Post Construction Stormwater Management Report

Project:	Proposed Wawa Food Market Route 30 (Lancaster Ave.) & Aberdeen Ave. Radnor Township Delaware County, Pennsylvania
Client:	Wayne Property Acquisition, Inc. 1747 Spring House Road Chester Springs, PA 19425
Project Number:	PC181016
Dated: Last Revised	July 13, 2018 August 31, 2018

Professional Engineer: Eric Britz, P.E.
PA License #PE074843

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GENERAL PROJECT DESCRIPTION

Wayne Property Acquisition Inc. proposes to develop the properties located at the southeast corner of East Lancaster Avenue and Aberdeen Avenue (Folio #36-03-01682-00 & Folio #36-03-01683-00) in Radnor Township, Delaware County into a 4,736 SF retail Wawa store (5,124 SF including retail store canopies) with retail sale of gas consisting of six (6) MPDs (multi-product dispensers), along with associated access, parking, lighting, landscaping, utility connections, and stormwater management controls necessary to support the site. This development proposes to replace the two (2) existing retail gas stores with retail gas (Sunoco and BP; currently a motor vehicle repair shop (Sunoco) and car wash (BP)), which consist of two (2) buildings totaling 4,230 SF with eleven (11) existing MPDs. As part of the application, the project proposes to consolidate the two (2) properties. The consolidated property will remain under the ownership of the Applicant and/or its successors.

The proposed Wawa convenience store constructed on site will consist of one (1) 1-story 4,736 square foot building and six multiple product fueling dispensers along with on-site parking to accommodate a total of 55 parking spaces. The new building will be served by both public sanitary sewer service and public water service. Vehicular access to the property will be provided by three (3) access driveways, two (2) on Lancaster Avenue and one (1) on Aberdeen Avenue, which is a reduction from the six (6) existing access points (four (4) on Lancaster Avenue and two (2) on Aberdeen Avenue). In addition to the buildings, fueling stations, and on-site parking areas, the project includes the installation of utilities, landscaping, and stormwater management controls necessary to support the development.

General PCSM Planning and Design
§102.8(b)

1. The following measures were taken to preserve the integrity of stream channels and to maintain and protect the physical, biological, and chemical qualities of the receiving stream:
   - Direct runoff from impervious surfaces including roadways to BMPs.
   - Use native species, which require less fertilization and chemical application than non-native species.
   - Maintain generally the same drainage patterns as in the existing condition
   - Perform soil amendments, which restore soil porosity through tilling and composting to improve the soil's capacity for infiltration and pollutant removal.

2. The following measures were taken to prevent an increase in the rate of storm water runoff:
   - Utilize underground slow release basin to help reduce runoff rates.
   - Minimize impervious areas where practical.
   - Maintain generally the same drainage patterns as in the existing condition

3. The following measures were taken to minimize any increase in storm water runoff volume:
   - Utilize underground slow release basin to help reduce runoff volume.
   - Provide landscape restoration to help reduce runoff volume.
   - Minimize impervious areas where practical.
   - Maintain generally the same drainage patterns as in the existing condition
   - Provide amended soils throughout the site to help reduce runoff volume.

4. The following measures were taken to minimize impervious areas:
   - Increase in pervious area within limit of disturbance by approximately 7%
   - Only provide sidewalk where required by code.
   - Maximize the number of landscaped island within the site.

5. The following measures are taken to maximize protection of existing drainage features and vegetation:
   - Access the site thru designated construction entrance.
   - Protect woodlands/existing trees with tree protection fencing.
   - Utilizing the existing conveyance system within Aberdeen Avenue

- Maintain existing flow path to POI#2

6. The following measures were taken to minimize land clearing and grading:
- Protect woodlands/existing trees with tree protection fencing.
- Adjust road slope and site grading so there are no drastic proposed cuts or fills to existing grades.
- Maintain existing grades within the site where plausible.

7. The following measures are taken to minimize soil compaction:
- Access the site thru designated construction entrance.
- As specified in the construction sequence, use treaded machinery where practical during earthmoving operations.
- Grade site to minimize extent of cuts/fills.

8. the following measures were taken to utilize other structural or nonstructural BMPs that prevent or minimize changes in storm water runoff:
- Direct runoff to an above ground storm water basin to control runoff rates.
- Utilize underground slow release basin to help reduce runoff volume.
- Provide landscape restoration to help reduce runoff volume.
- Minimize impervious areas where practical.

Types, Depth, Slope, Locations, and Limitations of the Soils and Geologic Formations §102.8(f)(2)

Soil Descriptions:

Soil	Description	Soil Group
Md	Made land, gabbro and diabase materials, 0 to 8 percent slopes	C

- No geologic mapping features were identified.

Geotechnical Testing:

The Preliminary Geotechnical Investigation as prepared by Whitestone Associates, Inc. on July 25, 2017, has been included in Appendix A of this report.

As detailed in the two page Preliminary Stormwater Management Area Evaluation letter, the Geotechnical Engineer has recommended that the site generally appears not to be conductive for infiltration design. This is the reasoning for utilizing a Slow Release Concept Basin instead of an infiltration basin. The two-page report is included in Appendix A of this report.

An additional Geotechnical Investigation was conducted by JK Environmental on February 27, 2018 which is also included in Appendix A of this report.

Past, Present and Proposed Land Uses and Proposed Alteration to Project Site §102.8(f)(3)

During the past 5 years, both existing lots have been utilized for the current use of Convenience store and fueling stations.

During the past 50 years, both existing lots have been utilized for the current use of Convenience store and fueling stations.

Geologic Formations or Soil Conditions

§102.8(f)(12)

There are no known geologic formations or soil conditions that could cause contaminant pollution during earth disturbance activities.

Potential Thermal Impacts
§102.8(f)(13)

A potential for thermal impacts exists in instances where surface runoff is directly conveyed to a receiving stream without adequate attenuation or cooling. To avoid thermal impacts, the following has been employed: underground pipe basin facilities, amended soils, and landscape restoration. All of these measures will help to control runoff volume and rate and thereby provide additional cooling time, thereby minimizing thermal impacts to the receiving stream.

Riparian Forest Buffer Management Plan
§102.8(f)(14)

Regarding existing or proposed riparian forest buffers, note the following:

- There are no existing/proposed riparian forest buffers located within or outside the limits of disturbance for this project.
- The following impairments are listed for this portion of the Ithan Creek
    - Water/Flow Variability
    - Siltation
    - Habitat Modification
    - Pathogens

Stormwater Management

Watershed

The overall property is within the tributary area of Ithan Creek, which is tributary to Darby Creek. Darby Creek ultimately flows to the Delaware River. Ithan Creek has a Chapter 93 classification of CWF (Cold Water Fishes) & MF (Migratory Fish). The project site is located within district A of the Stormwater Management District Watershed Map.

Design Methodology

The Design Method was used in Worksheet 4 of the BMP Manual to determine the change in 2-year storm volumes which is required to be controlled on site per the Radnor Township Stormwater Management Ordinance requirements set forth in Chapter 245 and the CG-1 guidelines of the PADEP BMP Manual. The Dekalb Rational Method was used to calculate peak runoff rates and generate hydrographs for the pre and post development conditions for the Points of Interests. The computer watershed software Hydraflow Hydrographs Extension for AutoCAD 2016® Civil 3D® 2016 was utilized for this analysis. The hydrographs generated for these calculations were based on the rainfall intensities from the NOAA Atlas 14, Volume 2, Version 3, Wayne, PA gauge. Actual land cover conditions, were assumed for the pre-development peak rate calculations for areas of disturbance, as detailed in the following report. In order to be compliant with §245-27.J of the Radnor Township Stormwater Management Ordinance, the stage storage volume for the underground slow release basin only includes the volume within the chambers. The stone bedding surrounding the basin was not included in the volume calculations. Management of stormwater runoff through the storage of the 2-year storm in one Slow Release Concept Basin and corresponding outlet structure provide the necessary volume and peak rate controls along with sufficient water quality to meet Radnor Township & PADEP regulations. It is by the recommendation of the Geotechnical Engineer that the site generally appears not to be conductive for infiltration design, therefore this project is proposing to utilize a Slow Release Concept basin. In review of the monitoring wells provided in the above mentioned report by

JK Environmental, the highest corrected groundwater elevation in the area of the proposed Slow Release Basin was determined to be 359.31', as shown in Monitoring Well table for MW-3. The invert of the proposed Slow Release basin was designed at 360.00' in order to provide 0.69' between the high water table elevation and the invert of the basin. The landscaped areas within the limit of disturbance outside of the proposed R.O.W. will utilize amended soils for water quality mitigation.

Peak Rate Control Standards

In accordance with the Radnor Township Chapter 245-25 Stormwater Management Ordinance, the pre-development pervious condition of the site has been assumed to be actual land cover conditions, except 20% existing impervious surface being considered meadow when computing runoff coefficients for the peak rate analysis. Based on these assumptions, the development will still result in an overall decrease in runoff rates and volume. The analysis conducted for this area compares the pre-development discharge rates to the post-development discharge rates in accordance the Radnor Township Chapter 245-25 Stormwater Management Ordinance. As the site is located within the Darby Creek watershed it must follow the peak rate runoff control standards set forth in Table 408.1 of the Ordinance. The reduction requirements are as follows:

Post Development Condition		Pre Development Condition
2-year	Reduced to	1-year
5-year	Reduced to	5-year
10-year	Reduced to	10-year
25-year	Reduced to	25-year
100-year	Reduced to	100-year

Pre-Development Conditions

The pre-development condition of the site consists of two (2) points of interest, which are delineated on the Pre-Development Drainage Area Plan. Stormwater runoff flows to either the existing conveyance system in Aberdeen Avenue or to the east of the existing curb line near the southeast corner of the site. The majority of the site runoff flows overland to the Aberdeen Avenue conveyance system with the exception of the small amount of runoff produced by the green area behind the curb line.

Post Development Conditions

The post-development condition of the site maintains the existing Points of Interest. The areas tributary to each POI have been delineated on the Pre and Post-Development Drainage Area Plans and hydrographs have been generated for the 1, 2, 5, 10, 25, and 100-year storms. The proposed Slow Release Concept basin has been utilized to manage a portion of the runoff within the proposed limit of disturbance. The calculations indicate that the design proposes to decrease the peak flow rates to the points of interest in accordance with the Radnor Township Chapter 245-25 Stormwater Management Ordinance peak rate design requirements listed above. State water quality requirements are addressed by the Underground Infiltration basin along with the utilization of Amended soils in the disturbed lawn areas.

Alternatives Analysis of PCSM BMPs

In a review of the volume reducing BMPs to consider if any other method was feasible the following considerations and constraints were evaluated:

Structural BMPs

1. Infiltration Testing completed in the Limit of Disturbance came back unfavorable due to high ground water.
    a. For these reason no Infiltration BMPs are feasible (BMPs 6.4.1 – 6.4.10)
2. Due to the delta 2-yr volume of approx. 3,000 cuft., it is not feasible to provide the entire amount of storage within a vegetated roof. The extensive cost to provide the roof structure and the ability to make a vegetated roof accessible through the proposed buildings also render this BMP infeasible (BMP 6.5.1)

3. Also due to the delta 2-yr volume of approx. 3,000 cuft., it is not feasible to provide the entire amount of storage within a capture and re-use system since the area needed to dewater within 7 days exceed the amount of non-basin landscape area available on site (BMP 6.5.2)

All Volume BMPs (6.4.1 – 6.4-10 and 6.5.1-2) have been analysis and deemed not feasible for this project, therefore requiring the design to utilize BMP 6.4.11 Slow Release Concept for management of the delta 2yr storm.

Non-Structural BMPs

4. BMP 5.4.1. Protect Sensitive/Special Value Features, is not feasible to account for up to 25% of the required volume because areas must be protected and undisturbed which is not possible in the Limit of Disturbance due to the improvements proposed.
5. BMP 5.4.2, Protect/Conserve/Enhance Riparian Areas, is not feasible to account for up to 25% of the required volume because there are no riparian areas located within the limit of disturbance.
6. BMP 5.4.3, Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design, is not feasible to account for up to 25% of the required volume because the natural flow pathway (Aberdeen Avenue conveyance system) is located outside the limit of disturbance.
7. BMP 5.6.1, Minimized Total Disturbed Area, is not feasible to account for up to 25% of the required volume because Chapter 8 states that areas must be protected and undisturbed which is not possible in the Limit of Disturbance due to the improvements proposed.
8. BMP 5.6.2, Minimize Soil Compaction in Disturbed Areas, is not feasible to account for up to 25% of the required volume because areas where minimum soil compaction occurs is already being account for with the proposed amended soils volume credit.
9. Non-Structural BMP 5.6.3 Revegetate and Reforest disturbed areas are not feasible to account for up to 25% of the required volume as a majority of the site sees a reduce in existing tree cover versus proposed tree cover and cannot utilize the revegetate/reforest volume credit.
10. BMP 5.7.1, 5.7.2 are not feasible to account for up to 25% of the required volume because they do not have any quantifiable volume reduction credit detailed in Chapter 8 of the PADEP BMP Manual. Parking and Street areas have been reduced as much as possible to still make the proposed use plausible.

All Non-Structural BMPs, except 5.6.3, 5.8.1, and 5.8.2 (5.4.1 – 5.7.2) have been analysis and deemed not feasible to account for up to 25% of the required volume for this project. therefore, requiring the design to utilize BMP 6.4.11 Slow Release Concept for management of the delta 2-yr storm.

Storm Drainage

The storm drainage system has been designed to intercept runoff at topographic low points and areas of significant runoff quantities and convey stormwater to the proposed Slow Release Concept basin. Conveyance design precipitation amounts are based on the rainfall intensities specified within the Radnor Township Chapter 245-25 Stormwater Management Ordinance for the 25-year storm event. Bentley StormCAD V8i has been utilized for the design of the storm conveyance system. The proposed stormwater management program described within this report has been designed to comply with the Radnor Township Chapter 245-25 Stormwater Management Ordinance

The storm drainage system consists of inlets placed within paved areas to capture runoff in order to minimize flows to both points of interest. Runoff is then conveyed to the Slow Release Concept basin which then outlets to the existing conveyance system in Aberdeen Avenue. Amended soils have also been provided in the disturbed landscape areas to provide water quality mitigation.

Post Construction Stormwater Management BMP's

Stormwater Management Facilities - The proposed Slow Release Concept basin is maintained to meet the volume and peak rate reduction requirements of the Radnor Township Chapter 245-25 Stormwater Management Ordinance, as well as the State water quality requirements.

5.6.2-Minimize Soil Compaction in Disturbed Areas - Minimizing soil compaction and ensuring topsoil quality is the practice of enhancing, protecting, and minimizing damage to soil quality caused by land development. The soil is able to maintain the pre-development stormwater management properties when undisturbed.

6.4.11-Slow Release Concept – The Slow Release systems proposed for this project utilizes an underground basin with a subsurface constructed filter with an underdrain within the outlet structure to ensure that the systems drain, yet water still filters through a leaf compost, sand, and clean stone filter before dewatering. The Slow Release Concept (SRC) is a stormwater strategy used to manage the increase in the pre vs. post development runoff volume through attenuation and discharge of storm events up to and including the 2-year 24-hour storm ($\Delta 2$ volume). The goal of the SRC is to mimic the normal baseflow hydrology in the receiving stream. The SRC can be used in tandem with volume management measures such as infiltration and evapotranspiration. This concept can be used in either above-ground or underground storage systems.

6.6.4-Water Quality Filters & Hydrodynamic Devices - These structural BMPs vary in size and function, but utilize some form of settling and filtration to remove particulate pollutants from stormwater runoff. Commercially available water quality filters, catch basin inserts, and hydrodynamic devices are generally configured to remove particulate contaminants, including coarse sediment, oil and grease, and debris. Water Quality Inlets are commonly used as pretreatment BMPs and can provide "hotspot" control by reducing sediment loads to infiltration devices. Hydrodynamic Devices are not truly inserts, but separate flow through devices designed to serve in concert with inlets and storm sewer. Ideally, the flow through the device should remove liter, oil, sediment, heavy metals, dissolved, solids, and nutrients. Clays and fine silts do not easily settle out unless they are coagulated with some kind of chemical addition or polymer.

6.7.2-Landscape Restoration - Landscape Restoration is an effective method of reducing runoff volume and rate, as well as significant nonpoint source load reduction/prevention. This BMP includes the restoration of forest and/or meadow and the conversion of turf to meadow. In a truly sustainable site design process, this practice should be considered only after the areas of development that require landscaping and/or vegetation are minimized. Landscape Restoration is characterized by the careful selection and use of vegetation that does not require significant chemical maintenance by fertilizers, herbicides, and pesticides. The use of native species is recommended as they have the greatest tolerance and resistance to pests and require less fertilization and chemical application than nonnative species.

6.7.3-Soil Amendment & Restoration - Soil Amendment and Restoration is the process of improving disturbed soils and low organic soils by restoring soil porosity and/or adding a soil amendment, for the purpose of reestablishing the soil's long-term capacity for infiltration and pollution removal. This BMP addresses minor and major compaction from various sources. Compaction typically leads to limited root growth and is dependent on bulk density. Limiting root growth will reduce the uptake of water and nutrients by vegetation. Soil organisms are also affected by compaction; biological activity is greatly reduced, decreasing their ability to intake and release nutrients.

INSPECTIONS AND MAINTENANCE

Until the site is stabilized and during the construction activities, all BMPs must be maintained properly by contractor. All permanent maintenance procedures shall be performed by the property owner. Maintenance must include inspections of all BMPs after each runoff event and on a weekly basis. All preventative and remedial maintenance work, including clean-out, repair, replacement, regrading, reseeding, remulching and renetting must be performed immediately and in accordance with these procedures, plans, and details. Any areas disturbed during maintenance must be stabilized immediately in accordance with the general conservation notes and specifications. All site inspections must be documented in an inspection log kept for this purpose indicating the compliance actions and the date, time and name of the person conducting the inspection. The inspection log must be kept on site at all times and made available to the district upon request.

Stormwater Management Facilities – Stormwater management basins shall be inspected for litter and sediment accumulation on an annual basis or as directed by the township engineer. Needed maintenance should be initiated immediately after the inspection. The litter and sediment must be removed to restore design capacities. The litter and sediment shall be disposed of in an approved manner and in accordance with applicable state regulations. Any areas disturbed during maintenance must be stabilized immediately in accordance with the general conservation notes and specifications.

Storm Drainage Systems – The stormwater management facilities including the inlets, stormwater piping, and other BMPs listed herein and shown on the plans for this site shall be maintained in proper working order in accordance with these plans and per the recommendation of the structure(s) manufacturer(s). Maintenance of these stormwater management facilities, as noted below, shall be the responsibility of the property owner(s) upon whose property the facilities are located.

All onsite inlets and stormwater piping shall be cleared of debris every three (3) months or when accumulation hinders operation of the facility. Systems shall be flushed every five (5) years.

All sediment/debris/oil removed from the stormwater management system shall be disposed per local, state, and federal standards.

Should onsite erosion occur from the landscaped areas, source of erosion shall be immediately stabilized and the inlets and stormwater piping shall be checked for accumulation and cleared if accumulation of sediment exists.

5.6.2-Minimizing Soil Compaction in Disturbed Areas - Sites that have minimized soil compaction areas designated properly during the development process should require considerably less maintenance than sites that have not. Some maintenance activities such as frequent lawn mowing can cause considerable soil compaction after construction and should be avoided whenever possible. Planting low-maintenance native vegetation is the best way to avoid damage due to maintenance.

6.4.11-Slow Release Concept – Slow release concept systems shall be inspected for sediment accumulation on an annual basis, after a significant runoff event or as directed by the township engineer. needed maintenance should be initiated immediately after the inspection. areas of erosion shall be regraded and stabilized and sediment must be removed to restore design capacities. any removed sediment shall be disposed of in an approved manner and in accordance with applicable state regulations. all areas disturbed during maintenance must be stabilized immediately in accordance with the general conservation notes and specifications.

6.6.4-Water Quality Filters & Hydrodynamic Devices - Maintenance is crucial to the effectiveness of this BMP and should be conducted in accordance with manufacturer recommendations. More frequent cleaning is desired and some sites benefit from keeping a log of removed sediment amount to determine a cleaning schedule. Disposal of removed material will depend on the nature of the drainage area and the intent and function of the water quality insert.

6.7.2-Landscape Restoration - Meadows and Forests are considered low maintenance. They usually require more frequent maintenance in the first few years immediately following installation. Forest restoration areas planted with a proper cover crop can be expected to require annual mowing in order to control invasives. Carefully selected herbicides, mowing, and cutting may be necessary especially in the initial two (2) to three (3) years of growth until the tree canopy begins to form. Meadow management may require a seasonal mowing or burning. Care must be taken to make sure that any management is coordinated with essential reseeding and other important aspects of meadow reestablishment. Weeds must be carefully controlled in the first year and mowed to a height of four (4) to six (6) inches up through the second year. Burn off the meadow when mid-spring arrives in the third season or mow it closely to the ground if this is not possible. Soil exposure to the sun is necessary; therefore, mowed material should be removed to encourage proper “warm season” plant growth.

6.7.3-Soil Amendment & Restoration – The soil restoration process may be repeated over time, due to compaction by use of settling. For example, playfields and park areas will be compacted by foot traffic.

Name: VALLEY FORGE
Date: 07/09/18
Scale: 1 inch = 1,000 ft.

Location: 040° 02' 36.75" N 075° 22' 52.11" W

Datum: NAD27

Custom Soil Resource Report
Soil Map

Map Scale: 1:1,170 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 15 30 60 90

Feet
0 50 100 200 300

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

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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

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

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

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

Soil Survey Area: Delaware County, Pennsylvania
Survey Area Data: Version 14, Nov 27, 2017

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

Date(s) aerial images were photographed: Jul 25, 2014—Aug 11, 2014

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Md	Made land, gabbro and diabase materials	5.7	100.0%
Totals for Area of Interest		**5.7**	**100.0%**

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Delaware County, Pennsylvania

Md—Made land, gabbro and diabase materials

Map Unit Setting

National map unit symbol: 121fx
Elevation: 300 to 2,000 feet
Mean annual precipitation: 36 to 55 inches
Mean annual air temperature: 41 to 62 degrees F
Frost-free period: 110 to 235 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents, unstable fill, and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents, Unstable Fill

Setting

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Acid loamy human transported material derived from interbedded sedimentary rock

Typical profile

C - 0 to 65 inches: extremely channery silt loam

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Glenelg

Percent of map unit: 5 percent
Hydric soil rating: No

PCSM WORKSHEET
PLAN PREPARER RECORD OF TRAINING AND EXPERIENCE IN
POST CONSTRUCTION STORMWATER MANAGEMENT METHODS AND TECHINQUES

NAME OF PLAN PREPARER: Eric A. Britz, P.E.

FORMAL EDUCATION:

Name of College or Technical Institute: Temple University

Curriculum or Program: Environmental Engineering Technology

Dates of Attendance: **From:** Fall 1993 **To:** May 1996

Degree Received: Bachelor of Science

OTHER TRAINING:

Name of Training: _____ **Presented By:** _____

Date: _____ _____

EMPLOYMENT HISTORY:

Current Employer: Bohler Engineering PA, LLC

Telephone: (215) 996-9100

Former Employer: Weeks Marine, Inc.

Telephone: (856) 963-0963

RECENT PCSM PLANS PREPARED:

Name of Project:	Maris Grove	Vertical Screen	PNC Bank
County:	Delaware	Bucks	Montgomery
Municipality:	Concord Township	Warminster Twp.	Whitpain Township
Permit Number:	_____	PAR10D618-R	_____
Approving Agency:	DCCD	BCCD	MCCD

Supporting Calculations

Worksheet 1 . General Site Information

Instructions: Fill out Worksheet 1 for each watershed.

Date: 08/31/2018

Project Name: Wawa Radnor

Municipality: Radnor Township

County: Delaware

Total Area (Acres): 1.5

Major River Basin Delaware River

http://www.pawaterplan.dep.state.pa.us/StateWaterPlan/docroot/default.aspx

Watershed: Darby Creek

Sub-Basin: Darby Creek

Nearest Surface Water(s) to Receive Runoff: Ithan Creek

Chapter 93 - Designated Water Use: CWF (Cold Water Fishes) & MF (Migratory Fish)

http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

Impaired according to Category 4 or 5 of the Integrated Water Quality Monitoring Assessment Report? Yes ☑ No ☐

http://www.portal.state.pa.us/portal/server.pt/community/water_quality_standards/10556/integrated_water_quality_repor

List Causes of Impairment: Water/Flow Variability, Siltation, Habitat Modification, Pathogens

Is there an established TMDL that applies?: Yes ☐ No ☑

Total Maximum Daily Loads(TMDLs):

http://www.dep.state.pa.us/watermanagement_apps/tmdl/

http://www.epa.gov/reg3wapd/tmdl/pa_tmdl/index.htm

Is project subject to, or part of:

Municipal Separate Storm Sewer System (MS4) Requirements? Yes ☑ No ☐

http://www.portal.state.pa.us/portal/server.pt/community/stormwater_management/10628/npdes_ms4%C2%A0information/669119

Existing or planned drinking water supply? Yes ☐ No ☑

If yes, distance from proposed discharge (miles):

Approved Act 167 Plan? Yes ☑ No ☐

http://www.portal.state.pa.us/portal/server.pt?open=514&objID=554325&mode=2

Existing River Conservation Program? Yes ☑ No ☐

http://www.dcnr.state.pa.us/brc/rivers/riversconservation/registry/

Worksheet 2 . Sensitive Resources

Project Name: **Wawa Radnor**

Instructions:

1. Provide Sensitive Resources Map according to non-structural BMP 5.4.1 in Chapter 5. This map should identify wetlands, woodlands, natural drainage ways, steep slopes and other sensitive natural areas.

2. Summarize the existing extent of each sensitive resource in the Existing Sensitive Resources Table (below, using acres). If none present, insert 0.

3. Summarize Total Protected Area as defined under BMPs in Chapter 5.

4. Do not count any area twice. For example, an area that is both a floodplain and a wetland may only be considered once.

Existing Natural Sensitive Resource	Mapped? Yes, No, N/A	Total Area (Ac)	Protected Area (Ac)
Waterbodies			
Floodplains			
Riparian Areas			
Wetlands			
Woodlands			
Natural Drainage Ways			
Steep Slopes, 15%-25%			
Steep Slopes, over 25%			
Other:			
Other:			
Other:			
Total Existing:		**0.00**	**0.00**

Worksheet 3 . Non-Structural BMP Credits

Project Name: **Wawa Radnor**

Protected Area

1.1	Area of Protected Sensitive/Special Value Features (see WS 2)	0.00	Ac
1.2	Area of Riparian Forest Buffer Protection		Ac
3.1	Area of Minimum Disturbance/Reduced Grading		Ac
	Total Protected Area (Ac)	**0.00**	**Ac**

Site Area	*minus*	Protected Area	=	Stormwater Management Area
1.50	-	0.00	=	**1.50**

This is the area that requires stormwater management

Non-Structural Volume Credits

3.1 Minimum Soil Compaction (See Chapter 8, Pg. 22 - SW BMP Manual)

Lawn		s.f.	x	1/4"	x	1/12	=	0.00	cuft
Meadow		s.f.	x	1/3"	x	1/12	=	0.00	cuft

3.3 Protect Existing Trees (See Chapter 8, Pg. 23 - SW BMP Manual)

For trees within 100 feet of impervious area:

Tree Canopy		s.f.	x	1/2"	x	1/12	=	0.00	cuft

5.1 Disconnect Roof Leaders to Vegetated Areas (See Chapter 8, Pg. 25 - SW BMP Manual)

For runoff directed to areas protected under 5.8.1 and 5.8.2

Roof Area		s.f.	x	1/3"	x	1/12	=	0.00	cuft

For all other disconnected roof areas

Roof Area		s.f.	x	1/4"	x	1/12	=	0.00	cuft

5.2 Disconnect Non-Roof Impervious to Vegetated Areas (See Chapter 8, Pg. 26 - SW BMP Manual)

For runoff directed to areas protected under 5.8.1 and 5.8.2

Impervious		s.f.	x	1/3"	x	1/12	=	0.00	cuft

For all other disconnected areas

Impervious		s.f.	x	1/4"	x	1/12	=	0.00	cuft

Total Non-Structural Volume Credit* **0.00** **cuft**

** For Use on Worksheet 5*

Worksheet 4 . Change in Runoff Volume for 2-Year Storm Event

Project Name: **Wawa Radnor**
Drainage Area: **Overall**
2-Year Rainfall: **3.27** in.

Total Site Area: 1.50 Acres
Protected Site Area: 0.00 Acres
Managed Area: 1.50 Acres

Existing Conditions *

Cover Type/Condition	Soil Type	Area (Ac)	CN	S	Ia (0.2 x S)	Q Runoff[1] (in)	Runoff Volume[2] (cuft)
Meadow	C	0.14	71	4.085	0.817	0.920	481.15
Woods, Good Condition	C	0.13	70	4.286	0.857	0.869	403.83
Impervious	C	0.98	98	0.204	0.041	3.037	10,837.73
Impervious (20% considered meadow)	C	0.25	71	4.085	0.817	0.920	821.96
	Total	**1.50**					**12,544.67**

***** *Per Chapter 3, the following must be implemented:*
1. Existing non-forested pervious areas must be considered meadow (good condition) or its equivalent.
2. Twenty-percent (20%) of existing impervious area, when present, shall be considered meadow (good condition).

Developed Conditions

Cover Type/Condition	Soil Type	Area (Ac)	CN	S	Ia (0.2 x S)	Q Runoff[1] (in)	Runoff Volume[2] (cuft)
Open Space (Lawns), Good Condition	C	0.29	74	3.514	0.703	1.084	1,121.35
Impervious	C	1.22	98	0.204	0.041	3.037	13,395.56
	Total	**1.50**					**14,516.92**

2-year Volume Increase = **1,972.25** cuft

2-year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume

1. Runoff (in) = Q = $(P - 0.2S)^2 / (P + 0.8S)$ where:
P = 2-year Rainfall (in)
S = (1000/CN) - 10

2. Runoff Volume (cf) = Q x Area x 1/12
Q = Runoff (in)
Area = Land use area (s.f.)

Note: Runoff Volume must be calculated for EACH land use type/condition and HSGI. The use of a weighted CN value for volume calculations is not acceptable.

Worksheet 4 . Change in Runoff Volume for 2-Year Storm Event

Project Name: **Wawa Radnor**
Drainage Area: **POI#1**
2-Year Rainfall: **3.27** in.

Total Site Area: 1.50 Acres
Protected Site Area: 0.00 Acres
Managed Area: 1.50 Acres

Existing Conditions *

Cover Type/Condition	Soil Type	Area (Ac)	CN	S	Ia (0.2 x S)	Q Runoff[1] (in)	Runoff Volume[2] (cuft)
Meadow	C	0.12	71	4.085	0.817	0.920	390.93
Woods, Good Condition	C	0.13	70	4.286	0.857	0.869	403.83
Impervious	C	0.98	98	0.204	0.041	3.037	10,837.73
Impervious (20% considered meadow)	C	0.25	71	4.085	0.817	0.920	821.96
	Total	**1.47**					**12,454.46**

***** *Per Chapter 3, the following must be implemented:*
1. Existing non-forested pervious areas must be considered meadow (good condition) or its equivalent.
2. Twenty-percent (20%) of existing impervious area, when present, shall be considered meadow (good condition).

Developed Conditions

Cover Type/Condition	Soil Type	Area (Ac)	CN	S	Ia (0.2 x S)	Q Runoff[1] (in)	Runoff Volume[2] (cuft)
Open Space (Lawns), Good Condition	C	0.27	74	3.514	0.703	1.084	1,074.14
Impervious	C	1.22	98	0.204	0.041	3.037	13,395.56
	Total	**1.49**					**14,469.70**

2-year Volume Increase = **2,015.25** cuft

2-year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume

1. Runoff (in) = Q = $(P - 0.2S)^2 / (P + 0.8S)$ where:
P = 2-year Rainfall (in)
S = (1000/CN) - 10

2. Runoff Volume (cf) = Q x Area x 1/12
Q = Runoff (in)
Area = Land use area (s.f.)

Note: Runoff Volume must be calculated for EACH land use type/condition and HSGI. The use of a weighted CN value for volume calculations is not acceptable.

Worksheet 4 . Change in Runoff Volume for 2-Year Storm Event

Project Name: **Wawa Radnor**
Drainage Area: **POI#2**
2-Year Rainfall: **3.27** in.

Total Site Area: 1.50 Acres
Protected Site Area: 0.00 Acres
Managed Area: 1.50 Acres

Existing Conditions *

Cover Type/Condition	Soil Type	Area (Ac)	CN	S	Ia (0.2 x S)	Q Runoff[1] (in)	Runoff Volume[2] (cuft)
Meadow	C	0.03	71	4.085	0.817	0.920	93.56
	Total	**0.03**					**93.56**

** Per Chapter 3, the following must be implemented:*
1. Existing non-forested pervious areas must be considered meadow (good condition) or its equivalent.
2. Twenty-percent (20%) of existing impervious area, when present, shall be considered meadow (good condition).

Developed Conditions

Cover Type/Condition	Soil Type	Area (Ac)	CN	S	Ia (0.2 x S)	Q Runoff[1] (in)	Runoff Volume[2] (cuft)
Open Space (Lawns), Good Condition	C	0.01	74	3.514	0.703	1.084	47.21
	Total	**0.01**					**47.21**

2-year Volume Increase = **-46.34** cuft

2-year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume

1. Runoff (in) = Q = $(P - 0.2S)^2 / (P + 0.8S)$ where:
P = 2-year Rainfall (in)
S = (1000/CN) - 10

2. Runoff Volume (cf) = Q x Area x 1/12
Q = Runoff (in)
Area = Land use area (s.f.)

Note: Runoff Volume must be calculated for EACH land use type/condition and HSGI. The use of a weighted CN value for volume calculations is not acceptable.

Worksheet 4 . Change in Runoff Volume for 2-Year Storm Event

Project Name: **Wawa Radnor**
Drainage Area: **DA to Basin #1**
2-Year Rainfall: **3.27** in.

Total Site Area: 1.50 Acres
Protected Site Area: 0.00 Acres
Managed Area: 1.50 Acres

Existing Conditions *

Cover Type/Condition	Soil Type	Area (Ac)	CN	S	Ia (0.2 x S)	Q Runoff[1] (in)	Runoff Volume[2] (cuft)
	Total						**0.00**

** Per Chapter 3, the following must be implemented:*
1. Existing non-forested pervious areas must be considered meadow (good condition) or its equivalent.
2. Twenty-percent (20%) of existing impervious area, when present, shall be considered meadow (good condition).

Developed Conditions

Cover Type/Condition	Soil Type	Area (Ac)	CN	S	Ia (0.2 x S)	Q Runoff[1] (in)	Runoff Volume[2] (cuft)
Impervious	C	0.49	98	0.204	0.041	3.037	5,446.43
Open Space (Lawns), Good Condition	C	0.02	74	3.514	0.703	1.084	78.69
	Total	**0.51**					**5,525.12**

2-year Volume Increase = **5,525.12** cuft

2-year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume

1. Runoff (in) = Q = $(P - 0.2S)^2 / (P + 0.8S)$ where:
P = 2-year Rainfall (in)
S = (1000/CN) - 10

2. Runoff Volume (cf) = Q x Area x 1/12
Q = Runoff (in)
Area = Land use area (s.f.)

Note: Runoff Volume must be calculated for EACH land use type/condition and HSGI. The use of a weighted CN value for volume calculations is not acceptable.

Worksheet 5 . Structural BMP Volume Credits

Project Name: **Wawa Radnor**
Sub-Basin:

Required Control Volume (ft^3) - *from Worksheet 4:*	1972.25
Non-structural Volume Credit (ft^3) - *from Worksheet 3:* (Maximum is 25% of Required Volume)	- 0
Structural Volume Requirement (ft^3) *(Required Control Volume minus Non-structural Credit)*	**1,972**

	Proposed BMP	Area (ft^2)	Volume Reduction Permanently Removed (ft^3)
6.4.1	Porous Pavement		
6.4.2	Infiltration Basin		
6.4.3	Infiltration Bed		
6.4.4	Infiltration Trench		
6.4.5	Rain Garden/Bioretention		
6.4.6	Dry Well/Seepage Pit		
6.4.7	Constructed Filter		
6.4.8	Vegetated Swale		
6.4.9	Vegetated Filter Strip		
6.4.10	Berm		
6.4.11	Slow Release Concept	22,216	2,781
6.5.1	Vegetated Roof		
6.5.2	Capture and Re-Use		
6.6.1	Constructed Wetlands		
6.6.2	Wet Pond/Retention Basin		
6.7.1	Riparian Buffer / Riparian Forest Buffer Restoration		
6.7.2	Landscape Restoration / Reforestation		
6.7.3	Soil Amendment		
6.8.1	Level Spreader		
6.8.2	Special Storage Areas		
Other			

Total Structural Volume (ft^3):	2,781
Structural Volume Requirement (ft^3):	1,972
DIFFERENCE	**809**

Worksheet 10 . Water Quality Compliance For Nitrate

Project Name: **Wawa Radnor**

Does the site design incorporate the following BMPs to address nitrate pollution? A summary "yes" rating is achieved if at least 2 Primary BMPs for nitrate are provided across the site or 4 secondary BMPs for nitrate are provided across the site (or the equivalent). "Provided across the site" is taken to mean the specifications for that BMP set forward in Sections 5 and 6 are satisfied.

