource Area Delineation. Mineway Brook runs from east to west across the site, and discharges under the old railroad bed through a 36-inch wide by 30-inch high open bottom stone culvert. The stream channel is generally clean/sandy bottom with 12 to 15-inch near vertical sides. The limits of the BLSF (100 year flood plain), was based upon the most recent FEMA Flood Insurance Rate Maps. The resource areas are shown on the submitted preliminary site plans.

2.0 Stormwater Management

2.1 Existing Stormwater Conditions

The overall existing drainage area analyzed under this report includes approximately 200 acres of land. This includes both on-site areas, upgradient areas mainly from the Town cemetery that drain onto the site, and off-site areas tributary Mineway Brock. Most of the stormwater runoff from the locus site is conveyed by overland flow; with the only exception begin the collection swale and basin at along Peter's Way. Surface runoff generally leaves the site in five locations and have been listed as Analysis Points (AP) 1 through 5 in the stormwater model:

AP1. Hudson Road: Overland flow to Hudson Road fronting along existing house #30. This area is currently developed as a single family dwelling.

AP2. Railroad Bed (South): Overland flow directed to the abutting railroad bed on the southerly portion of the site near Hudson Road. The drainage area includes mostly wooded upland areas.

AP3. Railroad Bed (Center): This analysis point includes what appears to be an existing cattle crossing that runs under the old railroad bed. The contributing tributary area is the largest area within the watershed. The area includes wooded uplands within the site and large portions of the upgradient Town cemetery land. Runoff from this area flows overland to an existing depression located adjacent to the railroad bed. This appears to be an old soil borrow hole. Soils within this depression are highly permeable. Any overflow from this area is discharged to the old cattle crossing under the rail road tracks.

AP4. Abutting Land Northeast: Located to the north of Peter's Way is the abutting land to the Northeast. Runoff discharges in this direction either as overland flow or as discharge from the existing basin along the south side of Peter's Way. This basin collects runoff from the Town cemetery land and some of the gravel path. There is no formal outlet structure, and once full runoff overtops the gravel path discharging toward the property line. After crossing the property line, runoff flows over the abutting land and enters Mineway Brook. This brook then re-enters the locus property as it flows to the west.

AP5. Undeveloped 30 Acres: The Northerly limit of the project area abuts the other land owned by the applicant consisting of undeveloped and agricultural land. Overland flow to this area includes Peter's Way and the upgradient cemetery land. Flow from upgradient areas flow over the applicants land without the benefit of an easement. The limit of the undeveloped land generally defines the limit of work for the project, with the exception of community gardens that may be created as an agricultural use on this land.

Table 1 provides a summary of the existing drainage area and surface conditions.

Table 2: Proposed Drainage Area Summary

	Hydrologic Soil Group				Time of Concentration Calculation				
Pr1									
	A	B	C	D	Segment	Elev	L	S	
Woods		8650			A	209			
Grass							50	0.06	Grass
Meadow					B	206			
Impervious - Site		1510					50	0.36	Grass
Impervious - Disconn		840			C	188			
Gravel									
11000	0	11000	0	0					
Pr2									
	A	B	C	D	Segment	Elev	L	S	
Woods					A	205			
Grass		2650	34400				50	0.22	Grass
Impervious - Disconn			4500		B	194			
Impervious - Roof Disconn			2900				30	0.30	Grass
					C	185			
44450	0	2650	41800						
Pr3									
	A	B	C	D	Segment	Elev	L	S	
Woods					A	197			
Grass		4535	14000				50	0.025	Paved
Impervious - Roof		6520	4385		B	195.75			
Impervious		11900					70	0.025	Paved
					C	194			
41340	0	22955	18385	0					
Pr4									
	A	B	C	D	Segment	Elev	L	S	
Woods		3600	10000		A	224			
Grass			6100				50	0.16	Grass
Meadow					B	216			
Impervious							70	0.23	Woods
Impervious - Disconn			1200		C	200			
Gravel			1300						
22200	0	3600	18600	0					
Pr5									
	A	B	C	D	Segment	Elev	L	S	
Woods		3000	153000	0	A	257			
Grass		12350	528150	0			50	0.06	Grass
Meadow			48000	0	B	254			
Impervious- Conn		12540	130305	0			150	0.05	Grass
Impervious - Roof		6655	74950	0	C	246			
Gravel			74000	0			200	0.02	Gravel
Impervious - Disconn			21000	0	D	242			
							130	0.02	Paved
1063950	0	34545	1029405		E	239			
							85	0.13	Grass
					F	228			
Pr6									
	A	B	C	D	Segment	Elev	L	S	
Woods			9000		A	204			
Grass		13075	71580				50	0.02	Grass
Meadow					B	203			
Impervious - Pave		26495	39495				225	0.05	Grass
Impervious - Roof		6680	12735		C	191			
Gravel							125	0.01	Paved
					D	189.5			
179060	0	46250	132810	0					
Totals	**A**	**B**	**C**	**D**					
1362000	**0**	**121000**	**1241000**	**0**					

2.2 Proposed Stormwater Conditions

The overall existing drainage area analyzed under this report includes approximately 200 acres of land. The overall existing drainage area that will be affected by the proposed development includes approximately 45 acres, and has the same five analysis points as described above under the existing conditions.

AP1. Hudson Road: Overland flow to Hudson Road is limited to a small contributing area associated with the existing residential dwelling at #30 Hudson Road, and the paved apron off Hudson Road up to the first set of catch basins. These catch basins have been set at the end of the curb rounding's as close as practical to the right of way.

AP2. Railroad tracks (South): Overland flow directed to the abutting railroad tracks on the southerly portion of the site near Hudson Road has been limited to the grass shoulder of the roadway and the rear half of the treatment plant roof top area. The overall tributary area to this point has been reduced by approximately 80%.

AP3. Railroad tracks (Center): The tributary subcatchment from the locus site has been eliminated and re-routed to the on-site detention system.

AP4. Abutting Land Northeast: The proposed drainage area tributary to this location has been reduced to include only pervious areas downgradient of the development. As in the existing conditions, after crossing the property line onto the abutting land runoff enters Mineway Brook. This brook then re-enters the locus property as it flows to the west.

AP5. Undeveloped 30 Acres: This analysis point includes the largest tributary area from the project area and includes essentially all of the proposed site development and upgradient areas. The on-site drainage areas have been divided into several parts as required to analyze the stormwater detention systems. The off-locus areas noted above in the existing conditions have also been included in the proposed overall watershed model. Additional detail on the drainage collection and stormwater management system are provided below.

Table 2 provides a summary of the proposed drainage area and surface conditions.

Table 1: Existing Drainage Area Summary

		Hydrologic Soil Group				Time of Concentration Calculation				
Ex1										
		A	B	C	D	Segment	Elev	L	S	
Woods			1500			A	209			
Grass			10800					50	0.06	Grass
Meadow			0			B	206			
Impervious			860					50	0.36	Grass
Impervious - Disconn			840			C	188			
Gravel										
	14000	0	14000	0	0					
Ex2										
		A	B	C	D	Segment	Elev	L	S	
Woods			1000	178000		A	258.5			
Grass			2800	20500				50	0.05	Woods
Impervious - Disconn			1200	7500		B	256			
Gravel								420	0.17	Woods
						C	185			
	211000	0	5000	206000						
Ex3										
		A	B	C	D	Segment	Elev	L	S	
Woods			81000	333000		A	257			
Grass				258000				50	0.06	Grass
Impervious - Disconn				21000		B	254			
Gravel				36000				150	0.05	Grass
						C	246			
	729000	0	81000	648000				200	0.02	Gravel
						D	242			
								130	0.02	Paved
						E	239			
								40	0.03	Grass
						F	238			
								565	0.10	Woods
						G	180			
								130	0.03	Woods
						H	176			
Ex4										
		A	B	C	D	Segment	Elev	L	S	
Woods			18000	41000		A	248.8			
Grass				36000				50	0.04	Grass
Meadow				46000		B	247			
Impervious				9000				215	0.14	Grass
Impervious - Disconn						C	217			
Gravel			3000	13000				85	0.20	Woods
						D	200			
	166000	0	21000	145000	0					
Ex5										
		A	B	C	D	Segment	Elev	L	S	
Woods						A	250			
Grass				22000				50	0.04	Grass
Meadow				43000		B	248			
Impervious								215	0.18	Grass
Impervious - Disconn						C	210			
Gravel				9000						
	74000	0	0	74000	0					
Ex6										
		A	B	C	D	Segment	Elev	L	S	
Woods				94000		A	249.5			
Grass				56000				50	0.03	Grass
Impervious - Disconn						B	247			
Gravel				18000				170	0.05	Grass
						C	239			
	168000	0	0	168000	0			635	0.10	Woods
						D	175.5			
								480	0.01	Woods
						E	170			
	Totals	A	B	C	D					
	1362000	0	121000	1241000	0					

2.3 Overall Watershed Model

The overall watershed to Mineway Brook also includes a relatively large off-locus drainage area. These areas include approximately 130 acres to the southeast of Concord Road and 42 acres to the northwest of Concord Road. Watershed flow from these areas enters Mineway Brook; combine with the on-site drainage areas; and then discharges under the railroad bed through a 36-inch wide by 30 inch tall open bottom stone culvert within the railroad bed right of way

The stormwater model has included these off-site areas to evaluate the impacts of the proposed development when combined with the larger watershed. The railroad culvert is the closest downstream restriction. The peak ponding elevation and peak rate of runoff at this culvert have been analyzed to verify there will be no off-site impacts or increase in the flooding elevation due to the proposed project.

2.4 Proposed Drainage System

Essentially the entire site development area and all upgradient areas will be collected by the proposed drainage collection system. This system will consist of swales and area drains to collect upgradient off site runoff; catch basins to collect surface runoff within the site; roof drainage collection; and conveyance pipe. All runoff collected by these systems will be conveyed to either of two subsurface stormwater detention systems. The detention systems will be constructed out of either corrugated metal (CM) pipe (detention system A), or high density polyethylene (HDPE) pipe (detention system B). The intent of the detention systems is to collect and store runoff, and then discharge at a controlled rate to match the existing conditions. The use of watertight joints or a sub-drainage system has been specified to eliminate the potential influence of groundwater. A more detailed description of each system is provided below, and additional product information including CMP lifespan data has been provided in Appendix H. The typical operation and maintenance plan has also been provided in Appendix F.

2.4.1 Detention System 'A'

The larger of the two detention systems. This system will collect runoff from a majority of the site development and upgradient areas. This system will consist of 2,050 linear feet of 144-inch CM pipe. This system is located within the courtyard between buildings #2, #4, and #5. The soils in this location are typical glacial till with dense substratum and seasonal high groundwater at 36 to 42 inches. The system has been designed with a drainage blanket and sub-drainage system to mitigate against any potential impacts to the detention system from groundwater. The outlet structure includes a concrete manhole with a weir wall to control the rate of runoff. Discharges will then be conveyed through the drainage system to a stabilized outlet. The edge of system has been set a minimum 20 feet from the foundation of buildings #2, #4, and #5, which is well outside the typical zone of influence of the foundation.

2.4.2 Detention System 'B'

The smaller of the two detention systems will collect runoff from the development entrance near Hudson Road, and from the lower parking area near the railroad bed. This system will consist of 1980 linear feet of 60 inch HDPE pipe. This system is located over the minimum required 25 feet from the treatment plant soil absorption system (SAS), and the system will be sealed with water tight joints. The edge of system has been set a minimum 20 feet from the foundation of building #1 and #2, which is well outside the typical zone of influence of the foundation. The outlet structure includes a concrete manhole with a baffle wall to control the rate of runoff. Discharges will then be conveyed through the drainage system to a stabilized outlet.

2.4.3 Discharge Location

The discharge for the site drainage and detention systems is located between the Maintenance building and building #3. The outlet consists of a headwall, 36-inch outlet discharge pipe, a preformed riprap scour hole, and cast in place concrete level spreader.

The preformed scour hole has been designed to provide vertical and lateral expansion of stormwater to allow energy dissipation. The sizing has been based upon the following calculations. Equation references can be found in Appendix C.

Rip Rap Size:

Min $d_{50} = (0.0125 D^2/TW)(Q/D^{2.5})^{1.333}$

D = 3 ft (pipe diameter)

TW = 1. 5 ft (tailwater)

Q = 14.5 cfs (100 year event)

Min d_{50} = 2-inches

Use MHD M2.02.03 Stone for Pipe Ends (d_{50}>8 inches)

Dimensions:	Min. required	Proposed
Length	18'	20'
Width	15'	30'
Depth	1.5'	1.5'

The outlet to the preformed scour hole has been provided with a 40-foot long level spreader. This device will be constructed of 8-inch thick cast-in-place concrete with a footing placed below the frost line.

Discharge from the drainage system has been reduced to the maximum extent practical. In a 2-year (3.2 inch) storm event the peak discharge from the drainage system would be approximately 3.4 cubic feet per second, which is the equivalent flow to that which can be handled in a 12-inch diameter pipe. During the 100 year storm, flow over the level spreader would have a

discharge velocity of less than 2 feet per second, which is well below the scour velocity for established woodlands.

2.5 Peak Rate of Runoff Calculation Methods and Design Standards

The pre- and post-development stormwater runoff has been analyzed using HydroCAD 9.10, which is a stormwater modeling computer program utilizing a collection of techniques for the generation and routing of hydrographs, including Soil Conservation Service (SCS) Technical Release No. 20 (TR-20) and SCS Technical Release 55 (TR-55), *Urban Hydrology for Small Watersheds.* Time of concentration calculations are based upon TR-55 and NRCS National Engineering Handbook Part 630.

The proposed discharge locations have been carefully designed and located outside of those areas regulated under the Massachusetts Wetlands Protection Act, or any associated buffer zones, and MassDEP has ruled that the stormwater discharge will not alter any area subject to regulation under the Wetlands Act (See Superseding Negative Determination of Applicability dated April 20, 2016).

2.6 Rainfall data

Rainfall depths for the design storms were taken from the "United States Department of Commerce, Weather Bureau, Technical Paper 40, *Rainfall frequency Atlas of the United States.*" This selection is based upon the most current MassDEP guidance, which specifies the use of Technical Paper 40 for calculating stormwater peak runoff rates unless an applicant voluntarily chooses to use alternative rates contained in NOAA Atlas 14 and the NRCC Atlas. The 24-hour rainfall maps have been attached in Appendix D, and the rainfall depths used in the calculations are listed below:

2 year	3.2 inches
10 year	4.8 inches
100 year	6.8 inches

The DEP Guidance dated November 2015 specifies that TP-40 rates should continue to be used rather than NOAA Atlas 14 or NRCC Atlas rates because MassDEP has determined that in some cases both NOAA and NRCC have lower precipitation rates that TP-40, and in some cases higher. Given the unreliability of both NOAA and NRCC Atlas rates and the need for further study, we have chosen to apply TP-40 rates as specified by MassDEP.

2.7 Summary of Results – On-Site

The following table summarizes the results and shows the post-development rate of runoff has been maintained at or below pre-development levels at all analysis points. The proposed stormwater management system addresses the peak rate of runoff control and conforms to Stormwater Management Standard No.2, which requires that post-development peak discharge rates do not exceed pre-development peak discharge rates. Further, the stormwater management system ensures that there is no downstream or offsite flooding in Mineway Brook, or increases in flow which exceed pre-development conditions.

Table 3: Peak Rate of Runoff Summary

Storm Event	2-year	10-year	100-year
Intensity	**3.2 inches**	**4.8 inches**	**6.8 inches**
	Existing (Proposed)	**Existing (Proposed)**	**Existing (Proposed)**
AP1 Hudson Road	0.2 cfs (0.2 cfs)	0.5 cfs (0.5 cfs)	1.1 cfs (0.9 cfs)
AP2 Railroad (South)	3.7 cfs (1.4 cfs)	9.0 cfs (3.0 cfs)	16.6 cfs (5.3 cfs)
AP3 Railroad (Center)	0 cfs (0 cfs)	0 cfs (0 cfs)	11.7 cfs (0.0 cfs)
AP4 Abutting Northeast	3.8 cfs (0.5 cfs)	12.5 cfs (1.3 cfs)	22.6 cfs (2.4 cfs)
AP5 Undeveloped 30 Acres	3.5 cfs (3.4 cfs)	8.1 cfs (7.2 cfs)	14.5 cfs (14.5 cfs)

*Rates above are reported in cubic feet per second (CFS)

2.8 Summary of Results – Overall Watershed

The overall watershed model was also conducted to verify there would be no downstream or offsite impacts or increase in flooding due to the proposed development. The following tables provide the peak rate of runoff (table 4) and maximum ponding elevation (table 5) at the downstream culvert, which is represented in the stormwater model as "Analysis Point 6."

Table 4: Peak rate of runoff to railroad culvert

Storm Event	**2-year**	**10-year**	**100-year**
Intensity	**3.2 inches**	**4.8 inches**	**6.8 inches**
	Existing (Proposed)	**Existing (Proposed)**	**Existing (Proposed)**
AP6 Railroad Culvert	24.3 cfs (23.3 cfs)	58.7 cfs (53.7 cfs)	111.9 cfs (102.3 cfs)

Table 5: Peak ponding elevations at railroad culvert

Storm Event	**2-year**	**10-year**	**100-year**
Intensity	**3.2 inches**	**4.8 inches**	**6.8 inches**
	Existing (Proposed)	**Existing (Proposed)**	**Existing (Proposed)**
AP6 Railroad Culvert	170.6 (170.6)	171.7 (171.6)	172.8 (172.7)

2.9 Stormwater Treatment

The proposed stormwater management system has implemented best management practices (BMP's) to provide pretreatment of runoff prior to discharge. The treatment BMP's have been sized to remove at least 80% removal of the average annual load of total suspended solids (TSS). This has been achieved through the use of deep sump catch basins throughout the project and two proprietary separators, one at each of the detention system outlets. The proprietary separators have been specified as Stormceptor Model 2400, which have been sized for a treatment flow rate equivalent to the 2-year storm event, which is greater than the typical 1-inch equivalent flow rate. TSS removal calculations have been provided below along with the Stormceptor sizing data. The operation and maintenance procedures for these BMP's have been included in the project O&M plan.

Area 1: To Detention System 1

1 **BMP**	2 **TSS removal**	3 **Starting TSS** (5 from previous BMP)	4 **TSS Removal** **(2 * 3)**	5 **Remaining TSS** **(3 - 4)**
Deep Sump catch Basins	25%	100%	25%	75%
STC 2400	83%	75%	62%	13%
		Area 1 TSS Removal =	87%	

Area 2: To Detention System 2

1 **BMP**	2 **TSS removal**	3 **Starting TSS** (5 from previous BMP)	4 **TSS Removal** **(2 * 3)**	5 **Remaining TSS** **(3 - 4)**
Deep Sump catch Basins	25%	100%	25%	75%
STC 2400	78%	75%	59%	16%
		Area 2 TSS Removal =	84%	

Area 3: to Catch Basins near Maintenance Building

1 **BMP**	2 **TSS removal**	3 **Starting TSS** (5 from previous BMP)	4 **TSS Removal** **(2 * 3)**	5 **Remaining TSS** **(3 - 4)**
Deep Sump Catch Basins	25%	100%	25%	75%
		Area 3 TSS Removal =	25%	

Total TSS removal:

(Area 1 x TSS) + (Area 2 x TSS) + (Area 3 x TSS) / (Area 1 + Area 2 + Area)

(5.68 ac. x 87%) + (1.96 ac. x 84%) + (0.30 ac. x 25%) / (7.94) = **84 % TSS Removal**

Stormceptor®

Stormceptor Sizing Detailed Report

PCSWMM for Stormceptor

Project Information

Date	5/16/2016
Project Name	Sudbury Station
Project Number	N/A
Location	Sudbury

Stormwater Quality Objective

This report outlines how Stormceptor System can achieve a defined water quality objective through the removal of total suspended solids (TSS). Attached to this report is the Stormceptor Sizing Summary.

Stormceptor System Recommendation

The Stormceptor System model STC 2400 achieves the water quality objective removing 83% TSS for a NJDEP (clay, silt, sand) particle size distribution; providing continuous positive treatment for a stormwater quality flow rate of 2 cfs.

The Stormceptor System

The Stormceptor oil and sediment separator is sized to treat stormwater runoff by removing pollutants through gravity separation and flotation. Stormceptor's patented design generates positive TSS removal for all rainfall events, including large storms. Significant levels of pollutants such as heavy metals, free oils and nutrients are prevented from entering natural water resources and the re-suspension of previously captured sediment (scour) does not occur.

Stormceptor provides a high level of TSS removal for small frequent storm events that represent the majority of annual rainfall volume and pollutant load. Positive treatment continues for large infrequent events, however, such events have little impact on the average annual TSS removal as they represent a small percentage of the total runoff volume and pollutant load.

Stormceptor is the only oil and sediment separator on the market sized to remove TSS for a wide range of particle sizes, including fine sediments (clays and silts), that are often overlooked in the design of other stormwater treatment devices.

Rinker MATERIALS™

Stormceptor®

Small storms dominate hydrologic activity, US EPA reports

"Early efforts in stormwater management focused on flood events ranging from the 2-yr to the 100-yr storm. Increasingly stormwater professionals have come to realize that small storms (i.e. < 1 in. rainfall) dominate watershed hydrologic parameters typically associated with water quality management issues and BMP design. These small storms are responsible for most annual urban runoff and groundwater recharge. Likewise, with the exception of eroded sediment, they are responsible for most pollutant washoff from urban surfaces. Therefore, the small storms are of most concern for the stormwater management objectives of ground water recharge, water quality resource protection and thermal impacts control."

"Most rainfall events are much smaller than design storms used for urban drainage models. In any given area, most frequently recurrent rainfall events are small (less than 1 in. of daily rainfall)."

"Continuous simulation offers possibilities for designing and managing BMPs on an individual site-by-site basis that are not provided by other widely used simpler analysis methods. Therefore its application and use should be encouraged."

– US EPA Stormwater Best Management Practice Design Guide, Volume 1 – General Considerations, 2004

Design Methodology

Each Stormceptor system is sized using PCSWMM for Stormceptor, a continuous simulation model based on US EPA SWMM. The program calculates hydrology from up-to-date local historical rainfall data and specified site parameters. With US EPA SWMM's precision, every Stormceptor unit is designed to achieve a defined water quality objective.

The TSS removal data presented follows US EPA guidelines to reduce the average annual TSS load. Stormceptor's unit process for TSS removal is settling. The settling model calculates TSS removal by analyzing (summary of analysis presented in Appendix 2):

- Site parameters
- Continuous historical rainfall, including duration, distribution, peaks (Figure 1)
- Interevent periods
- Particle size distribution
- Particle settling velocities (Stokes Law, corrected for drag)
- TSS load (Figure 2)
- Detention time of the system

The Stormceptor System maintains continuous positive TSS removal for all influent flow rates. Figure 3 illustrates the continuous treatment by Stormceptor throughout the full range of storm events analyzed. It is clear that large events do not significantly impact the average annual TSS removal. There is no decline in cumulative TSS removal, indicating scour does not occur as the flow rate increases.

WATER QUALITY UNIT - 1
(DETENTION SYSTEM - A)

Stormceptor®

Appendix 1
Stormceptor Design Summary

Project Information

Date	5/16/2016
Project Name	Sudbury Station
Project Number	N/A
Location	Sudbury

Designer Information

Company	SCA
Contact	vc

Notes

Detention System A

Drainage Area

Total Area (ac)	24.471
Imperviousness (%)	23.2

The Stormceptor System model STC 2400 achieves the water quality objective removing 83% TSS for a NJDEP (clay, silt, sand) particle size distribution; providing continuous positive treatment for a stormwater quality flow rate of 2 cfs.

Rainfall

Name	BOSTON WSFO AP
State	MA
ID	770
Years of Records	1948 to 2005
Latitude	42°21'38"N
Longitude	71°0'38"W

Water Quality Objective

TSS Removal (%)	83
WQ Flow Rate (cfs)	2 ← 2yr.

Upstream Storage

Storage (ac-ft)	Discharge (cfs)
0.000	00.000
0.228	00.400
0.626	00.600
1.041	00.700

Partial Listing

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %
STC 450i	70
STC 900	81
STC 1200	81
STC 1800	80
STC 2400	**83** ← USE 2400
STC 3600	83
STC 4800	86
STC 6000	86
STC 7200	88
STC 11000	91
STC 13000	91
STC 16000	93

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WATER QUALITY UNIT-1

(SYSTEM-A)

Stormceptor®

Particle Size Distribution

Removing silt particles from runoff ensures that the majority of the pollutants, such as hydrocarbons and heavy metals that adhere to fine particles, are not discharged into our natural water courses. The table below lists the particle size distribution used to define the annual TSS removal.

NJDEP (clay, silt, sand)

Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s		Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s
1	5	2.65	0.0012					
4	15	2.65	0.0012					
29	25	2.65	0.0025					
75	15	2.65	0.0133					
175	30	2.65	0.0619					
375	5	2.65	0.1953					
750	5	2.65	0.4266					

Stormceptor Design Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor.
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal.
- Only the STC 450i is adaptable to function with a catch basin inlet and/or inline pipes.
- Only the Stormceptor models STC 450i to STC 7200 may accommodate multiple inlet pipes.
- Inlet and outlet invert elevation differences are as follows:

Inlet and Outlet Pipe Invert Elevations Differences

Inlet Pipe Configuration	STC 450i	STC 900 to STC 7200	STC 11000 to STC 16000
Single inlet pipe	3 in.	1 in.	3 in.
Multiple inlet pipes	3 in.	3 in.	Only one inlet pipe.

- Design estimates are based on stable site conditions only, after construction is completed.
- Design estimates assume that the storm drain is not submerged during zero flows. For submerged applications, please contact your local Stormceptor representative.
- Design estimates may be modified for specific spills controls. Please contact your local Stormceptor representative for further assistance.
- For pricing inquiries or assistance, please contact Rinker Materials 1 (800) 909-7763 www.rinkerstormceptor.com

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WATER QUALITY UNIT-1
(DETENTION SYSTEM-A)

Stormceptor®

Appendix 2
Summary of Design Assumptions

SITE DETAILS

Site Drainage Area

Total Area (ac)	24.471	Imperviousness (%)	23.2

Surface Characteristics

Width (ft)	2064.904
Slope (%)	2
Impervious Depression Storage (in.)	0.02
Pervious Depression Storage (in.)	0.2
Impervious Manning's n	0.015
Pervious Manning's n	0.25

Infiltration Parameters

Horton's equation is used to estimate infiltration	
Max. Infiltration Rate (in/hr)	2.44
Min. Infiltration Rate (in/hr)	0.4
Decay Rate (s^{-1})	0.00055
Regeneration Rate (s^{-1})	0.01

Maintenance Frequency

Sediment build-up reduces the storage volume for sedimentation. Frequency of maintenance is assumed for TSS removal calculations.	
Maintenance Frequency (months)	12

Evaporation

Daily Evaporation Rate (inches/day)	0.1

Dry Weather Flow

Dry Weather Flow (cfs)	No

Upstream Attenuation

Stage-storage and stage-discharge relationship used to model attenuation upstream of the Stormceptor System is identified in the table below.

Storage ac-ft	Discharge cfs
0.000	00.000
0.228	00.400
0.626	00.600
1.041	00.700

Partial Listing

← UPSTREAM STORAGE

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WATER QUALITY UNIT -2

(detention System - B)

Stormceptor®

Appendix 1
Stormceptor Design Summary

Project Information

Date	5/16/2016
Project Name	Sudbury Station
Project Number	N/A
Location	Sudbury

Designer Information

Company	SCA
Contact	vc

Notes

Detention Systm B

Drainage Area

Total Area (ac)	4.11 ←
Imperviousness (%)	48 ←

The Stormceptor System model STC 2400 achieves the water quality objective removing 78% TSS for a NJDEP (clay, silt, sand) particle size distribution; providing continuous positive treatment for a stormwater quality flow rate of 0.7 cfs.

Rainfall

Name	BOSTON WSFO AP
State	MA
ID	770
Years of Records	1948 to 2005
Latitude	42°21'38"N
Longitude	71°0'38"W

Water Quality Objective

TSS Removal (%)	75
WQ Flow Rate (cfs)	0.7 ← 24hr

Upstream Storage

Storage (ac-ft)	Discharge (cfs)
0.000	00.000
0.011	00.400
0.134	00.600
0.339	01.000

Partial Listing

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %
STC 450i	64
STC 900	74
STC 1200	74
STC 1800	74
STC 2400	**78** ← USE 2400
STC 3600	79
STC 4800	82
STC 6000	83
STC 7200	85
STC 11000	89
STC 13000	89
STC 16000	91

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WATER QUALITY UNIT-2
(DETENTION SYSTEM-B)

Stormceptor®

Particle Size Distribution

Removing silt particles from runoff ensures that the majority of the pollutants, such as hydrocarbons and heavy metals that adhere to fine particles, are not discharged into our natural water courses. The table below lists the particle size distribution used to define the annual TSS removal.

NJDEP (clay, silt, sand)

Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s		Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s
1	5	2.65	0.0012					
4	15	2.65	0.0012					
29	25	2.65	0.0025					
75	15	2.65	0.0133					
175	30	2.65	0.0619					
375	5	2.65	0.1953					
750	5	2.65	0.4266					

Stormceptor Design Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor.
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal.
- Only the STC 450i is adaptable to function with a catch basin inlet and/or inline pipes.
- Only the Stormceptor models STC 450i to STC 7200 may accommodate multiple inlet pipes.
- Inlet and outlet invert elevation differences are as follows:

Inlet and Outlet Pipe Invert Elevations Differences

Inlet Pipe Configuration	STC 450i	STC 900 to STC 7200	STC 11000 to STC 16000
Single inlet pipe	3 in.	1 in.	3 in.
Multiple inlet pipes	3 in.	3 in.	Only one inlet pipe.

- Design estimates are based on stable site conditions only, after construction is completed.
- Design estimates assume that the storm drain is not submerged during zero flows. For submerged applications, please contact your local Stormceptor representative.
- Design estimates may be modified for specific spills controls. Please contact your local Stormceptor representative for further assistance.
- For pricing inquiries or assistance, please contact Rinker Materials 1 (800) 909-7763 www.rinkerstormceptor.com

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WATER QUALITY UNIT - 2
(detention system - B)

Stormceptor®

Appendix 2
Summary of Design Assumptions

SITE DETAILS

Site Drainage Area

Total Area (ac)	4.11	Imperviousness (%)	48

Surface Characteristics

Width (ft)	846
Slope (%)	2
Impervious Depression Storage (in.)	0.02
Pervious Depression Storage (in.)	0.2
Impervious Manning's n	0.015
Pervious Manning's n	0.25

Infiltration Parameters

Horton's equation is used to estimate infiltration	
Max. Infiltration Rate (in/hr)	2.44
Min. Infiltration Rate (in/hr)	0.4
Decay Rate (s^{-1})	0.00055
Regeneration Rate (s^{-1})	0.01

Maintenance Frequency

Sediment build-up reduces the storage volume for sedimentation. Frequency of maintenance is assumed for TSS removal calculations.	
Maintenance Frequency (months)	12

Evaporation

Daily Evaporation Rate (inches/day)	0.1

Dry Weather Flow

Dry Weather Flow (cfs)	No

Upstream Attenuation

Stage-storage and stage-discharge relationship used to model attenuation upstream of the Stormceptor System is identified in the table below.

Storage ac-ft	Discharge cfs
0.000	00.000
0.011	00.400
0.134	00.600
0.339	01.000

Partial Listing

← upstream Storage

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Stormceptor®

PARTICLE SIZE DISTRIBUTION

Particle Size Distribution

Removing fine particles from runoff ensures the majority of pollutants, such as heavy metals, hydrocarbons, free oils and nutrients are not discharged into natural water resources. The table below identifies the particle size distribution selected to define TSS removal for the design of the Stormceptor System.

NJDEP (clay, silt, sand)

Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s		Particle Size µm	Distribution %	Specific Gravity	Settling Velocity ft/s
1	5	2.65	0.0012					
4	15	2.65	0.0012					
29	25	2.65	0.0025					
75	15	2.65	0.0133					
175	30	2.65	0.0619					
375	5	2.65	0.1953					
750	5	2.65	0.4266					

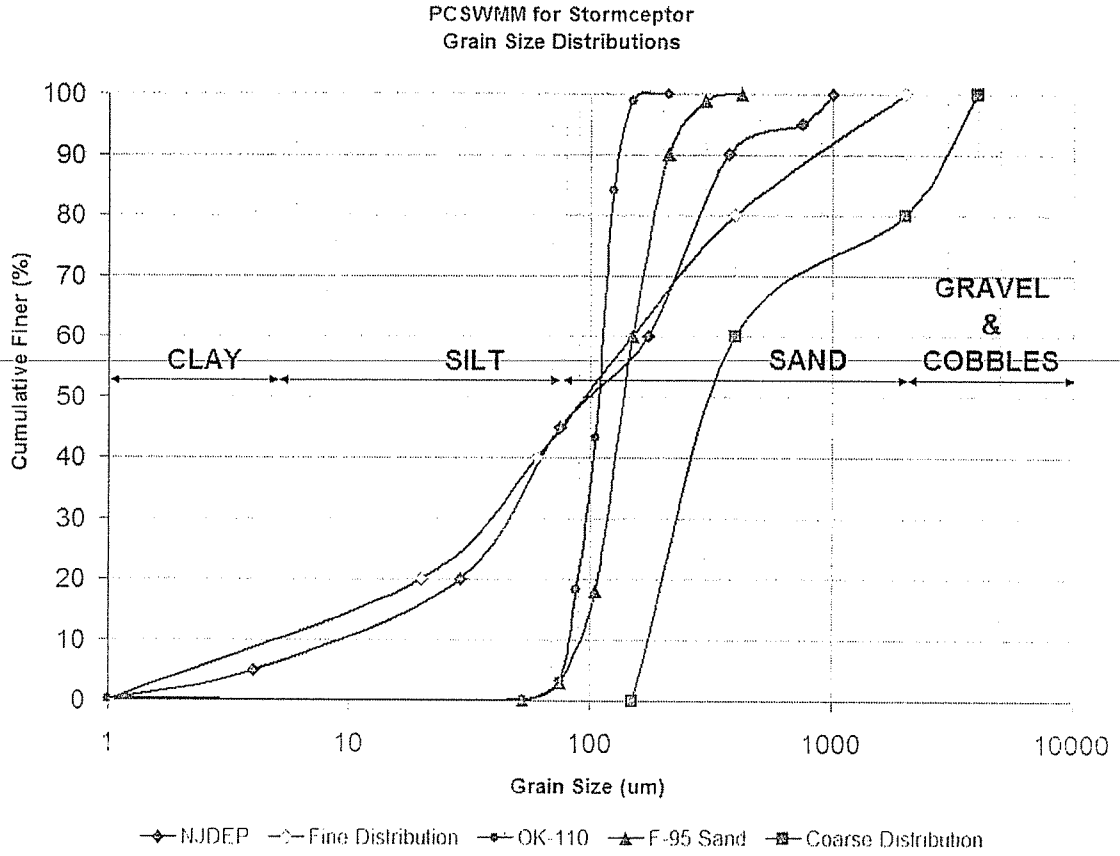

Figure 1. PCSWMM for Stormceptor standard design grain size distributions.

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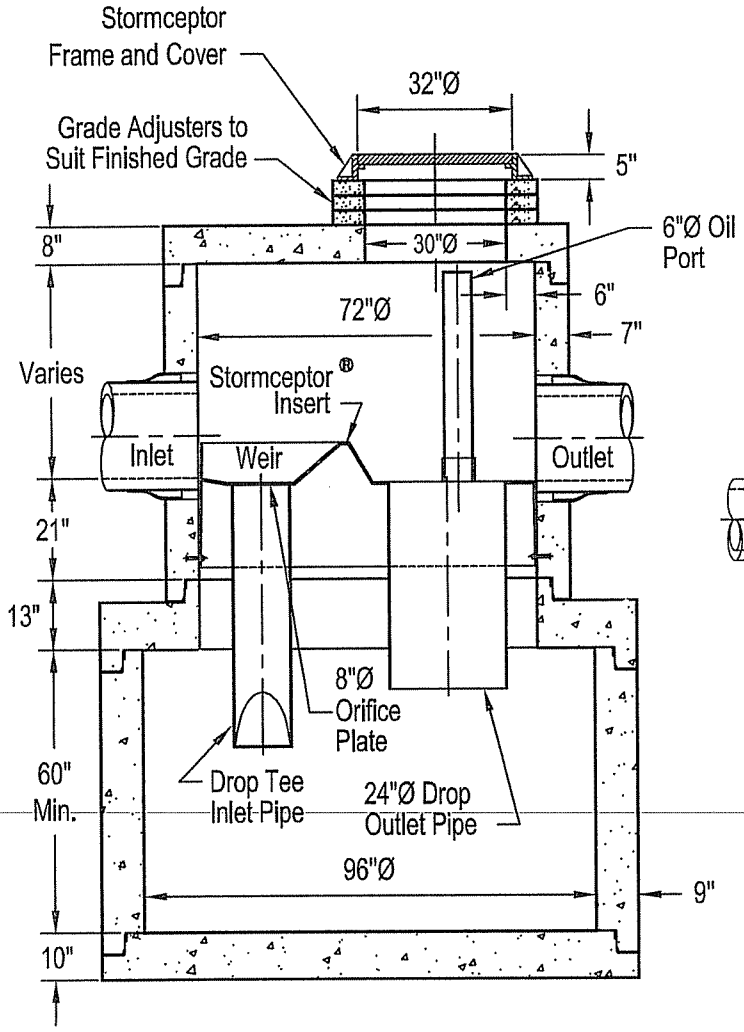
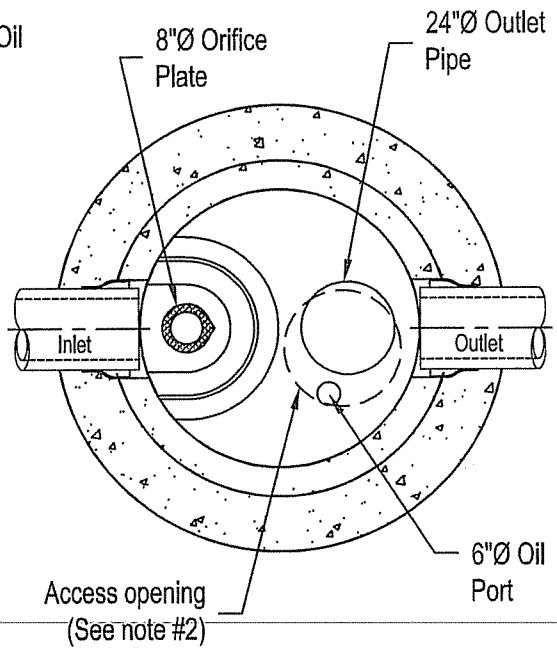
Typical Detail

STC 2400 Precast Concrete Stormceptor®
(2400 U.S. Gallon Capacity)



Section Thru Chamber



Plan View

Notes:

1. The Use Of Flexible Connection is Recommended at The Inlet and Outlet Where Applicable.
2. The Cover Should be Positioned Over The Outlet Drop Pipe and The Oil Port.
3. The Stormceptor System is protected by one or more of the following U.S. Patents: #4985148, #5498331, #5725760, #5753115, #5849181, #6068765, #6371690.
4. Contact a Concrete Pipe Division representative for further details not listed on this drawing.

2.10 Stormwater Recharge (revised 7/14/2016)

The proposed stormwater management system has provided groundwater recharge through a subsurface drywells located in the lower portion of the site. This drywell will receive pretreated runoff from the two detention and treatment systems. This drywell will consist of precast concrete galleys set in a bed of crushed stone. The sizing has been based upon the existing soil types and overall increase in site impervious area.

The proposed drywell has been located in an area of highly permeable soils with sufficient depth to groundwater. Testing in this location was performed during the design of the wastewater leach field and was witnessed by MassDEP and the Town of Sudbury Board of Health. Field permeability tests were also performed to verify the rates used in the design. The testing results showed coarse sand with permeability rates of 100 inches per hour. Groundwater was encountered 66-inches below grade, or at approximately elevation *173.5*.

They drywell has been sized per the Dynamic Field Method as outlined below:

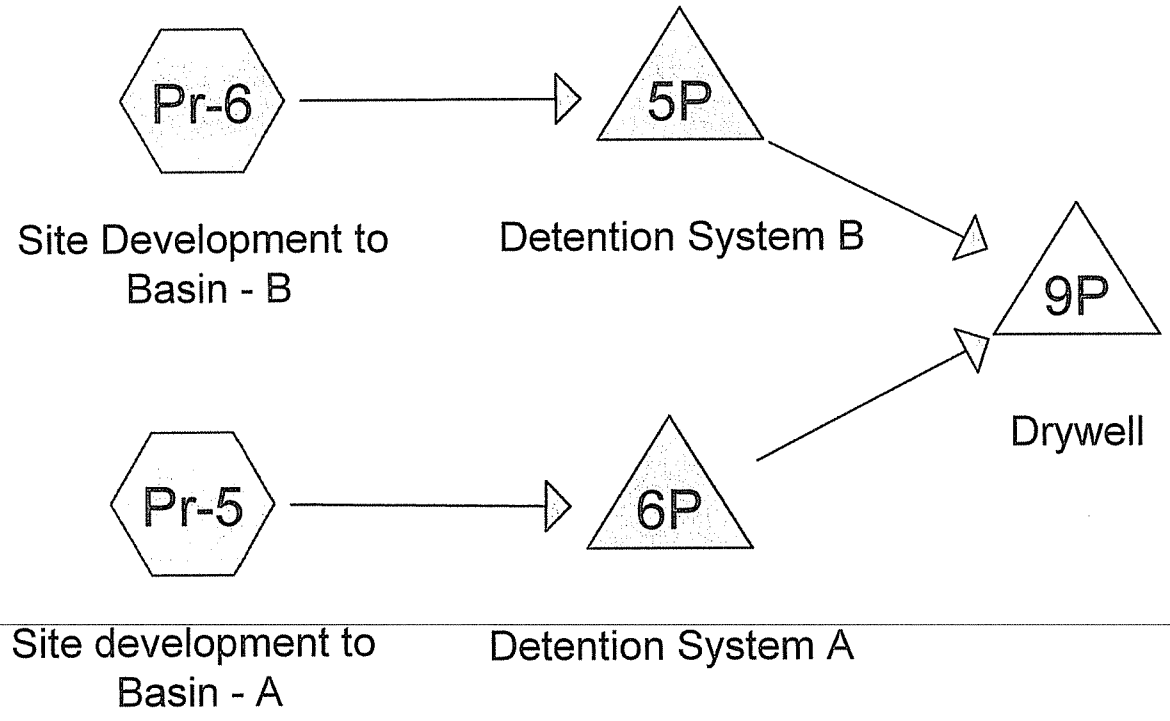
Total increase in impervious area = 324,210 sq. ft.
Area of Hydrologic Soil Group B = 70,240 sq. ft. (0.35 inches x impervious area)
Area of Hydrologic Soil Group C = 253,970 sq. ft. (0.25 inches x impervious area)
Required Recharge Volume =
Group B: 70,240 x 0.35 inches / *12 inches per foot* = 2,049 cubic feet
Group C: 253,970 x 0.25 inches / *12 inches per foot* = 5,291 cubic ft.
Total = 7,340 cubic feet
On-site Impervious Collected Area = 93%
Adjusted Required Volume 7,340 / 93% = 7,893 cubic feet
Total Required Recharge = **7,893 cubic feet**

Proposed Recharge Volume: (Dynamic Field Method)
Required Volume = 7,893 c.f. (0.181 acre feet)

1. Verify minimum sizing:
   Equivalent 24-hour storm over 12 hours = 1.18 inches
   Proposed bottom area = 1,620 sq. ft. (54'x30')
   Design exfiltration rate = 25 inches/hour (lowest field value = 96 in/hr)
   Maximum ponding depth = <0.1 feet

2. Calculate actual recharge volume:
   Equivalent 24-hour storm over 12 hours = 2.35 inches
   Proposed bottom area = 1,620 sq. ft. (54'x30')
   Design exfiltration rate = 25 inches/hour (lowest field value = 96 in/hr)
   Maximum ponding depth = 2.5 feet
   Available recharge = **22,000 cubic feet**

Pretreatment Provided:	>80%
Depth to Groundwater:	4' Min.
Drawdown Calculation:	Total storage volume = 3,600 C.F. (3,600 C.F.) / (25 in/hr x 1/12 x 1,620 sf) = 1.1 hour



Subcat Reach Pond Link

Drainage Diagram for 40B Drainage Overall
Prepared by Microsoft, Printed 6/10/2016

Summary for Subcatchment Pr-5: Site development to Basin - A

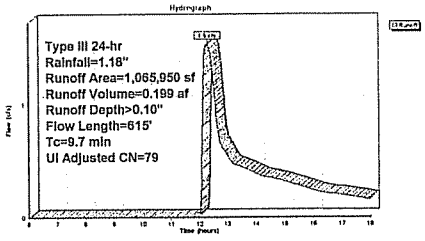
Runoff = 1.5 cfs @ 12.30 hrs, Volume= 0.199 af, Depth> 0.10"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.01 hrs
Type III 24-hr Rainfall=1.18"

Area (sf)	CN	Description
3,000	55	Woods, Good, HSG B
153,000	70	Woods, Good, HSG C
12,350	61	>75% Grass cover, Good, HSG B
528,150	74	>75% Grass cover, Good, HSG C
48,600	71	Meadow, non-grazed, HSG C
12,540	98	Paved parking, HSG B
130,305	98	Paved parking, HSG C
9,655	98	Roofs, HSG B
76,050	98	Roofs, HSG C
74,000	89	Gravel roads, HSG C
21,000	98	Unconnected pavement, HSG C
1,065,650	80	Weighted Average, UI Adjusted CN = 79
818,500		76.80% Pervious Area
247,450		23.21% Impervious Area
21,000		8.49% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
1.6	150	0.0530	1.61		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
1.6	200	0.0200	2.28		Shallow Concentrated Flow, C-D Unpaved Kv= 16.1 fps
0.7	150	0.0230	3.08		Shallow Concentrated Flow, D-E Paved Kv= 20.3 fps
0.6	85	0.1300	2.52		Shallow Concentrated Flow, E-F Short Grass Pasture Kv= 7.0 fps
9.8	615	Total			

Subcatchment Pr-5: Site development to Basin - A



Summary for Subcatchment Pr-6: Site Development to Basin - B

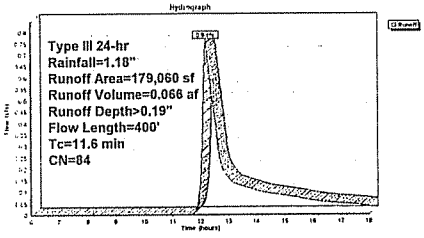
Runoff = 0.8 cfs @ 12.19 hrs, Volume= 0.066 af, Depth> 0.15"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.01 hrs
Type III 24-hr Rainfall=1.18"

Area (sf)	CN	Description
13,075	61	>75% Grass cover, Good, HSG B
71,580	74	>75% Grass cover, Good, HSG C
9,000	70	Woods, Good, HSG C
26,495	98	Paved roads w/curbs & sewers, HSG B
39,495	98	Paved parking, HSG C
6,680	98	Roofs, HSG B
12,735	98	Roofs, HSG C
179,060	84	Weighted Average
93,655		52.30% Pervious Area
85,405		47.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
2.4	225	0.0500	1.57		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
1.0	125	0.0100	2.03		Shallow Concentrated Flow, C-D Paved Kv= 20.3 fps
11.6	400	Total			

Subcatchment Pr-6: Site Development to Basin - B



Summary for Pond 6P: Detention System B

Inflow Area = 4.111 ac, 47.70% Impervious, Inflow Depth > 0.19"
Inflow = 0.8 cfs @ 12.19 hrs, Volume= 0.066 af
Outflow = 0.4 cfs @ 12.54 hrs, Volume= 0.066 af, Atten= 49%, Lag= 21.1 min
Primary = 0.4 cfs @ 12.54 hrs, Volume= 0.066 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.01 hrs
Peak Elev= 183.19' @ 12.54 hrs Surf Area= 1,600 sf Storage= 446 cf

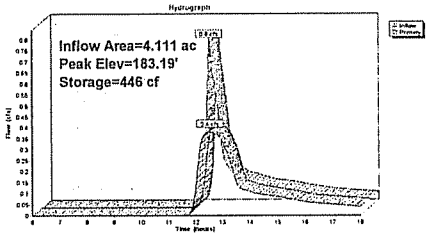
Plug-Flow detention time= 7.0 min calculated for 0.066 af (100% of inflow)
Center-of-Mass det. time= 7.7 min (825.0 - 818.2)

Volume	Invert	Avail.Storage	Storage Description
#1	183.00'	23,562 cf	60.0" D x 150.0'L Pipe Storage S= 0.0030 '/' x 8
#2	183.00'	2,358 cf	60.0" D x 60.0'L Pipe Storage x 2
#3	183.00'	7,658 cf	60.0" D x 390.0'L Pipe Storage S= 0.0025 '/'
#4	182.20'	5,301 cf	60.0" D x 270.0'L Pipe Storage S= 0.0030 '/'
		38,877 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	182.20'	4.0" Vert. Orifice/Grate C= 0.600
#2	Primary	184.60'	8.0" Vert. Orifice/Grate C= 0.600
#3	Primary	187.00'	5.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)

Primary OutFlow Max=0.4 cfs @ 12.54 hrs HW=183.19' (Free Discharge)
1=Orifice/Grate (Orifice Controls 0.4 cfs @ 4.36 fps)
2=Orifice/Grate (Controls 0.0 cfs)
3=Sharp-Crested Rectangular Weir (Controls 0.0 cfs)

Pond 6P: Detention System B



Summary for Pond 6P: Detention System A

Inflow Area = 24.471 ac, 23.21% Impervious, Inflow Depth > 0.10"
Inflow = 1.5 cfs @ 12.30 hrs, Volume= 0.199 af
Outflow = 0.3 cfs @ 15.68 hrs, Volume= 0.118 af, Atten= 83%, Lag= 202.9 min
Primary = 0.3 cfs @ 15.68 hrs, Volume= 0.118 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 184.57' @ 15.68 hrs Surf Area= 10,453 sf Storage= 4,002 cf

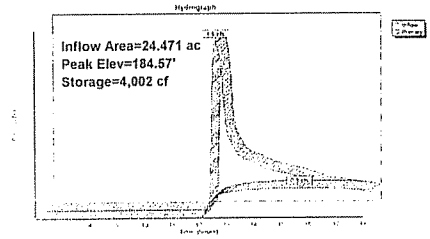
Plug-Flow detention time= 145.5 min calculated for 0.118 af (59% of inflow)
Center-of-Mass det. time= 73.5 min (914.4 - 840.9)

Volume	Invert	Avail.Storage	Storage Description
#1	184.00'	231,650 cf	144.0" D x 2,050.0'L Pipe Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	184.00'	4.0" Vert. Orifice/Grate C= 0.600
#2	Primary	187.62'	10.0" Vert. Orifice/Grate C= 0.600
#3	Primary	192.00'	8.0" Vert. Orifice/Grate C= 0.600
#4	Primary	185.00'	8.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)

Primary OutFlow Max=0.3 cfs @ 15.68 hrs HW=184.57' (Free Discharge)
1=Orifice/Grate (Orifice Controls 0.3 cfs @ 3.05 fps)
2=Orifice/Grate (Controls 0.0 cfs)
3=Orifice/Grate (Controls 0.0 cfs)
4=Sharp-Crested Rectangular Weir (Controls 0.0 cfs)

Pond 6P: Detention System A



Summary for Pond 9P: Drywell

Inflow Area = 28,581 sf, 26.74% Impervious, Inflow Depth > 0.05"
Inflow = 0.6 cfs @ 12.73 hrs, Volume= 0.184 af
Outflow = 0.6 cfs @ 12.74 hrs, Volume= 0.184 af, Atten= 0%, Lag= 0.5 min
Discarded = 0.6 cfs @ 12.74 hrs, Volume= 0.184 af
Primary = 0.0 cfs @ 6.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 178.19' @ 12.74 hrs Surf Area= 1,705 sf Storage= 24 cf

Plug-Flow detention time= 0.7 min calculated for 0.184 af (100% of inflow)
Center-of-Mass det. time= 0.4 min (883.0 - 882.6)

Volume	Invert	Avail.Storage	Storage Description
#1	178.65'	3,225 cf	5.16'W x 10.00'L x 2.50'H Prismatoid x 25 Inside #2
#2	178.15'	756 cf	31.00'W x 55.00'L x 3.00'H Prismatoid 5,115 cf Overall - 3,225 cf Embedded = 1,890 cf x 40.0% Voids
#3	160.00'	50 cf	4.00'D x 4.00'H Vertical Cone/Cylinder -Impervious
		4,031 cf	Total Available Storage

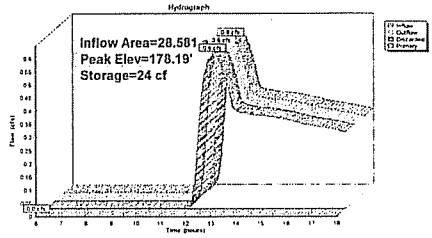
Device	Routing	Invert	Outlet Devices
#1	Primary	181.25'	36.0" Vert. Orifice/Grate C= 0.600
#2	Discarded	178.15'	25.000 in/hr Exfiltration over Horizontal area

Discarded OutFlow Max=1.0 cfs @ 12.74 hrs HW=178.19' (Free Discharge)
2=Exfiltration (Exfiltration Controls 1.0 cfs)

