

**Stormwater Management Report
William Wood Way
Andover, Massachusetts**

**Prepared for:
Steven Leed
22 William Street
Andover, Massachusetts 01810**

**February 1, 2022
Revised August 18, 2022
Revised September 29, 2022**

Prepared By:



**1 East River Place
Methuen, MA 01844**

Checklist for Stormwater Report



Checklist for Stormwater Report

A. Introduction

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



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

The Stormwater Report must include:

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

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

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

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

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

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



Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

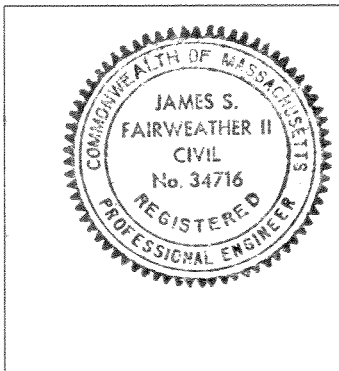
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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

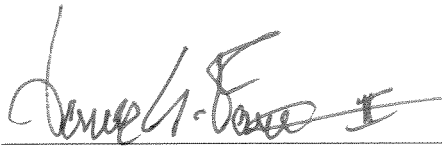
A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature



 9/29/2022

Signature and Date

Checklist

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

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



Checklist for Stormwater Report

Checklist (continued)

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

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

Standard 1: No New Untreated Discharges

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



Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

Standard 3: Recharge

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

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



Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

Standard 4: Water Quality

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

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



Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

Standard 6: Critical Areas

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



Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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



Checklist for Stormwater Report

Checklist (continued)

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

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

Standard 9: Operation and Maintenance Plan

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

Standard 10: Prohibition of Illicit Discharges

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

Stormwater Report Narrative

This Stormwater Report has been prepared to demonstrate compliance with the Massachusetts Stormwater Management Standards in accordance with the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00). Technically, this project is exempt from the Massachusetts Standards as a four lot subdivision. However, this report is prepared to demonstrate compliance with the Town of Andover's Rules and Regulations for stormwater design and mitigation per the **Town of Andover Stormwater Management and Erosion Control By-Law**.

Project Description

The Applicant, Steven Leed, is proposing to construct 315± long subdivision road that will support a four lot single family residential development. The project includes an existing dwelling that is to remain on a reconfigured lot (Lot 1) and proposes 3 new lots.

The proposed work will also include the construction of a subsurface infiltration/detention structure, lot grading, drainage and other utilities. The proposed road ends with a cul-de- sac and is within an existing 60-foot wide drainage and sewer easement. The subsurface infiltration/detention structure, at the end of the road, is proposed to treat and mitigate stormwater quality and quantity. The design accommodates the existing utilities while providing a new drainage system to discharge into the subsurface system. A new looped water main is to be constructed and each new lot will be serviced by this as well as new sewer service connections to the existing sewer, the existing sewer discharges north to south through the property.

No alteration of existing wetland resources are proposed, but the project will disturb more than an acre of land which requires the project to comply with the By-Law noted above as well as filing with the EPA for a Construction General Permit.

Site Description

The Project Site is on a 2.33-acre parcel of land located off of William Street in Northern Andover, Massachusetts. The Site lies within the surface watersheds of Hussy Brook and the Shawsheen River and runoff ultimately discharges into the Merrimack River. The existing parcel to be developed is within the single lot residential zoning district SRA and is surrounded by existing single family lots to the west, north and east. The Hunter Ridge Condominium abuts the parcel to the south.

There are no Wetland Resource Areas on the Site, but there is a Bordering Vegetated Wetland (flagged series "B") just south of the property, on the condominium property. Portions of the work are within the buffer zone of this wetland and jurisdictional under the State's WPA and the Town's Bylaw. Another wetland (flagged series "A") is approximately 100 feet west of the property so the work is outside of the buffer for this resource. The wetland series "A" is depicted on the national Wetland Inventory website, while series "B" is not.

According to the National Resources Conservation Service (NRCS), surface soils on the Site consist of Hinckley Loamy Sand (Map units 253B, 253C) and are classified as a Hydrologic Soil Groups (HSG) A soil, a soil with low runoff potential and high infiltration rates when thoroughly wetted.

The Site does not lie within floodplain according to FEMA Flood Insurance Rate Map 25009C0217F, dated July 3, 2012.

The Site is not in or near habitat of rare or endangered species according to the NHESP online map, dated 8-1-2021.

Existing Drainage Conditions

Under existing conditions, the Site is a combination of landscaped, mowed lawn and undeveloped woodland consisting of a combination of trees and grass ground covers. There are 2 existing single family dwellings within the watershed of the proposed roadway drainage system; the project proponent resides in one of them, at 22 William Street. Both dwelling lots have associated paved driveways that connect to William Street, the driveway area for abutting property, at 24 William Street, was approximated.

Topography on site ranges from a high elevation of 78 along the northern side of the property line, at William Street, to a low elevation of 67 at the southerly end of the property, just north of an existing retaining wall. In addition to the dwellings there is a large garage in the southeast corner of the lot, a shed, a pool and pool house along the south, and an existing tennis court in the southwest corner of the lot. These features will be razed during construction.

For purposes of this study, two subcatchment areas and design checkpoints are were analyzed. Existing subcatchment 1 (EX 1) is a 0.67± acre portion of the project area and its surrounds which discharges westerly from the site and consists of lawn, the existing tennis court and a small portion of roof and patio area on abutting property at 24 William Street.

Stormwater runoff from the majority of the site, and surrounds, comprise area 2 (EX 2), a 2.66± acre sub-watershed and discharges runoff southerly towards the flagged wetland series B. This area consists of lawn, woods/grass combination ground covers and includes the existing dwellings, graveled drives the large garage in the southeast corner of the lot, a shed, a pool and pool house along the south noted

above. Runoff from this area is principally via overland sheet flow with some internal area tributary to an existing drain discharging southerly.

Proposed Drainage Conditions

Under developed conditions, the Site is comprised of the two existing dwellings one on site, one abutting), three new single-family lots and the proposed roadway.

Under developed conditions, four subcatchment areas were analyzed. Developed subcatchment 1 (DEV 1) is a 0.36± acre portion of the project area and its surrounds consisting of offsite lawn at 24 William Street and the developed portion of the westerly side of the development not captured by the proposed swale on that side of the project. Ground covers in this area include the noted abutter lawn and an onsite area proposed to revegetate naturally after removal of the tennis court. This area discharges westerly and to be compared to EX1 for pre vs. post runoff conditions.

Developed area 2 (DEV2) is a 2.19± acre sub-watershed consisting of most of the proposed development and which is collected by the proposed drainage system or graded swale and is tributary to the proposed sub-surface infiltration/detention chamber system. This area also includes a small area of William Street, mostly paved, which will be picked up by the drainage system not originally tributary to the property.

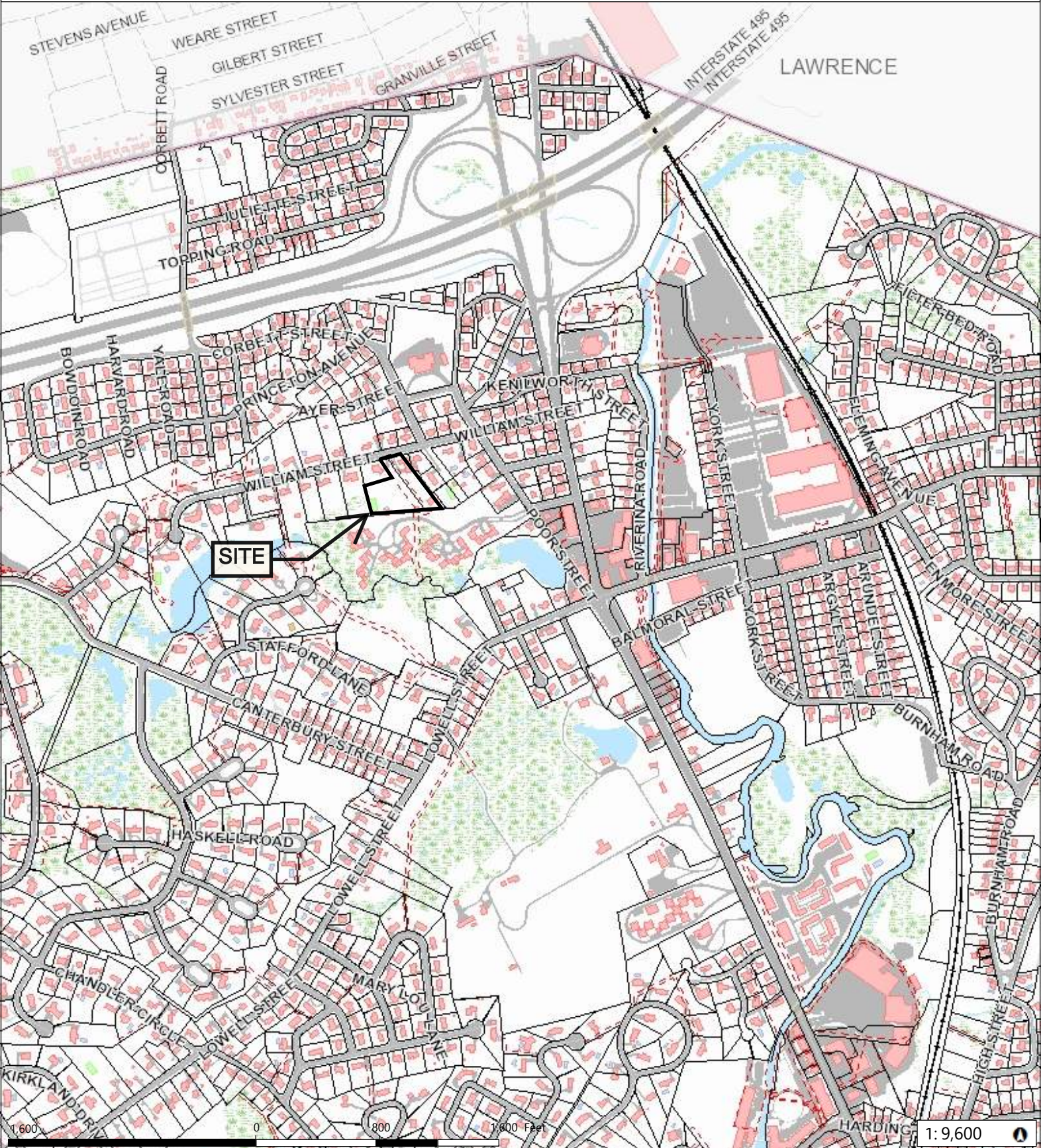
Developed area 3 (DEV3), 0.74± acre, is the remaining portion of the project property and surrounds which is not tributary the subsurface system and consists of the developed portion of lot 2, the lawn are over the chambers and a portion of the property, and abutting land, along the southerly end of the property that is proposed to revegetate naturally after removal the existing garage and shed. Runoff from this area is summed with the controlled runoff from the chambers to form SUM and forms the post developed runoff to be compared to EX2 for the pre vs. post condition.

Developed area 4 (DEV4), 0.03 ± acres, is a small portion of the proposed way that will discharge to the existing catch basins in William Street. The proposed roadway profile was raised slightly to facilitate this change. This also eliminates the two proposed catch basins and manhole at the entrance and their connecting pipes. This change was made at the direction of the Town Engineer.