PRIMARY BMPs FOR NITRATE:

	YES	NO
NS BMP 5.4.2 - Protect / Conserve / Enhance Riparian Buffers		X
NS BMP 5.5.4 - Cluster Uses at Each Site		X
NS BMP 5.6.1 - Minimize Total Disturbed Area		X
NS BMP 5.6.3 - Re-Vegetate / Re-Forest Disturbed Areas (Native Species)		X
NS BMP 5.9.1 - Street Sweeping / Vacuuming		X
Structural BMP 6.7.1 - Riparian Buffer Restoration		X
Structural BMP 6.7.2 - Landscape Restoration	X	

SECONDARY BMPs FOR NITRATE:

NS BMP 5.4.1 - Protect Sensitive / Special Value Features		X
NS BMP 5.4.3 - Protect / Utilize Natural Drainage Features		X
NS BMP 5.6.2 - Minimize Soil Compaction	X	
Structural BMP 6.4.5 - Rain Garden / Bioretention		X
Structural BMP 6.4.8 - Vegetated Swale		X
Structural BMP 6.4.9 - Vegetated Filter Strip		X
Structural BMP 6.6.1 - Constructed Wetland		X
Structural BMP 6.7.1 - Riparian Buffer Restoration		X
Structural BMP 6.7.2 - Landscape Restoration		X
Structural BMP 6.7.3 - Soils Amendment / Restoration	X	

Summary of Peak Flow Rates

Project: Wawa - Radnor Township

POI-1 - Runoff Rates On-Site (cfs)

Storm Frequency	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Pre-Development POI #1	5.53	6.58	7.71	8.51	9.44	10.08	10.70
Post-Dev. Basin#1 Outflow	--	0.03	0.03	0.04	0.37	0.56	0.74
Post-Dev. Bypass	--	4.24	4.97	5.48	6.09	6.49	6.89
Overall Post-Development POI #1 Allowed	--	**5.53**	**7.71**	**8.51**	**9.44**	**10.08**	**10.70**
Overall Post-Development Proposed (Combined POI #1)	--	**4.26**	**5.00**	**5.52**	**6.46**	**7.06**	**7.63**

POI-2 - Runoff Rates On-Site (cfs)

Storm Frequency	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Pre-Development POI #2	0.06	0.07	0.08	0.09	0.09	0.10	0.11
Post-Dev. POI #2 Bypass	--	0.03	0.03	0.03	0.04	0.04	0.04
Overall Post-Development POI #2 Allowed	--	**0.06**	**0.08**	**0.09**	**0.09**	**0.10**	**0.11**
Overall Post-Development Proposed POI#2	--	**0.03**	**0.03**	**0.03**	**0.04**	**0.04**	**0.04**

* - Permitted post-development peak rates are based on the requirements of the Radnor Township Chapter 245-25 Stormwater Management Peak Rate Control and Management Districts in the Darby and Cobbs Creeks Watershed, as follows:

District A Peak Rate Requirements
2-yr post-development = 1-yr pre-development
5-yr post-development = 5-yr pre-development
10-yr post-development = 10-yr pre-development
25yr post-development = 25-yr pre-development
50yr post-development = 50-yr pre-development
100-yr post-development = 100-yr pre-development

Runoff Calculations C Worksheet

Project: **Favorite Client**

Description: **Pre & Post-Development Drainage Areas**

Drainage Area	Land Use Description	C	Area (Acres)	Total Area (Acres)	Weighted C
Pre-Dev POI#1	Meadow	0.44	0.12	**1.47**	**0.90**
	Forest	0.45	0.13		
	Impervious	0.99	1.23		
Pre-Dev POI#2	Meadow	0.44	0.03	**0.03**	**0.44**
Post-Dev DA to Basin POI#1	Impervious	0.99	0.49	**0.51**	**0.97**
	Pervious	0.51	0.02		
Post-Dev Bypass POI#1	Pervious	0.51	0.24	**0.98**	**0.87**
	Impervious	0.99	0.74		
Post-Dev Bypass POI#2	Pervious	0.51	0.01	**0.01**	**0.51**

Time of Concentration (Tc) or (Tt) Calculations

Project: **Wawa - Radnor**

Description: **Pre-development**

Note: Space for as many as three segments per flow type can be used for each worksheet.

Sheet Flow ***(Applicable to Tc only)***		**Segment ID**						
1. Surface Description *(table 3-1)*			Dense grasses					
2. Manning's roughness coeff., n *(table 3-1)*								
3. Flow length, L *(total L ≤ 150 ft)*	ft							
4. Two-yr 24-hr rainfall, P_2	in							
5. Land slope, s*	ft/ft							
6. Tt =0.007(nL)$^{0.8}$ / $P_2^{0.5}$s$^{0.4}$	**Compute Tt hr**		+		+		=	
**S is averaged*								

Shallow Concentrated Flow		**Segment ID**	**AB**		**BC**			
7. Surface Description (paved or unpaved)			Paved		Paved			
8. Flow length, L	ft		205		223			
9. Watercourse slope, s*	ft/ft		0.0098		0.0304			
10. Average velocity, V	ft/sec		2.02		3.57			
11. Tt = L / 3600V			**0.0281**	+	**0.0174**	+	=	**0.0455**

Channel Flow		**Segment ID**						
12. Cross sectional flow area, a	ft^2							
13. Wetted perimeter, p	ft							
14. Hydraulic radius, r = a/wp	ft							
15. Channel Slope, s	ft/ft							
16. Manning's roughness coeff., n								
17. V=1.49r$^{2/3}$s$^{1/2}$ / n								
18. Flow length, L	ft							
19. Tt = L / 3600V				+		+	=	
20. Watershed or subarea T_c or T_t (add T_t in steps 6,11, and 19)								**0.0455**

Tc = **2.73** **minutes** ***Minimum is 5 minutes for Rational Method**

Prepared For:		
Name		
Company Name		
Street Address		
City		
State		Zip
Phone		
Fax		
Email		

Project Information:		
Name		
Street Address		
City		
State		Zip
Date:	(mm/dd)	

Engineer:		
Name		
Company Name		
Street Address		
City		
State		Zip
Phone		
Fax		
Email		

Calculations Performed By:		
Name		
Company Name		
Street Address		
City		
State		Zip
Phone		
Fax		
Email		

Input Given Parameters

Unit of Measure	English	
Select Model	Recharger 280HD	
Stone Porosity	40.0%	
Number of Header Systems	1 Header	
Stone Depth **Above** Chamber	6	inches
Stone Depth **Below** Chamber	6	inches
Workable Bed Depth	10.00	feet
Max. Bed Width	30.00	feet
Storage Volume Required	5000.00	cu. feet

Image for visual reference only.May not reflect selected model.

Chamber Specifications		
Height	26.5	inches
Width	47.00	inches
Length	8.00	feet
Installed Length	7.00	feet
Bare Chamber Volume	42.55	cu. feet
Installed Chamber Volume	64.46	cu. feet
Bed Depth	4.13	feet
Bed Width	27.58	feet
Storage Volume Provided	5341.97	cu. feet

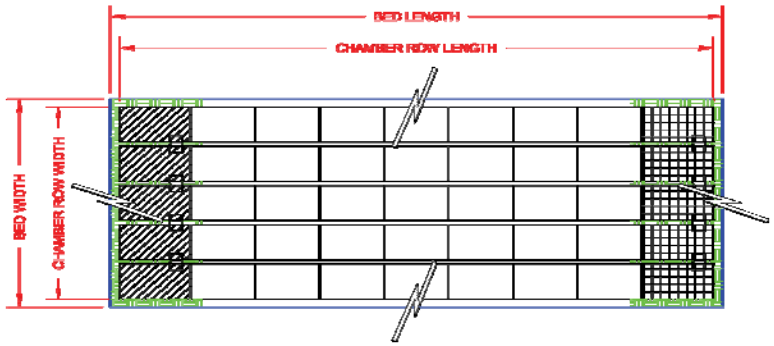
Materials List

Recharger 280HD Stormwater System by CULTEC, Inc.

Approx. Unit Count - not for construction	77	pieces
Actual Number of Chambers Required	78	pieces
Starter Chambers	6	pieces
Intermediate Chambers	66	pieces
End Chambers	6	pieces

HVLV FC-24 Feed Connector	5	pieces
CULTEC No. 410™ Filter Fabric	729.16	sq. yards
CULTEC No. 20L Polyethylene Liner	27.58	feet
Stone	183.75	cu. yards

Bed Detail



Number of Rows Wide	6	pieces
Number of Chambers Long	13	pieces
Chamber Row Width	25.58	feet
Chamber Row Length	92.00	feet
Bed Width	27.58	feet
Bed Length	94.00	feet
Bed Area Required	2592.83	sq. feet

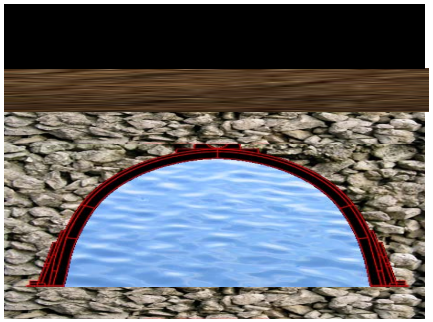
Bed detail for reference only. Not project specific. Not to scale. Use CULTEC StormGenie to output project specific detail.

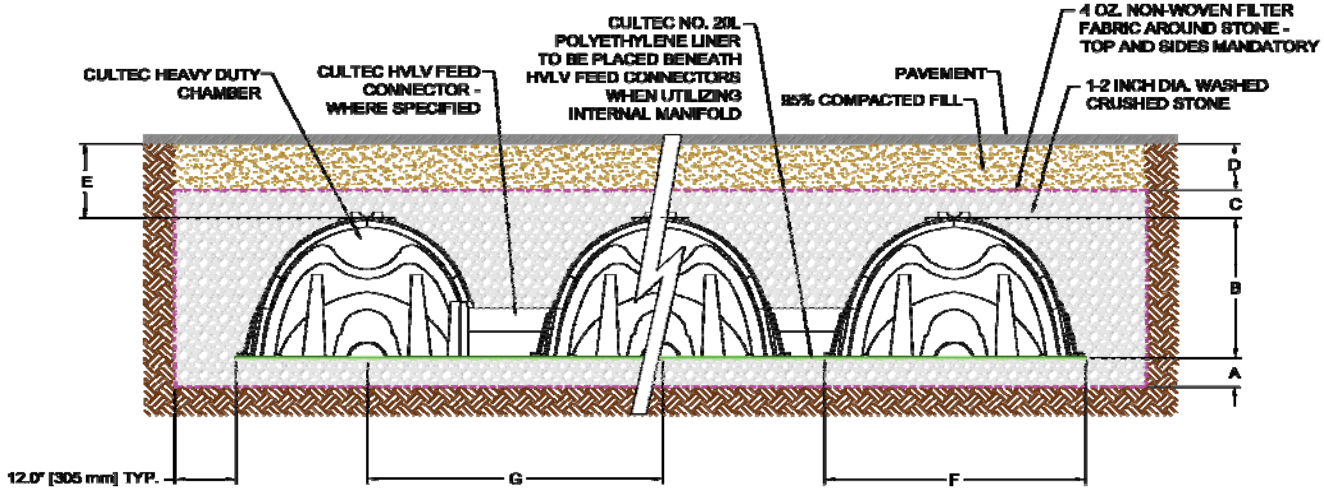
Project Name: Name **Date:** (mm/dd)

Cross Section Detail

Conceptual graphic only. Not job specific.

Recharger 280HD		
Pavement	**12**	inches
95% Compacted Fill	**8**	inches
Stone Above	**6**	inches
Chamber Height	**26.5**	inches
Stone Below	**6**	inches
Effective Depth	**38.5**	inches
Bed Depth	**58.5**	inches





A	Depth of Stone Base	**6.0**	inches
B	Chamber Height	**26.5**	inches
C	Depth of Stone Above Units	**6.0**	inches
D	Depth of 95% Compacted Fill	**8.0**	inches
E	Max. Depth of Cover Allowed Above Crown of Chamber	**12.0**	feet
F	Chamber Width	**47.0**	inches
G	Center to Center Spacing	**4.33**	feet

Breakdown of Storage Provided by Recharger 280HD	Stormwater System	
Chambers	**3355.61**	cu. feet
Feed Connectors	**1.90**	cu. feet
Stone	**1984.47**	cu. feet
Total Storage Provided	**5341.97**	cu. feet

CULTEC, Inc.
P.O. Box 280, Brookfield, CT 06804 USA
Phone: 203-775-4416 - Fax: 203-775-1462 - **www.cultec.com**

CULTEC, Inc.
P.O. Box 280
Brookfield, CT 06804

Phone: 203-775-4416
Fax: 203-775-1462
www.cultec.com
custservice@cultec.com

Project Information: **Date:**

Wawa - Radnor

	Recharger 280HD	
Chamber Model-		
Number of Rows-	6	units
Total number of chambers -	78	units
HVLV FC-24 Feed Connectors-	5	units
Stone Void -	40	%
Stone Base -	6	inches
Stone Above Units -	6	inches
Area -	2592.52	ft^2
Base of Stone Elevation-	359.50	ft

2592.52 Min. Area Required

Note: Min. Area required is based on 12" around the system and typ. spacing

Recharger 280HD Incremental Storage Volumes

Height of System	Chamber Volume	HVLV Feed Connector Volume	Stone Volume	Cumulative Storage Volume	Total Cumulative Storage Volume		Elevation
in	ft^3	ft3	ft^3	ft^3	ft^3	Acre-ft	ft
38.5	0.00	0.00	86.42	86.42	5342.18	0.12264	362.71
37.5	0.00	0.00	86.42	86.42	5255.77	0.12066	362.63
36.5	0.00	0.00	86.42	86.42	5169.35	0.11867	362.54
35.5	0.00	0.00	86.42	86.42	5082.93	0.11669	362.46
34.5	0.00	0.00	86.42	86.42	4996.52	0.11470	362.38
33.5	0.00	0.00	86.42	86.42	4910.10	0.11272	362.29
32.5	0.06	0.00	43.19	43.24	4823.68	0.11074	362.21
32	9.94	0.00	82.44	92.38	4780.44	0.10974	362.17
31	25.94	0.00	76.04	101.98	4688.06	0.10762	362.08
30	55.20	0.00	64.34	119.54	4586.08	0.10528	362.00
29	73.97	0.00	56.83	130.80	4466.54	0.10254	361.92
28	87.77	0.00	51.31	139.08	4335.74	0.09954	361.83
27	98.81	0.00	46.89	145.70	4196.66	0.09634	361.75
26	107.64	0.00	43.36	151.00	4050.96	0.09300	361.67
25	115.37	0.00	40.27	155.64	3899.96	0.08953	361.58
24	121.99	0.00	37.62	159.61	3744.32	0.08596	361.50
23	128.06	0.00	35.19	163.26	3584.71	0.08229	361.42
22	133.03	0.00	33.20	166.24	3421.45	0.07855	361.33
21	137.45	0.00	31.44	168.89	3255.22	0.07473	361.25
20	145.18	0.00	28.35	173.52	3086.33	0.07085	361.17
19	147.38	0.00	27.46	174.85	2912.81	0.06687	361.08
18	149.59	0.23	26.58	176.40	2737.96	0.06286	361.00
17	151.80	0.19	25.70	177.69	2561.56	0.05881	360.92
16	154.01	0.18	24.81	179.00	2383.87	0.05473	360.83
15	158.42	0.18	23.05	181.65	2204.87	0.05062	360.75
14	161.18	0.17	21.94	183.30	2023.22	0.04645	360.67
13	162.29	0.17	21.50	183.96	1839.91	0.04224	360.58
12	168.36	0.16	19.07	187.59	1655.96	0.03802	360.50
11	168.91	0.15	18.85	187.91	1468.37	0.03371	360.42
10	170.02	0.13	18.41	188.56	1280.46	0.02940	360.33
9	171.12	0.10	17.97	189.19	1091.90	0.02507	360.25
8	172.22	0.04	17.53	189.79	902.71	0.02072	360.17
7	179.95	0.03	14.44	194.42	712.92	0.01637	360.08
6	0.00	0.00	86.42	86.42	518.50	0.01190	360.00
5	0.00	0.00	86.42	86.42	432.09	0.00992	359.92
4	0.00	0.00	86.42	86.42	345.67	0.00794	359.83
3	0.00	0.00	86.42	86.42	259.25	0.00595	359.75
2	0.00	0.00	86.42	86.42	172.83	0.00397	359.67
1	0.00	0.00	86.42	86.42	86.42	0.00198	359.58
0	0.00	0.00	0.00	0.00	0.00	0.00000	359.50

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	Dekalb	------	5.529	6.575	-------	7.713	8.505	9.444	10.08	10.70	Pre-Dev POI#1
2	Dekalb	------	0.055	0.066	-------	0.077	0.085	0.094	0.101	0.107	Pre-Dev POI#2
4	Dekalb	------	2.067	2.459	-------	2.884	3.180	3.531	3.768	3.999	Post-Dev to Basin #1 (POI#1)
5	Dekalb	------	3.563	4.237	-------	4.971	5.481	6.086	6.493	6.893	Post-Dev Bypass POI#1
6	Dekalb	------	0.021	0.025	-------	0.030	0.033	0.036	0.039	0.041	Post-Dev Bypass POI#2
8	Reservoir	4	0.024	0.027	-------	0.030	0.041	0.373	0.563	0.740	Basin Routed

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Dekalb	5.529	1	25	4,960	------	------	------	Pre-Dev POI#1
2	Dekalb	0.055	1	25	49	------	------	------	Pre-Dev POI#2
4	Dekalb	2.067	1	25	1,854	------	------	------	Post-Dev to Basin #1 (POI#1)
5	Dekalb	3.563	1	25	3,196	------	------	------	Post-Dev Bypass POI#1
6	Dekalb	0.021	1	25	19	------	------	------	Post-Dev Bypass POI#2
8	Reservoir	0.024	1	50	1,796	4	360.91	1,811	Basin Routed

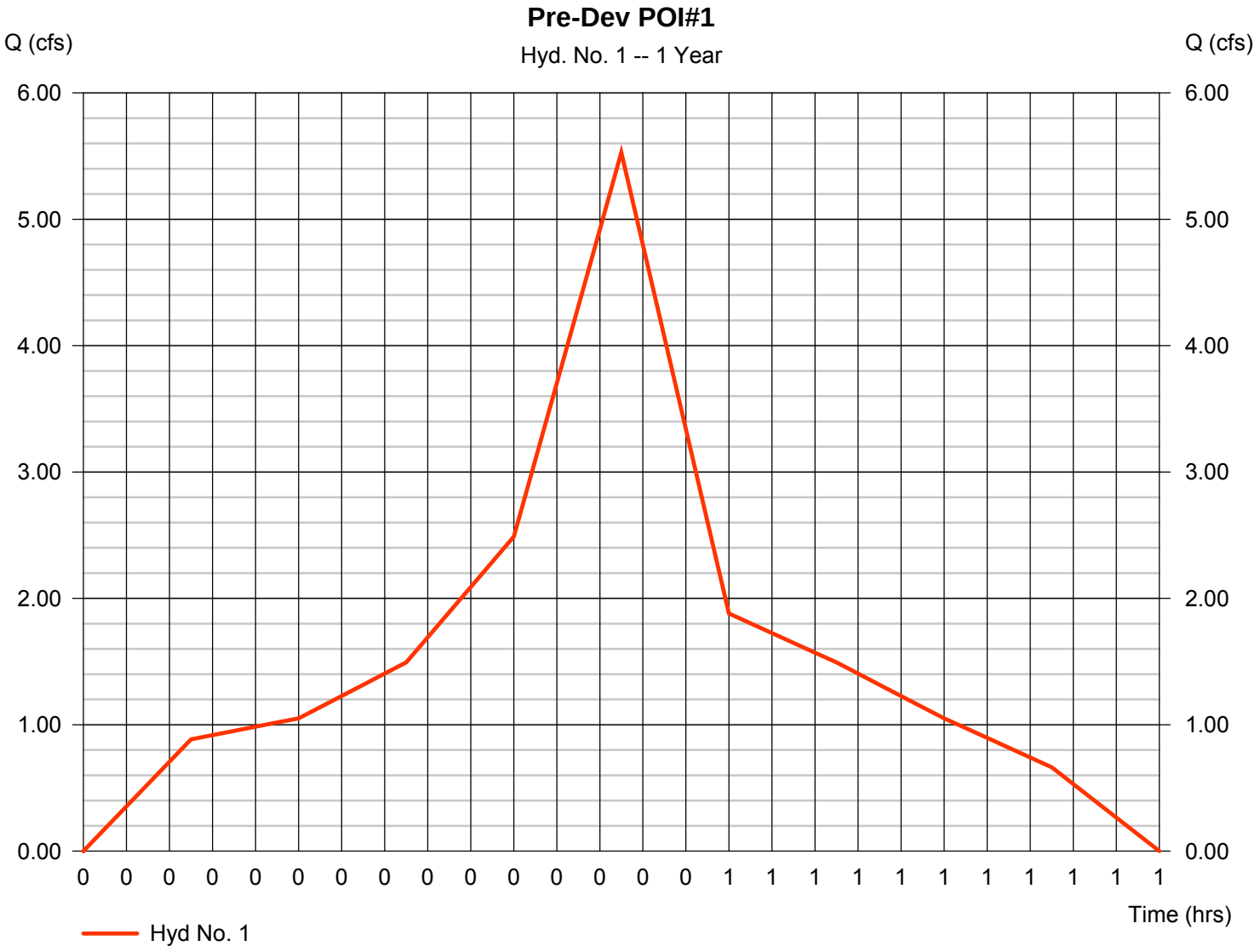
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 1

Pre-Dev POI#1

Hydrograph type	= Dekalb	Peak discharge	= 5.529 cfs
Storm frequency	= 1 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 4,960 cuft
Drainage area	= 1.470 ac	Runoff coeff.	= 0.9
Intensity	= 4.179 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



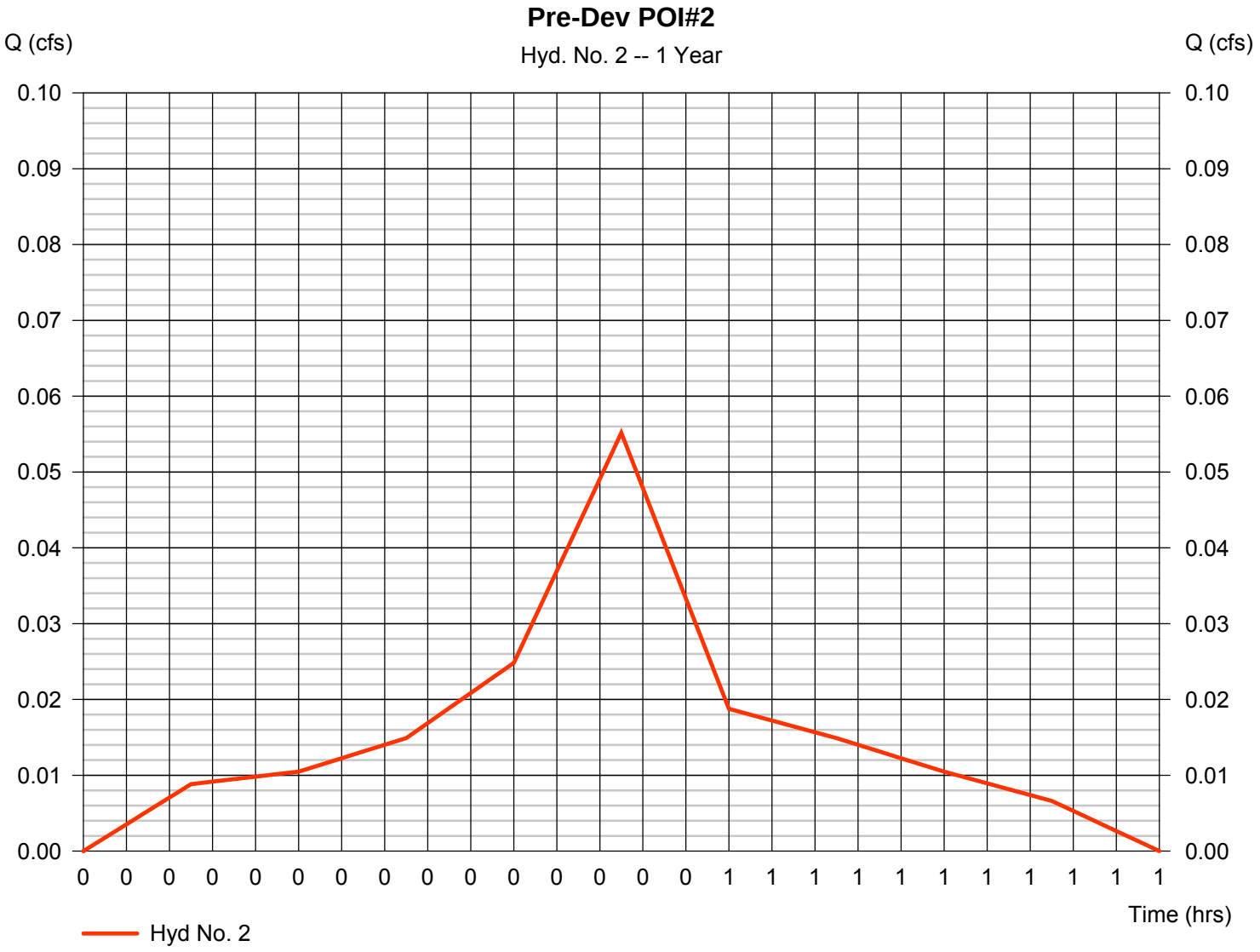
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 2

Pre-Dev POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.055 cfs
Storm frequency	= 1 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 49 cuft
Drainage area	= 0.030 ac	Runoff coeff.	= 0.44
Intensity	= 4.179 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



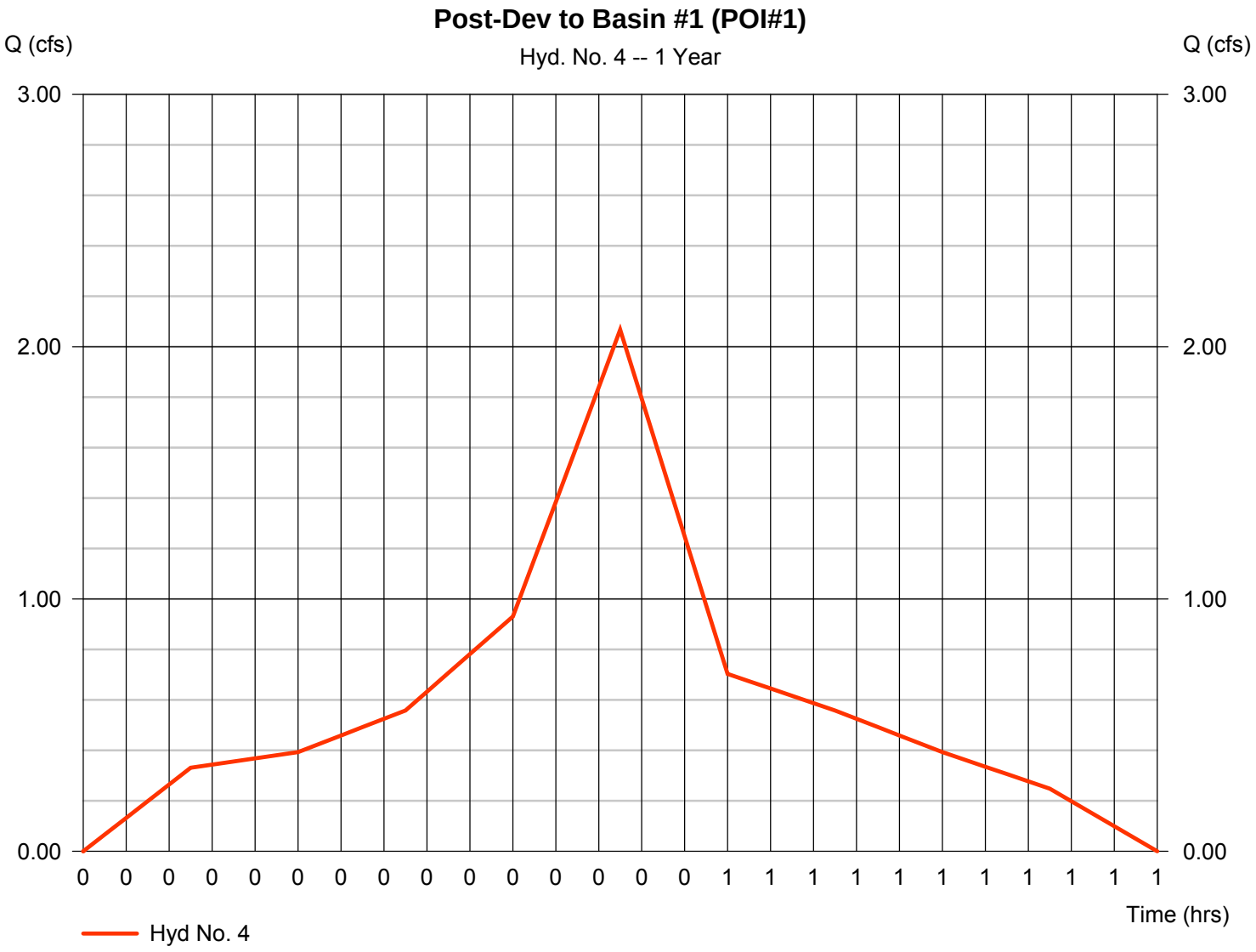
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 4

Post-Dev to Basin #1 (POI#1)

Hydrograph type	= Dekalb	Peak discharge	= 2.067 cfs
Storm frequency	= 1 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 1,854 cuft
Drainage area	= 0.510 ac	Runoff coeff.	= 0.97
Intensity	= 4.179 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a

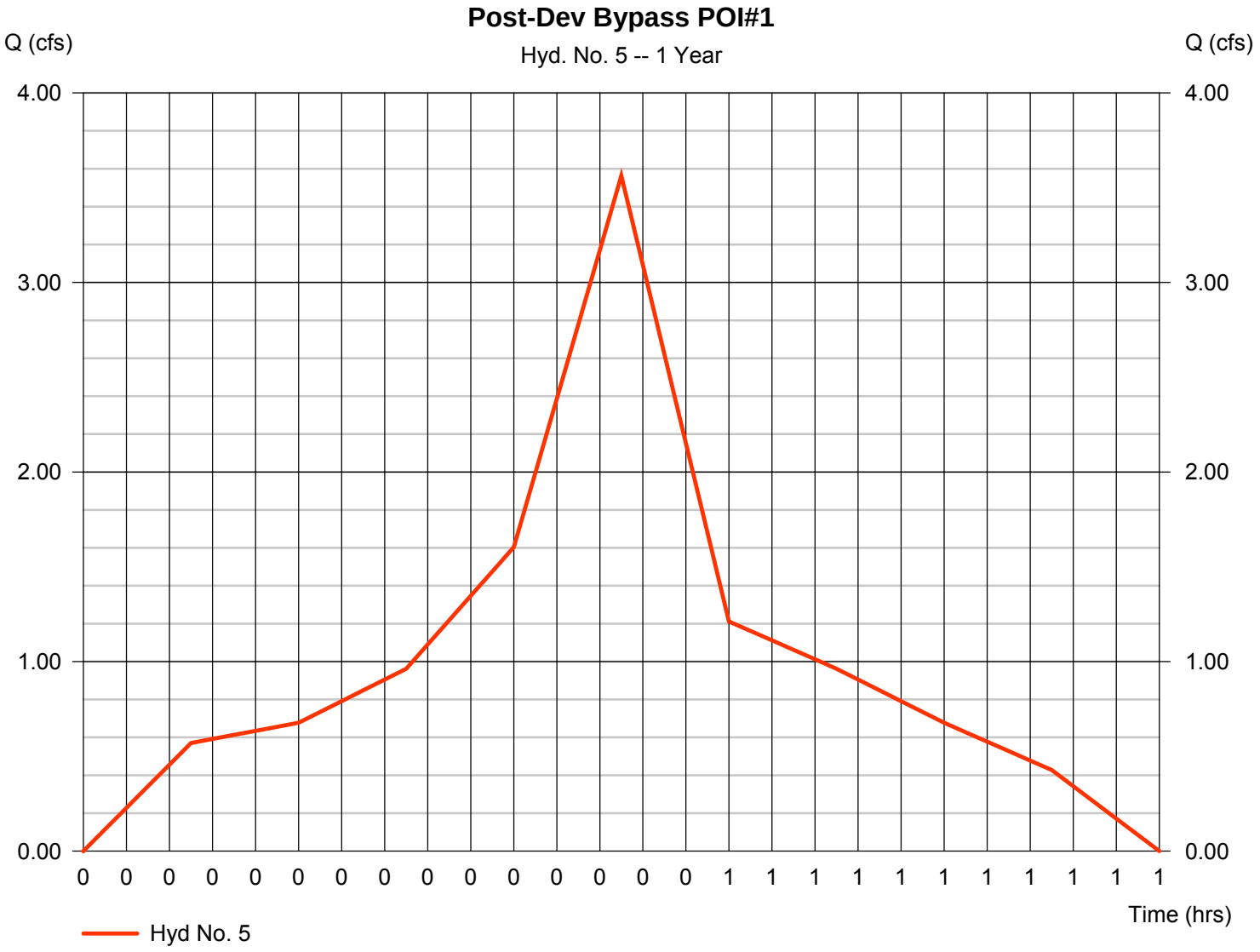


Hydrograph Report

Hyd. No. 5

Post-Dev Bypass POI#1

Hydrograph type	= Dekalb	Peak discharge	= 3.563 cfs
Storm frequency	= 1 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 3,196 cuft
Drainage area	= 0.980 ac	Runoff coeff.	= 0.87
Intensity	= 4.179 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



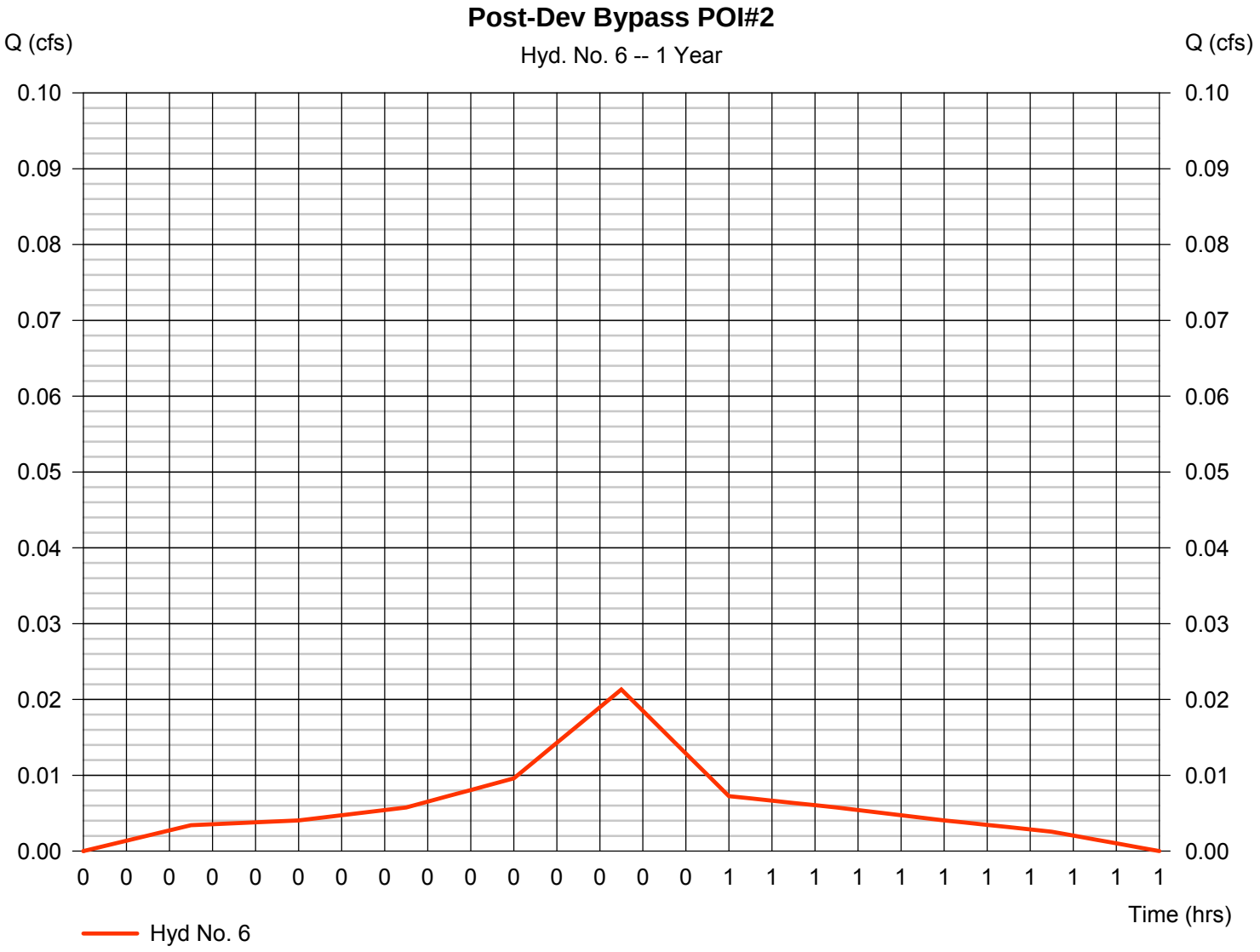
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 6

Post-Dev Bypass POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.021 cfs
Storm frequency	= 1 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 19 cuft
Drainage area	= 0.010 ac	Runoff coeff.	= 0.51
Intensity	= 4.179 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



Hydrograph Report

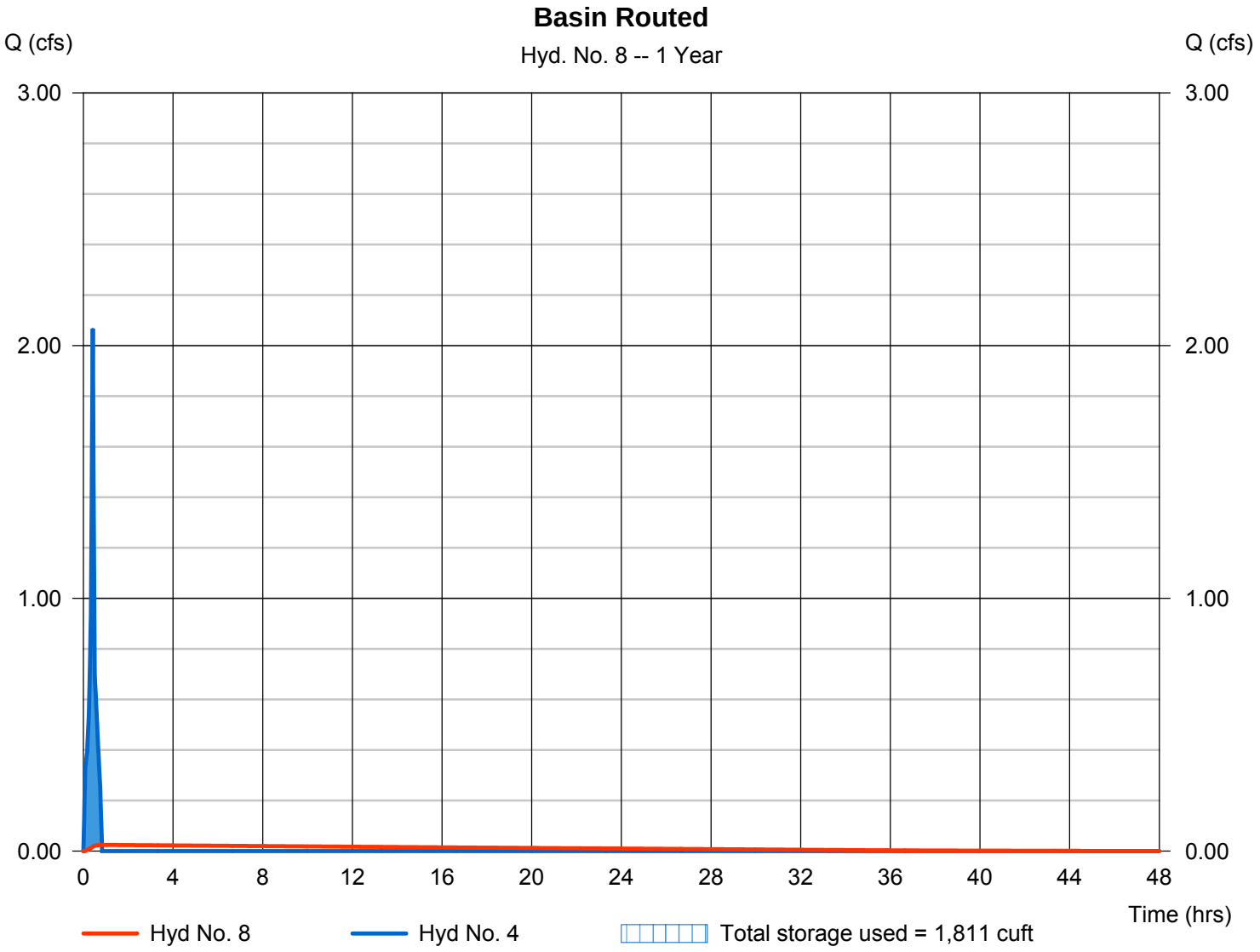
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 8

Basin Routed

Hydrograph type	= Reservoir	Peak discharge	= 0.024 cfs
Storm frequency	= 1 yrs	Time to peak	= 0.83 hrs
Time interval	= 1 min	Hyd. volume	= 1,796 cuft
Inflow hyd. No.	= 4 - Post-Dev to Basin #1 (POI #1)	Max. Elevation	= 360.91 ft
Reservoir name	= Basin #1	Max. Storage	= 1,811 cuft

Storage Indication method used.