Primary OutFlow Max=0.0 cfs @ 6.00 hrs HW=178.15' (Free Discharge)
1=Orifice/Grate (Controls 0.0 cfs)

1. 0.184 ac-ft = 8,015 c.f.
(> Min. 7,893 c.f.)
OK ✓

Pond 9P: Drywell



2. Peak elev. < overflow
∴ OK ✓

Summary for Subcatchment Pr-5: Site development to Basin - A

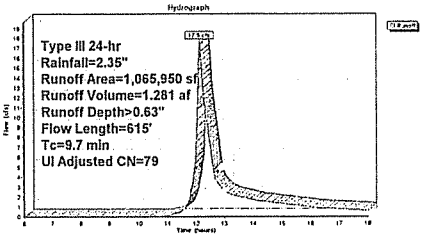
Runoff = 17.5 cfs @ 12.15 hrs, Volume= 1.281 af, Depth> 0.63"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.01 hrs
Type III 24-hr Rainfall=2.35"

Area (sf)	CN	Description
3,000	55	Woods, Good, HSG B
153,000	70	Woods, Good, HSG C
13,350	61	>75% Grass cover, Good, HSG B
528,150	74	>75% Grass cover, Good, HSG C
48,000	71	Meadow, non-grazed, HSG C
12,540	98	Paved parking, HSG B
130,305	98	Paved parking, HSG C
6,655	98	Roofs, HSG B
76,650	98	Roofs, HSG C
74,000	89	Gravel roads, HSG C
21,000	98	Unconnected pavement, HSG C
1,065,950	80	Weighted Average, UI Adjusted CN = 79
848,500		79.59% Pervious Area
217,450		20.41% Impervious Area
21,000		9.66% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	50	0.0600	0.16		**Sheet Flow, A-B** Grass Dense n= 0.240 P2= 3.20"
1.6	150	0.0530	1.61		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.5	200	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
0.7	130	0.0230	3.08		**Shallow Concentrated Flow, D-E** Paved Kv= 20.3 fps
0.6	85	0.1300	2.52		**Shallow Concentrated Flow, E-F** Short Grass Pasture Kv= 7.0 fps
9.7	615	Total			

Subcatchment Pr-5: Site development to Basin - A



Summary for Subcatchment Pr-6: Site Development to Basin - B

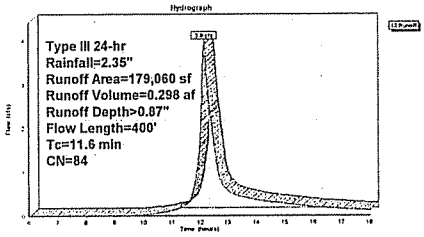
Runoff = 3.0 cfs @ 12.17 hrs, Volume= 0.298 af, Depth> 0.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 6.00-18.00 hrs, dt= 0.01 hrs
Type III 24-hr Rainfall=2.35"

Area (sf)	CN	Description
13,075	61	>75% Grass cover, Good, HSG B
71,580	74	>75% Grass cover, Good, HSG C
9,000	70	Woods, Good, HSG C
26,495	98	Paved roads w/curbs & sewers, HSG B
39,495	98	Paved parking, HSG C
6,660	98	Roofs, HSG B
12,735	98	Roofs, HSG C
179,060	84	Weighted Average
93,655		52.30% Pervious Area
85,405		47.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		Sheet Flow, A-B Grass Dense n= 0.240 P2= 3.20"
2.4	225	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.0	125	0.0100	2.03		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
11.6	400	Total			

Subcatchment Pr-6: Site Development to Basin - B



Summary for Pond 5P: Detention System B

Inflow Area = 4.111 ac, 47.70% Impervious, Inflow Depth > 0.87"
Inflow = 3.0 cfs @ 12.17 hrs, Volume= 0.298 af
Outflow = 0.6 cfs @ 13.02 hrs, Volume= 0.278 af, Atten= 80%, Lag= 51.5 min
Primary = 0.6 cfs @ 13.02 hrs, Volume= 0.278 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.01 hrs
Peak Elev= 184.14' @ 13.02 hrs Surf.Area= 7,648 sf Storage= 5,420 cf

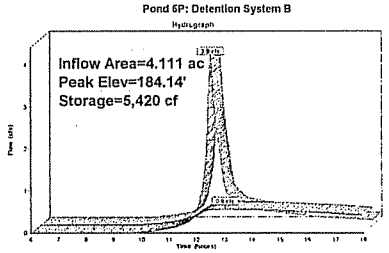
Plug-Flow detention time= 103.8 min calculated for 0.278 af (93% of inflow)
Center-of-Mass det. time= 88.7 min (870.5 - 781.9)

Volume	Invert	Avail.Storage	Storage Description
#1	183.00'	23,562 cf	**60.0" D x 150.0'L Pipe Storage S= 0.0030 '/' x 8**
#2	183.00'	2,356 cf	**60.0" D x 60.0'L Pipe Storage x 2**
#3	183.00'	7,658 cf	**60.0" D x 390.0'L Pipe Storage S= 0.0025 '/'**
#4	182.20'	5,301 cf	**60.0" D x 270.0'L Pipe Storage S= 0.0030 '/'**
		38,877 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	182.20'	**4.0" Vert. Orifice/Grate** C= 0.600
#2	Primary	184.50'	**8.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	187.00'	**5.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=0.6 cfs @ 13.02 hrs HW=184.14' (Free Discharge)
└1=Orifice/Grate (Orifice Controls 0.6 cfs @ 6.42 fps)
└2=Orifice/Grate (Controls 0.0 cfs)
└3=Sharp-Crested Rectangular Weir (Controls 0.0 cfs)

Pond 5P: Detention System B



Summary for Pond 6P: Detention System A

Inflow Area = 24.471 ac, 23.21% Impervious, Inflow Depth > 0.63"
Inflow = 17.5 cfs @ 12.15 hrs, Volume= 1.281 af
Outflow = 0.7 cfs @ 17.50 hrs, Volume= 0.326 af, Atten= 96%, Lag= 321.4 min
Primary = 0.7 cfs @ 17.50 hrs, Volume= 0.326 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 186.82' @ 17.50 hrs Surf.Area= 20,873 sf Storage= 41,631 cf

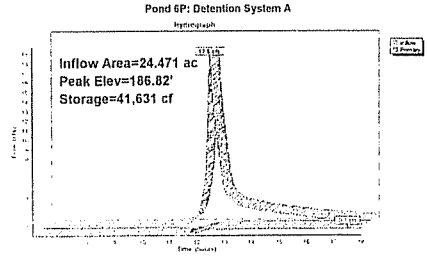
Plug-Flow detention time= 183.8 min calculated for 0.326 af (25% of inflow)
Center-of-Mass det. time= 103.3 min (903.9 - 800.6)

Volume	Invert	Avail.Storage	Storage Description
#1	184.00'	231,850 cf	**144.0" D x 2,050.0'L Pipe Storage**

Device	Routing	Invert	Outlet Devices
#1	Primary	184.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#2	Primary	187.00'	**10.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	192.00'	**8.0" Vert. Orifice/Grate** C= 0.600
#4	Primary	195.00'	**8.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=0.7 cfs @ 17.50 hrs HW=186.82' (Free Discharge)
└1=Orifice/Grate (Orifice Controls 0.7 cfs @ 7.85 fps)
└2=Orifice/Grate (Controls 0.0 cfs)
└3=Orifice/Grate (Controls 0.0 cfs)
└4=Sharp-Crested Rectangular Weir (Controls 0.0 cfs)

Pond 6P: Detention System A



Summary for Pond 9P: Drywell

Inflow Area = 28.581 ac, 26.74% Impervious, Inflow Depth > 0.25"
Inflow = 1.2 cfs @ 14.54 hrs, Volume= 0.604 af
Outflow = 1.0 cfs @ 12.26 hrs, Volume= 0.516 af, Atten= 16%, Lag= 0.0 min
Discarded = 1.0 cfs @ 12.26 hrs, Volume= 0.516 af
Primary = 0.0 cfs @ 6.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 6.00-18.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 181.06' @ 12.26 hrs Surf.Area= 1,705 sf Storage= 3,864 cf

Plug-Flow detention time= 25.6 min calculated for 0.515 af (85% of inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

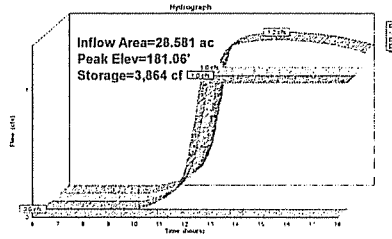
Volume	Invert	Avail.Storage	Storage Description
#1	178.65'	3,225 cf	**5.16'W x 10.00'L x 2.50'H Prismatoid x 25 Inside #2**
#2	178.15'	756 cf	**31.00'W x 55.00'L x 3.00'H Prismatoid** 5,115 cf Overall - 3,225 cf Embedded = 1,890 cf x 40.0% Voids
#3	160.00'	50 cf	**4.00'D x 4.00'H Vertical Cone/Cylinder -Impervious**
		4,031 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	181.25'	**36.0" Vert. Orifice/Grate** C= 0.600
#2	Discarded	178.15'	**25.000 in/hr Exfiltratio over Horizontal area**

Discarded OutFlow Max=1.0 cfs @ 12.26 hrs HW=178.21' (Free Discharge)
└2=Exfiltration (Exfiltration Controls 1.0 cfs)

Primary OutFlow Max=0.0 cfs @ 6.00 hrs HW=178.15' (Free Discharge)
└1=Orifice/Grate (Controls 0.0 cfs)

Pond 9P: Drywell



1. actual volume prior to overflow = 0.516 ac.ft or 22,477 CF. ok

2. Peak pond below overflow ok

2.11 Storm Drainage System Sizing Calculations (revised 7/14/2016)

The proposed storm drainage system has been designed from calculations based upon the 100-year storm frequency to ensure safe collection of runoff and conveyance to downstream discharge points.

2.11.1 Rate of Runoff Calculation

The proposed storm drainage system has been designed in accordance with the procedures outlined in THE Federal Highway Administration HEC 22, Urban Drainage design Manual. The peak discharge for design of the pavement drainage was determined using the Rational Method.

The formula for the Rational Method is: Q = CiA

Where: Q = peak discharge, cfs
C = runoff coefficient
i = average rainfall intensity, in./hr, for a storm duration equal to the time of concentration, Tc
A = drainage area, acres

The average intensity (i) utilized in the calculations was based upon exhibit 8-14 *Intensity – Duration – Frequency Curve for Worcester, MA.* The peak rate of runoff discharging from the subsurface detention systems was based upon HydroCAD model attached to the project Hydrologic and Hydraulic Analysis. The proposed drainage area (A) was based upon a field survey within the project limits and available GIS information for those upgradient areas.

2.11.2 Inlet Grates / Capacities

The plans provided inlet spaced at sufficient intervals along the running slopes and at low points to safely collect and convey surface runoff. Massachusetts standard cascade grates are used on all locations on continuous grades. At low points, rectangular bar rates are used because they efficiently accept flow from both directions and are safe for bicycles. Curb inlets have also been specified at critical low points as shown in the plan.

The inlet capacity of a typical cascade grate is 0.9 cfs for a single grate and 1.8 cfs for a double grate assuming a ponding depth of 0.2' and a wetted perimeter of 4.1' per grate. The 0.2' of head accounts for the grates to be set 0.1' below adjacent grade and 0.1' of flow depth. The inlet capacity of a standard bar grate to be used at low points would be 1.9 cfs for a single grate and 3.8 cfs for a double grate assuming a deeper depth of ponding of up to 4 inches and a wetted perimeter of 3.5 feet per grate. At double grates with curb inlets the capacity is increased to 5.2 cfs. The calculations and values listed above have assumed the grates will be 25% clogged.

Calculations are based upon the standard weir flow equation:

$Q = 3.33 \times L \times H^{3/2}$
Q = flow (ft^3/s)
L = perimeter of grate where flow is present (ft)
H = depth of water above grate (ft)

The inlet capacity of the two drop inlets would be 9.5 cfs prior to any surcharge above the cover. With 6 inches of surcharge the capacity increases to 15.6 cfs. The results are based upon the weir equation with two openings of 28 inches wide by 9 inches tall.

2.11.3 Summary of Drainage System Sizing Calculations

The following table presents the hydraulic calculations performed for sizing the site drainage system. The structure references refer to those as shown on the site plan submitted with this report.

DRAIN PIPE SIZING CALCULATIONS

PROJECT: The Village at Sudbury Crossing
Residential Development

LOCATION: Off Hudson & Concord Road
Sudbury, MA

BY: VC
DATE: 7/8/2016

n= 0.012
RETURN PERIOD: 100 YEAR
Impervious Area C = 0.95
Pervious Area C = 0.30

Line		Area	% Imperv.	C	CA	Tc	rain	Inlet flow Q	Pipe flow Qd	Pipe Size	Pipe Length	Slope	flowing full		Rim (feet)		Inv. El.	
FROM	TO	ac				min.	in/hr	cfs	cfs	in	ft	ft/ft	Qf	Vf	Upper	Lower	Upper	Lower
ACCESS DRIVE - 1																		
CB 0+10 R	DMH 0+40	0.35	45%	0.59	0.21	5.0	8.0	1.66	**1.66**	12	30	0.020	**5.46**	7.0	194.10	195.10	190.60	190.00
CB 0+27 L	DMH 0+40	0.08	100%	0.95	0.08	5.0	8.0	0.61	**0.61**	12	18	0.033	**7.05**	9.0	194.40	195.10	190.60	190.00
DMH 0+40	DMH 1+56				0.28	5.1	8.0		**2.27**	12	112	0.006	**2.94**	3.7	195.10	199.10	189.90	189.25
CB 1+46 R	DMH 1+56	0.50	25%	0.46	0.23	5.0	8.0	1.85	**1.85**	12	10	0.030	**6.69**	8.5	198.30	199.10	194.20	193.90
CB 1+46 L	DMH 1+56	0.06	100%	0.95	0.06	5.0	8.0	0.46	**0.46**	12	12	0.025	**6.11**	7.8	198.20	199.10	194.20	193.90
DMH 1+56	DMH 2+77				0.57	5.6	7.9	4.52	**4.52**	15	116	0.006	**5.24**	4.3	199.10	205.10	189.00	188.35
CB 2+67 R	DMH 2+77	0.25	30%	0.50	0.12	5.0	8.0	0.99	**0.99**	12	10	0.035	**7.22**	9.2	204.35	205.10	200.35	200.00
CB 2+67 L	DMH 2+77	0.08	100%	0.95	0.08	5.0	8.0	0.61	**0.61**	12	10	0.035	**7.22**	9.2	204.35	205.10	200.35	200.00
DMH 2+77	DMH 3+59				0.77	6.0	7.8		**6.02**	18	79	0.005	**8.10**	4.6	205.10	207.35	188.10	187.70
DMH 3+59	DMH 3+76				0.08	6.3	7.8		**0.59**	18	20	0.005	**8.05**	4.6	207.35	207.50	187.60	187.50
DMH 3+76	DMH 4+97				0.77	6.4	7.8		**6.02**	18	166	0.005	**7.90**	4.5	207.50	192.50	187.40	186.60

DRAIN PIPE SIZING CALCULATIONS

PROJECT: The Village at Sudbury Crossing
Residential Development

LOCATION: Off Hudson & Concord Road
Sudbury, MA

BY: VC
DATE: 7/8/2016

n= 0.012
RETURN PERIOD: **100 YEAR**
Impervious Area C = 0.95
Pervious Area C = 0.30

Line		Area	% Imperv.	C	CA	Tc	rain	Inlet flow Q	Pipe flow Qd	Pipe Size	Pipe Length	Slope	flowing full		Rim (feet)		Inv. El.	
FROM	TO	ac				min.	in/hr	cfs	cfs	in	ft	ft/ft	Qf	Vf	Upper	Lower	Upper	Lower
AD-4	AD-3	4.00	25%	0.46	1.85	15.0	5.5	10.18	**10.18**	18	8	0.031	**20.13**	11.4	228.00	223.00	219.25	219.00
AD-3	DMH E	0.10	0%	0.30	1.88	15.0	5.5	10.34	**10.34**	18	26	0.031	**19.97**	11.3	223.00	222.00	217.30	216.50
ROOF 12	DMH E	0.06	100%	0.95	0.06	5.0	8.0	0.46	**0.46**	6	175	0.035	**1.14**	5.8	---	222.00	223.00	216.90
DMH E	DMH 8+83	0.06	100%	0.95	1.99	15.0	5.5		**10.97**	18	65	0.029	**19.47**	11.0	222.00	214.60	211.50	209.60
CB 9+02 R	DMH 8+83	0.12	90%	0.89	0.11	5.0	8.0	0.85	**0.85**	12	24	0.035	**7.27**	9.3	214.95	214.60	210.95	210.10
CB 9+06 L	DMH 8+83	0.16	75%	0.79	0.13	5.0	8.0	1.01	**1.01**	12	28	0.021	**5.65**	7.2	214.70	214.60	210.70	210.10
DMH 8+83	DMH 7+93				2.23	15.1	5.5		**12.24**	18	86	0.035	**21.27**	12.0	214.60	211.50	209.50	206.50
CB 8+03 R	DMH 7+93	0.13	85%	0.85	0.11	5.0	8.0	0.89	**0.89**	12	15	0.057	**9.19**	11.7	211.80	211.50	207.80	206.95
CB 8+03 L	DMH 7+93	0.13	85%	0.85	0.11	5.0	8.0	0.89	**0.89**	12	21	0.021	**5.65**	7.2	211.40	211.50	207.40	206.95
DMH 7+93	DMH 7+05				2.45	15.2	5.5	13.46	**13.46**	18	85	0.041	**23.11**	13.1	211.50	207.46	206.40	202.90
AD-2	DMH D	0.52	0%	0.30	0.16	7.5	7.3	1.14	**1.14**	12	32	0.037	**7.48**	9.5	216.50	216.00	211.50	210.30
ROOF 11	DMH D	0.06	100%	0.95	0.06	5.0	8.0	0.46	**0.46**	6	175	0.054	**1.41**	7.2	---	216.00	220.00	210.60
DMH D	DMH 7+05	0.06	100%	0.95	0.27	7.6	7.3		**1.97**	12	66	0.029	**6.55**	8.3	216.00	207.46	205.30	203.40
CB 7+26 R	DMH 7+05	0.05	100%	0.95	0.05	5.0	8.0	0.38	**0.38**	12	23	0.026	**6.24**	7.9	208.20	207.46	204.00	203.40
CB 7+26 L	DMH 7+05	0.07	100%	0.95	0.07	5.0	8.0	0.53	**0.53**	12	28	0.021	**5.65**	7.2	207.80	207.46	204.00	203.40
DMH 7+05	DMH 6+83				2.72	7.7	7.3		**19.84**	24	18	0.028	**40.87**	13.0	207.46	206.66	202.30	201.80
AD-1	DMH C	1.70	0%	0.30	0.51	12.0	6.2	3.16	**3.16**	12	24	0.050	**8.63**	11.0	214.50	214.00	209.50	208.30
ROOF 9	DMH C	0.06	100%	0.95	0.06	5.0	8.0	0.46	**0.46**	6	175	0.031	**1.07**	5.4	---	214.00	214.00	208.60
ROOF 10	DMH C	0.06	100%	0.95	0.06	5.0	8.0	0.46	**0.46**	6	175	0.031	**1.07**	5.4	---	214.00	214.00	208.60
DMH C	DMH 5+26	0.12	100%	0.95	0.74	12.0	6.2		**4.58**	12	64	0.039	**7.63**	9.7	214.00	204.70	203.30	200.80
DMH 5+26	DMH 5+71				0.74	12.1	6.2		**4.58**	12	42	0.012	**4.21**	5.4	204.80	204.70	200.70	200.20
CB 5+60 R	DMH 5+71	0.38	85%	0.85	0.32	5.0	8.0	2.59	**2.59**	12	14	0.021	**5.65**	7.2	204.50	204.70	201.00	200.70
CB 5+60 L	DMH 5+71	0.32	85%	0.85	0.27	5.0	8.0	2.18	**2.18**	12	10	0.030	**6.69**	8.5	204.50	204.70	201.00	200.70
DMH 5+71	DMH 6+83				1.33	12.3	6.1		**8.14**	18	108	0.011	**11.75**	6.6	204.70	206.66	199.95	198.80

DRAIN PIPE SIZING CALCULATIONS

PROJECT The Village at Sudbury Crossing
Residential Development

LOCATION Off Hudson & Concord Road
Sudbury, MA

BY: VC
DATE: 7/8/2016

n= 0.012
RETURN PERIOD 100 YEAR
Impervious Area C = 0.95
Pervious Area C = 0.30

Line		Area	% Imperv.	C	CA	Tc	rain	Inlet flow Q	Pipe flow Qd	Pipe Size	Pipe Length	Slope	flowing full		Rim (feet)		Inv. El.	
FROM	TO	ac				min.	in/hr	cfs	cfs	in	ft	ft/ft	Qf	Vf	Upper	Lower	Upper	Lower
CB 11+19 R	DMH 11+29	0.11	75%	0.79	0.09	5.0	8.0	0.69	**0.69**	12	7	0.036	**7.30**	9.3	215.70	216.04	211.70	211.45
CB 11+19 L	DMH 11+29	0.10	85%	0.85	0.09	5.0	8.0	0.68	**0.68**	12	33	0.020	**5.42**	6.9	216.10	216.04	212.10	211.45
DMH 11+29	DMH 12+38				0.17	5.1	8.0		**1.38**	12	108	0.032	**6.95**	8.9	216.04	212.33	211.30	207.80
CB 12+22 L	DMH 12+38	0.15	65%	0.72	0.11	5.0	8.0	0.87	**0.87**	12	34	0.021	**5.54**	7.1	212.50	212.33	208.50	207.80
DMH 12+38	DMH 12+54				0.41	5.3	8.0		**3.31**	12	14	0.029	**6.53**	8.3	212.33	211.70	207.70	207.30
CB 12+52 R	DMH 12+54	0.14	100%	0.95	0.13	5.0	8.0	1.06	**1.06**	12	6	0.033	**7.05**	9.0	211.50	211.70	207.50	207.30
DMH 12+54	DMH 13+02				0.55	5.3	7.9		**4.32**	15	46	0.029	**12.00**	9.8	211.70	209.15	206.25	204.90
AD-6	DMH-A	3.50	20%	0.43	1.51	9.7	6.7	10.08	**10.08**	18	43	0.030	**19.80**	11.2	228.00	226.00	222.00	220.70
DMH-A	DMH-B				1.51	9.8	6.7		**10.08**	18	12	0.029	**19.45**	11.0	226.00	218.00	213.80	213.45
ROOF 13	AD-5	0.07	100%	0.95	0.07	5.0	8.0	0.53	**0.53**	8	180	0.022	**1.95**	5.6	---	222.50	223.00	219.00
AD-5	DMH-B	0.11	0%	0.30	0.10	5.0	8.0	0.80	**0.80**	8	66	0.068	**3.42**	9.8	222.50	218.00	218.50	214.00
DMH-B	DMH 13+02	0.06	100%	0.95	1.66	9.8	6.7		**11.13**	18	66	0.029	**19.32**	10.9	218.00	209.15	206.55	204.65
DMH 13+02	DMH 14+23				2.21	9.9	6.6	14.57	**14.57**	18	118	0.037	**21.86**	12.4	209.15	204.82	204.15	199.80
CB 14+11R	DMH 14+23	0.52	30%	0.50	0.26	5.0	8.0	2.06	**2.06**	12	24	0.021	**5.57**	7.1	204.50	204.82	200.70	200.20
CB 14+04 L	DMH 14+23	0.17	70%	0.76	0.13	5.0	8.0	1.03	**1.03**	12	21	0.038	**7.54**	9.6	205.00	204.82	201.00	200.20
DMH 14+23	DMH 0+41 D3				2.59	10.0	6.5	16.86	**16.86**	18	79	0.028	**19.00**	10.8	204.82	203.03	199.20	197.00

DRAIN PIPE SIZING CALCULATIONS

PROJECT: The Village at Sudbury Crossing
Residential Development

LOCATION: Off Hudson & Concord Road
Sudbury, MA

BY: VC
DATE: 7/8/2016

n= 0.012
RETURN PERIOD: 100 YEAR
Impervious Area C = 0.95
Pervious Area C = 0.30

Line		Area	% Imperv.	C	CA	Tc	rain	Inlet flow Q	Pipe flow Qd	Pipe Size	Pipe Length	Slope	flowing full		Rim (feet)		Inv. El.	
FROM	TO	ac				min.	in/hr	cfs	cfs	in	ft	ft/ft	Qf	Vf	Upper	Lower	Upper	Lower
PETERS WAY																		
Existing FE	DMH 0+17	2.25	15%	0.40	0.89	8.0	7.0	6.26	**6.26**	12	26	0.037	**7.42**	9.4	---	222.58	217.46	216.50
DMH 0+17	DMH 1+00				0.89	8.0	7.0		**6.26**	15	80	0.020	**9.90**	8.1	222.58	220.36	216.40	214.80
DMH 1+00	DMH 2+48				0.89	8.2	7.0		**6.26**	15	145	0.020	**9.82**	8.0	220.36	217.96	214.70	211.85
CB 2+36 R	DMH 2+48	0.25	100%	0.95	0.24	5.0	8.0	1.90	**1.90**	12	11	0.023	**5.82**	7.4	217.60	217.96	213.65	213.40
CB 2+36 L	DMH 2+48	0.62	40%	0.56	0.35	8.3	6.9	2.40	**2.40**	12	11	0.023	**5.82**	7.4	217.60	217.96	213.65	213.40
DMH 2+48	DMH 2+87				1.48	8.3	6.9		**10.21**	18	34	0.016	**14.48**	8.2	217.96	218.30	211.50	210.95
HW 2+87	DMH 2+87	1.75	10%	0.37	0.64	7.2	7.4	4.73	**4.73**	18	14	0.014	**13.61**	7.7	---	218.30	211.00	210.80
DMH 2+87	DMH 4+25				2.12	8.4	6.9		**14.61**	24	135	0.005	**17.66**	5.6	218.30	222.22	210.55	209.85
DMH 4+25	DMH 6+88				2.12	8.8	6.8		**14.40**	24	260	0.005	**17.67**	5.6	222.22	221.08	209.75	208.40
CB 6+75 R	DMH 6+88	0.08	100%	0.95	0.08	5.0	8.0	0.61	**0.61**	12	10	0.050	**8.63**	11.0	221.00	221.08	217.00	216.50
CB 6+75 L	DMH 6+88	0.61	20%	0.43	0.26	9.7	6.7	1.76	**1.76**	12	16	0.031	**6.83**	8.7	221.00	221.08	217.00	216.50
DMH 6+88	DMH 7+72				2.46	9.7	6.7		**16.46**	24	80	0.005	**17.34**	5.5	221.08	220.05	208.30	207.90
DMH 7+72	DMH 8+79				2.46	9.8	6.7		**16.46**	24	104	0.010	**24.05**	7.7	220.05	215.54	207.80	206.80
CB 8+74 R	DMH 8+79	0.09	100%	0.95	0.09	5.0	8.0	0.68	**0.68**	12	8	0.031	**6.83**	8.7	215.00	215.54	211.00	210.75
CB 8+74 L	DMH 8+79	0.38	35%	0.53	0.20	6.3	7.7	1.54	**1.54**	12	8	0.031	**6.83**	8.7	215.00	215.54	211.00	210.75
DMH 8+79	DMH 10+63				2.74	10.0	6.5		**17.82**	24	180	0.030	**42.48**	13.5	215.54	206.18	206.25	200.85
CB 10+58 R	DMH 10+63	0.08	100%	0.95	0.08	5.0	8.0	0.61	**0.61**	12	8	0.025	**6.11**	7.8	206.05	206.18	202.05	201.85
CB 10+58 L	DMH 10+63	0.17	60%	0.69	0.12	5.0	8.0	0.94	**0.94**	12	8	0.025	**6.11**	7.8	206.05	206.18	202.05	201.85
DMH 10+63	DMH 10+96				2.94	10.2	6.5	19.08	**19.08**	24	30	0.022	**36.10**	11.5	206.18	205.14	200.75	200.10
DI 10+85 L	DMH 10+96	2.10	25%	0.46	0.97	10.6	6.4	6.22	**6.22**	15	32	0.020	**9.98**	8.1	203.50	205.14	200.00	199.35
DMH 10+96	DMH 0+41 D3				3.91	10.7	6.4	25.00	**25.00**	24	82	0.020	**34.79**	11.1	205.14	203.03	198.35	196.70

DRAIN PIPE SIZING CALCULATIONS

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Residential Development

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BY: VC
DATE: 7/8/2016

n= 0.012
RETURN PERIOD: **100 YEAR**
Impervious Area C = 0.95
Pervious Area C = 0.30

Line		Area	% Imperv.	C	CA	Tc	rain	Inlet flow Q	Pipe flow Qd	Pipe Size	Pipe Length	Slope	flowing full		Rim (feet)		Inv. El.	
FROM	TO	ac				min.	in/hr	cfs	cfs	in	ft	ft/ft	Qf	Vf	Upper	Lower	Upper	Lower
ACCESS DRIVE 3																		
CB 0+61 R	DMH 0+41	0.14	100%	0.95	0.13	5.0	8.0	1.06	**1.06**	12	22	0.023	**5.82**	7.4	202.40	202.45	198.40	197.90
DMH 0+41	DMH 0+66				6.50	10.8	6.4		**41.60**	30	29	0.021	**63.97**	13.0	202.45	203.00	192.90	192.30
CB 0+66 L	DMH 0+66	0.20	80%	0.82	0.16	5.0	8.0	1.31	**1.31**	12	8	0.038	**7.48**	9.5	202.40	203.00	198.40	198.10
DMH 0+66	DET. A				6.66	10.8	6.4		**42.65**	30	15	0.020	**62.89**	12.8	203.00	---	186.30	186.00
DET. A	WQ-A	From Hyrdo Model						10.50	**10.50**	36	5	0.020	**102.27**	14.5	200.75	199.50	183.00	182.90
DET. B	WQ-B	From Hydro Model						3.80	**3.80**	24	5	0.020	**34.68**	11.0	201.50	199.70	182.10	182.00
WQ-A	DMH 2+22								**10.50**	36	25	0.010	**72.32**	10.2	199.50	199.00	182.80	182.55
WQ-B	DMH 2+22								**3.80**	24	10	0.010	**24.52**	7.8	199.70	199.00	181.90	181.80
DMH 2+22	DMH 2+76								**14.30**	36	47	0.0053	**52.74**	7.5	199.00	196.55	181.60	181.35
DMH 2+76	DMH 3+35								**14.30**	36	52	0.0054	**53.07**	7.5	196.55	194.50	181.25	180.97
DMH 3+35	DMH 3+51								**14.30**	36	60	0.0053	**52.81**	7.5	194.50	192.20	180.87	180.55
DMH 3+51	36" HW								**14.30**	36	37	0.0054	**53.17**	7.5	192.20	---	180.45	180.25
CB 2+77 L	DMH 2+38	0.46	70%	0.76	0.35	5.0	8.0	2.78	**2.78**	12	34	0.010	**3.92**	5.0	196.25	198.20	192.85	192.50
ROOF 2F	DMH 2+38	0.20	100%	0.95	0.19	5.0	8.0	1.52	**1.52**	12	265	0.010	**3.90**	5.0	---	198.20	195.20	192.50
DMH 2+38	DMH 1+88				0.54	5.0	8.0		**4.30**	15	44	0.010	**7.08**	5.8	198.20	199.90	192.40	191.95
ROOF 3F	DMH 1+88	0.20	100%	0.95	0.19	5.0	8.0	1.52	**1.52**	12	150	0.017	**4.99**	6.3	---	199.90	195.00	192.50
DMH 1+88	DET. A				0.54	5.0	8.0		**4.30**	15	14	0.014	**8.37**	6.8	199.90	---	191.85	191.65
CB 3+61 R	12" HW	0.40	80%	0.82	0.33	5.0	8.0	2.62	**2.62**	12	8	0.050	**8.63**	11.0	190.50	---	181.40	181.00

DRAIN PIPE SIZING CALCULATIONS

PROJECT The Village at Sudbury Crossing
Residential Development

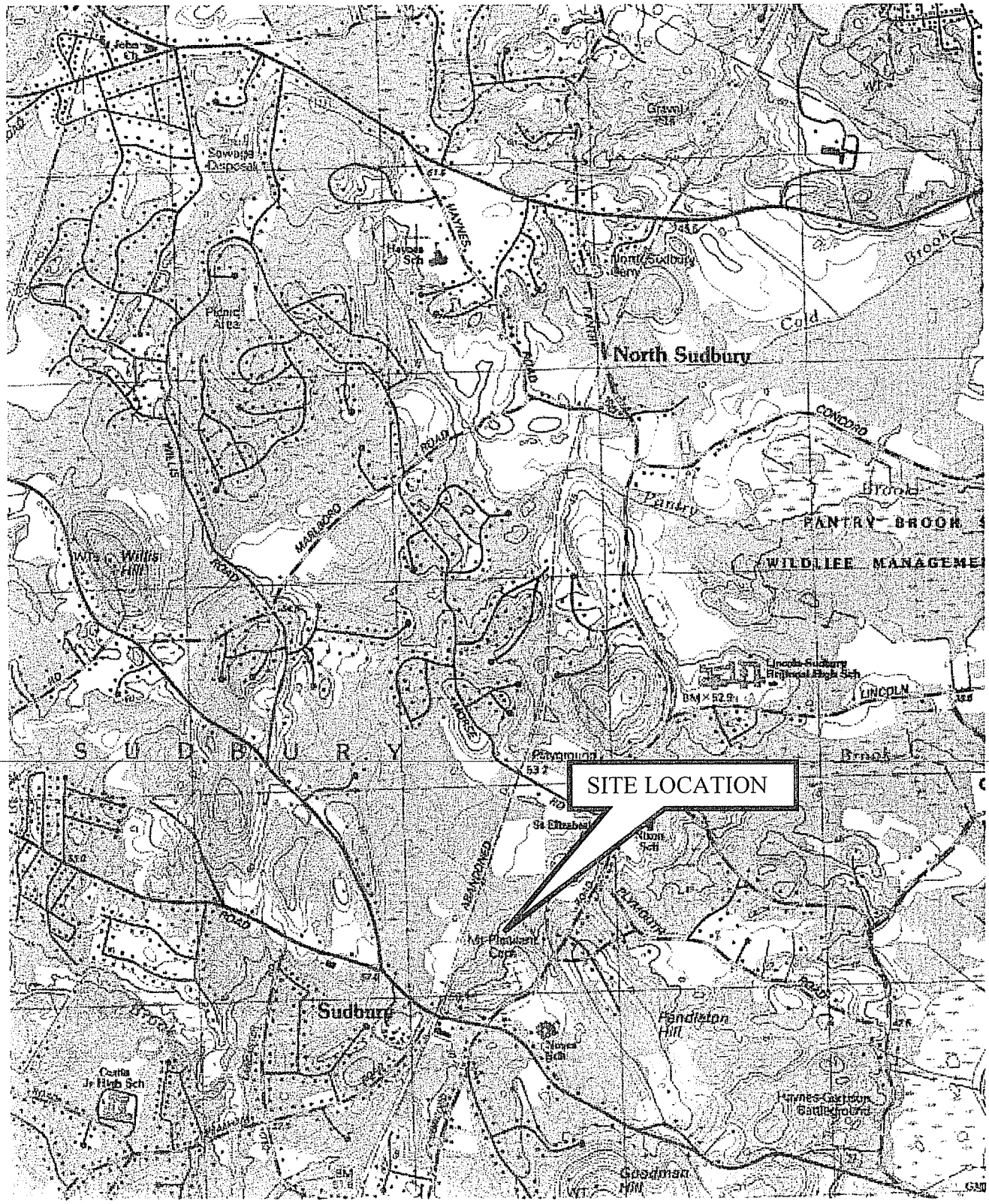
LOCATION Off Hudson & Concord Road
Sudbury, MA

BY: VC
DATE: 7/8/2016

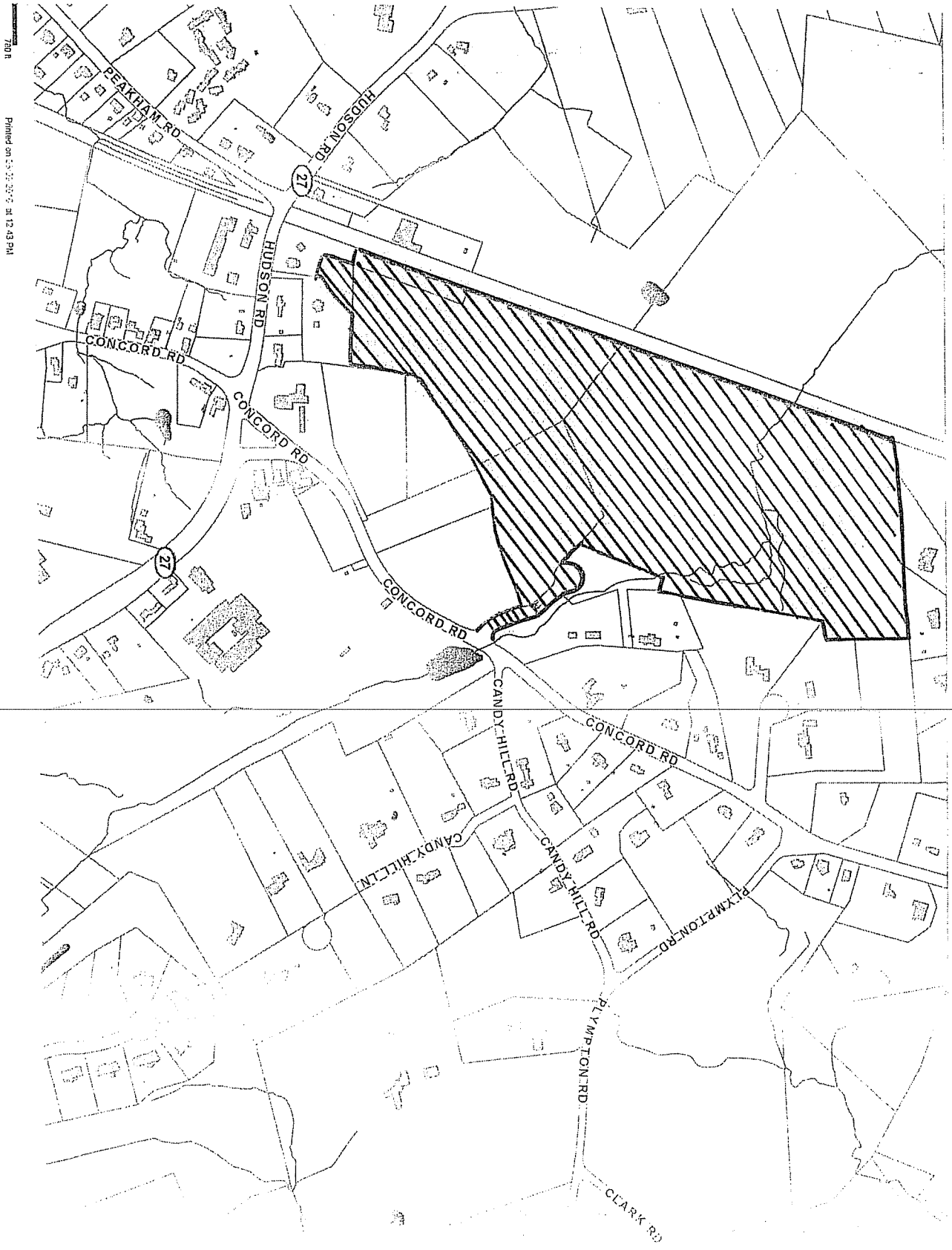
n= 0.012
RETURN PERIOD **100 YEAR**
Impervious Area C = 0.95
Pervious Area C = 0.30

Line		Area	% Imperv.	C	CA	Tc	rain	Inlet flow Q	Pipe flow Qd	Pipe Size	Pipe Length	Slope	flowing full		Rim (feet)		Inv. El.	
FROM	TO	ac				min.	in/hr	cfs	cfs	in	ft	ft/ft	Qf	Vf	Upper	Lower	Upper	Lower
ACCESS DRIVE - 2																		
DMH 6+83 D1	DMH 0+40				4.05	12.5	6.1		**24.72**	24	30	0.023	**37.46**	11.9	206.66	205.65	198.30	197.60
ROOF 6	DMH 0+40	0.04	100%	0.95	0.04	5.0	8.0	0.30	**0.30**	8	150	0.013	**1.47**	4.2	---	205.65	201.50	199.60
DMH 0+40	DMH 0+98				4.09	12.6	6.1		**24.95**	24	57	0.023	**37.04**	11.8	205.65	203.33	197.40	196.10
DMH 0+98	DMH 1+67				4.09	12.7	6.1		**24.95**	24	67	0.021	**35.45**	11.3	203.33	201.25	195.90	194.50
CB 1+57R	DMH 1+67	0.20	65%	0.72	0.14	5.0	8.0	1.16	**1.16**	12	15	0.033	**7.05**	9.0	201.45	201.25	197.45	196.95
CB 1+57 L	DMH 1+67	0.17	65%	0.72	0.12	5.0	8.0	0.98	**0.98**	12	21	0.024	**5.96**	7.6	201.10	201.25	197.45	196.95
DMH 1+67	DMH 2+21				4.36	12.8	6.1		**26.58**	24	50	0.025	**38.78**	12.3	201.25	198.00	194.25	193.00
CB 2+44 L	DMH 2+21	0.11	80%	0.82	0.09	5.0	8.0	0.72	**0.72**	12	29	0.010	**3.93**	5.0	195.90	198.00	192.90	192.60
ROOF 1F	DMH 2+21	0.17	100%	0.95	0.16	5.0	8.0	1.29	**1.29**	12	180	0.033	**7.05**	9.0	---	198.00	199.00	193.00
DMH 2+21	DMH 2+39				4.61	12.8	6.1		**28.12**	30	29	0.007	**36.93**	7.5	198.00	199.00	191.60	191.40
CB 2+44 R	DMH 2+39	0.08	85%	0.85	0.07	5.0	8.0	0.55	**0.55**	12	10	0.030	**6.69**	8.5	196.35	199.00	192.90	192.60
DMH 2+39	DMH 2+90				4.68	12.9	6.0		**28.07**	30	100	0.007	**37.21**	7.6	199.00	202.25	191.30	190.60
ROOF 5	C/O	0.33	100%	0.95	0.31	5.0	8.0	2.51	**2.51**	12	420	0.033	**7.05**	9.0	---	203.50	212.00	198.00
ROOF 4	C/O	0.33	100%	0.95	0.31	5.0	8.0	2.51	**2.51**	12	600	0.025	**6.11**	7.8	---	203.50	213.00	198.00
C/O	DMH 2+90				0.63	5.0	8.0		**5.02**	12	24	0.042	**7.88**	10.0	203.50	202.25	197.60	196.60
DMH 2+90	DMH 3+11				4.99	13.1	6.0		**29.95**	30	60	0.008	**40.60**	8.3	203.50	202.25	190.50	190.00
DMH 3+11	DET. A				4.99	13.1	6.0		**29.95**	30	10	0.020	**62.89**	12.8	202.25	---	186.20	186.00
CB 3+10 R	DET. B	1.20	10%	0.37	0.44	10.0	6.4	2.80	**2.80**	12	8	0.050	**8.63**	11.0	197.50	---	186.90	186.50
ROOF 2R	DET. B	0.20	100%	0.95	0.19	5.0	8.0	1.52	**1.52**	12	275	0.013	**4.36**	5.5	---	---	190.00	186.50
ROOF 1R	DET. B	0.17	100%	0.95	0.16	5.0	8.0	1.29	**1.29**	12	230	0.010	**3.86**	4.9	---	---	188.50	186.20
CB A	DMH F	0.57	75%	0.79	0.45	5.0	8.0	3.59	**3.59**	12	9	0.033	**7.05**	9.0	189.50	190.25	186.50	186.20
CB B	DMH F	0.60	90%	0.89	0.53	5.0	8.0	4.25	**4.25**	12	21	0.014	**4.62**	5.9	189.50	190.25	186.50	186.20
DMH F	DET. B				0.98	5.0	8.0	7.84	**7.84**	18	30	0.010	**11.39**	6.4	190.25	---	186.10	185.80

3.1 USGS Locus Map

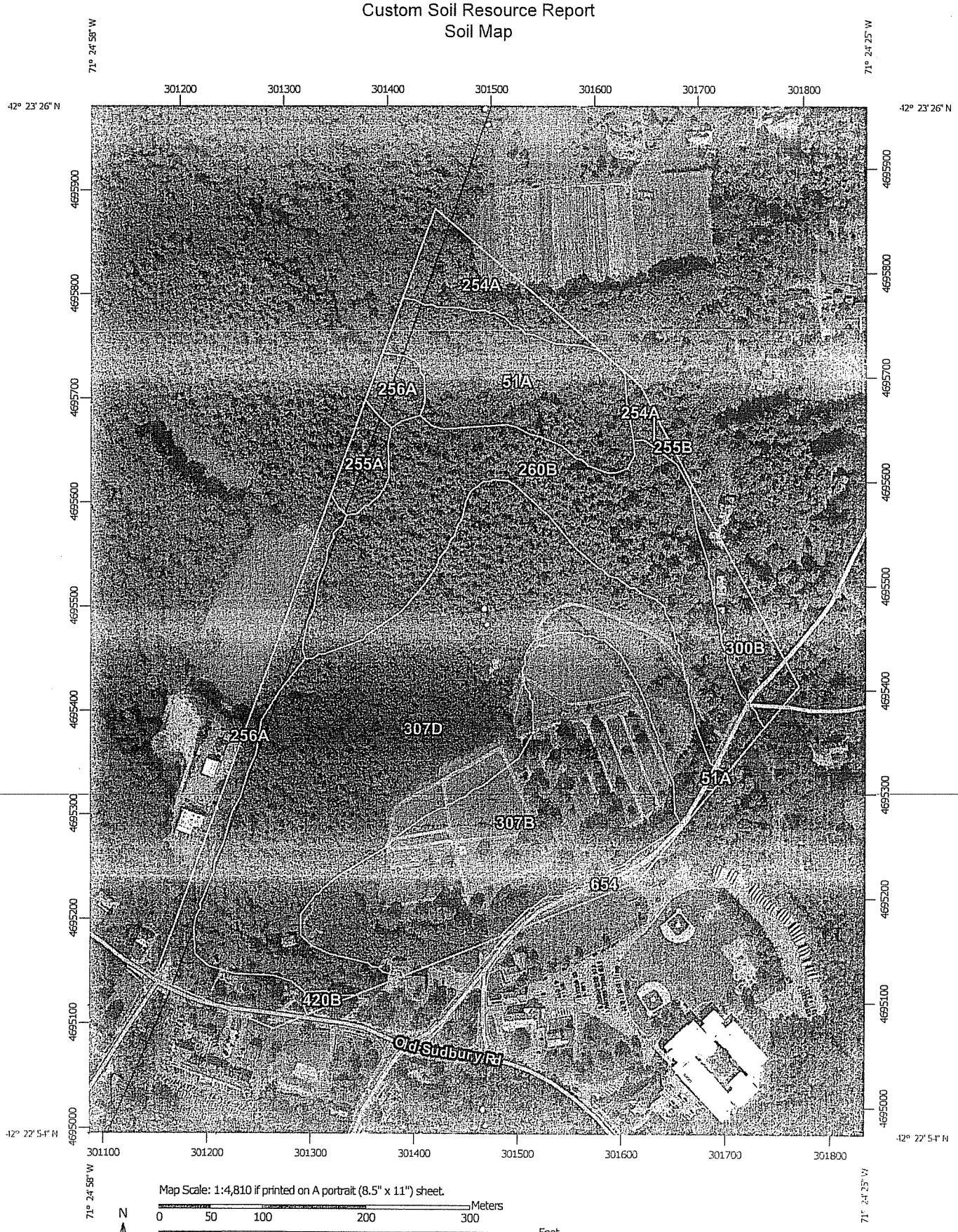


3.2 Sudbury GIS Mapping



Appendix A - NRCS SOIL MAPPING

Custom Soil Resource Report
Soil Map



Map Unit Legend

Middlesex County, Massachusetts (MA017)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
51A	Swansea muck, 0 to 1 percent slopes	5.7	8.8%
254A	Merrimac fine sandy loam, 0 to 3 percent slopes	2.5	3.8%
255A	Windsor loamy sand, 0 to 3 percent slopes	0.9	1.5%
255B	Windsor loamy sand, 3 to 8 percent slopes	0.1	0.2%
256A	Deerfield loamy sand, 0 to 3 percent slopes	4.2	6.5%
260B	Sudbury fine sandy loam, 3 to 8 percent slopes	11.9	18.5%
300B	Montauk fine sandy loam, 3 to 8 percent slopes	1.9	2.9%
307B	Paxton fine sandy loam, 0 to 8 percent slopes, extremely stony	13.6	21.0%
307D	Paxton fine sandy loam, 15 to 25 percent slopes, extremely stony	22.9	35.5%
420B	Canton fine sandy loam, 3 to 8 percent slopes	0.1	0.2%
654	Udorthents, loamy	0.7	1.2%
Totals for Area of Interest		**64.5**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

260B—Sudbury fine sandy loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 9915
Elevation: 0 to 2,100 feet
Mean annual precipitation: 45 to 54 inches
Mean annual air temperature: 43 to 54 degrees F
Frost-free period: 145 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Sudbury and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sudbury

Setting

Landform: Terraces, plains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Friable loamy eolian deposits over loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: fine sandy loam
H2 - 8 to 20 inches: fine sandy loam
H3 - 20 to 27 inches: loamy sand
H4 - 27 to 65 inches: stratified gravelly coarse sand to sand

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B

307B—Paxton fine sandy loam, 0 to 8 percent slopes, extremely stony

Map Unit Setting

National map unit symbol: 2w675
Elevation: 0 to 1,580 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Paxton, extremely stony, and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton, Extremely Stony

Setting

Landform: Hills, ground moraines, drumlins
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 10 inches: fine sandy loam
Bw1 - 10 to 17 inches: fine sandy loam
Bw2 - 17 to 28 inches: fine sandy loam
Cd - 28 to 67 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 20 to 43 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: C

Minor Components

Woodbridge, extremely stony
Percent of map unit: 10 percent
Landform: Ground moraines, drumlins, hills
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Concave
Across-slope shape: Linear

Charlton, extremely stony
Percent of map unit: 5 percent
Landform: Hills
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Convex
Across-slope shape: Convex

Ridgebury, extremely stony
Percent of map unit: 4 percent
Landform: Hills, drainageways, ground moraines, drumlins, depressions
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave

Whitman, extremely stony
Percent of map unit: 1 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave

307D—Paxton fine sandy loam, 15 to 25 percent slopes, extremely stony

Map Unit Setting
National map unit symbol: 2w67l
Elevation: 0 to 1,570 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition
Paxton, extremely stony, and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton, Extremely Stony

Setting

Landform: Hills, ground moraines, drumlins
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 10 inches: fine sandy loam
Bw1 - 10 to 17 inches: fine sandy loam
Bw2 - 17 to 28 inches: fine sandy loam
Cd - 28 to 67 inches: gravelly fine sandy loam

Properties and qualities

Slope: 15 to 25 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 20 to 43 inches to densic material
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C

Minor Components

Charlton, extremely stony

Percent of map unit: 9 percent
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex

Woodbridge, extremely stony

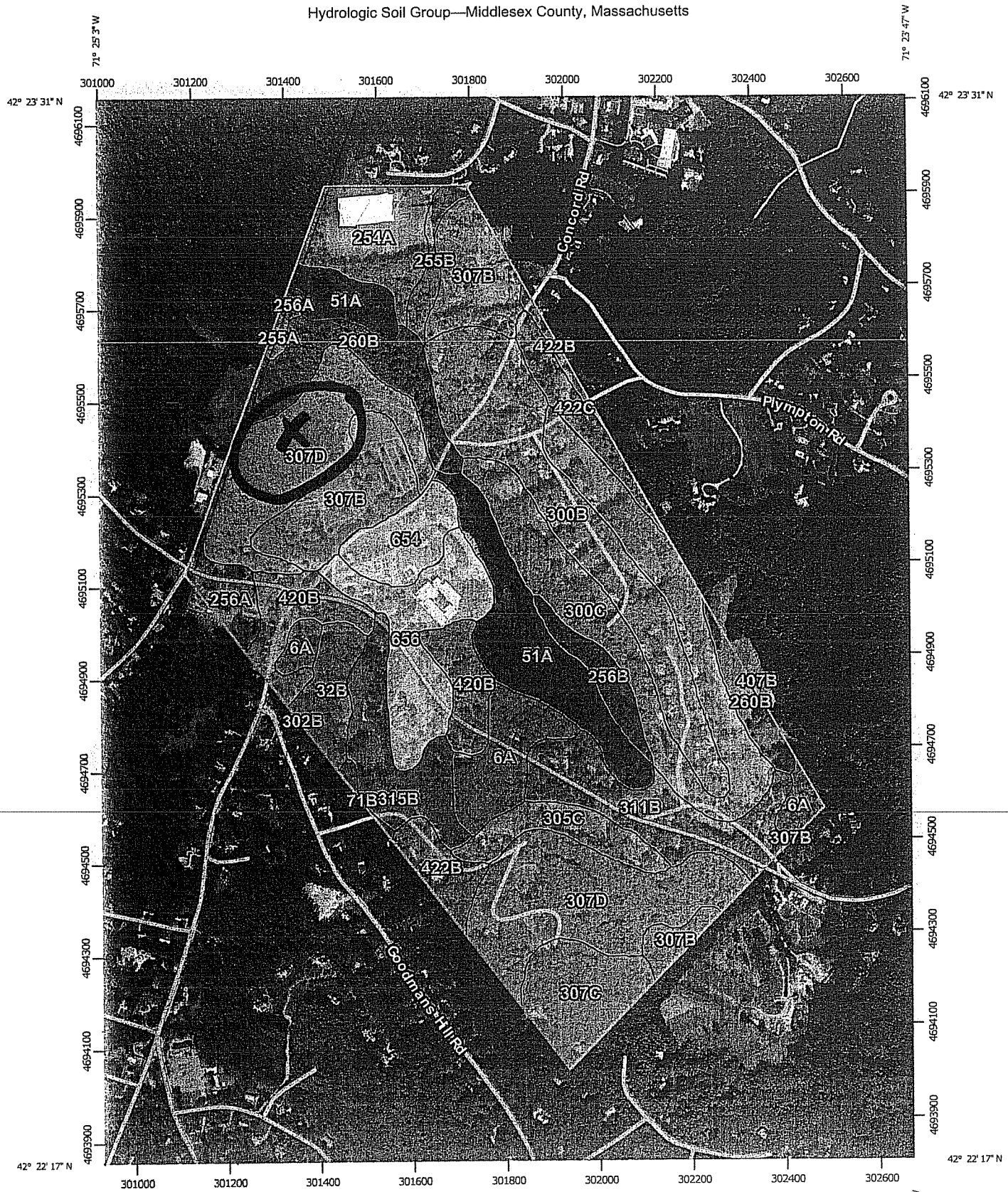
Percent of map unit: 5 percent
Landform: Ground moraines, drumlins, hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear

Ridgebury, extremely stony

Percent of map unit: 1 percent

OVERALL WATERSHED

Hydrologic Soil Group—Middlesex County, Massachusetts



Map Scale: 1:11,200 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 150 300 600 900

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Middlesex County, Massachusetts (MA017)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
6A	Scarboro mucky fine sandy loam, 0 to 3 percent slopes	A/D	14.3	4.2%
32B	Wareham loamy fine sand, 0 to 5 percent slopes	A/D	6.9	2.0%
51A	Swansea muck, 0 to 1 percent slopes	B/D	23.7	6.9%
71B	Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony	D	0.7	0.2%
254A	Merrimac fine sandy loam, 0 to 3 percent slopes	A	13.4	3.9%
255A	Windsor loamy sand, 0 to 3 percent slopes	A	0.8	0.2%
255B	Windsor loamy sand, 3 to 8 percent slopes	A	3.2	0.9%
256A	Deerfield loamy sand, 0 to 3 percent slopes	B	6.9	2.0%
256B	Deerfield loamy sand, 3 to 8 percent slopes	B	4.9	1.4%
260B	Sudbury fine sandy loam, 3 to 8 percent slopes	B	16.8	4.9%
300B	Montauk fine sandy loam, 3 to 8 percent slopes	C	32.6	9.5%
300C	Montauk fine sandy loam, 8 to 15 percent slopes	C	36.9	10.8%
302B	Montauk fine sandy loam, 0 to 8 percent slopes, extremely stony	C	0.0	0.0%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	C	7.7	2.3%
307B	Paxton fine sandy loam, 0 to 8 percent slopes, extremely stony	C	27.3	8.0%
307C	Paxton fine sandy loam, 8 to 15 percent slopes, extremely stony	C	12.1	3.5%

Hydrologic Soil Group— Summary by Map Unit — Middlesex County, Massachusetts (MA017)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
307D	Paxton fine sandy loam, 15 to 25 percent slopes, extremely stony	C	50.5	14.7%
311B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	C/D	17.6	5.1%
315B	Scituate fine sandy loam, 3 to 8 percent slopes	D	13.4	3.9%
407B	Charlton fine sandy loam, 3 to 8 percent slopes, extremely stony	A	0.1	0.0%
420B	Canton fine sandy loam, 3 to 8 percent slopes	A	14.9	4.3%
422B	Canton fine sandy loam, 3 to 8 percent slopes, extremely stony	A	6.7	2.0%
422C	Canton fine sandy loam, 8 to 15 percent slopes, extremely stony	A	6.1	1.8%
654	Udorthents, loamy		8.2	2.4%
656	Udorthents-Urban land complex		17.6	5.1%
Totals for Area of Interest			**343.5**	**100.0%**

Appendix B – SOIL EVALUATION FORMS

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

A. Facility Information

Chris Claussen
Client Name

Off Hudson Rd
Street Address

G09-0100 & 0300
Map/Lot #

Sudbury
City

MA
State

Zip Code

B. Site Information

1. (Check one) ☒ New Construction ☐ Upgrade ☐ Repair

2. Soil Survey Available? ☒ Yes ☐ No If yes: Sudbury GIS (Source) 255A, 260B, 307D

Windsor Loamy Sand, Sudbury & Paxton Fine Sandy Loam
Soil Name

Excessively Drained - Poor Filter for Untreated Wastewater
Soil Limitations

Outwash & Ablation Till
Geologic/Parent Material

Outwash Plain & Moraine
Landform

3. Surficial Geological Report Available? ☐ Yes ☒ No If yes: (Year Published/Source) (Publication) (Map Unit)

4. Flood Rate Insurance Map

Above the 500-year flood boundary? ☒ Yes ☐ No
If Yes, continue to #5.