Figure 1: Site Locus Map

Site Locus

12/21/2021



Data Sources: Produced by Merrimack Valley Planning Commission (MVPC) using data provided by the Town of Andover & MassIT/MassGIS. MVPC AND THE TOWN OF ANDOVER MAKES NO WARRANTIES, EXPRESSED OR IMPLIED, CONCERNING THE ACCURACY, COMPLETENESS, RELIABILITY, OR SUITABILITY OF THESE DATA. THE TOWN OF ANDOVER AND MVPC DOES NOT ASSUME ANY LIABILITY ASSOCIATED WITH THE USE OR MISUSE OF THIS INFORMATION



Legend	
Municipal Boundary	Building; <Null>
Water Tank	Fuel Tank
Pool	Bridge
Road Right of Way	Tennis Court
Rail Line	Unpaved
Wetlands	Hydrographic Features
Easement	Streams
Basketball Court	
Paved	

Figure 2: Existing Conditions Drainage Divide Area Map



Revision No.	Revision Description	Date
1	RESPONSE TO PEER REVIEW AND TOWN DEPTS. COMMENTS	AUG. 18, 2022

**DEFINITIVE SUBDIVISION
DRAINAGE DIVIDES-EXISTING
WILLIAM WOOD WAY
ANDOVER, MASSACHUSETTS**

PREPARED FOR: STEVEN LEED
DATE: FEBRUARY 1, 2022
SCALE: 1"=50'

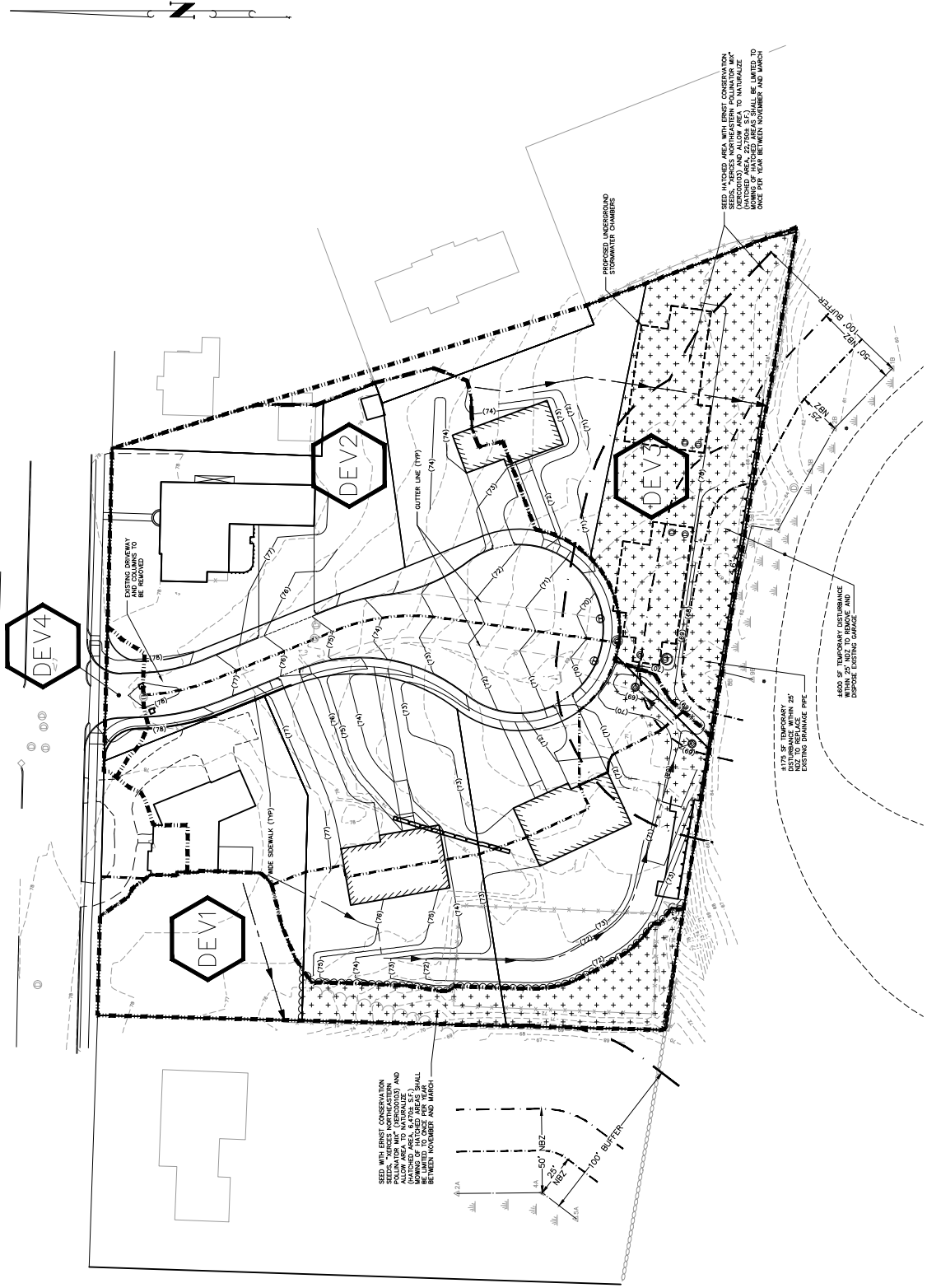
andover consultants inc.
1 East River Place
Methuen, Mass. 01844
Telephone: 978-687-3628

0 30 60 90 120 Ft.
0 8 16 32 Meter

Figure 3: Developed Conditions Drainage Divide Area Map

WILLIAM STREET

WILLIAM STREET

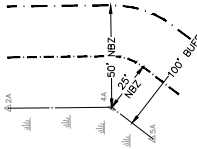


SEE ATTACHED AREA WITH EROSION CONTROL PLAN (RECORDED) AND ALLOW AREA TO NATURALIZE
 MORNING 5' HATCHED AREAS SHALL BE LIMITED TO
 ONCE PER YEAR BETWEEN NOVEMBER AND MARCH

8175 SF TEMPORARY 25'
 DISTURBANCE WITHIN 25'
 NBZ TO REMOVE EXISTING DRAINAGE PIPE

1400 SF TEMPORARY DISTURBANCE
 WITHIN 25' NBZ TO REMOVE AND
 DISPOSE EXISTING GARAGE

SEE ATTACHED AREA WITH EROSION CONTROL PLAN (RECORDED) AND ALLOW AREA TO NATURALIZE
 MORNING 5' HATCHED AREAS SHALL BE LIMITED TO ONCE PER YEAR
 BETWEEN NOVEMBER AND MARCH



Revision No.	Revision Description	Date
1	RESPONSE TO REE REVIEW AND TOWN DEPT. COMMENTS	MAY 18, 2022

**DEFINITIVE SUBDIVISION
 DRAINAGE DIVIDES—DEVELOPED**
 WILLIAM WOOD WAY
 ANDOVER, MASSACHUSETTS

PREPARED FOR: STEVEN LEED
 DATE: FEBRUARY 1, 2022
 SCALE: 1"=30'

andover consultants
 1 East River Pl.
 Methuen, Mass. 01844
 Telephone: 978-687-3828

0 30 60 90 120 Ft.
 0 8 16 32 Meter

Regulatory Compliance

Massachusetts Department of Environmental Protection (DEP) - Stormwater Management Standards

As demonstrated below, the proposed Project fully complies with the DEP Stormwater Management Standards and the Town of Andover's Rules and Regulations for Stormwater Design.

Standard 1: No New Untreated Discharges or Erosion to Wetlands

The Project has been designed to fully comply with Standard 1.

The Best Management Practices (BMPs) included in the proposed stormwater management system have been designed in accordance with the Massachusetts Stormwater Handbook. Supporting information and computations demonstrating that no new untreated discharges will result from the Project are presented through compliance with Standards 4 through 6.

Standard 2: Peak Rate Attenuation

The Project has been designed to comply with Standard 2.

The rainfall-runoff response of the Site under existing and proposed conditions was analyzed for storm events with recurrence intervals of 2, 10, 25, and 100-years. The results of the analysis, as summarized in the table below, indicate that there is no increase in peak discharge rates between the existing and proposed conditions for all storm events except for the 2 year event at point 2. This storm results in a very small increase rate of 0.2 cfs, and more importantly, a very small increase in runoff volume of just 59 cubic feet, which is minimal.

HydroCAD hydrologic modeling result printouts are attached at the end of this report.

Peak Discharge Rates (cfs*)

<i>Design Point</i>	<i>2-year</i>	<i>10-year</i>	<i>25-year</i>	<i>100-year</i>
Design Point 1: west property line				
Existing	0.0	0.2	0.4	1.1
Proposed	0.0	0.2	0.4	0.9

<i>Design Point</i>	<i>2-year</i>	<i>10-year</i>	<i>25-year</i>	<i>100-year</i>
Design Point 2: Wetland series "B"				
Existing	0.0	0.5	1.5	3.8
Proposed	0.0	0.2	1.5	3.5
<i>Design Point</i>	<i>2-year</i>	<i>10-year</i>	<i>25-year</i>	<i>100-year</i>
Design Point 4: To William St				
Existing	0.0	0.0	0.0	0.0
Proposed	0.0	0.1	0.1	0.2

Standard 3: Stormwater Recharge

The Project has been designed to comply with Standard 3.

In accordance with the Town of Andover Stormwater Management Regulations, and as calculated below, the Required Recharge Volume for the Project is 1,816.4 cubic feet.

$$Re_v = [(R_v) (A)]/12, \text{ where}$$

Re_v = required recharge volume

R_v = depth per soil type = 0.6 ft. for HSG A soil

A = total impervious area = 37,184 s.f. (includes offsite #24 roof area and driveway (3,325 sf), and portion to William St. (763 sf))

$$Re_v = [(0.6/12)*(37,184)]$$

$$Re_v = 1,859.2 \text{ c.f.}$$

Note: total impervious area not captured = 3,325 + 763 = 4,088 s.f. (unconnected roof and walk on lot 2 and area to William St)

Impervious area captured 37,184 - 4,088 = 33,096 sf and tributary to subsurface infiltration chamber

$$33,096/37,184 = 0.89 \text{ (89\% captured > 65\%, OK)}$$

$$\text{Area scale factor} = (1/0.89) = 1.124$$

$$R_v = 1.124 \times 1,859.2 \text{ cf} = 2,089.7 \text{ c.f.}$$

Volume below lowest invert out @ elevation 65.5 = 3,185 c.f. > 2,089.7 c.f., OK

Recharge of stormwater has been provided through the use of the subsurface infiltration structure and should drain completely within 72 hours per the following calculation using the static method and the provided recharge volume.

Where:

$$\text{Time}_{\text{Drawdown}} = R_v / (K) \text{ (Bottom Area)}$$

$$Re_v = 3,185 \text{ c.f.}$$

$$K = 2.41 \text{ in/hr for HSG A loamy sand}$$

Bottom Area = 4,914 s.f.

Time Drawdown = 3,185 c.f. / ((2.41 in/hr) (1'/12") (4,914 sf))
Time Drawdown = 3.2 hours < 72 hours, OK

Soil test pit data, recharge mounding evaluation and supporting information are included at the end of this report.

Standard 4: Water Quality

The Project has been designed to fully comply with Standard 4.

The proposed stormwater management system implements a treatment train of BMPs that has been designed to provide a minimum 80% TSS removal of stormwater runoff from all proposed impervious surfaces.

The required water quality volume required based on the total impervious area is calculated below:

$$V_{WQ} = (D_{WQ}/12''/\text{foot}) \times (A_{IMP})$$

Where:

V_{WQ} = Require Water Quality Volume (cf)

D_{WQ} = Water Quality Depth = 1" per Andover regulation

A_{IMP} = Total Impervious Area = 37,184 s.f.

$$V_{WQ} = (1'') \times (1'/12'') \times (37,184 \text{ s.f.})$$

$$V_{WQ} = 3,098.7 \text{ c.f.}$$

Invert out of chamber = 65.5

Storage provided below elevation 65.5 = 3,185c.f > 3,098.7, OK

TSS removal treatment:

Catch basin sumps = 25% TSS

Subsurface Chamber (infiltration) = 80% TSS

Treatment Device (Stormceptor® 900 water quality unit) is rated for 50% TSS removal by NJCAT)

Calculate WQF:

Water Quality Flow Rate:

$$WQF = Q_u \times A \times WQV$$

Where: $Q_u = 774 \text{ csm/in.}$, for $T_c = 0.1 \text{ hr}$

Paved area direct (roadway, sidewalks and driveways) (neglecting unconnected) = 23,253 + 1,874 (offsite #24 drive) = 25,127 s.f. = 0.0009 sm

$WQV = 1''$ (per by-law)

$$WQF = 774 \text{ csm/in.} \times 0.0009 \text{ sm} \times 1 \text{ in.} = 0.69 \text{ cfs}$$

Without #24 drive (partially unconnected), $Q_u = 23,253 / (5,280^2) = 0.00083 \text{ sm}$

$$WQF = 774 \times 0.00083 = 0.65$$

WQF for STC 900 is rated for 0.64 cfs, close enough, use 50% removal rate

TSS removal:

Total impervious area tributary (direct and unconnected) to drains and subsurface chamber (DEV2) = 34,946 s.f.
Uncaptured area = 1,475 s.f. (DEV 3)
Uncaptured area = 763 s.f. (DEV4)

TSS removal for paved roadway, drives and sidewalks tributary to the site drains and subsurface chambers:

TSS removal rate:
25% deep sump
50% Stormceptor
80% subsurface chamber
45% vegetated strip > 50 feet

Removal rate for area to Stormceptor = $((0.25 + 0.50(0.75) + 0.80(0.375)) = 0.925$, say 92.5%, a TSS calculation sheet is included at the end of this report.

Approx. weighted removal
Total impervious = 37,184 s.f. - 763 s.f. (to William St. drains per Town Engineer) = 36,421 s.f.
 $((0.925) \times 34,946 + (0.45) \times 1,475) / 36,421 = 32,988.8 / 36,421 = 0.905$ (90%)

Per the Town of Andover's Stormwater Management Regulations, the annual sediment volume load is calculated as:

Paved area to be sanded $\times 750$ lbs./acre storm $\div 90$ lbs./ft³ $\times 10$ storms/year = c.f. of sediment
Paved area = 25,064 s.f. = 0.575 acres

Volume = 0.575 acres $\times 750$ lbs. /acre storm $\div 90$ lbs. /ft³ $\times 10$ storms/year = 47.9 c.f. of sediment
Stormwater will pass through an oil & grit structure (Stormceptor 900) and will intercept this volume.