Pond Report

Pond No. 1 - Basin #1

Pond Data

Pond storage is based on user-defined values.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	360.00	n/a	0	0
0.17	360.17	n/a	352	352
0.33	360.33	n/a	341	693
0.50	360.50	n/a	337	1,031
0.67	360.67	n/a	323	1,354
0.83	360.83	n/a	312	1,666
1.00	361.00	n/a	301	1,968
1.17	361.17	n/a	293	2,260
1.33	361.33	n/a	270	2,531
1.50	361.50	n/a	250	2,781
1.67	361.67	n/a	223	3,004
1.83	361.83	n/a	187	3,191
2.00	362.00	n/a	129	3,320
2.17	362.17	n/a	36	3,356
2.29	362.29	n/a	0	3,356

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 18.00	1.00	0.00	0.00
Span (in)	= 18.00	1.00	0.00	0.00
No. Barrels	= 1	1	0	0
Invert El. (ft)	= 357.50	360.00	0.00	0.00
Length (ft)	= 89.00	0.00	0.00	0.00
Slope (%)	= 1.05	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	No	No

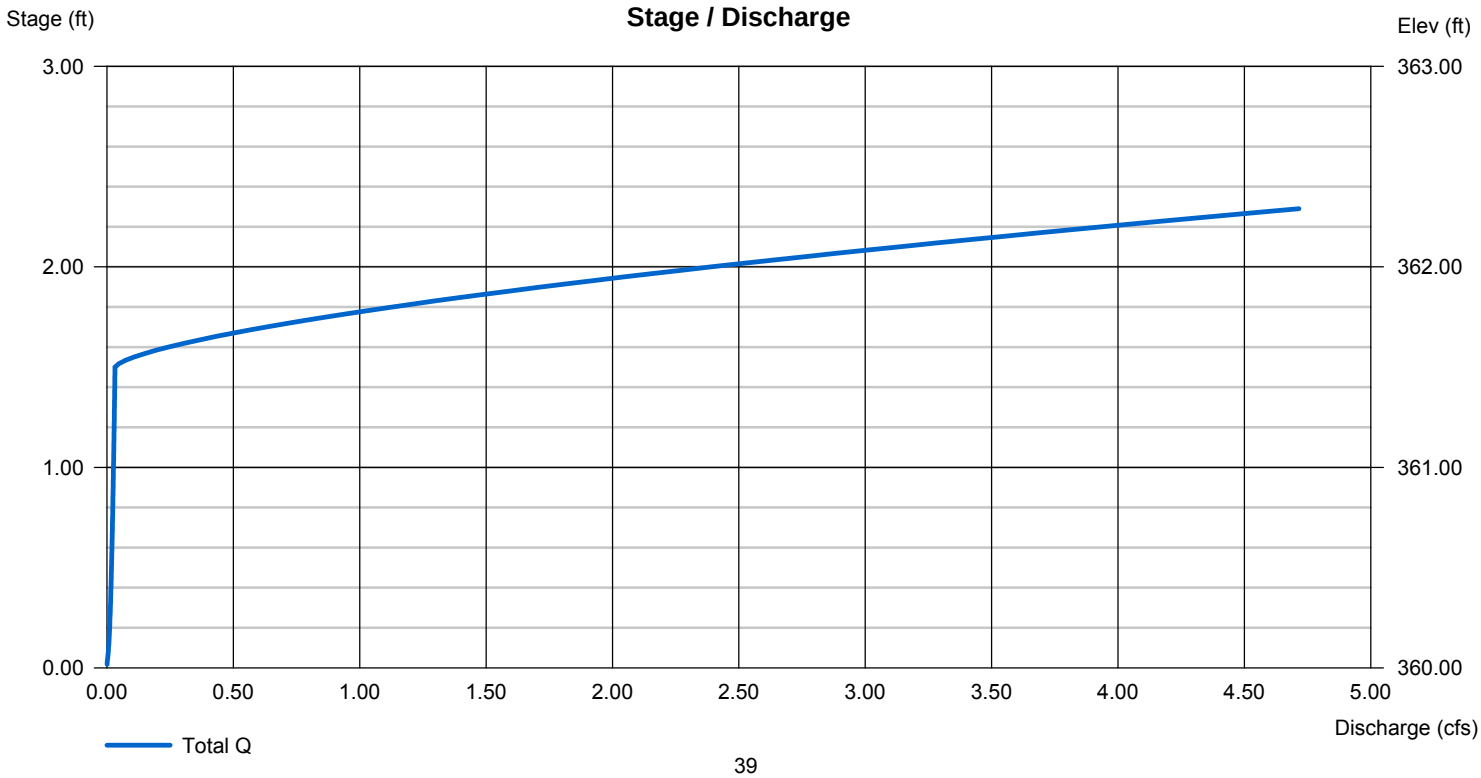
Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 2.00	0.00	0.00	0.00
Crest El. (ft)	= 361.50	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Rect	---	---	---
Multi-Stage	= Yes	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Dekalb	6.575	1	25	5,898	------	------	------	Pre-Dev POI#1
2	Dekalb	0.066	1	25	59	------	------	------	Pre-Dev POI#2
4	Dekalb	2.459	1	25	2,205	------	------	------	Post-Dev to Basin #1 (POI#1)
5	Dekalb	4.237	1	25	3,801	------	------	------	Post-Dev Bypass POI#1
6	Dekalb	0.025	1	25	23	------	------	------	Post-Dev Bypass POI#2
8	Reservoir	0.027	1	50	2,146	4	361.11	2,157	Basin Routed

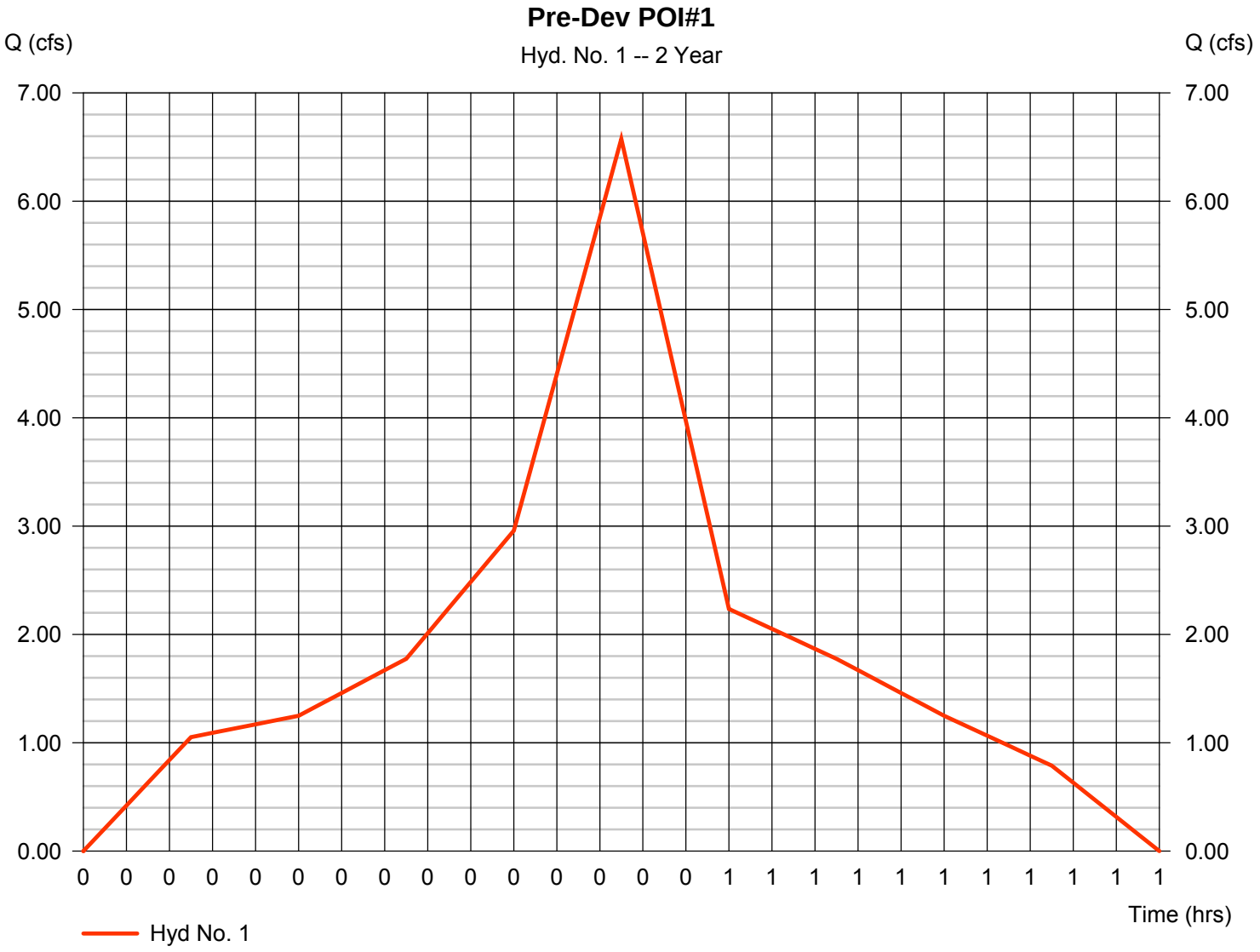
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 1

Pre-Dev POI#1

Hydrograph type	= Dekalb	Peak discharge	= 6.575 cfs
Storm frequency	= 2 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 5,898 cuft
Drainage area	= 1.470 ac	Runoff coeff.	= 0.9
Intensity	= 4.970 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



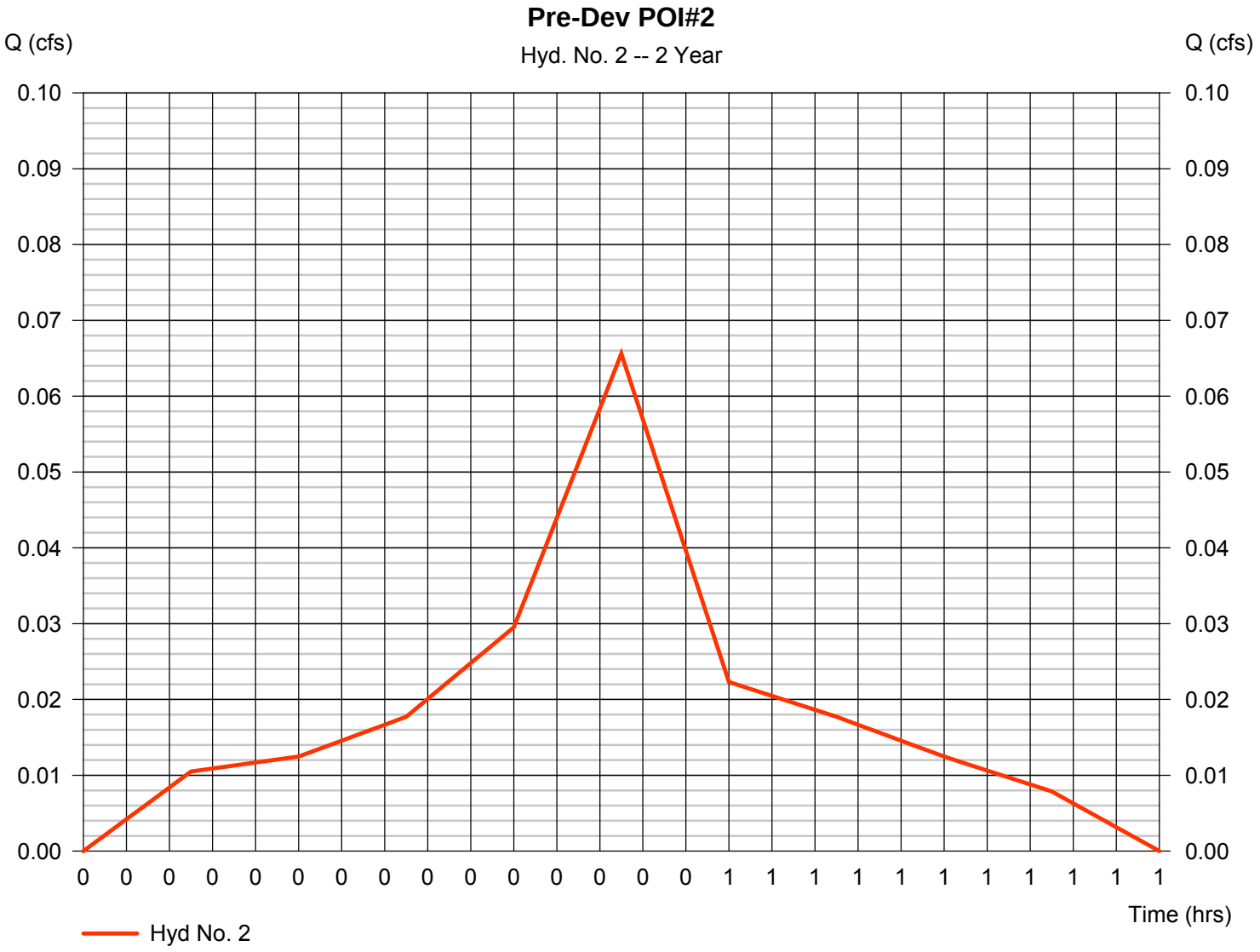
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 2

Pre-Dev POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.066 cfs
Storm frequency	= 2 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 59 cuft
Drainage area	= 0.030 ac	Runoff coeff.	= 0.44
Intensity	= 4.970 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



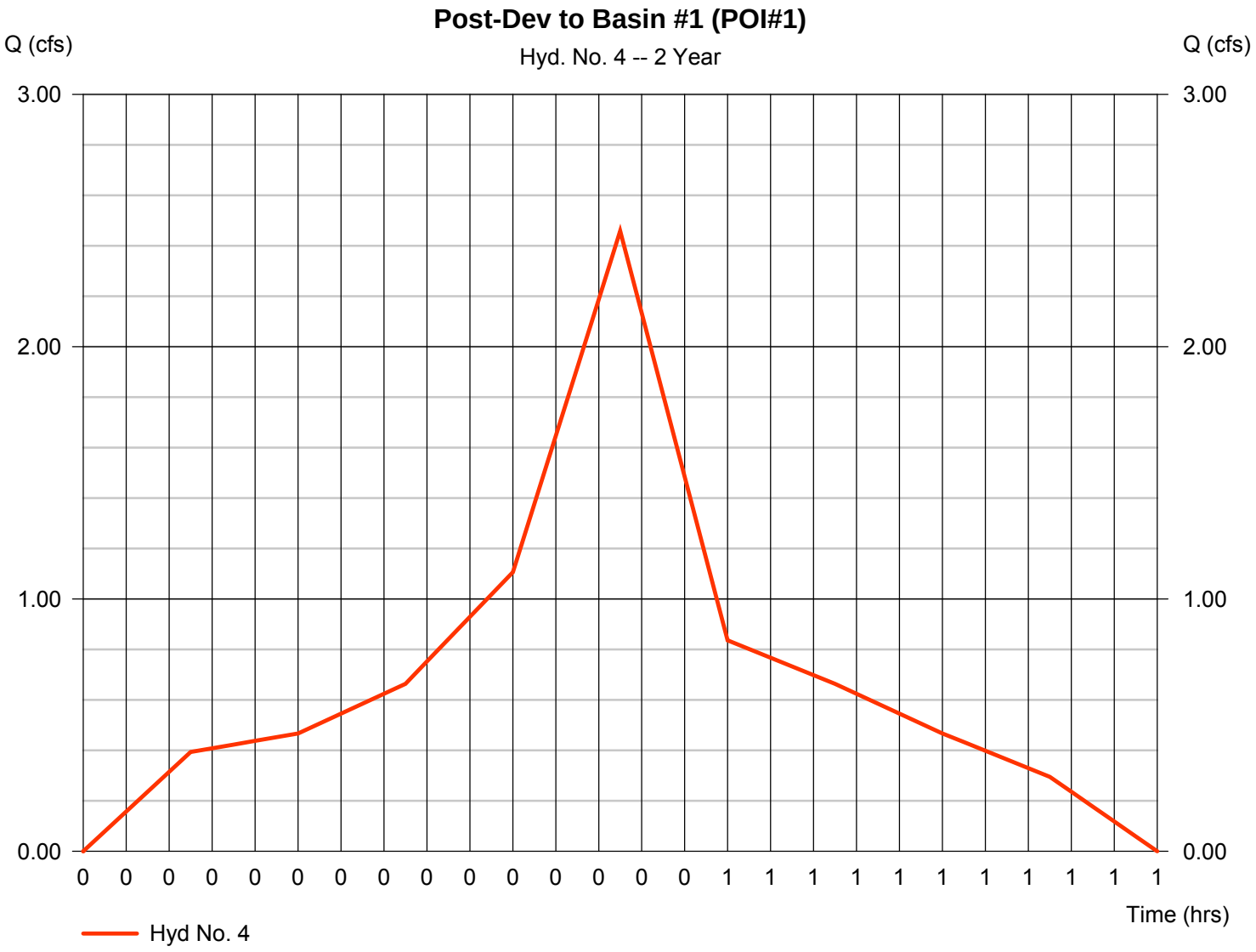
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 4

Post-Dev to Basin #1 (POI#1)

Hydrograph type	= Dekalb	Peak discharge	= 2.459 cfs
Storm frequency	= 2 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 2,205 cuft
Drainage area	= 0.510 ac	Runoff coeff.	= 0.97
Intensity	= 4.970 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



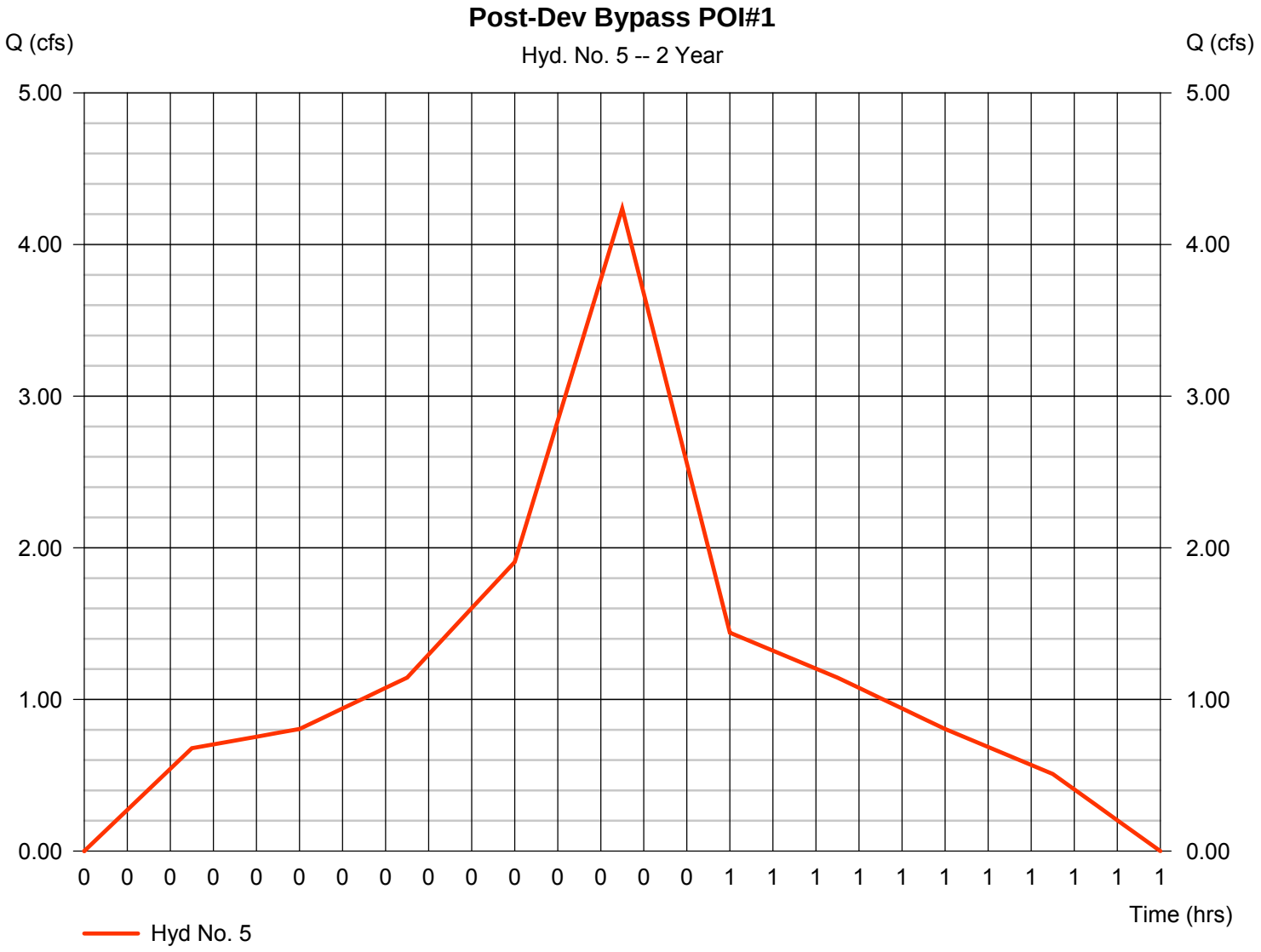
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 5

Post-Dev Bypass POI#1

Hydrograph type	= Dekalb	Peak discharge	= 4.237 cfs
Storm frequency	= 2 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 3,801 cuft
Drainage area	= 0.980 ac	Runoff coeff.	= 0.87
Intensity	= 4.970 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



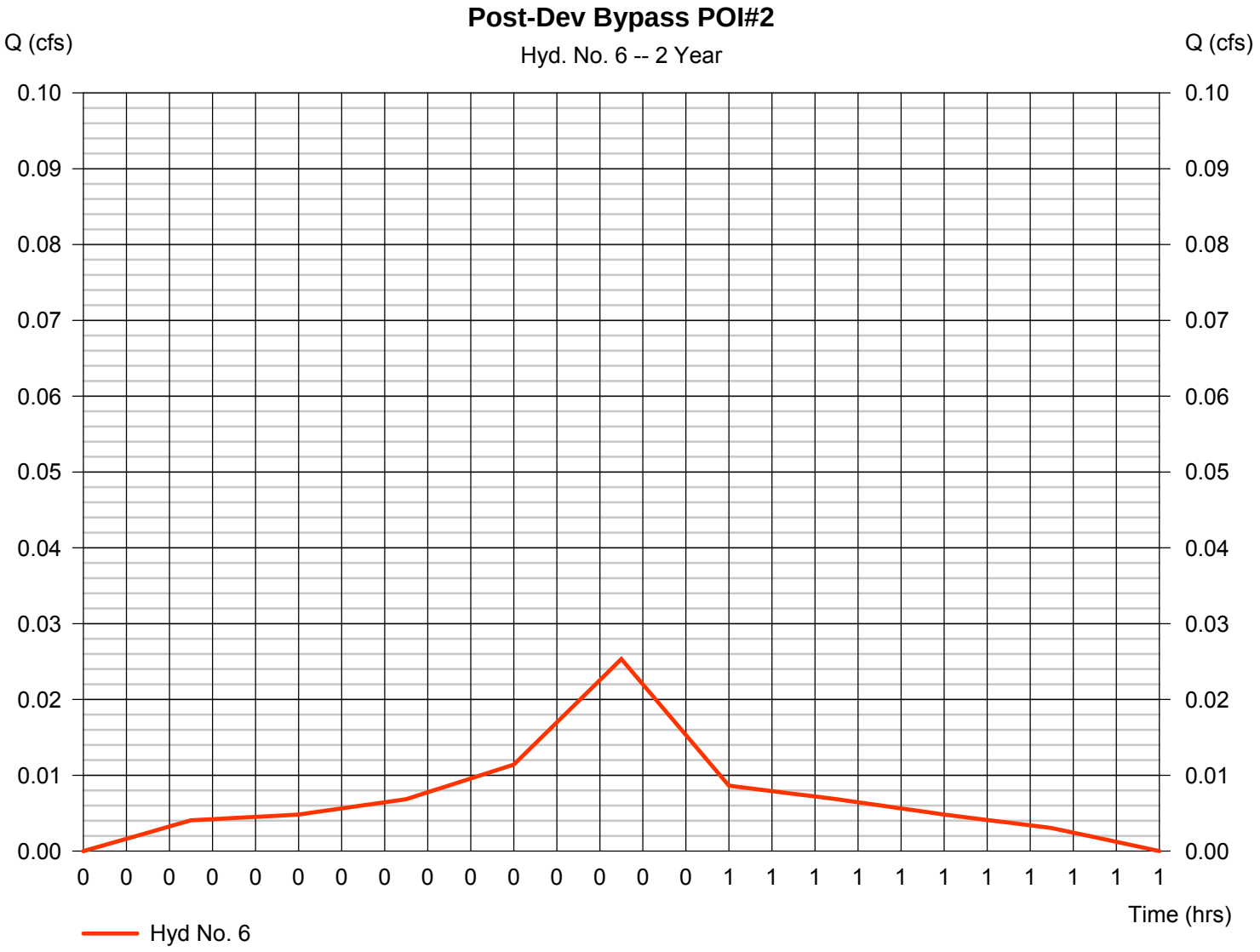
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 6

Post-Dev Bypass POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.025 cfs
Storm frequency	= 2 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 23 cuft
Drainage area	= 0.010 ac	Runoff coeff.	= 0.51
Intensity	= 4.970 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



Hydrograph Report

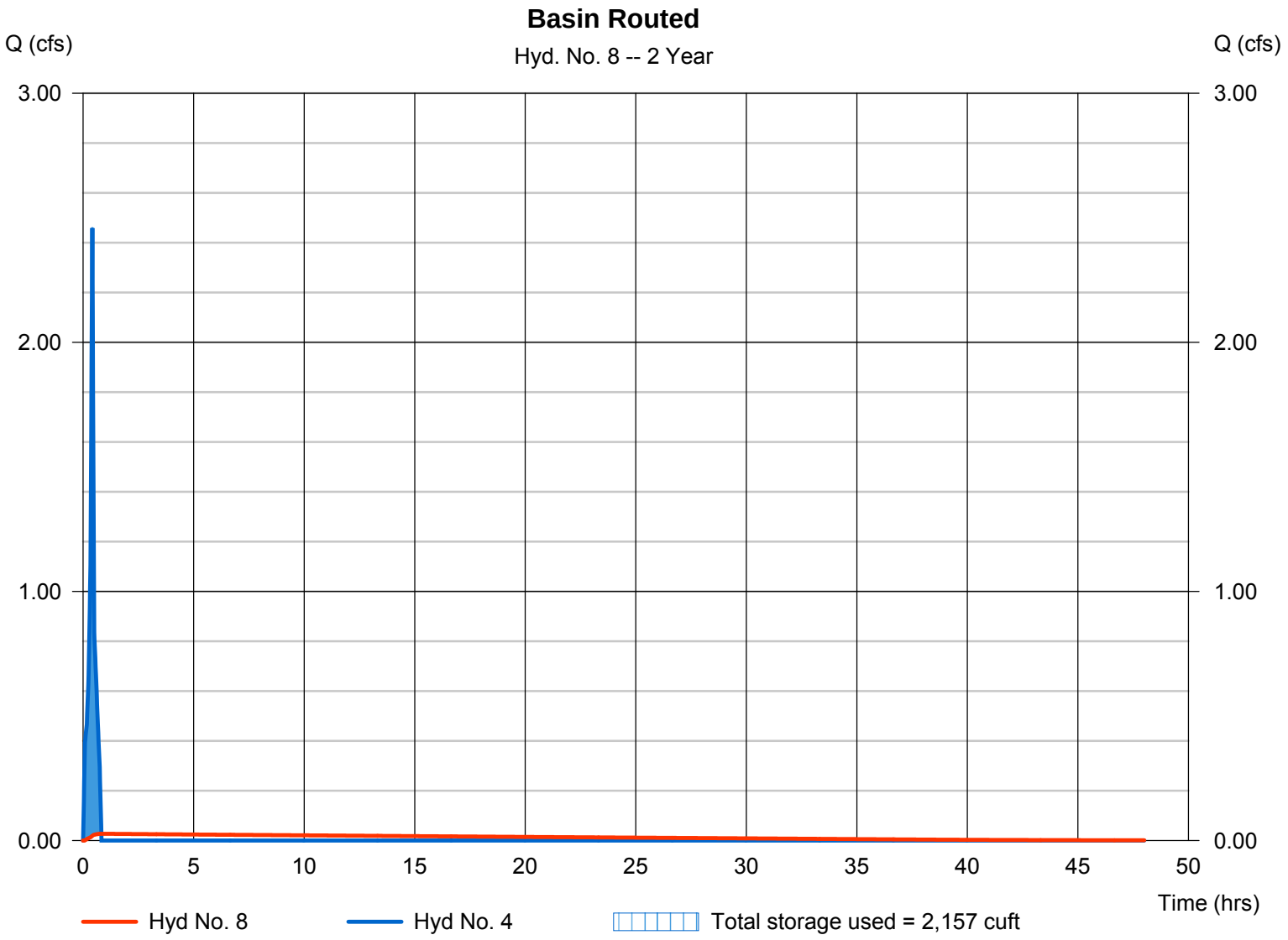
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 8

Basin Routed

Hydrograph type	= Reservoir	Peak discharge	= 0.027 cfs
Storm frequency	= 2 yrs	Time to peak	= 0.83 hrs
Time interval	= 1 min	Hyd. volume	= 2,146 cuft
Inflow hyd. No.	= 4 - Post-Dev to Basin #1 (POI #1)	Max. Elevation	= 361.11 ft
Reservoir name	= Basin #1	Max. Storage	= 2,157 cuft

Storage Indication method used.