Within the 500-year flood boundary? ☐ Yes ☒ No

Within the 100-year flood boundary? ☐ Yes ☒ No

5. Within a velocity zone? ☐ Yes ☒ No

6. Within a Mapped Wetland Area? ☐ Yes ☒ No

MassGIS Wetland Data Layer: (Wetland Type)

7. Current Water Resource Conditions (USGS): October 2015

Range: ☐ Above Normal ☐ Normal ☐ Below Normal

8. Other references reviewed:

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-8 | 10/29/2015 (Date) | 3:15 (Time) | Sun 65°F (Weather)

1. Location

   Ground Elevation at Surface of Hole: UNKNOWN feet Latitude/Longitude: UNKNOWN /

   Description of Location: Wooded Area

2. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Little Surface Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 0-3% (Slope (%))

   Pine & Oak (Vegetation) | Outwash plain (Landform) | Bottom (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from:

Open Water Body	>100 feet	Drainage Way	>10 feet	Wetlands	>100 feet
Property Line	>10 feet	Drinking Water Well	>100 feet	Other	feet

4. Parent Material: Outwash Unsuitable Materials Present: ☐ Yes ☒ No

   If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☒ No If yes: Not Obs. (Depth Weeping from Pit) | Not Obs. (Depth Standing Water in Hole)

   Estimated Depth to High Groundwater: 72 inches UNKNOWN elevation

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP-8

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-10	A	10YR3/2				LS			GRANULAR	LOOSE	FINE
10-22	B	10YR4/4				LS			GRANULAR	LOOSE	MEDIUM
22-78	C1	10YR5/3	72	10YR5/6 & 10YR5/1	15	S			GRANULAR	LOOSE	MEDIUM
78-108	C2	2.5Y4/3				LS			GRANULAR	FIRM	FINE

Additional Notes:

ANTICIPATE A 2 MIN / INCH PERC RATE BY INSPECTION OF SOIL TEXTURE

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-9 | 10/29/2015 (Date) | 3:00 (Time) | Sun 65°F (Weather)

1. Location

   Ground Elevation at Surface of Hole: UNKNOWN feet Latitude/Longitude: UNKNOWN /

   Description of Location: Wooded Area

2. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Little Surface Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 0-3% (Slope (%))

   Pine & Oak (Vegetation) | Outwash plain (Landform) | Bottom (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from:

Open Water Body	>100 feet	Drainage Way	>10 feet	Wetlands	>100 feet
Property Line	>10 feet	Drinking Water Well	>100 feet	Other	feet

4. Parent Material: Outwash Unsuitable Materials Present: ☐ Yes ☒ No

   If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☒ No If yes: Not Obs. (Depth Weeping from Pit) | Not Obs. (Depth Standing Water in Hole)

   Estimated Depth to High Groundwater: 54 inches UNKNOWN elevation

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP-9

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-12	A	10YR4/3				LS			GRANULAR	LOOSE	
12-24	B	2.5Y6/4				LS			GRANULAR	LOOSE	
24-96	C	2.5Y5/4	54	10YR5/6 & 10YR6/2	25	S			GRANULAR	LOOSE	MEDIUM

Additional Notes:

ANTICIPATE A 2 MIN / INCH PERC RATE BY INSPECTION OF SOIL TEXTURE OF C HORIZON

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-10 | 10/29/2015 (Date) | 3:45 (Time) | Sun 65°F (Weather)

1. Location

   Ground Elevation at Surface of Hole: UNKNOWN feet Latitude/Longitude: UNKNOWN /

   Description of Location: Wooded Area

2. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Little Surface Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 0-3% (Slope (%))

   Pine & Oak (Vegetation) | Outwash plain (Landform) | Bottom (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from:

Open Water Body	>100 feet	Drainage Way	>10 feet	Wetlands	>100 feet
Property Line	>10 feet	Drinking Water Well	>100 feet	Other	feet

4. Parent Material: Outwash Unsuitable Materials Present: ☐ Yes ☒ No

   If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☒ No If yes: Not Obs. (Depth Weeping from Pit) | Not Obs. (Depth Standing Water in Hole)

   Estimated Depth to High Groundwater: 72 inches UNKNOWN elevation

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP-10

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-12	A	10YR3/2				LS			GRANULAR	LOOSE	
12-24	B	2.5Y5/4				LS			GRANULAR	LOOSE	
24-108	C	2.5Y6/2	72	10YR5/6	10	S			GRANULAR	LOOSE	MEDIUM

Additional Notes:

ANTICIPATE A 2 MIN / INCH PERC RATE BY INSPECTION OF SOIL TEXTURE OF C HORIZON

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-11 | 10/29/2015 (Date) | 2:15 (Time) | Sun 65°F (Weather)

1. Location

   Ground Elevation at Surface of Hole: UNKNOWN feet Latitude/Longitude: UNKNOWN /

   Description of Location: Wooded Area

2. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Little Surface Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 0-3% (Slope (%))

   Pine & Oak (Vegetation) | Moraine (Landform) | On Slope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from:

Open Water Body	>100 feet	Drainage Way	>10 feet	Wetlands	>100 feet
Property Line	>10 feet	Drinking Water Well	>100 feet	Other	feet

4. Parent Material: Ablation Till Unsuitable Materials Present: ☐ Yes ☒ No

   If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☒ No If yes: Not Obs. (Depth Weeping from Pit) | Not Obs. (Depth Standing Water in Hole)

   Estimated Depth to High Groundwater: 36 inches UNKNOWN elevation

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP-11

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color- Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-12	A	10YR2/2				SL			MASSIVE	FRIABLE	
12-30	B	10YR4/3				SL			MASSIVE	FIRM	
30-54	C1	10YR5/2	36	10YR4/6	20	SL		15	BLOCKY	VERY FIRM	
54-66	C2	10YR4/2				S			GRANULAR	LOOSE	MEDIUM
66-108	C3	10YR5/2				LS			MASSIVE	VERY FIRM	

Additional Notes:

ANTICIPATE A 20 - 60 MIN / INCH PERC RATE BY INSPECTION OF SOIL TEXTURE OF C3 HORIZON

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-12 | 10/29/2015 (Date) | 1:45 (Time) | Sun 65°F (Weather)

1. Location

   Ground Elevation at Surface of Hole: UNKNOWN feet Latitude/Longitude: UNKNOWN /

   Description of Location: Wooded Area

2. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Little Surface Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 3-8% (Slope (%))

   Pine & Oak (Vegetation) | Moraine (Landform) | On-Slope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from:

Open Water Body	>100 feet	Drainage Way	>10 feet	Wetlands	>100 feet
Property Line	>10 feet	Drinking Water Well	>100 feet	Other	feet

4. Parent Material: Ablation Till Unsuitable Materials Present: ☐ Yes ☒ No

   If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☒ No If yes: Not Obs. (Depth Weeping from Pit) | Not Obs. (Depth Standing Water in Hole)

   Estimated Depth to High Groundwater: 42 inches UNKNOWN elevation

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP-12

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-12	A	10YR3/3				SL			MASSIVE	FRIABLE	FINE
12-36	B	2.5Y4/4				SL			MASSIVE	FIRM	FINE
36-108	C	2.5Y6/2	42	10YR5/4	10	SL		20	MASSIVE	FIRM	FINE

Additional Notes:

ANTICIPATE A 20 - 60 MIN / INCH PERC RATE BY INSPECTION OF SOIL TEXTURE OF C HORIZON

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-13 | 10/29/2015 (Date) | 1:15 (Time) | Sun 65°F (Weather)

1. Location

   Ground Elevation at Surface of Hole: UNKNOWN feet Latitude/Longitude: UNKNOWN /

   Description of Location: Wooded Area

2. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Little Surface Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 3-8% (Slope (%))

   Pine & Oak (Vegetation) | Moraine (Landform) | On-Slope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from:

Open Water Body	>100 feet	Drainage Way	>10 feet	Wetlands	>100 feet
Property Line	>10 feet	Drinking Water Well	>100 feet	Other	feet

4. Parent Material: Ablation Till Unsuitable Materials Present: ☐ Yes ☒ No

   If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☒ No If yes: Not Obs. (Depth Weeping from Pit) | Not Obs. (Depth Standing Water in Hole)

   Estimated Depth to High Groundwater: 38 inches UNKNOWN elevation

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP-13

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color- Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-6	A	10YR3/2				SL			GRANULAR	FRIABLE	FINE
6-22	B	2.5Y5/6				SL			GRANULAR	FRIABLE	FINE
22-36	C1	2.5Y6/3				S		15	GRANULAR	FIRM	MEDIUM
36-108	C2	2.5Y5/3	38	10YR5/8 & 2.5Y6/1	15	SL		15	GRANULAR	VERY FIRM	FINE

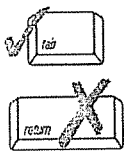
Additional Notes:

ANTICIPATE A 20 - 60 MIN / INCH PERC RATE BY INSPECTION OF SOIL TEXTURE OF C HORIZON

Commonwealth of Massachusetts
City/Town of Sudbury
Percolation Test
Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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



A. Site Information

Sudbury Station, LLC
Owner Name

124 Washington Street
Street Address or Lot #

Foxborough	MA	02035
City/Town	State	Zip Code

Chris Claussen	
Contact Person (if different from Owner)	Telephone Number

B. Test Results

	12/22/2015 Date	8:30 Time	12/22/2015 Date	9:30 Time
Observation Hole #	PT-14		PT-23	
Depth of Perc	30-48 INCHES		42-60 INCHES	
Start Pre-Soak	8:35		9:31	
End Pre-Soak	8:43		9:46	
Time at 12"	N/A (*)		9:46	
Time at 9"			9:49	
Time at 6"			9:53	
Time (9"-6")			4 MINUTES	
Rate (Min./Inch)	<2		<2	
	Test Passed: ☒ Test Failed: ☐		Test Passed: ☒ Test Failed: ☐	

Donald A. Provencher. P.E.
Test Performed By:

Bruce Bouck & Michelle Ly of DEP, and Bill Murphey of Sudbury Board of Health
Witnessed By:

Comments:

(*) Could not maintain presoak in PT-14, saturated with over 25 gallons of water in less than 15 minutes. Assume <2 minutes / inch perc rate

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

D. Determination of High Groundwater Elevation

1. Method Used:

	Obs. Hole #TP-18 & 23	Obs. Hole #TP-14
☐ Depth observed standing water in observation hole	_____ inches	_____ inches
☐ Depth weeping from side of observation hole	_____ inches	_____ inches
☒ Depth to soil redoximorphic features (mottles)	42 inches	90 inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	_____ inches	_____ inches

_____ Index Well Number _____ Reading Date

$S_h = S_c - [S_r \times (OW_c - OW_{max})/OW_r]$

Obs. Hole # _____ S_c _____ S_r _____ OW_c _____ OW_{max} _____ OW_r _____ S_h _____

Obs. Hole # _____ S_c _____ S_r _____ OW_c _____ OW_{max} _____ OW_r _____ S_h _____

E. Depth of Pervious Material

1. Depth of Naturally Occurring Pervious Material
   a. Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system?
      ☒ Yes ☐ No
   b. If yes, at what depth was it observed? Upper boundary: 114 inches Lower boundary: 84 inches
   c. If no, at what depth was impervious material observed? Upper boundary: _____ inches Lower boundary: _____ inches

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

F. Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.100 through 15.107.

Donald A. Provencher

Signature of Soil Evaluator

January 8, 2016
Date

Donald A. Provencher, P.E. / SE1076
Typed or Printed Name of Soil Evaluator / License #

June 30, 2016
Expiration Date of License

Bill Murphy – Sudbury Board of Health
Name of Board of Health Witness

Michelle Ly & Bruce Bouck - DEP
Board of Health

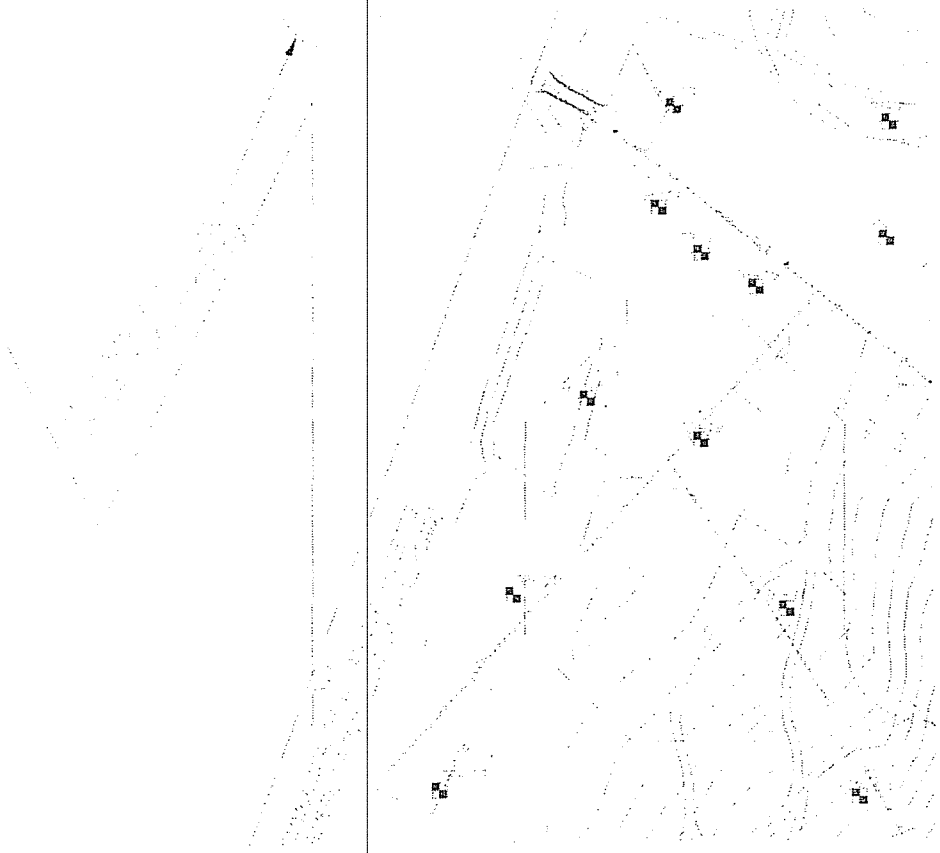
Note: In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

Commonwealth of Massachusetts
City/Town of Sudbury

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Field Diagrams

Use this sheet for field diagrams:



Test Logs

Sullivan Connors & Associates
121 Boston Post Road
Sudbury, MA

CLIENT: Chris Claussen
PROJECT: Sudbury Crossing

DATE: 10/29/2015
TIME: 12:00 PM
BY: VC

SOAK

VOLUME: 3 gal
STEADY STATE: Yes

UNCASED WELL

PERM-1

Well Dia (a):	2.5	inches
Bottom Depth:	22.0	inches
Height (D):	12	inches

	VOLUME (gal)	TIME Min	TIME Sec	FLOW q gal/min	FLOW q CF/min	
START	0.00	0	0			
	0.25	0	5	3.000	0.401	
	0.25	0	10	3.000	0.401	
	0.25	0	16	2.500	0.334	
	0.25	0	20	3.750	0.501	
	0.25	0	25	3.000	0.401	
	0.25	0	29	3.750	0.501	
	0.25	0	35	2.500	0.334	
				AVG =	193.8	cm3/sec

Kfs= (C x Q) / [(2 x 3.14 x H^2) + (C x 3.14 x a^2) + (2 x 3.14 x H / SC)]
Elrick & Reynolds, 1989
Where:

C = [(H / a) / (2.074 + 0.093 x (H/a)]^0.784

Coefficent	C	2.424	
Flow	Q	193.78	cm3/sec
	pi	3.14	
Head	H	30.48	cm
Radii	a	3.18	cm
Soil Coefficent	SC	0.36	(sand)

0.073 cm/sec
206.6 ft./day

K_{FS} = **103.3 in./hr**

Test Logs

Sullivan Connors & Associates
121 Boston Post Road
Sudbury, MA

CLIENT: Chris Claussen
PROJECT: Sudbury Crossing

DATE: 10/29/2015
TIME: 12:30 PM
BY: VC

SOAK

VOLUME: 3 gal
STEADY STATE: Yes

PERM-2

UNCASED WELL

Well Dia (a):	2.5	inches
Bottom Depth:	36.0	inches
Height (D):	11	inches

	VOLUME (gal)	TIME Min	TIME Sec	FLOW q gal/min	FLOW q CF/min	
START	0.00	0	0			
	0.25	0	5	3.000	0.401	
	0.25	0	10	3.000	0.401	
	0.25	0	16	2.500	0.334	
	0.25	0	22	2.500	0.334	
	0.25	0	28	2.500	0.334	
	0.25	0	35	2.143	0.286	
	0.25	0	42	2.143	0.286	
	0.25	0	48	2.500	0.334	
				AVG =	160.0	cm3/sec

Kfs= (C x Q) / [(2 x 3.14 x H^2) + (C x 3.14 x a^2) + (2 x 3.14 x H / SC)]
Elrick & Reynolds, 1989
Where:

C = [(H / a) / (2.074 + 0.093 x (H/a)]^0.784

Coefficent	C	2.314	
Flow	Q	159.99	cm3/sec
	pi	3.14	
Head	H	27.94	cm
Radii	a	3.18	cm
Soil Coefficent	SC	0.36	(sand)

0.068 cm/sec
192.0 ft./day

K_{FS} = **96.0 in./hr**

Test Logs

Sullivan Connors & Associates
121 Boston Post Road
Sudbury, MA

CLIENT: Chris Claussen
PROJECT: Sudbury Crossing

DATE: 10/29/2015
TIME: 1:00 PM
BY: VC

SOAK

VOLUME: 3 gal
STEADY STATE: Yes

PERM-3

UNCASED WELL

Well Dia (a):	2.5	inches
Bottom Depth:	36.0	inches
Height (D):	14	inches

	VOLUME (gal)	TIME Min	TIME Sec	FLOW q gal/min	FLOW q CF/min
START	0.00	0	0		
	0.25	0	5	3.000	0.401
	0.25	0	9	3.750	0.501
	0.25	0	13	3.750	0.501
	0.25	0	16	5.000	0.668
	0.25	0	20	3.750	0.501
	0.25	0	24	3.750	0.501
	0.25	0	28	3.750	0.501
	0.25	0	32	3.750	0.501
				AVG =	240.5 cm3/sec

Kfs= (C x Q) / [(2 x 3.14 x H^2) + (C x 3.14 x a^2) + (2 x 3.14 x H / SC)]
Elrick & Reynolds, 1989
Where:

C = [(H / a) / (2.074 + 0.093 x (H/a)]^0.784

Coefficent	C	2.624	
Flow	Q	240.54	cm3/sec
	pi	3.14	
Head	H	35.56	cm
Radii	a	3.18	cm
Soil Coefficent	SC	0.36	(sand)

0.073 cm/sec
206.9 ft./day

K_{FS} = **103.4 in./hr**

Test Methods:
The testing was performed using a constant well head permeameter in accordance with the procedures described by Elrick et al (1989), and methods developed for the Guelph Permeameter. The single head (one-ponded) technique was performed where a small diameter borehole is excavated, and water is supplied to maintain a constant level until a steady state flow rate has been achieved. The steady state flow is recorded over time and the results are used to calculate hydraulic conductivity (K_{fs}).

References / Equation Source

1. Elrick, D.E., W.D. Reynolds and K.A. Tan. 1989. Hydraulic conductivity measurements in the unsaturated zone using improved well analyses. Ground Water Monit. Rev. Vol. 9, No. 3, 184-193.

2. "Operating Instructions, Guelph Permeamter" Soil Moisture Equipment Corp. P.O. Box 30025, Santa Barbara, CA

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	α^*(cm^{-1})	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

<table>
<tr><td>One Head,
Combined Reservoir</td><td>$Q_1 = \bar{R}_1 \times 35.22$</td><td rowspan="2">$K_{fs} = \dfrac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\dfrac{H_1}{\alpha^*}\right)}$

$\Phi_m = \dfrac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$</td></tr>
<tr><td>One Head,
Inner Reservoir</td><td>$Q_1 = \bar{R}_1 \times 2.16$</td></tr>
<tr><td>Two Head,
Combined Reservoir</td><td>$Q_1 = \bar{R}_1 \times 35.22$

$Q_2 = \bar{R}_2 \times 35.22$</td><td rowspan="2">$G_1 = \dfrac{H_2 C_1}{\pi\left(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1)\right)}$

$G_2 = \dfrac{H_1 C_2}{\pi\left(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1)\right)}$

$K_{fs} = G_2Q_2 - G_1Q_1$

$G_3 = \dfrac{(2H_2^2 + a^2C_2)C_1}{2\pi\left(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1)\right)}$

$G_4 = \dfrac{(2H_1^2 + a^2C_1)C_2}{2\pi\left(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1)\right)}$

$\Phi_m = G_3Q_1 - G_4Q_2$</td></tr>
<tr><td>Two Head,
Inner Reservoir</td><td>$Q_1 = \bar{R}_1 \times 2.16$

$Q_2 = \bar{R}_2 \times 2.16$</td></tr>
</table>

Appendix C – RIPRAP SIZING DATA

Empirical Preformed Scour Hole Equations:

Type 1: Scour Hole Depression = one-half pipe rise, m (ft)

$d_{50} = (0.0276\ R_p^2/TW)\ (Q/R_p^{2.5})^{1.333}$ $\quad d_{50} = (0.0125 R_p^2/TW)\ (Q/R_p^{2.5})^{1.333}$ **(11.35)**

Type 2: Scour Hole Depression = full pipe rise, m (ft)

$d_{50} = (0.0181\ R_p^2/TW)\ (Q/R_p^{2.5})^{1.333}$ $\quad (d_{50} = (0.0082 R_p^2/TW)\ (Q/R_p^{2.5})^{1.333})$ **(11.36)**

d_{50} = median stone size required, m (ft)

For variables S_p, R_p, TW and Q, see Section 11.13.5.

Type 1 and 2 preformed scour hole dimensions (See Figure 11-15)

$C = 3S_p + 6F$	Basin Length m (ft)	
$B = 2S_p + 6F$	Basin Inlet and Outlet Width m (ft)	**(11.37)**
$F = 0.5R_p$ (Type 1) or R_p (Type 2)	Basin Depression m (ft)	

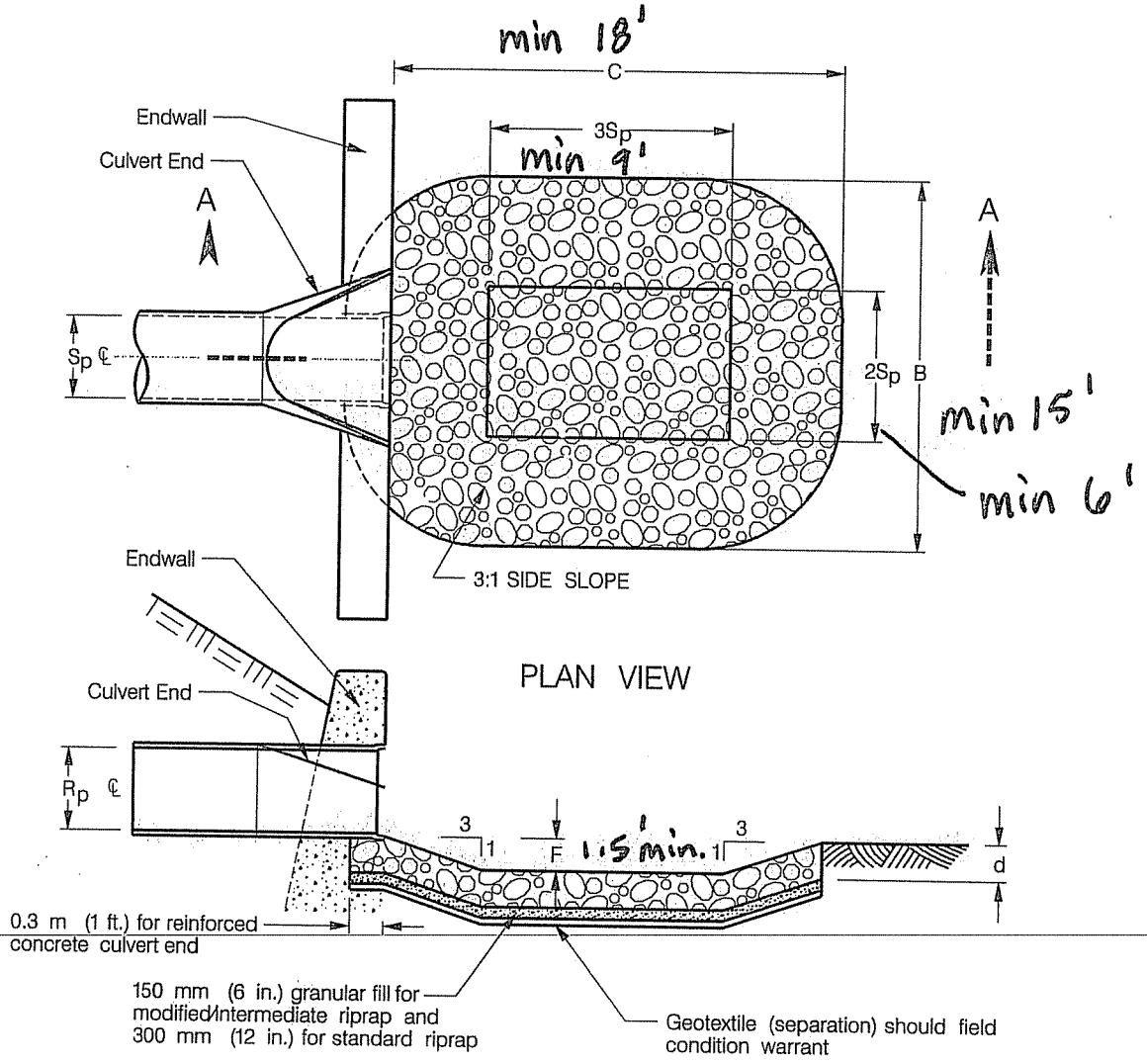
Table 11-14 solves the above set of equations for Type 1 and 2 preformed scour holes for various pipe sizes.

The type of riprap required is as follows:

Modified	$d_{50} < 0.13$m (0.42 ft)
Intermediate	0.13m (0.42 ft) $< d_{50} <$ 0.20m (0.67 ft)
Standard	0.20m (0.67 ft) $< d_{50} <$ 0.38m (1.25 ft)
Special Design	0.38m (1.25 ft) $< d_{50}$

Reference: Report No. FHWA-RD-75-508 ("Culvert Outlet Protection Design: Computer Program Documentation")

TW = 1.5' (per Mannig equation)
R_p = 3' (Pipe dia)
Q = 15 cfs (100 year)



min $d_{50} = 2''$

LEGEND

S_p = { Max. inside pipe span (non–circular sections) / Inside pipe diameter (circular sections)

R_p = { Max. inside pipe rise (non–circular sections) / Inside pipe diameter (circular sections)

d = { 300 mm (12 in.) Modified Riprap / 450 mm (18 in.) Intermediate Riprap / 900 mm (36 in.) Standard Riprap

Type 1 $F = 0.5\ R_p$

Type 2 $F = R_p$

$C = 3S_p + 6F$

$B = 2S_p + 6F$

Figure 11-15 Preformed Scour Hole Type 1 and Type 2

OUTLET PROTECTION
OUTLET VELOCITY > 14 feet/sec or Length of Apron exceeds limits shown on Tables 11-12.1 and 11-13.1

Preformed Scour Hole										
(See Figure 11-15)	PIPE DIAMETER OR SPAN (in)									
	12	15	18	24	30	36	42	48	54	60
Type 1										
B	5	6	8	10	13	15	18	20	23	25
C	6	8	9	12	15	18	21	24	27	30
d	Depends on riprap type(see Figure 11-15)									
$2S_p$	2.0	2.6	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
$3S_p$	3.0	3.9	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0
$F = 0.5\ S_p$	0.5	0.625	0.75	1	1.25	1.5	1.75	2	2.25	2.5
Type 2										
B	8	10	12	16	20	24	28	32	36	40
C	9	11	14	18	23	27	32	36	41	45
d	Depends on riprap size (see Figure 11-15)									
$2S_p$	2.0	2.6	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
$3S_p$	3.0	3.9	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0
$F = S_p$	1.0	1.3	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0

Table 11-14.1 - Dimensions of Preformed Scour Hole (Feet)

Appendix D – TP-40 RAINFALL DISTRIBUTION MAPS

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection
One Winter Street Boston, MA 02108 • 617-292-5500

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Matthew A. Beaton
Secretary

Martin Suuberg
Commissioner

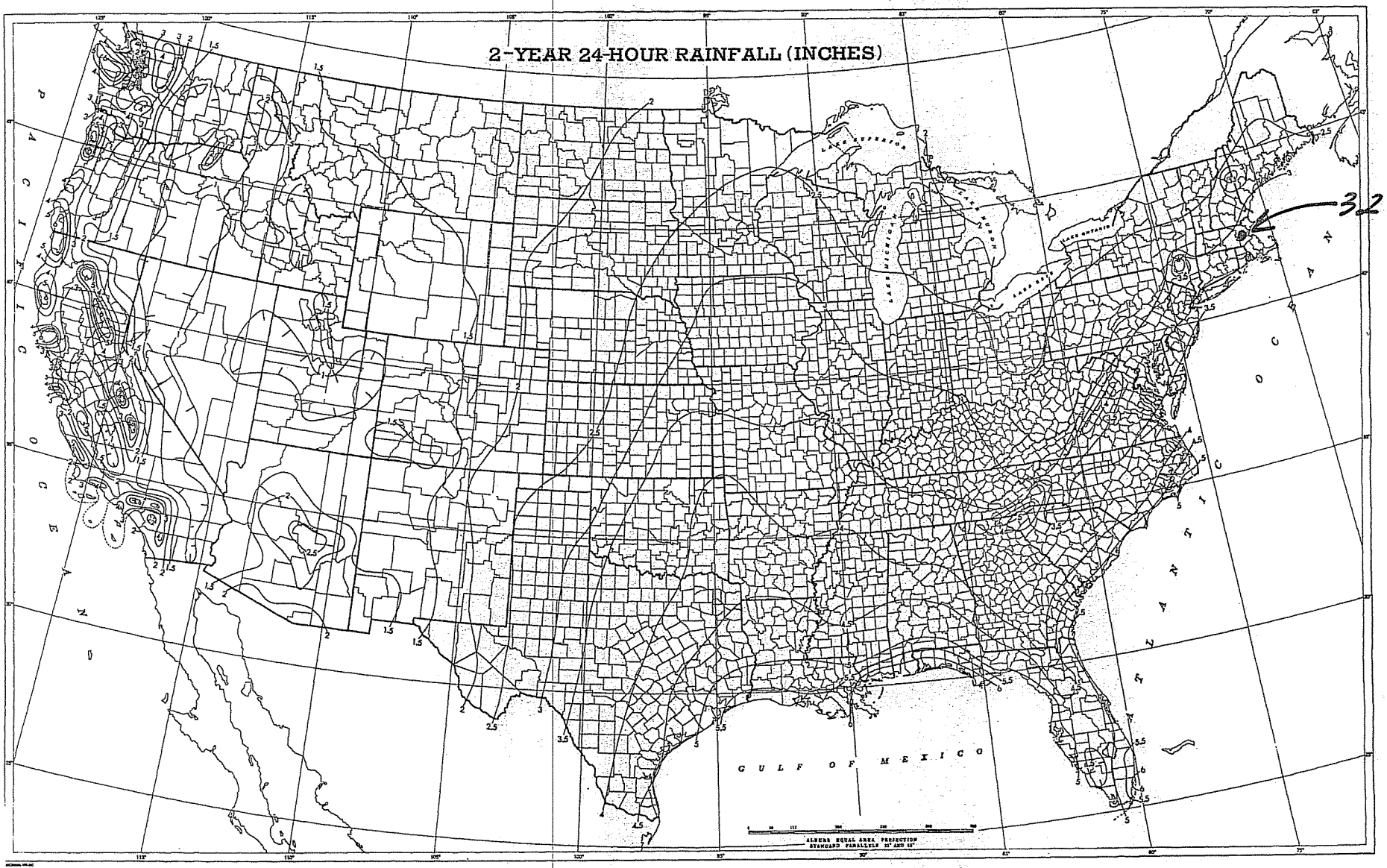
MassDEP to Review Recent Studies on Precipitation Rates in Massachusetts

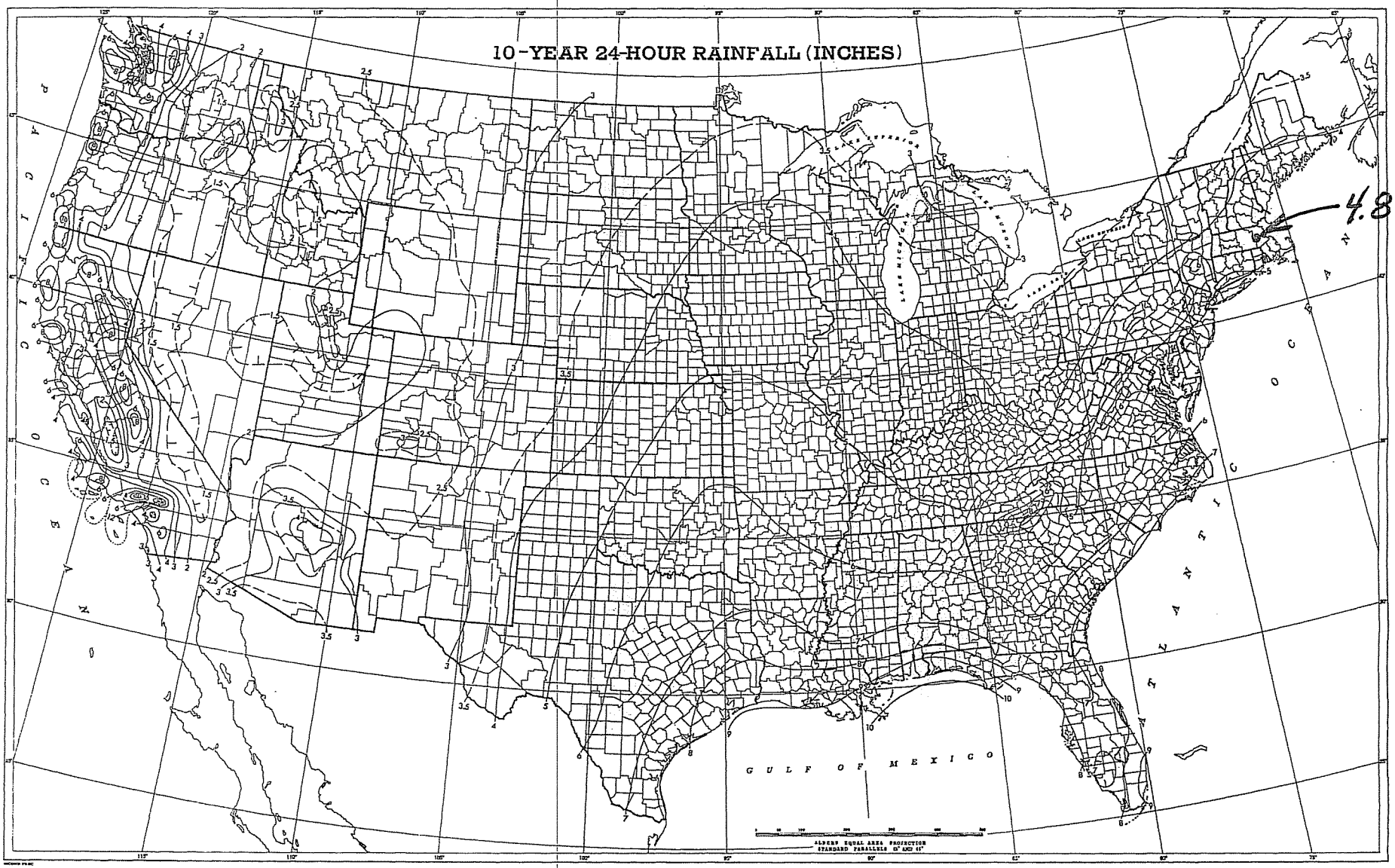
The Massachusetts Department of Environmental Protection (MassDEP) is currently evaluating the new precipitation frequency statistics published September 2015 online in the National Oceanic and Atmospheric Administration (NOAA) Atlas 14. The existing precipitation frequency statistics referenced in the Wetland regulations, the Hydrology Handbook for Conservation Commissioners, and the Massachusetts Stormwater Handbook are based on Technical Paper 40 (TP40), published by the U.S. Weather Bureau in 1961. In addition to the new NOAA study, MassDEP is also evaluating the precipitation frequency statistics prepared by the Northeast Regional Climate Center (NRCC) at Cornell University published online in 2008, relative to the currently used TP40 methodology.

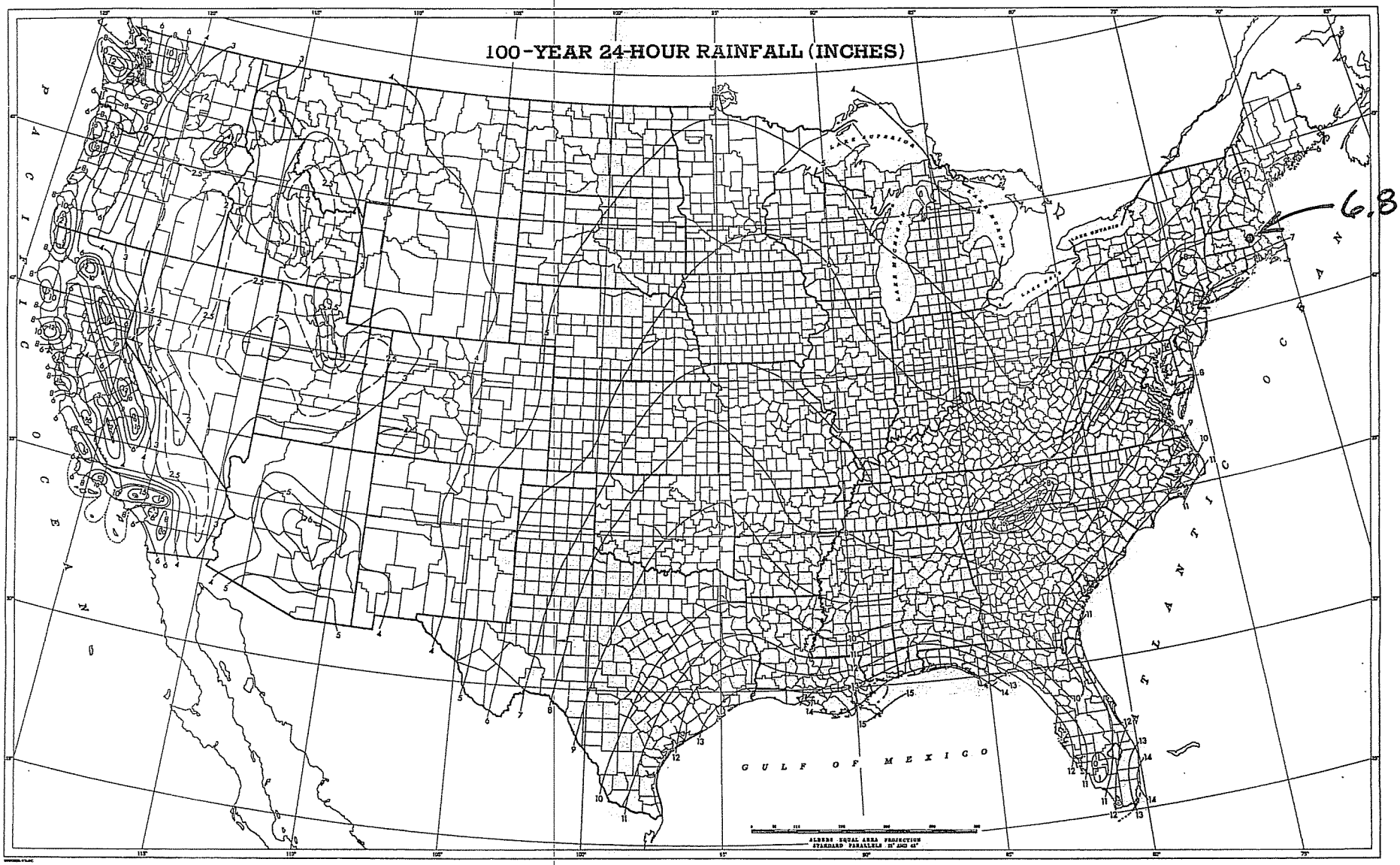
Precipitation frequency statistics are used in calculating stormwater peak runoff rates in order to reduce likelihood of flooding from land development and to measure the extent of vernal pools and bordering lands subject to flooding in the absence of information from the Federal Emergency Management Agency (FEMA). The precipitation frequency statistics are also used to determine the extent of the 10-year floodplain significant to wildlife habitat and the extent of isolated lands subject to flooding.

In order to update the wetland regulations and incorporate the findings of these most recent studies, a regulation amendment is needed to the Wetland regulations at 310 CMR 10.57. Concurrently, revisions will also be needed to the Hydrology and Stormwater Handbooks which incorporate either the NOAA or NRCC atlases in place of TP40. Preliminary MassDEP review indicates that in some cases both NOAA and NRCC have lower precipitation than TP40, while in other cases, greater precipitation rates are expected. MassDEP is considering the need for an Advisory Committee to review and compare each of the three studies. Following completion of the preliminary analysis, proposed regulatory amendments will be undertaken consistent with Massachusetts Executive Order 562 (http://www.mass.gov/governor/legislationexecorder/execorders/executive-order-no-562.html).

In the interim, TP 40 values should continue to be used for calculating stormwater peak runoff rates unless an applicant voluntarily chooses to use the NOAA or NRCC Atlases and the selected methodology has a higher precipitation value than that of TP40 for the geographic location being evaluated.