Phosphorus removal:

Based upon the "Stormwater Best Management Practices (BMP) Performance Analysis" document, dated March 2010, and prepared for EPA-Region 1 the subsurface structure removes 98% of TP exceeding the required removal per the Andover Stormwater Regulation.

Excerpts from the report noted above for infiltration basins and infiltration trenches are attached at the end of this report.

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

The Project is not considered a LUHPPL.

Standard 6: Critical Areas

The Project will not discharge stormwater near or to a critical area.

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the Maximum Extent Practicable

Although some of the property has been previously developed, this project is not considered a redevelopment.

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

The Project will disturb approximately 2.3± acres of land and is therefore required to obtain coverage under the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Construction General Permit. As required under this permit, a Stormwater Pollution Prevention Plan (SWPPP) will be developed and submitted before land disturbance begins.

A recommended construction period pollution prevention and erosion and sedimentation controls to be finalized in the SWPPP are included at the end of this report.

Standard 9: Operation and Maintenance Plan

In compliance with Standard 9, a Post Construction Stormwater Operation and Maintenance (O&M) Plan has been developed for the Project. The O&M Plan is included at the end of this report as part of the Long Term Pollution Prevention Plan.

Standard 10: Prohibition of Illicit Discharges

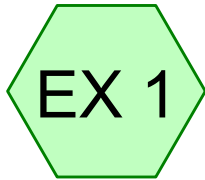
The site has a number of existing sewer and drainage infrastructure running through the site in existing easements, but there are no known illicit discharges generated by the property owner. No illicit discharges are proposed. Prior to land disturbance, an illicit discharge statement will be provided, if requested.

Appendix - Standard 2

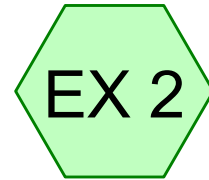
Supporting Information

Rainfall volumes used for this analysis were based on the Natural Resources Conservation Service (NRCS) Type III, 24-hour storm event for Andover, Massachusetts. Runoff coefficients for the existing and proposed conditions were determined using NRCS Technical Release 55 (TR-55) methodology as provided in HydroCAD. The HydroCAD model is based on the NRCS Technical Release 20 (TR-20) Model for Project Formulation Hydrology.

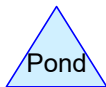
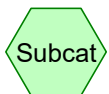
HydroCAD Analysis: Existing Conditions



Existing Area 1



Existing Area 2



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Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
11,790	76	Gravel roads, HSG A (EX 2)
10,066	98	Paved, HSG A (EX 2)
7,130	98	Tennis court, HSG A (EX 1, EX 2)
261	98	Unconnected patio, #24 offsite, HSG A (EX 1)
242	98	Unconnected roofs, #24 offsite, HSG A (EX 1)
8,285	98	Unconnected roofs, HSG A (EX 2)
107,658	32	Woods/grass comb., Good, HSG A (EX 1, EX 2)
145,432	47	TOTAL AREA

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Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
145,432	HSG A	EX 1, EX 2
0	HSG B	
0	HSG C	
0	HSG D	
0	Other	
145,432		TOTAL AREA

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Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover
11,790	0	0	0	0	11,790	Gravel roads
10,066	0	0	0	0	10,066	Paved
7,130	0	0	0	0	7,130	Tennis court
261	0	0	0	0	261	Unconnected patio, #24 offsite
8,285	0	0	0	0	8,285	Unconnected roofs
242	0	0	0	0	242	Unconnected roofs, #24 offsite
107,658	0	0	0	0	107,658	Woods/grass comb., Good
145,432	0	0	0	0	145,432	TOTAL AREA

21-31 William Wood Way-existing

Type III 24-hr 2-Year Rainfall=3.13"

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Time span=0.00-36.00 hrs, dt=0.02 hrs, 1801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment EX 1: Existing Area 1 Runoff Area=29,361 sf 22.04% Impervious Runoff Depth=0.05"
Flow Length=85' Tc=8.2 min UI Adjusted CN=46 Runoff=0.0 cfs 120 cf

Subcatchment EX 2: Existing Area 2 Runoff Area=116,071 sf 16.81% Impervious Runoff Depth=0.04"
Flow Length=424' Tc=9.2 min UI Adjusted CN=45 Runoff=0.0 cfs 352 cf

Total Runoff Area = 145,432 sf Runoff Volume = 472 cf Average Runoff Depth = 0.04"
82.13% Pervious = 119,448 sf 17.87% Impervious = 25,984 sf

21-31 William Wood Way-existing

Type III 24-hr 2-Year Rainfall=3.13"

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Summary for Subcatchment EX 1: Existing Area 1

Runoff = 0.0 cfs @ 15.24 hrs, Volume= 120 cf, Depth= 0.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.13"

Area (sf)	CN	Adj	Description
* 5,969	98		Tennis court, HSG A
* 242	98		Unconnected roofs, #24 offsite, HSG A
* 261	98		Unconnected patio, #24 offsite, HSG A
22,889	32		Woods/grass comb., Good, HSG A
29,361	47	46	Weighted Average, UI Adjusted
22,889			77.96% Pervious Area
6,472			22.04% Impervious Area
503			7.77% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0220	0.10		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.2	35	0.0450	3.42		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
8.2	85	Total			

Summary for Subcatchment EX 2: Existing Area 2

Runoff = 0.0 cfs @ 15.58 hrs, Volume= 352 cf, Depth= 0.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.13"

Area (sf)	CN	Adj	Description
* 1,161	98		Tennis court, HSG A
11,790	76		Gravel roads, HSG A
* 10,066	98		Paved, HSG A
8,285	98		Unconnected roofs, HSG A
84,769	32		Woods/grass comb., Good, HSG A
116,071	48	45	Weighted Average, UI Adjusted
96,559			83.19% Pervious Area
19,512			16.81% Impervious Area
8,285			42.46% Unconnected

21-31 William Wood Way-existing

Type III 24-hr 2-Year Rainfall=3.13"

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Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.7	50	0.0240	0.11		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.7	104	0.0130	2.31		Shallow Concentrated Flow, Paved Kv= 20.3 fps
0.3	60	0.0500	3.60		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.4	112	0.0540	4.72		Shallow Concentrated Flow, Paved Kv= 20.3 fps
0.1	98	0.0550	11.53	9.05	Pipe Channel, 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012
9.2	424	Total			

21-31 William Wood Way-existing

Type III 24-hr 10-Year Rainfall=4.97"

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Time span=0.00-36.00 hrs, dt=0.02 hrs, 1801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment EX 1: Existing Area 1 Runoff Area=29,361 sf 22.04% Impervious Runoff Depth=0.48"
Flow Length=85' Tc=8.2 min UI Adjusted CN=46 Runoff=0.2 cfs 1,171 cf

Subcatchment EX 2: Existing Area 2 Runoff Area=116,071 sf 16.81% Impervious Runoff Depth=0.43"
Flow Length=424' Tc=9.2 min UI Adjusted CN=45 Runoff=0.5 cfs 4,183 cf

Total Runoff Area = 145,432 sf Runoff Volume = 5,355 cf Average Runoff Depth = 0.44"
82.13% Pervious = 119,448 sf 17.87% Impervious = 25,984 sf

21-31 William Wood Way-existing

Type III 24-hr 10-Year Rainfall=4.97"

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Summary for Subcatchment EX 1: Existing Area 1

Runoff = 0.2 cfs @ 12.32 hrs, Volume= 1,171 cf, Depth= 0.48"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.97"

Area (sf)	CN	Adj	Description
* 5,969	98		Tennis court, HSG A
* 242	98		Unconnected roofs, #24 offsite, HSG A
* 261	98		Unconnected patio, #24 offsite, HSG A
22,889	32		Woods/grass comb., Good, HSG A
29,361	47	46	Weighted Average, UI Adjusted
22,889			77.96% Pervious Area
6,472			22.04% Impervious Area
503			7.77% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0220	0.10		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.2	35	0.0450	3.42		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
8.2	85	Total			

Summary for Subcatchment EX 2: Existing Area 2

Runoff = 0.5 cfs @ 12.36 hrs, Volume= 4,183 cf, Depth= 0.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.97"

Area (sf)	CN	Adj	Description
* 1,161	98		Tennis court, HSG A
11,790	76		Gravel roads, HSG A
* 10,066	98		Paved, HSG A
8,285	98		Unconnected roofs, HSG A
84,769	32		Woods/grass comb., Good, HSG A
116,071	48	45	Weighted Average, UI Adjusted
96,559			83.19% Pervious Area
19,512			16.81% Impervious Area
8,285			42.46% Unconnected

21-31 William Wood Way-existing

Type III 24-hr 10-Year Rainfall=4.97"

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Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.7	50	0.0240	0.11		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.7	104	0.0130	2.31		Shallow Concentrated Flow, Paved Kv= 20.3 fps
0.3	60	0.0500	3.60		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.4	112	0.0540	4.72		Shallow Concentrated Flow, Paved Kv= 20.3 fps
0.1	98	0.0550	11.53	9.05	Pipe Channel, 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012
9.2	424	Total			

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Type III 24-hr 25-Year Rainfall=6.11"

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Time span=0.00-36.00 hrs, dt=0.02 hrs, 1801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment EX 1: Existing Area 1 Runoff Area=29,361 sf 22.04% Impervious Runoff Depth=0.91"
Flow Length=85' Tc=8.2 min UI Adjusted CN=46 Runoff=0.4 cfs 2,234 cf

Subcatchment EX 2: Existing Area 2 Runoff Area=116,071 sf 16.81% Impervious Runoff Depth=0.85"
Flow Length=424' Tc=9.2 min UI Adjusted CN=45 Runoff=1.5 cfs 8,180 cf

Total Runoff Area = 145,432 sf Runoff Volume = 10,414 cf Average Runoff Depth = 0.86"
82.13% Pervious = 119,448 sf 17.87% Impervious = 25,984 sf

21-31 William Wood Way-existing

Type III 24-hr 25-Year Rainfall=6.11"

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Summary for Subcatchment EX 1: Existing Area 1

Runoff = 0.4 cfs @ 12.15 hrs, Volume= 2,234 cf, Depth= 0.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Adj	Description
* 5,969	98		Tennis court, HSG A
* 242	98		Unconnected roofs, #24 offsite, HSG A
* 261	98		Unconnected patio, #24 offsite, HSG A
22,889	32		Woods/grass comb., Good, HSG A
29,361	47	46	Weighted Average, UI Adjusted
22,889			77.96% Pervious Area
6,472			22.04% Impervious Area
503			7.77% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0220	0.10		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.2	35	0.0450	3.42		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
8.2	85	Total			

Summary for Subcatchment EX 2: Existing Area 2

Runoff = 1.5 cfs @ 12.18 hrs, Volume= 8,180 cf, Depth= 0.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Adj	Description
* 1,161	98		Tennis court, HSG A
11,790	76		Gravel roads, HSG A
* 10,066	98		Paved, HSG A
8,285	98		Unconnected roofs, HSG A
84,769	32		Woods/grass comb., Good, HSG A
116,071	48	45	Weighted Average, UI Adjusted
96,559			83.19% Pervious Area
19,512			16.81% Impervious Area
8,285			42.46% Unconnected

21-31 William Wood Way-existing

Type III 24-hr 25-Year Rainfall=6.11"

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Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.7	50	0.0240	0.11		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.7	104	0.0130	2.31		Shallow Concentrated Flow, Paved Kv= 20.3 fps
0.3	60	0.0500	3.60		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.4	112	0.0540	4.72		Shallow Concentrated Flow, Paved Kv= 20.3 fps
0.1	98	0.0550	11.53	9.05	Pipe Channel, 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012
9.2	424	Total			

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Type III 24-hr 100-Year Rainfall=7.87"

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Time span=0.00-36.00 hrs, dt=0.02 hrs, 1801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment EX 1: Existing Area 1 Runoff Area=29,361 sf 22.04% Impervious Runoff Depth=1.77"
Flow Length=85' Tc=8.2 min UI Adjusted CN=46 Runoff=1.1 cfs 4,323 cf

Subcatchment EX 2: Existing Area 2 Runoff Area=116,071 sf 16.81% Impervious Runoff Depth=1.67"
Flow Length=424' Tc=9.2 min UI Adjusted CN=45 Runoff=3.8 cfs 16,134 cf

Total Runoff Area = 145,432 sf Runoff Volume = 20,456 cf Average Runoff Depth = 1.69"
82.13% Pervious = 119,448 sf 17.87% Impervious = 25,984 sf