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Dekalb	7.713	1	25	6,918	------	------	------	Pre-Dev POI#1
2	Dekalb	0.077	1	25	69	------	------	------	Pre-Dev POI#2
4	Dekalb	2.884	1	25	2,587	------	------	------	Post-Dev to Basin #1 (POI#1)
5	Dekalb	4.971	1	25	4,459	------	------	------	Post-Dev Bypass POI#1
6	Dekalb	0.030	1	25	27	------	------	------	Post-Dev Bypass POI#2
8	Reservoir	0.030	1	50	2,512	4	361.33	2,533	Basin Routed

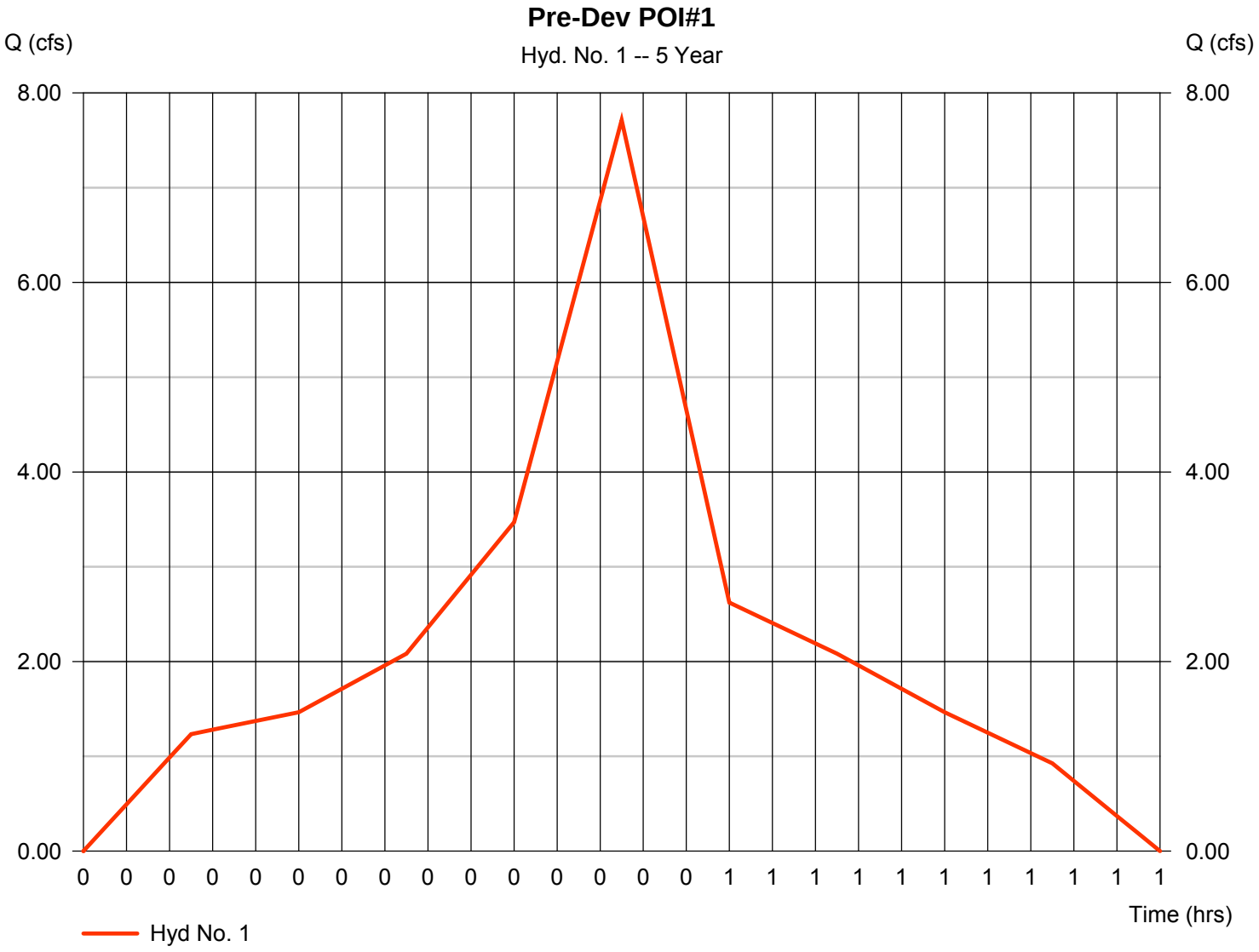
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 1

Pre-Dev POI#1

Hydrograph type	= Dekalb	Peak discharge	= 7.713 cfs
Storm frequency	= 5 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 6,918 cuft
Drainage area	= 1.470 ac	Runoff coeff.	= 0.9
Intensity	= 5.830 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



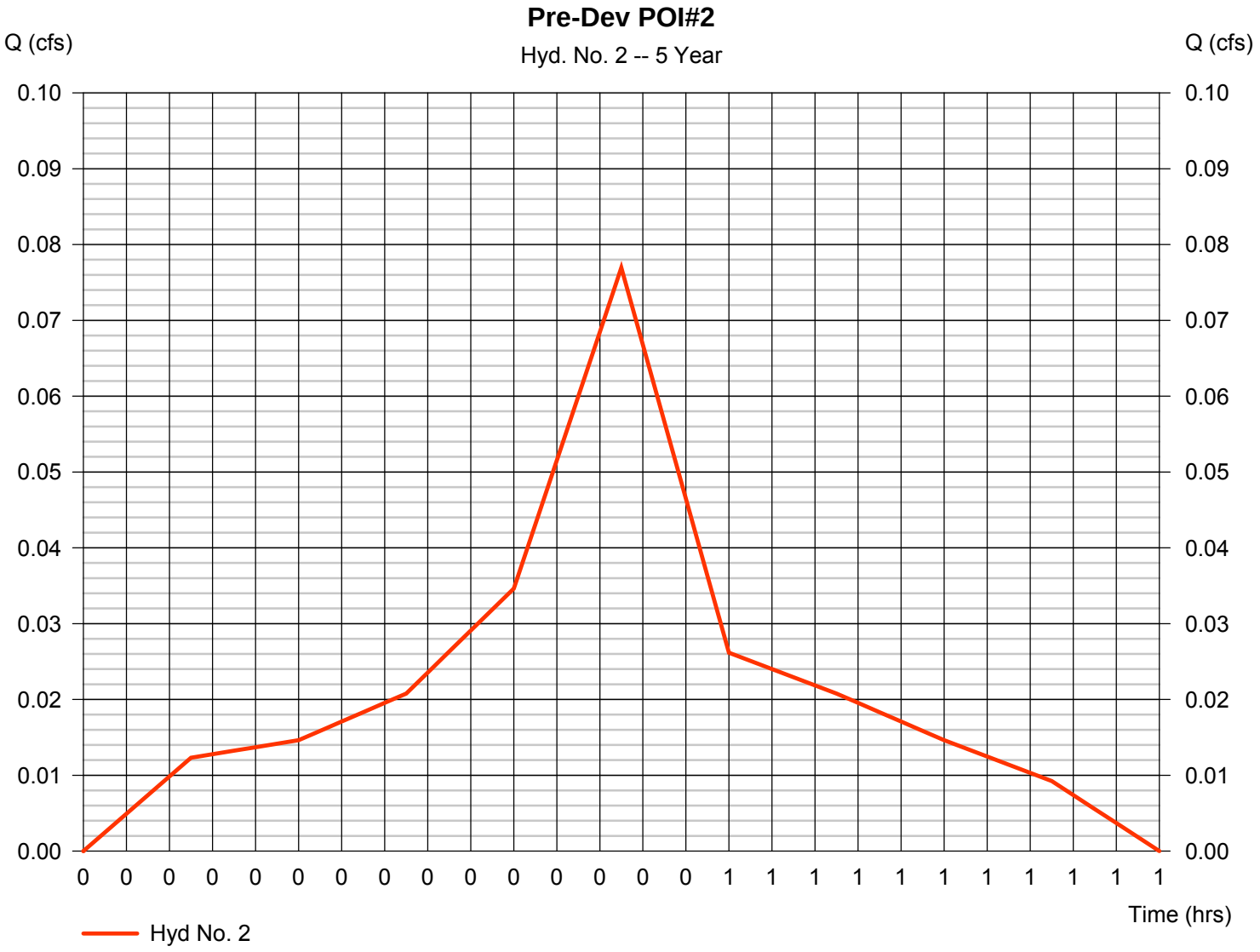
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 2

Pre-Dev POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.077 cfs
Storm frequency	= 5 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 69 cuft
Drainage area	= 0.030 ac	Runoff coeff.	= 0.44
Intensity	= 5.830 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



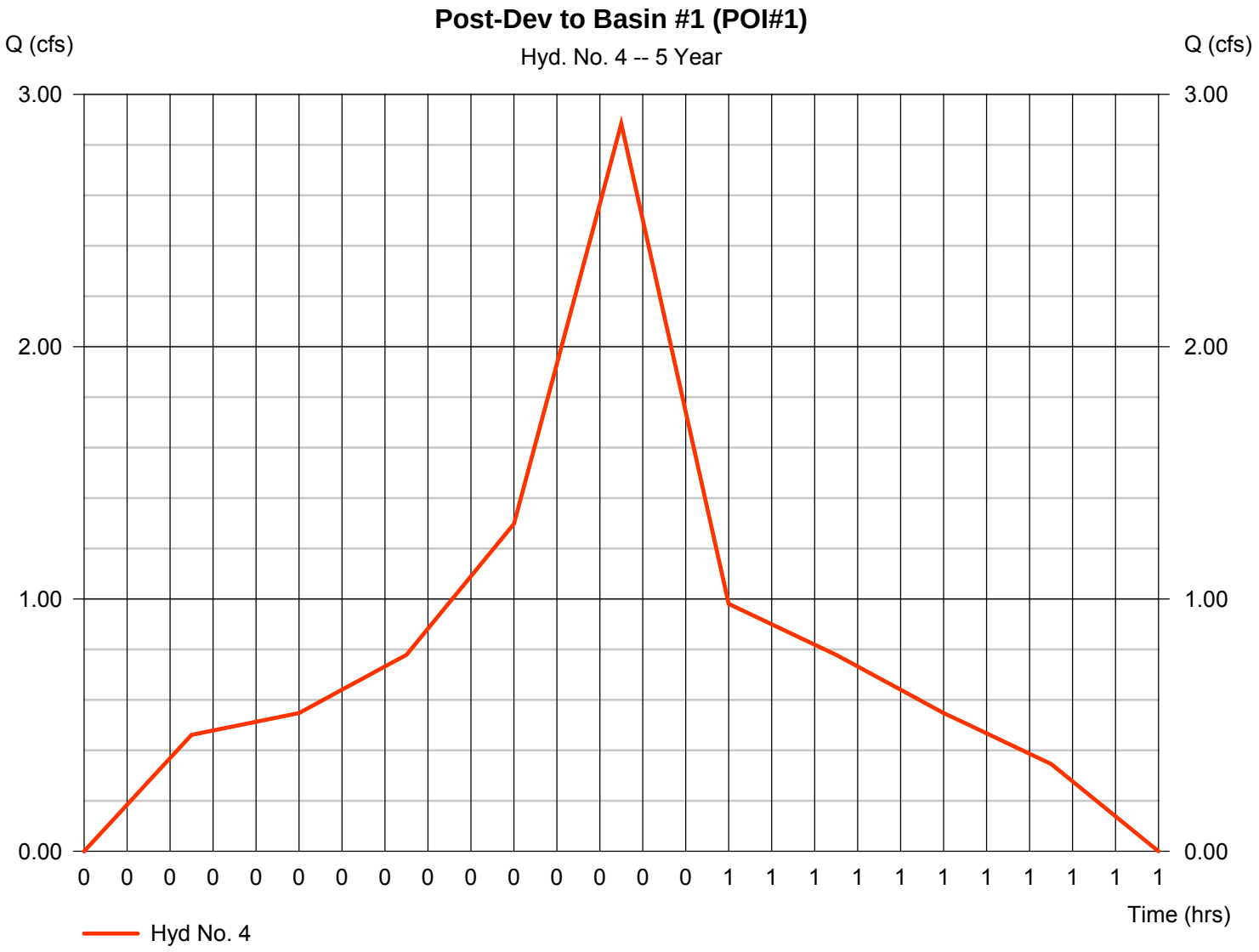
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 4

Post-Dev to Basin #1 (POI#1)

Hydrograph type	=	Dekalb	Peak discharge	=	2.884 cfs
Storm frequency	=	5 yrs	Time to peak	=	0.42 hrs
Time interval	=	1 min	Hyd. volume	=	2,587 cuft
Drainage area	=	0.510 ac	Runoff coeff.	=	0.97
Intensity	=	5.830 in/hr	Tc by User	=	5.00 min
IDF Curve	=	Hilltown.IDF	Asc/Rec limb fact	=	n/a

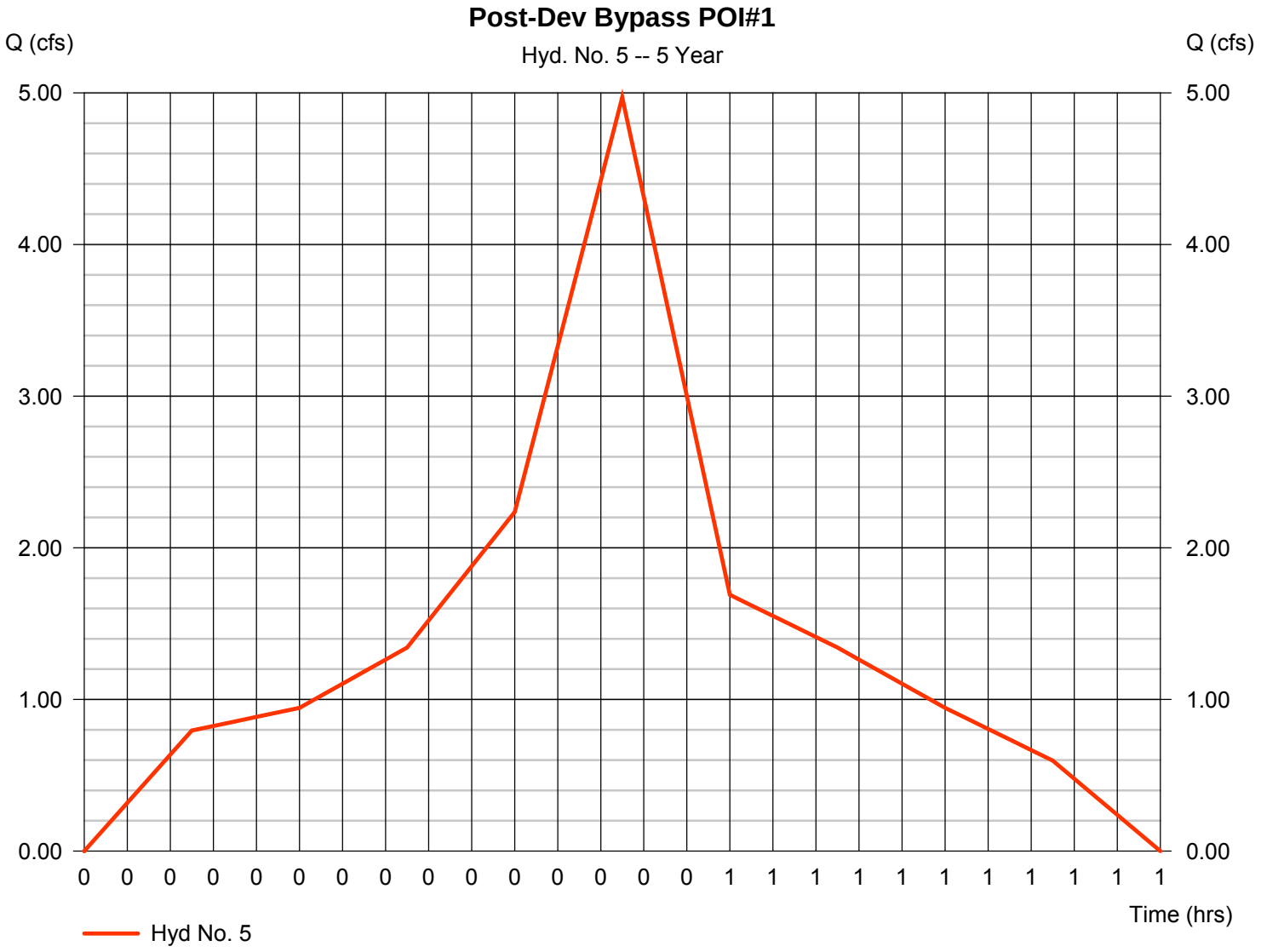


Hydrograph Report

Hyd. No. 5

Post-Dev Bypass POI#1

Hydrograph type	= Dekalb	Peak discharge	= 4.971 cfs
Storm frequency	= 5 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 4,459 cuft
Drainage area	= 0.980 ac	Runoff coeff.	= 0.87
Intensity	= 5.830 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a

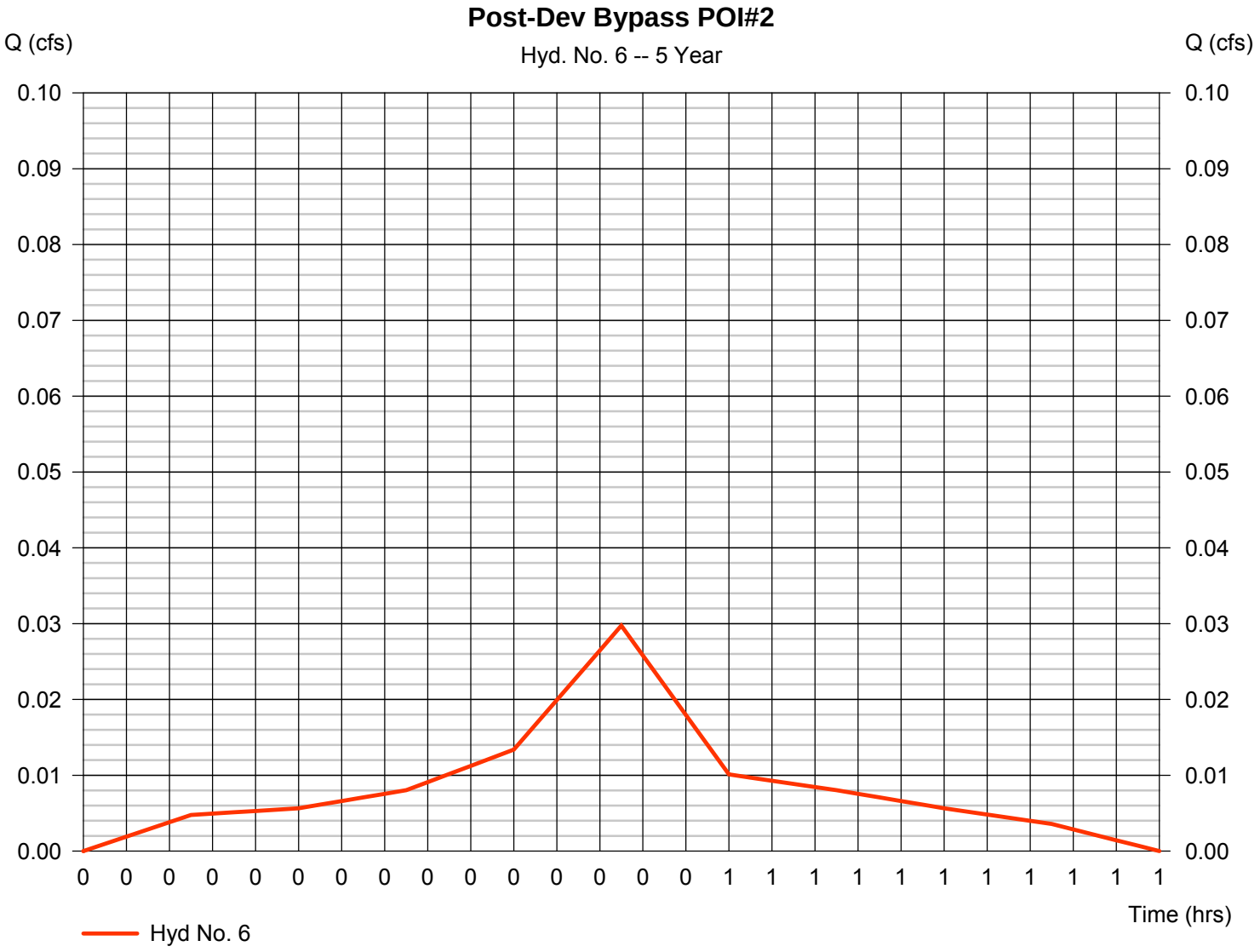


Hydrograph Report

Hyd. No. 6

Post-Dev Bypass POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.030 cfs
Storm frequency	= 5 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 27 cuft
Drainage area	= 0.010 ac	Runoff coeff.	= 0.51
Intensity	= 5.830 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



Hydrograph Report

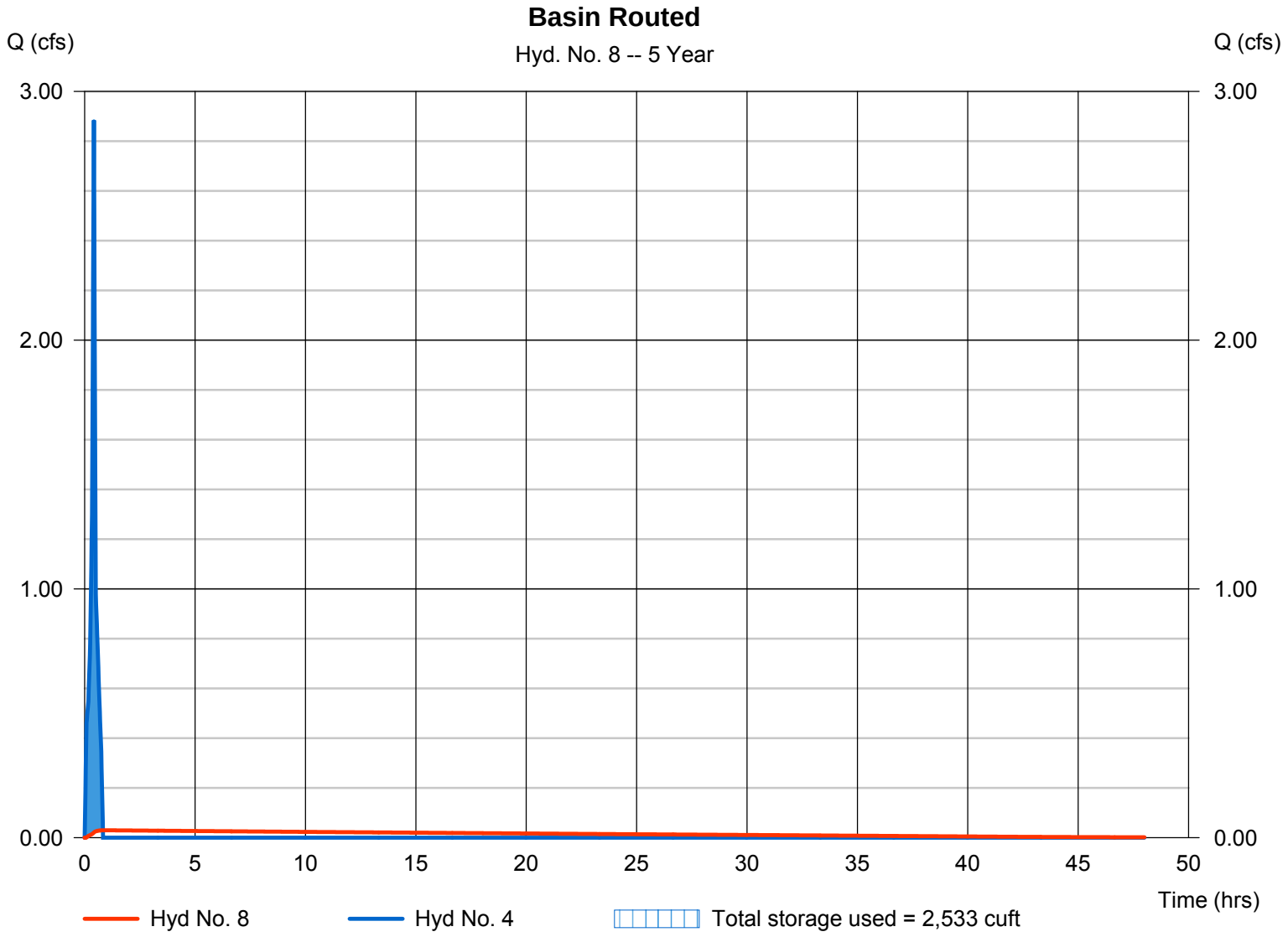
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 8

Basin Routed

Hydrograph type	= Reservoir	Peak discharge	= 0.030 cfs
Storm frequency	= 5 yrs	Time to peak	= 0.83 hrs
Time interval	= 1 min	Hyd. volume	= 2,512 cuft
Inflow hyd. No.	= 4 - Post-Dev to Basin #1 (POI #1)	Max. Elevation	= 361.33 ft
Reservoir name	= Basin #1	Max. Storage	= 2,533 cuft

Storage Indication method used.



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Dekalb	8.505	1	25	7,629	------	------	------	Pre-Dev POI#1
2	Dekalb	0.085	1	25	76	------	------	------	Pre-Dev POI#2
4	Dekalb	3.180	1	25	2,853	------	------	------	Post-Dev to Basin #1 (POI#1)
5	Dekalb	5.481	1	25	4,916	------	------	------	Post-Dev Bypass POI#1
6	Dekalb	0.033	1	25	29	------	------	------	Post-Dev Bypass POI#2
8	Reservoir	0.041	1	49	2,762	4	361.51	2,794	Basin Routed

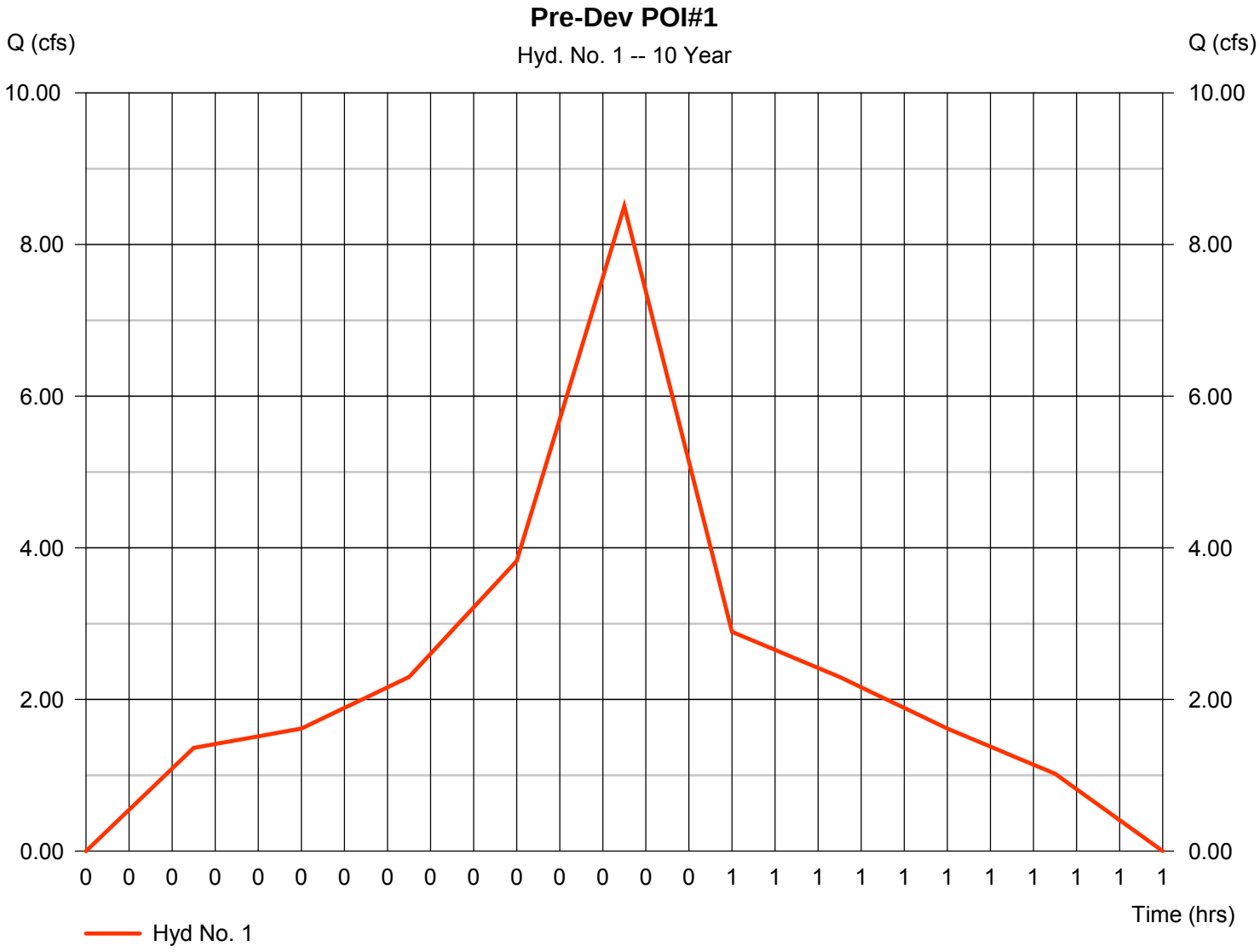
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 1

Pre-Dev POI#1

Hydrograph type	= Dekalb	Peak discharge	= 8.505 cfs
Storm frequency	= 10 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 7,629 cuft
Drainage area	= 1.470 ac	Runoff coeff.	= 0.9
Intensity	= 6.428 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



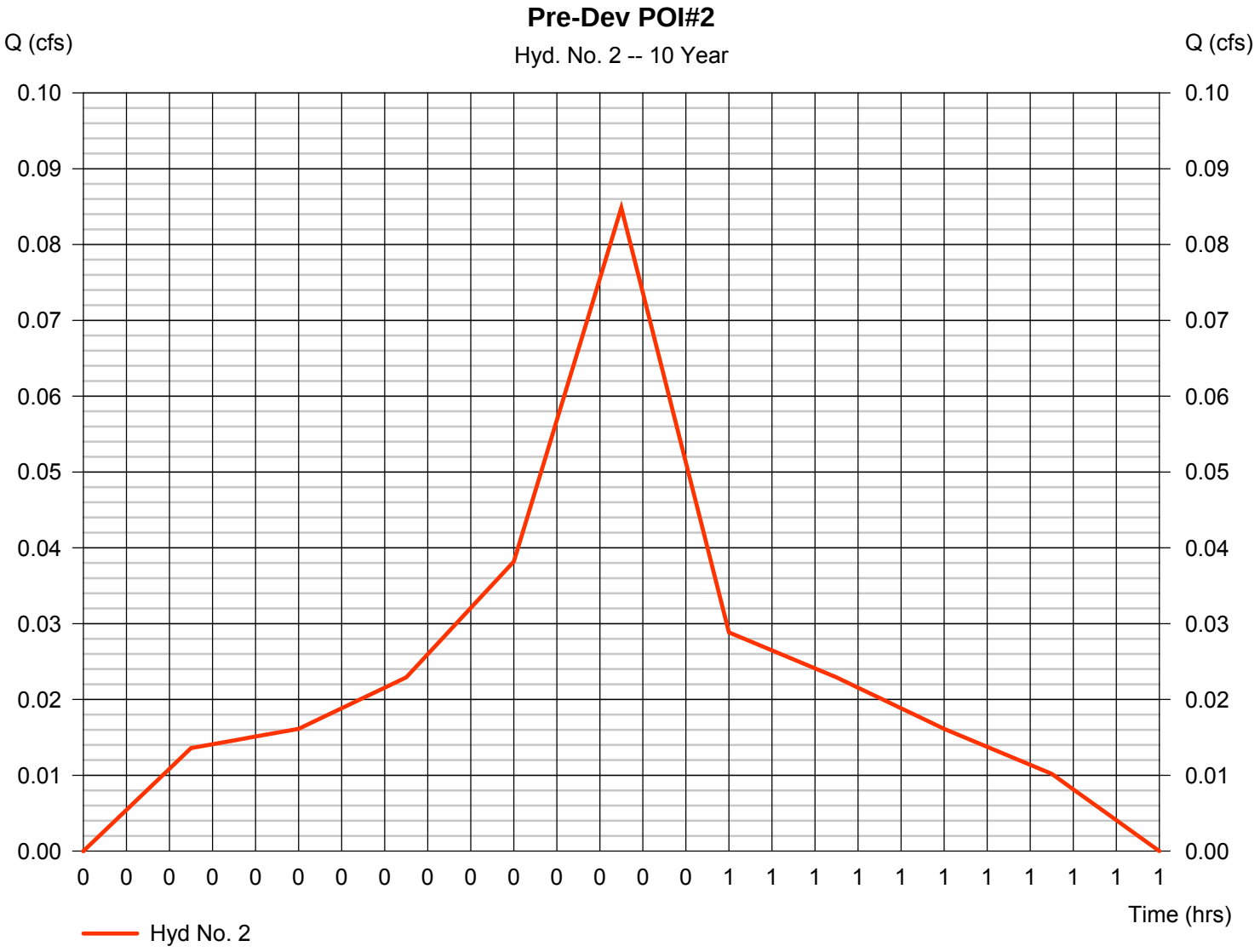
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 2

Pre-Dev POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.085 cfs
Storm frequency	= 10 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 76 cuft
Drainage area	= 0.030 ac	Runoff coeff.	= 0.44
Intensity	= 6.428 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



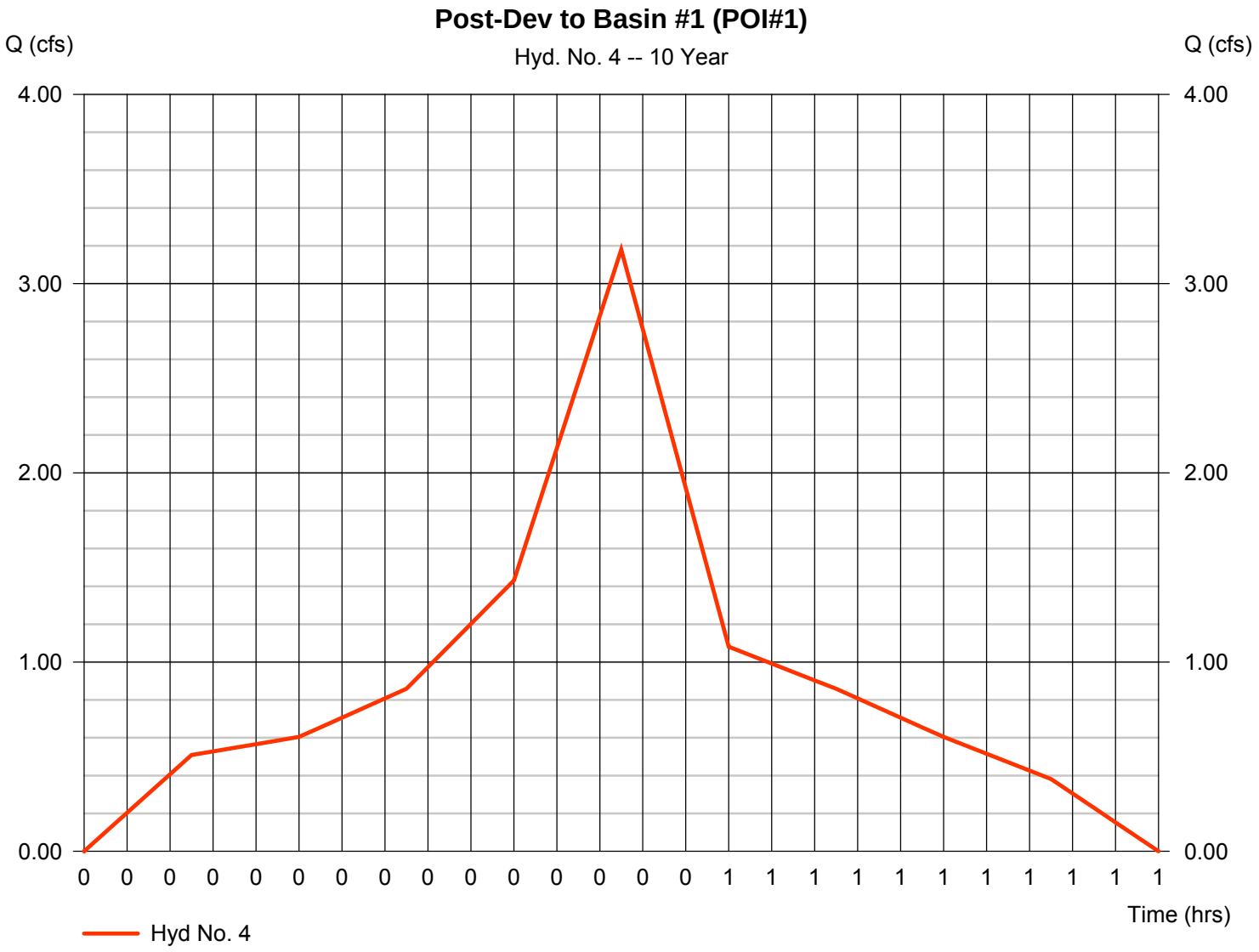
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 4

Post-Dev to Basin #1 (POI#1)

Hydrograph type	=	Dekalb	Peak discharge	=	3.180 cfs
Storm frequency	=	10 yrs	Time to peak	=	0.42 hrs
Time interval	=	1 min	Hyd. volume	=	2,853 cuft
Drainage area	=	0.510 ac	Runoff coeff.	=	0.97
Intensity	=	6.428 in/hr	Tc by User	=	5.00 min
IDF Curve	=	Hilltown.IDF	Asc/Rec limb fact	=	n/a



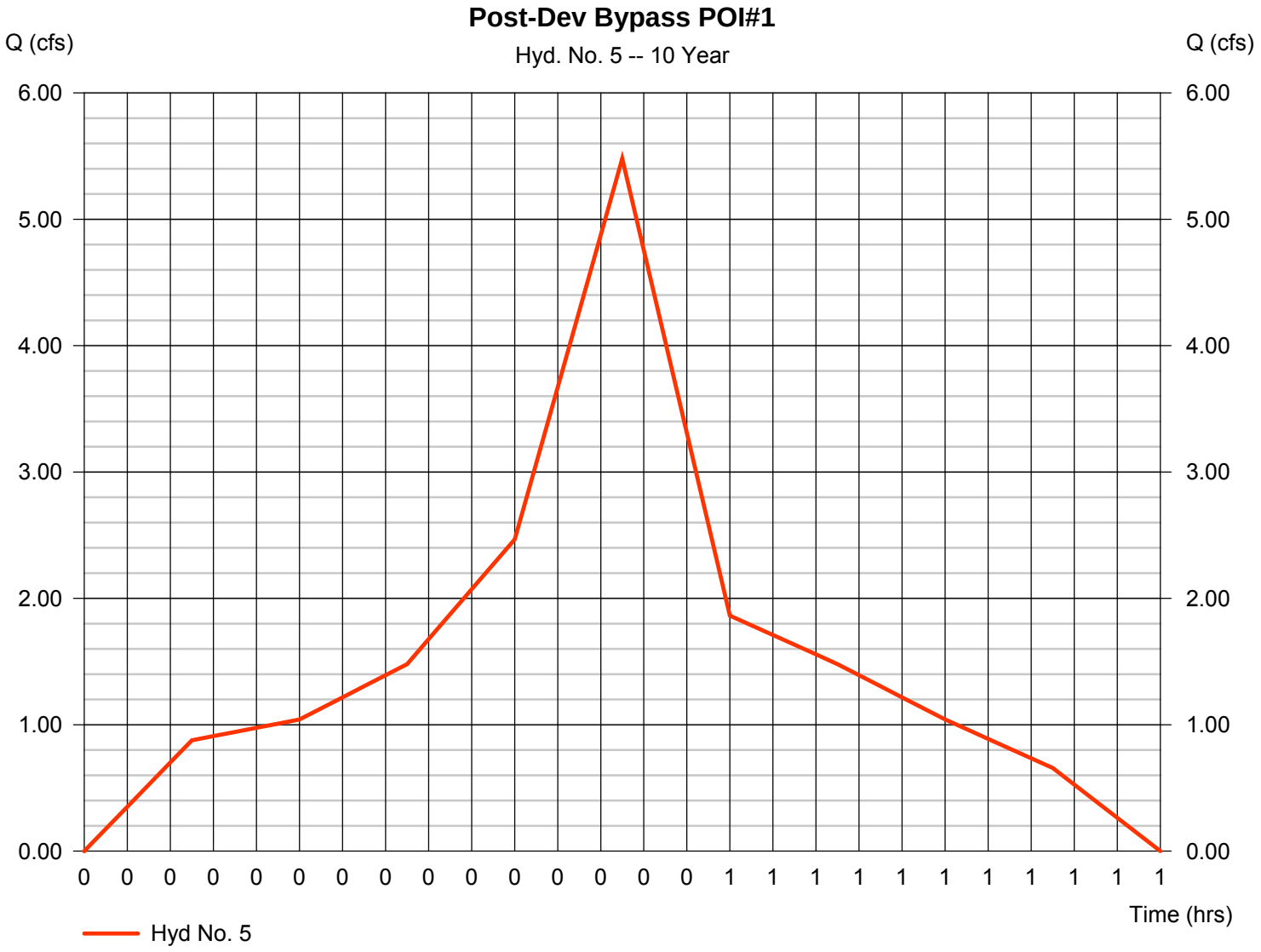
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 5

Post-Dev Bypass POI#1

Hydrograph type	= Dekalb	Peak discharge	= 5.481 cfs
Storm frequency	= 10 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 4,916 cuft
Drainage area	= 0.980 ac	Runoff coeff.	= 0.87
Intensity	= 6.428 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



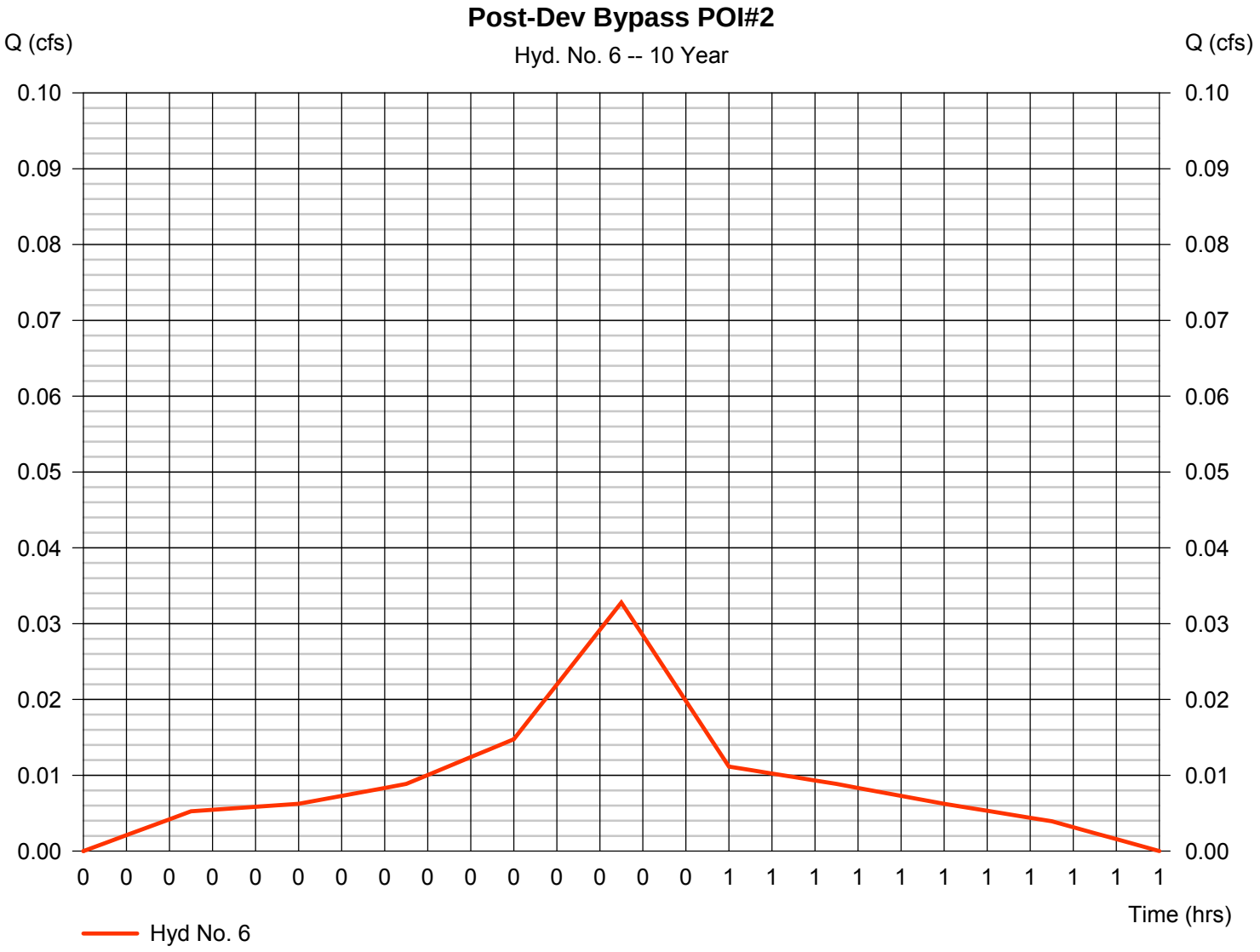
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 6