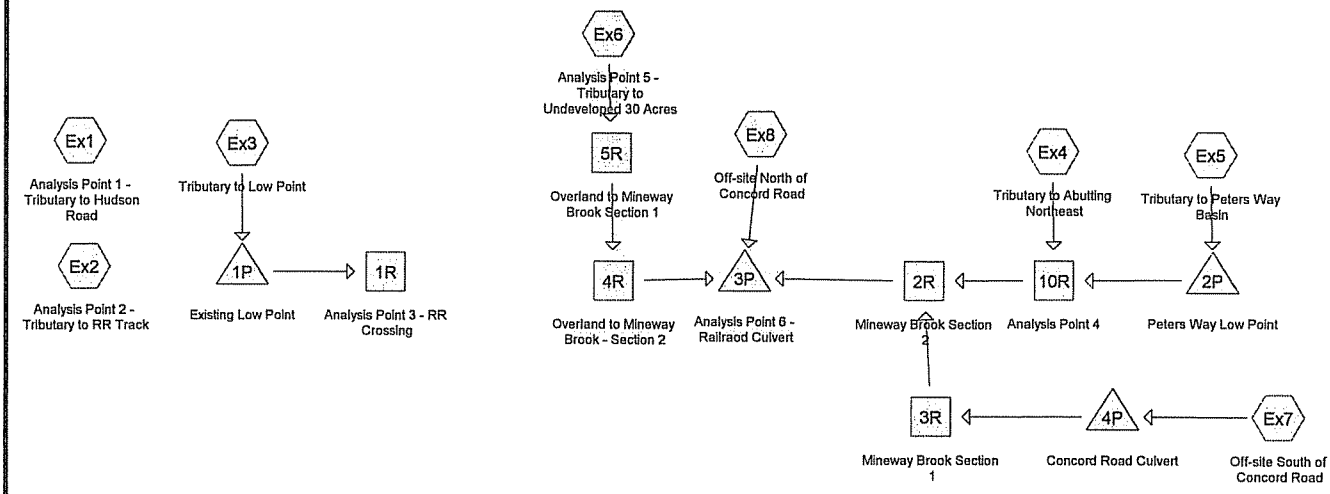

2-YEAR 24-HOUR RAINFALL (INCHES)
GULF OF MEXICO
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29° AND 45°

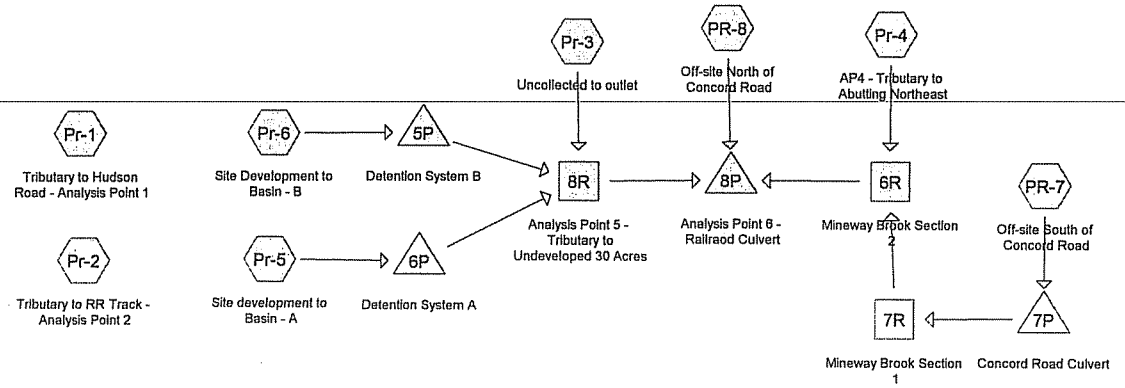

10-YEAR 24-HOUR RAINFALL (INCHES)
4.8 inches
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29° AND 45°

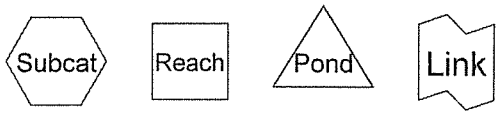

100-YEAR 24-HOUR RAINFALL (INCHES)
GULF OF MEXICO
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29° AND 45°

6, Bincles

Appendix E – HYDROCAD MODEL OUTPUT

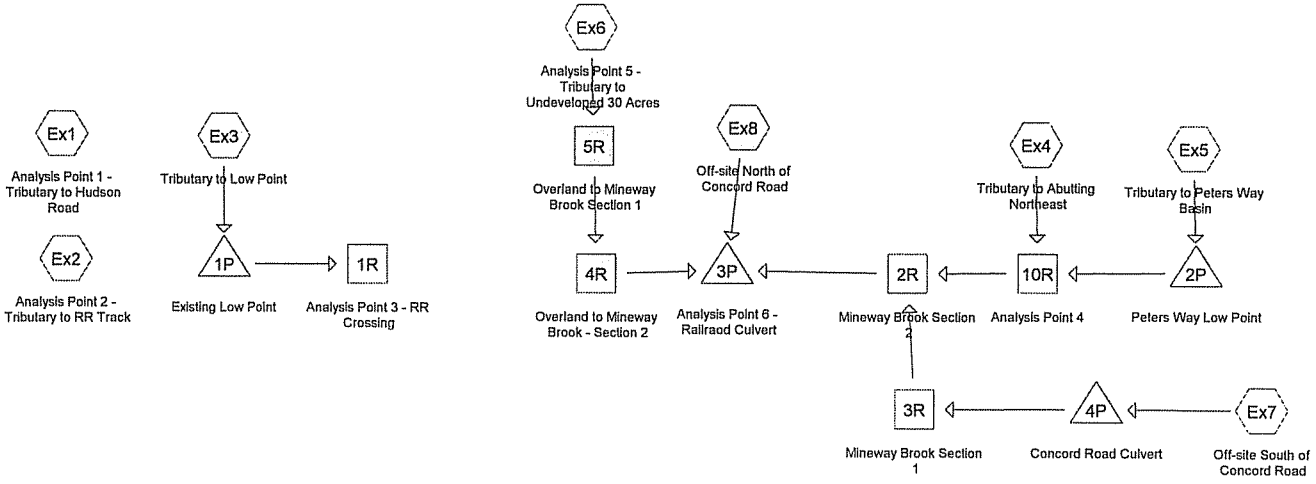






Drainage Diagram for 40B Drainage Overall
Prepared by Microsoft, Printed 6/10/2016

EXISTING CONDITIONS
2-, 10-, 100-YEAR



Subcat Reach Pond Link

Drainage Diagram for 40B Drainage Overall
Prepared by Microsoft, Printed 6/10/2016

Summary for Subcatchment Ex1: Analysis Point 1 - Tributary to Hudson Road

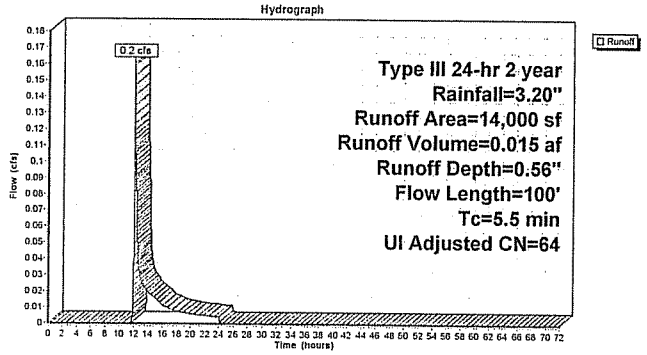
Runoff = 0.2 cfs @ 12.10 hrs, Volume= 0.015 af, Depth= 0.56"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
1,500	55	Woods, Good, HSG B
10,800	61	>75% Grass cover, Good, HSG B
860	98	Paved parking, HSG B
840	98	Unconnected pavement, HSG B
14,000	65	Weighted Average, UI Adjusted CN = 64
12,300		87.86% Pervious Area
1,700		12.14% Impervious Area
840		49.41% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
0.2	50	0.3600	4.20		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
5.5	100	Total			

Subcatchment Ex1: Analysis Point 1 - Tributary to Hudson Road



Summary for Subcatchment Ex2: Analysis Point 2 - Tributary to RR Track

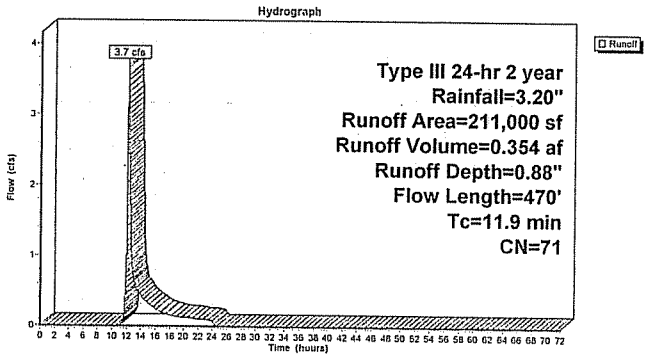
Runoff = 3.7 cfs @ 12.18 hrs, Volume= 0.354 af, Depth= 0.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
1,000	55	Woods, Good, HSG B
178,000	70	Woods, Good, HSG C
2,800	61	>75% Grass cover, Good, HSG B
20,500	74	>75% Grass cover, Good, HSG C
1,200	98	Unconnected pavement, HSG B
7,500	98	Unconnected pavement, HSG C
211,000	71	Weighted Average
202,300		95.88% Pervious Area
8,700		4.12% Impervious Area
8,700		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	50	0.0500	0.10		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
3.4	420	0.1700	2.06		**Shallow Concentrated Flow, B-C** Woodland Kv= 5.0 fps
11.9	470	Total			

Subcatchment Ex2: Analysis Point 2 - Tributary to RR Track



Summary for Subcatchment Ex3: Tributary to Low Point

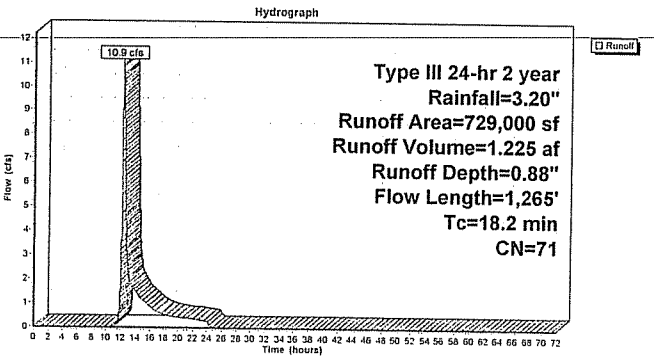
Runoff = 10.9 cfs @ 12.28 hrs, Volume= 1.225 af, Depth= 0.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
81,000	55	Woods, Good, HSG B
333,000	70	Woods, Good, HSG C
258,000	74	>75% Grass cover, Good, HSG C
21,000	98	Unconnected pavement, HSG C
36,000	89	Gravel roads, HSG C
729,000	71	Weighted Average
708,000		97.12% Pervious Area
21,000		2.88% Impervious Area
21,000		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.6	150	0.0530	1.61		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.5	200	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
0.7	130	0.0230	3.08		**Shallow Concentrated Flow, D-E** Paved Kv= 20.3 fps
0.6	40	0.0250	1.11		**Shallow Concentrated Flow, E-F** Short Grass Pasture Kv= 7.0 fps
6.0	565	0.1000	1.58		**Shallow Concentrated Flow, F-G** Woodland Kv= 5.0 fps
2.5	130	0.0300	0.87		**Shallow Concentrated Flow, G-H** Woodland Kv= 5.0 fps
18.2	1,265	Total			

Subcatchment Ex3: Tributary to Low Point



Summary for Subcatchment Ex4: Tributary to Abutting Northeast

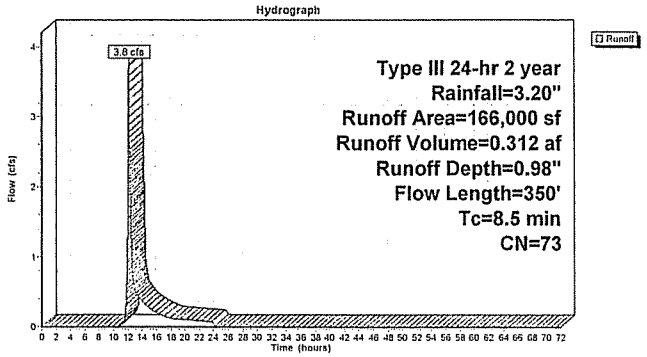
Runoff = 3.8 cfs @ 12.13 hrs, Volume= 0.312 af, Depth= 0.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
18,000	55	Woods, Good, HSG B
41,000	70	Woods, Good, HSG C
46,000	71	Meadow, non-grazed, HSG C
36,000	74	>75% Grass cover, Good, HSG C
3,000	85	Gravel roads, HSG B
13,000	89	Gravel roads, HSG C
* 9,000	98	Concord Road
166,000	73	Weighted Average
157,000		94.58% Pervious Area
9,000		5.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	50	0.0360	0.13		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.4	215	0.1400	2.62		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.6	85	0.2000	2.24		**Shallow Concentrated Flow, C-D** Woodland Kv= 5.0 fps
8.5	350	Total			

Subcatchment Ex4: Tributary to Abutting Northeast



Summary for Subcatchment Ex5: Tributary to Peters Way Basin

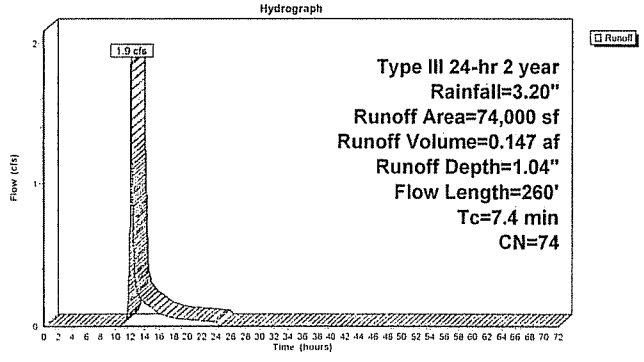
Runoff = 1.9 cfs @ 12.11 hrs, Volume= 0.147 af, Depth= 1.04"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
43,000	71	Meadow, non-grazed, HSG C
22,000	74	>75% Grass cover, Good, HSG C
9,000	89	Gravel roads, HSG C
74,000	74	Weighted Average
74,000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	50	0.0400	0.13		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.2	210	0.1800	2.97		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
7.4	260	Total			

Subcatchment Ex5: Tributary to Peters Way Basin



Summary for Subcatchment Ex6: Analysis Point 5 - Tributary to Undeveloped 30 Acres

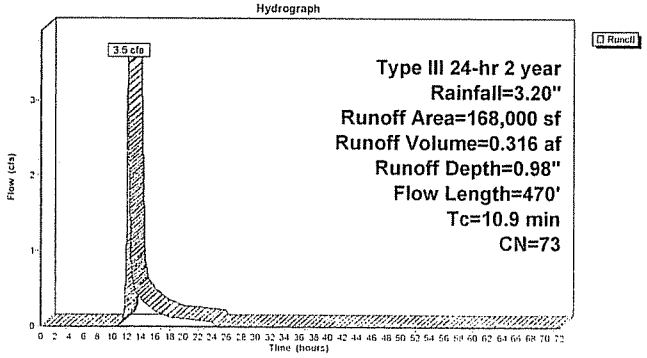
Runoff = 3.5 cfs @ 12.16 hrs, Volume= 0.316 af, Depth= 0.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
94,000	70	Woods, Good, HSG C
56,000	74	>75% Grass cover, Good, HSG C
18,000	85	Gravel roads, HSG B
168,000	73	Weighted Average
168,000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	50	0.0300	0.12		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.8	170	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
2.1	250	0.1600	2.00		**Shallow Concentrated Flow, C-D** Woodland Kv= 5.0 fps
10.9	470	Total			

Subcatchment Ex6: Analysis Point 5 - Tributary to Undeveloped 30 Acres



Summary for Subcatchment Ex7: Off-site South of Concord Road

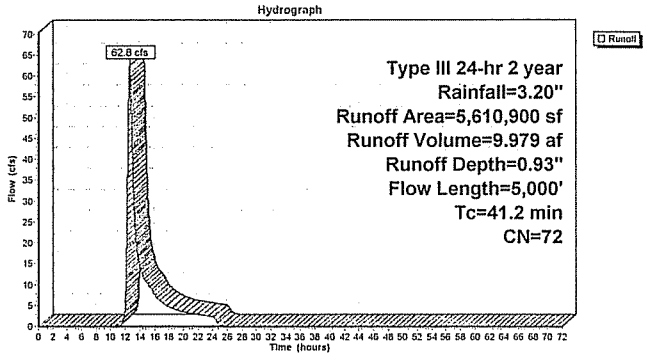
Runoff = 62.8 cfs @ 12.63 hrs, Volume= 9.979 af, Depth= 0.93"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
70,700	30	Woods, Good, HSG A
213,700	55	Woods, Good, HSG B
1,691,800	70	Woods, Good, HSG C
1,462,100	77	Woods, Good, HSG D
1,203,300	79	1 acre lots, 20% imp, HSG C
321,700	84	1 acre lots, 20% imp, HSG D
* 647,600	57	Udorthents, 30% imp, HSG A
5,610,900	72	Weighted Average
5,111,620		91.10% Pervious Area
499,280		8.90% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.9	50	0.0600	0.10		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
14.0	1,450	0.1200	1.73		**Shallow Concentrated Flow, B-C** Woodland Kv= 5.0 fps
4.1	300	0.0300	1.21		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.2	3,200	0.0050	3.52	21.12	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=1.00' Z= 1.0 '/' Top.W=7.00' n= 0.025 Earth, clean & winding
41.2	5,000	Total			

Subcatchment Ex7: Off-site South of Concord Road



Summary for Subcatchment Ex8: Off-site North of Concord Road

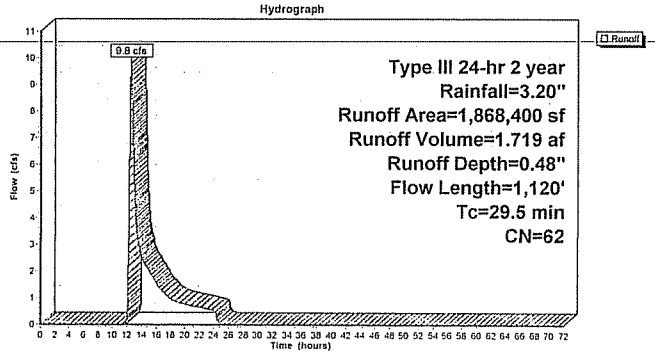
Runoff = 9.8 cfs @ 12.55 hrs, Volume= 1.719 af, Depth= 0.48"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
217,000	30	Woods, Good, HSG A
386,500	55	Woods, Good, HSG B
400,400	70	Woods, Good, HSG C
284,800	77	Woods, Good, HSG D
381,900	79	1 acre lots, 20% imp, HSG C
197,800	39	Pasture/grassland/range, Good, HSG A
1,868,400	62	Weighted Average
1,792,020		95.91% Pervious Area
76,380		4.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0700	0.11		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
5.2	340	0.0480	1.10		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
15.3	480	0.0110	0.52		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.5	250	0.0050	2.82	10.73	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=0.67' Z= 1.0 '/' Top.W=6.34' n= 0.025 Earth, clean & winding
29.5	1,120	Total			

Subcatchment Ex8: Off-site North of Concord Road

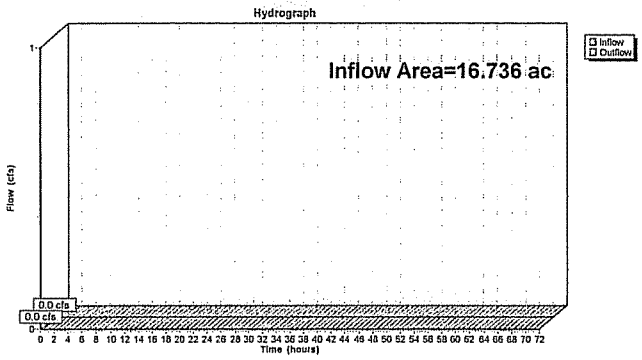


Summary for Reach 1R: Analysis Point 3 - RR Crossing

Inflow Area = 16.736 ac, 2.88% Impervious, Inflow Depth = 0.00" for 2 year event
Inflow = 0.0 cfs @ 0.00 hrs, Volume= 0.000 af
Outflow = 0.0 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Reach 1R: Analysis Point 3 - RR Crossing



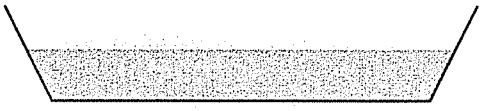
Summary for Reach 2R: Mineway Brook Section 2

Inflow Area = 134.318 ac, 8.69% Impervious, Inflow Depth = 0.85" for 2 year event
Inflow = 18.6 cfs @ 13.61 hrs, Volume= 9.501 af
Outflow = 18.6 cfs @ 13.75 hrs, Volume= 9.501 af, Atten= 0%, Lag= 8.2 min

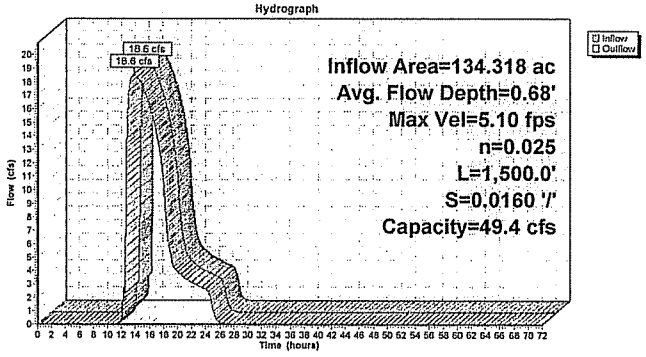
Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 5.10 fps, Min. Travel Time= 4.9 min
Avg. Velocity = 2.30 fps, Avg. Travel Time= 10.9 min

Peak Storage= 5,472 cf @ 13.66 hrs
Average Depth at Peak Storage= 0.68'
Bank-Full Depth= 1.25', Capacity at Bank-Full= 49.4 cfs

5.00' x 1.25' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.25'
Length= 1,500.0' Slope= 0.0160 '/'
Inlet Invert= 192.00', Outlet Invert= 168.00'



Reach 2R: Mineway Brook Section 2



Summary for Reach 3R: Mineway Brook Section 1

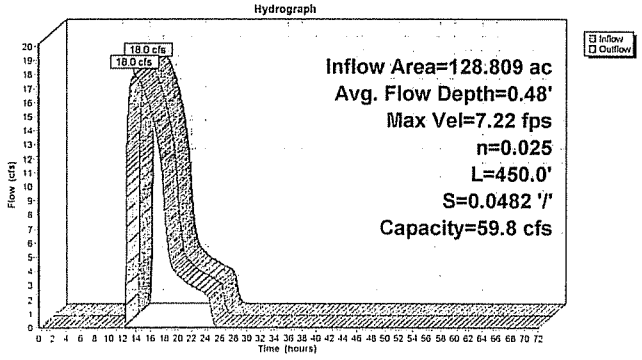
Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 0.85" for 2 year event
Inflow = 18.0 cfs @ 13.67 hrs, Volume= 9.097 af
Outflow = 18.0 cfs @ 13.69 hrs, Volume= 9.097 af, Atten= 0%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 7.22 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 4.40 fps, Avg. Travel Time= 1.7 min

Peak Storage= 1,123 cf @ 13.68 hrs
Average Depth at Peak Storage= 0.48'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 59.8 cfs

5.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.00'
Length= 450.0' Slope= 0.0482 '/'
Inlet Invert= 213.70', Outlet Invert= 192.00'

Reach 3R: Mineway Brook Section 1



Summary for Reach 4R: Overland to Mineway Brook - Section 2

Inflow Area = 3.857 ac, 0.00% Impervious, Inflow Depth = 0.98" for 2 year event
Inflow = 3.3 cfs @ 12.26 hrs, Volume= 0.316 af
Outflow = 1.9 cfs @ 12.94 hrs, Volume= 0.316 af, Atten= 43%, Lag= 40.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.48 fps, Min. Travel Time= 24.5 min
Avg. Velocity = 0.22 fps, Avg. Travel Time= 52.0 min

Peak Storage= 2,771 cf @ 12.53 hrs
Average Depth at Peak Storage= 0.16'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 1,499.6 cfs

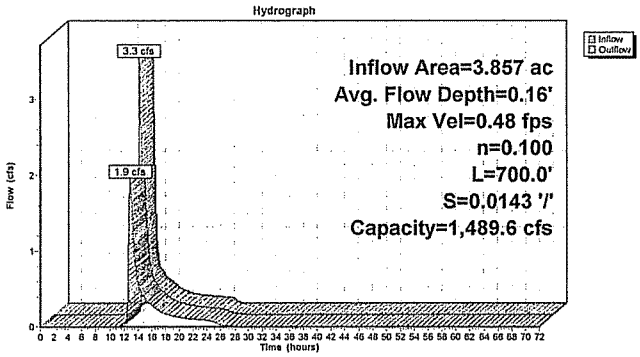
Custom cross-section, Length= 700.0' Slope= 0.0143 '/'
Constant n= 0.100 Very weedy reaches w/pools
Inlet Invert= 180.00', Outlet Invert= 170.00'

‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
-100.00	4.00	0.00
-10.00	0.00	4.00
0.00	0.00	4.00
10.00	0.00	4.00
130.00	4.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	20.0	0	0.0
4.00	500.0	230.2	350,000	1,489.6

Reach 4R: Overland to Mineway Brook - Section 2



Summary for Reach 5R: Overland to Mineway Brook Section 1

Inflow Area = 3.857 ac, 0.00% Impervious, Inflow Depth = 0.98" for 2 year event
Inflow = 3.5 cfs @ 12.16 hrs, Volume= 0.316 af
Outflow = 3.3 cfs @ 12.26 hrs, Volume= 0.316 af, Atten= 5%, Lag= 5.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.93 fps, Min. Travel Time= 3.2 min
Avg. Velocity = 0.35 fps, Avg. Travel Time= 8.6 min

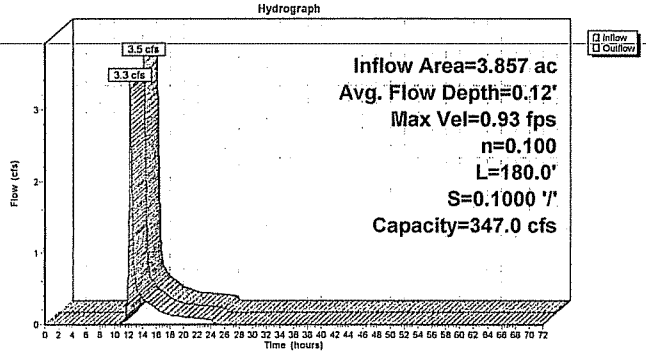
Peak Storage= 646 cf @ 12.20 hrs
Average Depth at Peak Storage= 0.12'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 347.0 cfs

Custom cross-section, Length= 180.0' Slope= 0.1000 '/'
Constant n= 0.100 Heavy timber, flow below branches
Inlet Invert= 198.00', Outlet Invert= 180.00'

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
-100.00	1.00	0.00
-10.00	0.00	1.00
0.00	0.00	1.00
10.00	0.00	1.00
100.00	1.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	20.0	0	0.0
1.00	110.0	200.0	19,800	347.0

Reach 5R: Overland to Mineway Brook Section 1

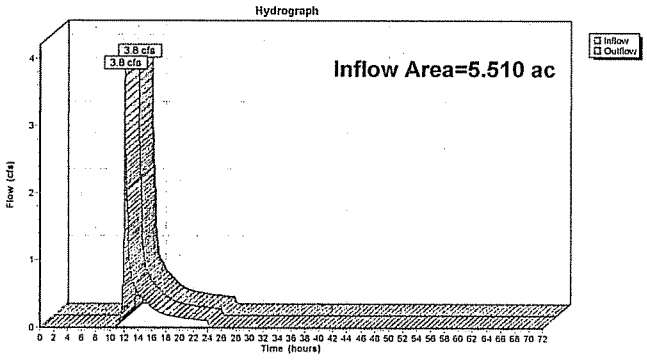


Summary for Reach 10R: Analysis Point 4

Inflow Area = 5.510 ac, 3.75% Impervious, Inflow Depth = 0.88" for 2 year event
Inflow = 3.8 cfs @ 12.13 hrs, Volume= 0.403 af
Outflow = 3.8 cfs @ 12.13 hrs, Volume= 0.403 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Reach 10R: Analysis Point 4



Summary for Pond 1P: Existing Low Point

Inflow Area = 16.736 ac, 2.88% Impervious, Inflow Depth = 0.88" for 2 year event
Inflow = 10.9 cfs @ 12.28 hrs, Volume= 1.225 af
Outflow = 3.0 cfs @ 12.91 hrs, Volume= 1.225 af, Atten= 73%, Lag= 37.7 min
Discarded = 3.0 cfs @ 12.91 hrs, Volume= 1.225 af
Primary = 0.0 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 176.99' @ 12.91 hrs Surf.Area= 15,612 sf Storage= 16,177 cf

Plug-Flow detention time= 67.3 min calculated for 1.224 af (100% of inflow)
Center-of-Mass det. time= 67.3 min (950.8 - 883.5)

Volume	Invert	Avail.Storage	Storage Description
#1	174.50'	18,015 cf	**Area A-1 (Prismatic)** Listed below (Recalc)
#2	176.00'	7,353 cf	**Area A-2 (Prismatic)** Listed below (Recalc)
#3	177.50'	82,925 cf	**Area A-3 (Prismatic)** Listed below (Recalc) -Impervious
		108,293 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
174.50	40	0	0
175.00	2,280	580	580
175.50	5,420	1,925	2,505
176.00	6,950	3,093	5,598
176.50	7,770	3,680	9,278
177.00	8,640	4,103	13,380
177.50	9,900	4,635	18,015

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
176.00	10	0	0
176.50	2,400	603	603
177.00	7,100	2,375	2,978
177.50	10,400	4,375	7,353

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
177.50	20,300	0	0
178.00	25,700	11,500	11,500
178.50	40,900	16,650	28,150
179.00	55,100	24,000	52,150
179.50	68,000	30,775	82,925

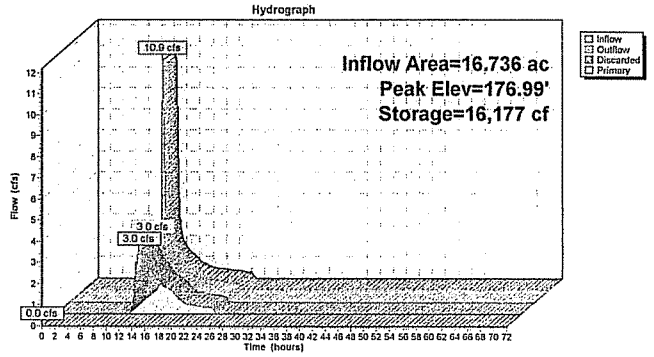
Device	Routing	Invert	Outlet Devices
#1	Primary	178.60'	**12.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

#2 Discarded 174.50' **8.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=3.0 cfs @ 12.91 hrs HW=176.99' (Free Discharge)
↳2=**Exfiltration** (Exfiltration Controls 3.0 cfs)

Primary OutFlow Max=0.0 cfs @ 0.00 hrs HW=174.50' (Free Discharge)
↳1=**Broad-Crested Rectangular Weir** (Controls 0.0 cfs)

Pond 1P: Existing Low Point



Summary for Pond 2P: Peters Way Low Point

Inflow Area = 1.699 ac, 0.00% Impervious, Inflow Depth = 1.04" for 2 year event
Inflow = 1.9 cfs @ 12.11 hrs, Volume= 0.147 af
Outflow = 0.6 cfs @ 12.51 hrs, Volume= 0.091 af, Atten= 69%, Lag= 23.7 min
Primary = 0.6 cfs @ 12.51 hrs, Volume= 0.091 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 212.38' @ 12.51 hrs Surf.Area= 1,629 sf Storage= 2,551 cf

Plug-Flow detention time= 205.6 min calculated for 0.091 af (62% of inflow)
Center-of-Mass det. time= 88.2 min (951.6 - 863.4)

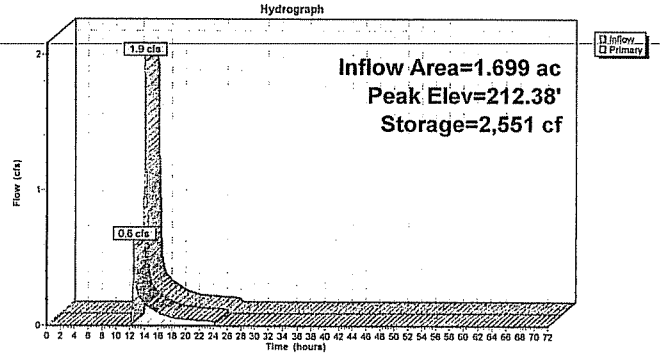
Volume	Invert	Avail.Storage	Storage Description
#1	208.60'	12,859 cf	**Custom Stage Data (Conic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
208.60	50	0	0	50
210.00	400	276	276	406
212.00	1,400	1,699	1,975	1,427
214.00	2,800	4,120	6,095	2,863
216.00	4,000	6,764	12,859	4,132

Device	Routing	Invert	Outlet Devices
#1	Primary	212.30'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.6 cfs @ 12.51 hrs HW=212.38' (Free Discharge)
↳1=**Broad-Crested Rectangular Weir** (Weir Controls 0.6 cfs @ 0.71 fps)

Pond 2P: Peters Way Low Point



Summary for Pond 3P: Analysis Point 6 - Railraod Culvert

Inflow Area = 181.067 ac, 7.41% Impervious, Inflow Depth = 0.76" for 2 year event
Inflow = 24.3 cfs @ 12.93 hrs, Volume= 11.536 af
Outflow = 22.8 cfs @ 13.47 hrs, Volume= 11.536 af, Atten= 6%, Lag= 32.4 min
Primary = 22.8 cfs @ 13.47 hrs, Volume= 11.536 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 170.62' @ 13.47 hrs Surf.Area= 22,908 sf Storage= 11,006 cf

Plug-Flow detention time= 5.2 min calculated for 11.536 af (100% of inflow)
Center-of-Mass det. time= 5.2 min (983.0 - 977.8)

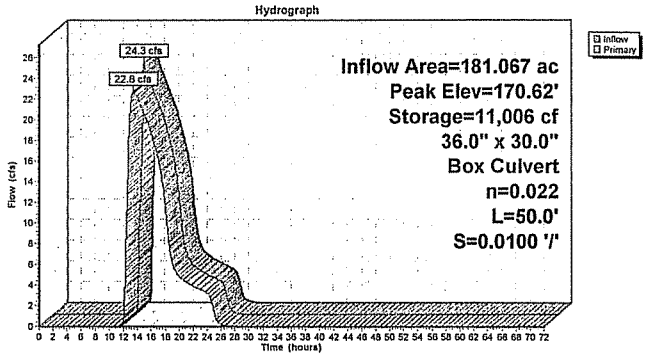
Volume	Invert	Avail.Storage	Storage Description
#1	168.70'	2,431,665 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
168.70	100	0	0
170.00	4,000	2,665	2,665
172.00	65,000	69,000	71,665
174.00	280,000	345,000	416,665
176.00	520,000	800,000	1,216,665
178.00	695,000	1,215,000	2,431,665

Device	Routing	Invert	Outlet Devices
#1	Primary	168.70'	**36.0" W x 30.0" H Box Culvert** L= 50.0' Ke= 0.200 Inlet / Outlet Invert= 168.70' / 168.20' S= 0.0100 '/' Cc= 0.900 n= 0.022 Earth, clean & straight

Primary OutFlow Max=22.8 cfs @ 13.47 hrs HW=170.62' (Free Discharge)
↳**1=Culvert** (Barrel Controls 22.8 cfs @ 5.27 fps)

Pond 3P: Analysis Point 6 - Railraod Culvert



Summary for Pond 4P: Concord Road Culvert

Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 0.93" for 2 year event
Inflow = 62.8 cfs @ 12.63 hrs, Volume= 9.979 af
Outflow = 18.0 cfs @ 13.67 hrs, Volume= 9.097 af, Atten= 71%, Lag= 62.2 min
Primary = 18.0 cfs @ 13.67 hrs, Volume= 9.097 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 217.02' @ 13.67 hrs Surf.Area= 165,045 sf Storage= 149,396 cf

Plug-Flow detention time= 120.4 min calculated for 9.097 af (91% of inflow)
Center-of-Mass det. time= 76.6 min (978.0 - 901.4)

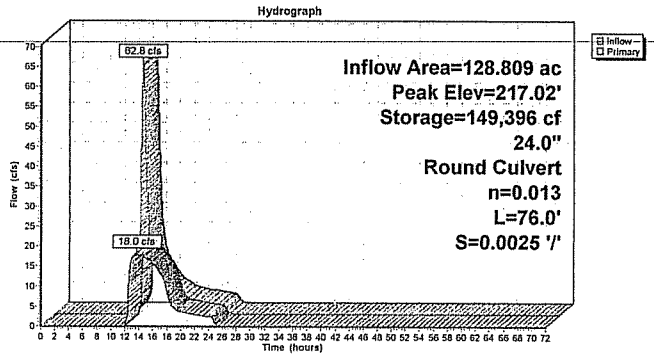
Volume	Invert	Avail.Storage	Storage Description
#1	214.00'	2,610,000 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
214.00	20,000	0	0
216.00	30,000	50,000	50,000
218.00	295,000	325,000	375,000
220.00	556,000	851,000	1,226,000
222.00	828,000	1,384,000	2,610,000

Device	Routing	Invert	Outlet Devices
#1	Primary	213.85'	**24.0" Round Culvert** L= 76.0' Ke= 0.500 Inlet / Outlet Invert= 213.85' / 213.66' S= 0.0025 '/' Cc= 0.900 n= 0.013

Primary OutFlow Max=18.0 cfs @ 13.67 hrs HW=217.02' TW=215.60' (Fixed TW Elev= 215.60')
↳**1=Culvert** (Inlet Controls 18.0 cfs @ 5.74 fps)

Pond 4P: Concord Road Culvert



Summary for Subcatchment Ex1: Analysis Point 1 - Tributary to Hudson Road

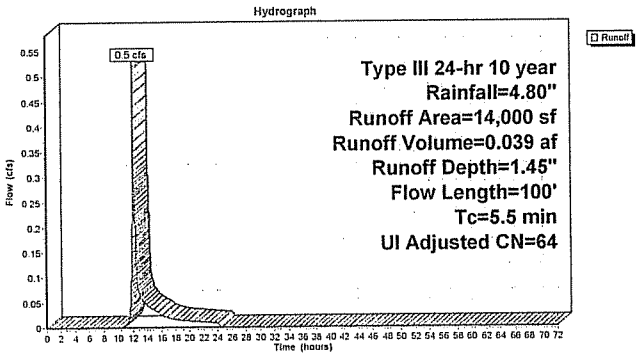
Runoff = 0.5 cfs @ 12.09 hrs, Volume= 0.039 af, Depth= 1.45"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
1,500	55	Woods, Good, HSG B
10,800	61	>75% Grass cover, Good, HSG B
860	98	Paved parking, HSG B
840	98	Unconnected pavement, HSG B
14,000	65	Weighted Average, UI Adjusted CN = 64
12,300		87.86% Pervious Area
1,700		12.14% Impervious Area
840		49.41% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
0.2	50	0.3600	4.20		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
5.5	100	Total			

Subcatchment Ex1: Analysis Point 1 - Tributary to Hudson Road



Summary for Subcatchment Ex2: Analysis Point 2 - Tributary to RR Track

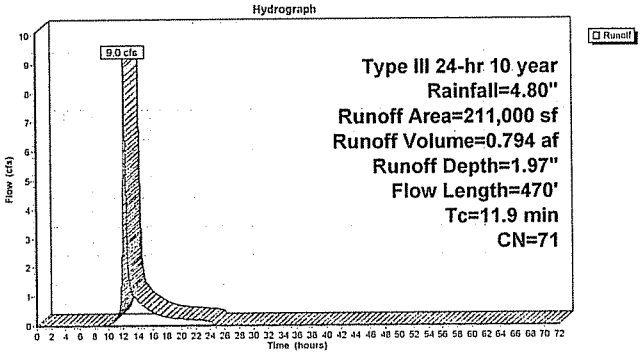
Runoff = 9.0 cfs @ 12.17 hrs, Volume= 0.794 af, Depth= 1.97"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
1,000	55	Woods, Good, HSG B
178,000	70	Woods, Good, HSG C
2,800	61	>75% Grass cover, Good, HSG B
20,500	74	>75% Grass cover, Good, HSG C
1,200	98	Unconnected pavement, HSG B
7,500	98	Unconnected pavement, HSG C
211,000	71	Weighted Average
202,300		95.88% Pervious Area
8,700		4.12% Impervious Area
8,700		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	50	0.0500	0.10		Sheet Flow, A-B Woods: Light underbrush n= 0.400 P2= 3.20"
3.4	420	0.1700	2.06		Shallow Concentrated Flow, B-C Woodland Kv= 5.0 fps
11.9	470	Total			

Subcatchment Ex2: Analysis Point 2 - Tributary to RR Track



Summary for Subcatchment Ex3: Tributary to Low Point

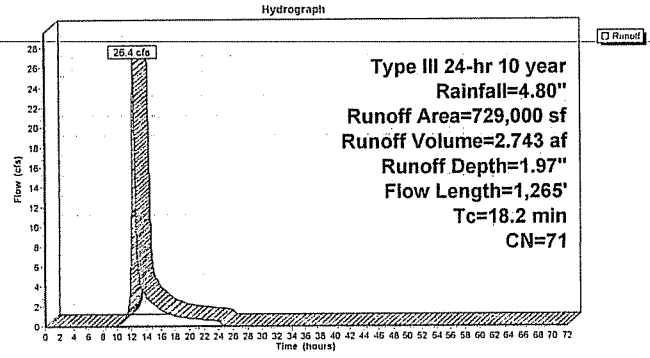
Runoff = 26.4 cfs @ 12.26 hrs, Volume= 2.743 af, Depth= 1.97"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
81,000	55	Woods, Good, HSG B
333,000	70	Woods, Good, HSG C
258,000	74	>75% Grass cover, Good, HSG C
21,000	98	Unconnected pavement, HSG C
36,000	89	Gravel roads, HSG C
729,000	71	Weighted Average
708,000		97.12% Pervious Area
21,000		2.88% Impervious Area
21,000		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
1.6	150	0.0530	1.61		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
1.5	200	0.0200	2.28		Shallow Concentrated Flow, C-D Unpaved Kv= 16.1 fps
0.7	130	0.0230	3.08		Shallow Concentrated Flow, D-E Paved Kv= 20.3 fps
0.6	40	0.0250	1.11		Shallow Concentrated Flow, E-F Short Grass Pasture Kv= 7.0 fps
6.0	565	0.1000	1.58		Shallow Concentrated Flow, F-G Woodland Kv= 5.0 fps
2.5	130	0.0300	0.87		Shallow Concentrated Flow, G-H Woodland Kv= 5.0 fps
18.2	1,265	Total			

Subcatchment Ex3: Tributary to Low Point



Summary for Subcatchment Ex4: Tributary to Abutting Northeast

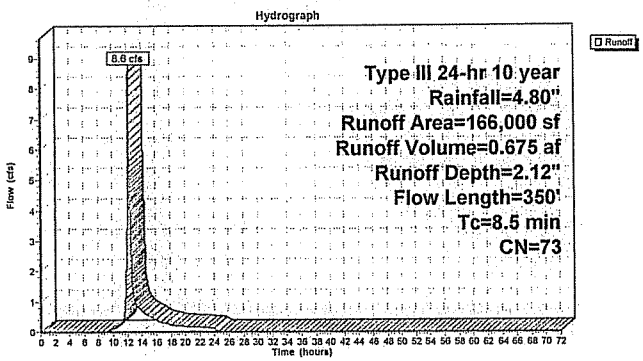
Runoff = 8.6 cfs @ 12.12 hrs, Volume= 0.675 af, Depth= 2.12"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
18,000	55	Woods, Good, HSG B
41,000	70	Woods, Good, HSG C
46,000	71	Meadow, non-grazed, HSG C
36,000	74	>75% Grass cover, Good, HSG C
3,000	85	Gravel roads, HSG B
13,000	89	Gravel roads, HSG C
* 9,000	98	Concord Road
166,000	73	Weighted Average
157,000		94.58% Pervious Area
9,000		5.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	50	0.0360	0.13		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
1.4	215	0.1400	2.62		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
0.6	85	0.2000	2.24		Shallow Concentrated Flow, C-D Woodland Kv= 5.0 fps
8.5	350	Total			

Subcatchment Ex4: Tributary to Abutting Northeast



Summary for Subcatchment Ex5: Tributary to Peters Way Basin

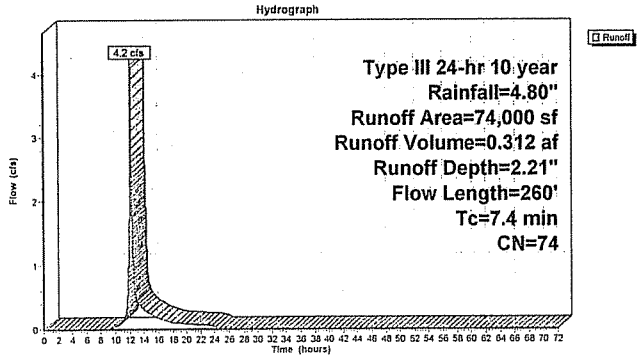
Runoff = 4.2 cfs @ 12.11 hrs, Volume= 0.312 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
43,000	71	Meadow, non-grazed, HSG C
22,000	74	>75% Grass cover, Good, HSG C
9,000	89	Gravel roads, HSG C
74,000	74	Weighted Average
74,000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	50	0.0400	0.13		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
1.2	210	0.1800	2.97		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
7.4	260	Total			

Subcatchment Ex5: Tributary to Peters Way Basin



Summary for Subcatchment Ex6: Analysis Point 5 - Tributary to Undeveloped 30 Acres

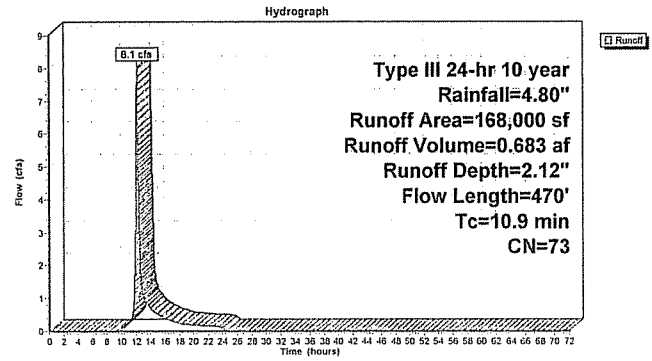
Runoff = 8.1 cfs @ 12.15 hrs, Volume= 0.683 af, Depth= 2.12"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
94,000	70	Woods, Good, HSG C
56,000	74	>75% Grass cover, Good, HSG C
18,000	85	Gravel roads, HSG B
168,000	73	Weighted Average
168,000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	50	0.0300	0.12		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
1.8	170	0.0500	1.57		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
2.1	250	0.1600	2.00		Shallow Concentrated Flow, C-D Woodland Kv= 5.0 fps
10.9	470	Total			

Subcatchment Ex6: Analysis Point 5 - Tributary to Undeveloped 30 Acres



Summary for Subcatchment Ex7: Off-site South of Concord Road

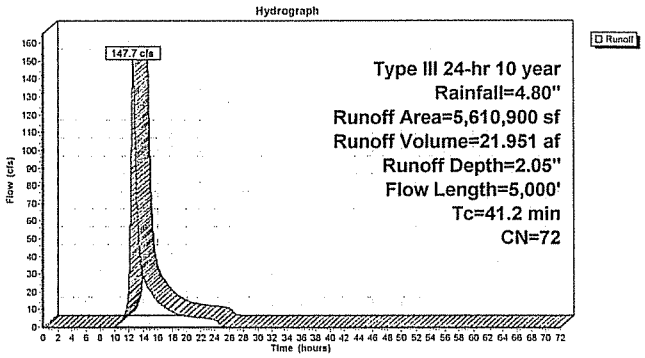
Runoff = 147.7 cfs @ 12.59 hrs, Volume= 21.951 af, Depth= 2.05"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
70,700	30	Woods, Good, HSG A
213,700	55	Woods, Good, HSG B
1,691,800	70	Woods, Good, HSG C
1,462,100	77	Woods, Good, HSG D
1,203,300	79	1 acre lots, 20% Imp, HSG C
321,700	84	1 acre lots, 20% Imp, HSG D
* 647,600	57	Udorthents, 30% Imp, HSG A
5,610,900	72	Weighted Average
5,111,620		91.10% Pervious Area
499,280		8.90% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.9	50	0.0600	0.10		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
14.0	1,450	0.1200	1.73		**Shallow Concentrated Flow, B-C** Woodland Kv= 5.0 fps
4.1	300	0.0300	1.21		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.2	3,200	0.0050	3.52	21.12	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=1.00' Z= 1.0 '/' Top.W=7.00' n= 0.025 Earth, clean & winding
41.2	5,000	Total			

Subcatchment Ex7: Off-site South of Concord Road



Summary for Subcatchment Ex8: Off-site North of Concord Road

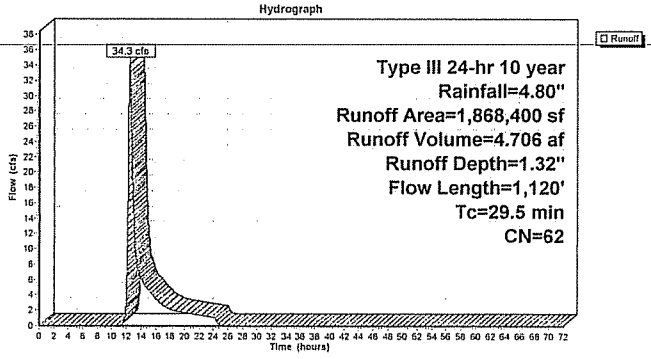
Runoff = 34.3 cfs @ 12.46 hrs, Volume= 4.706 af, Depth= 1.32"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
217,000	30	Woods, Good, HSG A
386,500	55	Woods, Good, HSG B
400,400	70	Woods, Good, HSG C
284,800	77	Woods, Good, HSG D
381,900	79	1 acre lots, 20% Imp, HSG C
197,800	39	Pasture/grassland/range, Good, HSG A
1,868,400	62	Weighted Average
1,792,020		95.91% Pervious Area
76,380		4.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0700	0.11		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
5.2	340	0.0480	1.10		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
15.3	480	0.0110	0.52		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.5	250	0.0050	2.82	10.73	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=0.67' Z= 1.0 '/' Top.W=6.34' n= 0.025 Earth, clean & winding
29.5	1,120	Total			

Subcatchment Ex8: Off-site North of Concord Road

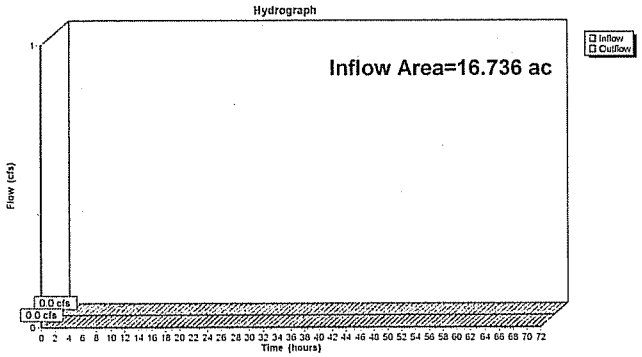


Summary for Reach 1R: Analysis Point 3 - RR Crossing

Inflow Area = 16.736 ac, 2.68% Impervious, Inflow Depth = 0.00" for 10 year event
Inflow = 0.0 cfs @ 0.00 hrs, Volume= 0.000 af
Outflow = 0.0 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Reach 1R: Analysis Point 3 - RR Crossing



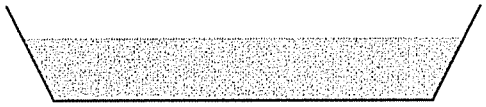
Summary for Reach 2R: Mineway Brook Section 2

Inflow Area = 134.318 ac, 8.69% Impervious, Inflow Depth = 1.97" for 10 year event
Inflow = 25.5 cfs @ 13.84 hrs, Volume= 22.001 af
Outflow = 25.4 cfs @ 13.97 hrs, Volume= 22.001 af, Atten= 0%, Lag= 7.8 min

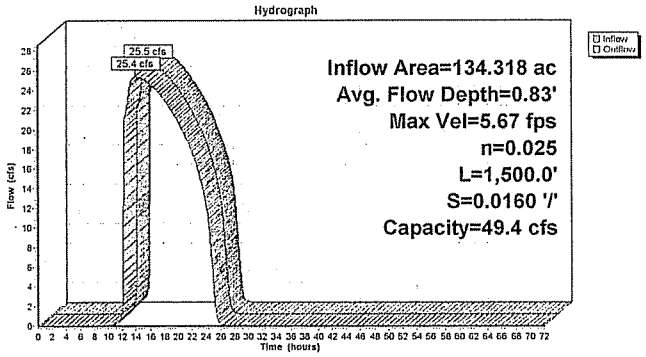
Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 5.67 fps, Min. Travel Time= 4.4 min
Avg. Velocity = 3.07 fps, Avg. Travel Time= 8.1 min

Peak Storage= 6,733 cf @ 13.90 hrs
Average Depth at Peak Storage= 0.83'
Bank-Full Depth= 1.25', Capacity at Bank-Full= 49.4 cfs

5.00' x 1.25' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.25'
Length= 1,500.0' Slope= 0.0160 '/'
Inlet Invert= 192.00', Outlet Invert= 168.00'



Reach 2R: Mineway Brook Section 2



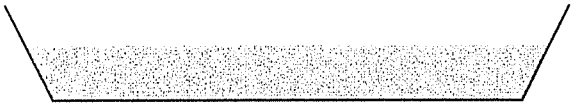
Summary for Reach 3R: Mineway Brook Section 1

Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 1.96" for 10 year event
Inflow = 24.5 cfs @ 14.33 hrs, Volume= 21.070 af
Outflow = 24.5 cfs @ 14.36 hrs, Volume= 21.070 af, Atten= 0%, Lag= 1.5 min

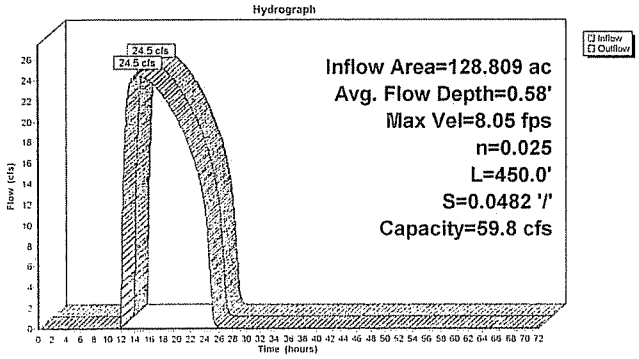
Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 8.05 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 6.24 fps, Avg. Travel Time= 1.2 min

Peak Storage= 1,369 cf @ 14.34 hrs
Average Depth at Peak Storage= 0.58'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 59.8 cfs

5.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.00'
Length= 450.0' Slope= 0.0482 '/'
Inlet Invert= 213.70', Outlet Invert= 192.00'



Reach 3R: Mineway Brook Section 1



Summary for Reach 4R: Overland to Mineway Brook - Section 2

Inflow Area = 3.857 ac, 0.00% Impervious, Inflow Depth = 2.12" for 10 year event
Inflow = 7.8 cfs @ 12.23 hrs, Volume= 0.683 af
Outflow = 5.1 cfs @ 12.71 hrs, Volume= 0.683 af, Atten= 35%, Lag= 28.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.65 fps, Min. Travel Time= 17.9 min
Avg. Velocity = 0.25 fps, Avg. Travel Time= 47.2 min

Peak Storage= 5,444 cf @ 12.41 hrs
Average Depth at Peak Storage= 0.28'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 1,489.6 cfs

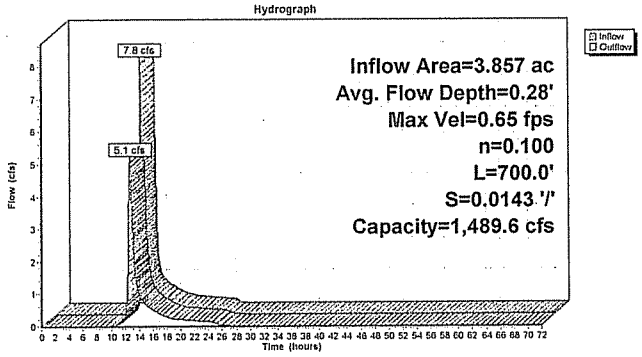
Custom cross-section, Length= 700.0' Slope= 0.0143 '/'
Constant n= 0.100 Very weedy reaches w/pools
Inlet Invert= 180.00', Outlet Invert= 170.00'

‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
-100.00	4.00	0.00
-10.00	0.00	4.00
0.00	0.00	4.00
10.00	0.00	4.00
130.00	4.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	20.0	0	0.0
4.00	500.0	230.2	350,000	1,489.6

Reach 4R: Overland to Mineway Brook - Section 2



Summary for Reach 5R: Overland to Mineway Brook Section 1

Inflow Area = 3.857 ac, 0.00% Impervious, Inflow Depth = 2.12" for 10 year event
Inflow = 8.1 cfs @ 12.15 hrs, Volume= 0.683 af
Outflow = 7.8 cfs @ 12.23 hrs, Volume= 0.683 af, Atten= 4%, Lag= 4.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.18 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 0.42 fps, Avg. Travel Time= 7.2 min

Peak Storage= 1,188 cf @ 12.19 hrs
Average Depth at Peak Storage= 0.18'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 347.0 cfs

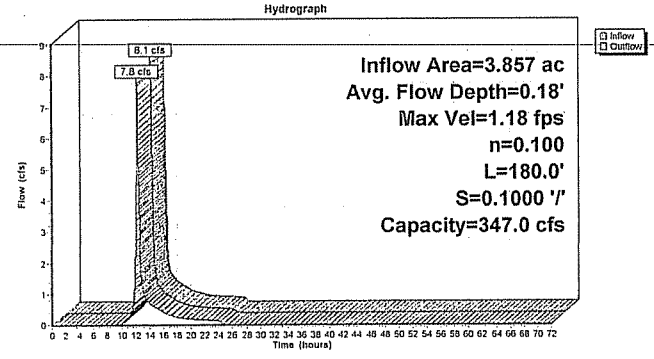
Custom cross-section, Length= 180.0' Slope= 0.1000 '/'
Constant n= 0.100 Heavy timber, flow below branches
Inlet Invert= 198.00', Outlet Invert= 180.00'

‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
-100.00	1.00	0.00
-10.00	0.00	1.00
0.00	0.00	1.00
10.00	0.00	1.00
100.00	1.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	20.0	0	0.0
1.00	110.0	200.0	19,800	347.0

Reach 5R: Overland to Mineway Brook Section 1

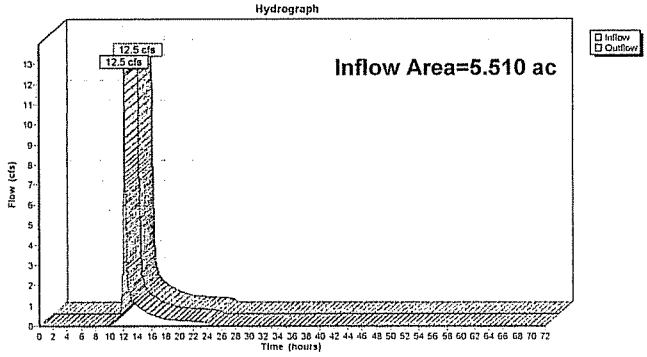


Summary for Reach 10R: Analysis Point 4

Inflow Area = 5.510 ac, 3.75% Impervious, Inflow Depth = 2.03" for 10 year event
Inflow = 12.5 cfs @ 12.13 hrs, Volume= 0.931 af
Outflow = 12.5 cfs @ 12.13 hrs, Volume= 0.931 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Reach 10R: Analysis Point 4