21-31 William Wood Way-existing

Type III 24-hr 100-Year Rainfall=7.87"

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Summary for Subcatchment EX 1: Existing Area 1

Runoff = 1.1 cfs @ 12.13 hrs, Volume= 4,323 cf, Depth= 1.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.87"

Area (sf)	CN	Adj	Description
* 5,969	98		Tennis court, HSG A
* 242	98		Unconnected roofs, #24 offsite, HSG A
* 261	98		Unconnected patio, #24 offsite, HSG A
22,889	32		Woods/grass comb., Good, HSG A
29,361	47	46	Weighted Average, UI Adjusted
22,889			77.96% Pervious Area
6,472			22.04% Impervious Area
503			7.77% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0220	0.10		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.2	35	0.0450	3.42		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
8.2	85	Total			

Summary for Subcatchment EX 2: Existing Area 2

Runoff = 3.8 cfs @ 12.15 hrs, Volume= 16,134 cf, Depth= 1.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.87"

Area (sf)	CN	Adj	Description
* 1,161	98		Tennis court, HSG A
11,790	76		Gravel roads, HSG A
* 10,066	98		Paved, HSG A
8,285	98		Unconnected roofs, HSG A
84,769	32		Woods/grass comb., Good, HSG A
116,071	48	45	Weighted Average, UI Adjusted
96,559			83.19% Pervious Area
19,512			16.81% Impervious Area
8,285			42.46% Unconnected

21-31 William Wood Way-existing

Type III 24-hr 100-Year Rainfall=7.87"

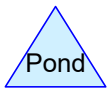
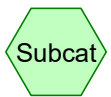
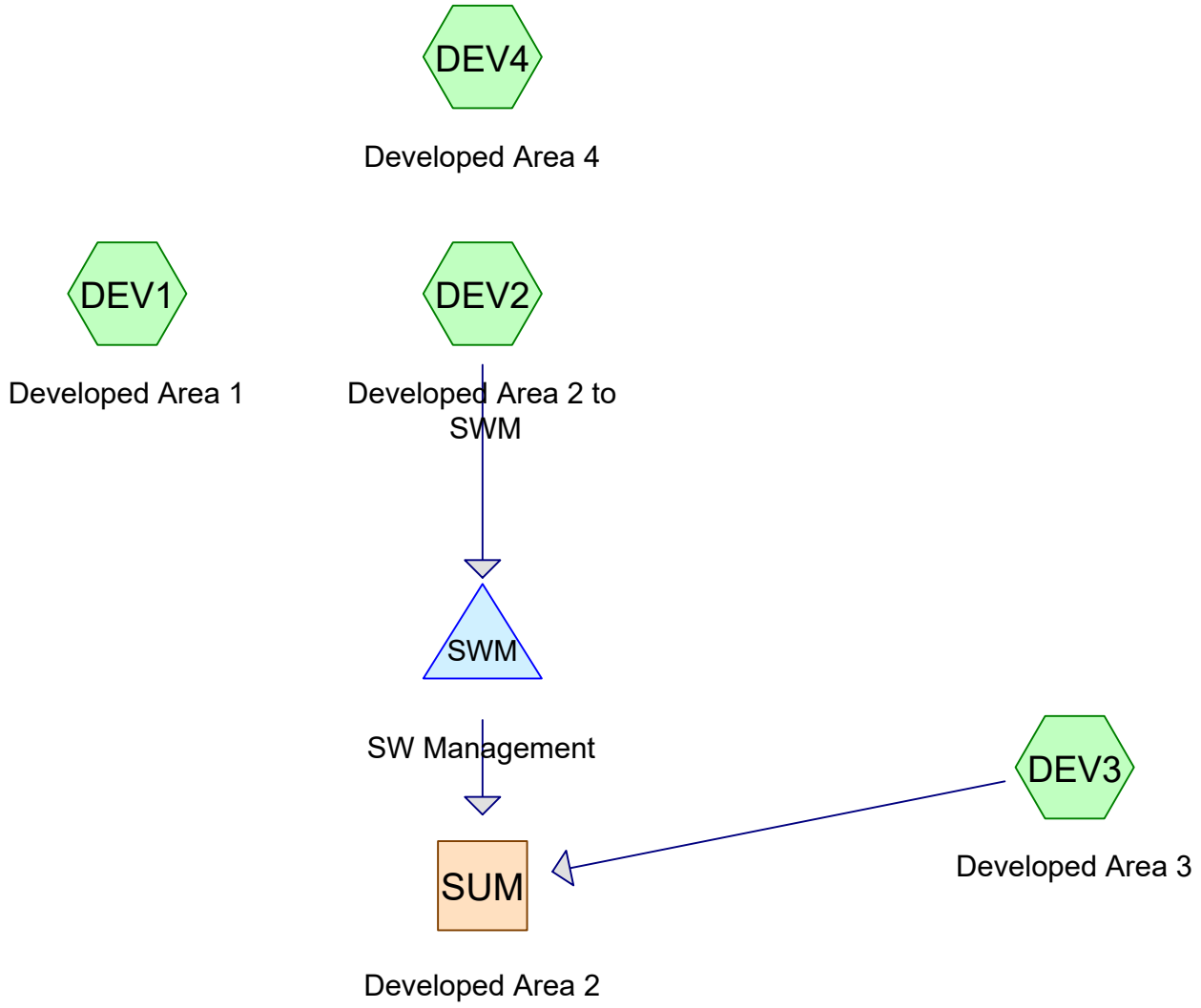
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Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.7	50	0.0240	0.11		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.7	104	0.0130	2.31		Shallow Concentrated Flow, Paved Kv= 20.3 fps
0.3	60	0.0500	3.60		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.4	112	0.0540	4.72		Shallow Concentrated Flow, Paved Kv= 20.3 fps
0.1	98	0.0550	11.53	9.05	Pipe Channel, 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012
9.2	424	Total			

HydroCAD Analysis: Proposed Conditions



Routing Diagram for 21-31 William Wood Way-developed-Chambers

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Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
80,943	68	>75% Grass cover, Good, HSG A (DEV1, DEV2, DEV3)
898	39	>75% Grass cover, Good, HSG A (DEV4)
26,407	30	Meadow, non-grazed, HSG A (DEV1, DEV3)
1,874	98	Paved parking, #24 offsite, HSG A (DEV2)
23,253	98	Paved, HSG A (DEV2, DEV4)
1,451	98	Unconnected roofs, #24 offsite, HSG A (DEV2)
10,236	98	Unconnected roofs, HSG A (DEV2, DEV3)
370	98	Unconnected walk, HSG A (DEV3)
145,432	69	TOTAL AREA

21-31 William Wood Way-developed-Chambers

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Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
145,432	HSG A	DEV1, DEV2, DEV3, DEV4
0	HSG B	
0	HSG C	
0	HSG D	
0	Other	
145,432		TOTAL AREA

21-31 William Wood Way-developed-Chambers

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Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover
81,841	0	0	0	0	81,841	>75% Grass cover, Good
26,407	0	0	0	0	26,407	Meadow, non-grazed
23,253	0	0	0	0	23,253	Paved
1,874	0	0	0	0	1,874	Paved parking, #24 offsite
10,236	0	0	0	0	10,236	Unconnected roofs
1,451	0	0	0	0	1,451	Unconnected roofs, #24 offsite
370	0	0	0	0	370	Unconnected walk
145,432	0	0	0	0	145,432	TOTAL AREA

21-31 William Wood Way-developed-Chambers

Type III 24-hr 2-Year Rainfall=3.13"

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Time span=0.00-36.00 hrs, dt=0.01 hrs, 3601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DEV1: Developed Area 1 Runoff Area=15,830 sf 0.00% Impervious Runoff Depth=0.16"
Flow Length=85' Tc=8.2 min CN=52 Runoff=0.0 cfs 207 cf

Subcatchment DEV2: Developed Area 2 to Runoff Area=95,455 sf 36.61% Impervious Runoff Depth=1.28"
Flow Length=420' Tc=7.8 min CN=79 Runoff=3.0 cfs 10,217 cf

Subcatchment DEV3: Developed Area 3 Runoff Area=32,486 sf 4.54% Impervious Runoff Depth=0.04"
Tc=6.0 min UI Adjusted CN=45 Runoff=0.0 cfs 99 cf

Subcatchment DEV4: Developed Area 4 Runoff Area=1,661 sf 45.94% Impervious Runoff Depth=0.61"
Tc=6.0 min CN=66 Runoff=0.0 cfs 84 cf

Reach SUM: Developed Area 2 Inflow=0.0 cfs 207 cf
Outflow=0.0 cfs 207 cf

Pond SWM: SW Management Peak Elev=65.64' Storage=3,809 cf Inflow=3.0 cfs 10,217 cf
Discarded=0.4 cfs 13,300 cf Primary=0.0 cfs 108 cf Outflow=0.4 cfs 13,408 cf

Total Runoff Area = 145,432 sf Runoff Volume = 10,606 cf Average Runoff Depth = 0.88"
74.43% Pervious = 108,248 sf 25.57% Impervious = 37,184 sf

Summary for Subcatchment DEV1: Developed Area 1

Runoff = 0.0 cfs @ 12.46 hrs, Volume= 207 cf, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.13"

Area (sf)	CN	Description
* 9,356	68	>75% Grass cover, Good, HSG A
* 6,474	30	Meadow, non-grazed, HSG A
15,830	52	Weighted Average
15,830		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0220	0.10		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.2	35	0.0450	3.42		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
8.2	85	Total			

Summary for Subcatchment DEV2: Developed Area 2 to SWM

Runoff = 3.0 cfs @ 12.12 hrs, Volume= 10,217 cf, Depth= 1.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.13"

Area (sf)	CN	Description
* 22,490	98	Paved, HSG A
* 1,874	98	Paved parking, #24 offsite, HSG A
9,131	98	Unconnected roofs, HSG A
* 1,451	98	Unconnected roofs, #24 offsite, HSG A
* 60,509	68	>75% Grass cover, Good, HSG A
95,455	79	Weighted Average
60,509		63.39% Pervious Area
34,946		36.61% Impervious Area
10,582		30.28% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	50	0.0280	0.17		Sheet Flow, Grass: Short n= 0.150 P2= 3.10"
0.2	41	0.0800	4.55		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.3	266	0.0160	1.90		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.3	63	0.0060	3.81	2.99	Pipe Channel, 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012

7.8 420 Total

Summary for Subcatchment DEV3: Developed Area 3

Runoff = 0.0 cfs @ 15.54 hrs, Volume= 99 cf, Depth= 0.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.13"

Area (sf)	CN	Adj	Description
1,105	98		Unconnected roofs, HSG A
* 370	98		Unconnected walk, HSG A
* 19,933	30		Meadow, non-grazed, HSG A
* 11,078	68		>75% Grass cover, Good, HSG A
32,486	46	45	Weighted Average, UI Adjusted
31,011			95.46% Pervious Area
1,475			4.54% Impervious Area
1,475			100.00% Unconnected

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

Summary for Subcatchment DEV4: Developed Area 4

Runoff = 0.0 cfs @ 12.11 hrs, Volume= 84 cf, Depth= 0.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.13"

Area (sf)	CN	Description
* 763	98	Paved, HSG A
898	39	>75% Grass cover, Good, HSG A
1,661	66	Weighted Average
898		54.06% Pervious Area
763		45.94% Impervious Area

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

Summary for Reach SUM: Developed Area 2

Inflow Area = 127,941 sf, 28.47% Impervious, Inflow Depth = 0.02" for 2-Year event
Inflow = 0.0 cfs @ 12.98 hrs, Volume= 207 cf
Outflow = 0.0 cfs @ 12.98 hrs, Volume= 207 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs

Summary for Pond SWM: SW Management

Inflow Area = 95,455 sf, 36.61% Impervious, Inflow Depth = 1.28" for 2-Year event
 Inflow = 3.0 cfs @ 12.12 hrs, Volume= 10,217 cf
 Outflow = 0.4 cfs @ 12.98 hrs, Volume= 13,408 cf, Atten= 87%, Lag= 51.9 min
 Discarded = 0.4 cfs @ 12.98 hrs, Volume= 13,300 cf
 Primary = 0.0 cfs @ 12.98 hrs, Volume= 108 cf

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 3
 Starting Elev= 65.50' Surf.Area= 4,550 sf Storage= 3,185 cf
 Peak Elev= 65.64' @ 12.98 hrs Surf.Area= 4,550 sf Storage= 3,809 cf (624 cf above start)
 Flood Elev= 68.80' Surf.Area= 4,550 sf Storage= 18,200 cf (15,015 cf above start)

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

Volume	Invert	Avail.Storage	Storage Description
#1	64.80'	18,200 cf	7.00'W x 13.00'L x 4.00'H Prismaoid x 50