Post-Dev Bypass POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.033 cfs
Storm frequency	= 10 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 29 cuft
Drainage area	= 0.010 ac	Runoff coeff.	= 0.51
Intensity	= 6.428 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



Hydrograph Report

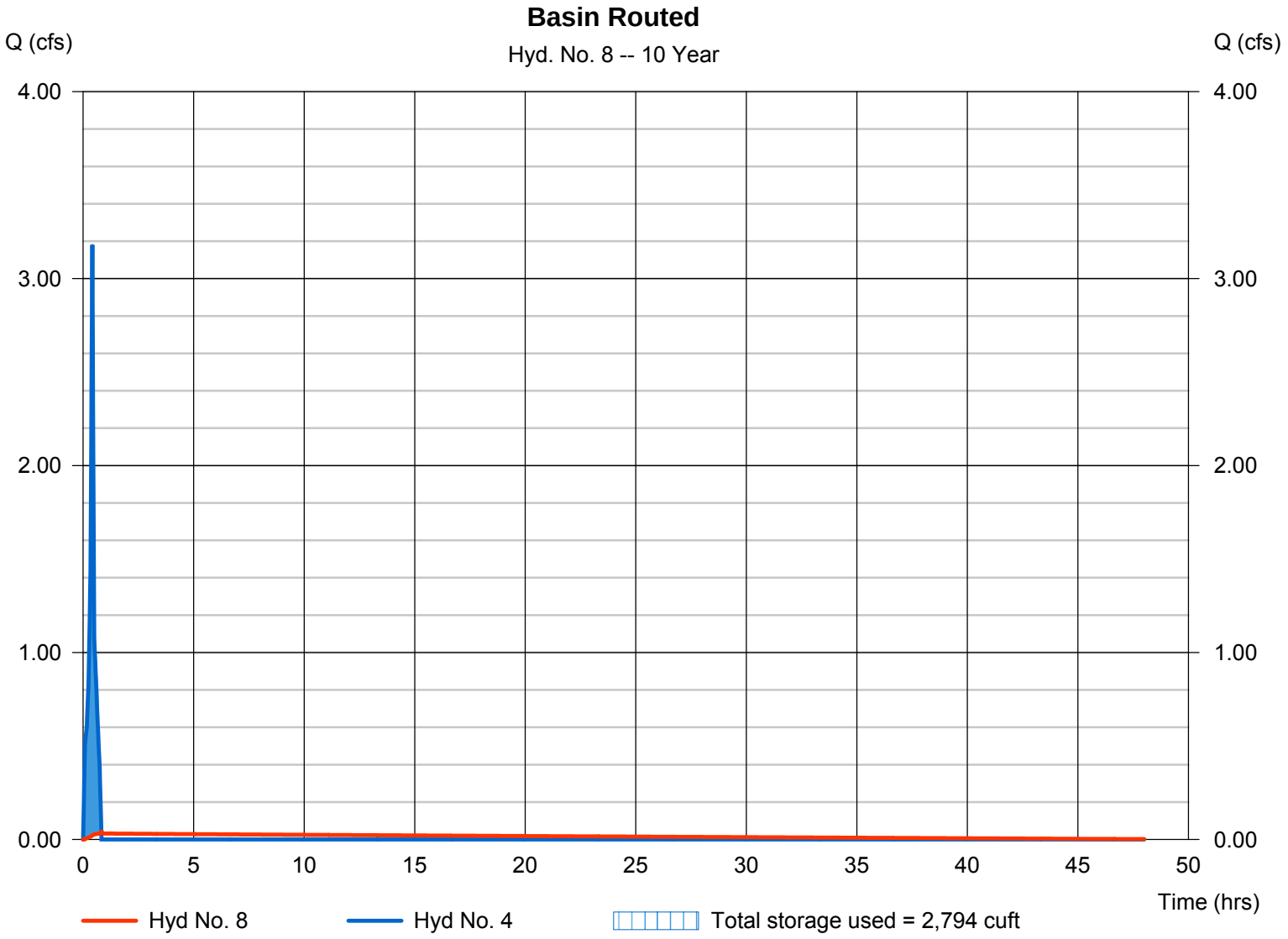
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 8

Basin Routed

Hydrograph type	= Reservoir	Peak discharge	= 0.041 cfs
Storm frequency	= 10 yrs	Time to peak	= 0.82 hrs
Time interval	= 1 min	Hyd. volume	= 2,762 cuft
Inflow hyd. No.	= 4 - Post-Dev to Basin #1 (POI #1)	Max. Elevation	= 361.51 ft
Reservoir name	= Basin #1	Max. Storage	= 2,794 cuft

Storage Indication method used.



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Dekalb	9.444	1	25	8,471	------	------	------	Pre-Dev POI#1
2	Dekalb	0.094	1	25	85	------	------	------	Pre-Dev POI#2
4	Dekalb	3.531	1	25	3,168	------	------	------	Post-Dev to Basin #1 (POI#1)
5	Dekalb	6.086	1	25	5,459	------	------	------	Post-Dev Bypass POI#1
6	Dekalb	0.036	1	25	33	------	------	------	Post-Dev Bypass POI#2
8	Reservoir	0.373	1	46	3,074	4	361.64	2,961	Basin Routed

Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 1

Pre-Dev POI#1

Hydrograph type	= Dekalb	Peak discharge	= 9.444 cfs
Storm frequency	= 25 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 8,471 cuft
Drainage area	= 1.470 ac	Runoff coeff.	= 0.9
Intensity	= 7.138 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a

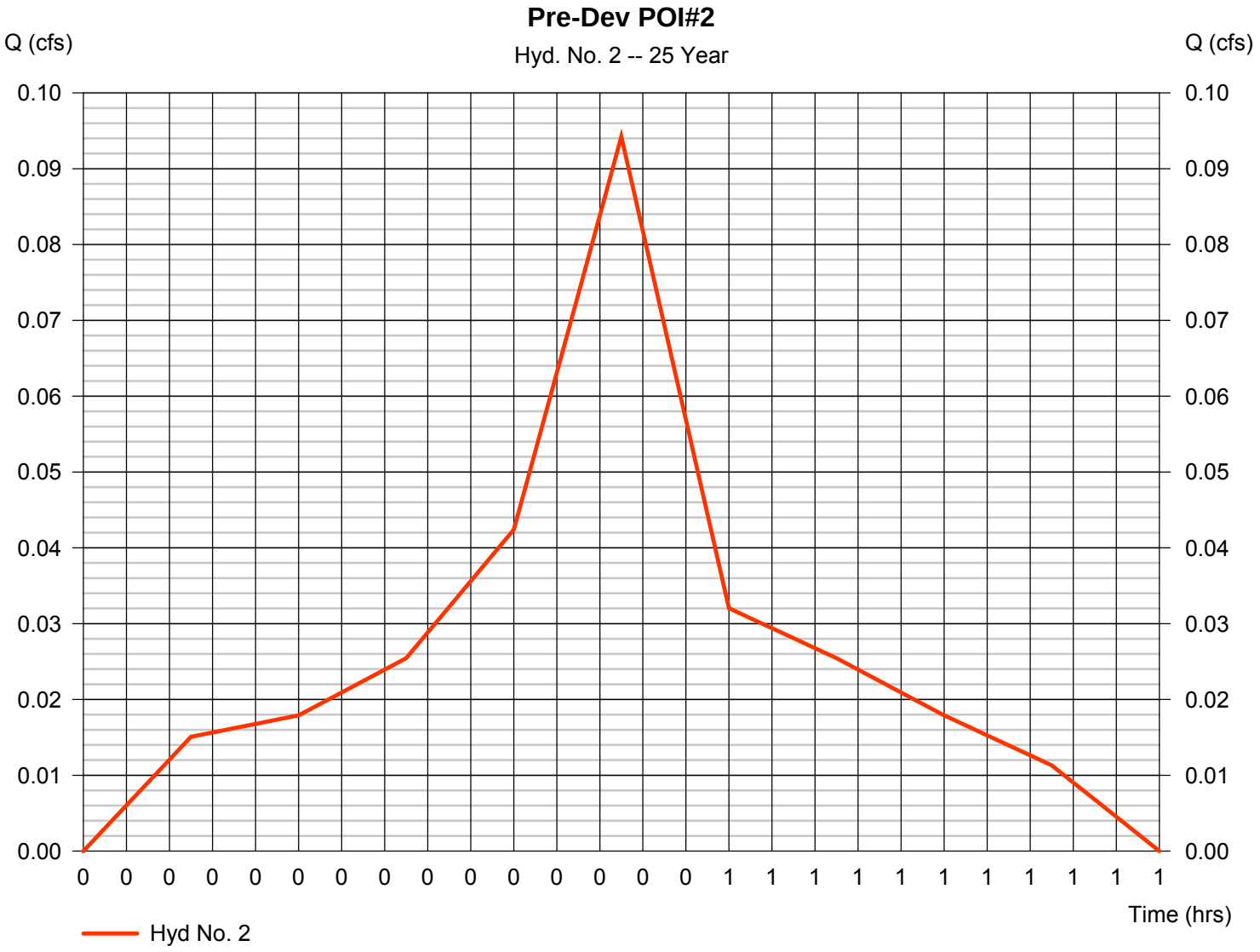
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 2

Pre-Dev POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.094 cfs
Storm frequency	= 25 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 85 cuft
Drainage area	= 0.030 ac	Runoff coeff.	= 0.44
Intensity	= 7.138 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



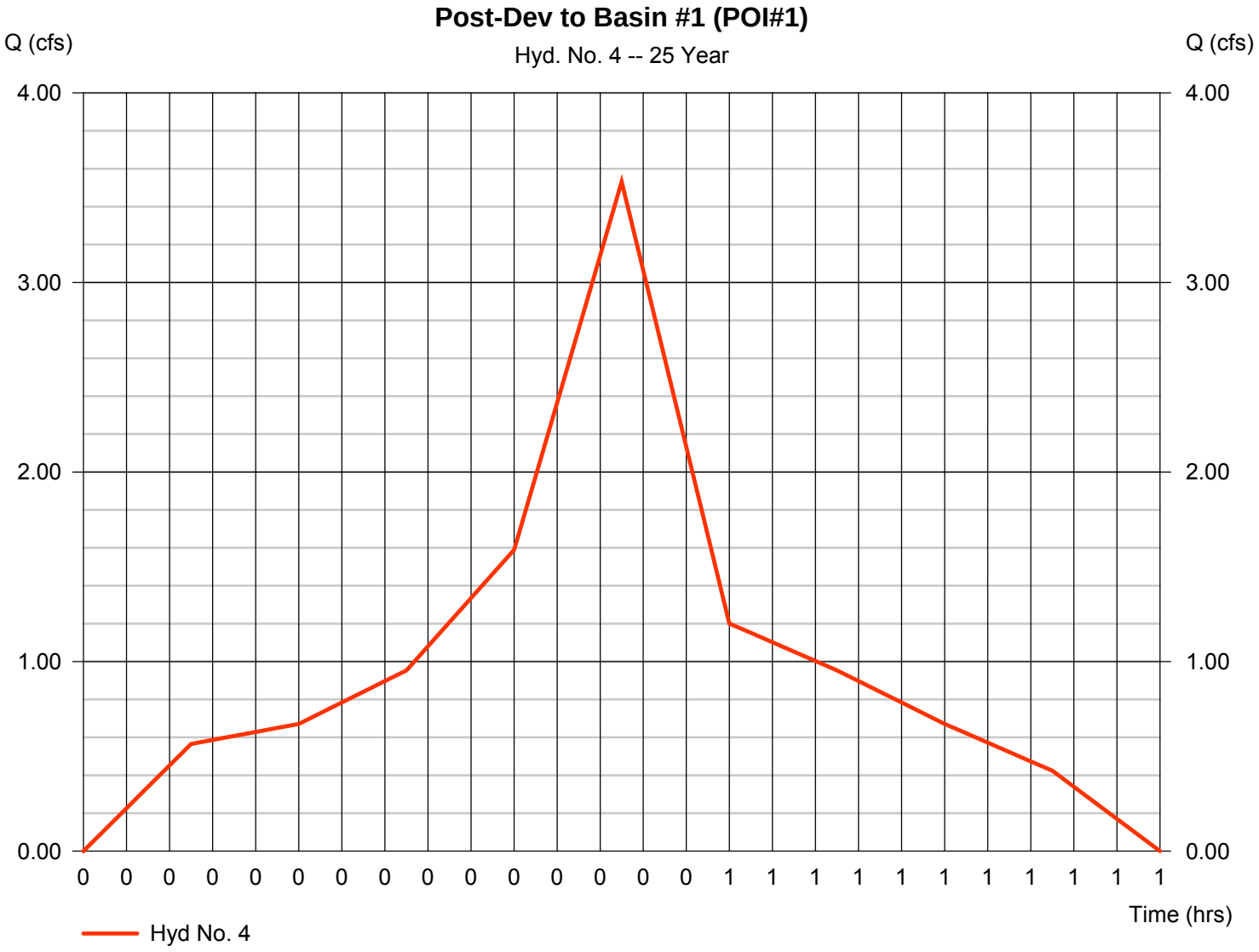
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 4

Post-Dev to Basin #1 (POI#1)

Hydrograph type	= Dekalb	Peak discharge	= 3.531 cfs
Storm frequency	= 25 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 3,168 cuft
Drainage area	= 0.510 ac	Runoff coeff.	= 0.97
Intensity	= 7.138 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



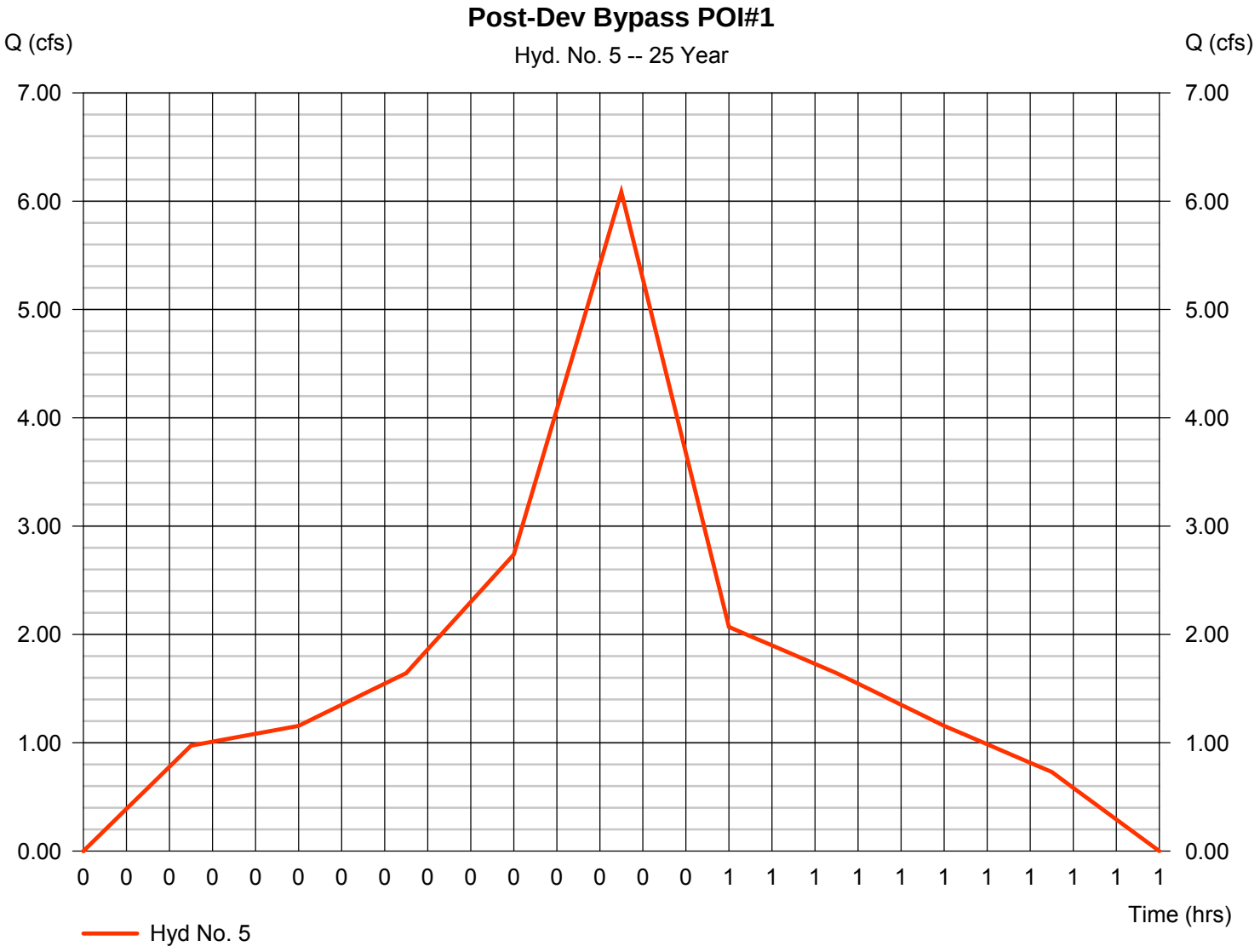
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 5

Post-Dev Bypass POI#1

Hydrograph type	= Dekalb	Peak discharge	= 6.086 cfs
Storm frequency	= 25 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 5,459 cuft
Drainage area	= 0.980 ac	Runoff coeff.	= 0.87
Intensity	= 7.138 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



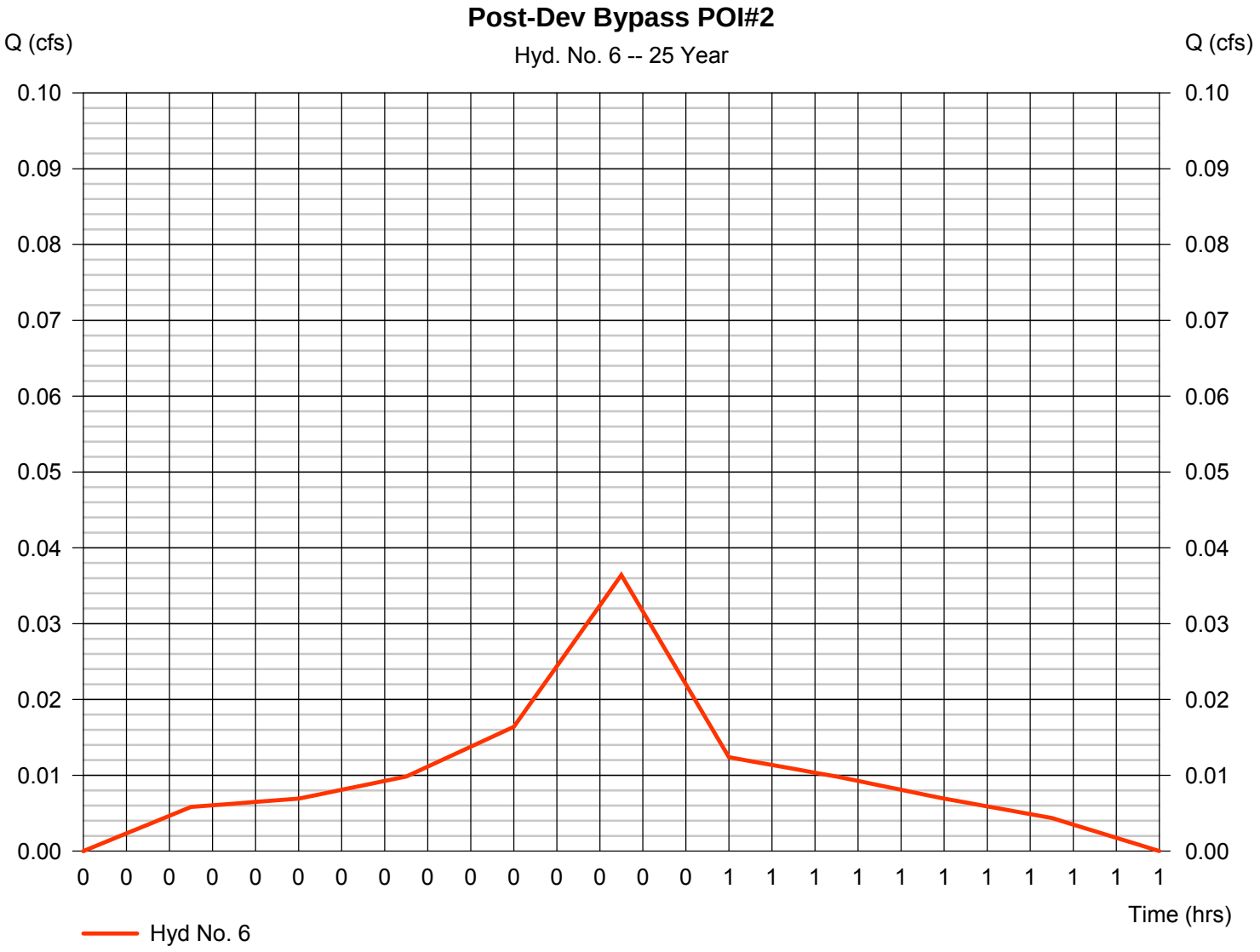
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 6

Post-Dev Bypass POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.036 cfs
Storm frequency	= 25 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 33 cuft
Drainage area	= 0.010 ac	Runoff coeff.	= 0.51
Intensity	= 7.138 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



Hydrograph Report

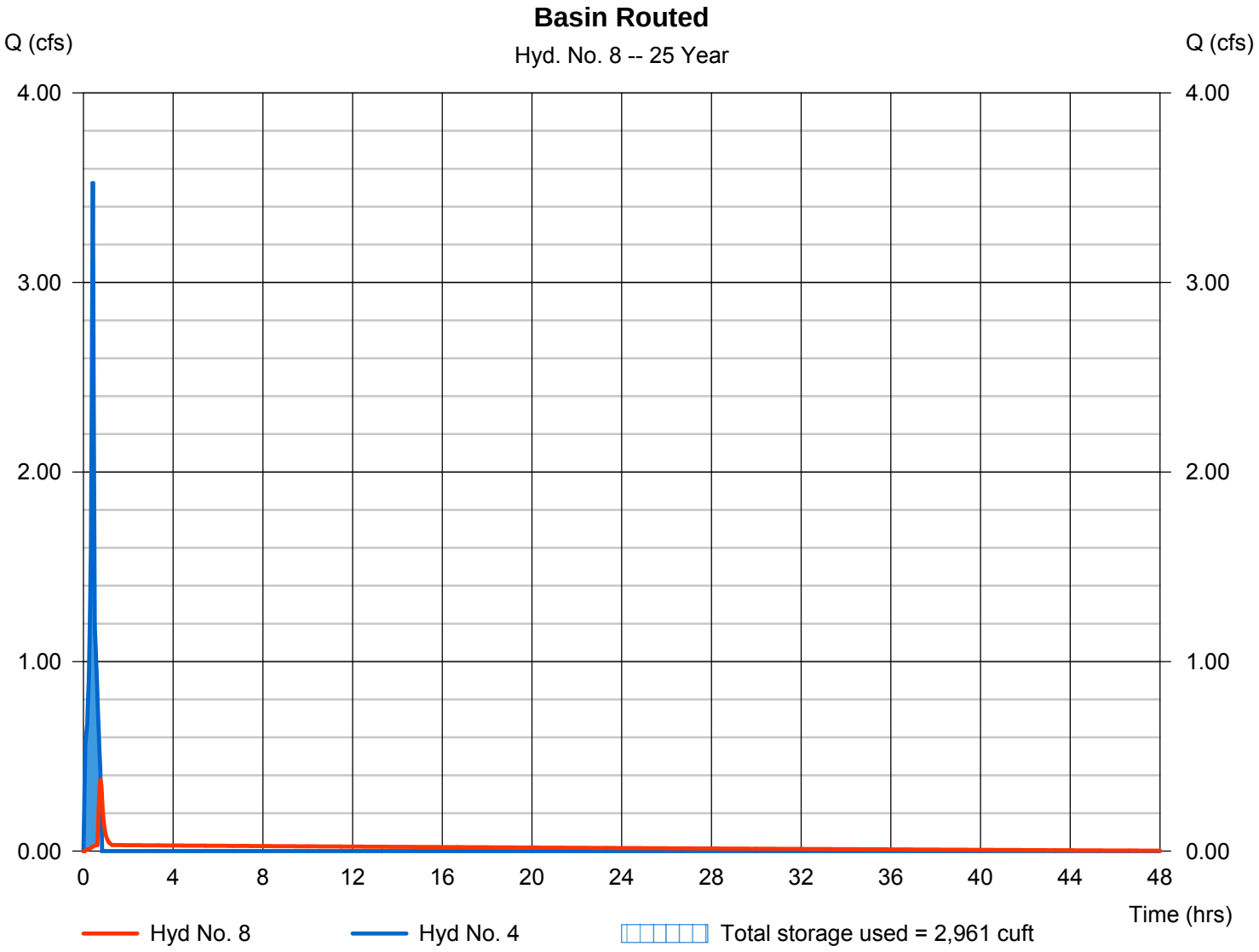
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 8

Basin Routed

Hydrograph type	= Reservoir	Peak discharge	= 0.373 cfs
Storm frequency	= 25 yrs	Time to peak	= 0.77 hrs
Time interval	= 1 min	Hyd. volume	= 3,074 cuft
Inflow hyd. No.	= 4 - Post-Dev to Basin #1 (POI #1)	Max. Elevation	= 361.64 ft
Reservoir name	= Basin #1	Max. Storage	= 2,961 cuft

Storage Indication method used.



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Dekalb	10.08	1	25	9,038	------	------	------	Pre-Dev POI#1
2	Dekalb	0.101	1	25	90	------	------	------	Pre-Dev POI#2
4	Dekalb	3.768	1	25	3,380	------	------	------	Post-Dev to Basin #1 (POI#1)
5	Dekalb	6.493	1	25	5,825	------	------	------	Post-Dev Bypass POI#1
6	Dekalb	0.039	1	25	35	------	------	------	Post-Dev Bypass POI#2
8	Reservoir	0.563	1	43	3,286	4	361.68	3,021	Basin Routed

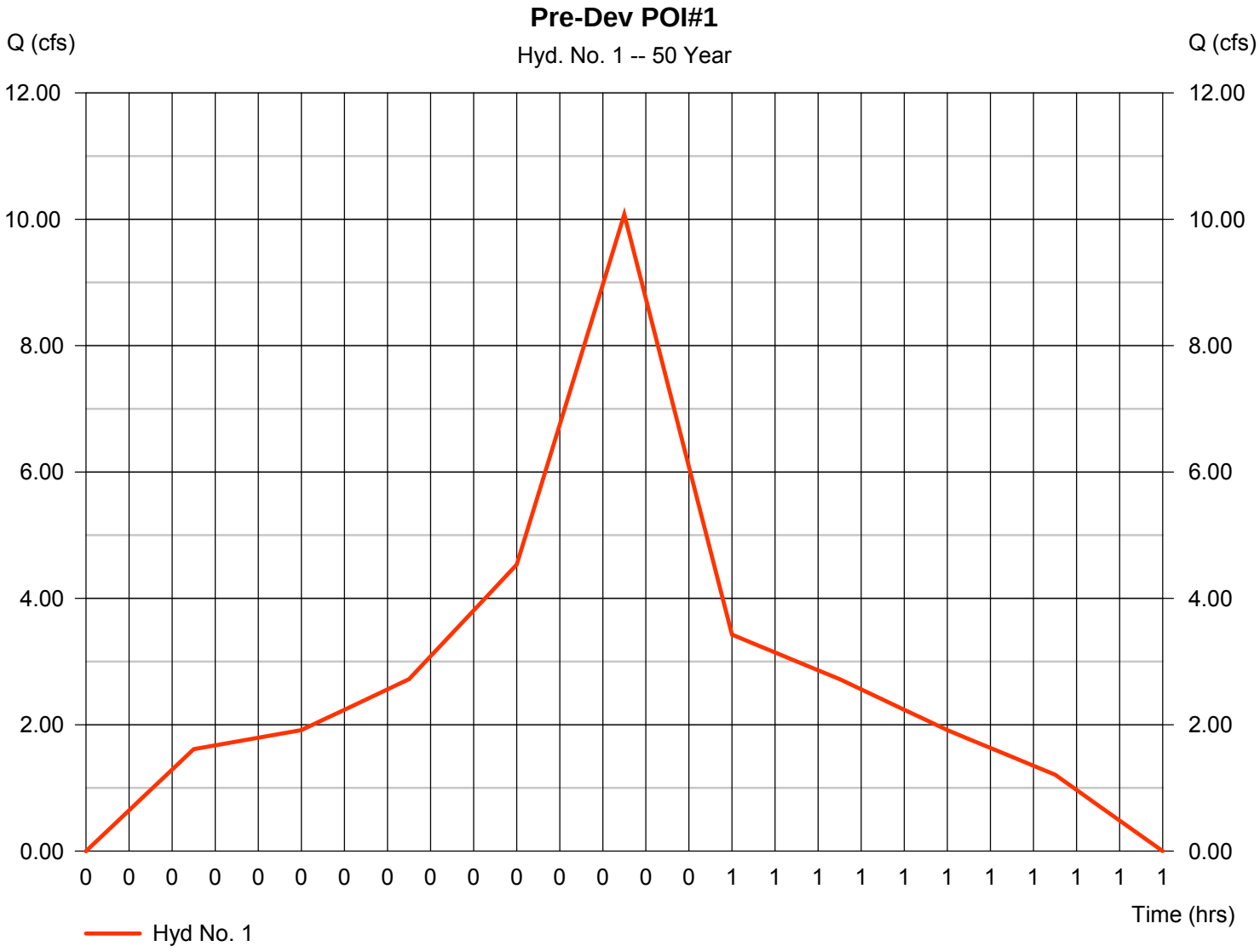
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 1

Pre-Dev POI#1

Hydrograph type	= Dekalb	Peak discharge	= 10.08 cfs
Storm frequency	= 50 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 9,038 cuft
Drainage area	= 1.470 ac	Runoff coeff.	= 0.9
Intensity	= 7.616 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



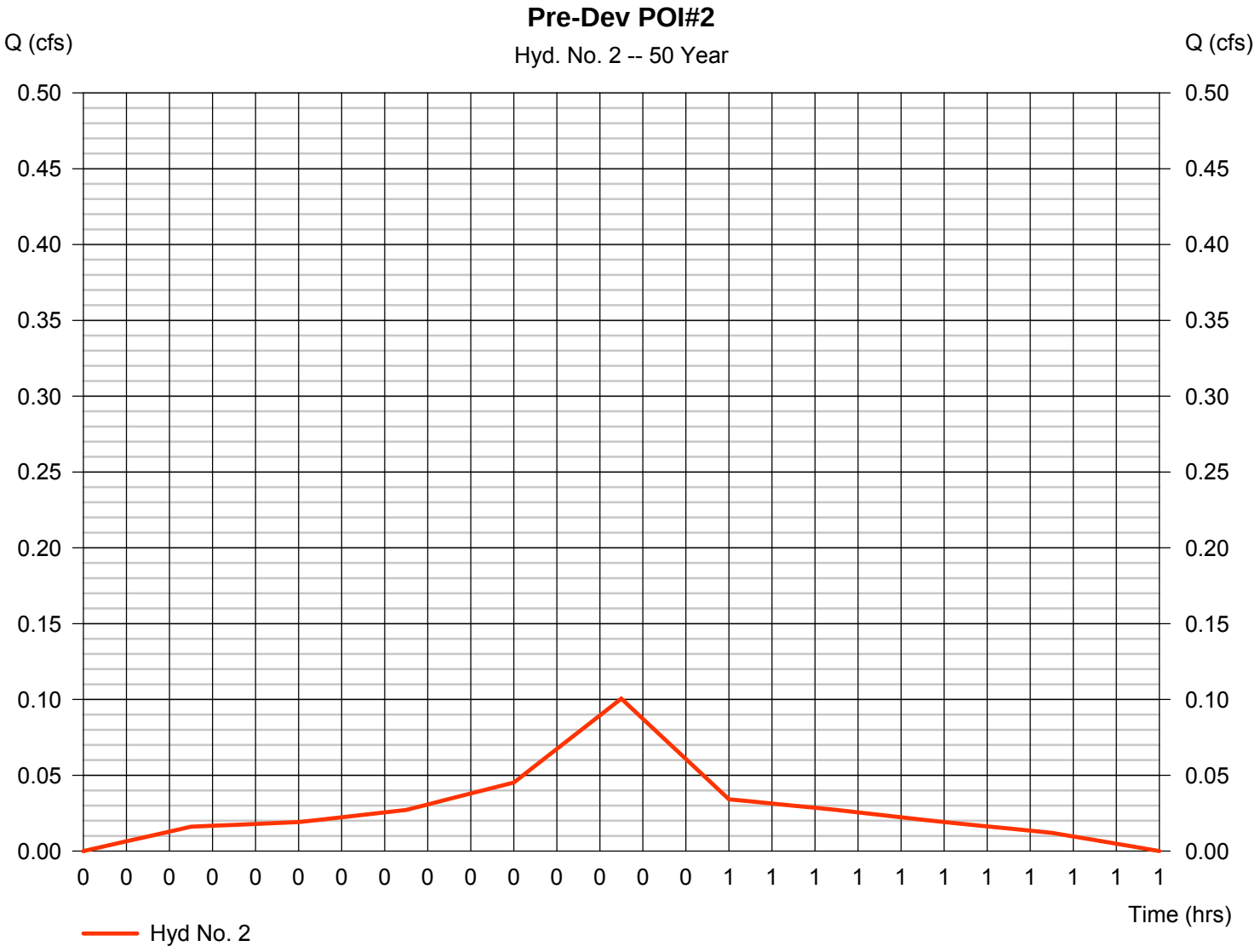
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 2

Pre-Dev POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.101 cfs
Storm frequency	= 50 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 90 cuft
Drainage area	= 0.030 ac	Runoff coeff.	= 0.44
Intensity	= 7.616 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



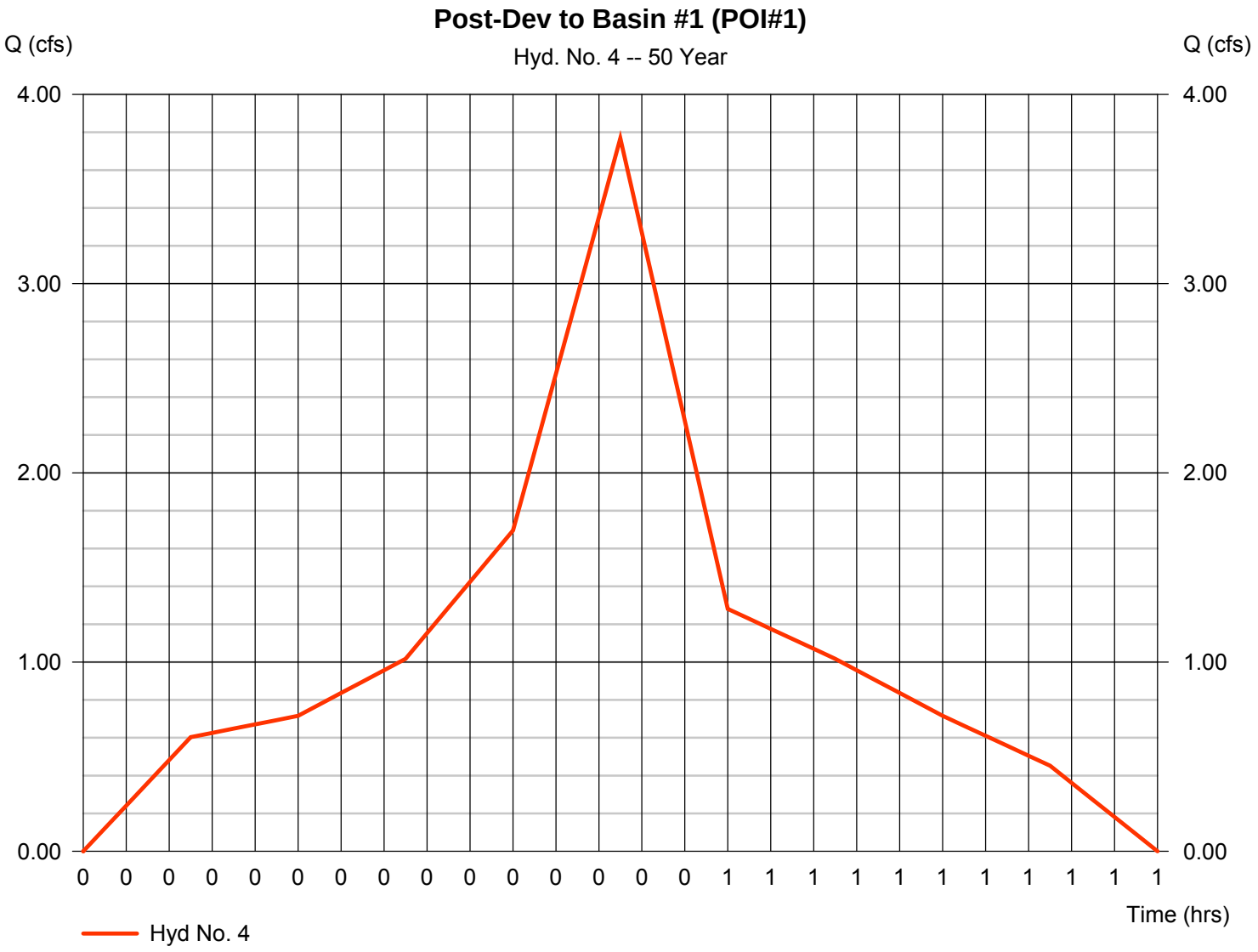
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 4