Summary for Pond 1P: Existing Low Point

Inflow Area = 16.736 ac, 2.88% Impervious, Inflow Depth = 1.97" for 10 year event
Inflow = 26.4 cfs @ 12.26 hrs, Volume= 2.743 af
Outflow = 3.9 cfs @ 12.32 hrs, Volume= 2.743 af, Atten= 85%, Lag= 3.4 min
Discarded = 3.9 cfs @ 12.32 hrs, Volume= 2.743 af
Primary = 0.0 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 178.37' @ 13.33 hrs Surf.Area= 20,300 sf Storage= 48,448 cf

Plug-Flow detention time= 130.7 min calculated for 2.742 af (100% of inflow)
Center-of-Mass det. time= 130.7 min (989.3 - 858.6)

Volume	Invert	Avail.Storage	Storage Description
#1	174.50'	18,015 cf	Area A-1 (Prismatic) Listed below (Recalc)
#2	176.00'	7,353 cf	Area A-2 (Prismatic) Listed below (Recalc)
#3	177.50'	82,925 cf	Area A-3 (Prismatic) Listed below (Recalc) -Impervious
		108,293 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
174.50	40	0	0
175.00	2,280	580	580
175.50	5,420	1,925	2,505
176.00	6,950	3,093	5,598
176.50	7,770	3,680	9,278
177.00	8,640	4,103	13,380
177.50	9,900	4,635	18,015

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
176.00	10	0	0
176.50	2,400	603	603
177.00	7,100	2,375	2,978
177.50	10,400	4,375	7,353

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
177.50	20,300	0	0
178.00	25,700	11,500	11,500
178.50	40,900	16,650	28,150
179.00	55,100	24,000	52,150
179.50	68,000	30,775	82,925

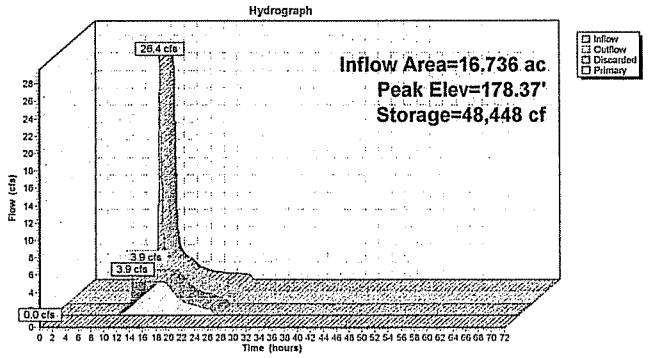
Device	Routing	Invert	Outlet Devices
#1	Primary	178.60'	**12.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

#2 Discarded 174.50' **8.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=3.9 cfs @ 12.32 hrs HW=177.53' (Free Discharge)
↳2=Exfiltration (Exfiltration Controls 3.9 cfs)

Primary OutFlow Max=0.0 cfs @ 0.00 hrs HW=174.50' (Free Discharge)
↳1=Broad-Crested Rectangular Weir (Controls 0.0 cfs)

Pond 1P: Existing Low Point



Summary for Pond 2P: Peters Way Low Point

Inflow Area = 1.699 ac, 0.00% Impervious, Inflow Depth = 2.21" for 10 year event
Inflow = 4.2 cfs @ 12.11 hrs, Volume= 0.312 af
Outflow = 3.9 cfs @ 12.14 hrs, Volume= 0.257 af, Atten= 5%, Lag= 1.9 min
Primary = 3.9 cfs @ 12.14 hrs, Volume= 0.257 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 212.59' @ 12.14 hrs Surf.Area= 1,762 sf Storage= 2,904 cf

Plug-Flow detention time= 108.4 min calculated for 0.257 af (82% of inflow)
Center-of-Mass det. time= 34.7 min (875.5 - 840.8)

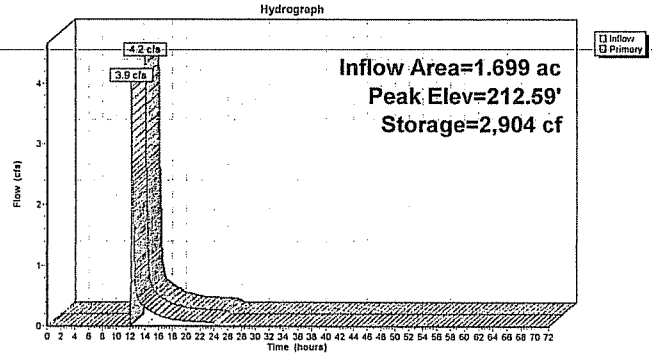
Volume	Invert	Avail.Storage	Storage Description
#1	208.60'	12,859 cf	**Custom Stage Data (Conic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
208.60	50	0	0	50
210.00	400	276	276	406
212.00	1,400	1,699	1,975	1,427
214.00	2,800	4,120	6,095	2,863
216.00	4,000	6,764	12,859	4,132

Device	Routing	Invert	Outlet Devices
#1	Primary	212.30'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=3.9 cfs @ 12.14 hrs HW=212.59' (Free Discharge)
↳1=Broad-Crested Rectangular Weir (Weir Controls 3.9 cfs @ 1.36 fps)

Pond 2P: Peters Way Low Point



Summary for Pond 3P: Analysis Point 6 - Railraod Culvert

Inflow Area = 181.067 ac, 7.41% Impervious, Inflow Depth = 1.82" for 10 year event
Inflow = 58.7 cfs @ 12.52 hrs, Volume= 27.390 af
Outflow = 42.2 cfs @ 13.00 hrs, Volume= 27.390 af, Atten= 28%, Lag= 28.7 min
Primary = 42.2 cfs @ 13.00 hrs, Volume= 27.390 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 171.68' @ 13.00 hrs Surf.Area= 55,116 sf Storage= 52,203 cf

Plug-Flow detention time= 11.6 min calculated for 27.390 af (100% of inflow)
Center-of-Mass det. time= 11.5 min (1,048.7 - 1,037.1)

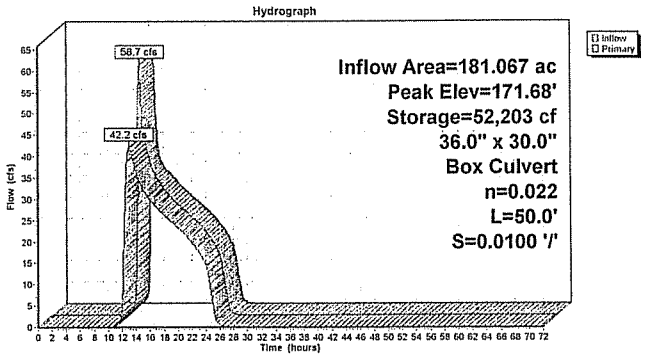
Volume	Invert	Avail.Storage	Storage Description
#1	168.70'	2,431,665 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
168.70	100	0	0
170.00	4,000	2,665	2,665
172.00	65,000	69,000	71,665
174.00	280,000	345,000	416,665
176.00	520,000	800,000	1,216,665
178.00	695,000	1,215,000	2,431,665

Device	Routing	Invert	Outlet Devices
#1	Primary	168.70'	**36.0" W x 30.0" H Box Culvert** L= 50.0' Ke= 0.200 Inlet / Outlet Invert= 168.70' / 168.20' S= 0.0100 '/' Cc= 0.900 n= 0.022 Earth, clean & straight

Primary OutFlow Max=42.2 cfs @ 13.00 hrs HW=171.68' (Free Discharge)
↳1=Culvert (Barrel Controls 42.2 cfs @ 6.30 fps)

Pond 3P: Analysis Point 6 - Railraod Culvert



Summary for Pond 4P: Concord Road Culvert

Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 2.05" for 10 year event
Inflow = 147.7 cfs @ 12.59 hrs, Volume= 21.951 af
Outflow = 24.5 cfs @ 14.33 hrs, Volume= 21.070 af, Atten= 83%, Lag= 104.7 min
Primary = 24.5 cfs @ 14.33 hrs, Volume= 21.070 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 218.22' @ 14.33 hrs Surf.Area= 323,792 sf Storage= 443,261 cf

Plug-Flow detention time= 214.9 min calculated for 21.070 af (96% of inflow)
Center-of-Mass det. time= 192.7 min (1,070.0 - 877.3)

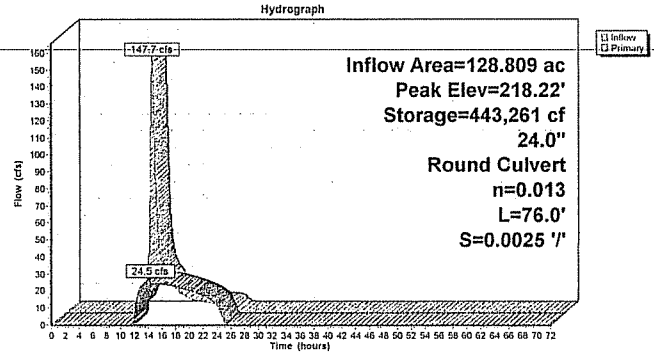
Volume	Invert	Avail.Storage	Storage Description
#1	214.00'	2,610,000 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
214.00	20,000	0	0
216.00	30,000	50,000	50,000
218.00	295,000	325,000	375,000
220.00	556,000	851,000	1,226,000
222.00	828,000	1,384,000	2,610,000

Device	Routing	Invert	Outlet Devices
#1	Primary	213.85'	**24.0" Round Culvert** L= 76.0' Ke= 0.500 Inlet / Outlet Invert= 213.85' / 213.66' S= 0.0025 '/' Cc= 0.900 n= 0.013

Primary OutFlow Max=24.5 cfs @ 14.33 hrs HW=218.22' TW=215.60' (Fixed TW Elev= 215.60')
↳1=Culvert (Inlet Controls 24.5 cfs @ 7.79 fps)

Pond 4P: Concord Road Culvert



Summary for Subcatchment Ex1: Analysis Point 1 - Tributary to Hudson Road

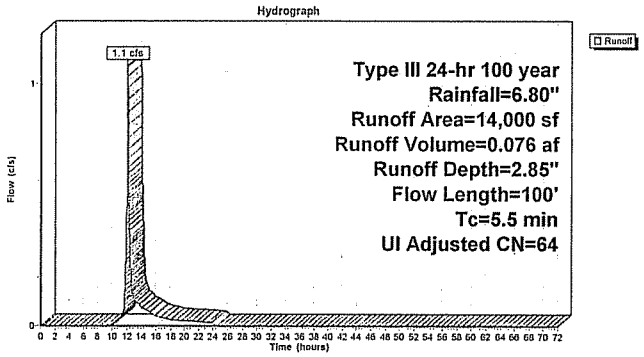
Runoff = 1.1 cfs @ 12.09 hrs, Volume= 0.076 af, Depth= 2.85"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
1,500	55	Woods, Good, HSG B
10,800	61	>75% Grass cover, Good, HSG B
860	98	Paved parking, HSG B
840	98	Unconnected pavement, HSG B
14,000	65	Weighted Average, UI Adjusted CN = 64
12,300		87.86% Pervious Area
1,700		12.14% Impervious Area
840		49.41% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
0.2	50	0.3600	4.20		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
5.5	100	Total			

Subcatchment Ex1: Analysis Point 1 - Tributary to Hudson Road



Summary for Subcatchment Ex2: Analysis Point 2 - Tributary to RR Track

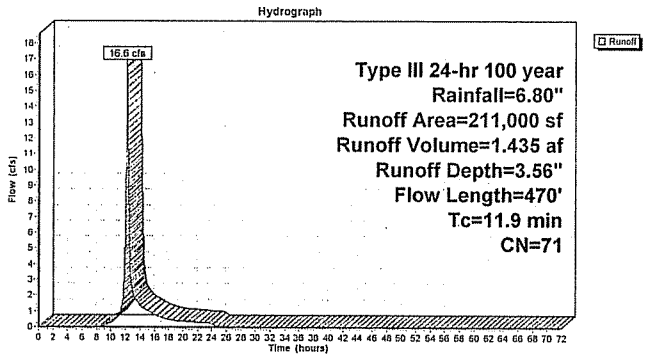
Runoff = 16.6 cfs @ 12.17 hrs, Volume= 1.435 af, Depth= 3.56"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
1,000	55	Woods, Good, HSG B
178,000	70	Woods, Good, HSG C
2,800	61	>75% Grass cover, Good, HSG B
20,500	74	>75% Grass cover, Good, HSG C
1,200	98	Unconnected pavement, HSG B
7,500	98	Unconnected pavement, HSG C
211,000	71	Weighted Average
202,300		95.88% Pervious Area
8,700		4.12% Impervious Area
8,700		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	50	0.0500	0.10		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
3.4	420	0.1700	2.06		**Shallow Concentrated Flow, B-C** Woodland Kv= 5.0 fps
11.9	470	Total			

Subcatchment Ex2: Analysis Point 2 - Tributary to RR Track



Summary for Subcatchment Ex3: Tributary to Low Point

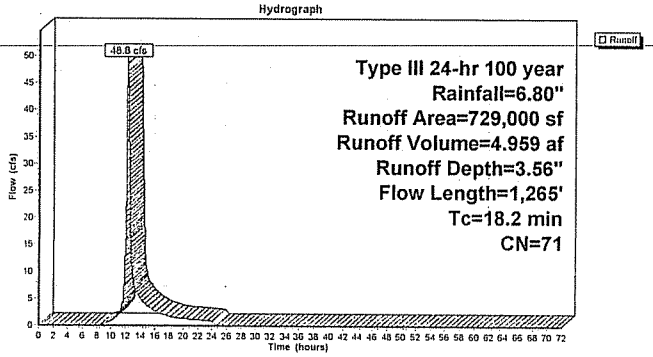
Runoff = 48.8 cfs @ 12.25 hrs, Volume= 4.959 af, Depth= 3.56"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
81,000	55	Woods, Good, HSG B
333,000	70	Woods, Good, HSG C
258,000	74	>75% Grass cover, Good, HSG C
21,000	98	Unconnected pavement, HSG C
36,000	89	Gravel roads, HSG C
729,000	71	Weighted Average
708,000		97.12% Pervious Area
21,000		2.88% Impervious Area
21,000		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.6	150	0.0530	1.61		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.5	200	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
0.7	130	0.0230	3.08		**Shallow Concentrated Flow, D-E** Paved Kv= 20.3 fps
0.6	40	0.0250	1.11		**Shallow Concentrated Flow, E-F** Short Grass Pasture Kv= 7.0 fps
6.0	565	0.1000	1.58		**Shallow Concentrated Flow, F-G** Woodland Kv= 5.0 fps
2.5	130	0.0300	0.87		**Shallow Concentrated Flow, G-H** Woodland Kv= 5.0 fps
18.2	1,265	Total			

Subcatchment Ex3: Tributary to Low Point



Summary for Subcatchment Ex4: Tributary to Abutting Northeast

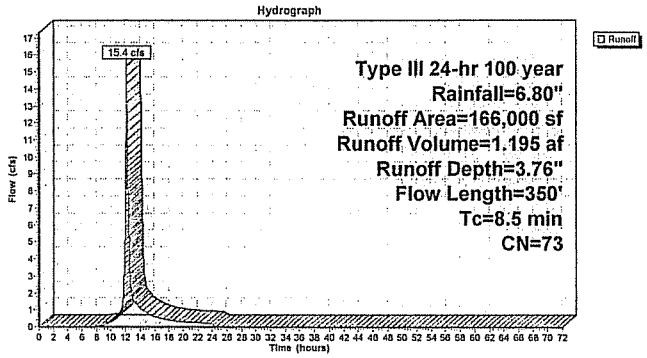
Runoff = 15.4 cfs @ 12.12 hrs, Volume= 1.195 af, Depth= 3.76"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
18,000	55	Woods, Good, HSG B
41,000	70	Woods, Good, HSG C
46,000	71	Meadow, non-grazed, HSG C
36,000	74	>75% Grass cover, Good, HSG C
3,000	85	Gravel roads, HSG B
13,000	89	Gravel roads, HSG C
* 9,000	98	Concord Road
166,000	73	Weighted Average
157,000		94.58% Pervious Area
9,000		5.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	50	0.0360	0.13		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
1.4	215	0.1400	2.62		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
0.6	85	0.2000	2.24		Shallow Concentrated Flow, C-D Woodland Kv= 5.0 fps
8.5	350	Total			

Subcatchment Ex4: Tributary to Abutting Northeast



Summary for Subcatchment Ex5: Tributary to Peters Way Basin

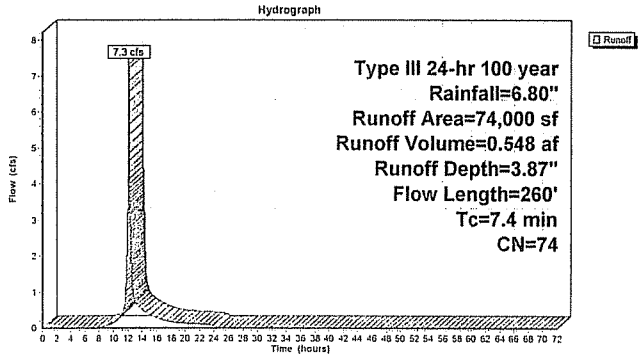
Runoff = 7.3 cfs @ 12.11 hrs, Volume= 0.548 af, Depth= 3.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
43,000	71	Meadow, non-grazed, HSG C
22,000	74	>75% Grass cover, Good, HSG C
9,000	89	Gravel roads, HSG C
74,000	74	Weighted Average
74,000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	50	0.0400	0.13		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
1.2	210	0.1800	2.97		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
7.4	260	Total			

Subcatchment Ex5: Tributary to Peters Way Basin



Summary for Subcatchment Ex6: Analysis Point 5 - Tributary to Undeveloped 30 Acres

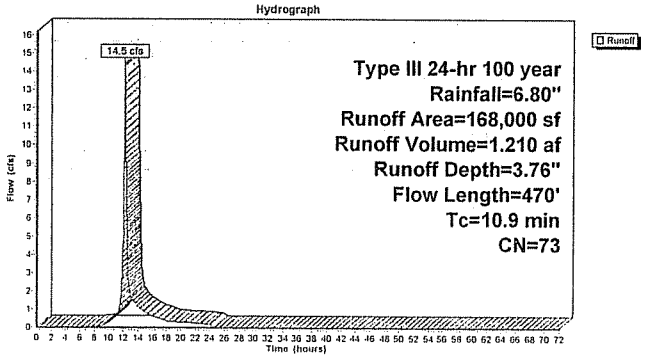
Runoff = 14.5 cfs @ 12.15 hrs, Volume= 1.210 af, Depth= 3.76"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
94,000	70	Woods, Good, HSG C
56,000	74	>75% Grass cover, Good, HSG C
18,000	85	Gravel roads, HSG B
168,000	73	Weighted Average
168,000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	50	0.0300	0.12		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
1.8	170	0.0500	1.57		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
2.1	250	0.1600	2.00		Shallow Concentrated Flow, C-D Woodland Kv= 5.0 fps
10.9	470	Total			

Subcatchment Ex6: Analysis Point 5 - Tributary to Undeveloped 30 Acres



Summary for Subcatchment Ex7: Off-site South of Concord Road

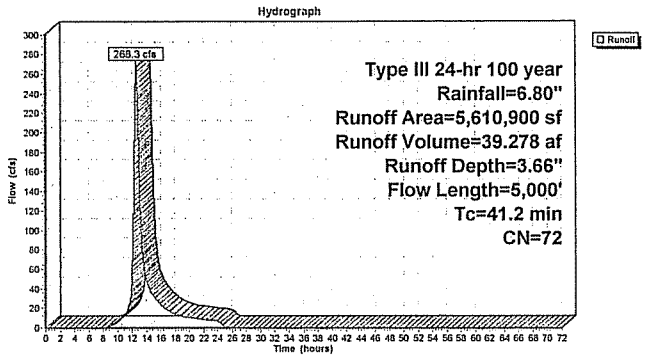
Runoff = 268.3 cfs @ 12.59 hrs, Volume= 39.278 af, Depth= 3.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
70,700	30	Woods, Good, HSG A
213,700	55	Woods, Good, HSG B
1,691,800	70	Woods, Good, HSG C
1,462,100	77	Woods, Good, HSG D
1,203,300	79	1 acre lots, 20% Imp, HSG C
321,700	84	1 acre lots, 20% Imp, HSG D
* 647,600	57	Udorthents, 30% Imp, HSG A
5,610,900	72	Weighted Average
5,111,620		91.10% Pervious Area
499,280		8.90% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.9	50	0.0600	0.10		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
14.0	1,450	0.1200	1.73		**Shallow Concentrated Flow, B-C** Woodland Kv= 5.0 fps
4.1	300	0.0300	1.21		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.2	3,200	0.0050	3.52	21.12	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=1.00' Z= 1.0 '/' Top.W=7.00' n= 0.025 Earth, clean & winding
41.2	5,000	Total			

Subcatchment Ex7: Off-site South of Concord Road



Summary for Subcatchment Ex8: Off-site North of Concord Road

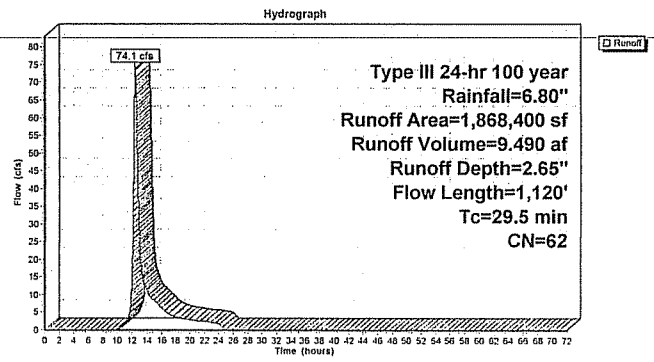
Runoff = 74.1 cfs @ 12.43 hrs, Volume= 9.490 af, Depth= 2.65"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
217,000	30	Woods, Good, HSG A
386,500	55	Woods, Good, HSG B
400,400	70	Woods, Good, HSG C
284,800	77	Woods, Good, HSG D
381,900	79	1 acre lots, 20% Imp, HSG C
197,800	39	Pasture/grassland/range, Good, HSG A
1,868,400	62	Weighted Average
1,792,020		95.91% Pervious Area
76,380		4.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0700	0.11		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
5.2	340	0.0480	1.10		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
15.3	480	0.0110	0.52		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.5	250	0.0050	2.82	10.73	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=0.67' Z= 1.0 '/' Top.W=6.34' n= 0.025 Earth, clean & winding
29.5	1,120	Total			

Subcatchment Ex8: Off-site North of Concord Road

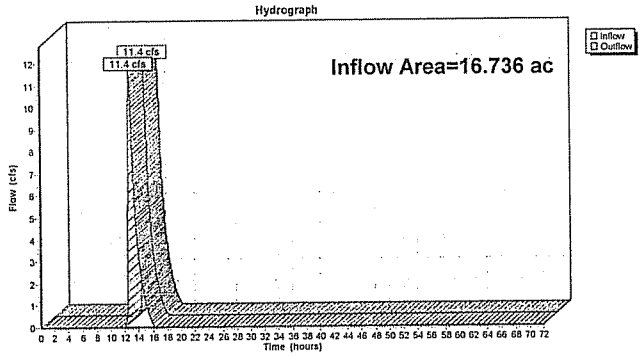


Summary for Reach 1R: Analysis Point 3 - RR Crossing

Inflow Area = 16.736 ac, 2.88% Impervious, Inflow Depth = 0.83" for 100 year event
Inflow = 11.4 cfs @ 12.74 hrs, Volume= 1.160 af
Outflow = 11.4 cfs @ 12.74 hrs, Volume= 1.160 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Reach 1R: Analysis Point 3 - RR Crossing



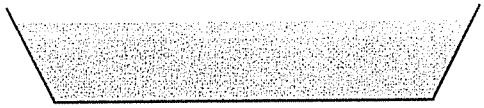
Summary for Reach 2R: Mineway Brook Section 2

Inflow Area = 134.318 ac, 8.69% Impervious, Inflow Depth = 3.58" for 100 year event
Inflow = 39.0 cfs @ 12.13 hrs, Volume= 40.084 af
Outflow = 37.1 cfs @ 12.24 hrs, Volume= 40.084 af, Atten= 5%, Lag= 6.5 min

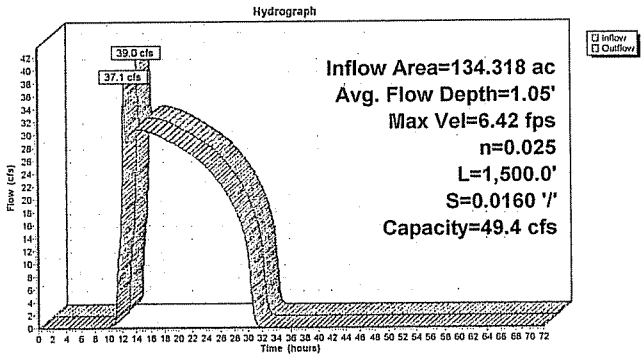
Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 6.42 fps, Min. Travel Time= 3.9 min
Avg. Velocity = 3.72 fps, Avg. Travel Time= 6.7 min

Peak Storage= 8,687 cf @ 12.17 hrs
Average Depth at Peak Storage= 1.05'
Bank-Full Depth= 1.25', Capacity at Bank-Full= 49.4 cfs

5.00' x 1.25' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.25'
Length= 1,500.0' Slope= 0.0160 '/'
Inlet Invert= 192.00', Outlet Invert= 168.00'



Reach 2R: Mineway Brook Section 2



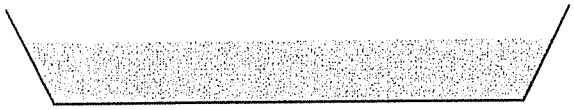
Summary for Reach 3R: Mineway Brook Section 1

Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 3.58" for 100 year event
Inflow = 29.6 cfs @ 15.29 hrs, Volume= 38.397 af
Outflow = 29.6 cfs @ 15.31 hrs, Volume= 38.397 af, Atten= 0%, Lag= 1.5 min

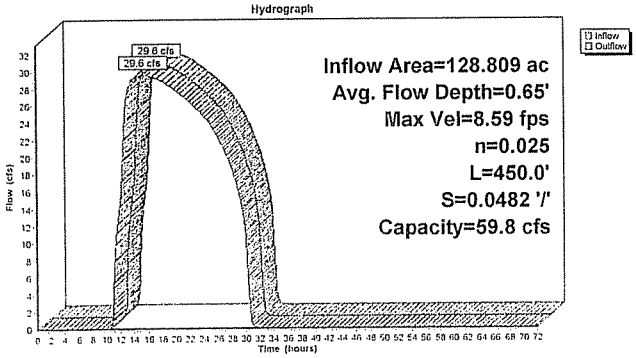
Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 8.59 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 7.07 fps, Avg. Travel Time= 1.1 min

Peak Storage= 1,550 cf @ 15.30 hrs
Average Depth at Peak Storage= 0.65'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 59.8 cfs

5.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.00'
Length= 450.0' Slope= 0.0482 '/'
Inlet Invert= 213.70', Outlet Invert= 192.00'



Reach 3R: Mineway Brook Section 1



Summary for Reach 4R: Overland to Mineway Brook - Section 2

Inflow Area = 3.857 ac, 0.00% Impervious, Inflow Depth = 3.76" for 100 year event
Inflow = 14.0 cfs @ 12.22 hrs, Volume= 1.210 af
Outflow = 9.9 cfs @ 12.60 hrs, Volume= 1.210 af, Atten= 30%, Lag= 23.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.80 fps, Min. Travel Time= 14.6 min
Avg. Velocity = 0.28 fps, Avg. Travel Time= 42.4 min

Peak Storage= 8,680 cf @ 12.35 hrs
Average Depth at Peak Storage= 0.40'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 1,489.6 cfs

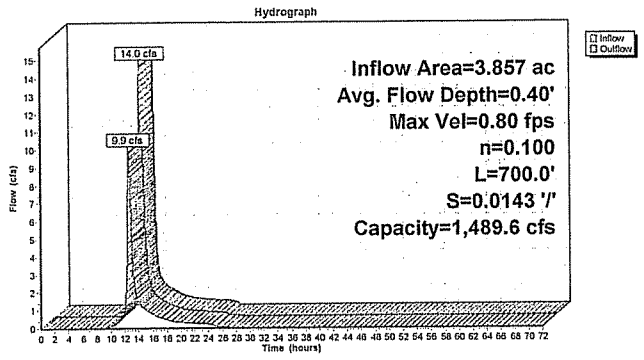
Custom cross-section, Length= 700.0' Slope= 0.0143 '/'
Constant n= 0.100 Very weedy reaches w/pools
Inlet Invert= 180.00', Outlet Invert= 170.00'

‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
-100.00	4.00	0.00
-10.00	0.00	4.00
0.00	0.00	4.00
10.00	0.00	4.00
130.00	4.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	20.0	0	0.0
4.00	500.0	230.2	350,000	1,489.6

Reach 4R: Overland to Mineway Brook - Section 2



Summary for Reach 5R: Overland to Mineway Brook Section 1

Inflow Area = 3.857 ac, 0.00% Impervious, Inflow Depth = 3.76" for 100 year event
Inflow = 14.5 cfs @ 12.15 hrs, Volume= 1.210 af
Outflow = 14.0 cfs @ 12.22 hrs, Volume= 1.210 af, Atten= 3%, Lag= 3.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.38 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 0.48 fps, Avg. Travel Time= 6.2 min

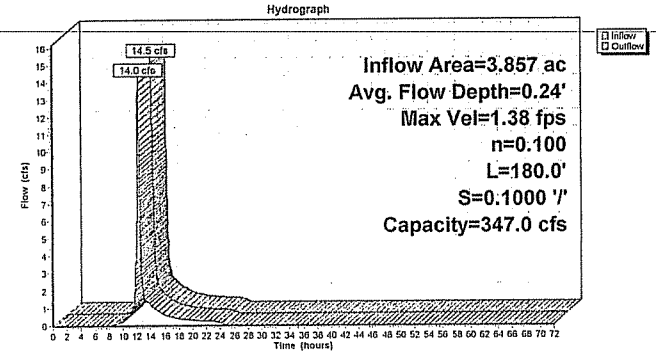
Peak Storage= 1,830 cf @ 12.18 hrs
Average Depth at Peak Storage= 0.24'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 347.0 cfs

Custom cross-section, Length= 180.0' Slope= 0.1000 '/'
Constant n= 0.100 Heavy timber, flow below branches
Inlet Invert= 198.00', Outlet Invert= 180.00'

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
-100.00	1.00	0.00
-10.00	0.00	1.00
0.00	0.00	1.00
10.00	0.00	1.00
100.00	1.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	20.0	0	0.0
1.00	110.0	200.0	19,800	347.0

Reach 5R: Overland to Mineway Brook Section 1

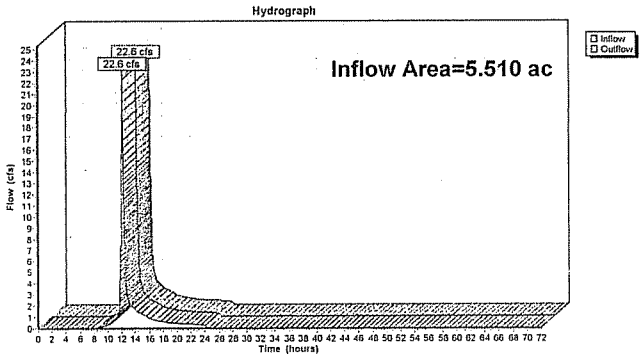


Summary for Reach 10R: Analysis Point 4

Inflow Area = 5.510 ac, 3.75% Impervious, Inflow Depth = 3.67" for 100 year event
Inflow = 22.6 cfs @ 12.12 hrs, Volume= 1.687 af
Outflow = 22.6 cfs @ 12.12 hrs, Volume= 1.687 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Reach 10R: Analysis Point 4



Summary for Pond 1P: Existing Low Point

Inflow Area = 16.736 ac, 2.88% Impervious, Inflow Depth = 3.56" for 100 year event
Inflow = 48.8 cfs @ 12.25 hrs, Volume= 4.959 af
Outflow = 15.3 cfs @ 12.74 hrs, Volume= 4.959 af, Atten= 69%, Lag= 29.2 min
Discarded = 3.9 cfs @ 12.11 hrs, Volume= 3.799 af
Primary = 11.4 cfs @ 12.74 hrs, Volume= 1.160 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 179.11' @ 12.74 hrs Surf.Area= 20,300 sf Storage= 83,720 cf

Plug-Flow detention time= 143.0 min calculated for 4.958 af (100% of inflow)
Center-of-Mass det. time= 143.0 min (984.2 - 841.3)

Volume	Invert	Avail.Storage	Storage Description
#1	174.50'	18,015 cf	**Area A-1 (Prismatic)** Listed below (Recalc)
#2	176.00'	7,353 cf	**Area A-2 (Prismatic)** Listed below (Recalc)
#3	177.50'	82,925 cf	**Area A-3 (Prismatic)** Listed below (Recalc) -Impervious
		108,293 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
174.50	40	0	0
175.00	2,280	580	580
175.50	5,420	1,925	2,505
176.00	6,950	3,093	5,598
176.50	7,770	3,680	9,278
177.00	8,640	4,103	13,380
177.50	9,900	4,635	18,015

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
176.00	10	0	0
176.50	2,400	603	603
177.00	7,100	2,375	2,978
177.50	10,400	4,375	7,353

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
177.50	20,300	0	0
178.00	25,700	11,500	11,500
178.50	40,900	16,650	28,150
179.00	55,100	24,000	52,150
179.50	68,000	30,775	82,925

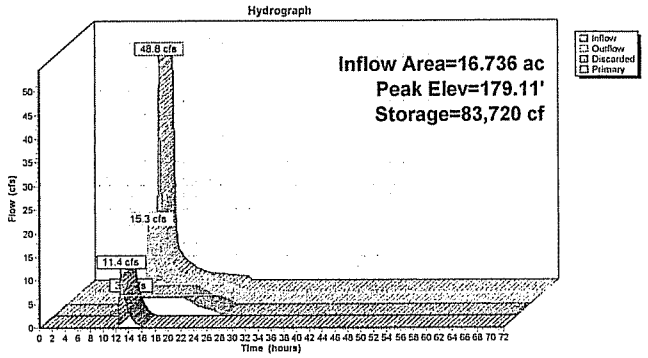
Device	Routing	Invert	Outlet Devices
#1	Primary	178.60'	**12.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

#2 Discarded 174.50' **8.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=3.9 cfs @ 12.11 hrs HW=177.51' (Free Discharge)
└**2=Exfiltration** (Exfiltration Controls 3.9 cfs)

Primary OutFlow Max=11.4 cfs @ 12.74 hrs HW=179.11' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 11.4 cfs @ 1.86 fps)

Pond 1P: Existing Low Point



Summary for Pond 2P: Peters Way Low Point

Inflow Area = 1.699 ac, 0.00% Impervious, Inflow Depth = 3.87" for 100 year event
Inflow = 7.3 cfs @ 12.11 hrs, Volume= 0.548 af
Outflow = 7.2 cfs @ 12.13 hrs, Volume= 0.492 af, Atten= 2%, Lag= 1.2 min
Primary = 7.2 cfs @ 12.13 hrs, Volume= 0.492 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 212.72' @ 12.13 hrs Surf.Area= 1,852 sf Storage= 3,150 cf

Plug-Flow detention time= 72.4 min calculated for 0.492 af (90% of inflow)
Center-of-Mass det. time= 23.2 min (847.8 - 824.5)

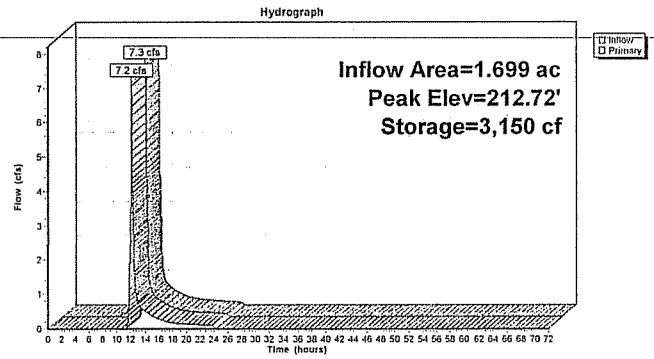
Volume	Invert	Avail.Storage	Storage Description
#1	208.60'	12,859 cf	**Custom Stage Data (Conic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
208.60	50	0	0	50
210.00	400	276	276	406
212.00	1,400	1,699	1,975	1,427
214.00	2,800	4,120	6,095	2,863
216.00	4,000	6,764	12,859	4,132

Device	Routing	Invert	Outlet Devices
#1	Primary	212.30'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=7.1 cfs @ 12.13 hrs HW=212.72' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 7.1 cfs @ 1.68 fps)

Pond 2P: Peters Way Low Point



Summary for Pond 3P: Analysis Point 6 - Railraod Culvert

Inflow Area = 181.067 ac, 7.41% Impervious, Inflow Depth = 3.37" for 100 year event
Inflow = 111.9 cfs @ 12.46 hrs, Volume= 50.784 af
Outflow = 56.4 cfs @ 13.13 hrs, Volume= 50.784 af, Atten= 50%, Lag= 40.5 min
Primary = 56.4 cfs @ 13.13 hrs, Volume= 50.784 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 172.79' @ 13.13 hrs Surf.Area= 149,986 sf Storage= 156,645 cf

Plug-Flow detention time= 20.2 min calculated for 50.784 af (100% of inflow)
Center-of-Mass det. time= 20.2 min (1,153.1 - 1,132.9)

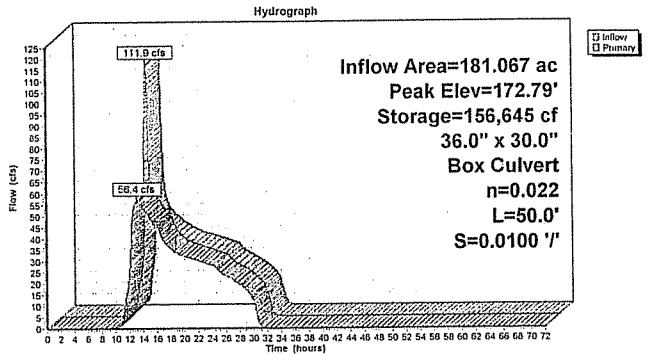
Volume	Invert	Avail.Storage	Storage Description
#1	168.70'	2,431,665 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
168.70	100	0	0
170.00	4,000	2,665	2,665
172.00	65,000	69,000	71,665
174.00	280,000	345,000	416,665
176.00	520,000	800,000	1,216,665
178.00	695,000	1,215,000	2,431,665

Device	Routing	Invert	Outlet Devices
#1	Primary	168.70'	**36.0" W x 30.0" H Box Culvert** L= 50.0' Ke= 0.200 Inlet / Outlet Invert= 168.70' / 168.20' S= 0.0100 '/' Cc= 0.900 n= 0.022 Earth, clean & straight

Primary OutFlow Max=56.4 cfs @ 13.13 hrs HW=172.79' (Free Discharge)
↳1=**Culvert** (Barrel Controls 56.4 cfs @ 7.52 fps)

Pond 3P: Analysis Point 6 - Railraod Culvert



Summary for Pond 4P: Concord Road Culvert

Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 3.66" for 100 year event
Inflow = 268.3 cfs @ 12.59 hrs, Volume= 39.278 af
Outflow = 29.6 cfs @ 15.29 hrs, Volume= 38.397 af, Atten= 89%, Lag= 162.1 min
Primary = 29.6 cfs @ 15.29 hrs, Volume= 38.397 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 219.43' @ 15.29 hrs Surf.Area= 481,146 sf Storage= 928,548 cf

Plug-Flow detention time= 360.9 min calculated for 38.397 af (98% of inflow)
Center-of-Mass det. time= 347.6 min (1,208.0 - 860.4)

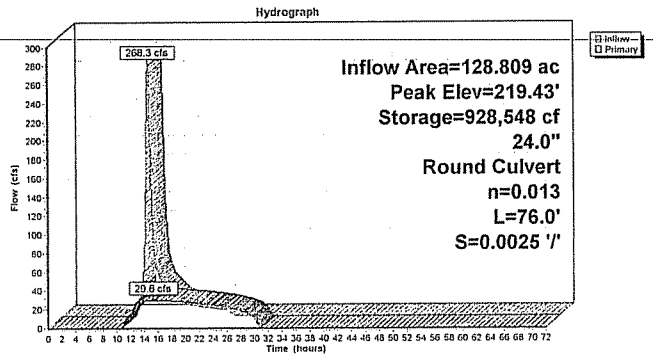
Volume	Invert	Avail.Storage	Storage Description
#1	214.00'	2,610,000 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
214.00	20,000	0	0
216.00	30,000	50,000	50,000
218.00	295,000	325,000	375,000
220.00	556,000	851,000	1,226,000
222.00	828,000	1,384,000	2,610,000

Device	Routing	Invert	Outlet Devices
#1	Primary	213.85'	**24.0" Round Culvert** L= 76.0' Ke= 0.500 Inlet / Outlet Invert= 213.85' / 213.66' S= 0.0025 '/' Cc= 0.900 n= 0.013

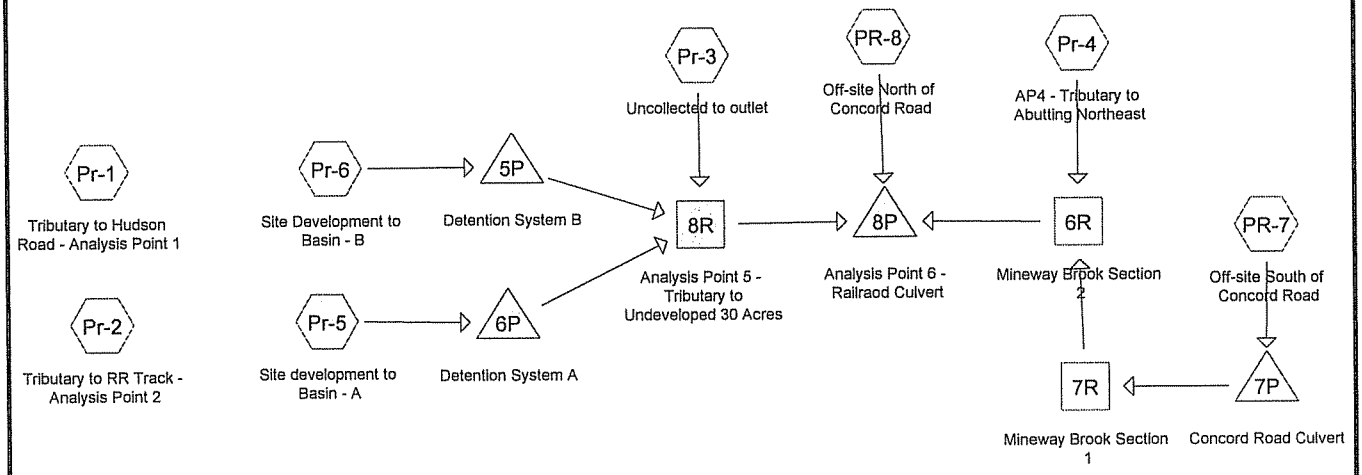
Primary OutFlow Max=29.6 cfs @ 15.29 hrs HW=219.43' TW=215.60' (Fixed TW Elev= 215.60')
↳1=**Culvert** (Inlet Controls 29.6 cfs @ 9.42 fps)

Pond 4P: Concord Road Culvert



PROPOSED CONDITIONS

2-, 10-, 100-YEAR



Subcat Reach Pond Link

Drainage Diagram for 40B Drainage Overall
Prepared by Microsoft, Printed 6/10/2016
HydroCAD® 9.10 s/n 01413 © 2011 HydroCAD Software Solutions LLC

Summary for Subcatchment Pr-1: Tributary to Hudson Road - Analysis Point 1

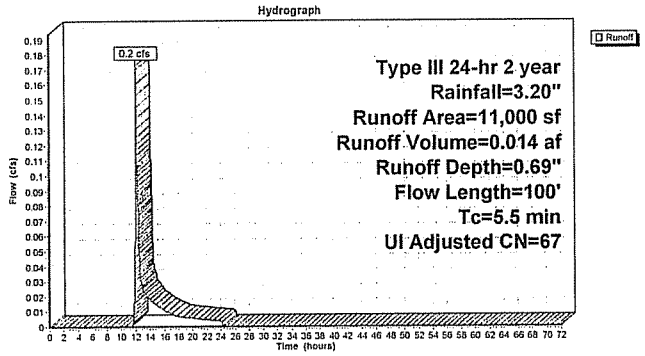
Runoff = 0.2 cfs @ 12.10 hrs, Volume= 0.014 af, Depth= 0.69"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
8,650	61	>75% Grass cover, Good, HSG B
1,510	98	Paved parking, HSG B
840	98	Unconnected pavement, HSG B
11,000	69	Weighted Average, UI Adjusted CN = 67
8,650		78.64% Pervious Area
2,350		21.36% Impervious Area
840		35.74% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
0.2	50	0.3600	4.20		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
5.5	100	Total			

Subcatchment Pr-1: Tributary to Hudson Road - Analysis Point 1



Summary for Subcatchment Pr-2: Tributary to RR Track - Analysis Point 2

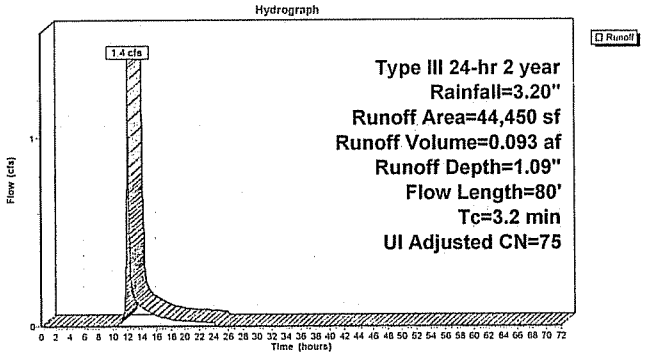
Runoff = 1.4 cfs @ 12.05 hrs, Volume= 0.093 af, Depth= 1.09"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
2,650	61	>75% Grass cover, Good, HSG B
34,400	74	>75% Grass cover, Good, HSG C
4,500	98	Unconnected pavement, HSG C
2,900	98	Unconnected roofs, HSG C
44,450	77	Weighted Average, UI Adjusted CN = 75
37,050		83.35% Pervious Area
7,400		16.65% Impervious Area
7,400		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.1	50	0.2200	0.27		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
0.1	30	0.3000	3.83		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
3.2	80	Total			

Subcatchment Pr-2: Tributary to RR Track - Analysis Point 2



Summary for Subcatchment Pr-3: Uncollected to outlet

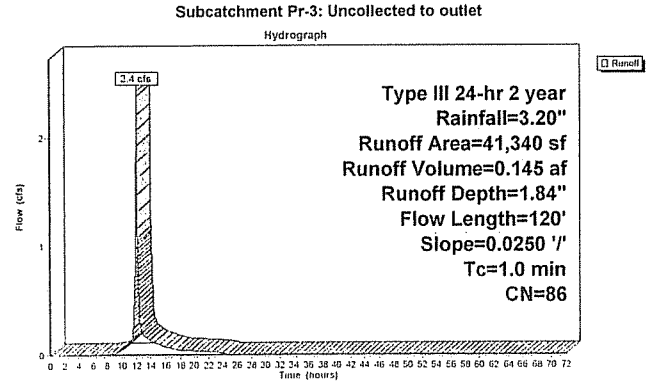
Runoff = 2.4 cfs @ 12.02 hrs, Volume= 0.145 af, Depth= 1.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
4,535	61	>75% Grass cover, Good, HSG B
14,000	74	>75% Grass cover, Good, HSG C
11,900	98	Paved parking, HSG B
6,520	98	Roofs, HSG B
4,385	98	Roofs, HSG C
41,340	86	Weighted Average
18,535		44.84% Pervious Area
22,805		55.16% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.6	50	0.0250	1.31		**Sheet Flow, A-B** Smooth surfaces n= 0.011 P2= 3.20"
0.4	70	0.0250	3.21		**Shallow Concentrated Flow, B-C** Paved Kv= 20.3 fps
1.0	120	Total			

Subcatchment Pr-3: Uncollected to outlet



Summary for Subcatchment Pr-4: AP4 - Tributary to Abutting Northeast

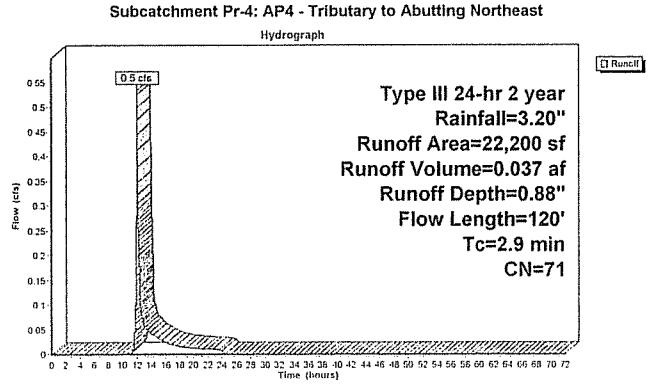
Runoff = 0.5 cfs @ 12.05 hrs, Volume= 0.037 af, Depth= 0.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
3,600	55	Woods, Good, HSG B
10,000	70	Woods, Good, HSG C
6,100	74	>75% Grass cover, Good, HSG C
1,300	89	Gravel roads, HSG C
1,200	98	Paved parking, HSG C
22,200	71	Weighted Average
21,000		94.59% Pervious Area
1,200		5.41% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.4	50	0.1600	0.34		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.20"
0.5	70	0.2300	2.40		**Shallow Concentrated Flow, B-C** Woodland Kv= 5.0 fps
2.9	120	Total			

Subcatchment Pr-4: AP4 - Tributary to Abutting Northeast



Summary for Subcatchment Pr-5: Site development to Basin - A

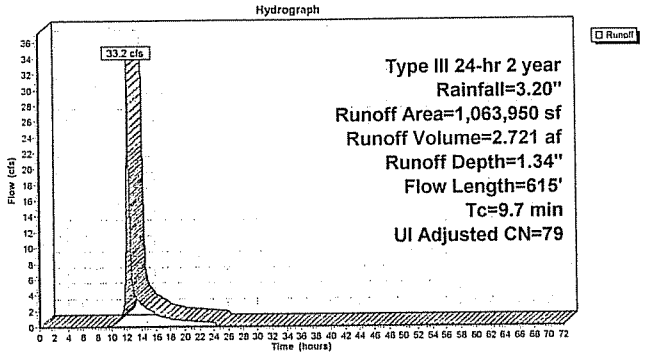
Runoff = 33.2 cfs @ 12.14 hrs, Volume= 2.721 af, Depth= 1.34"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
3,000	55	Woods, Good, HSG B
153,000	70	Woods, Good, HSG C
12,350	61	>75% Grass cover, Good, HSG B
528,150	74	>75% Grass cover, Good, HSG C
48,000	71	Meadow, non-grazed, HSG C
12,540	98	Paved parking, HSG B
130,305	98	Paved parking, HSG C
6,655	98	Roofs, HSG B
74,950	98	Roofs, HSG C
74,000	89	Gravel roads, HSG C
21,000	98	Unconnected pavement, HSG C
1,063,950	80	Weighted Average, UI Adjusted CN = 79
818,500		76.93% Pervious Area
245,450		23.07% Impervious Area
21,000		8.56% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.6	150	0.0530	1.61		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.5	200	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
0.7	130	0.0230	3.08		**Shallow Concentrated Flow, D-E** Paved Kv= 20.3 fps
0.6	85	0.1300	2.52		**Shallow Concentrated Flow, E-F** Short Grass Pasture Kv= 7.0 fps
9.7	615	Total			

Subcatchment Pr-5: Site development to Basin - A



Summary for Subcatchment Pr-6: Site Development to Basin - B

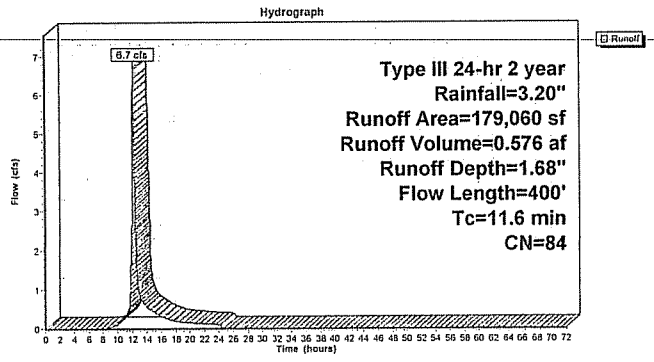
Runoff = 6.7 cfs @ 12.16 hrs, Volume= 0.576 af, Depth= 1.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
13,075	61	>75% Grass cover, Good, HSG B
71,580	74	>75% Grass cover, Good, HSG C
9,000	70	Woods, Good, HSG C
26,495	98	Paved roads w/curbs & sewers, HSG B
39,495	98	Paved parking, HSG C
6,680	98	Roofs, HSG B
12,735	98	Roofs, HSG C
179,060	84	Weighted Average
93,655		52.30% Pervious Area
85,405		47.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.4	225	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.0	125	0.0100	2.03		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
11.6	400	Total			