Device	Routing	Invert	Outlet Devices
#1	Primary	64.50'	15.0" Round Culvert Outlet L= 30.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 64.50' / 64.25' S= 0.0083 '/ Cc= 0.900 n= 0.020 Corrugated PE, corrugated interior, Flow Area= 1.23 sf
#2	Discarded	64.80'	2.410 in/hr Exfiltration over Horizontal area Conductivity to Groundwater Elevation = 62.80' Phase-In= 0.01'
#3	Device 1	65.50'	2.0" W x 1.0" H Vert. Orifice/Grate C= 0.600
#4	Device 1	67.10'	18.0" W x 4.0" H Vert. Orifice/Grate C= 0.600
#5	Device 1	68.30'	2.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) 0.5' Crest Height

Discarded OutFlow Max=0.4 cfs @ 12.98 hrs HW=65.64' (Free Discharge)
 ↑**2=Exfiltration** (Controls 0.4 cfs)

Primary OutFlow Max=0.0 cfs @ 12.98 hrs HW=65.64' (Free Discharge)
 ↑**1=Culvert Outlet** (Passes 0.0 cfs of 3.1 cfs potential flow)
 |
 |**3=Orifice/Grate** (Orifice Controls 0.0 cfs @ 1.48 fps)
 |
 |**4=Orifice/Grate** (Controls 0.0 cfs)
 |
 |**5=Sharp-Crested Rectangular Weir** (Controls 0.0 cfs)

21-31 William Wood Way-developed-Chambers

Type III 24-hr 10-Year Rainfall=4.97"

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Time span=0.00-36.00 hrs, dt=0.01 hrs, 3601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DEV1: Developed Area 1 Runoff Area=15,830 sf 0.00% Impervious Runoff Depth=0.79"
Flow Length=85' Tc=8.2 min CN=52 Runoff=0.2 cfs 1,042 cf

Subcatchment DEV2: Developed Area 2 to Runoff Area=95,455 sf 36.61% Impervious Runoff Depth=2.78"
Flow Length=420' Tc=7.8 min CN=79 Runoff=6.7 cfs 22,081 cf

Subcatchment DEV3: Developed Area 3 Runoff Area=32,486 sf 4.54% Impervious Runoff Depth=0.43"
Tc=6.0 min UI Adjusted CN=45 Runoff=0.1 cfs 1,171 cf

Subcatchment DEV4: Developed Area 4 Runoff Area=1,661 sf 45.94% Impervious Runoff Depth=1.71"
Tc=6.0 min CN=66 Runoff=0.1 cfs 236 cf

Reach SUM: Developed Area 2 Inflow=0.2 cfs 2,916 cf
Outflow=0.2 cfs 2,916 cf

Pond SWM: SW Management Peak Elev=66.96' Storage=9,807 cf Inflow=6.7 cfs 22,081 cf
Discarded=0.5 cfs 23,527 cf Primary=0.1 cfs 1,745 cf Outflow=0.6 cfs 25,272 cf

Total Runoff Area = 145,432 sf Runoff Volume = 24,530 cf Average Runoff Depth = 2.02"
74.43% Pervious = 108,248 sf 25.57% Impervious = 37,184 sf

Summary for Subcatchment DEV1: Developed Area 1

Runoff = 0.2 cfs @ 12.15 hrs, Volume= 1,042 cf, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.97"

Area (sf)	CN	Description
* 9,356	68	>75% Grass cover, Good, HSG A
* 6,474	30	Meadow, non-grazed, HSG A
15,830	52	Weighted Average
15,830		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0220	0.10		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.2	35	0.0450	3.42		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
8.2	85				Total

Summary for Subcatchment DEV2: Developed Area 2 to SWM

Runoff = 6.7 cfs @ 12.11 hrs, Volume= 22,081 cf, Depth= 2.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.97"

Area (sf)	CN	Description
* 22,490	98	Paved, HSG A
* 1,874	98	Paved parking, #24 offsite, HSG A
9,131	98	Unconnected roofs, HSG A
* 1,451	98	Unconnected roofs, #24 offsite, HSG A
* 60,509	68	>75% Grass cover, Good, HSG A
95,455	79	Weighted Average
60,509		63.39% Pervious Area
34,946		36.61% Impervious Area
10,582		30.28% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	50	0.0280	0.17		Sheet Flow, Grass: Short n= 0.150 P2= 3.10"
0.2	41	0.0800	4.55		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.3	266	0.0160	1.90		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.3	63	0.0060	3.81	2.99	Pipe Channel, 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012

7.8 420 Total

Summary for Subcatchment DEV3: Developed Area 3

Runoff = 0.1 cfs @ 12.31 hrs, Volume= 1,171 cf, Depth= 0.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.97"

Area (sf)	CN	Adj	Description
1,105	98		Unconnected roofs, HSG A
* 370	98		Unconnected walk, HSG A
* 19,933	30		Meadow, non-grazed, HSG A
* 11,078	68		>75% Grass cover, Good, HSG A
32,486	46	45	Weighted Average, UI Adjusted
31,011			95.46% Pervious Area
1,475			4.54% Impervious Area
1,475			100.00% Unconnected

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

Summary for Subcatchment DEV4: Developed Area 4

Runoff = 0.1 cfs @ 12.09 hrs, Volume= 236 cf, Depth= 1.71"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.97"

Area (sf)	CN	Description
* 763	98	Paved, HSG A
898	39	>75% Grass cover, Good, HSG A
1,661	66	Weighted Average
898		54.06% Pervious Area
763		45.94% Impervious Area

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

Summary for Reach SUM: Developed Area 2

Inflow Area = 127,941 sf, 28.47% Impervious, Inflow Depth = 0.27" for 10-Year event
 Inflow = 0.2 cfs @ 12.34 hrs, Volume= 2,916 cf
 Outflow = 0.2 cfs @ 12.34 hrs, Volume= 2,916 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs

Summary for Pond SWM: SW Management

Inflow Area = 95,455 sf, 36.61% Impervious, Inflow Depth = 2.78" for 10-Year event
 Inflow = 6.7 cfs @ 12.11 hrs, Volume= 22,081 cf
 Outflow = 0.6 cfs @ 13.28 hrs, Volume= 25,272 cf, Atten= 91%, Lag= 69.9 min
 Discarded = 0.5 cfs @ 13.28 hrs, Volume= 23,527 cf
 Primary = 0.1 cfs @ 13.28 hrs, Volume= 1,745 cf

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 3
 Starting Elev= 65.50' Surf.Area= 4,550 sf Storage= 3,185 cf
 Peak Elev= 66.96' @ 13.28 hrs Surf.Area= 4,550 sf Storage= 9,807 cf (6,622 cf above start)
 Flood Elev= 68.80' Surf.Area= 4,550 sf Storage= 18,200 cf (15,015 cf above start)

Plug-Flow detention time= (not calculated: outflow precedes inflow)
 Center-of-Mass det. time= 69.3 min (895.7 - 826.4)

Volume	Invert	Avail.Storage	Storage Description
#1	64.80'	18,200 cf	7.00'W x 13.00'L x 4.00'H Prismaoid x 50

Device	Routing	Invert	Outlet Devices
#1	Primary	64.50'	15.0" Round Culvert Outlet L= 30.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 64.50' / 64.25' S= 0.0083 '/ Cc= 0.900 n= 0.020 Corrugated PE, corrugated interior, Flow Area= 1.23 sf
#2	Discarded	64.80'	2.410 in/hr Exfiltration over Horizontal area Conductivity to Groundwater Elevation = 62.80' Phase-In= 0.01'
#3	Device 1	65.50'	2.0" W x 1.0" H Vert. Orifice/Grate C= 0.600
#4	Device 1	67.10'	18.0" W x 4.0" H Vert. Orifice/Grate C= 0.600
#5	Device 1	68.30'	2.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) 0.5' Crest Height

Discarded OutFlow Max=0.5 cfs @ 13.28 hrs HW=66.96' (Free Discharge)
 ↑**2=Exfiltration** (Controls 0.5 cfs)

Primary OutFlow Max=0.1 cfs @ 13.28 hrs HW=66.96' (Free Discharge)
 ↑**1=Culvert Outlet** (Passes 0.1 cfs of 6.7 cfs potential flow)
 ↑**3=Orifice/Grate** (Orifice Controls 0.1 cfs @ 5.72 fps)
 ↑**4=Orifice/Grate** (Controls 0.0 cfs)
 ↑**5=Sharp-Crested Rectangular Weir** (Controls 0.0 cfs)

21-31 William Wood Way-developed-Chambers

Type III 24-hr 25-Year Rainfall=6.11"

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Time span=0.00-36.00 hrs, dt=0.01 hrs, 3601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DEV1: Developed Area 1 Runoff Area=15,830 sf 0.00% Impervious Runoff Depth=1.35"
Flow Length=85' Tc=8.2 min CN=52 Runoff=0.4 cfs 1,777 cf

Subcatchment DEV2: Developed Area 2 to Runoff Area=95,455 sf 36.61% Impervious Runoff Depth=3.78"
Flow Length=420' Tc=7.8 min CN=79 Runoff=9.1 cfs 30,053 cf

Subcatchment DEV3: Developed Area 3 Runoff Area=32,486 sf 4.54% Impervious Runoff Depth=0.85"
Tc=6.0 min UI Adjusted CN=45 Runoff=0.5 cfs 2,289 cf

Subcatchment DEV4: Developed Area 4 Runoff Area=1,661 sf 45.94% Impervious Runoff Depth=2.52"
Tc=6.0 min CN=66 Runoff=0.1 cfs 349 cf

Reach SUM: Developed Area 2 Inflow=1.5 cfs 8,298 cf
Outflow=1.5 cfs 8,298 cf

Pond SWM: SW Management Peak Elev=67.53' Storage=12,421 cf Inflow=9.1 cfs 30,053 cf
Discarded=0.6 cfs 27,235 cf Primary=1.3 cfs 6,008 cf Outflow=1.9 cfs 33,244 cf

Total Runoff Area = 145,432 sf Runoff Volume = 34,468 cf Average Runoff Depth = 2.84"
74.43% Pervious = 108,248 sf 25.57% Impervious = 37,184 sf

Summary for Subcatchment DEV1: Developed Area 1

Runoff = 0.4 cfs @ 12.13 hrs, Volume= 1,777 cf, Depth= 1.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Description
* 9,356	68	>75% Grass cover, Good, HSG A
* 6,474	30	Meadow, non-grazed, HSG A
15,830	52	Weighted Average
15,830		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0220	0.10		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"
0.2	35	0.0450	3.42		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
8.2	85				Total

Summary for Subcatchment DEV2: Developed Area 2 to SWM

Runoff = 9.1 cfs @ 12.11 hrs, Volume= 30,053 cf, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Description
* 22,490	98	Paved, HSG A
* 1,874	98	Paved parking, #24 offsite, HSG A
9,131	98	Unconnected roofs, HSG A
* 1,451	98	Unconnected roofs, #24 offsite, HSG A
* 60,509	68	>75% Grass cover, Good, HSG A
95,455	79	Weighted Average
60,509		63.39% Pervious Area
34,946		36.61% Impervious Area
10,582		30.28% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	50	0.0280	0.17		Sheet Flow, Grass: Short n= 0.150 P2= 3.10"
0.2	41	0.0800	4.55		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.3	266	0.0160	1.90		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.3	63	0.0060	3.81	2.99	Pipe Channel, 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012

7.8 420 Total

Summary for Subcatchment DEV3: Developed Area 3

Runoff = 0.5 cfs @ 12.12 hrs, Volume= 2,289 cf, Depth= 0.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Adj	Description
1,105	98		Unconnected roofs, HSG A
* 370	98		Unconnected walk, HSG A
* 19,933	30		Meadow, non-grazed, HSG A
* 11,078	68		>75% Grass cover, Good, HSG A
32,486	46	45	Weighted Average, UI Adjusted
31,011			95.46% Pervious Area
1,475			4.54% Impervious Area
1,475			100.00% Unconnected

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

Summary for Subcatchment DEV4: Developed Area 4

Runoff = 0.1 cfs @ 12.09 hrs, Volume= 349 cf, Depth= 2.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Description
* 763	98	Paved, HSG A
898	39	>75% Grass cover, Good, HSG A
1,661	66	Weighted Average
898		54.06% Pervious Area
763		45.94% Impervious Area

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

Summary for Reach SUM: Developed Area 2

Inflow Area = 127,941 sf, 28.47% Impervious, Inflow Depth = 0.78" for 25-Year event
Inflow = 1.5 cfs @ 12.52 hrs, Volume= 8,298 cf
Outflow = 1.5 cfs @ 12.52 hrs, Volume= 8,298 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs

Summary for Pond SWM: SW Management

Inflow Area = 95,455 sf, 36.61% Impervious, Inflow Depth = 3.78" for 25-Year event
 Inflow = 9.1 cfs @ 12.11 hrs, Volume= 30,053 cf
 Outflow = 1.9 cfs @ 12.56 hrs, Volume= 33,244 cf, Atten= 79%, Lag= 27.1 min
 Discarded = 0.6 cfs @ 12.56 hrs, Volume= 27,235 cf
 Primary = 1.3 cfs @ 12.56 hrs, Volume= 6,008 cf

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 3
 Starting Elev= 65.50' Surf.Area= 4,550 sf Storage= 3,185 cf
 Peak Elev= 67.53' @ 12.56 hrs Surf.Area= 4,550 sf Storage= 12,421 cf (9,236 cf above start)
 Flood Elev= 68.80' Surf.Area= 4,550 sf Storage= 18,200 cf (15,015 cf above start)

Plug-Flow detention time= (not calculated: outflow precedes inflow)
 Center-of-Mass det. time= 89.8 min (907.4 - 817.6)

Volume	Invert	Avail.Storage	Storage Description
#1	64.80'	18,200 cf	7.00'W x 13.00'L x 4.00'H Prismaoid x 50

Device	Routing	Invert	Outlet Devices
#1	Primary	64.50'	15.0" Round Culvert Outlet L= 30.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 64.50' / 64.25' S= 0.0083 '/ Cc= 0.900 n= 0.020 Corrugated PE, corrugated interior, Flow Area= 1.23 sf
#2	Discarded	64.80'	2.410 in/hr Exfiltration over Horizontal area Conductivity to Groundwater Elevation = 62.80' Phase-In= 0.01'
#3	Device 1	65.50'	2.0" W x 1.0" H Vert. Orifice/Grate C= 0.600
#4	Device 1	67.10'	18.0" W x 4.0" H Vert. Orifice/Grate C= 0.600
#5	Device 1	68.30'	2.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) 0.5' Crest Height

Discarded OutFlow Max=0.6 cfs @ 12.56 hrs HW=67.53' (Free Discharge)
 ↑**2=Exfiltration** (Controls 0.6 cfs)

Primary OutFlow Max=1.3 cfs @ 12.56 hrs HW=67.53' (Free Discharge)
 ↑**1=Culvert Outlet** (Passes 1.3 cfs of 7.9 cfs potential flow)
 |
 |**3=Orifice/Grate** (Orifice Controls 0.1 cfs @ 6.79 fps)
 |**4=Orifice/Grate** (Orifice Controls 1.2 cfs @ 2.43 fps)
 |**5=Sharp-Crested Rectangular Weir** (Controls 0.0 cfs)

21-31 William Wood Way-developed-Chambers

Type III 24-hr 100-Year Rainfall=7.87"

Prepared by Andover Consultants, Inc.

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Time span=0.00-36.00 hrs, dt=0.01 hrs, 3601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DEV1: Developed Area 1 Runoff Area=15,830 sf 0.00% Impervious Runoff Depth=2.38"
Flow Length=85' Tc=8.2 min CN=52 Runoff=0.9 cfs 3,138 cf

Subcatchment DEV2: Developed Area 2 to Runoff Area=95,455 sf 36.61% Impervious Runoff Depth=5.39"
Flow Length=420' Tc=7.8 min CN=79 Runoff=12.9 cfs 42,851 cf

Subcatchment DEV3: Developed Area 3 Runoff Area=32,486 sf 4.54% Impervious Runoff Depth=1.67"
Tc=6.0 min UI Adjusted CN=45 Runoff=1.2 cfs 4,516 cf

Subcatchment DEV4: Developed Area 4 Runoff Area=1,661 sf 45.94% Impervious Runoff Depth=3.90"
Tc=6.0 min CN=66 Runoff=0.2 cfs 540 cf

Reach SUM: Developed Area 2 Inflow=3.5 cfs 19,504 cf
Outflow=3.5 cfs 19,504 cf

Pond SWM: SW Management Peak Elev=68.43' Storage=16,519 cf Inflow=12.9 cfs 42,851 cf
Discarded=0.7 cfs 31,054 cf Primary=3.0 cfs 14,989 cf Outflow=3.7 cfs 46,042 cf

Total Runoff Area = 145,432 sf Runoff Volume = 51,045 cf Average Runoff Depth = 4.21"
74.43% Pervious = 108,248 sf 25.57% Impervious = 37,184 sf

Summary for Subcatchment DEV1: Developed Area 1

Runoff = 0.9 cfs @ 12.13 hrs, Volume= 3,138 cf, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.87"

Area (sf)	CN	Description
* 9,356	68	>75% Grass cover, Good, HSG A
* 6,474	30	Meadow, non-grazed, HSG A
15,830	52	Weighted Average
15,830		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description	
8.0	50	0.0220	0.10		Sheet Flow, Grass: Dense n= 0.240 P2= 3.10"	
0.2	35	0.0450	3.42		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps	
8.2	85	Total				

Summary for Subcatchment DEV2: Developed Area 2 to SWM

Runoff = 12.9 cfs @ 12.11 hrs, Volume= 42,851 cf, Depth= 5.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.87"

Area (sf)	CN	Description
* 22,490	98	Paved, HSG A
* 1,874	98	Paved parking, #24 offsite, HSG A
9,131	98	Unconnected roofs, HSG A
* 1,451	98	Unconnected roofs, #24 offsite, HSG A
* 60,509	68	>75% Grass cover, Good, HSG A
95,455	79	Weighted Average
60,509		63.39% Pervious Area
34,946		36.61% Impervious Area
10,582		30.28% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0	50	0.0280	0.17		Sheet Flow, Grass: Short n= 0.150 P2= 3.10"
0.2	41	0.0800	4.55		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
2.3	266	0.0160	1.90		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.3	63	0.0060	3.81	2.99	Pipe Channel, 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012

7.8 420 Total

Summary for Subcatchment DEV3: Developed Area 3

Runoff = 1.2 cfs @ 12.10 hrs, Volume= 4,516 cf, Depth= 1.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.87"

Area (sf)	CN	Adj	Description
1,105	98		Unconnected roofs, HSG A
* 370	98		Unconnected walk, HSG A
* 19,933	30		Meadow, non-grazed, HSG A
* 11,078	68		>75% Grass cover, Good, HSG A
32,486	46	45	Weighted Average, UI Adjusted
31,011			95.46% Pervious Area
1,475			4.54% Impervious Area
1,475			100.00% Unconnected

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

Summary for Subcatchment DEV4: Developed Area 4

Runoff = 0.2 cfs @ 12.09 hrs, Volume= 540 cf, Depth= 3.90"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.87"

Area (sf)	CN	Description
* 763	98	Paved, HSG A
898	39	>75% Grass cover, Good, HSG A
1,661	66	Weighted Average
898		54.06% Pervious Area
763		45.94% Impervious Area

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

Summary for Reach SUM: Developed Area 2

Inflow Area = 127,941 sf, 28.47% Impervious, Inflow Depth = 1.83" for 100-Year event
Inflow = 3.5 cfs @ 12.45 hrs, Volume= 19,504 cf
Outflow = 3.5 cfs @ 12.45 hrs, Volume= 19,504 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs

Summary for Pond SWM: SW Management

Inflow Area = 95,455 sf, 36.61% Impervious, Inflow Depth = 5.39" for 100-Year event
 Inflow = 12.9 cfs @ 12.11 hrs, Volume= 42,851 cf
 Outflow = 3.7 cfs @ 12.48 hrs, Volume= 46,042 cf, Atten= 71%, Lag= 22.0 min
 Discarded = 0.7 cfs @ 12.48 hrs, Volume= 31,054 cf
 Primary = 3.0 cfs @ 12.48 hrs, Volume= 14,989 cf

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.01 hrs / 3
 Starting Elev= 65.50' Surf.Area= 4,550 sf Storage= 3,185 cf
 Peak Elev= 68.43' @ 12.48 hrs Surf.Area= 4,550 sf Storage= 16,519 cf (13,334 cf above start)
 Flood Elev= 68.80' Surf.Area= 4,550 sf Storage= 18,200 cf (15,015 cf above start)

Plug-Flow detention time= (not calculated: outflow precedes inflow)
 Center-of-Mass det. time= 91.6 min (899.1 - 807.5)

Volume	Invert	Avail.Storage	Storage Description
#1	64.80'	18,200 cf	7.00'W x 13.00'L x 4.00'H Prismaoid x 50

Device	Routing	Invert	Outlet Devices
#1	Primary	64.50'	15.0" Round Culvert Outlet L= 30.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 64.50' / 64.25' S= 0.0083 '/' Cc= 0.900 n= 0.020 Corrugated PE, corrugated interior, Flow Area= 1.23 sf
#2	Discarded	64.80'	2.410 in/hr Exfiltration over Horizontal area Conductivity to Groundwater Elevation = 62.80' Phase-In= 0.01'
#3	Device 1	65.50'	2.0" W x 1.0" H Vert. Orifice/Grate C= 0.600
#4	Device 1	67.10'	18.0" W x 4.0" H Vert. Orifice/Grate C= 0.600
#5	Device 1	68.30'	2.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) 0.5' Crest Height

Discarded OutFlow Max=0.7 cfs @ 12.48 hrs HW=68.43' (Free Discharge)
 ↑**2=Exfiltration** (Controls 0.7 cfs)

Primary OutFlow Max=3.0 cfs @ 12.48 hrs HW=68.43' (Free Discharge)
 ↑**1=Culvert Outlet** (Passes 3.0 cfs of 9.5 cfs potential flow)
 ↑**3=Orifice/Grate** (Orifice Controls 0.1 cfs @ 8.18 fps)
 ↑**4=Orifice/Grate** (Orifice Controls 2.6 cfs @ 5.19 fps)
 ↑**5=Sharp-Crested Rectangular Weir** (Weir Controls 0.3 cfs @ 1.22 fps)

Appendix - Standard 3 Supporting Information

Soil Evaluation and Analysis

SOIL TEST PIT LOG

Deep Observation Hole Number: TP-1 _____ Ground elevation: 67.8

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color- Moist (Munsell)	Redoximorphic		Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Consistence (Moist)	Soil Structure	Other
			Depth	Color		Percent	Gravel			
0-8	A	10YR 2/2			fine loamy sand			fri	massive	
8-60	BC	10YR 7/3			fls			fri	massive	
60-84	C	10YR 6/4	60"	10YR 5/8	fs & g			fri	massive	

Soil Evaluator Jim Fairweather SE#702

Date of test 10-14-21

Additional Notes:

Seeping at 70", roots to 60", standing @80", ESHWT 60" (EL. 62.8)

SOIL TEST PIT LOG

Deep Observation Hole Number: TP-2 Ground elevation: 70.1

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color- Moist (Munsell)	Redoximorphic			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-6	A	10YR 2/2				fine loamy sand			massive	fri	
6-72	fill										

Soil Evaluator Jim Fairweather SE#702

Date of test 10-14-21

Additional Notes:

roots to 60", hit sprinkler line at 72" +/-

Mounding Analysis

Values of specific yield, from Johnson (1967)

Material	Specific Yield (%)		
	min	avg	max
<i>Unconsolidated deposits</i>			
Clay	0	2	5
Sandy clay (mud)	3	7	12
Silt	3	18	19
Fine sand	10	21	28
Medium sand	15	26	32
Coarse sand	20	27	35
Gravelly sand	20	25	35
Fine gravel	21	25	35
Medium gravel	13	23	26
Coarse gravel	12	22	26
<i>Consolidated deposits</i>			
Fine-grained sandstone		21	
Medium-grained sandstone		27	
Limestone		14	
Schist		26	
Siltstone		12	
Tuff		21	
<i>Other deposits</i>			
Dune sand		38	
Loess		18	
Peat		44	
Till, predominantly silt		6	
Till, predominantly sand		16	
Till, predominantly gravel		16	

See also

- Aquifer test
- Soil mechanics
- Groundwater flow equation describes how these terms are used in the context of solving groundwater flow

within a subsurface geological formation. Such a geological formation is said to be

TABLE 5.2 Representative Values of Saturated Hydraulic Conductivity of Different Soil Textures

Texture	Saturated Hydraulic Conductivity, K (m/yr)
Sand	5.55×10^3
Loamy sand	4.93×10^3
Sandy loam	1.09×10^2
Silty loam	2.27×10^2
Loam	2.19×10^2
Sandy clay loam	1.99×10^2
Silty clay loam	5.36×10^1
Clay loam	7.73×10^1
Sandy clay	6.84×10^1
Silty clay	3.21×10^1
Clay	4.05×10^1

Source: Clapp and Homberger (1978).

heterogeneous. If the properties of the geologic formation are invariable in space, the formation is homogeneous. A geological formation is said to be isotropic if at any point in the medium, the values of the saturated hydraulic conductivity (K) are independent of the direction of measurement. Again, because of the usually stratified nature of unconsolidated sedimentary soil materials, soils are usually anisotropic. Within an anisotropic geological formation, the vertical component of the saturated hydraulic conductivity is usually smaller (one to two orders of magnitude) than the horizontal component.