Post-Dev to Basin #1 (POI#1)

Hydrograph type	= Dekalb	Peak discharge	= 3.768 cfs
Storm frequency	= 50 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 3,380 cuft
Drainage area	= 0.510 ac	Runoff coeff.	= 0.97
Intensity	= 7.616 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



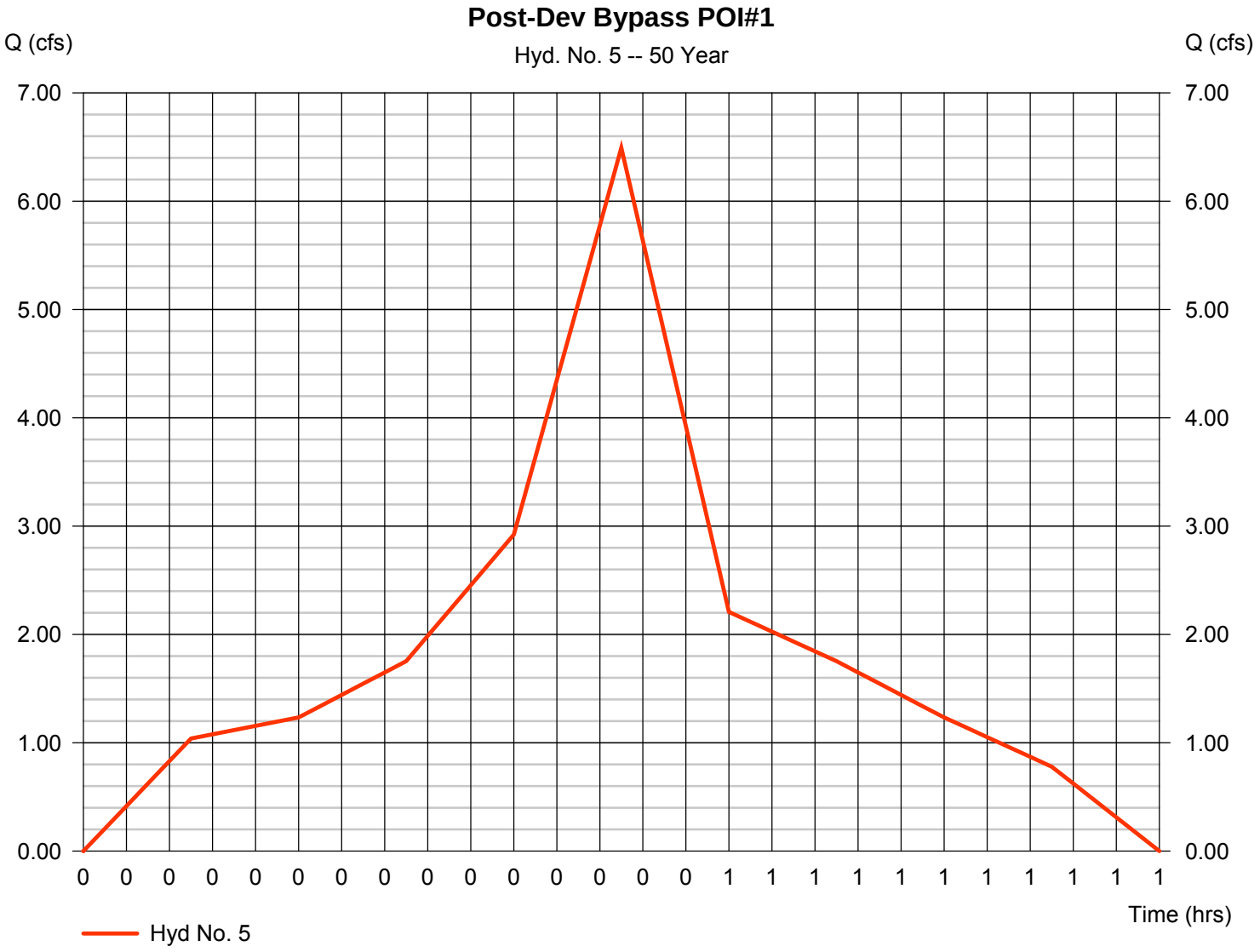
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 5

Post-Dev Bypass POI#1

Hydrograph type	= Dekalb	Peak discharge	= 6.493 cfs
Storm frequency	= 50 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 5,825 cuft
Drainage area	= 0.980 ac	Runoff coeff.	= 0.87
Intensity	= 7.616 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



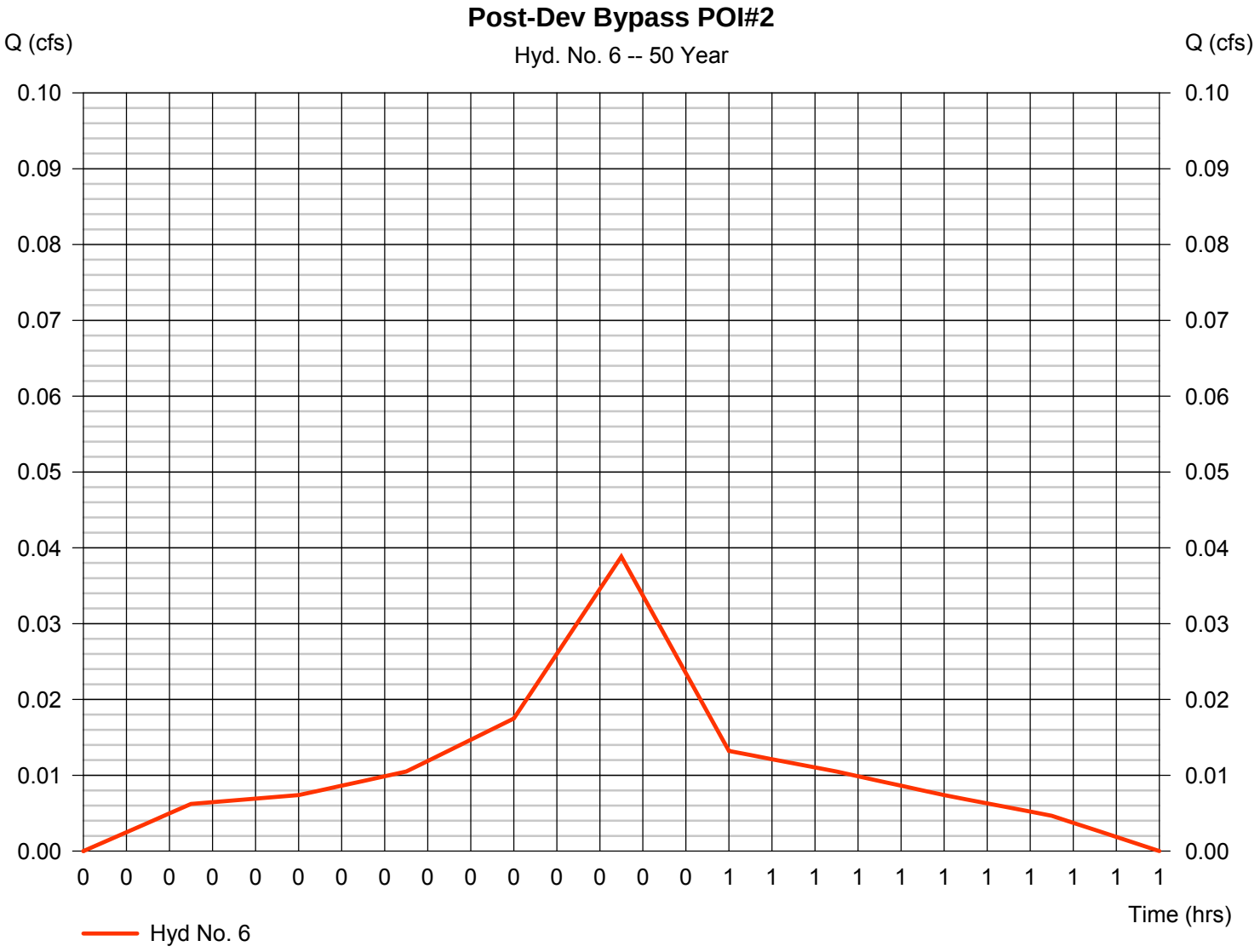
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 6

Post-Dev Bypass POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.039 cfs
Storm frequency	= 50 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 35 cuft
Drainage area	= 0.010 ac	Runoff coeff.	= 0.51
Intensity	= 7.616 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



Hydrograph Report

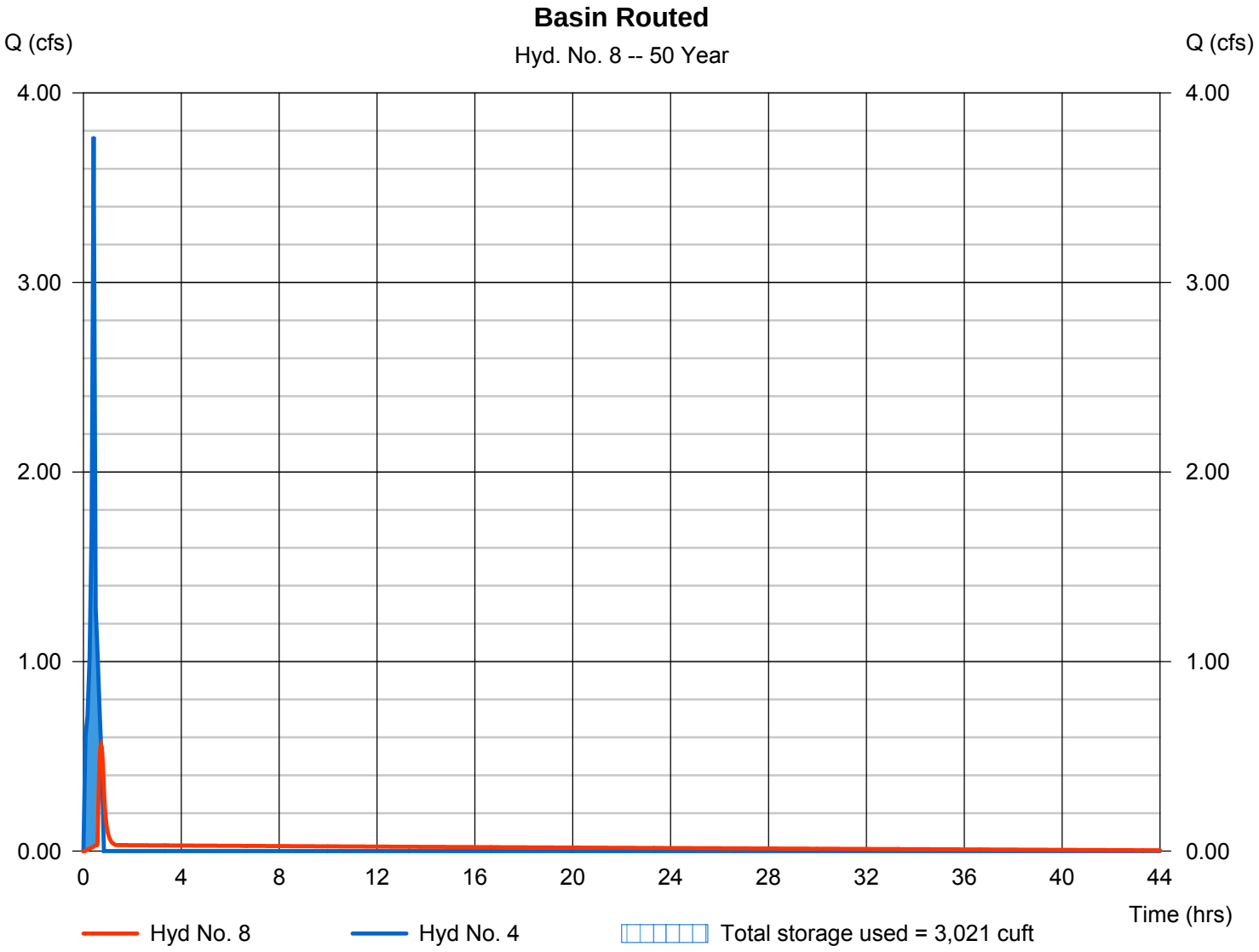
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 8

Basin Routed

Hydrograph type	= Reservoir	Peak discharge	= 0.563 cfs
Storm frequency	= 50 yrs	Time to peak	= 0.72 hrs
Time interval	= 1 min	Hyd. volume	= 3,286 cuft
Inflow hyd. No.	= 4 - Post-Dev to Basin #1 (POI #1)	Max. Elevation	= 361.68 ft
Reservoir name	= Basin #1	Max. Storage	= 3,021 cuft

Storage Indication method used.



Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	Dekalb	10.70	1	25	9,594	------	------	------	Pre-Dev POI#1
2	Dekalb	0.107	1	25	96	------	------	------	Pre-Dev POI#2
4	Dekalb	3.999	1	25	3,587	------	------	------	Post-Dev to Basin #1 (POI#1)
5	Dekalb	6.893	1	25	6,183	------	------	------	Post-Dev Bypass POI#1
6	Dekalb	0.041	1	25	37	------	------	------	Post-Dev Bypass POI#2
8	Reservoir	0.740	1	40	3,494	4	361.72	3,067	Basin Routed

Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 1

Pre-Dev POI#1

Hydrograph type	= Dekalb	Peak discharge	= 10.70 cfs
Storm frequency	= 100 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 9,594 cuft
Drainage area	= 1.470 ac	Runoff coeff.	= 0.9
Intensity	= 8.084 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a

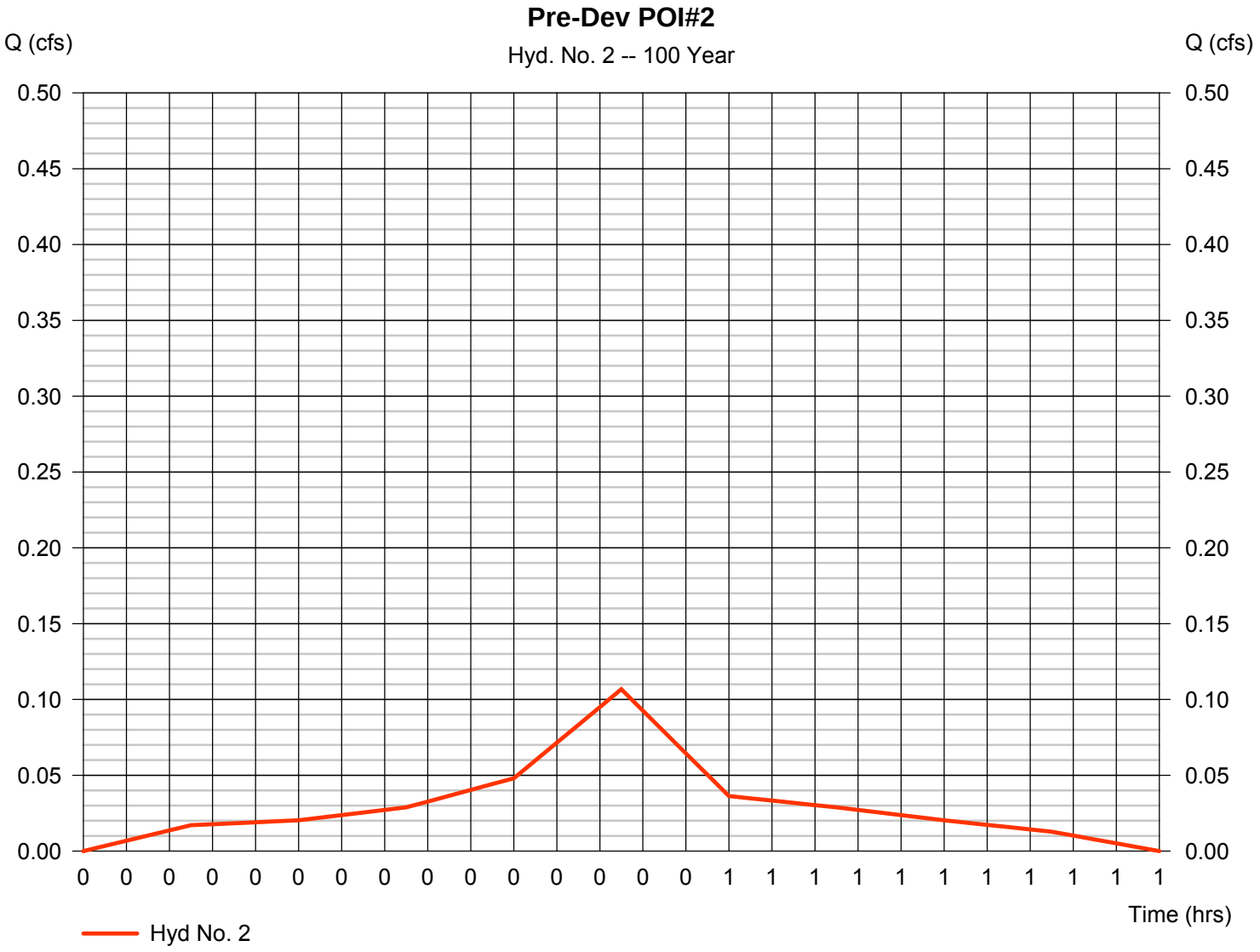
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 2

Pre-Dev POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.107 cfs
Storm frequency	= 100 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 96 cuft
Drainage area	= 0.030 ac	Runoff coeff.	= 0.44
Intensity	= 8.084 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



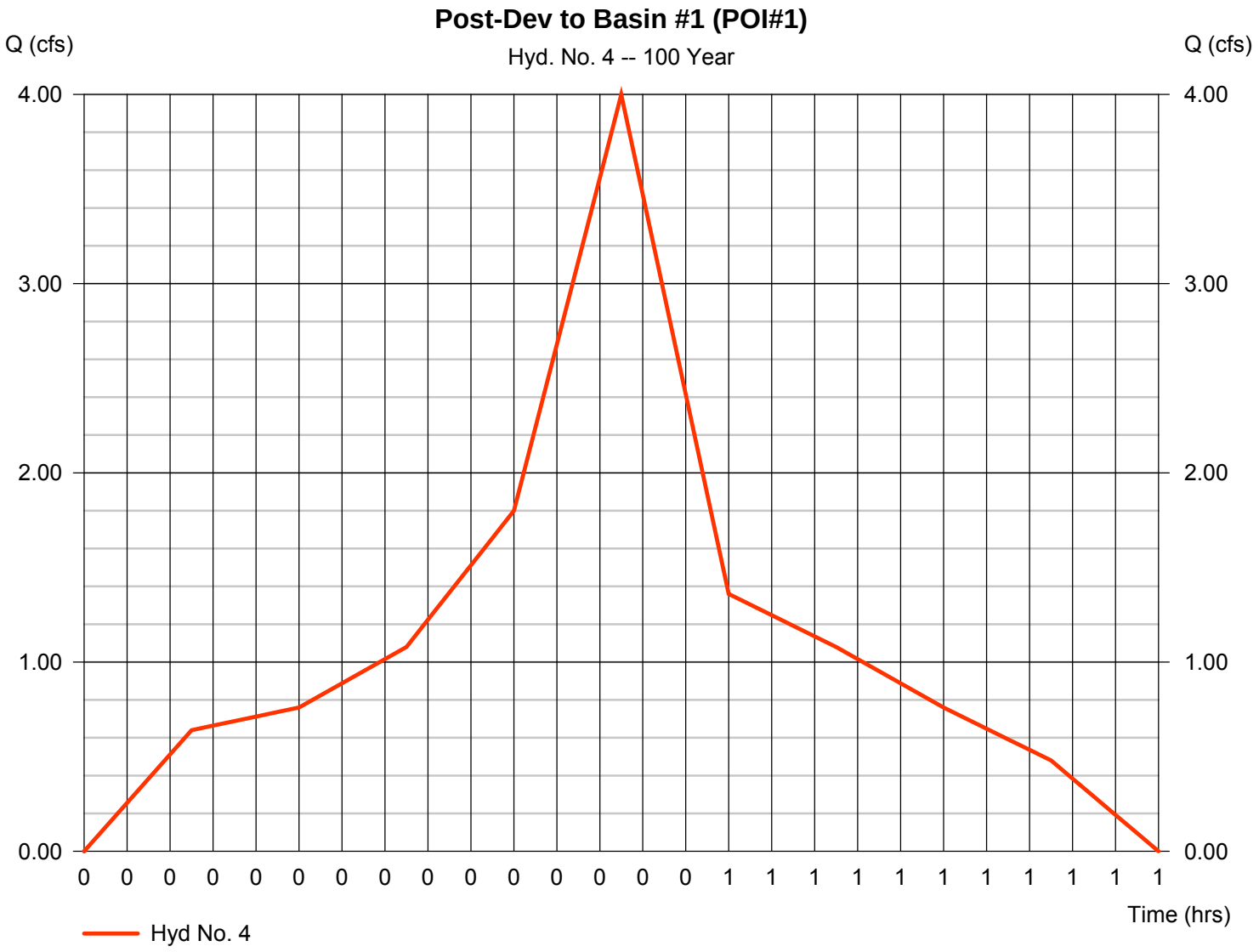
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 4

Post-Dev to Basin #1 (POI#1)

Hydrograph type	=	Dekalb	Peak discharge	=	3.999 cfs
Storm frequency	=	100 yrs	Time to peak	=	0.42 hrs
Time interval	=	1 min	Hyd. volume	=	3,587 cuft
Drainage area	=	0.510 ac	Runoff coeff.	=	0.97
Intensity	=	8.084 in/hr	Tc by User	=	5.00 min
IDF Curve	=	Hilltown.IDF	Asc/Rec limb fact	=	n/a



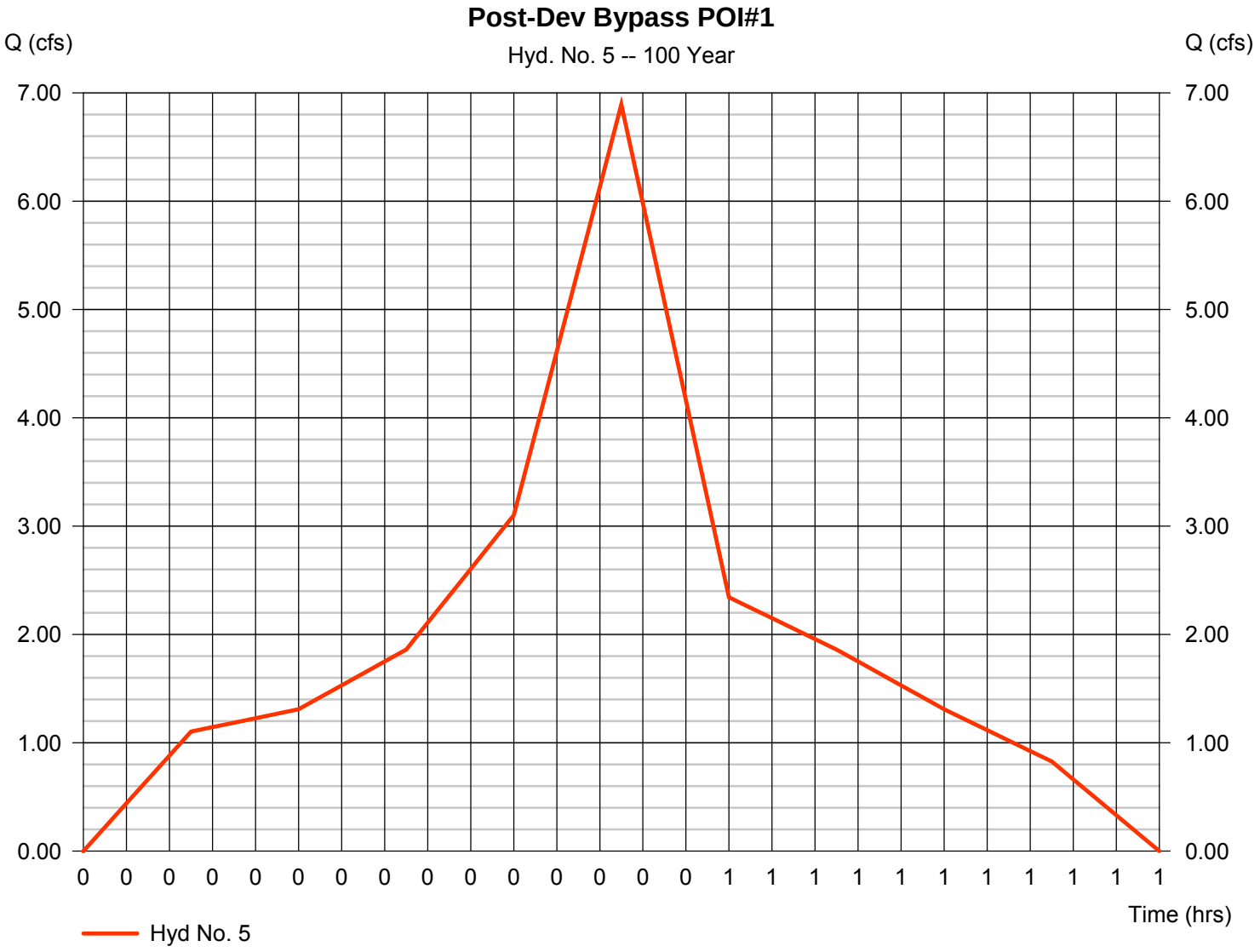
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 5

Post-Dev Bypass POI#1

Hydrograph type	= Dekalb	Peak discharge	= 6.893 cfs
Storm frequency	= 100 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 6,183 cuft
Drainage area	= 0.980 ac	Runoff coeff.	= 0.87
Intensity	= 8.084 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



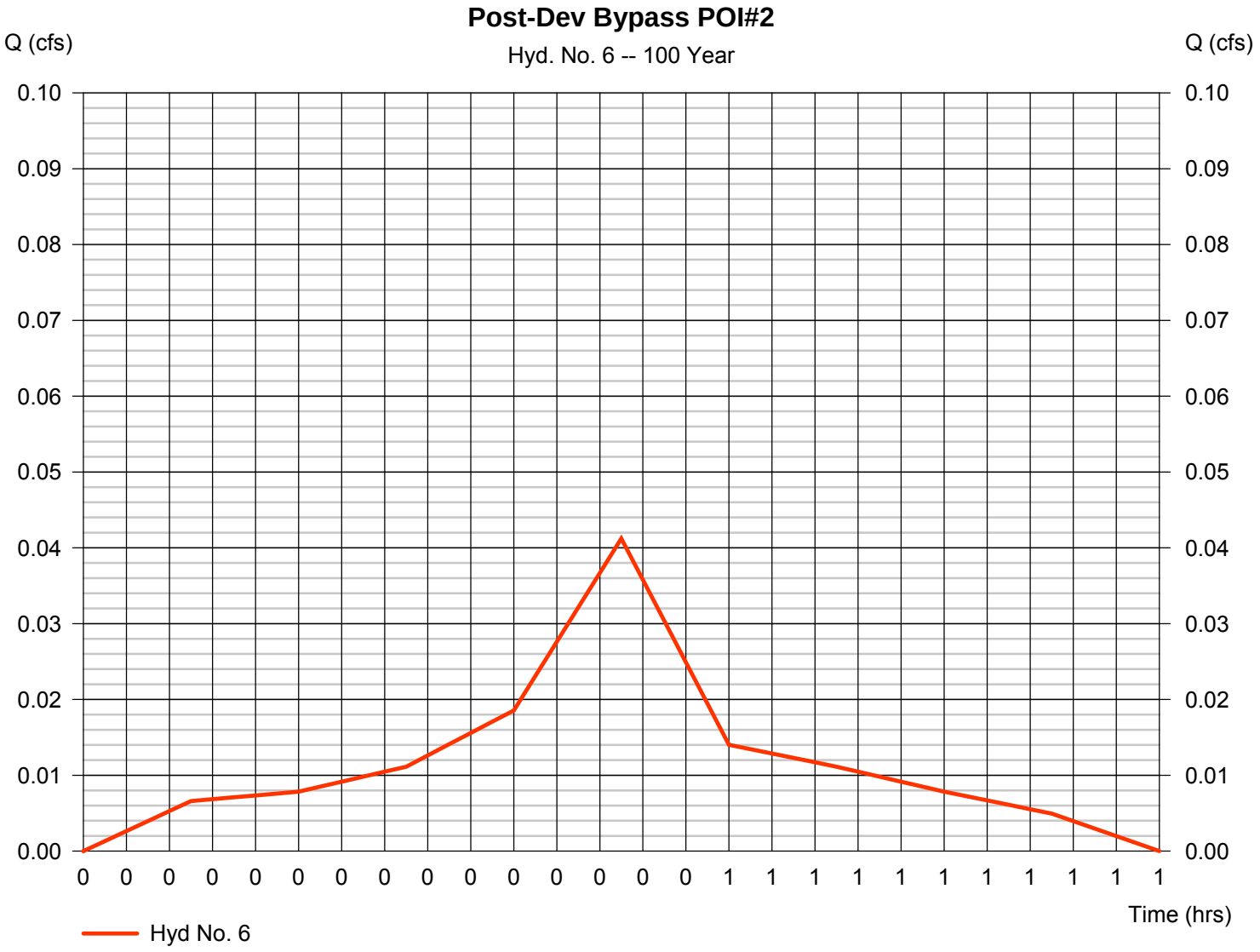
Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 6

Post-Dev Bypass POI#2

Hydrograph type	= Dekalb	Peak discharge	= 0.041 cfs
Storm frequency	= 100 yrs	Time to peak	= 0.42 hrs
Time interval	= 1 min	Hyd. volume	= 37 cuft
Drainage area	= 0.010 ac	Runoff coeff.	= 0.51
Intensity	= 8.084 in/hr	Tc by User	= 5.00 min
IDF Curve	= Hilltown.IDF	Asc/Rec limb fact	= n/a



Hydrograph Report

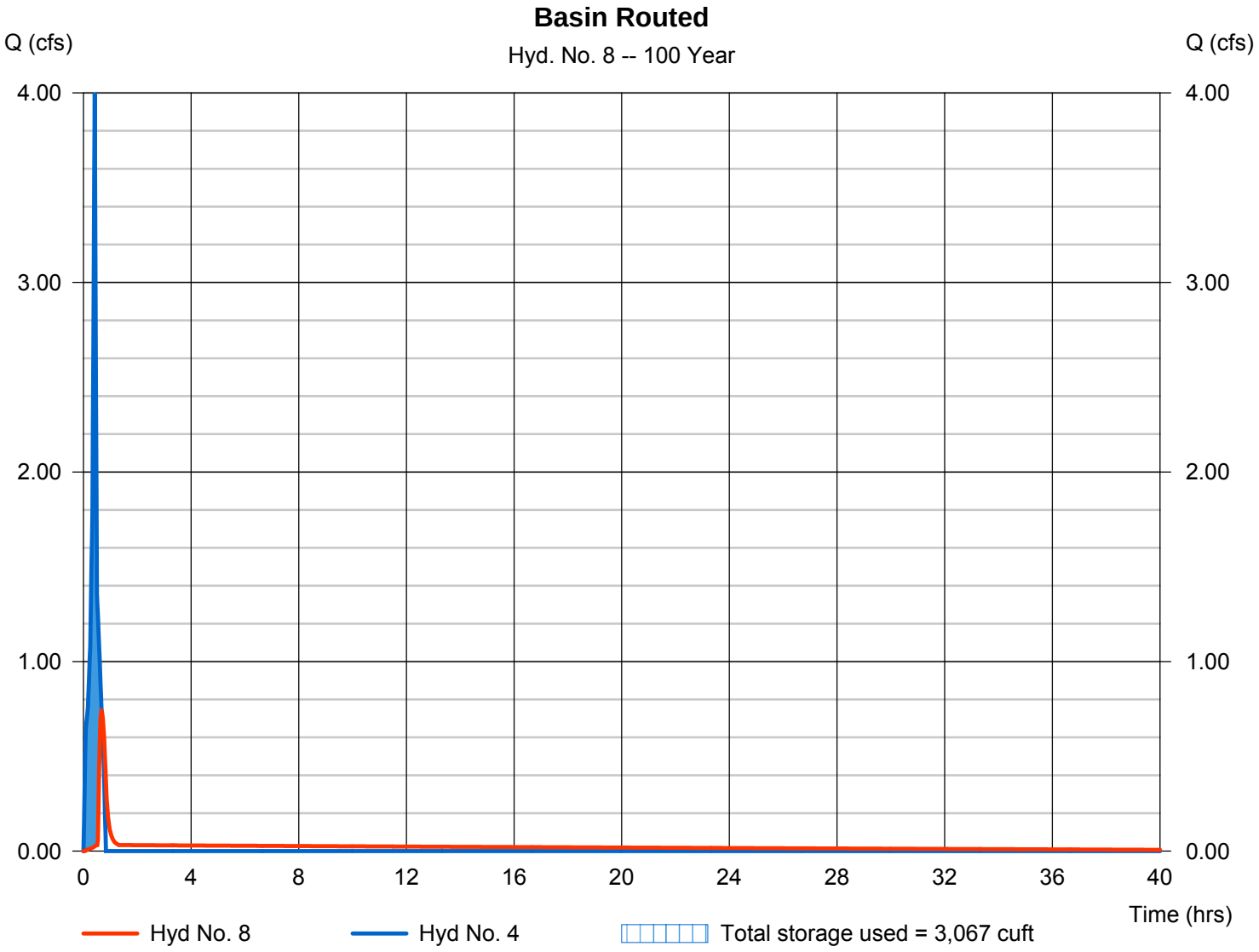
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 08 / 30 / 2018

Hyd. No. 8

Basin Routed

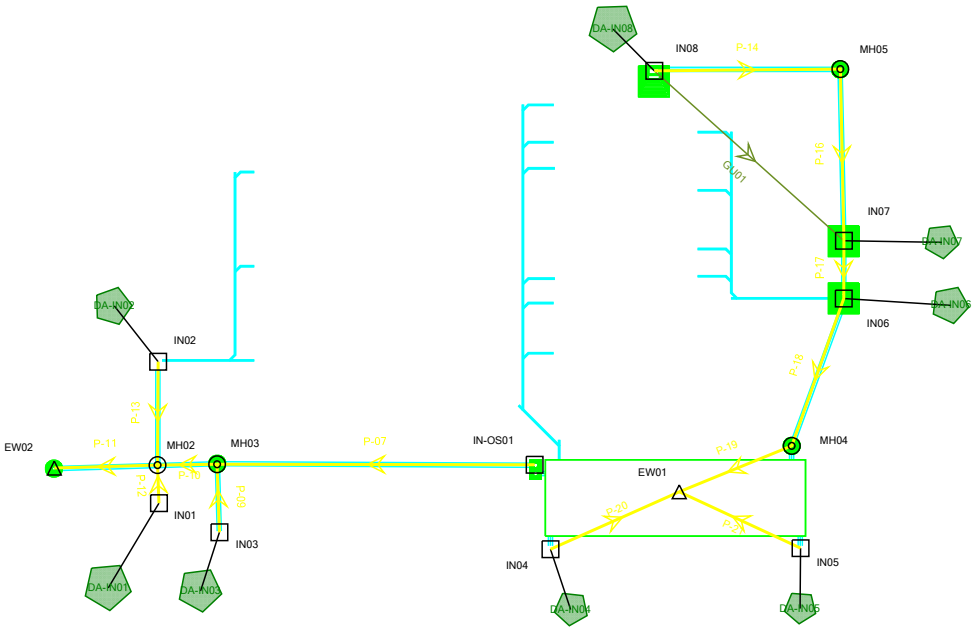
Hydrograph type	= Reservoir	Peak discharge	= 0.740 cfs
Storm frequency	= 100 yrs	Time to peak	= 0.67 hrs
Time interval	= 1 min	Hyd. volume	= 3,494 cuft
Inflow hyd. No.	= 4 - Post-Dev to Basin #1 (POI #1)	Max. Elevation	= 361.72 ft
Reservoir name	= Basin #1	Max. Storage	= 3,067 cuft

Storage Indication method used.