Subcatchment Pr-6: Site Development to Basin - B



Summary for Subcatchment PR-7: Off-site South of Concord Road

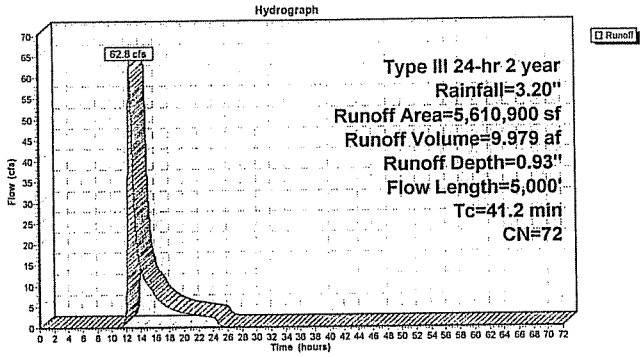
Runoff = 62.8 cfs @ 12.63 hrs, Volume= 9.979 af, Depth= 0.93"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
70,700	30	Woods, Good, HSG A
213,700	55	Woods, Good, HSG B
1,691,800	70	Woods, Good, HSG C
1,462,100	77	Woods, Good, HSG D
1,203,300	79	1 acre lots, 20% imp, HSG C
321,700	84	1 acre lots, 20% imp, HSG D
* 647,600	57	Udorthents, 30% imp, HSG A
5,610,900	72	Weighted Average
5,111,620		91.10% Pervious Area
499,280		8.90% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.9	50	0.0600	0.10		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
14.0	1,450	0.1200	1.73		**Shallow Concentrated Flow, B-C** Woodland Kv= 5.0 fps
4.1	300	0.0300	1.21		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.2	3,200	0.0050	3.52	21.12	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=1.00' Z= 1.0 '/' Top.W=7.00' n= 0.025 Earth, clean & winding
41.2	5,000	Total			

Subcatchment PR-7: Off-site South of Concord Road



Summary for Subcatchment PR-8: Off-site North of Concord Road

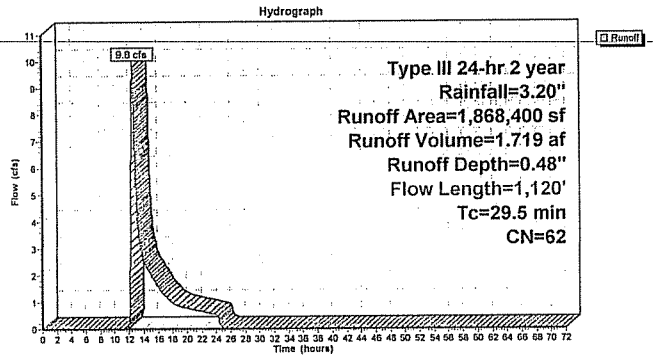
Runoff = 9.8 cfs @ 12.55 hrs, Volume= 1.719 af, Depth= 0.48"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 year Rainfall=3.20"

Area (sf)	CN	Description
217,000	30	Woods, Good, HSG A
386,500	55	Woods, Good, HSG B
400,400	70	Woods, Good, HSG C
284,800	77	Woods, Good, HSG D
381,900	79	1 acre lots, 20% imp, HSG C
197,800	39	Pasture/grassland/range, Good, HSG A
1,868,400	62	Weighted Average
1,792,020		95.91% Pervious Area
76,380		4.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0700	0.11		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
5.2	340	0.0480	1.10		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
15.3	480	0.0110	0.52		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.5	250	0.0050	2.82	10.73	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=0.67' Z= 1.0 '/' Top.W=6.34' n= 0.025 Earth, clean & winding
29.5	1,120	Total			

Subcatchment PR-8: Off-site North of Concord Road



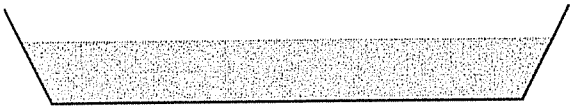
Summary for Reach 6R: Mineway Brook Section 2

Inflow Area = 129.318 ac, 8.88% Impervious, Inflow Depth = 0.85" for 2 year event
Inflow = 18.1 cfs @ 13.68 hrs, Volume= 9.135 af
Outflow = 18.1 cfs @ 13.83 hrs, Volume= 9.135 af, Atten= 0%, Lag= 8.5 min

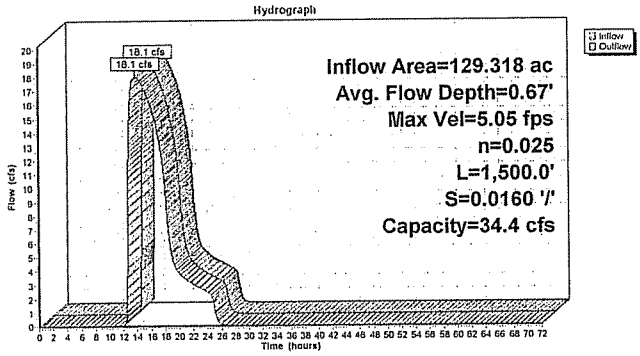
Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 5.05 fps, Min. Travel Time= 5.0 min
Avg. Velocity = 2.17 fps, Avg. Travel Time= 11.5 min

Peak Storage= 5,366 cf @ 13.74 hrs
Average Depth at Peak Storage= 0.67'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 34.4 cfs

5.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.00'
Length= 1,500.0' Slope= 0.0160 '/'
Inlet Invert= 192.00', Outlet Invert= 168.00'



Reach 6R: Mineway Brook Section 2



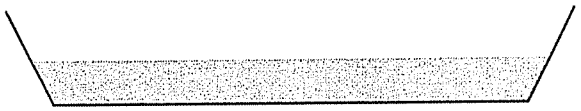
Summary for Reach 7R: Mineway Brook Section 1

Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 0.85" for 2 year event
Inflow = 18.0 cfs @ 13.67 hrs, Volume= 9.097 af
Outflow = 18.0 cfs @ 13.69 hrs, Volume= 9.097 af, Atten= 0%, Lag= 1.7 min

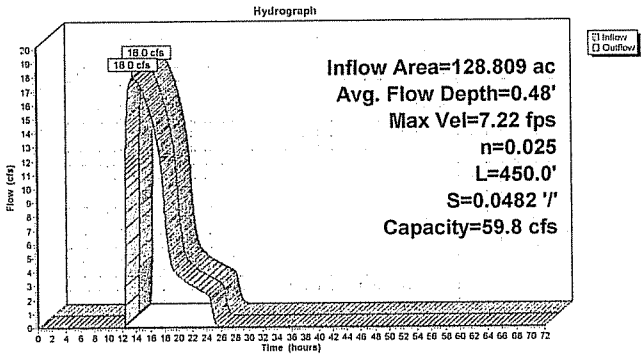
Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 7.22 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 4.40 fps, Avg. Travel Time= 1.7 min

Peak Storage= 1,123 cf @ 13.68 hrs
Average Depth at Peak Storage= 0.48'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 59.8 cfs

5.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.00'
Length= 450.0' Slope= 0.0482 '/'
Inlet Invert= 213.70', Outlet Invert= 192.00'



Reach 7R: Mineway Brook Section 1



Summary for Reach 8R: Analysis Point 5 - Tributary to Undeveloped 30 Acres

Inflow Area = 29.485 ac, 27.54% Impervious, Inflow Depth > 1.40" for 2 year event
Inflow = 3.4 cfs @ 12.02 hrs, Volume= 3.442 af
Outflow = 2.7 cfs @ 15.83 hrs, Volume= 3.442 af, Atten= 20%, Lag= 228.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.53 fps, Min. Travel Time= 21.9 min
Avg. Velocity = 0.31 fps, Avg. Travel Time= 38.0 min

Peak Storage= 3,510 cf @ 15.46 hrs
Average Depth at Peak Storage= 0.20'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 1,489.6 cfs

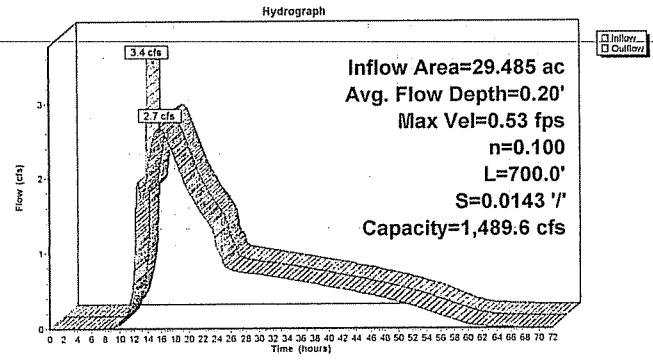
Custom cross-section, Length= 700.0' Slope= 0.0143 '/'
Constant n= 0.100 Heavy timber, flow below branches
Inlet Invert= 180.00', Outlet Invert= 170.00'

‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
-100.00	4.00	0.00
-10.00	0.00	4.00
0.00	0.00	4.00
10.00	0.00	4.00
130.00	4.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	20.0	0	0.0
4.00	500.0	230.2	350,000	1,489.6

Reach 8R: Analysis Point 5 - Tributary to Undeveloped 30 Acres



Summary for Pond 5P: Detention System B

Inflow Area = 4.111 ac, 47.70% Impervious, Inflow Depth = 1.68" for 2 year event
Inflow = 6.7 cfs @ 12.16 hrs, Volume= 0.576 af
Outflow = 0.7 cfs @ 13.57 hrs, Volume= 0.576 af, Atten= 90%, Lag= 84.4 min
Primary = 0.7 cfs @ 13.57 hrs, Volume= 0.576 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 184.79' @ 13.57 hrs Surf.Area= 9,151 sf Storage= 10,870 cf

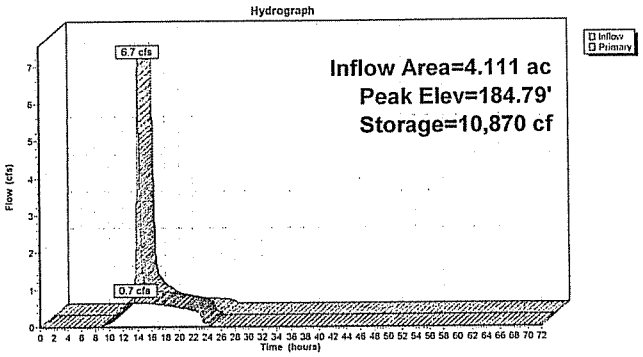
Plug-Flow detention time= 170.0 min calculated for 0.576 af (100% of inflow)
Center-of-Mass det. time= 170.0 min (1,004.8 - 834.7)

Volume	Invert	Avail.Storage	Storage Description
#1	183.00'	23,562 cf	**60.0" D x 150.0'L Pipe Storage S= 0.0030 '/' x 8**
#2	183.00'	2,356 cf	**60.0" D x 60.0'L Pipe Storage x 2**
#3	183.00'	7,658 cf	**60.0" D x 390.0'L Pipe Storage S= 0.0025 '/'**
#4	182.20'	5,301 cf	**60.0" D x 270.0'L Pipe Storage S= 0.0030 '/'**
		38,877 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	182.20'	**4.0" Vert. Orifice/Grate** C= 0.600
#2	Primary	184.90'	**8.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	187.00'	**5.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=0.7 cfs @ 13.57 hrs HW=184.79' (Free Discharge)
1=Orifice/Grate (Orifice Controls 0.7 cfs @ 7.49 fps)
2=Orifice/Grate (Controls 0.0 cfs)
3=Sharp-Crested Rectangular Weir (Controls 0.0 cfs)

Pond 5P: Detention System B



Summary for Pond 6P: Detention System A

Inflow Area = 24.425 ac, 23.07% Impervious, Inflow Depth = 1.34" for 2 year event
Inflow = 33.2 cfs @ 12.14 hrs, Volume= 2.721 af
Outflow = 2.0 cfs @ 15.34 hrs, Volume= 2.721 af, Atten= 94%, Lag= 191.9 min
Primary = 2.0 cfs @ 15.34 hrs, Volume= 2.721 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 188.20' @ 15.34 hrs Surf.Area= 23,470 sf Storage= 72,367 cf

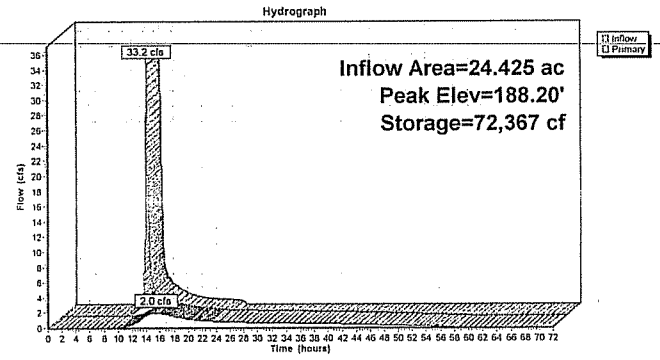
Plug-Flow detention time= 807.3 min calculated for 2.721 af (100% of inflow)
Center-of-Mass det. time= 807.3 min (1,656.7 - 849.4)

Volume	Invert	Avail.Storage	Storage Description
#1	184.00'	231,850 cf	**144.0" D x 2,050.0'L Pipe Storage**

Device	Routing	Invert	Outlet Devices
#1	Primary	184.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#2	Primary	187.60'	**10.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	192.00'	**8.0" Vert. Orifice/Grate** C= 0.600
#4	Primary	195.00'	**8.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=2.0 cfs @ 15.34 hrs HW=188.20' (Free Discharge)
1=Orifice/Grate (Orifice Controls 0.8 cfs @ 9.67 fps)
2=Orifice/Grate (Orifice Controls 1.1 cfs @ 2.64 fps)
3=Orifice/Grate (Controls 0.0 cfs)
4=Sharp-Crested Rectangular Weir (Controls 0.0 cfs)

Pond 6P: Detention System A



Summary for Pond 7P: Concord Road Culvert

Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 0.93" for 2 year event
Inflow = 62.8 cfs @ 12.63 hrs, Volume= 9.979 af
Outflow = 18.0 cfs @ 13.67 hrs, Volume= 9.097 af, Atten= 71%, Lag= 62.2 min
Primary = 18.0 cfs @ 13.67 hrs, Volume= 9.097 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 217.02' @ 13.67 hrs Surf.Area= 165,045 sf Storage= 149,396 cf

Plug-Flow detention time= 120.4 min calculated for 9.097 af (91% of inflow)
Center-of-Mass det. time= 76.6 min (978.0 - 901.4)

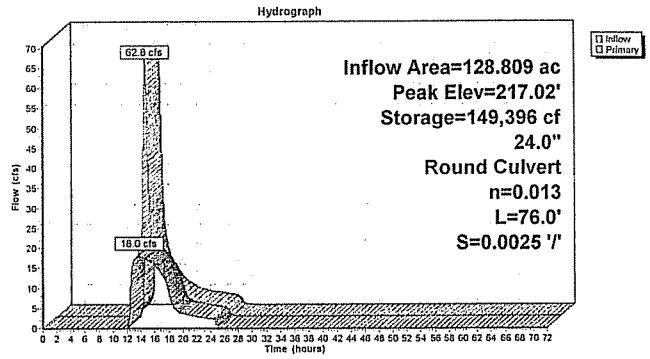
Volume	Invert	Avail.Storage	Storage Description
#1	214.00'	2,610,000 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
214.00	20,000	0	0
216.00	30,000	50,000	50,000
218.00	295,000	325,000	375,000
220.00	556,000	851,000	1,226,000
222.00	828,000	1,384,000	2,610,000

Device	Routing	Invert	Outlet Devices
#1	Primary	213.85'	**24.0" Round Culvert** L= 76.0' Ke= 0.500 Inlet / Outlet Invert= 213.85' / 213.65' S= 0.0025 '/' Cc= 0.900 n= 0.013

Primary OutFlow Max=18.0 cfs @ 13.67 hrs HW=217.02' TW=215.60' (Fixed TW Elev= 215.60')
↑1=Culvert (Inlet Controls 18.0 cfs @ 5.74 fps)

Pond 7P: Concord Road Culvert



Summary for Pond 8P: Analysis Point 6 - Railraod Culvert

Inflow Area = 201.695 ac, 10.59% Impervious, Inflow Depth = 0.85" for 2 year event
Inflow = 23.3 cfs @ 12.95 hrs, Volume= 14.296 af
Outflow = 22.7 cfs @ 14.05 hrs, Volume= 14.296 af, Atten= 3%, Lag= 66.5 min
Primary = 22.7 cfs @ 14.05 hrs, Volume= 14.296 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 170.61' @ 14.05 hrs Surf.Area= 22,749 sf Storage= 10,886 cf

Plug-Flow detention time= 5.2 min calculated for 14.294 af (100% of inflow)
Center-of-Mass det. time= 5.2 min (1,126.8 - 1,121.7)

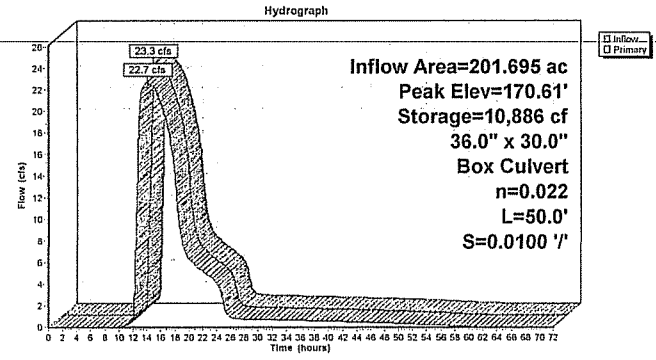
Volume	Invert	Avail.Storage	Storage Description
#1	168.70'	2,431,665 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
168.70	100	0	0
170.00	4,000	2,665	2,665
172.00	65,000	69,000	71,665
174.00	280,000	345,000	416,665
176.00	520,000	800,000	1,216,665
178.00	695,000	1,215,000	2,431,665

Device	Routing	Invert	Outlet Devices
#1	Primary	168.70'	**36.0" W x 30.0" H Box Culvert** L= 50.0' Ke= 0.200 Inlet / Outlet Invert= 168.70' / 168.20' S= 0.0100 '/' Cc= 0.900 n= 0.022 Earth, clean & straight

Primary OutFlow Max=22.7 cfs @ 14.05 hrs HW=170.61' (Free Discharge)
↑1=Culvert (Barrel Controls 22.7 cfs @ 5.27 fps)

Pond 8P: Analysis Point 6 - Railraod Culvert



Summary for Subcatchment Pr-1: Tributary to Hudson Road - Analysis Point 1

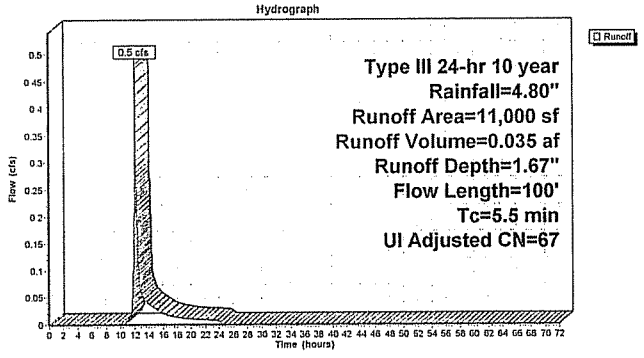
Runoff = 0.5 cfs @ 12.09 hrs, Volume= 0.035 af, Depth= 1.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
8,650	61	>75% Grass cover, Good, HSG B
1,510	98	Paved parking, HSG B
840	98	Unconnected pavement, HSG B
11,000	69	Weighted Average, UI Adjusted CN = 67
8,650		78.64% Pervious Area
2,350		21.36% Impervious Area
840		35.74% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
0.2	50	0.3600	4.20		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
5.5	100	Total			

Subcatchment Pr-1: Tributary to Hudson Road - Analysis Point 1



Summary for Subcatchment Pr-2: Tributary to RR Track - Analysis Point 2

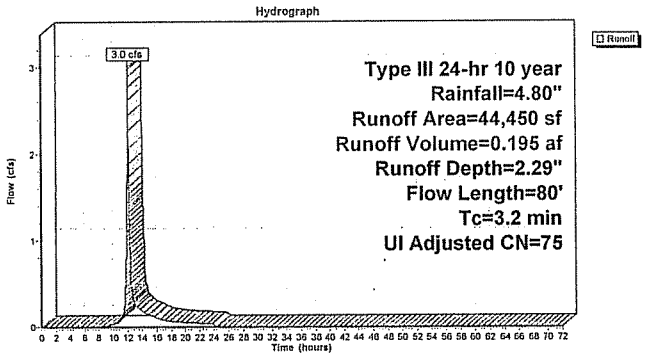
Runoff = 3.0 cfs @ 12.05 hrs, Volume= 0.195 af, Depth= 2.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
2,650	61	>75% Grass cover, Good, HSG B
34,400	74	>75% Grass cover, Good, HSG C
4,500	98	Unconnected pavement, HSG C
2,900	98	Unconnected roofs, HSG C
44,450	77	Weighted Average, UI Adjusted CN = 75
37,050		83.35% Pervious Area
7,400		16.65% Impervious Area
7,400		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.1	50	0.2200	0.27		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
0.1	30	0.3000	3.83		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
3.2	80	Total			

Subcatchment Pr-2: Tributary to RR Track - Analysis Point 2



Summary for Subcatchment Pr-3: Uncollected to outlet

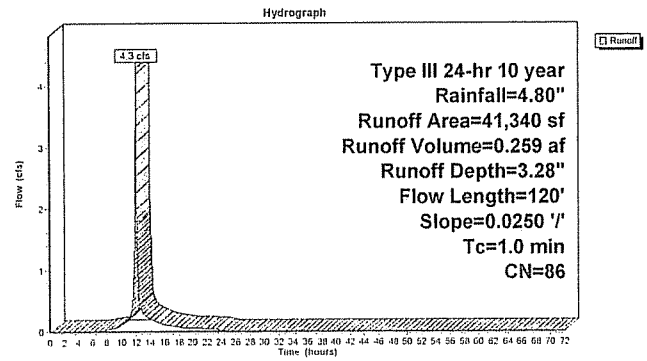
Runoff = 4.3 cfs @ 12.02 hrs, Volume= 0.259 af, Depth= 3.28"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
4,535	61	>75% Grass cover, Good, HSG B
14,000	74	>75% Grass cover, Good, HSG C
11,900	98	Paved parking, HSG B
6,520	98	Roofs, HSG B
4,385	98	Roofs, HSG C
41,340	86	Weighted Average
18,535		44.84% Pervious Area
22,805		55.16% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.6	50	0.0250	1.31		Sheet Flow, A-B Smooth surfaces n= 0.011 P2= 3.20"
0.4	70	0.0250	3.21		Shallow Concentrated Flow, B-C Paved Kv= 20.3 fps
1.0	120	Total			

Subcatchment Pr-3: Uncollected to outlet



Summary for Subcatchment Pr-4: AP4 - Tributary to Abutting Northeast

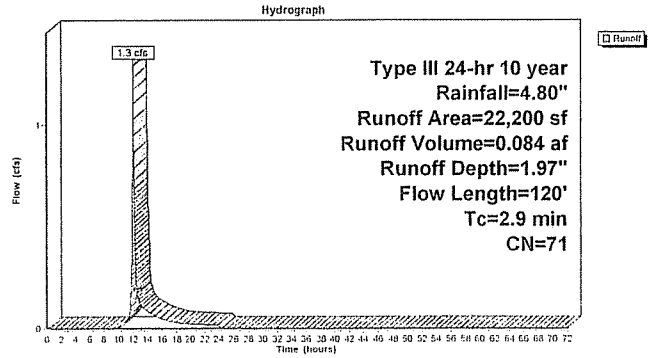
Runoff = 1.3 cfs @ 12.05 hrs, Volume= 0.084 af, Depth= 1.97"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
3,600	55	Woods, Good, HSG B
10,000	70	Woods, Good, HSG C
6,100	74	>75% Grass cover, Good, HSG C
1,300	89	Gravel roads, HSG C
1,200	98	Paved parking, HSG C
22,200	71	Weighted Average
21,000		94.59% Pervious Area
1,200		5.41% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.4	50	0.1600	0.34		Sheet Flow, A-B Grass: Short n= 0.150 P2= 3.20"
0.5	70	0.2300	2.40		Shallow Concentrated Flow, B-C Woodland Kv= 5.0 fps
2.9	120	Total			

Subcatchment Pr-4: AP4 - Tributary to Abutting Northeast



Summary for Subcatchment Pr-5: Site development to Basin - A

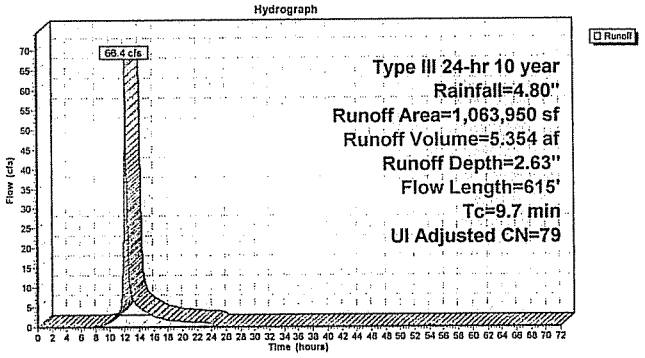
Runoff = 66.4 cfs @ 12.14 hrs, Volume= 5.354 af, Depth= 2.63"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
3,000	55	Woods, Good, HSG B
153,000	70	Woods, Good, HSG C
12,350	61	>75% Grass cover, Good, HSG B
528,150	74	>75% Grass cover, Good, HSG C
48,000	71	Meadow, non-grazed, HSG C
12,540	98	Paved parking, HSG B
130,305	98	Paved parking, HSG C
6,655	98	Roofs, HSG B
74,950	98	Roofs, HSG C
74,000	89	Gravel roads, HSG C
21,000	98	Unconnected pavement, HSG C
1,063,950	80	Weighted Average, UI Adjusted CN = 79
818,500		76.93% Pervious Area
245,450		23.07% Impervious Area
21,000		8.56% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.6	150	0.0530	1.61		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.5	200	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
0.7	130	0.0230	3.08		**Shallow Concentrated Flow, D-E** Paved Kv= 20.3 fps
0.6	85	0.1300	2.52		**Shallow Concentrated Flow, E-F** Short Grass Pasture Kv= 7.0 fps
9.7	615	Total			

Subcatchment Pr-5: Site development to Basin - A



Summary for Subcatchment Pr-6: Site Development to Basin - B

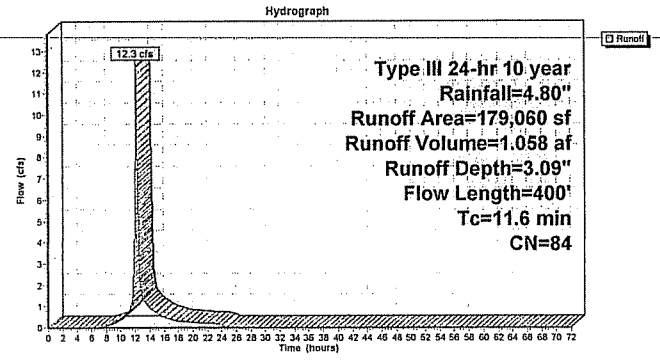
Runoff = 12.3 cfs @ 12.16 hrs, Volume= 1.058 af, Depth= 3.09"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
13,075	61	>75% Grass cover, Good, HSG B
71,580	74	>75% Grass cover, Good, HSG C
9,000	70	Woods, Good, HSG C
26,495	98	Paved roads w/curbs & sewers, HSG B
39,495	98	Paved parking, HSG C
6,680	98	Roofs, HSG B
12,735	98	Roofs, HSG C
179,060	84	Weighted Average
93,655		52.30% Pervious Area
85,405		47.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.4	225	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.0	125	0.0100	2.03		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
11.6	400	Total			

Subcatchment Pr-6: Site Development to Basin - B



Summary for Subcatchment PR-7: Off-site South of Concord Road

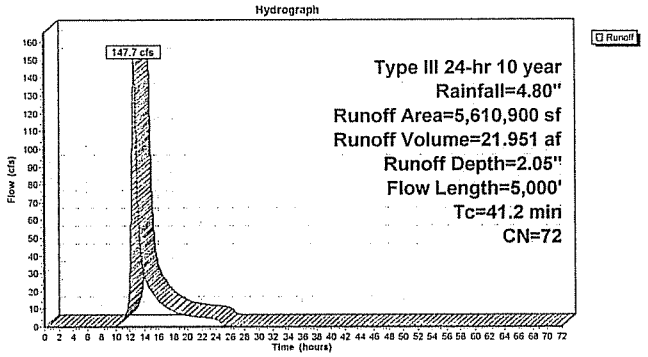
Runoff = 147.7 cfs @ 12.59 hrs, Volume= 21.951 af, Depth= 2.05"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
70,700	30	Woods, Good, HSG A
213,700	55	Woods, Good, HSG B
1,691,800	70	Woods, Good, HSG C
1,462,100	77	Woods, Good, HSG D
1,203,300	79	1 acre lots, 20% imp, HSG C
321,700	84	1 acre lots, 20% imp, HSG D
* 647,600	57	Udorthents, 30% Imp, HSG A
5,610,900	72	Weighted Average
5,111,620		91.10% Pervious Area
499,280		8.90% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.9	50	0.0600	0.10		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
14.0	1,450	0.1200	1.73		**Shallow Concentrated Flow, B-C** Woodland Kv= 5.0 fps
4.1	300	0.0300	1.21		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.2	3,200	0.0050	3.52	21.12	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=1.00' Z= 1.0 '/' Top.W=7.00' n= 0.025 Earth, clean & winding
41.2	5,000	Total			

Subcatchment PR-7: Off-site South of Concord Road



Summary for Subcatchment PR-8: Off-site North of Concord Road

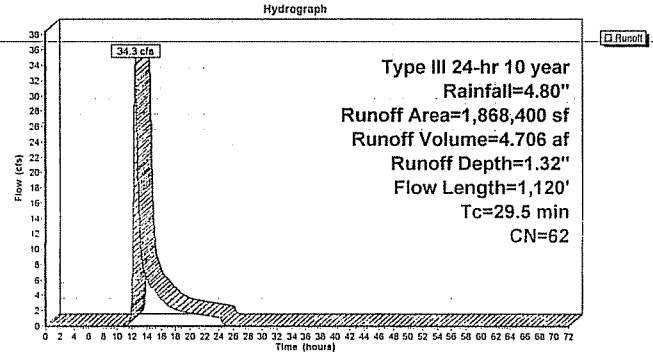
Runoff = 34.3 cfs @ 12.46 hrs, Volume= 4.706 af, Depth= 1.32"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 year Rainfall=4.80"

Area (sf)	CN	Description
217,000	30	Woods, Good, HSG A
386,500	55	Woods, Good, HSG B
400,400	70	Woods, Good, HSG C
284,800	77	Woods, Good, HSG D
381,900	79	1 acre lots, 20% imp, HSG C
197,800	39	Pasture/grassland/range, Good, HSG A
1,868,400	62	Weighted Average
1,792,020		95.91% Pervious Area
76,380		4.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0700	0.11		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
5.2	340	0.0480	1.10		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
15.3	480	0.0110	0.52		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.5	250	0.0050	2.82	10.73	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=0.67' Z= 1.0 '/' Top.W=6.34' n= 0.025 Earth, clean & winding
29.5	1,120	Total			

Subcatchment PR-8: Off-site North of Concord Road



Summary for Reach 6R: Mineway Brook Section 2

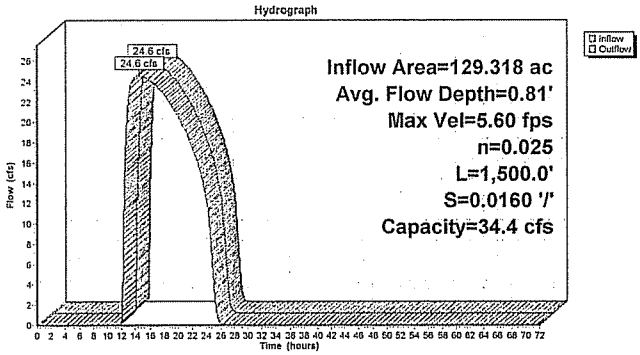
Inflow Area = 129.318 ac, 8.88% Impervious, Inflow Depth = 1.96" for 10 year event
Inflow = 24.6 cfs @ 14.33 hrs, Volume= 21.153 af
Outflow = 24.6 cfs @ 14.46 hrs, Volume= 21.153 af, Atten= 0%, Lag= 7.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 5.60 fps, Min. Travel Time= 4.5 min
Avg. Velocity = 2.90 fps, Avg. Travel Time= 8.6 min

Peak Storage= 6,575 cf @ 14.38 hrs
Average Depth at Peak Storage= 0.81'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 34.4 cfs

5.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.00'
Length= 1,500.0' Slope= 0.0160 '/'
Inlet Invert= 192.00', Outlet Invert= 168.00'

Reach 6R: Mineway Brook Section 2



Summary for Reach 7R: Mineway Brook Section 1

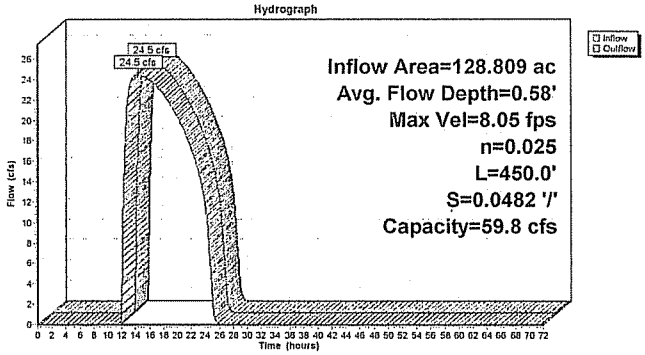
Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 1.96" for 10 year event
Inflow = 24.5 cfs @ 14.33 hrs, Volume= 21.070 af
Outflow = 24.5 cfs @ 14.36 hrs, Volume= 21.070 af, Atten= 0%, Lag= 1.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 8.05 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 6.24 fps, Avg. Travel Time= 1.2 min

Peak Storage= 1,369 cf @ 14.34 hrs
Average Depth at Peak Storage= 0.58'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 59.8 cfs

5.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.00'
Length= 450.0' Slope= 0.0482 '/'
Inlet Invert= 213.70', Outlet Invert= 192.00'

Reach 7R: Mineway Brook Section 1



Summary for Reach 8R: Analysis Point 5 - Tributary to Undeveloped 30 Acres

Inflow Area = 29.485 ac, 27.54% Impervious, Inflow Depth > 2.71" for 10 year event
Inflow = 7.3 cfs @ 12.92 hrs, Volume= 6.671 af
Outflow = 7.2 cfs @ 13.59 hrs, Volume= 6.670 af, Atten= 1%, Lag= 40.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.73 fps, Min. Travel Time= 16.0 min
Avg. Velocity = 0.34 fps, Avg. Travel Time= 33.9 min

Peak Storage= 6,970 cf @ 13.32 hrs
Average Depth at Peak Storage= 0.34'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 1,489.6 cfs

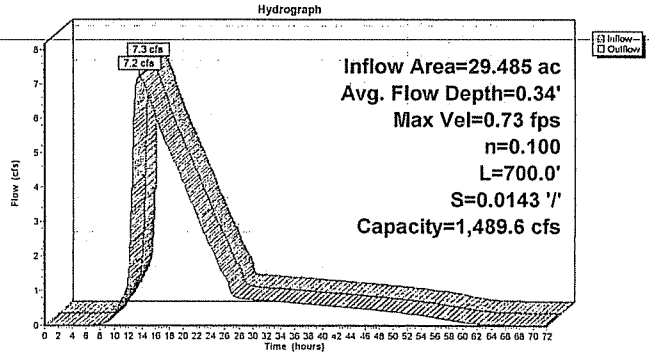
Custom cross-section, Length= 700.0' Slope= 0.0143 '/'
Constant n= 0.100 Heavy timber, flow below branches
Inlet Invert= 180.00', Outlet Invert= 170.00'

‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
-100.00	4.00	0.00
-10.00	0.00	4.00
0.00	0.00	4.00
10.00	0.00	4.00
130.00	4.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	20.0	0	0.0
4.00	500.0	230.2	350,000	1,489.6

Reach 8R: Analysis Point 5 - Tributary to Undeveloped 30 Acres



Summary for Pond 5P: Detention System B

Inflow Area = 4.111 ac, 47.70% Impervious, Inflow Depth = 3.09" for 10 year event
Inflow = 12.3 cfs @ 12.16 hrs, Volume= 1.058 af
Outflow = 1.9 cfs @ 12.79 hrs, Volume= 1.058 af, Atten= 84%, Lag= 37.9 min
Primary = 1.9 cfs @ 12.79 hrs, Volume= 1.058 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 185.72' @ 12.79 hrs Surf.Area= 9,817 sf Storage= 19,883 cf

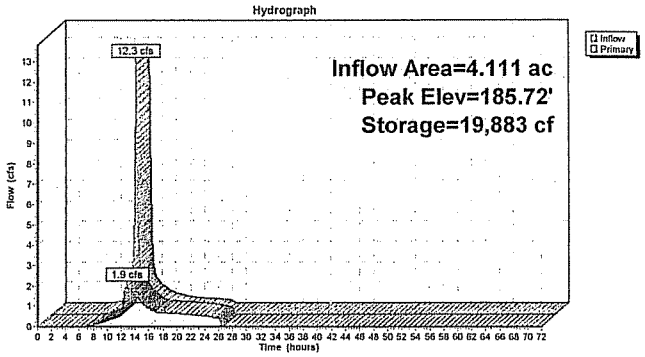
Plug-Flow detention time= 186.0 min calculated for 1.058 af (100% of inflow)
Center-of-Mass det. time= 186.0 min (1,003.3 - 817.4)

Volume	Invert	Avail.Storage	Storage Description
#1	183.00'	23,562 cf	**60.0" D x 150.0'L Pipe Storage S= 0.0030 '/' x 8**
#2	183.00'	2,356 cf	**60.0" D x 60.0'L Pipe Storage x 2**
#3	183.00'	7,658 cf	**60.0" D x 390.0'L Pipe Storage S= 0.0025 '/'**
#4	182.20'	5,301 cf	**60.0" D x 270.0'L Pipe Storage S= 0.0030 '/'**
		38,877 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	182.20'	**4.0" Vert. Orifice/Grate C= 0.600**
#2	Primary	184.90'	**8.0" Vert. Orifice/Grate C= 0.600**
#3	Primary	187.00'	**5.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)**

Primary OutFlow Max=1.9 cfs @ 12.79 hrs HW=185.72' (Free Discharge)
1=Orifice/Grate (Orifice Controls 0.8 cfs @ 8.82 fps)
2=Orifice/Grate (Orifice Controls 1.2 cfs @ 3.37 fps)
3=Sharp-Crested Rectangular Weir (Controls 0.0 cfs)

Pond 5P: Detention System B



Summary for Pond 6P: Detention System A

Inflow Area = 24.425 ac, 23.07% Impervious, Inflow Depth = 2.63" for 10 year event
Inflow = 66.4 cfs @ 12.14 hrs, Volume= 5.354 af
Outflow = 5.2 cfs @ 13.90 hrs, Volume= 5.353 af, Atten= 92%, Lag= 106.1 min
Primary = 5.2 cfs @ 13.90 hrs, Volume= 5.353 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 190.50' @ 13.90 hrs Surf.Area= 24,514 sf Storage= 128,216 cf

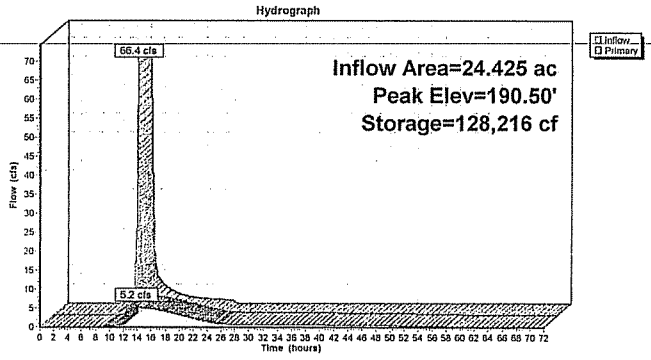
Plug-Flow detention time= 554.1 min calculated for 5,353 af (100% of inflow)
Center-of-Mass det. time= 554.4 min (1,384.1 - 829.7)

Volume	Invert	Avail.Storage	Storage Description
#1	184.00'	231,850 cf	**144.0" D x 2,050.0'L Pipe Storage**

Device	Routing	Invert	Outlet Devices
#1	Primary	184.00'	**4.0" Vert. Orifice/Grate C= 0.600**
#2	Primary	187.60'	**10.0" Vert. Orifice/Grate C= 0.600**
#3	Primary	192.00'	**8.0" Vert. Orifice/Grate C= 0.600**
#4	Primary	195.00'	**8.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s)**

Primary OutFlow Max=5.2 cfs @ 13.90 hrs HW=190.50' (Free Discharge)
1=Orifice/Grate (Orifice Controls 1.1 cfs @ 12.12 fps)
2=Orifice/Grate (Orifice Controls 4.1 cfs @ 7.59 fps)
3=Orifice/Grate (Controls 0.0 cfs)
4=Sharp-Crested Rectangular Weir (Controls 0.0 cfs)

Pond 6P: Detention System A



Summary for Pond 7P: Concord Road Culvert

Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 2.05" for 10 year event
Inflow = 147.7 cfs @ 12.59 hrs, Volume= 21.951 af
Outflow = 24.5 cfs @ 14.33 hrs, Volume= 21.070 af, Atten= 83%, Lag= 104.7 min
Primary = 24.5 cfs @ 14.33 hrs, Volume= 21.070 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 218.22' @ 14.33 hrs Surf.Area= 323,792 sf Storage= 443,261 cf

Plug-Flow detention time= 214.9 min calculated for 21.070 af (96% of inflow)
Center-of-Mass det. time= 192.7 min (1,070.0 - 877.3)

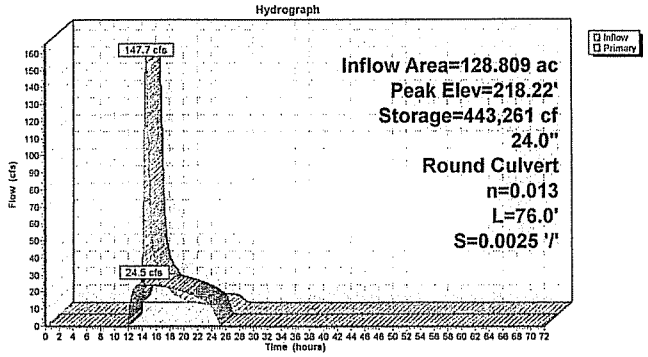
Volume	Invert	Avail.Storage	Storage Description
#1	214.00'	2,610,000 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
214.00	20,000	0	0
216.00	30,000	50,000	50,000
218.00	295,000	325,000	375,000
220.00	556,000	851,000	1,226,000
222.00	828,000	1,384,000	2,610,000

Device	Routing	Invert	Outlet Devices
#1	Primary	213.85'	**24.0" Round Culvert** L= 76.0' Ke= 0.500 Inlet / Outlet Invert= 213.85' / 213.66' S= 0.0025 '/' Cc= 0.900 n= 0.013

Primary OutFlow Max=24.5 cfs @ 14.33 hrs HW=218.22' TW=215.60' (Fixed TW Elev= 215.60')
↳**1=Culvert** (Inlet Controls 24.5 cfs @ 7.79 fps)

Pond 7P: Concord Road Culvert



Summary for Pond 8P: Analysis Point 6 - Railraod Culvert

Inflow Area = 201.695 ac, 10.59% Impervious, Inflow Depth = 1.94" for 10 year event
Inflow = 53.7 cfs @ 12.53 hrs, Volume= 32.529 af
Outflow = 40.7 cfs @ 13.24 hrs, Volume= 32.529 af, Atten= 24%, Lag= 42.8 min
Primary = 40.7 cfs @ 13.24 hrs, Volume= 32.529 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 171.60' @ 13.24 hrs Surf.Area= 52,900 sf Storage= 48,278 cf

Plug-Flow detention time= 12.8 min calculated for 32.529 af (100% of inflow)
Center-of-Mass det. time= 12.8 min (1,119.4 - 1,106.6)

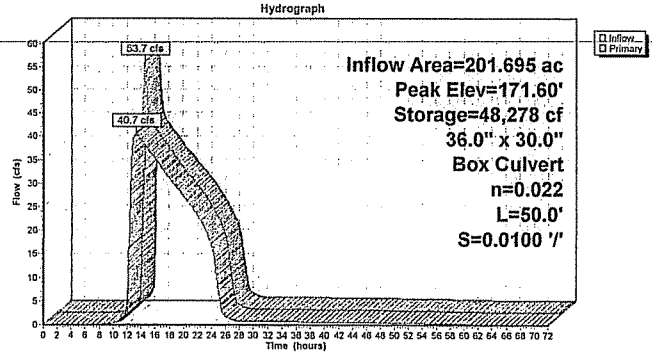
Volume	Invert	Avail.Storage	Storage Description
#1	168.70'	2,431,665 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
168.70	100	0	0
170.00	4,000	2,665	2,665
172.00	65,000	69,000	71,665
174.00	280,000	345,000	416,665
176.00	520,000	800,000	1,216,665
178.00	695,000	1,215,000	2,431,665

Device	Routing	Invert	Outlet Devices
#1	Primary	168.70'	**36.0" W x 30.0" H Box Culvert** L= 50.0' Ke= 0.200 Inlet / Outlet Invert= 168.70' / 168.20' S= 0.0100 '/' Cc= 0.900 n= 0.022 Earth, clean & straight

Primary OutFlow Max=40.7 cfs @ 13.24 hrs HW=171.60' (Free Discharge)
↳**1=Culvert** (Barrel Controls 40.7 cfs @ 6.24 fps)

Pond 8P: Analysis Point 6 - Railraod Culvert



Summary for Subcatchment Pr-1: Tributary to Hudson Road - Analysis Point 1

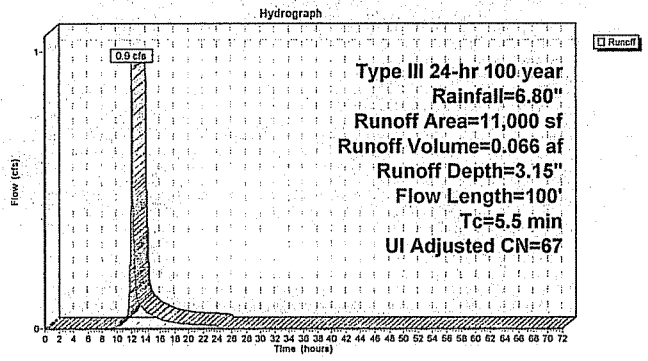
Runoff = 0.9 cfs @ 12.08 hrs, Volume= 0.066 af, Depth= 3.15"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
8,650	61	>75% Grass cover, Good, HSG B
1,510	98	Paved parking, HSG B
840	98	Unconnected pavement, HSG B
11,000	69	Weighted Average, UI Adjusted CN = 67
8,650		78.64% Pervious Area
2,350		21.36% Impervious Area
840		35.74% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
0.2	50	0.3600	4.20		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
5.5	100	Total			

Subcatchment Pr-1: Tributary to Hudson Road - Analysis Point 1



Summary for Subcatchment Pr-2: Tributary to RR Track - Analysis Point 2

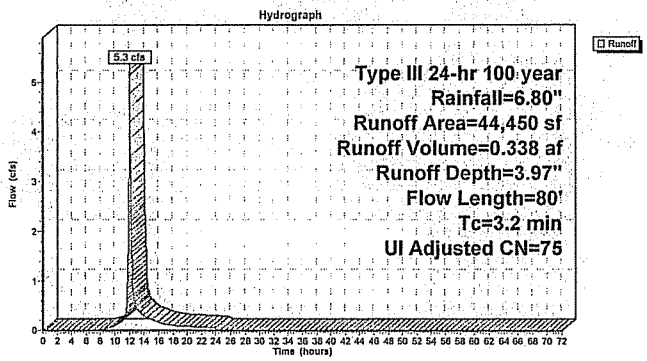
Runoff = 5.3 cfs @ 12.05 hrs, Volume= 0.338 af, Depth= 3.97"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
2,650	61	>75% Grass cover, Good, HSG B
34,400	74	>75% Grass cover, Good, HSG C
4,500	98	Unconnected pavement, HSG C
2,900	98	Unconnected roofs, HSG C
44,450	77	Weighted Average, UI Adjusted CN = 75
37,050		83.35% Pervious Area
7,400		16.65% Impervious Area
7,400		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.1	50	0.2200	0.27		Sheet Flow, A-B Grass: Dense n= 0.240 P2= 3.20"
0.1	30	0.3000	3.83		Shallow Concentrated Flow, B-C Short Grass Pasture Kv= 7.0 fps
3.2	80	Total			

Subcatchment Pr-2: Tributary to RR Track - Analysis Point 2



Summary for Subcatchment Pr-3: Uncollected to outlet

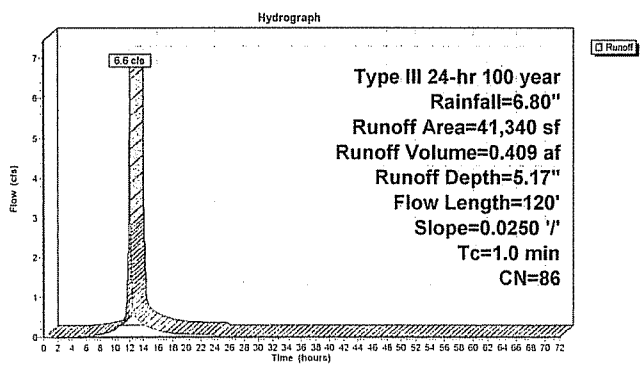
Runoff = 6.6 cfs @ 12.02 hrs, Volume= 0.409 af, Depth= 5.17"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
4,535	61	>75% Grass cover, Good, HSG B
14,000	74	>75% Grass cover, Good, HSG C
11,900	98	Paved parking, HSG B
6,520	98	Roofs, HSG B
4,385	98	Roofs, HSG C
41,340	86	Weighted Average
18,535		44.84% Pervious Area
22,805		55.16% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.6	50	0.0250	1.31		Sheet Flow, A-B Smooth surfaces n= 0.011 P2= 3.20"
0.4	70	0.0250	3.21		Shallow Concentrated Flow, B-C Paved Kv= 20.3 fps
1.0	120	Total			

Subcatchment Pr-3: Uncollected to outlet



Summary for Subcatchment Pr-4: AP4 - Tributary to Abutting Northeast

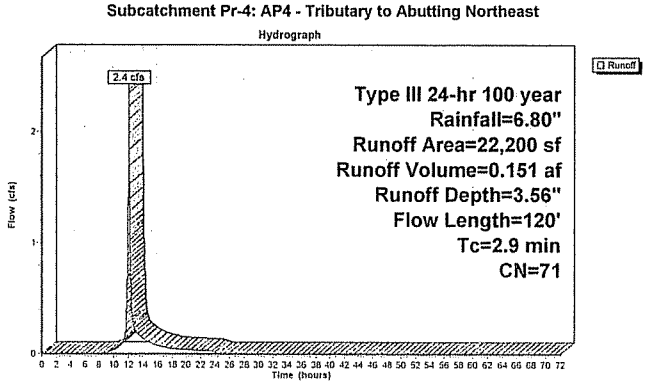
Runoff = 2.4 cfs @ 12.05 hrs, Volume= 0.151 af, Depth= 3.56"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
3,600	55	Woods, Good, HSG B
10,000	70	Woods, Good, HSG C
6,100	74	>75% Grass cover, Good, HSG C
1,300	89	Gravel roads, HSG C
1,200	98	Paved parking, HSG C
22,200	71	Weighted Average
21,000		94.59% Pervious Area
1,200		5.41% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.4	50	0.1600	0.34		Sheet Flow, A-B Grass: Short n= 0.150 P2= 3.20"
0.5	70	0.2300	2.40		Shallow Concentrated Flow, B-C Woodland Kv= 5.0 fps
2.9	120	Total			

Subcatchment Pr-4: AP4 - Tributary to Abutting Northeast



Summary for Subcatchment Pr-5: Site development to Basin - A

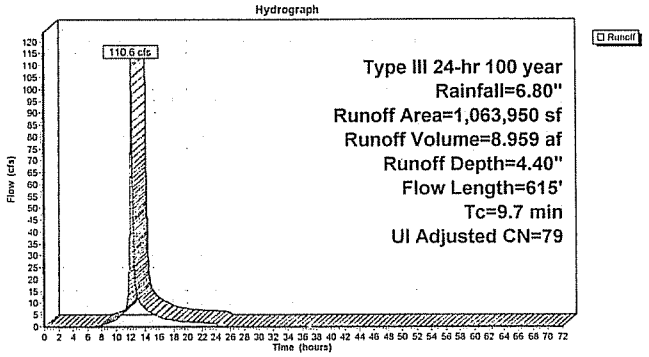
Runoff = 110.6 cfs @ 12.13 hrs, Volume= 8.959 af, Depth= 4.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
3,000	55	Woods, Good, HSG B
153,000	70	Woods, Good, HSG C
12,350	61	>75% Grass cover, Good, HSG B
528,150	74	>75% Grass cover, Good, HSG C
48,000	71	Meadow, non-grazed, HSG C
12,540	98	Paved parking, HSG B
130,305	98	Paved parking, HSG C
6,655	98	Roofs, HSG B
74,950	98	Roofs, HSG C
74,000	89	Gravel roads, HSG C
21,000	98	Unconnected pavement, HSG C
1,063,950	80	Weighted Average, UI Adjusted CN = 79
818,500		76.93% Pervious Area
245,450		23.07% Impervious Area
21,000		8.56% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.3	50	0.0600	0.16		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.6	150	0.0530	1.61		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.5	200	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
0.7	130	0.0230	3.08		**Shallow Concentrated Flow, D-E** Paved Kv= 20.3 fps
0.6	85	0.1300	2.52		**Shallow Concentrated Flow, E-F** Short Grass Pasture Kv= 7.0 fps
9.7	615	Total			