5.2 MEASUREMENT METHODOLOGY

The saturated hydraulic conductivity of water in soil (or the intrinsic permeability of the soil) can be measured by both field and laboratory experiments. Either way, the experimental measurement of K (or k) consists in determining the numerical value for the coefficient in Darcy's equation.

The methodology used for the experimental determination of K (or k) in either laboratory or field experiments is based on the following procedures (Bear 1972):

1. Assume a flow pattern (such as one-dimensional flow in a porous medium) that can be described analytically by Darcy's law,

$4,930 \text{ m/yr} \times 3.28 \text{ ft/m} \times 1 \text{ yr}/365 \text{ days} = 44.3'/\text{day}$

Table 15.-Physical Properties of the Soils--continued

Map symbol and soil name	Depth	Clay	Moist bulk density	Permeability (Ksat)	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility index
									Kw	Kf	T	
622C: Paxton-----	In	Pct	g/cc	In/hr	um/sec	In/in	Pct	Pct	Kw	Kf	T	Wind erodibility index
	0-7	3-12	1.00-1.25	0.6-2	4.23-14.11	0.10-0.20	0.0-2.9	2.0-5.0	.24	.32	3	86
	7-13	3-12	1.35-1.60	0.6-2	4.23-14.11	0.08-0.18	0.0-2.9	1.0-3.0	.32	.49		
	13-22	3-12	1.35-1.60	0.6-2	4.23-14.11	0.08-0.18	0.0-2.9	1.0-3.0	.32	.49		
	22-26	3-12	1.70-2.00	0.01-0.2	0.09-1.41	0.05-0.10	0.0-2.9	0.0-2.0	.24	.37		
26-65	3-12	1.70-2.00	0.01-0.2	0.09-1.41	0.05-0.10	0.0-2.9	0.0-2.0	.24	.37			
Urban land-----	---	---	---	---	---	---	---	---	---	---	---	0
623C: Woodbridge-----	0-2	---	0.10-0.30	0.6-6	4.23-42.34	0.35-0.45	0.0-2.9	50-99	---	---	3	0
	2-4	3-12	1.00-1.25	0.6-2	4.23-14.11	0.10-0.20	0.0-2.9	2.0-6.0	.24	.32		
	4-30	3-12	1.35-1.60	0.6-2	4.23-14.11	0.08-0.18	0.0-2.9	1.0-3.0	.32	.49		
	30-65	3-12	1.70-2.00	0.01-0.2	0.09-1.41	0.05-0.10	0.0-2.9	0.0-2.0	.24	.37		
	Urban land-----	---	---	---	---	---	---	---	---	---	---	0
624B: Haven-----	0-2	5-18	1.10-1.40	2-6	14.11-42.34	0.15-0.25	0.0-2.9	2.0-6.0	.32	.37	3	86
	2-20	5-18	1.10-1.40	2-6	14.11-42.34	0.09-0.20	0.0-2.9	1.0-3.0	.24	.28		
	20-32	2-18	1.25-1.50	2-6	14.11-42.34	0.08-0.12	0.0-2.9	1.0-3.0	.24	.28		
	32-65	0-3	1.40-1.50	20-100	141.14-705.00	0.01-0.03	0.0-2.9	0.0-2.0	.17	.20		
	Urban land-----	---	---	---	---	---	---	---	---	---	---	0
626B: Merrimac-----	0-9	3-7	1.10-1.20	2-6	14.11-42.34	0.14-0.19	0.0-2.9	1.0-5.0	.24	.32	3	86
	9-18	1-4	1.20-1.40	2-6	14.11-42.34	0.14-0.17	0.0-2.9	1.0-3.0	.24	.32		
	18-26	1-3	1.20-1.40	2-20	14.11-141.14	0.03-0.12	0.0-2.9	0.0-2.0	.17	.28		
	26-33	0-3	1.30-1.50	6-20	42.34-141.14	0.01-0.06	0.0-2.9	0.0-1.0	.10	.37		
	33-65	0-3	1.30-1.50	6-20	42.34-141.14	0.01-0.06	0.0-2.9	0.0-1.0	.10	.37		
Urban land-----	---	---	---	---	---	---	---	---	---	---	0	
627C: Newport-----	0-8	4-10	1.10-1.30	0.6-6	4.23-42.34	0.11-0.21	0.0-2.9	2.0-6.0	.24	.37	3	56
	8-18	3-10	1.30-1.60	0.6-6	4.23-42.34	0.11-0.21	0.0-2.9	1.0-3.0	.37	.55		
	18-24	3-10	1.70-2.00	0.01-0.2	0.09-1.41	0.05-0.12	0.0-2.9	0.0-2.0	.24	.43		
	24-65	3-10	1.70-2.00	0.01-0.2	0.09-1.41	0.05-0.12	0.0-2.9	0.0-2.0	.24	.43		
	Urban land-----	---	---	---	---	---	---	---	---	---	---	0
629C: Canton-----	0-8	1-8	0.90-1.20	2-6	14.11-42.34	0.11-0.19	0.0-2.9	1.0-6.0	.24	.32	3	86
	8-21	1-8	1.20-1.50	2-6	14.11-42.34	0.09-0.17	0.0-2.9	0.0-2.0	.28	.37		
	21-65	0-5	1.30-1.50	6-20	42.34-141.14	0.04-0.08	0.0-2.9	0.0-2.0	.17	.20		

6-20 in/hr = 12-40 ft/day

Rawls rate = 2.41 in/hr = 4.82 ft/day, typical assumption for ksat horizontal = 10 x Rawls rate = 48.2 ft/day. Conservative to use average of above = 26 ft/day

28 - chamber system (approximate 70' long x 32' wide)

This spreadsheet will calculate the height of a groundwater mound beneath a stormwater infiltration basin. More information can be found in the U.S. Geological Survey Scientific Investigations Report 2010-5102 "Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins".

The user must specify infiltration rate (R), specific yield (Sy), horizontal hydraulic conductivity (Kh), basin dimensions (x, y), duration of infiltration period (t), and the initial thickness of the saturated zone (hi(0), height of the water table if the bottom of the aquifer is the datum). For a square basin the half width equals the half length (x = rectangular basin, if the user wants the water-table changes perpendicular to the long side, specify x as the short dimension and y as the long dimension. Conversely, if the user wants the water-table changes perpendicular to the short side, specify y as the short dimension, x as the long dimension. All distances are from the center of the basin. Users can specify distances from the center of the basin at which water-table and aquifer thickness are calculated.

Cells highlighted in yellow are values that can be changed by the user. Cells highlighted in red are output values based on user-specified inputs. **The user MUST click the "Re-Calculate Now" button each time ANY of the user-specified inputs are changed** otherwise necessary iterations to converge on the correct solution will not be done and values shown will be incorrect. Use consistent units for all input values (for example, feet and days)

Input Values		use consistent units (e.g. feet & days or inches & hours)	Conversion Table	
			inch/hour	feet/day
0.4000	R	Recharge (infiltration) rate (feet/day)	0.67	1.33
0.210	Sy	Specific yield, Sy (dimensionless, between 0 and 1)		
26.00	K	Horizontal hydraulic conductivity, Kh (feet/day)*	2.00	4.00
35.000	x	1/2 length of basin (x direction, in feet)		
16.000	y	1/2 width of basin (y direction, in feet)	hours	days
1.500	t	duration of infiltration period (days)	36	1.50
10.000	hi(0)	initial thickness of saturated zone (feet)		

In the report accompanying (USGS SIR 2010-5102), velocity (ft/d) is assumed to be or hydraulic conductivity (ft/d)

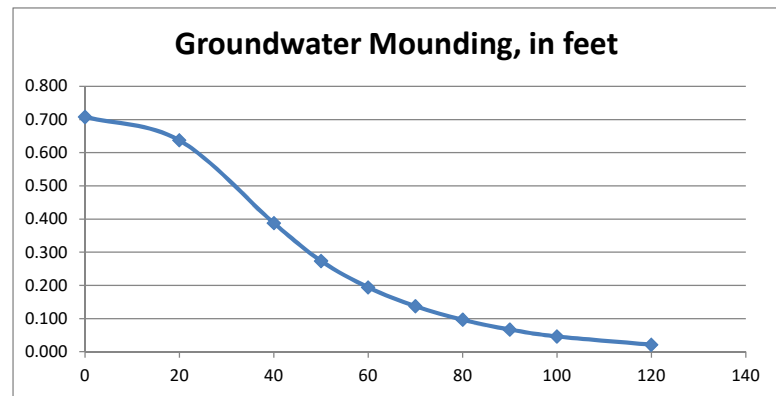
10.708	h(max)	maximum thickness of saturated zone (beneath center of basin at end of infiltration period)
0.708	Δh(max)	maximum groundwater mounding (beneath center of basin at end of infiltration period)

Ground-water Mounding, in feet	Distance from center of basin in x direction, in feet
--------------------------------	---

0.708	0
0.637	20
0.388	40
0.274	50
0.194	60
0.137	70
0.096	80
0.067	90
0.046	100
0.021	120



Re-Calculate Now



Disclaimer

This spreadsheet solving the Hantush (1967) equation for ground-water mounding beneath an infiltration basin is made available to the general public as a convenience for those wishing to replicate values documented in the USGS Scientific Investigations Report 2010-5102 "Groundwater mounding beneath hypothetical stormwater infiltration basins" or to calculate values based on user-specified site conditions. Any changes made to the spreadsheet (other than values identified as user-specified) after transmission from the USGS could have unintended, undesirable consequences. These consequences could include, but may not be limited to: erroneous output, numerical instabilities, and violations of underlying assumptions that are inherent in results presented in the accompanying USGS published report. The USGS assumes no responsibility for the consequences of any changes made to the spreadsheet. If changes are made to the spreadsheet, the user is responsible for documenting the changes and justifying the results and conclusions.

R:
 Recharge depth provided = 65.4-64.8 = 0.6 feet, R = 0.60 feet / 1.5 days = 0.40 ft/day
 For Sy = 0.21, & K = 26 ft/day see attached data for typical values

30 - chamber system 84' long x 40' wide

This spreadsheet will calculate the height of a groundwater mound beneath a stormwater infiltration basin. More information can be found in the U.S. Geological Survey Scientific Investigations Report 2010-5102 "Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins".

The user must specify infiltration rate (R), specific yield (Sy), horizontal hydraulic conductivity (Kh), basin dimensions (x, y), duration of infiltration period (t), and the initial thickness of the saturated zone (hi(0), height of the water table if the bottom of the aquifer is the datum). For a square basin the half width equals the half length (x = rectangular basin, if the user wants the water-table changes perpendicular to the long side, specify x as the short dimension and y as the long dimension. Conversely, specify the values perpendicular to the short side, specify y as the short dimension, x as the long dimension. All distances are from the center of the basin. Users can specify distances from the center of the basin at which water-table and aquifer thickness are calculated.