Conveyance Calculations

Scenario: 25-Year



Runoff Calculations C Worksheet

Project: **Favorite Client**

Description: **Inlet Drainage Areas**

Drainage Area	Land Use Description	C	Area (Acres)	Total Area (Acres)	Weighted C
IN01	Impervious	0.99	0.11	**0.11**	**0.99**
IN02	Impervious	0.99	0.33	**0.33**	**0.99**
IN03	Impervious	0.99	0.05	**0.05**	**0.99**
IN04	Impervious	0.99	0.05	**0.05**	**0.99**
IN05	Impervious	0.99	0.08	**0.08**	**0.99**
IN06	Impervious	0.99	0.12	**0.13**	**0.95**
	Pervious	0.51	0.01		
IN07	Impervious	0.99	0.13	**0.14**	**0.96**
	Pervious	0.51	0.01		
IN08	Impervious	0.99	0.01	**0.01**	**0.99**

Scenario: 25-Year
Current Time Step: 0.000Hr
Conduit FlexTable: Combined Pipe/Node Report

Label	Start Node	Stop Node	Upstream Inlet C	Upstream Inlet Area (acres)	System CA (acres)	System Intensity (in/h)	Flow (Link) (ft³/s)	Number of Barrels	Diameter (in)	Capacity (Design) (ft³/s)	Velocity (Average) (ft/s)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Slope (ft/ft)	Length (Unified) (ft)
P-07	IN-OS01	MH03	(N/A)	(N/A)	0.000	7.140	0.03	1	18.0	8.36	1.09	357.50	356.88	0.0054	115.0
P-09	IN03	MH03	0.990	0.050	0.049	7.140	0.36	1	18.0	8.21	2.32	357.87	357.74	0.0052	25.0
P-10	MH03	MH02	(N/A)	(N/A)	0.049	6.629	0.36	1	18.0	8.40	2.37	356.71	356.59	0.0055	22.0
P-11	MH02	EW02	(N/A)	(N/A)	0.369	6.584	2.48	1	18.0	16.51	6.72	356.42	355.62	0.0211	38.0
P-12	IN01	MH02	0.990	0.110	0.109	7.140	0.78	1	18.0	8.05	2.89	356.61	356.59	0.0050	4.0
P-13	IN02	MH02	0.990	0.330	0.211	7.140	1.52	1	18.0	23.79	7.55	358.12	356.59	0.0437	35.0
P-14	IN08	MH05	0.990	0.010	0.010	7.140	0.07	1	18.0	8.63	1.48	361.87	361.49	0.0058	66.0
P-16	MH05	IN07	(N/A)	(N/A)	0.010	6.925	0.07	1	18.0	8.74	1.48	361.32	360.96	0.0059	61.0
P-17	IN07	IN06	0.960	0.140	0.144	6.726	0.98	1	18.0	8.73	3.27	360.79	360.69	0.0059	17.0
P-18	IN06	MH04	0.950	0.130	0.268	6.700	1.81	1	18.0	8.68	3.88	360.52	360.20	0.0058	55.0
P-19	MH04	EW01	(N/A)	(N/A)	0.268	6.632	1.79	1	18.0	8.81	3.91	360.03	360.00	0.0060	5.0
P-20	IN04	EW01	0.990	0.500	0.495	7.140	3.56	1	18.0	25.44	10.15	360.20	360.00	0.0500	4.0
P-21	IN05	EW01	0.990	0.080	0.079	7.140	0.57	1	18.0	25.44	5.90	360.20	360.00	0.0500	4.0

R:\18\PC181016\Technical\Stormwater & E&S\Rev 1\StormCAD\PC181016_Rev-1.stc

Scenario: 25-Year
Current Time Step: 0.000Hr
Catch Basin FlexTable: Node Report

Label	Inlet	Inlet DA (acres)	Inlet C	Local CA (acres)	Inlet Tc (min)	Local Intensity (in/h)	System CA (acres)	I (in/h)	System Tc (min)	System Rational Q (ft³/s)	Rim (ft)	Elevation (Invert) (ft)	Sump (ft)	HGL In (ft)	HGL Out (ft)
IN01	PADOT Type 'C'	0.110	0.990	0.109	5.000	7.140	0.109	7.140	5.000	0.78	359.74	356.61	0.00	357.04	357.04
IN02	PADOT Type 'C'	0.330	0.990	0.327	5.000	7.140	0.211	7.140	5.000	1.52	361.25	358.12	0.00	358.58	358.58
IN03	PADOT Type 'C'	0.050	0.990	0.049	5.000	7.140	0.049	7.140	5.000	0.36	361.00	357.87	0.00	358.09	358.09
IN04	PADOT Type 'C'	0.500	0.990	0.495	5.000	7.140	0.495	7.140	5.000	3.56	364.70	360.20	0.00	361.14	361.14
IN05	PADOT Type 'C'	0.080	0.990	0.079	5.000	7.140	0.079	7.140	5.000	0.57	364.60	360.20	0.00	361.19	361.19
IN06	PADOT Type 'M'	0.130	0.950	0.123	5.000	7.140	0.268	7.140	5.000	1.81	364.70	360.52	0.00	361.21	361.19
IN07	PADOT Type 'M'	0.140	0.960	0.134	5.000	7.140	0.144	7.140	5.000	0.98	364.70	360.79	0.00	361.19	361.19
IN08	PADOT Type 'C'	0.010	0.990	0.010	5.000	7.140	0.010	7.140	5.000	0.07	365.50	361.87	0.00	361.97	361.97
IN-OS01	PADOT Type 'M'	(N/A)	(N/A)	0.000	0.000	7.140	0.000	7.140	5.000	0.00	365.21	357.50	0.00	357.56	357.56

Appendix A

WHITESTONE ASSOCIATES, INC.
Environmental & Geotechnical Engineers & Consultants

NEW BRITAIN CORPORATE CENTER
1600 MANOR DRIVE
SUITE 220
CHALFONT, PA 18914
215.712.2700
whitestoneassoc.com

July 12, 2018

via email

THE AUTOWASH GROUP
444 Egypt Road
Norristown, Pennsylvania 19403

Attention: Peter Karakelian, P.E.
President

Regarding: PRELIMINARY STORMWATER MANAGEMENT AREA EVALUATION
PROPOSED WAWA FOOD MARKET
LANCASTER AVENUE & ABERDEEN AVENUE
RADNOR TOWNSHIP, CHESTER COUNTY, PENNSYLVANIA
WHITESTONE PROJECT NO.: GP1714612.000

Dear Mr. Karakelian:

Whitestone Associates, Inc. (Whitestone) is pleased to submit this *Preliminary Stormwater Management (SWM) Area Evaluation* report for the above-referenced project. This assessment provides preliminary SWM area recommendations for the proposed Wawa Food Market redevelopment based on available groundwater information provided by The Autowash Group (TAG) and subsurface information presented in Whitestone's July 25, 2017 *Report of Geotechnical Investigation,* previously performed in support of the proposed site redevelopment.

1.0 PROJECT DESCRIPTION / SUBSURFACE DATA

Based on the project information provided by Bohler Engineering PA, LLC (Bohler), the site redevelopment potentially will include underground SWM facilities at an approximate elevation of 362 feet, as referenced from the North American Vertical Datum of 1988 (NAVD88). The final types, locations, and size of the proposed SWM facilities have not been determined at the time of this report.

The groundwater data provided by TAG included 17 monitoring well logs prepared by JK Environmental Services, LLC (JKES). Based on the monitoring well data, the groundwater table was recorded at relatively shallow depths that corresponding to elevations ranging between 356.6 feet and 361.0 feet.

Whitestone's subsurface data obtained from the geotechnical investigation revealed that the soil types encountered between the approximate elevations of 363 feet and 358 feet consist of a combination of generally fine-grained existing fill materials and fine-grained natural soils.

2.0 PRELIMINARY SWM RECOMMENDATIONS

Based on the groundwater information provided by TAG and subsurface data obtained from Whitestone's previously performed geotechnical investigation, the site generally appears not to be conducive for infiltration design.

A site specific investigation and testing may be required in order to confirm these preliminary conclusions.

Whitestone appreciates the opportunity to be of continued service to the Autowash Group. Please contact us with any questions or comments regarding this report addendum.

Sincerely,

WHITESTONE ASSOCIATES, INC.

James M. Morgan
Senior Project Manager

Laurence W. Keller, P.E.
Principal, Geotechnical Services

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REPORT OF GEOTECHNICAL INVESTIGATION

PROPOSED WAWA FOOD MARKET & FUELING STATION
LANCASTER AVENUE & ABERDEEN AVENUE
WAYNE (RADNOR TOWNSHIP), CHESTER COUNTY, PENNSYLVANIA

Prepared for:

THE AUTOWASH GROUP
444 Egypt Road
Norristown, Pennsylvania 19403

Prepared by:

WHITESTONE ASSOCIATES, INC.
New Britain Corporate Center
1600 Manor Drive, Suite 220
Chalfont, Pennsylvania 18914

James M. Morgan
Senior Project Manager

Laurence W. Keller, P.E.
Principal, Geotechnical Services

Whitestone Project No.: GP1714612.000
July 25, 2017

July 25, 2017

via email

THE AUTOWASH GROUP
444 Egypt Road
Norristown, Pennsylvania 19403

Attention: Peter Karakelian, P.E.
President

Regarding: REPORT OF GEOTECHNICAL INVESTIGATION
PROPOSED WAWA FOOD MARKET & FUELING STATION
LANCASTER AVENUE & ABERDEEN AVENUE
RADNOR TOWNSHIP (WAYNE), CHESTER COUNTY, PENNSYLVANIA
WHITESTONE PROJECT NO.: GP1714612.000

Dear Mr. Karakelian:

Whitestone Associates, Inc. is pleased to submit the attached *Report of Geotechnical Investigation* for the above-referenced project. The attached report presents the results of Whitestone's soils exploration efforts and presents recommendations for design of the proposed structural foundations, floor slab, pavements, utilities, and related earthwork associated with the proposed Wawa Food Market and fueling station development.

Whitestone's geotechnical division appreciates the opportunity to be of service to The Autowash Group. Please note that Whitestone has the capability to perform the additional geotechnical engineering services recommended herein. Please contact us at (215) 712-2700 with any questions regarding the enclosed report.

Sincerely,

WHITESTONE ASSOCIATES, INC.

James M. Morgan
Senior Project Manager

Laurence W. Keller, P.E.
Principal, Geotechnical Services

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Enclosures

FIGURES

APPENDICES

SECTION 1.0
Summary of Findings and Recommendations

An exploration and evaluation of the subsurface conditions has been performed on the site of the proposed Wawa Food Market and fueling station development located within the southeastern quadrant of the intersection of the Lancaster Avenue and Aberdeen Avenue in Radnor Township (Wayne), Chester County, Pennsylvania. The site of the proposed construction is shown on the *Boring Location Plan* included as Figure 1.

At the time of the investigation, the western portion of the site was developed with a Sunoco gasoline station with associated pavements and utilities, including underground storage tanks (USTs). The eastern portion was developed with a BP gasoline station with associated pavements and utilities, including USTs.

Based on a review of available historical aerial imagery dating back to 1948, several former structures previously occupied the subject property. Additionally, several existing USTs are in-place adjacent to the proposed Wawa Food Market building, canopy area, and new USTs location.

Based on the elevations provided by a hand-held Trimble Geo-XT GPS instrument, the site has approximate existing elevations ranging between +364 feet in the western and southern portions of the site and +370 feet in the northern portions of the site, as referenced from mean sea level (msl) elevation.

Based on a May 11, 2017 *Site Plan* prepared by JK Environmental, the proposed site redevelopment includes demolition of the existing structures and utilities and the construction of a single-story Wawa Food Market building, a canopy over fuel dispenser stations, up to five USTs, and associated new pavements, trash enclosure, identification signs, and utilities. The proposed development may include stormwater management (SWM) facilities, but final type, location, and size have not been provided at the time of this report. Whitestone anticipates that the proposed site grading will require maximum earth cuts and fills on the order of two feet. No site retaining walls are anticipated.

The geotechnical investigation included performing a reconnaissance of the project site, drilling seven soil borings (and one associated offset), and collecting soil samples for laboratory analysis. The data from this exploration and analysis were analyzed by Whitestone in light of the project information provided by The Autowash Group (TAG).

A summary of Whitestone's findings is presented in the following table and detailed descriptions of the subsurface conditions encountered are presented in Section 4.0.

Subsurface Profile	Description	Bottom of Stratum (fbgs)
Surface Cover Materials	Asphalt Pavement: 6.0 inches underlain by up to 6.0 inches of subbase material.	1.0
Existing Fill Materials	Encountered all of the borings. Consisting of clay, silt, and sand mixtures with trace amounts of concrete, brick, and metal fragments.	3.0 to 8.0
Residual Soils	Lean clay (USCS: CL), silt (USCS: ML), and sand (USCS: SM) with lesser amounts of gravel.	+24.7
Groundwater	Static groundwater was encountered in majority of test borings at depths of 3.5 fbgs to 9.0 fbgs	+3.5

fbgs: feet below ground surface.

Recommendations developed upon consideration of these findings are summarized in the table below and presented in greater detail in the indicated sections of the report.

Geotechnical Consideration	Recommendation	Report Section
Demolition of Existing Structures	Demolition of the existing structures should include complete removal of slabs, foundation walls, and footings. The resultant excavations should be backfilled in a controlled manner using approved structural backfill materials.	5.2
Demolition of Existing Utilities	The in-place USTs associated with existing site development are located in close proximity to the proposed Wawa building, canopy, and new UST field. All existing USTs should be removed and backfilled with structural fill in accordance with this report.	5.2
Groundwater Control	Construction phase dewatering is anticipated for canopy foundations, USTs, and utility construction. Temporary dewatering is expected to include the use of sump pits and pumps installed within excavations. Submerged fill consisting of open-graded, crushed, three-quarter inch clean stone will be required within excavations that extend below groundwater level.	5.4
Supplemental Investigation	A significant portion of the proposed development was occupied by existing structures at the time of the investigation and was inaccessible to the drilling equipment. As such, additional exploration should be performed at a later date following demolition of the existing structures in order to confirm foundation design recommendations herein. In addition, construction phase evaluation of the existing fill materials should be performed by the owner's geotechnical engineer.	5.12
Foundation System	Shallow spread and continuous footings bearing on approved and recompacted existing fill materials, natural soils, and imported structural fill. Based on the extensive former site development, buried remnant slabs and foundations may be encountered. Isolated areas of overexcavation and replacement are anticipated.	5.5
Floor Slab & Pavements	A majority of the on-site soils will be suitable for support of the proposed floor slab and pavements following compaction and proofroll inspections. Isolated areas of overexcavation and replacement are anticipated.	5.6
On-Site Soil Reuse	A majority of the site soils above groundwater lever are expected to be suitable for reuse as structural fill and/or backfill provided that moisture levels are maintained within two percent of optimum moisture content.	5.3

SECTION 2.0
Introduction

2.1 AUTHORIZATION

Peter Karakelian, P.E. of TAG issued authorization to Whitestone to perform a geotechnical investigation on this site relevant to the construction of the proposed Wawa Food Market and fueling station located at the southeastern quadrant of the intersection of Lancaster Avenue (U.S. Route 30) and Aberdeen Avenue in Radnor Township (Wayne), Chester County, Pennsylvania. The geotechnical investigation was performed in general accordance with Whitestone's June 2, 2017 revised proposal to TAG.

2.2 PURPOSE

The purpose of this subsurface exploration and analysis was to:

- ascertain the various soil profile components at test locations;
- estimate the engineering characteristics of the proposed foundation bearing and subgrade materials;
- provide geotechnical criteria for use by the design engineers in preparing the foundation, slab, and pavement design;
- provide recommendations for required earthwork and subgrade preparation;
- record groundwater levels (if encountered) at the time of the investigation and discuss the potential impact on the proposed construction; and
- recommend additional investigation and/or analysis (if warranted).

2.3 SCOPE

The scope of the exploration and analysis included the subsurface exploration, field testing and sampling, laboratory analysis, and an engineering analysis and evaluation of the foundation materials. This *Report of Geotechnical Investigation* is limited to addressing the site conditions related to the physical support of the proposed construction. Any references to suspicious odors, materials, or conditions are provided strictly for the client's information. A *Limited Phase II Environmental Site Assessment* report has been prepared by Whitestone's environmental division and submitted under separate cover.

2.3.1 Field Exploration

Field exploration of the project site was conducted by means of seven soil borings and one associated offset, identified as SB-01 through SB-07. The soil borings were advanced with a ATV-mounted Acker XLS drill rig equipped with hollow-stem augers. The locations of the soil borings are shown on the *Boring Location Plan* included as Figure 1. *Records of Subsurface Exploration* are provided in Appendix A. The test boring locations and termination depths are presented in the table below:

SOIL BORING & TERMINATION DEPTH TABLE		
Proposed Construction	**Boring Location(s)**	**Termination Depth (fbgs*)**
Wawa Food Market Building	SB-04 and SB-05	20.0
Fuel Canopy/Dispenser Islands	SB-01 and SB-03	13.0 to 20.0
UST Field	SB-02/SB-02A	3.5 to 24.7
Proposed Trash Enclosure/Pavements	SB-06 and SB-07	11.0

* fbgs: feet below ground surface

The boring locations were based on the project information available at the time of the investigation provided by TAG, including the May 11, 2017 *Site Plan* prepared by JK Environmental. In addition, the investigation was performed in general accordance with scope of work outlined in the December 13, 2002 (implementation date February 20, 2006) *Geotechnical Report Standards* prepared by Wawa, Inc.

The soil borings were conducted in the presence of a Whitestone engineer who performed field tests, recorded visual classifications, and collected samples of the various strata encountered. The test areas were located in the field using normal taping procedures and estimated right angles. These locations are presumed to be accurate within a few feet.

Soil borings and Standard Penetration Tests (SPTs) were conducted in general accordance with ASTM International (ASTM) designation D 1586. The SPT resistance value (N) can be used as an indicator of the consistency of fine-grained soils and the relative density of coarse-grained soils. The N-value for various soil types can be correlated with the engineering behavior of earthworks and foundations.

Groundwater level observations, where encountered, were recorded during and immediately after the completion of field operations prior to backfilling the borings. Groundwater elevations derived from sources other than seasonally observed groundwater monitor wells may not be representative of true groundwater levels.

2.3.2 Laboratory Testing Program

In addition to the field investigation, a laboratory testing program was conducted to determine additional, pertinent engineering characteristics of representative samples of on-site soils. The laboratory testing program was performed in general accordance with applicable ASTM standard test methods and included physical testing of proposed building foundation bearing and pavement subgrade stratum.

Physical/Textural Analyses: Representative samples of selected strata encountered were subjected to a laboratory testing program that included Atterberg limits determinations (ASTM D-4318), moisture content determinations (ASTM D-2216) and washed gradation analyses (ASTM D-422) in order to perform supplementary engineering soil classifications in general accordance with ASTM D-2487. The soil strata tested were classified by the Unified Soil Classification System (USCS) and results of the laboratory testing are summarized in the following table. Quantitative test results are provided in Appendix B.

PHYSICAL/TEXTURAL ANALYSES SUMMARY

Boring No.	Sample	Depth (fbgs)	% Passing No. 200 Sieve	Moisture Content (%)	Liquid Limit	Plastic Index	USCS Classification
SB-02A	S-4	6.0 to 8.0	14.0	13.1	Non-Plastic		SM
SB-04	S-2	3.0 to 5.0	8.8	24.0	40	20	CL

fbgs: feet below ground surface

The engineering classifications are useful when considered in conjunction with the additional site data to estimate properties of the soil types encountered and to predict the soil's behavior under construction and service loads.

SECTION 3.0
Site Description

3.1 LOCATION AND DESCRIPTION

The subject site comprises approximately 1.3 acres and is located within the southeastern quadrant of the intersection of Lancaster Avenue (U.S. Route 30) and Aberdeen Avenue in Radnor Township (Wayne), Chester County, Pennsylvania. The site is bordered by Lancaster Avenue to the north, followed by a gasoline station and retail development; retail and office building developments to the east; residential development to the site; Aberdeen Avenue to the west, followed by various retail and office building developments.

3.2 EXISTING CONDITIONS

Surface Cover/Development: At the time of the investigation, the site was developed. The western portion of the site was developed with a Sunoco gasoline station with associated pavements and utilities, including USTs. The eastern portion was developed with a BP gasoline station with associated pavements and utilities, including USTs.

Previous Site Development: Based on a review of available historical aerial imagery dating back to 1948, the subject property appeared developed with residential properties, with the surrounding roads in place. Sometime between 1948 and 1950, the residential structures and trees were removed and the western portion of the site was paved. Sometime between 1950 and 1958, the eastern portion of the site appeared to be a automotive service station. The site remained relatively unchanged until sometime between 1967 and 1971, when the western portion of the site was redeveloped to the existing Sunoco gasoline station layout. Sometime between 1971 and 1992, the eastern portion of the site was redeveloped to the existing BP gasoline station layout. No significant changes to the property were apparent between 1992 and present day.

Topography & Site Coordinates: A survey plan with existing topographical information was not available at the time of this report; however Whitestone utilized a handheld Trimble Geo-XT with sub-meter accuracy to approximate the coordinates and existing surface elevations of the test boring locations. Based on the elevations provided by the Trimble Geo-XT, the site has approximate existing elevations ranging between +364 feet in the western and southern portions of the site and +370 feet in the northern portions of the site.

The coordinates and surface elevations of the test boring locations recorded at the time of the investigation are presented in Appendix D.

Utilities: The existing structures are serviced by natural gas, water, stormwater, electric, and telecommunications. In addition, underground utilities traversed the perimeter of the site at the time of the investigation, including natural gas, sanitary sewer, water, stormwater, electric and telecommunications. The utility information contained in this report is presented for general discussion only and is not intended for construction purposes.

Site Drainage: Surface runoff generally consists of sheet flow across the existing ground surface and generally appears to flow from the north to the south. Stormwater collection facilities traverse the perimeter of the site as part as the existing roadways.

3.3 SITE BEDROCK GEOLOGY

The *Geologic Map of Pennsylvania* prepared by the Commonwealth of Pennsylvania Department of Environmental Resources Bureau of *Topographic and Geologic Survey*, dated 1980, indicates that subject site is located within the Upland Section of the Piedmont Physiographic Province of Pennsylvania. Specifically, the site is underlain by the Precambrian-aged Mafic Gneiss Formation. This formation consists of dark, medium-grained gneiss and includes rock of probable sedimentary origin and the parent bedrock weathers to silty sand and silt with upper layers of lean clay. The subsurface conditions encountered generally are consistent with the mapped geology.

3.4 PROPOSED CONSTRUCTION

Based on the aforementioned *Site Plan,* the proposed site redevelopment includes demolition of the existing structures, pavements and associated utilities and construction of a single-story Wawa Food Market building, a canopy over fuel dispenser stations, USTs, and associated new pavements, trash enclosure, identification signs, and utilities. The proposed development may include SWM facilities. No proposed grading plans were available at the time of this report, however, Whitestone anticipates maximum cuts and fills on the order of two feet. No site retaining walls are anticipated.

Whitestone anticipates that the proposed structures will consist of a combination of load-bearing masonry walls with steel joist and column framing and concrete slab-on-grade. Final maximum design loads have not been determined at this time; however, based on past experience with similar Wawa projects, maximum design loads are assumed to be less than the following:

- column load - 65 kips;
- wall load - 2.0 kips per linear foot;
- floor slab load - 100 pounds per square foot; and
- canopy overturning moment - 50 foot-kips.

The scope of Whitestone's investigation and the professional advice contained in this report were generated based on the project details and loading noted herein. Any revisions or additions to the design details enumerated in this report should be brought to the attention of Whitestone for additional evaluation as warranted.

SECTION 4.0
Subsurface Conditions

Details of the subsurface materials encountered are presented on the *Records of Subsurface Exploration* presented in Appendix A of this report. The subsurface soil conditions encountered in the soil borings consisted of the following generalized strata in order of increasing depth.

4.1 SUBSURFACE CONDITIONS

Surficial Cover Materials: The soil borings were performed within the existing pavement areas associated with the existing gasoline stations. These test locations encountered approximately six inches of asphalt underlain by approximately six inches of granular subbase materials.

Existing Fill Materials: Underlying the surficial cover materials, existing fill materials were encountered in all of the boring locations. The existing fill materials consisted generally of lean clay, silt, and sand mixtures with trace amounts of brick, asphalt, concrete, metal, and gravel. Several of the locations revealed loose or very soft soil conditions, especially in location SB-07, where approximately two feet of material could be penetrated by the weight of the sampling hammer. The existing fill materials extended to depths ranging from approximately 3.0 fbgs to 8.0 fbgs. Boring SB-02 was terminated within the existing fill materials and offset due to a utility concern.

Residual Soils: Beneath the existing fill materials, the test locations encountered residual soils composed of lean clay (USCS: CL) with variable amounts of sand; silt (USCS: ML) with variable amounts of gravel and sand; and sand with varying amounts of silt (USCS: SM). The tests were terminated within the residual soils at depths ranging from 11.0 fbgs to 24.7 fbgs. SPT N-values within coarse-grained portions of this stratum ranged between four bpf and 63 bpf, generally indicating loose to very dense relative densities and averaging approximately 12 bpf. Pocket penetrometer tests performed on the residual cohesive soils indicated unconfined compressive strengths (q_u) ranging between approximately 0.5 tons per square foot (tsf), and 1.5 tsf, generally indicating medium stiff to stiff soil consistencies.

Groundwater: Static groundwater was encountered during this investigation in majority of the boring locations at depths ranging from 3.5 fbgs to 9.0 fbgs, corresponding to approximate elevations ranging between +359 feet and +361 feet. In addition, perched/trapped water was encountered throughout the site within the existing fill materials and at the confluence of the fill materials and the cohesive materials. Static and perched/trapped water conditions generally will fluctuate seasonally and following periods of precipitation.

SECTION 5.0
Conclusions and Recommendations

5.1 GENERAL

Whitestone recommends supporting the proposed structures on conventional shallow foundations bearing within approved and compacted existing fill materials, residual soils, and/or controlled structural fill soils provided they are properly inspected, placed and compacted in accordance with Sections 5.2, 5.3, and 5.12 of this report. Existing fill materials should be overexcavated where encountered at or below proposed foundation bearing elevations if deemed unsuitable during inspection by the owner's geotechnical engineer.

Whitestone anticipates that the proposed floor slab and pavements may be supported on approved and compacted existing fill materials, underlying residual soils, and/or controlled structural fill materials subject to supplemental evaluation and subgrade preparation as described herein with limited areas of overexcavation and replacement, and/or mechanical stabilization anticipated due to the inherent variability of existing fill materials.

Due to the structures associated with the existing gasoline stations, significant portions of the proposed development were not accessible to drilling equipment at the time of Whitestone's exploration. Whitestone preliminarily anticipates that the subsurface conditions within the unexplored portions of the proposed building footprint will be suitable for support of shallow foundations and floor slabs, Whitestone recommends confirming the anticipated suitable subsurface conditions within the proposed Wawa Food Market building footprint by means of test pit excavations following demolition of the existing structures or during early phases of construction.

Whitestone anticipates that a majority of the natural site soils and approved existing fill material above groundwater level will be suitable for reuse as structural fill/backfill provided that soil moisture contents are controlled within two percent of optimum moisture level. Additionally, portions of the site soils are especially moisture sensitive and must be properly protected, compacted, proofrolled, and evaluated during construction as described herein. Immediate reuse of the site soils should not be expected, especially if construction occurs following inclement weather.

5.2 SITE PREPARATION AND EARTHWORK

Surface Cover Stripping and Demolition: Prior to stripping operations, all utilities should be identified and secured. Any surficial vegetation and pavements should be stripped at least 10 feet beyond the limits of the proposed building, canopy, UST field, and associated pavement areas. Any remnant structures

encountered including foundation walls, footings, slabs, and utilities should be removed entirely from below proposed foundations and slabs including their zones of influence (as determined by the Geotechnical Engineer) and excavated to at least two feet below proposed construction subgrade levels elsewhere.

Existing UST Removal: Existing USTs associated with current site development are located in close proximity of the proposed building, canopy, and UST field. All existing USTs should be removed and backfilled in a controlled manner with structural fill in accordance with Section 5.3 of this report.

Demolition of Existing Building and Canopy Structures: The existing single-story structures are situated within or near the proposed canopy structure and trash enclosure. Demolition of the existing buildings should include complete removal of the floor slab, foundation walls, and footings. The existing canopy structures are located within areas of the proposed canopy structure and the proposed food market building. Demolition of the existing canopies should include complete removal of the footings. The resultant excavation should be backfilled in a controlled manner using approved structural backfill materials in accordance with Section 5.3.

Existing Fill Materials Overexcavation and Replacement: During the investigation, the existing fill generally consisted of silt, clay, and sand with trace amounts of brick, concrete, and metal, however, SPT-N values within portions of these materials indicate these materials were likely placed in an uncontrolled manner. As such, Whitestone anticipates that isolated areas of overexcavation and replacement will be necessary in accordance with the recommendations presented in the following sections.

Surface Preparation/Proofrolling: Prior to placing any fill, backfill or subbase materials to raise or restore grades to the desired building or pavement subgrade elevations, the exposed soils should be compacted to a firm and unyielding surface with a minimum of two passes in two perpendicular directions of a minimum 10-ton, vibratory smooth drum roller. The surface should be proofrolled with a loaded tandem axle truck in the presence of the geotechnical engineer to help identify soft or loose pockets that may require removal and replacement or further investigation. Any fill or backfill should be placed and compacted in accordance with Section 5.3.

Weather Performance Criteria: Every effort must be made to maintain drainage of surface water runoff away from construction areas by grading and limiting the exposure of excavations and prepared subgrades to rainfall. Accordingly, excavation and fill placement procedures should be performed during favorable weather conditions. Overexcavation of saturated soils and replacement with controlled structural fill per Section 5.3 of this report may be required prior to resuming work on disturbed subgrade soils.

On-Site Soil Protection and Maintenance: The site soils are will degrade if exposed to inclement weather, freeze-thaw cycles, or repeated construction traffic. However, if properly protected and maintained as recommended herein, the site soils will provide adequate support for the proposed construction. The site contractors should employ appropriate means and methods to protect the subgrade including, but not limited to the following:

- leaving existing pavements in-place as long as practical to help minimize subgrade exposure to inclement weather;
- sealing exposed subgrade soils on a daily basis with a vibratory smooth drum roller;
- regrading the site as needed to maintain positive drainage away from open earthwork construction areas and to prevent standing water;
- removing wet surficial soils immediately; and
- limiting exposure to construction traffic and precipitation especially following inclement weather and subgrade thawing.

Pavement Subgrade Stabilization and Inspection: Pavement subgrade soils which are exposed to inclement weather and heavy construction traffic will degrade and require either extensive drying time or overexcavation and replacement in order to provide a suitable subgrade for pavements. Overexcavation of unstable soils (existing fill materials or natural soils) within pavement areas typically should be limited to approximately 1.5 feet below planned subgrade unless directed otherwise by the owner's geotechnical engineer, provided that a reinforcing geogrid approved by the owner's geotechnical engineer is used. Alternatively, unstable materials may be completely overexcavated and either aerated and recompacted or replaced with imported structural fill per Section 5.3. However, this option is likely least economical.

Geogrids typically are economical when proposed undercut depths exceed approximately 16 inches. The geogrid (Tensar TriAx TX130S, or similar) should be placed directly on the exposed subgrade and backfill should consist of a well-graded gravel and sand blend. The services of the geotechnical engineer should be retained to inspect soil conditions during construction and to provide specific recommendations for stabilizing subgrades. Additionally, a geotechnical engineer should be retained to verify the suitability of prepared foundation, floor slab and pavement subgrades for support of design loads.

5.3 STRUCTURAL FILL AND BACKFILL

Imported Fill Material: Any imported material placed as structural fill or backfill to raise elevations or restore design grades should consist of clean, relatively well-graded sand or gravel with a maximum particle size of two inches and five percent to 15 percent of material finer than a #200 sieve. Silts, clays, and silty or clayey sands and gravels with higher percentage of fines and with a liquid limit less than 40 and a plasticity index less than 20 may be considered subject to the owner's approval, provided that the

required moisture content and compaction controls are met during favorable weather conditions. The material should be free of clay lumps, organics, and deleterious material. Imported structural fill material should be approved by a qualified geotechnical engineer prior to delivery to the site.

On-Site Materials: Based on the conditions disclosed by the soil borings, Whitestone anticipates that a majority of the existing fill materials and natural soils above the groundwater level will be suitable for reuse as structural fill/backfill material provided that soil moisture contents are controlled within two percent of optimum moisture level. Additionally, the site soils must be properly compacted and evaluated during the construction phase as described in Section 5.3 and 5.12.

Materials that are below groundwater level or become exceedingly wet will likely require discing and aerating. Alternatively, imported fill materials may be used to attain the desired grades and expedite earthwork operations during wet weather periods. The contractor should cover stockpiled soils, seal subgrades, and provide proper surface drainage prior to forecasted wet weather.

Submerged Fill: If necessary during the construction of the canopy and the UST field, up to two feet of an open-graded, crushed, three-quarter inch stone may be placed in the wet to provide a working mat, expedite dewatering efforts and enable subsequent placement of structural fill or backfill in the dry. Prior to placing submerged fill materials, free water and disturbed materials should be removed to the extent recommended by the geotechnical engineer. A fines barrier geotextile, such as Mirafi 140N or equivalent, should be placed at the base and sides of the overexcavation to separate the stone from underlying and adjacent soils. The fabric also should be placed on top of the stone prior to subsequent fill placement if fill soils with a substantial amount of fines are to be used to restore grade. Submerged fill may be required during excavation activities for the UST field and canopy.

Demolition Material: Demolition material, free of environmental concerns, may be used as fill material provided the material is properly segregated and processed as recommended herein. Concrete and masonry materials should be crushed to a well graded blend with a maximum size of 1.5 inches in diameter. Stripped asphalt and deleterious building materials such as wood, insulation, metal, shingles etc. should not be used as structural fill material. Milled or recycled asphalt pavement (RAP) may be re-used as granular base for proposed pavements provided that the RAP particle size meets Pennsylvania Department of Transportation (PENNDOT) standard specifications for granular base and no more than 50% of the pavement granular base contains RAP.

Compaction and Placement Requirements: On-site soils and imported materials used as fill or backfill should be placed in maximum nine-inch loose lifts and compacted using a 10-ton smooth drum vibratory drum during mass grading activities or a small walk-behind roller or hand-held vibratory compactor within excavations. All structural fill and backfill, including 10 feet outside new exterior walls, should be compacted to at least 95 percent of the maximum dry density within two percent of the optimum moisture

content as determined by ASTM D 1557 (Modified Proctor). Fill and backfill placed within non-structural areas may be compacted to 92 percent of the maximum dry density within three percent of optimum moisture content as determined by ASTM D 1557 (Modified Proctor).

Structural Fill Testing: A sample of the imported fill material or any on-site material proposed for reuse as structural fill or backfill should be submitted to the geotechnical engineer for analysis and approval at least one week prior to its use. The placement of all fill and backfill should be monitored by a qualified engineering technician to ensure that the specified material and lift thicknesses are properly installed. A sufficient number of in-place density tests should be performed to ensure that the specified compaction is achieved throughout the height of the fill or backfill.

5.4 GROUNDWATER CONTROL

Based on static groundwater levels encountered during the investigation, Whitestone anticipates that groundwater will be deeper than anticipated Wawa Food Market building foundations and shallow utility excavations.

However, Whitestone anticipates that dewatering of static groundwater will be required for installation of the USTs, canopy structure, and deeper utility excavations. The total amount of groundwater to be removed will depend on the size of the excavation, the depth of shoring used to cut-off flow and the length of time that the excavation remains open.

Because portions of the subsurface soils will soften when exposed to water, every effort must be made to maintain drainage of surface water runoff away from construction areas by grading and limiting the exposure of excavations to rainfall. Overexcavation of saturated soils and replacement with controlled structural fill and/or one foot to two feet of open graded gravel (such as 3/4 inch clean crushed stone) may be required prior to resuming work on disturbed subgrade soils.

5.5 FOUNDATIONS

Shallow Foundation Design Criteria: Whitestone recommends supporting the proposed building and canopy structures on conventional shallow spread and continuous footings designed to bear within approved existing fill material, natural soils, and/or structural fill materials provided these materials are properly evaluated, placed, and compacted in accordance with Sections 5.3 and 5.12 of this report. Foundations bearing within these materials may be designed using a maximum allowable net bearing pressure of 2,000 pounds per square foot.

All footing bottoms should be improved by in-trench compaction in the presence of the geotechnical engineer. Regardless of loading conditions, proposed foundations should be sized no less than minimum dimensions of 24 inches for continuous wall footings and 36 inches for isolated column footings.

Footings should be designed so that the maximum toe pressure due to the combined effect of vertical loads and overturning moment does not exceed the recommended maximum allowable net bearing pressure. In addition, positive contact pressure should be maintained throughout the base of the footings such that no uplift or tension exists between the base of the footings and the supporting soil. Uplift loads should be resisted by the weight of the concrete. Side friction should be neglected when proportioning the footings so that lateral resistance should be provided by friction resistance at the base of the footings. An allowable coefficient of friction against sliding of 0.30 is recommended for use in the design of the foundations bearing within the on-site soils or imported structural backfill.

Inspection Criteria: Whitestone recommends that the suitability of the bearing soils along the footing bottoms be verified by a geotechnical engineer prior to placing concrete for the footings. Special attention should be given to areas underlain by existing fill materials. In the event that isolated areas of unsuitable materials are encountered in footing excavations, overexcavation and replacement of the materials or deeper foundation embedment may be necessary to provide a suitable footing subgrade. Any overexcavation to be restored with structural fill will need to extend at least one foot laterally beyond footing edges for each vertical foot of overexcavation. Lateral overexcavation may be eliminated if grade is restored with lean concrete. The bottoms of overexcavated areas should be compacted with vibratory smooth drum rollers, walk-behind compactors, vibrating plates or plate tampers ("jumping jacks") to compact locally disturbed materials and densify any underlying loose zones. Any standing water within the footing excavation should be removed with a mechanical pump prior to concrete placement.

Settlement: Whitestone estimates post construction settlements of new foundations will be on the order of less than one inch if the recommendations outlined in this report are properly implemented. Differential settlement between individual footings should be less than one-half inch.

Frost Coverage: Footings subject to frost action should be placed at least 36 inches below adjacent exterior grades or the depth required by local building codes to provide protection from frost penetration. Interior footings not subject to frost action may be placed at a minimum depth of 18 inches below the slab subgrade.

5.6 FLOOR SLAB

Whitestone anticipates that approved site materials and new fill materials placed to raise grades (if necessary) will provide suitable support for the floor slab. The exposed subgrade should be inspected and compacted in accordance with Sections 5.3 and 5.12 of this report. Any areas that become softened or

disturbed as a result of wetting and/or repeated exposure to construction traffic should be removed and replaced with compacted structural fill. The properly prepared site soils and structural fill/backfill materials are expected to yield a minimum subgrade modulus (k) of 150 psi/in.

A minimum four inch layer of three-quarter inch crushed stone (AASHTO No. 57 stone or similar) should be installed below the floor slab to provide a uniform subgrade and capillary break. A moisture vapor barrier should be placed beneath the floor slab where recommended by the flooring manufacturer.

5.7 PAVEMENT DESIGN CRITERIA

General: Whitestone anticipates that the majority of the site soils and/or compacted structural fill/backfill placed to raise or restore design elevations will be suitable for support of the proposed pavements provided these materials are properly evaluated, compacted, and proofrolled in accordance with this report during favorable weather conditions. Subgrade stabilization with a triaxial geogrid, approved by the owner's geotechnical engineer, may be used to minimize depths of overexcavation (if necessary) as discussed further in Section 5.3.