Subcatchment Pr-5: Site development to Basin - A



Summary for Subcatchment Pr-6: Site Development to Basin - B

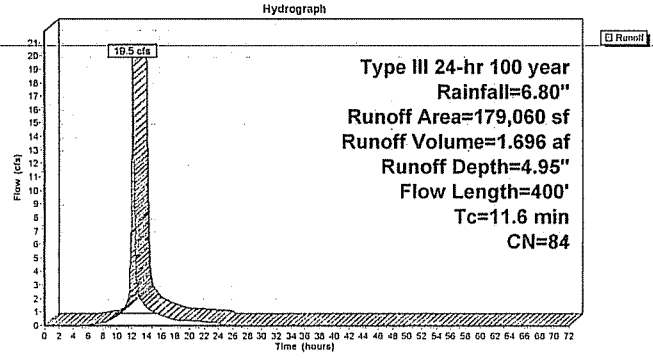
Runoff = 19.5 cfs @ 12.16 hrs, Volume= 1.696 af, Depth= 4.95"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
13,075	61	>75% Grass cover, Good, HSG B
71,580	74	>75% Grass cover, Good, HSG C
9,000	70	Woods, Good, HSG C
26,495	98	Paved roads w/curbs & sewers, HSG B
39,495	98	Paved parking, HSG C
6,680	98	Roofs, HSG B
12,735	98	Roofs, HSG C
179,060	84	Weighted Average
93,655		52.30% Pervious Area
85,405		47.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.4	225	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.0	125	0.0100	2.03		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
11.6	400	Total			

Subcatchment Pr-6: Site Development to Basin - B



Summary for Subcatchment PR-7: Off-site South of Concord Road

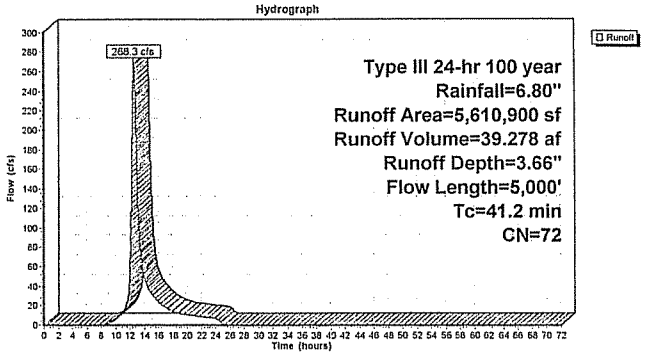
Runoff = 268.3 cfs @ 12.59 hrs, Volume= 39.278 af, Depth= 3.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
70,700	30	Woods, Good, HSG A
213,700	55	Woods, Good, HSG B
1,691,800	70	Woods, Good, HSG C
1,462,100	77	Woods, Good, HSG D
1,203,300	79	1 acre lots, 20% Imp, HSG C
321,700	84	1 acre lots, 20% Imp, HSG D
* 647,600	57	Udorthents, 30% Imp, HSG A
5,610,900	72	Weighted Average
5,111,620		91.10% Pervious Area
499,280		8.90% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.9	50	0.0600	0.10		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
14.0	1,450	0.1200	1.73		**Shallow Concentrated Flow, B-C** Woodland Kv= 5.0 fps
4.1	300	0.0300	1.21		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.2	3,200	0.0050	3.52	21.12	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=1.00' Z= 1.0 '/' Top.W=7.00' n= 0.025 Earth, clean & winding
41.2	5,000	Total			

Subcatchment PR-7: Off-site South of Concord Road



Summary for Subcatchment PR-8: Off-site North of Concord Road

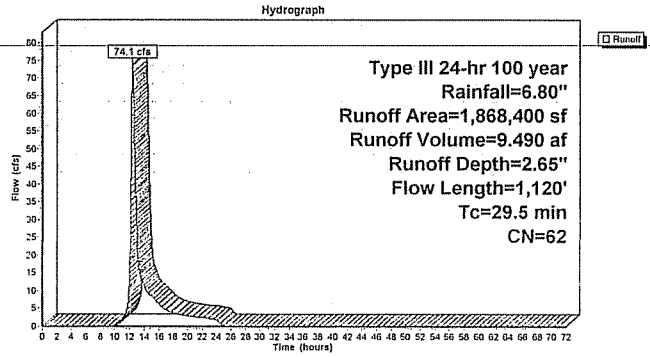
Runoff = 74.1 cfs @ 12.43 hrs, Volume= 9.490 af, Depth= 2.65"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 year Rainfall=6.80"

Area (sf)	CN	Description
217,000	30	Woods, Good, HSG A
386,500	55	Woods, Good, HSG B
400,400	70	Woods, Good, HSG C
284,800	77	Woods, Good, HSG D
381,900	79	1 acre lots, 20% Imp, HSG C
197,600	39	Pasture/grassland/range, Good, HSG A
1,868,400	62	Weighted Average
1,792,020		95.91% Pervious Area
76,380		4.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0700	0.11		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
5.2	340	0.0480	1.10		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
15.3	480	0.0110	0.52		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.5	250	0.0050	2.82	10.73	**Trap/Vee/Rect Channel Flow,** Bot.W=5.00' D=0.67' Z= 1.0 '/' Top.W=6.34' n= 0.025 Earth, clean & winding
29.5	1,120	Total			

Subcatchment PR-8: Off-site North of Concord Road



Summary for Reach 6R: Mineway Brook Section 2

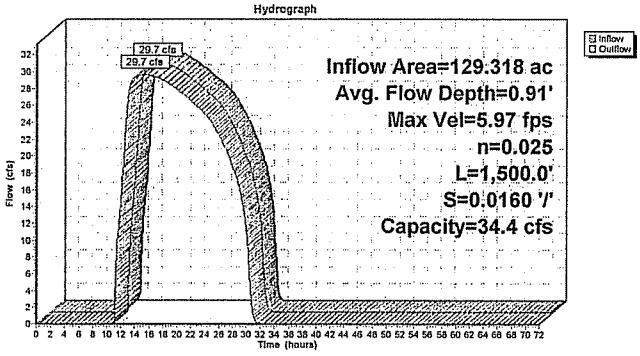
Inflow Area = 129.318 ac, 8.88% Impervious, Inflow Depth = 3.58" for 100 year event
Inflow = 29.7 cfs @ 15.19 hrs, Volume= 38.548 af
Outflow = 29.7 cfs @ 15.30 hrs, Volume= 38.548 af, Atten= 0%, Lag= 6.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 5.97 fps, Min. Travel Time= 4.2 min
Avg. Velocity = 3.56 fps, Avg. Travel Time= 7.0 min

Peak Storage= 7,464 cf @ 15.23 hrs
Average Depth at Peak Storage= 0.91'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 34.4 cfs

5.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.00'
Length= 1,500.0' Slope= 0.0160 '/'
Inlet Invert= 192.00', Outlet Invert= 168.00'

Reach 6R: Mineway Brook Section 2



Summary for Reach 7R: Mineway Brook Section 1

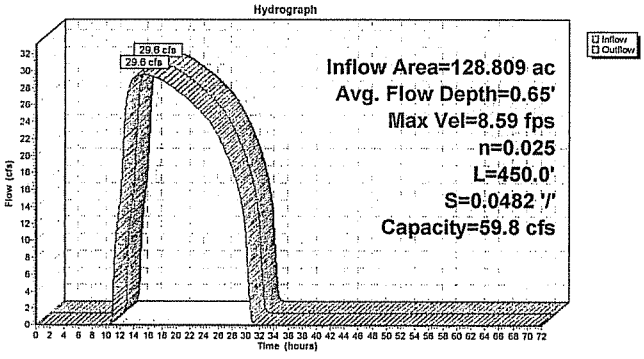
Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 3.58" for 100 year event
Inflow = 29.6 cfs @ 15.29 hrs, Volume= 38.397 af
Outflow = 29.6 cfs @ 15.31 hrs, Volume= 38.397 af, Atten= 0%, Lag= 1.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 8.59 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 7.07 fps, Avg. Travel Time= 1.1 min

Peak Storage= 1,550 cf @ 15.30 hrs
Average Depth at Peak Storage= 0.65'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 59.8 cfs

5.00' x 1.00' deep channel, n= 0.025 Earth, clean & winding
Side Slope Z-value= 0.5 '/' Top Width= 6.00'
Length= 450.0' Slope= 0.0482 '/'
Inlet Invert= 213.70', Outlet Invert= 192.00'

Reach 7R: Mineway Brook Section 1



Summary for Reach 8R: Analysis Point 5 - Tributary to Undeveloped 30 Acres

Inflow Area = 29.485 ac, 27.54% Impervious, Inflow Depth > 4.50" for 100 year event
Inflow = 14.5 cfs @ 12.70 hrs, Volume= 11.063 af
Outflow = 14.1 cfs @ 13.18 hrs, Volume= 11.063 af, Atten= 3%, Lag= 28.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.88 fps, Min. Travel Time= 13.2 min
Avg. Velocity = 0.38 fps, Avg. Travel Time= 30.8 min

Peak Storage= 11,181 cf @ 12.96 hrs
Average Depth at Peak Storage= 0.49'
Bank-Full Depth= 4.00', Capacity at Bank-Full= 1,489.6 cfs

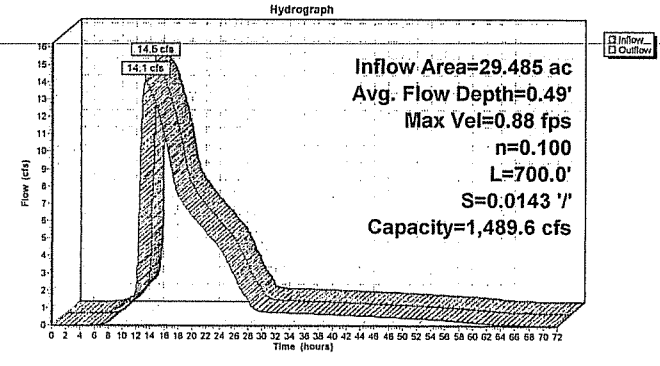
Custom cross-section, Length= 700.0' Slope= 0.0143 '/'
Constant n= 0.100 Heavy timber, flow below branches
Inlet Invert= 180.00', Outlet Invert= 170.00'

‡

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
-100.00	4.00	0.00
-10.00	0.00	4.00
0.00	0.00	4.00
10.00	0.00	4.00
130.00	4.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	20.0	0	0.0
4.00	500.0	230.2	350,000	1,489.6

Reach 8R: Analysis Point 5 - Tributary to Undeveloped 30 Acres



Summary for Pond 5P: Detention System B

Inflow Area = 4.111 ac, 47.70% Impervious, Inflow Depth = 4.95" for 100 year event
Inflow = 19.5 cfs @ 12.16 hrs, Volume= 1.696 af
Outflow = 3.8 cfs @ 12.67 hrs, Volume= 1.696 af, Atten= 80%, Lag= 30.8 min
Primary = 3.8 cfs @ 12.67 hrs, Volume= 1.696 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 187.11' @ 12.67 hrs Surf.Area= 7,945 sf Storage= 32,623 cf

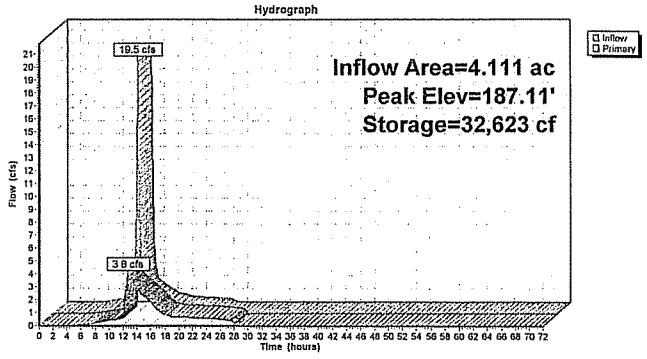
Plug-Flow detention time= 175.7 min calculated for 1.696 af (100% of inflow)
Center-of-Mass det. time= 175.7 min (979.7 - 804.0)

Volume	Invert	Avail.Storage	Storage Description
#1	183.00'	23,562 cf	**60.0" D x 150.0'L Pipe Storage S= 0.0030 '/' x 8**
#2	183.00'	2,356 cf	**60.0" D x 60.0'L Pipe Storage x 2**
#3	183.00'	7,658 cf	**60.0" D x 390.0'L Pipe Storage S= 0.0025 '/'**
#4	182.20'	5,301 cf	**60.0" D x 270.0'L Pipe Storage S= 0.0030 '/'**
		38,877 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	182.20'	**4.0" Vert. Orifice/Grate** C= 0.600
#2	Primary	184.90'	**8.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	187.00'	**5.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=3.8 cfs @ 12.67 hrs HW=187.11' (Free Discharge)
└1=Orifice/Grate (Orifice Controls 0.9 cfs @ 10.48 fps)
└2=Orifice/Grate (Orifice Controls 2.3 cfs @ 6.59 fps)
└3=Sharp-Crested Rectangular Weir (Weir Controls 0.6 cfs @ 1.08 fps)

Pond 5P: Detention System B



Summary for Pond 6P: Detention System A

Inflow Area = 24.425 ac, 23.07% Impervious, Inflow Depth = 4.40" for 100 year event
Inflow = 110.6 cfs @ 12.13 hrs, Volume= 8.959 af
Outflow = 10.5 cfs @ 13.22 hrs, Volume= 8.959 af, Atten= 91%, Lag= 64.9 min
Primary = 10.5 cfs @ 13.22 hrs, Volume= 8.959 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 194.45' @ 13.22 hrs Surf.Area= 16,513 sf Storage= 214,258 cf

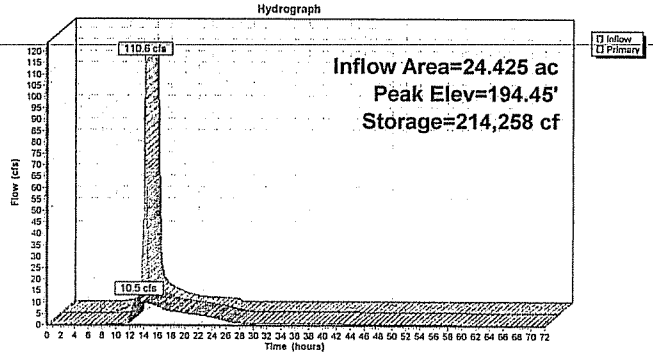
Plug-Flow detention time= 471.7 min calculated for 8.957 af (100% of inflow)
Center-of-Mass det. time= 471.9 min (1,286.9 - 815.0)

Volume	Invert	Avail.Storage	Storage Description
#1	184.00'	231,850 cf	**144.0" D x 2,050.0'L Pipe Storage**

Device	Routing	Invert	Outlet Devices
#1	Primary	184.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#2	Primary	187.60'	**10.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	192.00'	**8.0" Vert. Orifice/Grate** C= 0.600
#4	Primary	195.00'	**8.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=10.5 cfs @ 13.22 hrs HW=194.45' (Free Discharge)
└1=Orifice/Grate (Orifice Controls 1.3 cfs @ 15.44 fps)
└2=Orifice/Grate (Orifice Controls 6.7 cfs @ 12.21 fps)
└3=Orifice/Grate (Orifice Controls 2.4 cfs @ 7.00 fps)
└4=Sharp-Crested Rectangular Weir (Controls 0.0 cfs)

Pond 6P: Detention System A



Summary for Pond 7P: Concord Road Culvert

Inflow Area = 128.809 ac, 8.90% Impervious, Inflow Depth = 3.66" for 100 year event
Inflow = 268.3 cfs @ 12.59 hrs, Volume= 39.278 af
Outflow = 29.6 cfs @ 15.29 hrs, Volume= 38.397 af, Atten= 89%, Lag= 162.1 min
Primary = 29.6 cfs @ 15.29 hrs, Volume= 38.397 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 219.43' @ 15.29 hrs Surf.Area= 481,146 sf Storage= 928,548 cf

Plug-Flow detention time= 360.9 min calculated for 38.397 af (98% of inflow)
Center-of-Mass det. time= 347.6 min (1,208.0 - 860.4)

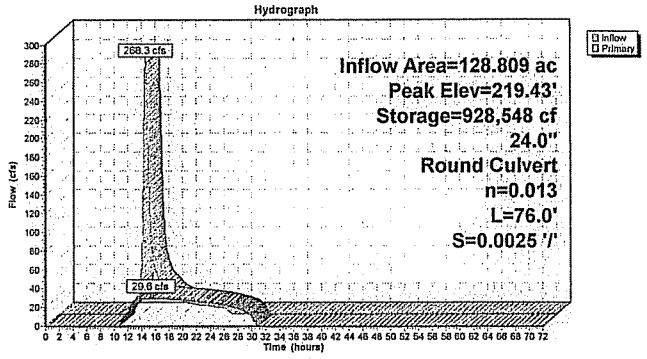
Volume	Invert	Avail.Storage	Storage Description
#1	214.00'	2,610,000 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
214.00	20,000	0	0
216.00	30,000	50,000	50,000
218.00	295,000	325,000	375,000
220.00	556,000	851,000	1,226,000
222.00	828,000	1,384,000	2,610,000

Device	Routing	Invert	Outlet Devices
#1	Primary	213.85'	**24.0" Round Culvert** L= 76.0' Ke= 0.500 Inlet / Outlet Invert= 213.85' / 213.66' S= 0.0025 '/' Cc= 0.900 n= 0.013

Primary OutFlow Max=29.6 cfs @ 15.29 hrs HW=219.43' TW=215.60' (Fixed TW Elev= 215.60')
└1=**Culvert** (Inlet Controls 29.6 cfs @ 9.42 fps)

Pond 7P: Concord Road Culvert



Summary for Pond 8P: Analysis Point 6 - Railraod Culvert

Inflow Area = 201.695 ac, 10.59% Impervious, Inflow Depth = 3.52" for 100 year event
Inflow = 102.3 cfs @ 12.46 hrs, Volume= 59.101 af
Outflow = 55.9 cfs @ 13.70 hrs, Volume= 59.101 af, Atten= 45%, Lag= 74.4 min
Primary = 55.9 cfs @ 13.70 hrs, Volume= 59.101 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 172.75' @ 13.70 hrs Surf.Area= 146,010 sf Storage= 151,171 cf

Plug-Flow detention time= 24.2 min calculated for 59.093 af (100% of inflow)
Center-of-Mass det. time= 24.2 min (1,192.7 - 1,168.5)

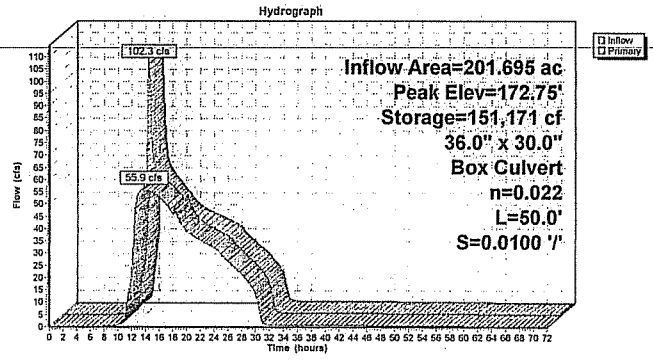
Volume	Invert	Avail.Storage	Storage Description
#1	168.70'	2,431,665 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
168.70	100	0	0
170.00	4,000	2,665	2,665
172.00	65,000	69,000	71,665
174.00	280,000	345,000	416,665
176.00	520,000	800,000	1,216,665
178.00	695,000	1,215,000	2,431,665

Device	Routing	Invert	Outlet Devices
#1	Primary	168.70'	**36.0" W x 30.0" H Box Culvert** L= 50.0' Ke= 0.200 Inlet / Outlet Invert= 168.70' / 168.20' S= 0.0100 '/' Cc= 0.900 n= 0.022 Earth, clean & straight

Primary OutFlow Max=55.9 cfs @ 13.70 hrs HW=172.75' (Free Discharge)
└1=**Culvert** (Barrel Controls 55.9 cfs @ 7.45 fps)

Pond 8P: Analysis Point 6 - Railraod Culvert



Stormwater Operations and Management Plan

The Village at Sudbury Station
Hudson & Concord Road
Sudbury, MA

June 10, 2016
Revised July 14, 2016

Stormwater Management System Owner: and Responsible Party:

Name: Sudbury Station LLC

Signature: _____

Title: _____

This Operation and Maintenance Plan has been prepared in accordance with the MA Department of Environmental Protection stormwater standards and recommendations outlined in the stormwater handbook. Though these Standards do not apply to the project site because there are no discharges into any wetland or water body resulting from the operation of the Stormwater Management System, nor any other discharge which triggers the application of the Massachusetts Stormwater Standards. This plan outlines the minimum efforts necessary to ensure that the stormwater collection and detention system for this site operates in accordance with the proposed design and will bind the operation and management of the system. Efforts in addition to the minimum listed herein may be required to ensure adequate stormwater management.

This plan includes (1) general site restrictions, (2) routine/non-routine operation & maintenance, (3) reporting and record keeping, and (4) emergency response. The locations of stormwater components are shown on the Site Plans for "The Village at Sudbury Station," and are made part of this document.

1. General Site Restrictions

The following conditions are imposed as part of this Plan.

- Illicit discharges into stormwater management system are perpetually prohibited.
- The use of fertilizers should be limited to slow-release, low-nitrogen fertilizers.

2. Operation and Maintenance:

At a minimum, **the Subsurface Detention System and trach racks shall be inspected monthly and all other stormwater management facilities should be inspected a minimum of two times per year, and following at least one major storm per year.** Upon completion of inspection, the inspector should specify any necessary corrective actions to be taken by ownership of the facility. The items to be inspected and maintained are described in the following sections.

Based on the observed conditions, the Responsible Party shall immediately schedule the appropriate maintenance. Some minor maintenance, such as the removal of blockages, debris and saplings in the basins may be conducted at the time of the inspection. More difficult maintenance activities, requiring special equipment, will have to be scheduled, such as the removal of excessive sediment or the repair of eroded areas. All sediment must be removed at least once per year.

Subsurface Detention System

Detention structures shall be inspected after every major storm for the first three months after construction. After the initial period, the system, outlet structure and trash racks shall be inspected monthly, or at increased frequency as dictated by the initial inspection period. The rate at which the system collects pollutants will depend on site activities rather than the size or configuration of the system. The outlet structure and trash racks will be checked for sediment accumulation and structural condition of the weir wall.

Inspection is the key to effective maintenance and is easily performed. Ongoing monthly inspections of the accumulated sediment should be performed. Sediment deposition and transport may vary from year to year and monthly inspections will help insure that systems are cleaned out at the appropriate time. Inspections may need to be performed more often in the winter months in climates where sanding operations may lead to rapid accumulations.

Systems shall be cleaned when inspection reveals that accumulated sediment has reached a depth that may impact the functionality of the system, and trash racks shall be cleaned monthly. Any clogging or accumulated debris that may restrict flow through the outlet structure or orifices shall be removed immediately. A 24 foot aluminum pole with 8-inch 'tee' suitable for manually cleaning the 4-inch orifice from the surface shall be provided by the contractor and kept in the maintenance building at all times. An emergency drawdown valve is provided to allow drawdown of stormwater in the event of a blockage. The vavle can be manually controlled from the surface and accessed through the manhole cover.

The system should be inspected during the high groundwater periods for any evidence of inflow, if such inflow is found the condition should be reported to a qualified engineer. The systems have been designed with an access/inspection manhole situated at or near the inlet and the outlet orifice. Should it be necessary to get inside the system to perform maintenance activities, all appropriate precautions regarding confined space entry and OSHA regulations should be followed. A record of each inspection shall be kept on file at the maintenance facility. A sample inspection log is included.

Maintaining an underground detention or retention system is easiest when there is no flow entering the system. For this reason, it is a good idea to schedule the cleanout during dry weather. Accumulated sediment and trash can typically be evacuated through the manhole over the outlet orifice. If maintenance is not performed as recommended, sediment and trash may accumulate in front of the outlet orifice. Manhole covers should be securely seated following cleaning activities.

Catch Basins and Manholes

The actual removal of sediments and associated pollutants and trash occurs only when sumps are cleaned out; therefore, regular maintenance is required. The more frequent the cleaning, the less likely sediments will be re-suspended and subsequently discharged. Frequent cleaning also results in more volume available for future storms and enhances the overall performance.

Deep sumps shall be inspected four times annually, and cleaned whenever sediment accumulation exceeds half the sump depth (typically two feet). Disposal of the accumulated sediment and hydrocarbons must be in accordance with applicable local, state, and federal guidelines and regulations. At each inspection, inspect gas trap hoods and repair as necessary. Inspect outlet pipe and remove debris.

Clamshell buckets are typically used to remove sediment in Massachusetts. However, vacuum trucks are preferable, because they remove more trapped sediment and supernatant than clamshells. Vacuuming is also a speedier process and is less likely to snap the cast iron hood within the deep sump catch basin.

Pipe Inlets / Outlets

Outlet structures shall be checked for: (1) signs of seepage, (2) separation of joints, (3) cracks, breaks, or deterioration of materials, and (4) differential settlement. The outlet channel itself shall be free from obstruction (e.g., fallen trees) and bank scour, or the undermining of riprap. The level spreader should be checked for settlement, damage, cracks, etc. to ensure a level uniform discharge. Downgradient areas should be checked for signs of flow concentration.

The inspector shall ensure that there are no signs of scour around the inlets. Vegetation and riprap shall be in good condition (e.g., grass shall be dense and healthy looking; riprap shall be free from undermining and/or deterioration). Outlet channels should be free from obstruction (e.g., fallen trees) and bank scour, or the undermining of riprap. Damaged natural areas along the outlet channel should be filled, compacted, and reseeded, to lined with geotextile fabric. Damaged rip rapped areas should be replaced and supplemented.

Vegetation

The initial vegetation inspection shall occur four (4) weeks after final stabilization of the site; vegetation shall be dense (and aesthetically acceptable on all portions of the project, including the side slopes, buffer strips and the embankments). The inspector shall determine and document: (1) whether fertilizing is required (2) the areas where grass shall be mowed, and (3) the areas which shall be protected against erosion. In addition, recently seeded areas shall be inspected for failures.

Eroded areas shall be filled and compacted, if necessary, and reseeded as soon as possible. If an area erodes twice, then a geotextile fabric is to be installed to stabilize the area to allow vegetation to be established. These maintenance activities shall take place during the planting season. Areas affected by lack of rainfall shall be watered. If a recently established vegetated area is determined to be inadequate for erosion control it shall be re-fertilized with microbial release, not sulfur encapsulated, fertilizer, (using half of the rate originally applied). If the stand is more than 60% damaged, it shall be reestablished, following the original preparation and seeding instructions. Areas of repeated erosion/scour problems shall be lined with riprap only after twice attempting to stabilize the area with geotextile fabric.

Debris Accumulation

The inspector shall check basins and channels for both sediment and debris accumulations. Debris and sediment shall be removed at the time of the inspection, if feasible. Sediment shall not be allowed to accumulate and restrict flows. Most debris can be removed by hand or with hand tools (e.g. shovel). Some larger objects, such as fallen tree limbs, may have to be cut up before removal by hand is possible.

Snow Removal

Snow windrows located within the sight triangle areas of internal driveways and at the intersections of Hudson Road and Concord Road that exceed 2-feet in height or that would otherwise inhibit sight lines shall be promptly removed. Snow shall not be plowed onto abutting properties or the Agricultural Preservation Land along Peter's Way nor stockpiled or stored within 125 feet of the buffer zone of bordering vegetated wetlands adjacent to Mineway Brook at the intersection of Concord Road until Peter's Way exits said buffer zone. The responsible party shall delineate this location on-site. All inlets shall be uncovered and functional immediately after snow plowing. Snow storage shall be managed to maintain access to all hydrants, building utilities, emergency exits, etc. Any snow in excess of that which can be stored on-site shall be legally disposed of off-site.

Street Sweeping

Street sweeping of the roadway should be performed at least twice per year, preferably in the spring after the snow has melted and in the fall, prior to snowfall. Disposal of the sweepings must be in accordance with applicable local, state, and federal guidelines and regulations.

Infiltration Drywell

Infiltration Drywells shall be inspected after every major storm in the first three months after construction. After this initial period, the systems shall be inspected at least twice annually (spring and fall) and after at least one major storm to see if they have fully drained. The Inspection ports or covers should be opened and the infiltration system checked for accumulated debris and sediment. If any sediment is present and/or if the infiltration system does not drain within 72 hours of the end of a storm, then remediation may be necessary. It may be possible to flood the system to suspend sediment and debris and remove it with a vacuum truck. Otherwise replacement of the soil around and under the infiltration system may be required.

Stormceptor Water Quality Structures

The Stormceptor Water Quality structures shall be maintained in accordance with the manufactures recommendations (see attached). Structures should be inspected four times annually, and cleaned whenever sediment accumulation exceeds a depth of 12 inches. Disposal of the accumulated sediment and hydrocarbons must be in accordance with applicable local, state, and federal guidelines and regulations. At each inspection, the responsible party shall inspect the inlet/outlet pipe and structural condition.

3. Reporting and Record Keeping

The responsible party will be responsible for maintaining accurate Maintenance Logs for all maintenance and inspections. The maintenance logs shall be kept on site for a minimum of TEN (10) years and be available for inspection by the Town municipal departments or other auditing authority, including inspections, repairs, replacement and disposal (for disposal, the log shall indicate the type of material and the disposal location). This will be a perpetual requirement of the Owners or their Designated Party.

The Site Maintenance Log will be completed as described above, and at a minimum will include the following items:

- Date activity performed;
- Last rain event;
- BMP's inspected and condition;
- Specific maintenance task;
- Staff or contractor performing activity;
- Verification of maintenance activity;
- For disposal include type of material and the disposal location; and
- Recommended additional maintenance tasks.

4. Emergency Response Plan / Spill Control Practices

Outdoor on-site storage of hazardous materials shall not be allowed. A spill cleanup kit shall be kept in the maintenance building at all times.

In the event of a spill or other accident on-site where a significant amount of gasoline, petroleum, chemicals, or other hazardous product is released, the following procedure should be followed:

1. Immediately contact the following agencies:
   Sudbury Fire Department (978) 443-2239
   MassDEP Emergency Response (888) 304-1133

2. Provide support to agencies listed above, which may include contacting an outside contractor to provide clean-up or contacting a Licensed Site Professional (LSP) to lead the clean-up.

If the volume of spill has reached the catch basins or detention system, these structures should be cleaned by a licensed liquid waste hauler. The outlet to the drainage system should be inspected. If there is evidence of discharge from the drainage system, additional corrective actions must be taken extending to the receiving water or beyond.

The MassDEP fact sheet summarizing the management of spills of oil and hazardous materials can be found at http://www.mass.gov/eea/docs/dep/cleanup/laws/spillmgm.pdf.

Attachments: Snow Storage Exhibit
O&M Inspection forms
MassDEP Fact Sheet - Managing spills of oil and hazardous material
CMP Detention and Infiltration Inspection and Maintenance Guide.
Stormceptor System Owners' Manual

MAINTENANCE INSPECTION FORM
<u>The Village at Sudbury Crossing</u>
Sudbury, MA

Date:____________ Inspector:_______________________ Signature:__________________

General Summary	Inspected	Date inspected	Action Required
1. Inspect Catch Basins	______	______	______
2. Inspect Area Drains	______	______	______
3. Inspect Treatment Structures	______	______	______
4. Inspect Subsurface Detention Systems	______	______	______
5. Inspect Subsurface Infiltration System	______	______	______
6. Inspect Trash Rack Manholes	______	______	______
7. Inspect Surface Conditions on Site	______	______	______
8. Pipe outfalls	______	______	______

1. Catch Basins

Number	Sediment Depth	Floatables Depth	Structural Condition	Inlet Condition	Last Cleaned	Action Required

2. Area Drains

Number	Sediment Depth	Floatables Depth	Structural Condition	Inlet Condition	Last Cleaned	Action Required

3. Treatment Structures (Stormceptor 2400)

Number	Sediment Depth	Structural Condition	Inlet Condition	Last Cleaned	Action Required

4. Detention System

Number	Sediment Depth	Depth Trash	Outlet Condition	Last Cleaned	Action Required

5. Infiltration Systems

	Depth of Sediment	Inlet / Outlet Condition	Depth of Water	Action required
Drywell –1				

6. Surface Conditions

	Condition	Action Required
Pavement		
Vegetation		

7. Pipe Outfall

	Depth of Sediment	Outlet Condition	Level Spreader Condition	Downstream Condition	Action required
Level Spreader					

8. Trash-Rack Manholes

Number	Sediment Depth	Debris Present	Screed Condition	Inlet Condition	Last Cleaned	Action Required

COMMENTS / MAINTENANCE REQUIRED:

NOTES:

1. SNOW STORAGE SHALL BE MANAGED TO MAINTAIN ACCESS TO ALL HYDRANTS, BUILDING UTILITIES, EMERGENCY EXITS, ETC.

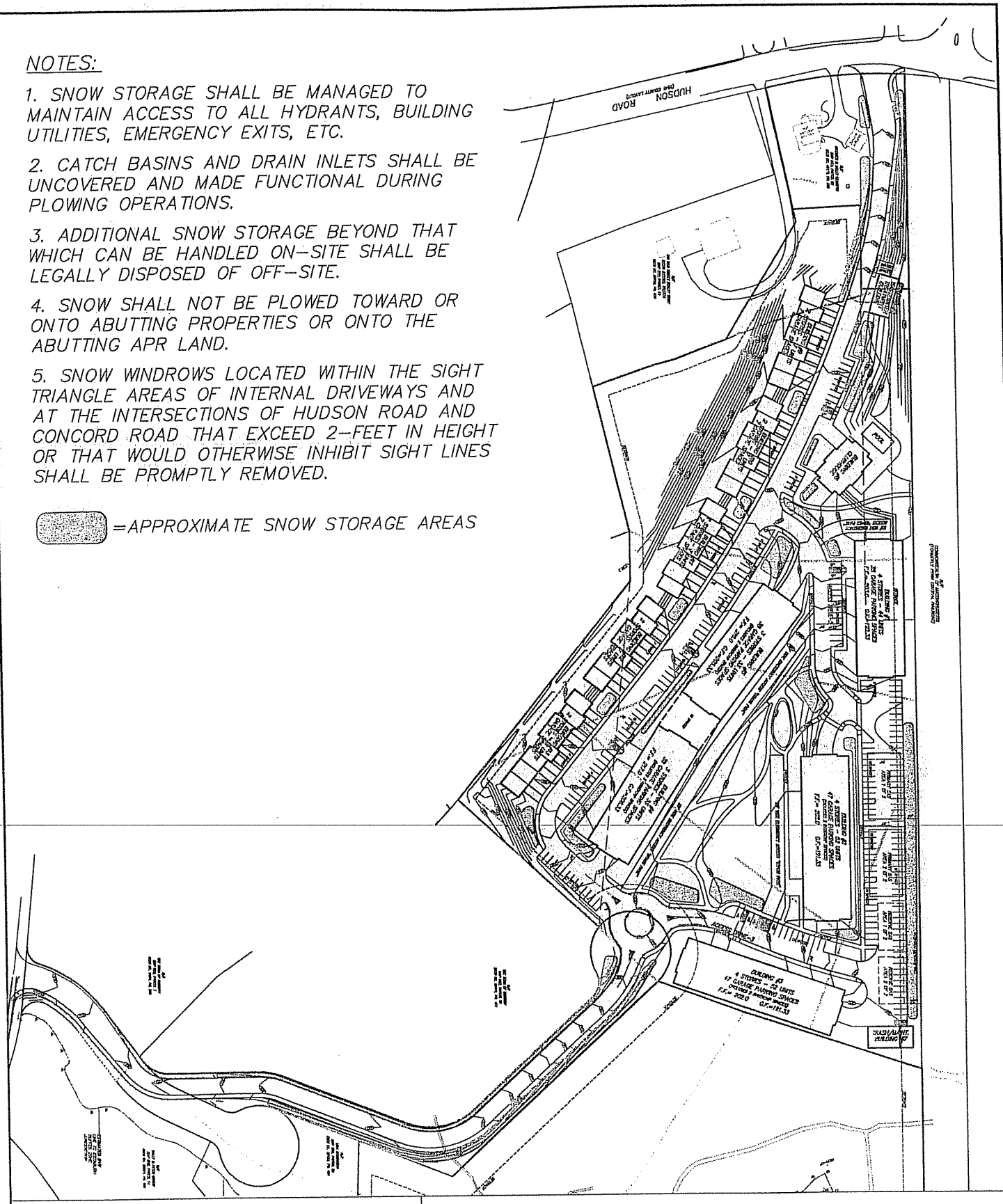
2. CATCH BASINS AND DRAIN INLETS SHALL BE UNCOVERED AND MADE FUNCTIONAL DURING PLOWING OPERATIONS.

3. ADDITIONAL SNOW STORAGE BEYOND THAT WHICH CAN BE HANDLED ON-SITE SHALL BE LEGALLY DISPOSED OF OFF-SITE.

4. SNOW SHALL NOT BE PLOWED TOWARD OR ONTO ABUTTING PROPERTIES OR ONTO THE ABUTTING APR LAND.

5. SNOW WINDROWS LOCATED WITHIN THE SIGHT TRIANGLE AREAS OF INTERNAL DRIVEWAYS AND AT THE INTERSECTIONS OF HUDSON ROAD AND CONCORD ROAD THAT EXCEED 2-FEET IN HEIGHT OR THAT WOULD OTHERWISE INHIBIT SIGHT LINES SHALL BE PROMPTLY REMOVED.

=APPROXIMATE SNOW STORAGE AREAS



SNOW STORAGE EXHIBIT	
DATE: JUNE 8, 2016	SCALE: NONE

SULLIVAN, CONNORS & ASSOC.
LAND SURVEYING AND CIVIL ENGINEERING
121 BOSTON POST ROAD
SUDBURY, MASSACHUSETTS 01776

Massachusetts Department of ENVIRONMENTAL PROTECTION

fact sheet

Managing spills of oil and hazardous materials

Information for municipalities

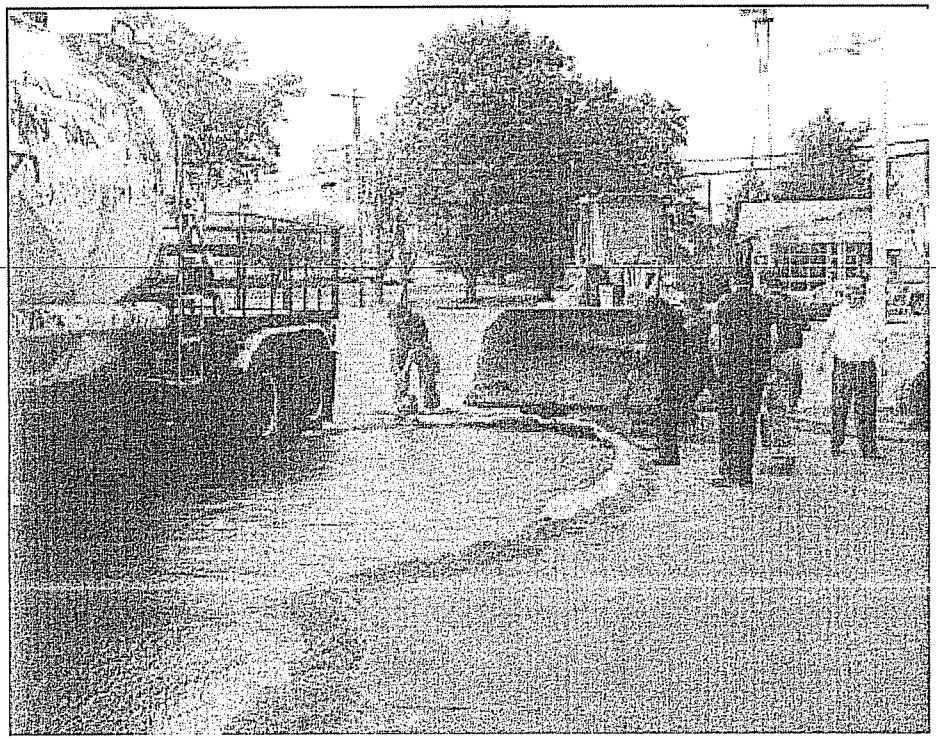
Purpose

Oil or chemical spill responses are local events. Because timely action is critical to the success of any cleanup, the Massachusetts Department of Environmental Protection (MassDEP) has prepared this guide to help municipal officials:

- Take defensive action at all spills to identify receptors and limit/contain the release
- After relevant training, take proactive actions to control and clean up spills of limited scope
- Provide support, in accordance with the Incident Management System, to the Fire Department, which normally is the lead agency in spill response situations
- Determine when MassDEP or a Licensed Site Professional (LSP) needs to lead a cleanup
- Represent the municipality's interests in cleanup decisions

Who must clean up a spill?

The primary responsibility for hiring contractors for on-site cleanup and disposal of waste materials, including all associated costs, rests with the person or party that causes or contributes to the release and/or with the owner of the property where it happens. They are collectively referred to as Potentially Responsible Parties (PRPs).[1]



Methuen Fire Department response to liquid asphalt spill. Photo by Steven Ross, MassDEP.

[1] M.G.L. Chapter 21E (the Massachusetts Oil and Hazardous Material Release Prevention Act) and 310 CMR 40.0000 (the Massachusetts Contingency Plan, or MCP) spell out the procedures and requirements for release notification, spill response and the cleanup standards that must be met.

Does the size, type, or location of a spill make a difference?

Yes. Depending on the size and type of spill, MassDEP and other local, state, and federal agencies may have a role in spill response. The PRP must report spills to MassDEP if they exceed specific thresholds. Some releases are exempt from reporting requirements under the MCP. These are spills that involve:

- less than 10 gallons of petroleum and which does not impact a waterbody
- less than one pound of hazardous chemicals and which does not pose an imminent hazard
- fuel from passenger vehicle accidents or
- a vault or building with a watertight floor and with walls that completely contain all released chemicals

Regardless of whether MassDEP notification is required, all spills of oil and hazardous materials must be cleaned up to the extent that no risk to human health is present.

Who responds to oil and hazardous material releases of a limited scope?

The fire department normally responds to spills, initiates containment, and usually directs cleanup of spills of limited scope, i.e. those that do not trigger MassDEP reporting thresholds. When the PRP is unable or unwilling to take responsibility, the fire department may also arrange for cleanup, either by hiring an outside contractor or by using in-house resources. The municipal public works department or other local agencies sometimes provide support. MassDEP generally does not respond to non-reportable releases or those of limited scope, but will be available for technical support. MassDEP will always respond to larger and more complicated spills with potential for posing imminent health, safety, or environmental hazards. MassDEP also attempts to respond to releases where public safety officials request assistance in directing the cleanup.

What specific roles do local officials play?

First responders to a spill are usually equipped to take some action to contain it. Containment is critical to protecting resources at risk. For example, the fire department might take measures to stop the flow or contain the release with absorbents, while public works personnel deliver and spread sand, pick up debris, and provide street drainage maps to aid in the spill investigation. Some municipalities have one or more environmental cleanup firm on retainer to help deal with responses to spills of limited scope.

When PRPs are unable or unwilling to respond, a statewide comprehensive "Hazardous Materials and Medical Waste Collection and Disposal" (FAC36) contract can be used by towns, cities, and state agencies to hire cleanup companies. The contract also provides for emergency response preparedness training for government workers. The contract establishes "Not to Exceed" rates for labor, transportation, and oil and hazardous materials disposal. Information about the Comm-PASS contract may be found at the web site of the Massachusetts Operational Services Division at www.mass.gov/osd.

What training is necessary for cleanup workers?

Because of their roles as first responders and the associated risks of direct exposure to hazardous chemicals, fire department personnel typically undergo training to deal with petroleum and chemical releases, as described in OSHA 1910.120. The International Association of Fire Fighters and the Massachusetts Firefighting Academy offer training programs.

Basic awareness training is highly recommended for staff from other municipal agencies who may be at less risk of direct exposure but still play critical support roles.

How do wastes from spill cleanups need to be handled?

Sand and absorbents contaminated with petroleum can be reused, disposed, or otherwise handled as described in MassDEP policy WSC-94-400, Interim Remediation Waste Management Policy for Petroleum Contaminated Soils, www.mass.gov/dep/images/wsc94400.pdf. But sand and absorbents that are saturated

Massachusetts Department of
Environmental Protection
One Winter Street
Boston, MA 02108-4746

Commonwealth of Massachusetts
Mitt Romney, Governor
Kerry Healey, Lt. Governor

Executive Office of
Environmental Affairs
Stephen R. Pritchard, Secretary

Department of
Environmental Protection
Robert W. Golledge, Jr.,
Commissioner

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alternate format by calling our ADA
Coordinator at
(617) 56-1057.

with petroleum products or by other hazardous chemicals may need special handling (disposal) by licensed transporters. Depending on the size and severity of a spill, a Licensed Site Professional (LSP) may also need to be hired to oversee the cleanup and sign-off on the disposal. MassDEP requires municipalities to properly manage and store small quantities of hazardous materials from spill cleanups. If storage that is consistent with MassDEP guidelines is not possible, an environmental waste removal firm should be hired to remove the material.

Contacting MassDEP Regional Offices:

Northeast Regional Office – 205B Lowell Street, Wilmington, Massachusetts 01887
http://www.mass.gov/dep/about/region/northeas.htm (978) 694-3200
Southeast Regional Office - 20 Riverside Dr., Lakeville, MA 02347
http://www.mass.gov/dep/about/region/southeas.htm (508) 946-2700
Central Regional Office - 627 Main St., Worcester, MA 01608
http://www.mass.gov/dep/about/region/centralr.htm (508) 792-7650
Western Regional Office - 436 Dwight St., Springfield, MA 01103
http://www.mass.gov/dep/about/region/westernr.htm (413) 784-1100

Visit http://www.mass.gov/dep/about/region/findyour.htm to determine which MassDEP regional office serves your community.

For more information:

- If you have questions, please email MassDEP at BWSC.Information@state.ma.us.
- For copies of MassDEP regulations, policies, and other publications, visit: http://www.mass.gov/dep/bwsc/pubs.htm

Related regulations and guidance documents:

- Interim Remediation Waste Management Policy for Petroleum Contaminated Soil, WSC-94-400, www.mass.gov/dep/images/wsc94400.pdf
- Reuse and Disposal of Contaminated Soil at Massachusetts Landfills, COMM-97-001, http://www.mass.gov/dep/recycle/laws/97-001.htm
- Characteristics of Hazardous Waste, 310 CMR 30.120, http://www.mass.gov/dep/service/regulations/310cmr30.pdf
- A Summary of Requirements for Small Quantity Generators, http://www.mass.gov/dep/recycle/laws/sqgsum.pdf

MassDEP Telephone numbers:

- Hazardous Waste Compliance Assistance Line – (617) 292-5898
- Household Hazardous Products Hotline – (800) 343-3420

Above ground or underground storage tanks:
Call the local fire department or the Massachusetts Department of Fire Services at (978) 567-3100 or 413-587-3181.

LSP information:
Visit the LSP Board's web page at http://www.mass.gov/lsp or call (617) 556-1091.

MassDEP 24-hour Spill Reporting
To report a release of oil or hazardous materials, and other environmental emergencies, call the MassDEP 24-hour notification line toll-free at
(888) 304-1133

Massachusetts Department of Environmental Protection
One Winter Street
Boston, MA 02108-4746

Commonwealth of Massachusetts
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CMP Detention and Infiltration Inspection and Maintenance Guide

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Maintenance

Underground storm water detention and retention systems should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size or configuration of the system.

Inspection

Inspection is the key to effective maintenance and is easily performed. Contech Engineered Solutions recommends ongoing quarterly inspections of the accumulated sediment. Sediment deposition and transport may vary from year to year and quarterly inspections will help insure that systems are cleaned out at the appropriate time. Inspections should be performed more often in the winter months in climates where sanding operations may lead to rapid accumulations, or in equipment washdown areas. It is very useful to keep a record of each inspection. A sample inspection log is included for your use.

Systems should be cleaned when inspection reveals that accumulated sediment or trash is clogging the discharge orifice. Contech suggests that all systems be designed with an access/inspection manhole situated at or near the inlet and the outlet orifice. Should it be necessary to get inside the system to perform maintenance activities, all appropriate precautions regarding confined space entry and OSHA regulations should be followed.

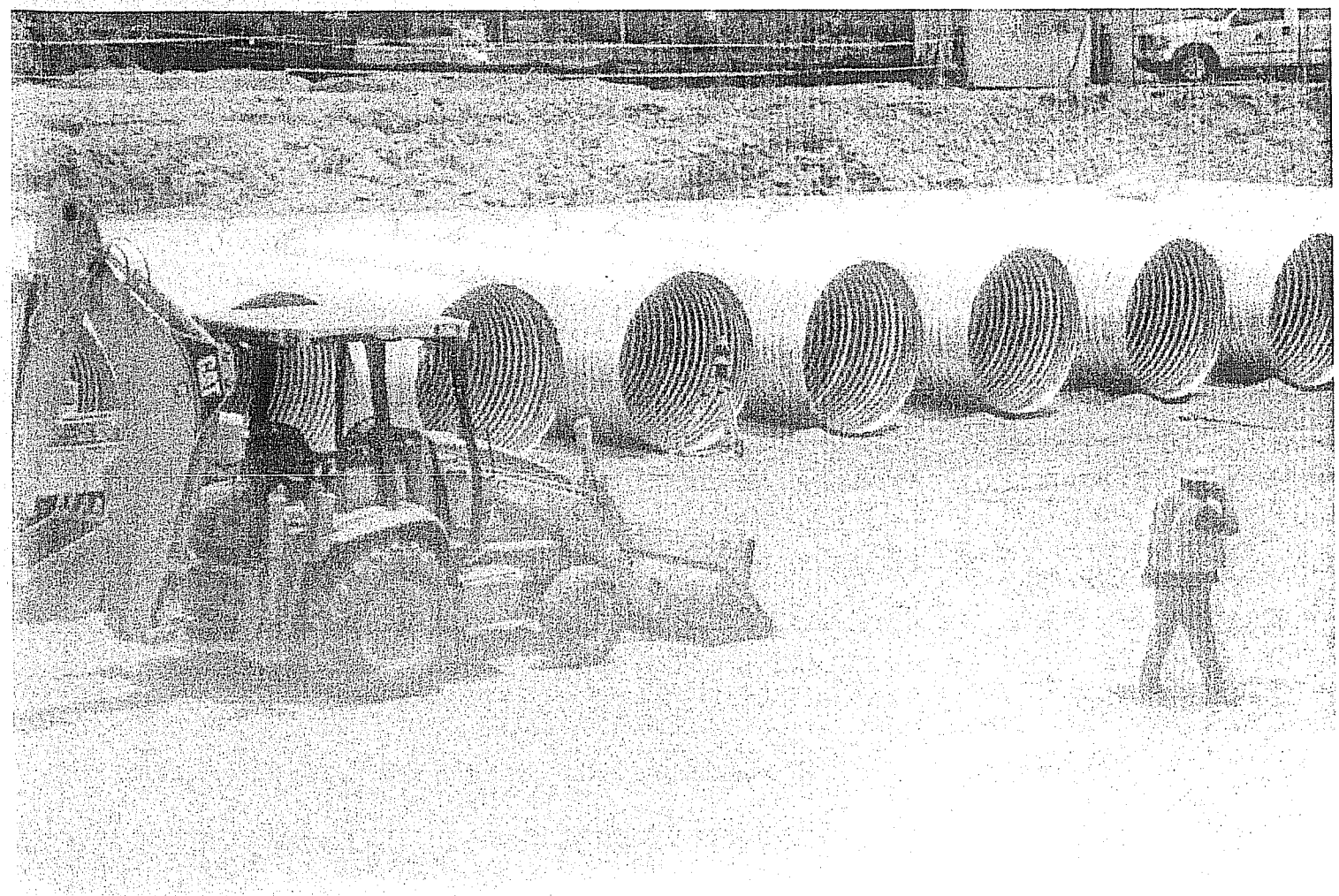
Cleaning

Maintaining an underground detention or retention system is easiest when there is no flow entering the system. For this reason, it is a good idea to schedule the cleanout during dry weather.

Accumulated sediment and trash can typically be evacuated through the manhole over the outlet orifice. If maintenance is not performed as recommended, sediment and trash may accumulate in front of the outlet orifice. Manhole covers should be securely seated following cleaning activities.