Cells highlighted in yellow are values that can be changed by the user. Cells highlighted in red are output values based on user-specified inputs. **The user MUST click the "Re-Calculate Now" button each time ANY of the user-specified inputs are changed** otherwise necessary iterations to converge on the correct solution will not be done and values shown will be incorrect. Use consistent units for all input values (for example, feet and days)

Input Values		use consistent units (e.g. feet & days or inches & hours)	Conversion Table	
			inch/hour	feet/day
0.4000	R	Recharge (infiltration) rate (feet/day)	0.67	1.33
0.210	Sy	Specific yield, Sy (dimensionless, between 0 and 1)		
26.00	K	Horizontal hydraulic conductivity, Kh (feet/day)*	2.00	4.00
42.000	x	1/2 length of basin (x direction, in feet)		
20.000	y	1/2 width of basin (y direction, in feet)	hours	days
1.500	t	duration of infiltration period (days)	36	1.50
10.000	hi(0)	initial thickness of saturated zone (feet)		

In the report accompanying (USGS SIR 2010-5102), velocity (ft/d) is assumed to be or hydraulic conductivity (ft/d)

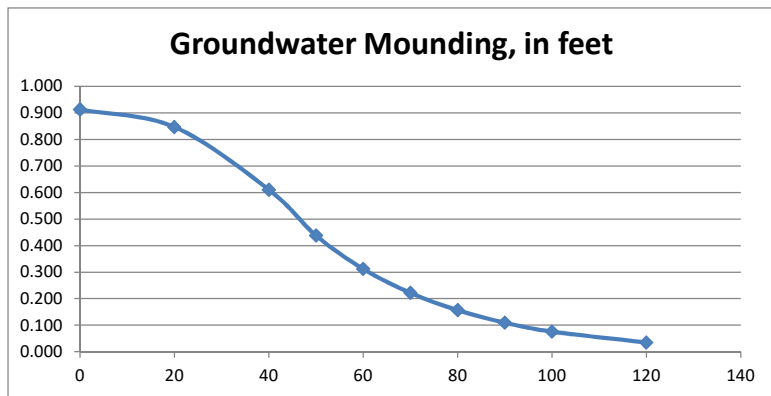
10.913	h(max)	maximum thickness of saturated zone (beneath center of basin at end of infiltration period)
0.913	Δh(max)	maximum groundwater mounding (beneath center of basin at end of infiltration period)

Ground-water Mounding, in feet	Distance from center of basin in x direction, in feet
--------------------------------	---

0.913	0
0.847	20
0.610	40
0.438	50
0.312	60
0.222	70
0.157	80
0.110	90
0.076	100
0.035	120



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Appendix - Standard 4 Supporting Information

TSS Removal Worksheet

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

1. Sheet is nonautomated. Print sheet and complete using hand calculations. Column A and B: See MassDEP Structural BMP Table
2. The calculations must be completed using the Column Headings specified in Chart and Not the Excel Column Headings
3. To complete Chart Column D, multiple Column B value within Row x Column C value within Row
4. To complete Chart Column E value, subtract Column D value within Row from Column C within Row
5. Total TSS Removal = Sum All Values in Column D

Location: William Court-Andover, Massachusetts

A	B	C	D	E
BMP ¹	TSS Removal Rate ¹	Starting TSS Load*	Amount Removed (B*C)	Remaining Load (C-D)
Deep Sump & Hooded Catch Basins	0.25	1.00	0.25	0.75
Proprietary Treatment Device: Stormceptor 900	0.46	0.75	0.345	0.405
Subsurface Infiltration Structure	0.80	0.405	0.324	0.081

Total TSS Removal = 0.919

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

Project: 21-31
Prepared By: jsf
Date: 12-21-21

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

EPA Phosphorus Removal

BMP Performance Curve: Infiltration Trench

BMP Performance Table

BMP Name: Infiltration Trench

Soil Infiltration Rate: 2.41 in/hr

Land Use	Pollutant	Depth of Runoff Treated (inches)								
		0.1	0.2	0.4	0.6	0.8	1	1.5	2	
Commercial	TSS	50%	77%	97%	100%	100%	100%	100%	100%	100%
	TP	32%	55%	81%	91%	96%	98%	100%	100%	100%
	Zn	81%	98%	100%	100%	100%	100%	100%	100%	100%
Industrial	TSS	51%	78%	97%	100%	100%	100%	100%	100%	100%
	TP	33%	56%	81%	92%	96%	98%	100%	100%	100%
	Zn	55%	84%	99%	100%	100%	100%	100%	100%	100%
High-Density Residential	TSS	52%	79%	97%	100%	100%	100%	100%	100%	100%
	TP	33%	55%	81%	91%	96%	98%	100%	100%	100%
	Zn	63%	92%	100%	100%	100%	100%	100%	100%	100%
Medium-Density Residential	TSS	62%	86%	98%	100%	100%	100%	100%	100%	100%
	TP	33%	55%	80%	90%	95%	97%	99%	100%	100%
	Zn	25%	48%	79%	94%	99%	100%	100%	100%	100%
Low-Density Residential	TSS	57%	80%	96%	99%	100%	100%	100%	100%	100%
	TP	35%	56%	80%	90%	95%	97%	99%	100%	100%
	Zn	19%	39%	71%	89%	97%	100%	100%	100%	100%
Runoff Volume Reduction		34%	55%	78%	88%	93%	96%	99%	100%	100%

Annual Pollutant Loading Rates

Land use	Pollutant load (lbs/acre-year)		
	TSS	TP	Zn
Commercial	1117.77	1.66	2.33
Industrial	745.22	1.43	0.45
High-Density Residential	465.08	1.10	0.79
Medium-Density Residential	274.63	0.55	0.11
Low-Density Residential	72.11	0.042	0.043

BMP Performance Curve: Infiltration Basin

BMP Performance Table

BMP Name: Infiltration Basin

Soil Infiltration Rate: 2.41 in/hr

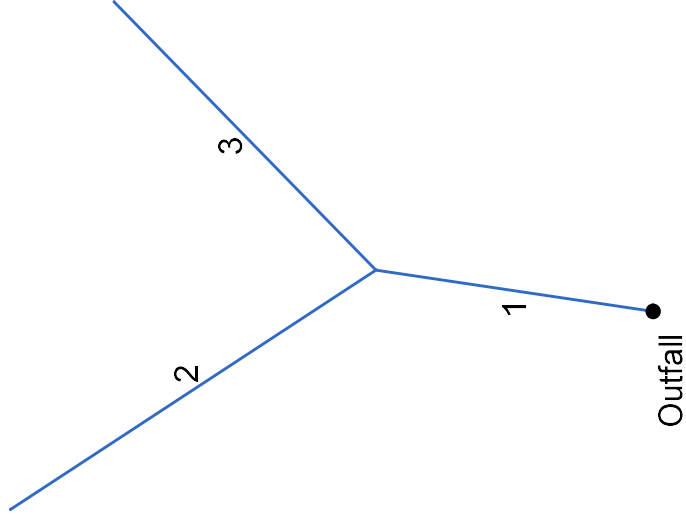
Land Use	Pollutant	Depth of Runoff Treated (inches)									
		0.1	0.2	0.4	0.6	0.8	1	1.5	2		
Commercial	TSS	70%	88%	98%	100%	100%	100%	100%	100%	100%	100%
	TP	45%	67%	87%	94%	97%	98%	100%	100%	100%	100%
	Zn	82%	95%	100%	100%	100%	100%	100%	100%	100%	100%
Industrial	TSS	70%	88%	98%	100%	100%	100%	100%	100%	100%	100%
	TP	46%	67%	87%	94%	97%	99%	100%	100%	100%	100%
	Zn	69%	88%	99%	100%	100%	100%	100%	100%	100%	100%
High Density Residential	TSS	71%	88%	98%	100%	100%	100%	100%	100%	100%	100%
	TP	46%	67%	87%	94%	97%	98%	100%	100%	100%	100%
	Zn	74%	91%	99%	100%	100%	100%	100%	100%	100%	100%
Medium Density Residential	TSS	76%	91%	99%	100%	100%	100%	100%	100%	100%	100%
	TP	46%	67%	87%	94%	97%	98%	100%	100%	100%	100%
	Zn	45%	68%	89%	96%	99%	100%	100%	100%	100%	100%
Low Density Residential	TSS	74%	89%	98%	99%	100%	100%	100%	100%	100%	100%
	TP	48%	68%	87%	94%	97%	98%	100%	100%	100%	100%
	Zn	38%	61%	84%	94%	98%	99%	100%	100%	100%	100%
Runoff Volume Reduction		33%	54%	78%	88%	93%	96%	99%	100%	100%	100%

Annual Pollutant Loading Rates

Land use	Pollutant load (lbs/acre-year)		
	TSS	TP	Zn
Commercial	1117.77	1.66	2.33
Industrial	745.22	1.43	0.45
High Density Residential	465.08	1.10	0.79
Medium Density Residential	274.63	0.55	0.11
Low Density Residential	72.11	0.042	0.043

Closed Drainage Calculations

Hydraflow Storm Sewers Extension for Autodesk® Civil 3D® Plan

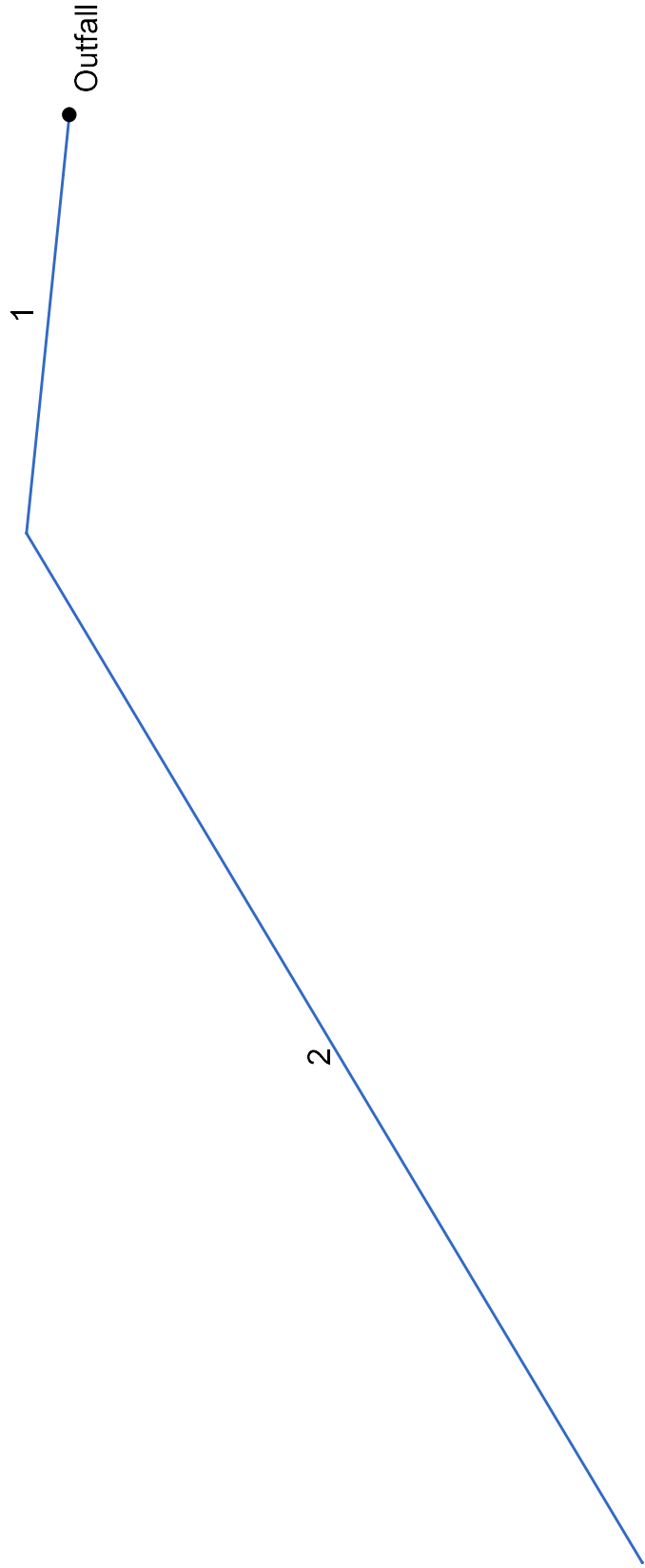


Storm Sewer Tabulation

Station	Line	To Line	Len		Drng Area		Rnoff coeff	Area x C		Tc		Rain (l)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID		
			Incr	Total	Incr	Total		Inlet	Syst	Incr	Total					Inlet	Slope	Dn	Up	Dn	Up	Dn	Up		Dn	Up
			(ft)		(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)			
3	1	12.000	0.86	0.86	0.61	0.52	0.52	10.0	10.0	6.3	3.29	6.46	3.88	15	1.00	65.40	65.52	66.34	66.25	70.20	69.50	PDP-5				
2	1	14.000	0.78	0.78	0.69	0.54	0.54	10.0	10.0	6.3	3.38	6.46	3.94	15	1.00	65.40	65.54	66.34	66.28	70.20	69.50	PDP-6				
1	End	9.000	0.00	1.64	0.00	1.06	0.00	0.0	10.1	6.3	6.66	6.81	6.22	15	1.11	65.20	65.30	66.20	66.34	70.10	70.20	PDP-7				
Project File: cb 3 cb 4.stm																	Number of lines: 3					Run Date: 9/29/2022				

NOTES: Intensity = 86.32 / (Inlet time + 13.90) ^ 0.83; Return period = Yrs. 100 ; c = cir e = ellip b = box

Hydraflow Storm Sewers Extension for Autodesk® Civil 3D® Plan



Storm Sewer Tabulation

Station	Line	To Line	Len (ft)	Drng Area		Rnoff coeff (C)	Area x C		Tc		Rain (l) (in/hr)	Total flow (cfs)	Cap full (cfs)	Vel (ft/s)	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
				Incr (ac)	Total (ac)		Inlet (min)	Syst (min)	Incr	Total					Inlet (min)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
2	1	End	45.000	0.50	0.50	0.36	0.18	0.18	10.0	10.0	6.3	1.13	2.60	3.20	12	0.53	65.36	65.60	65.82	66.06	68.80	68.80	PDP-8
1			14.000	0.06	0.56	0.40	0.02	0.20	5.0	10.2	6.2	1.27	3.01	3.56	12	0.71	65.20	65.30	65.65	65.78	69.47	68.80	PDP-9

Project File: New.stm

Number of lines: 2

Run Date: 9/29/2022

NOTES: Intensity = 86.32 / (Inlet time + 13.90) ^ 0.83; Return period = Yrs. 100 ; c = cir e = ellip b = box