Inspection & Maintenance Log Sample Template

____ " Diameter System			Location:		
Date	Depth of Sediment	Accumulated Trash	Maintenance Performed	Maintenance Personnel	Comments



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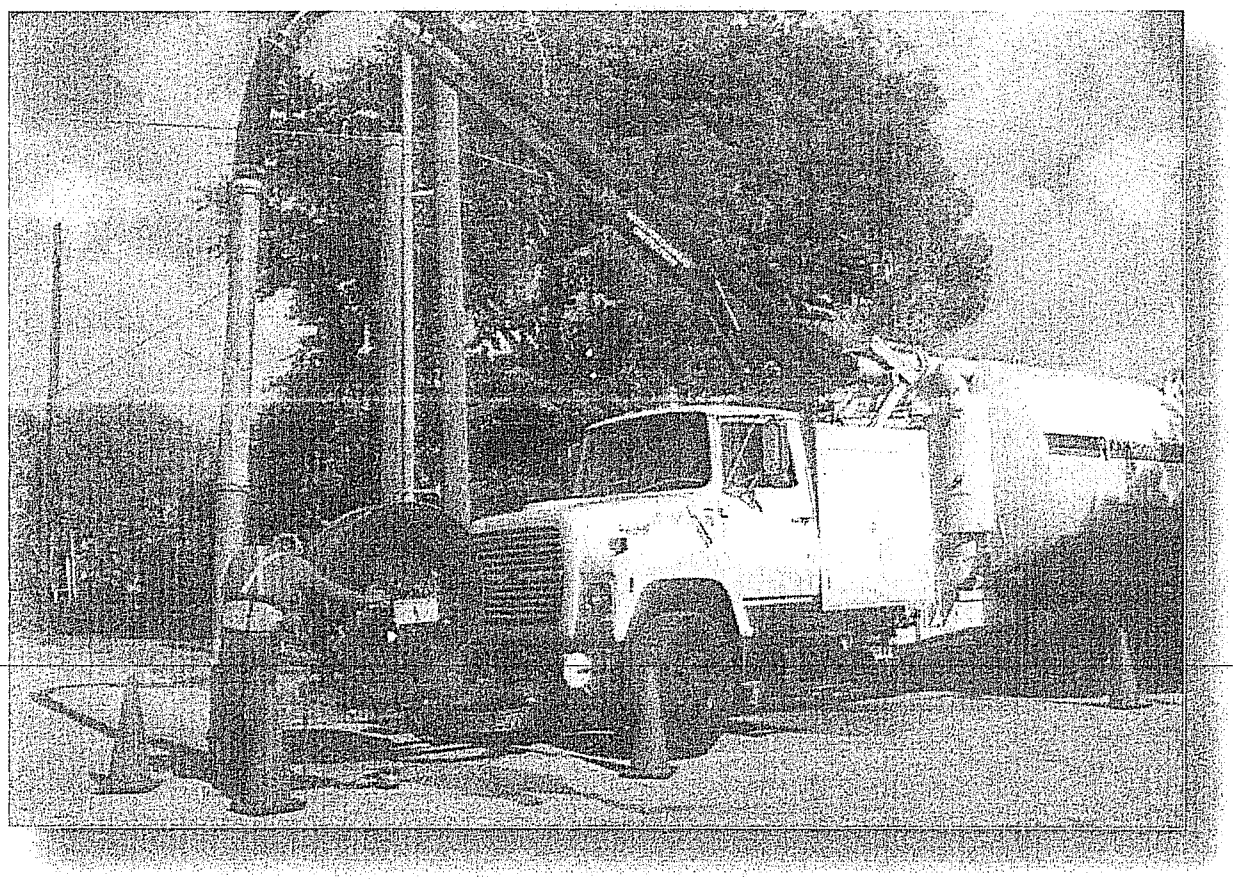
Support

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

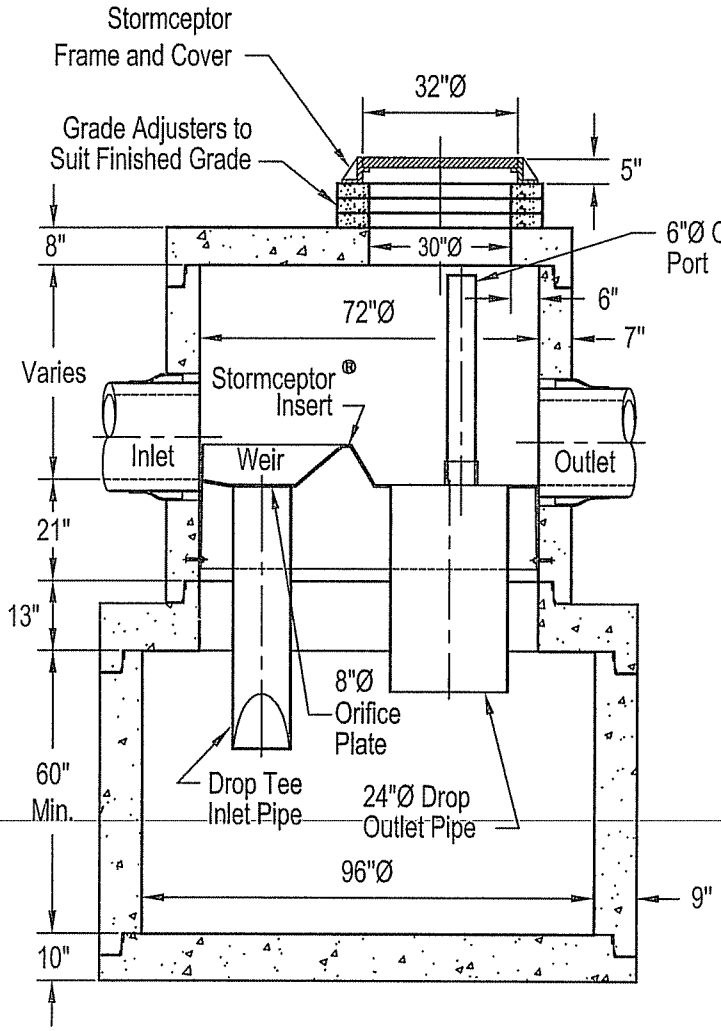
Rinker MATERIALS™



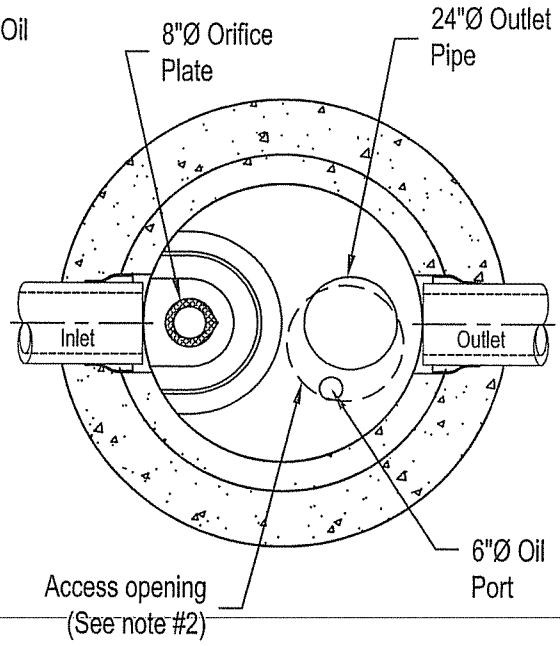
THE STORMCEPTOR® SYSTEM

Owner's Manual

STC 2400 Precast Concrete Stormceptor®
(2400 U.S. Gallon Capacity)



Section Thru Chamber



Plan View

Notes:

1. The Use Of Flexible Connection is Recommended at The Inlet and Outlet Where Applicable.
2. The Cover Should be Positioned Over The Outlet Drop Pipe and The Oil Port.
3. The Stormceptor System is protected by one or more of the following U.S. Patents: #4985148, #5498331, #5725760, #5753115, #5849181, #6068765, #6371690.
4. Contact a Concrete Pipe Division representative for further details not listed on this drawing.

Stormceptor® Owner's Manual Contents

Rev. 3/2006

Thank You!

We want to thank you for selecting the Stormceptor System to use in your efforts in protecting the environment. Stormceptor is one of the most effective and maintenance friendly storm water quality treatment devices available. If you have any questions regarding the operation and maintenance of the Stormceptor System, please call your local Rinker Materials representative, or the Stormceptor Information Line at (800) 909-7763.

1. *Stormceptor Overview*

The Stormceptor System is a water quality device used to remove total suspended solids (TSS) and free oil (TPH) from storm water run-off. Stormceptor takes the place of a conventional manhole or inlet structure within a storm drain system. Rinker Materials manufactures the Stormceptor System with precast concrete components and a fiberglass disc insert. A fiberglass Stormceptor can also be provided for special applications.

The Stormceptor System product line consists of four patented designs:

- The In-Line (Conventional) Stormceptor, available in eight model sizes ranging from 900 to 7200 gallon storage capacity.
- An In-Line (Series) Stormceptor is available in three model sizes ranging from 11,000 to 16,000 gallon storage capacity.
- The Submerged Stormceptor, an in-line system designed for oil and sediment removal in partially submerged pipes, available in all models sizes ranging from 450*i* to 16,000 gallon storage capacity.
- The Inlet Stormceptor is a 450 gallon unit designed for small drainage areas.

Stormceptor removes free oil and suspended solids from storm water preventing hazardous spills and non-point source pollution from entering downstream lakes and rivers. Rinker Materials and its affiliates market and manufacture the Stormceptor System in the United States and Australia. Several thousand Stormceptor Systems have been installed in various locations throughout North America, Australia and the Caribbean since 1990.

In the Stormceptor, a fiberglass insert separates the treatment chamber from the by-pass chamber. The different insert designs are illustrated in Figures 1 and 2. These designs are easily distinguishable from the surface once the cover has been removed.

There are four versions of the in-line disc insert: single inlet/outlet, multiple inlet, in-line series insert and submerged designs. In the non-submerged "disc" design you will be able to see the inlet pipe, the drop pipe opening to the lower chamber, the weir, a 6" oil inspection/cleanout pipe, a large 24" riser pipe opening offset on the outlet side of the structure, and the outlet pipe from the unit. The weir will be around the 24" outlet pipe on the multiple inlet disc insert and on large diameter pipe applications.

The STC (series) Stormceptors consist of two chambers comprised of similar fiberglass inserts. These units also contain a 6" oil/inspection cleanout pipe and 24" outlet riser pipes.

The submerged disc insert has a higher weir and a second inlet drop pipe. In the inlet design you will be able to see an inlet drop pipe and an outlet riser pipe as well as a central oil inspection/cleanout port.

2. *Stormceptor System Operation*

The Stormceptor consists of a lower treatment chamber, which is always full of water, and a by-pass chamber. Storm water flows into the by-pass chamber via the storm sewer pipe or grated inlet (Inlet Stormceptor). Normal flows are diverted by a weir and drop pipe arrangement into a treatment chamber. Water flows up through the submerged outlet pipe based on the head at the inlet weir and is discharged back into the by-pass chamber downstream of the weir. The treated storm water continues down stream via the storm sewer system.

Oil and other liquids with a specific gravity less than water rise in the treatment chamber and become trapped under the fiberglass insert. Sediment will settle to the bottom of the chamber by gravity. The circular design of the treatment chamber is critical to prevent turbulent eddy currents and to promote settling.

During infrequent high flow conditions, storm water will by-pass the weir and be conveyed to the outlet sewer directly. The by-pass is an integral part of the Stormceptor since other oil/grit separators have been noted to scour during high flow conditions (Schueler and Shepp, 1993).

For further details please refer to *The Stormceptor System Technical Manual.*

The key benefits of Stormceptor include:

- Capable of removing more than 80% of the total sediment load when properly applied as a source control for small drainage areas
- Removes free oil from storm water during normal flow conditions
- Will not scour or resuspend trapped pollutants
- Ideal spill control device for commercial and industrial developments
- Vertical orientation facilitates maintenance and inspections
- Small foot print

3. *Identification of Stormceptor*

All In-Line (including Submerged) Stormceptors are provided with their own frame and cover. The cover has the name STORMCEPTOR clearly embossed on it to allow easy identification of the unit. The name Stormceptor is not embossed on the inlet models due to the variability of inlet grates used/approved across North America. You will be able to identify the Inlet Stormceptor by looking into the grate since the insert will be visible.

Once you have located a unit, there still may be a question as to the size of the unit. Comparing the measured depth from the water level (bottom of insert) to the bottom of the tank with Table 1 should help determine the size of the unit.

Table 1. Stormceptor Dimensions*	
Model	**Pipe Invert to Top of Base Slab**
450*i*	60"
900	55"
1200	71"
1800	105"
2400	94"
3600	134"
4800	128"
6000	150"
7200	134"
11000*s*	128"**
13000*s*	150"**
16000*s*	134"**

* *Depths are approximate*

** *Depths per structure*

Starting in 1996, a metal serial number tag has been affixed to the fiberglass insert. If the unit does not have a serial number, or if there is any uncertainty regarding the size of the Stormceptor using depth measurements, please contact the Rinker Materials Stormceptor information line at (800) 909-7763 for assistance.

4. *Stormceptor Maintenance Guidelines*

The performance of all storm water quality measures that rely on sedimentation decreases as they fill with sediment (See Table 2 for Stormceptor capacities). An estimate of performance loss can be made from the relationship between performance and storage volume. Rinker Materials recommends maintenance be performed when the sediment volume in the unit reaches 15% of the total storage. This recommendation is based on several factors:

- Sediment removal is easier when removed on a regular basis (as sediment builds up it compacts and solidifies making maintenance more difficult).
- Development of a routine maintenance interval helps ensure a regular maintenance schedule is followed. Although the frequency of maintenance will depend on site conditions, it is estimated that annual maintenance will be required for most applications; annual maintenance is a routine occurrence which is easy to plan for and remember.
- A minimal performance degradation due to sediment build-up can occur.

In the event of any hazardous material spill, Rinker Materials recommends maintenance be performed immediately. Maintenance should be performed by a licensed liquid waste hauler. You should also notify the appropriate regulatory agencies as required.

Table 2. Stormceptor Capacities			
Model	**Sediment Capacity ft³ (L)**	**Oil Capacity US gal (L)**	**Total Holding Capacity US gal (L)**
450*i*	45 (1276)	86 (326)	470 (1779)
900	75 (2135)	251 (950)	952 (3604)
1200	113 (3202)	251 (950)	1234 (4671)
1800	193 (5470)	251 (950)	1833 (6939)
2400	155 (4387)	840 (3180)	2462 (9320)
3600	323 (9134)	840 (3180)	3715 (14063)
4800	465 (13158)	909 (3441)	5059 (19150)
6000	609 (17235)	909 (3441)	6136 (23227)
7200	726 (20551)	1059 (4009)	7420 (28088)
11000*s*	942 (26687)	2797 (10588)*	11194 (42374)
13000*s*	1230 (34841)	2797 (10588)*	13348 (50528)
16000*s*	1470 (41632)	3055 (11564)*	15918 (60256)

* *Total both structures combined*

4.1 *Recommended Maintenance Procedure*

For the "disc" design, oil is removed through the 6" inspection/cleanout pipe and sediment is removed through the 24" diameter outlet riser pipe. Alternatively, oil could be removed from the 24" opening if water is removed from the treatment chamber, lowering the oil level below the drop pipes.

The depth of sediment can be measured from the surface of the Stormceptor with a dipstick tube equipped with a ball valve (Sludge Judge®). It is recommended that maintenance be performed once the sediment depth exceeds the guideline values provided in Table 3 for the reasons noted in Section 4.0 Stormceptor Maintenance Guidelines.

Table 3. Sediment Depths Indicating Required Maintenance	
Model	**Sediment Depth***
450*i*	8" (200 mm)
900	8" (200 mm)
1200	10" (250 mm)
1800	15" (375 mm)
2400	12" (300 mm)
3600	17" (425 mm)
4800	15" (375 mm)
6000	18" (450 mm)
7200	15" (375 mm)
11000*s*	17" (425 mm)**
13000*s*	20" (500 mm)**
16000*s*	17" (425 mm)**

* *Depths are approximate*

** *In each structure*

No entry into the unit is required for routine maintenance of the Inlet Stormceptor or the smaller disc insert models of the In-Line Stormceptor. Entry to the level of the disc insert may be required for servicing the larger disc insert models. Any potential obstructions at the inlet can be observed from the surface. The fiberglass insert has been designed as a platform for authorized maintenance personnel in the event that an obstruction needs to be removed.

Typically, maintenance is performed by the Vacuum Service Industry, a well established sector of the service industry that cleans underground tanks, sewers, and catch-basins. Costs to clean a Stormceptor will vary based on the size of the unit and transportation distances. If you need assistance for cleaning a Stormceptor unit, contact your local Rinker Materials representative, or the Stormceptor Information Line at (800) 909-7763.

Figures 1 and 2 will help illustrate the access point for routine maintenance of Stormceptor.

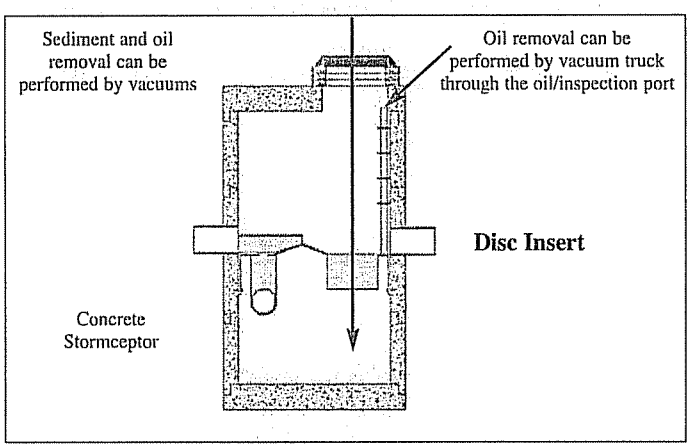


Figure 1 Single Inlet/Outlet "Disc" Insert
In-Line Stormceptor

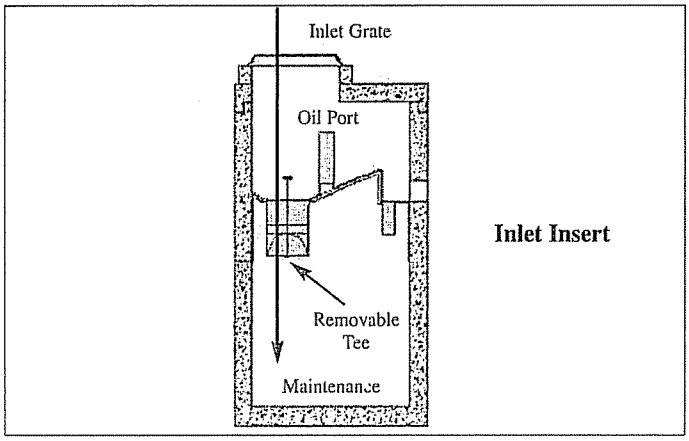


Figure 2 STC 450*i*
Inlet Stormceptor

4.2 *Disposal of Trapped Material from Stormceptor*

The requirements for the disposal of material from Stormceptor are similar to that of any other Best Management Practices (BMP). Local guidelines should be consulted prior to disposal of the separator contents.

In most areas the sediment, once dewatered, can be disposed of in a sanitary landfill. It is not anticipated that the sediment would be classified as hazardous waste. In some areas, mixing the water with the sediment will create a slurry that can be discharged into a trunk sanitary sewer. In all disposal options, approval from the disposal facility operator/agency is required. Petroleum waste products collected in Stormceptor (oil/chemical/fuel spills) should be removed by a licensed waste management company.

What if I see an oil rainbow or sheen at the Stormceptor outlet?

With a steady influx of water with high concentrations of oil, a sheen may be noticeable at the Stormceptor outlet. This may occur because a rainbow or sheen can be seen at very small oil concentrations (< 10 ppm). Stormceptor will remove over 95% of all free oil and the appearance of a sheen at the outlet with high influent oil concentrations does not mean that the unit is not working to this level of removal. In addition, if the influent oil is emulsified, the Stormceptor will not be able to remove it. The Stormceptor is designed for free oil removal and not emulsified or dissolved oil conditions.

5.0 *Recommended Safety Procedures*

Rinker Materials strongly recommends that any person who enters a Stormceptor System follow all applicable OSHA regulations for entry in permit required confined spaces, as outlined in 29 CFR 1910.146. A permit required confined space consists of a space that:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry and exit.
- Is not designed for continuous employee occupancy.
- Contains or has one of the following:
  - a potential to contain a hazardous atmosphere.
  - a material that has the potential for engulfing an entrant.
  - any other recognized serious safety hazard.

Storm water and wastewater systems fall under OSHA guidelines for a permit required confined space. Failure to follow OSHA guidelines for entry and work in a permit required confined space can result in serious injury or death. Please exercise extreme caution and follow appropriate safety procedures when entering any confined space.

Two square pick holes in the cover vent the Stormceptor, allow for removal of the cover, and provide sampling ports for air quality monitoring before the cover is removed. If you must enter the Stormceptor, please note that if the disc insert inside is wet, it can be slippery.

Call the Stormceptor Information Line (800-909-7763) for more detailed information and test results.

TECHNICAL INFORMATION:

- Stormceptor CD ROM
- Stormceptor Technical Manual
- Stormceptor Installation Guide
- Stormceptor Brochure

TEST RESULTS:

- STEP Report (Independent Verification)
- University of Coventry Study
- ETV Canada (Federal Verification)
- National Water Research Institute Test
- Westwood, MA Field Monitoring Study
- Edmonton, Canada Field Monitoring Study
- Seattle Field Monitoring
- Como Park, MN Field Monitoring Study
- Florida Atlantic University Submerged Stormceptor Testing
- Oil Removal Field Validation
- Sludge Analyses and Particle Size Analyses

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Rev. 3/2006

Photo 1 – Typical section of Mineway Brook (Reach 2R and 6R)

Photo 2 – Culvert under the old Railroad Bed (Analysis Point 6)

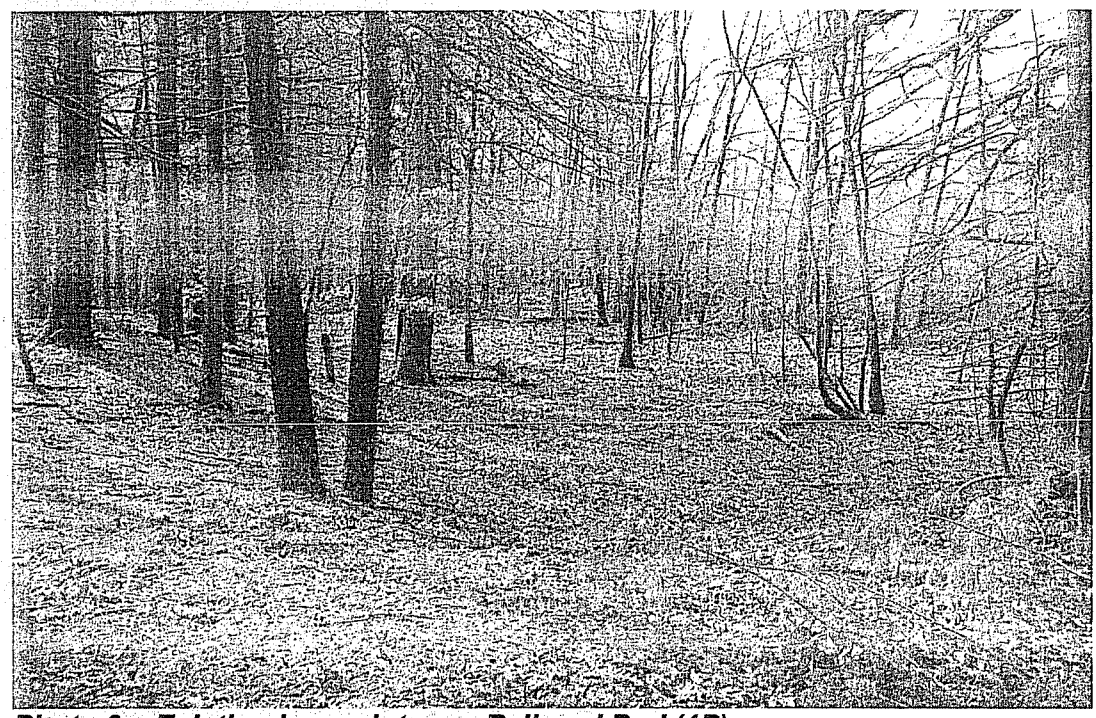


Photo 3 – Existing low point near Railroad Bed (1P)

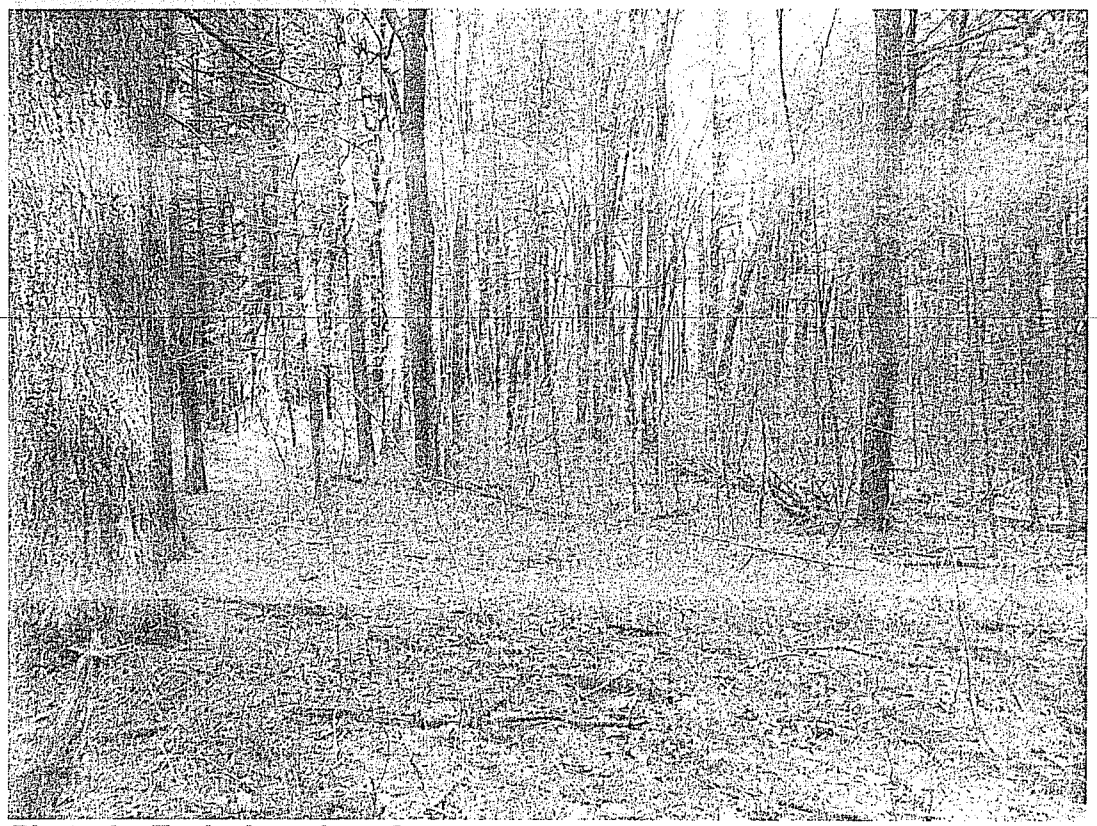


Photo 4 – Typical section of stormwater discharge location (Reach 4R/8R)

Photo 5 – Existing low point at Peter's Way

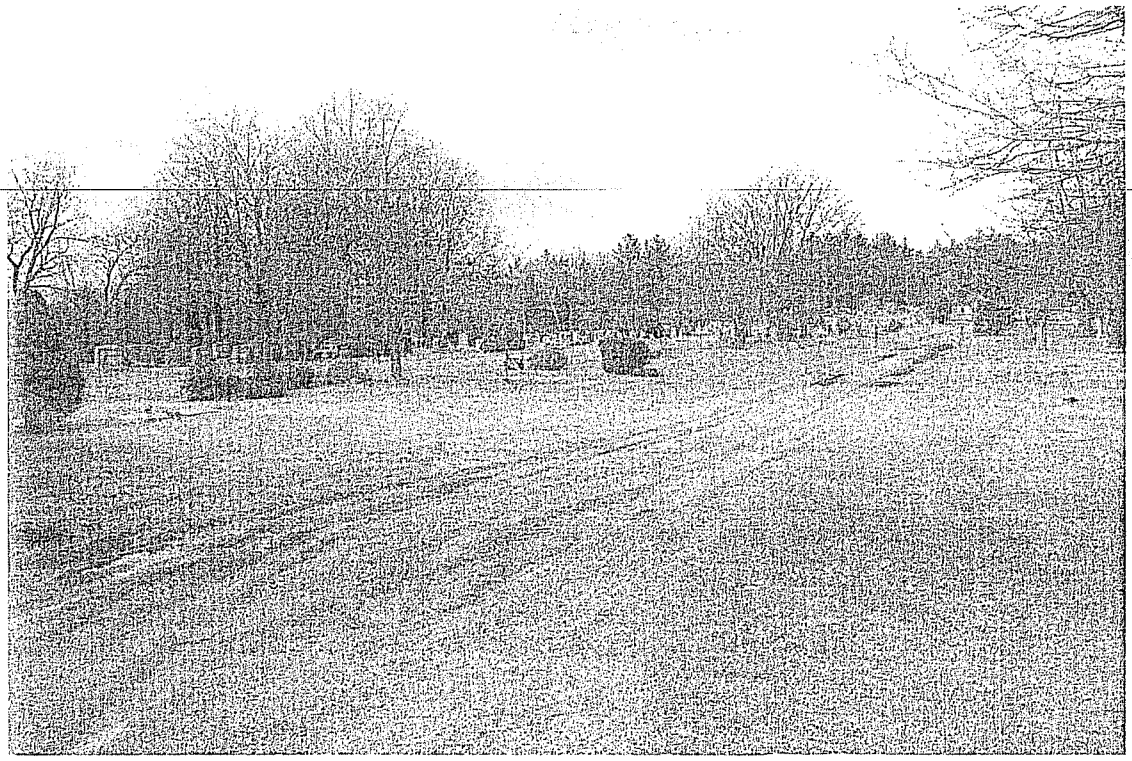
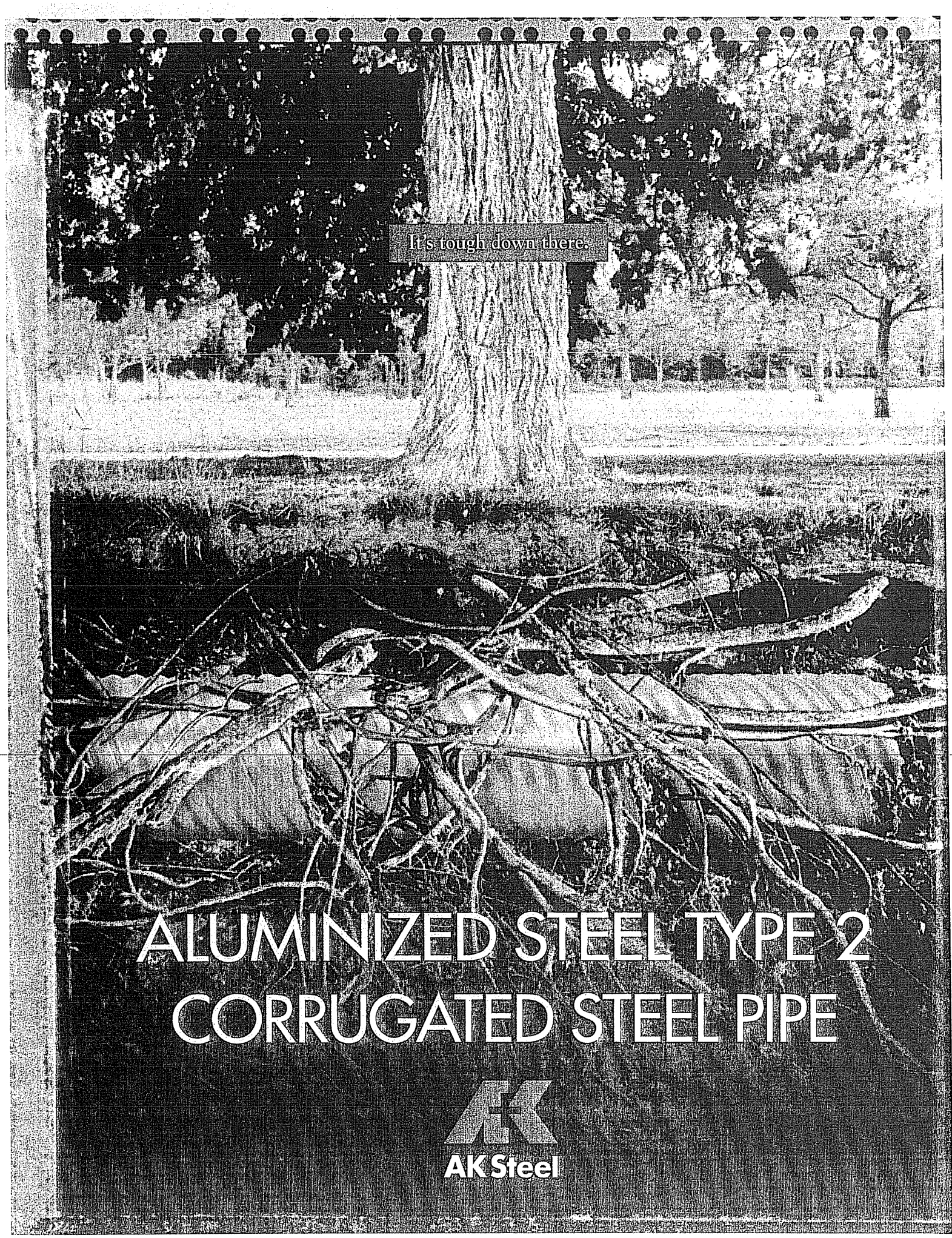


Photo 6 – Typical view of upgradient Town cemetery land

Appendix G – REPRESENTATIVE SITE PHOTGRAPHS

Appendix H – STORMWATER DETENTION SYSTEM PRODUCT DATA



ALUMINIZED STEEL TYPE 2 CORRUGATED STEEL PIPE

AK Steel

Aluminized Steel Type 2 Pipe for added durability.

Strength of steel, corrosion resistance of aluminum

Corrugated Steel Pipe manufactured from Aluminized Steel Type 2 offers the corrosion resistance and surface characteristics of aluminum with the strength and economy of Corrugated Steel Pipe.

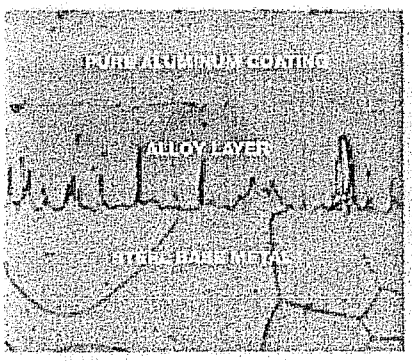
The product is fabricated from steel coils that have been hot dip coated in a bath of commercially pure aluminum. The coating has uniform thickness on *both sides* of the sheet, with a strong metallurgical bond between the metals. The Aluminized Steel Type 2 material meets AASHTO specifications M274 and ASTM A 929.

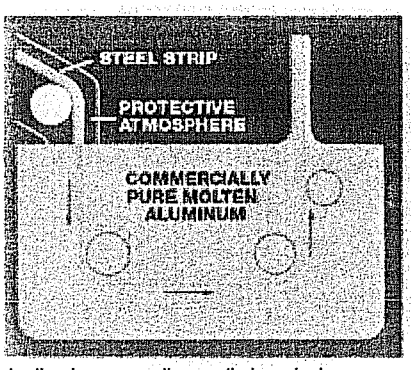
The coils are then fabricated into helically corrugated pipe meeting the requirements of AASHTO specifications M36 and ASTM A 760. Helically corrugated steel pipe has been a standard of the construction industry for decades. Pipe is fabricated with lock seams or welded seams depending on the job requirements, and each pipe end can be reformed to provide at least two annular corrugations.

Excellent barrier protection

Aluminum forms a passive aluminum oxide film that adds to the service life by providing good barrier protection. This passive film forms rapidly and maintains better protection over a wider environmental range than zinc reaction product films. The aluminum oxide passive film is effective in both hard and soft water.

The passive oxide film will endure as long as the free aluminum coating layer lasts. When this layer is eventually penetrated, there is an underlying hard, thick aluminum-iron alloy layer that provides further corrosion protection plus some significant abrasion protection.





The photomicrograph on the left shows how the thick alloy layer metallurgically bonds the aluminum coating to the steel base metal, as well as how the coating provides continuous protection to the base metal. The same coating protection is provided to both sides of the steel base metal.

Based on field studies of 42–43 year installations, Aluminized Steel Type 2 service life is estimated to be 75 years minimum at 16 gage in the 5–9 pH and ≥1,500 ohm-cm resistivity ranges.

In some cases, the pH/resistivity ranges may be extended somewhat as is the case in arid regions where moisture availability is generally a controlling factor, and satisfactory service life may be realized at soil resistivities somewhat below the 1,500 ohm-cm lower limit. In wetter climates, satisfactory service life may be realized at soil pH values below the 5.0 lower limit when resistivities are relatively high.

In general, however, environments outside the recommended pH/resistivity ranges should be subjected to additional testing to see if conditions conducive to accelerated corrosion actually exist. For example, low resistivity waters and soils may contain excessive concentrations of corrosive chloride and sulfates salts. In addition, any dark or light gray, blue, or olive-colored clay constituents observed in a heterogeneous soil should be isolated for pH measurement since these sometimes contain water-soluble heavy metal salts. These constituents induce strong acidification necessitating the use of a bituminous coating to ensure normal soilside corrosion behavior.

Environments that are far outside the recommended pH/resistivity ranges should be avoided, including acid minewater, seawater, estuary brackish water, and sanitary/industrial sewage.

Ideal for storm sewers

Aluminized Steel Type 2 corrugated steel pipe is an ideal material for municipal storm sewers or any

Standard specifications

1. AASHTO M274 (Aluminized Steel Type 2 material) and ASTM A 929.
2. AASHTO M36 and ASTM A 760 (conduit, pipe.)
3. AASHTO Standard Bridge Design Specifications, Section 12 (structural design) and ASTM A 796.
4. ASTM A 798 (installation).

75 years minimum service life. And still counting.

normal drainage project. Aluminized Steel Type 2 pipe offers a durable and economical alternate to reinforced concrete pipe. Features include light weight, long lengths, and joints that have positive pull-apart resistance and the ability to adjust to yielding foundations.

Pipe and pipe-arch are available in four corrugations (2 2/3" x 1/2", 3" x 1", 125mm x 25mm, and Spiral Rib's 3/4" x 3/4" x 7 1/2" rib corrugation) and in all standard diameters and 16 gage through 10 gage.

Long-term field testing

Based on extensive data from actual field installations dating back 43 years, Aluminized Steel Type 2 is a superior product for storm sewer and drainage projects. It has better corrosion resistance than galvanized structures and displays better abrasion resistance.

Prior to 1953, Aluminized Steel Type 2 and galvanized steel culverts were exposed in sites across the U.S. These sites represented a variety of service conditions including farm field drainage, fresh water swamps, alkali soils, and erosive applications. Test installations were sampled after eight years and again after 24 years. Weight loss data analyzed at all sites indicate Aluminized Steel Type 2 provided significant additional corrosion resistance.

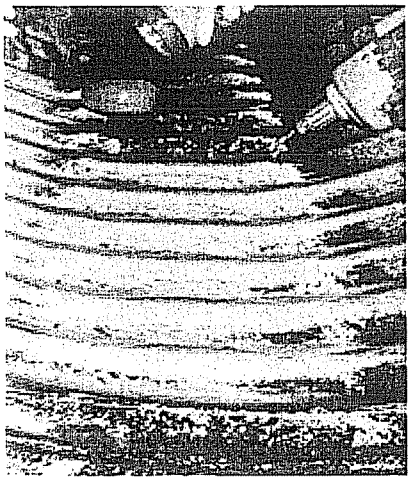
In addition to the careful sampling and evaluation accomplished during this 24-year program, simple visual inspection revealed that:

- The appearance of Aluminized Steel Type 2 was clearly superior to that of conventional metallic coating.
- The condition of Aluminized Steel Type 2 pipe inverts—a critical point in durability design—was excellent.

In 1952–53, an additional 135 composite culverts of Aluminized Steel Type 2 and galvanized steel were installed in 20 states. Based on the current conditions of the pipes available, the data indicates a minimum 75-year service life for 16 gage Aluminized Steel Type 2 pipe when installed in the recommended environment.

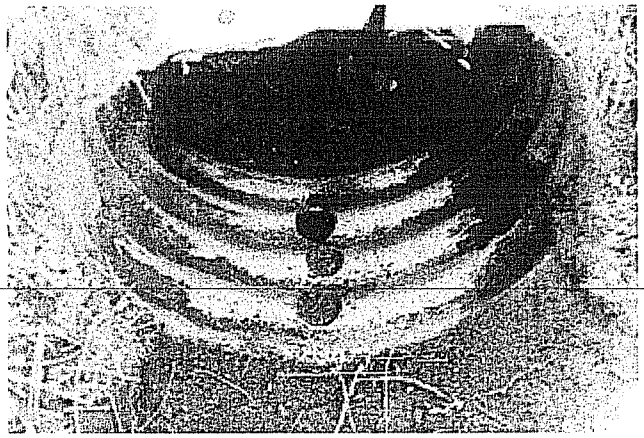
Independent studies

Many independent studies have been performed that confirm AK Steel Corporation's long-term field test.



This close-up view shows the Aluminized Steel Type 2 pipe installed in Garland, Maine, with the dark staining wiped away to reveal the like-new underlying aluminum.

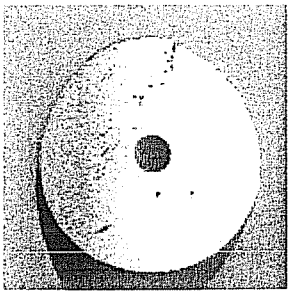
This Aluminized Steel Type 2 corrugated steel pipe was installed in 1953 in El Dorado, California. It was inspected in 1982 and in 1995. Coupons were removed in 1995 for evaluation by the AK Steel Research Center and CALTRANS.



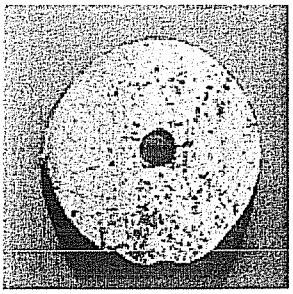
AK Steel Research Center's corrosion engineers and Missouri D.O.T. material engineers inspect a 43-year old Aluminized Steel Type 2 pipe installation. This is one of two culvert installations in Carter County, Missouri, installed in a series containing half Aluminized Steel Type 2 pipe and half galvanized steel pipe.

Performance proven by 43-year field test

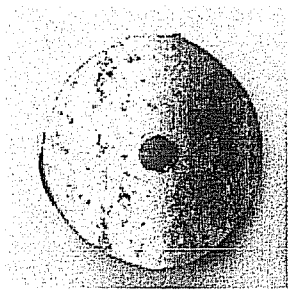
42- and 43-year old Aluminized Steel Type 2 coupons taken from pipe inverts around the United States



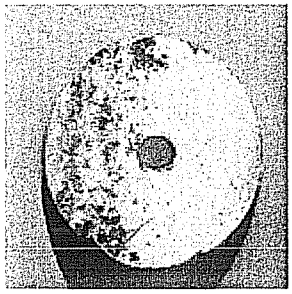
Marshall County, IA
Installed 1952
Inspected 1995



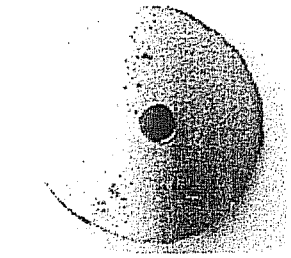
Lafayette County, MO
Installed 1952
Inspected 1995



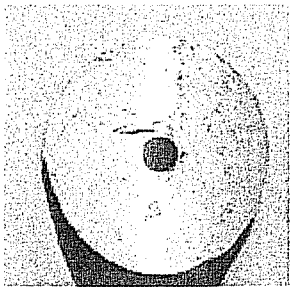
Snohomish County, WA
Installed 1952
Inspected 1995



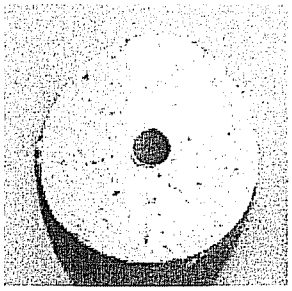
Morgan County, IL
Installed 1952
Inspected 1995



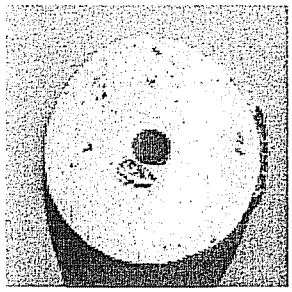
Bernalillo County, NM
Installed 1952
Inspected 1995



Oklahoma County, OK
Installed 1953
Inspected 1995

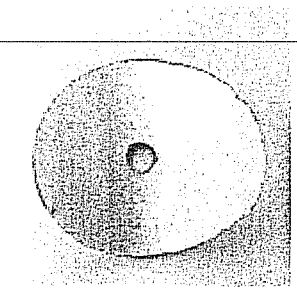


San Benito County, CA
Installed 1953
Inspected 1995

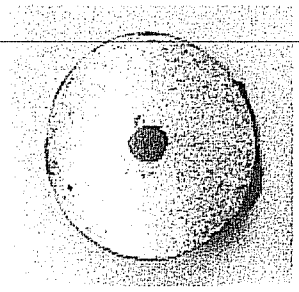


Decatur County, KS
Installed 1953
Inspected 1995

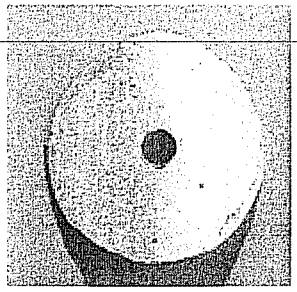
Newer pipe sites inspected. Same long-term performance expected.



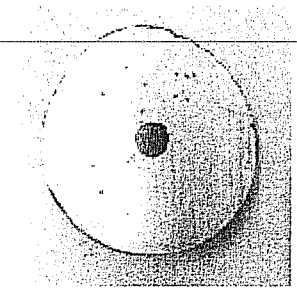
Richland County, SC
Installed 1978
Inspected 1995



Merrill Township, ME
Installed 1979
Inspected 1995



Montgomery County, MD
Installed 1980
Inspected 1995



Gwinnett County, GA
Installed in 1983
Inspected 1995

AK Steel has inspected many more pipe sites around the United States, and these field research studies indicate a minimum 75-year service life for Aluminized Steel Type 2 Corrugated Steel Pipe installed in the recommended environment.

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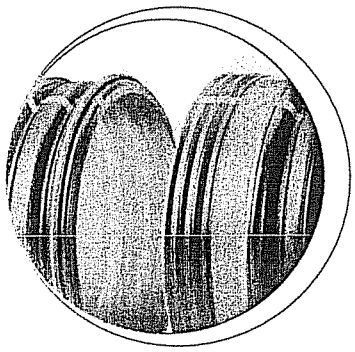
Middletown, OH 45043-0001
800-331-5050
www.aksteel.com
www.alt2csp.com

The product, engineering and research information in this literature is applicable exclusively to AK Steel Aluminized Steel Type 2.

4250-0221 10M CP 6-01

N-12® WT IB PIPE (PER ASTM F2648)



Our N-12 WT IB (per ASTM F2648) pipe offers significant performance advantages over reinforced concrete and corrugated metal pipe. Plus, it has the best watertight joint in the industry. Better yet, it's green. N-12 WT IB (per ASTM F2648) pipe is manufactured in diameters 4"-60" (100-1500 mm).

Today's N-12 WT IB pipe (per ASTM F2648) has a minimum recycled content of 40% using an engineered blend of virgin and recycled high-density polyethylene resins to provide impressive material properties. The performance you've come to expect from N-12, with the added benefit of helping promote responsible use of resources.

ADS N-12 WT IB (per ASTM F2648) pipe contains a superior built-in bell-and-spigot joint. An exterior bell wrap provides a quick visual indicator to customers and inspectors that a watertight product is being used. A patented gasket, that meets all requirements of ASTM F477, increases its sealing forces as temporary internal or external hydrostatic pressure increases. The flared bell and spigot significantly improve ease of installation. N-12 WT IB (per ASTM F2648) pipe is so advanced in its design that it is easy to put your confidence in for long-term reliability.

APPLICATIONS:

Storm Sewers
Retention/Detention
Ditch Enclosures
Roof Drainage
Culverts & Cross Drains
Slope/Edge Drains
Mining/Forestry/Industrial

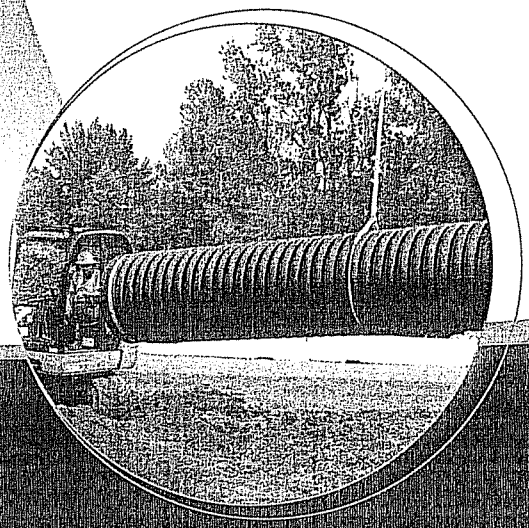
BENEFITS:

- Variety of diameters and lengths fit any project
- Pipe requires no extra couplers, grout or other sealants for installation due to built-in bell and factory-installed gasket. This means fewer components to risk performance
- Installation cost savings from lower shipping costs, fewer people, and less heavy equipment required
- Hydraulic efficiency from smooth interior
- Long-term durability of HDPE

FEATURES:

- 4"–60" (100 - 1500 mm) diameters available
- Nominal 20 ft. (6m) and 13 ft. (4m) lengths available
- Integral bell and factory-installed gasket
- Joint meets or exceeds ASTM D3212 lab test as well as ASTM F2487 and ASTM F1417 watertight field test
- Exceptional joint strength
- Excellent abrasion and corrosion resistance
- Light weight
- Fast installation times
- Structural strength that will support H-25 or HL-93 live loads with 1' (0.3 m) minimum cover; 60" (1500 mm) pipe requires 2' (0.6 m) cover for H-25 or HL-93 loads

ADS Service: **ADS representatives are committed to providing you with the answers to all your questions, including specifications, and installation and more.**



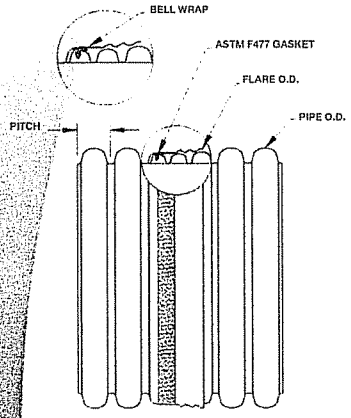
ADS N-12® WT IB PIPE (PER ASTM F2648) SPECIFICATION

SCOPE
This specification describes 4- through 60-inch (100 to 1500 mm) ADS N-12 WT IB pipe (per ASTM F2648) for use in gravity-flow drainage applications.

PIPE REQUIREMENTS
ADS N-12 WT IB pipe (per ASTM F2648) shall have a smooth interior and annular exterior corrugations.
- 4 - through 60-inch (100 to 1500 mm) shall meet ASTM F2648
- Manning's "n" value for use in design shall be 0.012.

JOINT PERFORMANCE
4 - through 60-inch (100 to 1500 mm) pipe shall be watertight according to the requirements of ASTM D3212. Gaskets shall meet the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.

12- though 60-inch (300 to 1500 mm) diameters shall have an exterior bell wrap installed by the manufacturer.



12"-60"
(300-1500 mm)

FITTINGS
Fittings shall conform to ASTM F2306. Bell and spigot connections shall utilize a spun-on or welded bell and valley or saddle gasket meeting the watertight joint performance requirements of ASTM F2306.

FIELD PIPE AND JOINT PERFORMANCE
To assure watertightness, field performance verification may be accomplished by testing in accordance with ASTM F2487. Appropriate safety precautions must be used when field testing any pipe material. Contact the manufacturer for recommended leakage rates.

MATERIAL PROPERTIES
Material for pipe production shall be an engineered compound of virgin and recycled high-density polyethylene conforming with the minimum requirements of cell classification 424420C (ESCR Test Condition B) for 4- through 10-inch (100 to 250 mm) diameters, and 435420C (ESCR Test Condition B) for 12- through 60-inch (300 to 1500 mm) diameters, as defined and described in the latest version of ASTM D3350, except that carbon black content should not exceed 4%. The design engineer shall verify compatibility with overall system including structural, hydraulic, material and installation requirements for a given application.

INSTALLATION
Installation shall be in accordance with ASTM D2321 and ADS published installation guidelines, with the exception that minimum cover in trafficked areas for 4- through 48-inch (100 to 1200 mm) diameters shall be one foot (0.3 m) and for 60-inch (1500 mm) diameters, the minimum cover shall be 2 foot (0.6 m) in single run applications. Backfill for minimum cover situations shall consist of Class 1 (compacted) or Class 2 (minimum 90% SPD). Maximum fill heights depend on embedment material and compaction level; please refer to Technical Note 2.02. Contact your local ADS representative or visit our website at www.ads-pipe.com for a copy of the latest installation guidelines.

PIPE DIMENSIONS

Nominal Pipe ID - in (mm)	4 (100)	6 (150)	8 (200)	10 (250)	12 (300)	15 (375)	18 (450)	24 (600)	30 (750)	36 (900)	42 (1050)	48 (1200)	54* (1350)	60 (1500)
Nominal Pipe O.D.** - in (mm)	4.8 (122)	6.9 (175)	9.1 (231)	11.4 (290)	14.5 (368)	18 (457)	22 (559)	28 (711)	36 (914)	42 (1067)	48 (1219)	54 (1372)	61 (1549)	67 (1702)

*Check with sales representative for availability by region.
**Pipe O.D. values are provided for reference purposes only. values stated for 12- through 60-inch are ±1 inch. Contact a sales representative for exact values.

Advanced Drainage Systems, Inc.
4640 Trueman Blvd., Hilliard, OH 43026
1-800-821-6710 www.ads-pipe.com

Appendix I – EXISTING AND PROPOSED DRAINAGE AREA MAPS

(24" x 36" plan sheets attached separately)