Design Criteria: A California Bearing Ratio (CBR) value of 4.0 has been assigned to the properly prepared subgrade soils for pavement design purposes. This value was correlated with pertinent soil support values and assumed traffic loads to prepare flexible and rigid pavement designs per the AASHTO *Guide for the Design of Pavement Structures*.

Design traffic loads were estimated based on Whitestone's past experience with similar projects and correlated with 18-kip equivalent single axle loads (ESAL) for a 15-year life. Estimated maximum pavement loads of 25,000 ESALs and 60,000 ESALs were used for the standard duty and heavy duty pavement areas, respectively. These values assume the pavements primarily will accommodate both automobile and limited heavier truck traffic, with the heavier truck traffic designated to the main drive lanes. Actual loading experienced is anticipated to be less than this value.

Pavement Sections: The recommended flexible pavement sections are presented in the table below:

FLEXIBLE PAVEMENT SECTIONS DESIGN			
Layer	**Material**	**Standard Duty Thickness (Inches)**	**Heavy Duty Thickness (Inches)**
Asphalt Surface	PENNDOT Super Pave 9.5 mm PG 64-22 Surface Course	1.5	2.0
Asphalt Base	PENNDOT Super Pave 19.0 mm PG 64-22 Base Course	3.0	3.0
Granular Subbase	PENNDOT 2A Stone	6.0	6.0

A rigid concrete pavement should be used to provide suitable support at areas of high traffic or severe turns (such as loading areas, driveway aprons, and garbage dumpster aprons). The recommended rigid pavement is presented below in tabular format:

RIGID PAVEMENT SECTIONS DESIGN			
Layer	**Material**	**Standard Duty Thickness (Inches)**	**Heavy Duty Thickness (Inches)**
Surface	4000 psi air-entrained concrete	6.0	7.0
Base	PENNDOT 2A Stone	6.0	8.0

Additional Design Considerations: The pavement section thickness designs presented in this report are based on the design parameters detailed herein and are contingent on proper construction, inspection, and maintenance. Additional pavement thickness may be required by local code. The designs are contingent on achieving the minimum soil support value in the field. To accomplish this requirement, all subgrade soil and supporting fill or backfill must be properly evaluated, placed, and prepared as detailed in Sections 5.2, 5.3, and 5.12 of this report. Proper drainage must be provided for the pavement structure including appropriate grading and surface water control, as well as measures to drain water from the subgrade.

The performance of the pavement also will depend on the quality of materials and workmanship. Whitestone recommends that PENNDOT standards for materials, workmanship, and maintenance be applied to this site. Project specifications should include verifying that the installed asphaltic concrete material composition is within tolerance for the specified materials and that the percentage of air voids of the installed pavement is within specified ranges for the respective materials. All rigid concrete pavements should be suitably air-entrained, jointed, and reinforced.

5.8 RETAINING WALL/LATERIAL EARTH PRESSURES

No retaining walls are proposed at the time of this report. However, Whitestone anticipates that a temporary excavation support will be required during installation of the proposed USTs. Whitestone should be notified if any other retaining structures or design considerations requiring lateral earth pressure estimations are proposed.

Retaining structures free to rotate generally can be designed to resist active earth pressures. Retaining structures restrained from movement and with corners need to be designed to resist at-rest earth pressures. The following soil parameters apply to the site soils encountered in a well-drained, level backfill condition and may be used for design of temporary retaining structures:

LATERAL EARTH PRESSURE PARAMETERS	
Parameters	**Site Soils**
Moist Density (γ_{moist})	140 pcf
Internal Friction Angle (φ)	26°
Active Earth Pressure Coefficient (K_a)	0.39
Passive Earth Pressure Coefficient (K_p)	2.56
At-Rest Earth Pressure Coefficient (K_o)	0.56

Lateral earth pressure will depend on the slope angle of construction phase grades and subgrades. The effect of other surcharges also will need to be included in earth pressure calculations, possibly including the loads imposed by adjacent traffic. Whitestone would be pleased to assist with the calculation of lateral earth pressures based on the soil parameters presented herein, if necessary.

5.9 SEISMIC AND LIQUEFACTION CONSIDERATIONS

The subsurface conditions are most consistent with a Site Class D as defined by the *International Building Code* (IBC) *2009*. Based on the seismic zone and soil profile, liquefaction considerations are not expected to have a substantial impact on design. The following spectral accelerations are recommended:

SEISMIC SITE PARAMETERS			
S_s	**S_1**	**F_a**	**F_v**
0.278g	0.061g	1.578	2.400

5.10 EXCAVATIONS

Temporary Excavations: The existing fill materials and natural soils encountered during this investigation typically are, at a minimum, consistent with Type C Soil Conditions as defined by 29 CFR Part 1926 (OSHA) which require a maximum unbraced excavation angle of 1.5:1 (horizontal:vertical). Actual conditions encountered during construction should be evaluated by a competent person (as defined by OSHA) to ensure that safe excavation methods and/or shoring and bracing requirements are implemented. Particular attention to the stability of the UST excavation should be considered.

Due to the anticipated depth for the proposed UST excavation, the use of a temporary retaining structure most likely will be necessary. Such structures should be properly designed by the contractor's licensed engineer and should consider potential effects to adjacent roadways, the possibility of encountered obstructions in the existing site soils, and economy.

The specific design of temporary retaining structures is beyond the scope of this report. Whitestone would be pleased to provide additional consultation regarding the design of temporary retaining structures, if requested.

5.11 UST EMBEDMENT

The proposed USTs may be embedded within very dense granular soils and below the anticipated groundwater elevation, which will result in a partially submerged condition for proposed USTs. To prevent hydrostatic uplift of the tanks due to perched water within the tank pit, fastening of the tanks to anchors such as tie-downs and/or "dead men" to the bottom of the excavation should be provided to counteract the effects of buoyancy. Additionally, all USTs should be properly embedded beneath a properly designed concrete mat.

5.12 SUPPLEMENTAL POST INVESTIGATION SERVICES

Supplemental Evaluation of Existing Fill Materials and Inaccessible Areas: The conditions disclosed by the investigation indicated that a majority of the existing fill materials encountered will be suitable for reuse as structural backfill/fill and for supporting proposed foundations, slab, and pavement construction if evaluated and prepared as described herein. However, there is a potential risk of variability in existing fill materials, which may not be disclosed by soils borings performed throughout the site. In addition, based on available historic aerials, the site has been through several different redevelopments and significant portions of the proposed structures were inaccessible at the time of the investigation due to existing structures. As such, Whitestone recommends confirming further the condition of the existing fill and inaccessible areas by means of supplemental test pit excavations or subgrade proofroll in the early stages of construction to enable an assessment for the depths, areal extent, presence of voids, uncontrolled conditions, or deleterious materials. If unsuitable conditions are encountered, alternative recommendations, such as additional overexcavation and replacement, or subgrade stabilization methods may be required.

Construction Inspection and Monitoring: The owner's geotechnical engineer should perform inspection, testing, and consultation during construction as described in previous sections of this report. Monitoring and testing should also be performed to verify that the existing surface cover materials and are removed as recommended herein and, suitable materials, used for controlled fill, are properly placed and compacted over suitable subgrade soils. Any overexcavation of existing fill materials encountered within the proposed building footprint that are unsuitable for foundation and floor slab support should be witnessed and documented by the owner's geotechnical engineer. The proper placement of structural backfill within the building should also be documented by the owner's geotechnical engineer.

SECTION 6.0
General Comments

Supplemental recommendations may be required upon finalization of construction plans or if significant changes are made in the characteristics or location of the proposed structure. Soil bearing conditions should be checked at the appropriate time for consistency with those conditions encountered during Whitestone's geotechnical investigation.

The recommendations presented herein should be utilized by a qualified engineer in preparing the project plans and specifications. The engineer should consider these recommendations as minimum physical standards which may be superseded by local and regional building codes and structural considerations. These recommendations are prepared for the sole use of The Autowash Group for the specific project detailed and should not be used by any third party. These recommendations are relevant to the design phase and should not be substituted for construction specifications.

The possibility exists that conditions between borings may differ from those at specific boring locations, and conditions may not be as anticipated by the designers or contractors. In addition, the construction process may alter soil and rock conditions. Therefore, experienced geotechnical personnel should observe and document the construction procedures used and the conditions encountered.

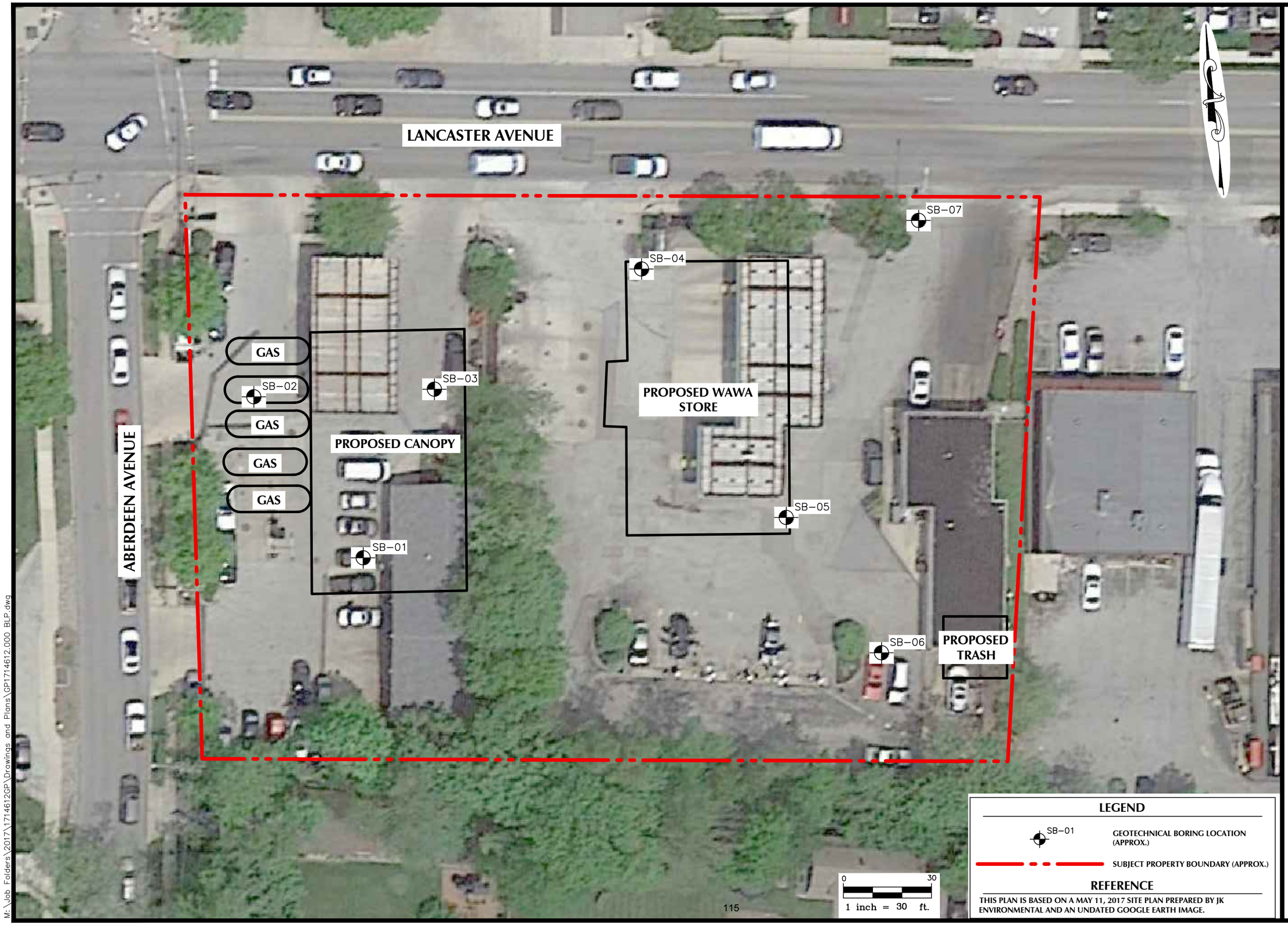
Whitestone assumes that a qualified contractor will be employed to perform the construction work, and that the contractor will be required to exercise care to ensure all excavations are performed in accordance with applicable regulations and good practice. Particular attention should be paid to avoiding damaging or undermining adjacent properties and maintaining slope stability.

Whitestone recommends that the services of the geotechnical engineer be engaged to test and evaluate the soils in the footing excavations prior to concreting in order to determine that the soils will support the bearing capacities. Monitoring and testing also should be performed to verify that suitable materials are used for controlled fills and that they are properly placed and compacted over suitable subgrade soils.

The exploration and analysis of the foundation conditions reported herein are considered sufficient in detail and scope to form a reasonable basis for the foundation design. The recommendations submitted for the proposed construction are based on the available soil information and the design details furnished by The Autowash Group. Deviations from the noted subsurface conditions encountered during construction should be brought to the attention of the geotechnical engineer.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been promulgated after being prepared in accordance with generally accepted professional engineering practice in the fields of foundation engineering, soil mechanics, and engineering geology. No other warranties are implied or expressed.

FIGURE 1
Boring Location Plan



LEGEND

SB–01 — GEOTECHNICAL BORING LOCATION (APPROX.)

SUBJECT PROPERTY BOUNDARY (APPROX.)

REFERENCE

THIS PLAN IS BASED ON A MAY 11, 2017 SITE PLAN PREPARED BY JK ENVIRONMENTAL AND AN UNDATED GOOGLE EARTH IMAGE.

WHITESTONE ASSOCIATES, INC.
Environmental & Geotechnical Engineers & Consultants
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215.712.2700 WHITESTONEASSOC.COM

DRAWING TITLE: **BORING LOCATION PLAN**

CLIENT: **THE AUTOWASH GROUP**

PROJECT: PROPOSED WAWA FOOD MARKET & FUEL STATION
LANCASTER AVENUE & ABERDEEN AVENUE
RADNOR TOWNSHIP (WAYNE), CHESTER COUNTY, PA

PROJECT #: **GP1714612.000**

DESIGNED BY:	PROJ. MGR.:
GR	JMM
DATE: 7/10/17	FIGURE: 2
SCALE: 1" = 30'	

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APPENDIX A
Records of Subsurface Exploration

WHITESTONE ASSOCIATES, INC

RECORD OF SUBSURFACE EXPLORATION

Boring No.: SB-01

Page 1 of 1

Project:	Proposed Wawa Food Market & Fuel Station	**WAI Project No.:**	GP1714612.000
Location:	Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA	**Client:**	The Autowash Group, Inc.

				Water Depth | Elevation (feet bgs) | (feet)	Cave-In Depth | Elevation (feet bgs) | (feet)
Surface Elevation:	± 365.6 feet	**Date Started:**	7/5/2017		
Termination Depth:	20.0 feet bgs	**Date Completed:**	7/5/2017		
Proposed Location:	Fuel Canopy	**Logged By:**	ML	**During:** 6.5 | 359.1	
Drill / Test Method:	HSA / SPT	**Contractor:**	AWD	**At Completion:** 6.5 | 359.1	**At Completion:** --- | ---
		Equipment:	Acker XLS	**24 Hours:** --- | ---	**24 Hours:** --- | ---

SAMPLE INFORMATION						DEPTH	STRATA		DESCRIPTION OF MATERIALS (Classification)	REMARKS
Depth (feet)	No	Type	Blows Per 6"	Rec. (in.)	N	(feet)				
						0.0				
						1.0	PAVEMENT		6" Asphalt, 6" Gravel Subbase	Soft Dig Excavation to 3.0 fbgs
0 - 3	S-1		Grab from Hand Auger	--	---	2.0	FILL		Gray and Light Brown Silty Sand, Moist (FILL)	PID = 0.0 ppm
3 - 5	S-2		3 - 2 - 5 - 6	24	7		RESIDUAL		Gray and Brown Sandy Lean Clay, Moist, Medium Stiff (CL)	Qu = 0.75 tsf (Shear) PID = 0.0 ppm
5 - 7	S-3		9 - 8 - 9 - 9	24	17	5.0			As Above, Moist to Wet, Stiff to Very Stiff (CL)	Qu = 0.75 (Shear) PID = 0.0 ppm
7 - 9	S-4		2 - 2 - 2 - 3	22	4				Gray Silty Sand, Wet, Loose (SM)	PID = 0.0 ppm
9 - 11	S-5		3 - 3 - 4 - 4	22	7	10.0			Gray and Light Brown Sandy Silt, Trace Gravel, Moist, Medium Stiff (ML)	Qu = 0.75 (Shear) PID = 0.0 ppm
						13.0				
13 - 15	S-6		1 - 2 - 3 - 4	22	5	15.0			Light Brown and Dark Brown Silty Sand, Moist, Loose (SM)	PID = 0.0 ppm
18 - 20	S-7		3 - 6 - 16 - 23	21	22	20.0			As Above, Brown, Wet, Medium Dense (SM)	PID = 0.0 ppm
						25.0			Boring Log SB-01 Terminated at a Depth of 20.0 Feet Below Ground Surface	

WHITESTONE ASSOCIATES, INC

RECORD OF SUBSURFACE EXPLORATION

Boring No.: SB-02

Page 1 of 1

Project:	Proposed Wawa Food Market & Fuel Station	**WAI Project No.:**	GP1714612.000
Location:	Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA	**Client:**	The Autowash Group, Inc.

				Water Depth | Elevation (feet bgs) | (feet)	Cave-In Depth | Elevation (feet bgs) | (feet)
Surface Elevation:	± 364.3 feet	**Date Started:**	7/5/2017		
Termination Depth:	3.5 feet bgs	**Date Completed:**	7/5/2017		
Proposed Location:	UST Field	**Logged By:**	ML	**During:** NE | ---	
Drill / Test Method:	HSA / SPT	**Contractor:**	AWD	**At Completion:** NE | ---	**At Completion:** --- | ---
		Equipment:	Acker XLS	**24 Hours:** --- | ---	**24 Hours:** --- | ---

SAMPLE INFORMATION						DEPTH	STRATA		DESCRIPTION OF MATERIALS (Classification)	REMARKS
Depth (feet)	No	Type	Blows Per 6"	Rec. (in.)	N	(feet)				
						0.0				
							PAVEMENT		6" Asphalt, 6" Gravel Subbase	Soft Dig Excavation to 3.0 fbgs
						1.0				
0 - 3	S-1		Grab from Hand Auger	--	---		FILL		Gray Silty Sand and Gravel, Moist (FILL)	
3 - 3.5	S-2		50/5"	4	50/4"	3.5			As Above, Moist (FILL)	
									Boring Log SB-2 Terminated at a Depth of 3.5 Feet Below Ground Surface Due to Utility Concern, Offset Approx. 6 Feet North to SB-2A	
						5.0				
						10.0				
						15.0				
						20.0				
						25.0				

WHITESTONE ASSOCIATES, INC

RECORD OF SUBSURFACE EXPLORATION

Boring No.: SB-02A

Page 1 of 1

Project:	Proposed Wawa Food Market & Fuel Station	**WAI Project No.:**	GP1714612.000
Location:	Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA	**Client:**	The Autowash Group, Inc.

				Water Depth | Elevation (feet bgs) | (feet)	Cave-In Depth | Elevation (feet bgs) | (feet)
Surface Elevation:	± 364.3 feet	**Date Started:**	7/5/2017		
Termination Depth:	24.7 feet bgs	**Date Completed:**	7/5/2017		
Proposed Location:	UST Field	**Logged By:**	ML	**During:** 4.0 | 360.3	
Drill / Test Method:	HSA / SPT	**Contractor:**	AWD	**At Completion:** 4.0 | 360.3	**At Completion:** --- | ---
		Equipment:	Acker XLS	**24 Hours:** --- | ---	**24 Hours:** --- | ---

SAMPLE INFORMATION						DEPTH	STRATA	DESCRIPTION OF MATERIALS (Classification)	REMARKS
Depth (feet)	No	Type	Blows Per 6"	Rec. (in.)	N	(feet)			
						0.0			
							PAVEMENT	6" Asphalt, 6" Gravel Subbase	Offset 6' North from SB-2
						1.0			Soft Dig to 4.0 fbgs
0 - 4	---		Grab from Hand Auger	--	---		FILL	Gray Silty Sand and Gravel, Moist (FILL)	PID = 12 ppm
						3.0			PID = 346 ppm
						4.0			
						4.5		Brown Silty Sand, Moist (FILL)	PID = 277 ppm
4 - 6	S-3		2 - 1 - 1 - 1	16	2	5.0		White Poorly-Graded Sand with Silt, Moist (FILL)	PID = 344 ppm
						5.5		Gray Silty Sand, Moist (FILL)	PID = 655 ppm
6 - 8	S-4		2 - 4 - 6 - 6	24	10			As Above, Wet (FILL)	PID = 1046 ppm PID = 1254 ppm
						8.0			
8 - 10	S-5		6 - 7 - 8 - 12	24	15		RESIDUAL	Gray Brown Silty Sand, Wet, Medium Dense (SM)	PID = 4 to 8 ppm
						10.0			
13 - 15	S-6		5 - 6 - 9 - 23	12	15			As Above, Brown and White, Wet, Medium Dense (SM)	PID = 1 to 3 ppm
						15.0			
18 - 20	S-7		10 - 13 - 15 - 25	18	28			As Above, Wet, Medium Dense (SM)	PID = 0.0 ppm
						20.0			
23 - 24.7	S-8		19 - 20 - 43 - 50/2"	24	63			As Above, Wet, Very Dense (SM)	PID = 0.0 ppm
						24.7		Boring Log SB-02A Terminated at a Depth of 24.7 Feet Below Ground Surface	

WHITESTONE ASSOCIATES, INC.

RECORD OF SUBSURFACE EXPLORATION

Boring No.: SB-03

Page 1 of 1

Project:	Proposed Wawa Food Market & Fuel Station	**WAI Project No.:**	GP1714612.000
Location:	Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA	**Client:**	The Autowash Group, Inc.

				Water Depth | Elevation (feet bgs) | (feet)	Cave-In Depth | Elevation (feet bgs) | (feet)
Surface Elevation:	± 368.4 feet	**Date Started:**	7/5/2017		
Termination Depth:	13.0 feet bgs	**Date Completed:**	7/5/2017		
Proposed Location:	Fuel Canopy	**Logged By:**	ML	**During:** NE | ---	
Drill / Test Method:	HSA / SPT	**Contractor:**	AWD	**At Completion:** NE | ---	**At Completion:** --- | ---
		Equipment:	Acker XLS	**24 Hours:** --- | ---	**24 Hours:** --- | ---

SAMPLE INFORMATION						DEPTH	STRATA		DESCRIPTION OF MATERIALS (Classification)	REMARKS
Depth (feet)	No	Type	Blows Per 6"	Rec. (in.)	N	(feet)				
						0.0				
						1.0	PAVEMENT		6" Asphalt, 6" Gravel Subbase	Soft Dig to 3.0 fbgs
0 - 3	S-1		Grab from Hand Auger	--	---		FILL		Gray and Brown Silt with Sand and Gravel, Moist (FILL)	PID = 0.0 ppm Qu = 0.5 tsf
3 - 5	S-2		2 - 3 - 3 - 2	12	6				As Above, with 15% Brick Fragments (FILL)	PID = 0.0 ppm Qu = 0.5 tsf
						5.0				
5 - 7	S-3		2 - 2 - 2 - 2	6	4				Gray and Brown Silty Sand with Gravel, Moist (FILL)	PID = 0.0 ppm
7 - 9	S-4		1 - 2 - 2 - 2	24	4		RESIDUAL		Gray and Brown Sandy Silt, Moist, Medium Stiff (ML)	PID = 0.0 ppm Qu = 0.5 tsf (Shear)
9 - 11	S-5		2 - 2 - 2 - 2	22	4	10.0			As Above, Gray, Brown and Block, Moist, Medium Stiff (ML)	PID = 0.0 ppm Qu = 0.5 tsf (Shear)
11 - 13	S-6		4 - 8 - 10 - 12	24	18	13.0			Brown, Gray and White Silty Sand, Moist, Medium Dense (SM)	PID = 0.0 ppm
									Boring Log SB-03 Terminated at a Depth of 13.0 Feet Below Ground Surface	
						15.0				
						20.0				
						25.0				

WHITESTONE ASSOCIATES, INC

RECORD OF SUBSURFACE EXPLORATION

Boring No.: SB-04

Page 1 of 1

Project:	Proposed Wawa Food Market & Fuel Station	**WAI Project No.:**	GP1714612.000
Location:	Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA	**Client:**	The Autowash Group, Inc.

				Water Depth | Elevation (feet bgs) | (feet)	Cave-In Depth | Elevation (feet bgs) | (feet)
Surface Elevation:	± 369.9 feet	**Date Started:**	7/5/2017		
Termination Depth:	20.0 feet bgs	**Date Completed:**	7/5/2017		
Proposed Location:	Food Market Building	**Logged By:**	ML	**During:** 9.0 | 360.9	
Drill / Test Method:	HSA / SPT	**Contractor:**	AWD	**At Completion:** 9.0 | 360.9	**At Completion:** --- | ---
		Equipment:	Acker XLS	**24 Hours:** --- | ---	**24 Hours:** --- | ---

SAMPLE INFORMATION						DEPTH	STRATA		DESCRIPTION OF MATERIALS (Classification)	REMARKS
Depth (feet)	No	Type	Blows Per 6"	Rec. (in.)	N	(feet)				
						0.0				
							PAVEMENT		6" Asphalt, 6" Gravel Subbase	Soft Dig to 3.0 fbgs
						1.0				
0 - 3	S-1		Grab from Hand Auger	--	---		FILL		Gray and Brown Lean Clay, Moist (FILL)	PID = 0.0 ppm Qu = 1.5 tsf
3 - 5	S-2		1 - 1 - 1 - 2	24	2				As Above, Trace Black Wire Fragments, Moist (FILL)	PID = 0.0 ppm Qu = 1.5 tsf
						5.0				
5 - 7	S-3		3 - 4 - 4 - 7	24	8				Gray and Brown Sandy Silt, Moist, Medium Stiff (ML)	PID = 0.0 ppm Qu = 0.5 tsf (Shear)
7 - 9	S-4		5 - 5 - 5 - 5	20	10	8.0			As Above, with 30% Quartz Sand, Moist, Medium Stiff (ML)	PID = 0.0 ppm Qu = 0.5 tsf (Shear)
9 - 11	S-5		1 - 1 - 2 - 2	18	3	10.0			As Above, Orange Brown, Wet , Soft to Medium Stiff (ML)	PID = 0.0 ppm Qu = 0.5 tsf (Shear)
11 - 13	S-6		W O H - 1 - 3 - 3	24	4				As Above, Wet, Soft to Medium Stiff (ML)	PID = 0.0 ppm Qu = 0.5 tsf (Shear)
13 - 15	S-7		2 - 4 - 5 - 6	24	9				As Above, Wet, Medium Stiff to Stiff (ML)	PID = 0.0 ppm Qu = 0.5 tsf (Shear)
						15.0				
18 - 20	S-8		5 - 5 - 8 - 8	11	13	20.0			As Above, Wet, Stiff (ML)	PID = 0.0 ppm Qu = 0.5 tsf (Shear)
									Boring Log SB-04 Terminated at a Depth of 20.0 Feet Below Ground Surface	
						25.0				

WHITESTONE ASSOCIATES, INC.

RECORD OF SUBSURFACE EXPLORATION

Boring No.: SB-05

Page 1 of 1

Project:	Proposed Wawa Food Market & Fuel Station	**WAI Project No.:**	GP1714612.000
Location:	Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA	**Client:**	The Autowash Group, Inc.

				Water Depth | Elevation (feet bgs) | (feet)	Cave-In Depth | Elevation (feet bgs) | (feet)
Surface Elevation:	± 364.1 feet	**Date Started:**	7/5/2017		
Termination Depth:	20.0 feet bgs	**Date Completed:**	7/5/2017		
Proposed Location:	Food Market Building	**Logged By:**	ML	**During:** 3.5 | 360.6	
Drill / Test Method:	HSA / SPT	**Contractor:**	AWD	**At Completion:** 3.5 | 360.6	**At Completion:** --- | ---
		Equipment:	Acker XLS	**24 Hours:** --- | ---	**24 Hours:** --- | ---

SAMPLE INFORMATION						DEPTH	STRATA		DESCRIPTION OF MATERIALS (Classification)	REMARKS
Depth (feet)	No	Type	Blows Per 6"	Rec. (in.)	N	(feet)				
						0.0				
							PAVEMENT		6" Asphalt, 6" Gravel Subbase	Soft Dig to 3.0 fbgs
						1.0				
0 - 3	S-1		Grab from Hand Auger	--	---		FILL		Gray and Brown Silty Sand with Gravel, Moist (FILL)	PID = 0.0 ppm
3 - 5	S-2		3 - 3 - 4 - 4	12	7				Brown Sandy Silt, Trace Gravel, Moist (FILL)	PID = 0.0 ppm
						5.0				
5 - 7	S-3		3 - 3 - 2 - 4	14	5		RESIDUAL		Gray Silty Sand with 10% Gravel, Wet (ML)	PID = 0.0 ppm
						7.0				
7 - 9	S-4		6 - 3 - 4 - 3	24	7				Gray and Brown Sandy Silt, Wet, Medium Stiff (ML)	PID = 0.0 ppm Qu = 1.5 tsf
9 - 11	S-5		2 - 3 - 2 - 3	24	5	10.0			As Above, Wet, Medium Stiff (ML)	PID = 0.0 ppm Qu = 1.5 tsf
13 - 15	S-6		2 - 2 - 3 - 5	24	5	14.0			As Above, Wet, Medium Stiff (ML)	PID = 0.0 ppm
						15.0			Orange Brown Silty Sand, Wet, Loose (SM)	
18 - 20	S-7		5 - 3 - 8 - 11	24	11	20.0			As Above, Wet, Medium Dense (SM)	PID = 0.0 ppm
									Boring Log SB-05 Terminated at a Depth of 20.0 Feet Below Ground Surface	
						25.0				

WHITESTONE ASSOCIATES, INC.

RECORD OF SUBSURFACE EXPLORATION

Boring No.: SB-06

Page 1 of 1

Project:	Proposed Wawa Food Market & Fuel Station	**WAI Project No.:**	GP1714612.000
Location:	Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA	**Client:**	The Autowash Group, Inc.

				Water Depth | Elevation (feet bgs) | (feet)	Cave-In Depth | Elevation (feet bgs) | (feet)
Surface Elevation:	± 367.1 feet	**Date Started:**	7/5/2017		
Termination Depth:	11.0 feet bgs	**Date Completed:**	7/5/2017		
Proposed Location:	Trash Enclosure / Pavement	**Logged By:**	ML	**During:** 8.0 | 359.1	
Drill / Test Method:	HSA / SPT	**Contractor:**	AWD	**At Completion:** 8.0 | 359.1	**At Completion:** --- | ---
		Equipment:	Acker XLS	**24 Hours:** --- | ---	**24 Hours:** --- | ---

SAMPLE INFORMATION						DEPTH	STRATA		DESCRIPTION OF MATERIALS (Classification)	REMARKS
Depth (feet)	No	Type	Blows Per 6"	Rec. (in.)	N	(feet)				
						0.0				
							PAVEMENT		6" Asphalt, 6" Gravel Subbase	Soft Dig to 3.0 fbgs
						1.0				
0 - 3	S-1		Grab from Hand Auger	--	---		FILL		Brown and Gray Silty Sand, Moist (FILL)	PID = 0.0 ppm
						3.0				
3 - 5	S-2		2 - 1 - 1 - 1	15	2		RESIDUAL		Brown and Gray Sandy Silt, Moist, Soft (ML)	PID = 0.0 ppm
						5.0				
5 - 7	S-3		5 - 6 - 5 - 4	16	11				As Above, Some Gravel, Moist, Stiff (ML)	PID = 0.0 ppm
						7.0				
7 - 9	S-4		5 - 4 - 4 - 3	16	8				Orange Silty Sand, Wet, Loose (SM)	PID = 0.0 ppm
9 - 11	S-5		3 - 3 - 3 - 5	NR	6	10.0			No Recovery Due to Gravel In Spoon Tip, Assumed As Above, Loose (SM)	PID = 0.0 ppm
									Boring Log SB-06 Terminated at a Depth of 11.0 Feet Below Ground Surface	
						15.0				
						20.0				
						25.0				

WHITESTONE ASSOCIATES, INC

RECORD OF SUBSURFACE EXPLORATION

Boring No.: SB-07

Page 1 of 1

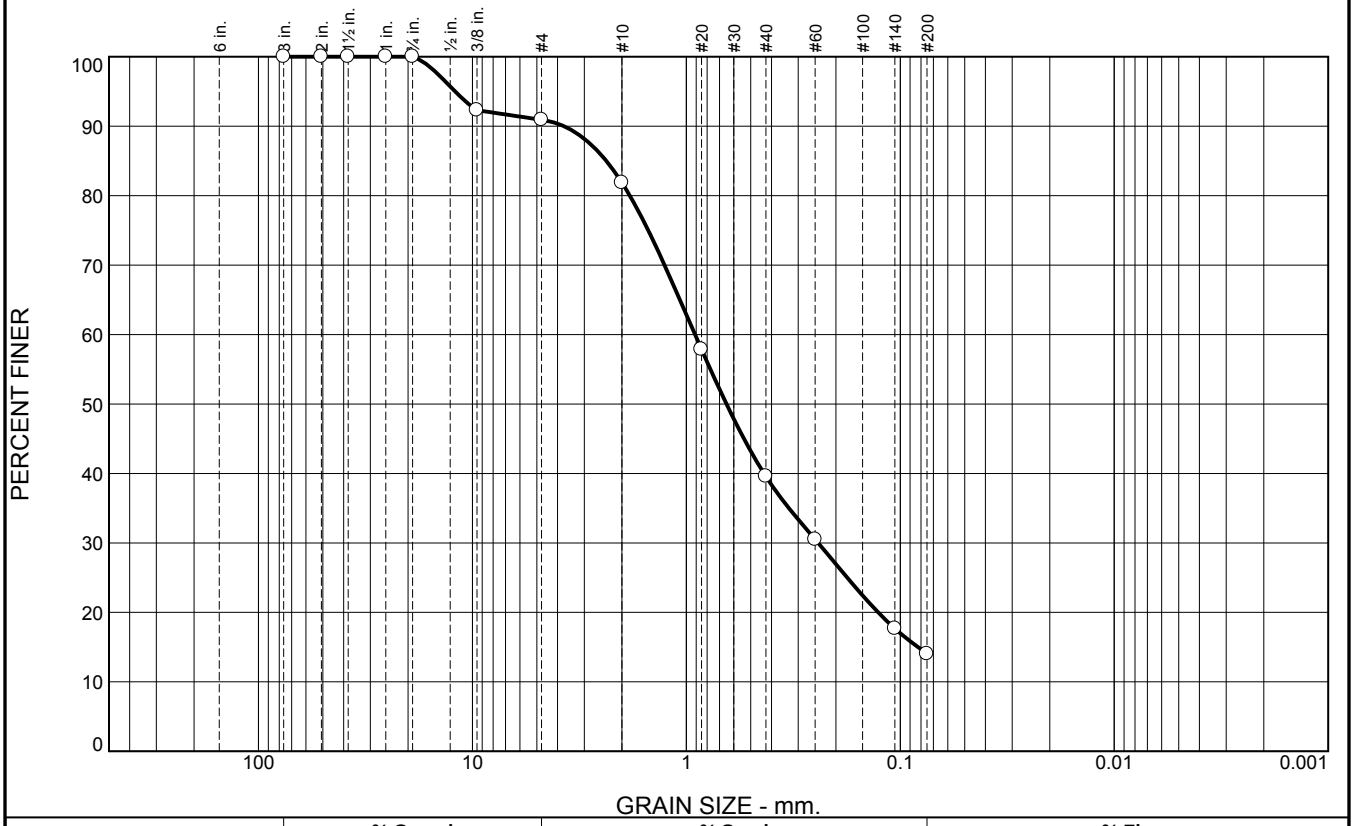
Project:	Proposed Wawa Food Market & Fuel Station	**WAI Project No.:**	GP1714612.000
Location:	Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA	**Client:**	The Autowash Group, Inc.

				Water Depth | Elevation (feet bgs) | (feet)	Cave-In Depth | Elevation (feet bgs) | (feet)
Surface Elevation:	± 369.0 feet	**Date Started:**	7/5/2017		
Termination Depth:	11.0 feet bgs	**Date Completed:**	7/5/2017		
Proposed Location:	Pavement	**Logged By:**	ML	**During:** 9.0 | 360.0	
Drill / Test Method:	HSA / SPT	**Contractor:**	AWD	**At Completion:** 9.0 | 360.0	**At Completion:** --- | ---
		Equipment:	Acker XLS	**24 Hours:** --- | ---	**24 Hours:** --- | ---

SAMPLE INFORMATION						DEPTH	STRATA		DESCRIPTION OF MATERIALS (Classification)	REMARKS
Depth (feet)	No	Type	Blows Per 6"	Rec. (in.)	N	(feet)				
						0.0				
							PAVEMENT		6" Asphalt, 6" Gravel Subbase	Soft Dig to 3.0 fbgs
						1.0				
0 - 3	S-1		Grab from Hand Auger	--	---		FILL		Brown and Gray Silty Sand and Gravel, Moist (FILL)	PID = 0.0 ppm
3 - 5	S-2		WOH / 24"	21	WOH				Gray and Brown Silty Clay, Moist (FILL)	PID = 0.0 ppm
						5.0				
5 - 7	S-3		1 - 3 - 2 - 3	20	5		RESIDUAL		Gray and Brown Silty Clay with 10% Gravel, Moist, Medium Stiff (CL)	PID = 0.0 ppm
						6.6				
7 - 9	S-4		1 - 2 - 2 - 2	16	4				Orange Brown Sandy Silt, Moist, Medium Stiff (ML) As Above, Moist, Medium Stiff (ML)	PID = 0.0 ppm
9 - 11	S-5		2 - 2 - 2 - 3	22	4	10.0			As Above, Wet, Medium Stiff (ML)	PID = 0.0 ppm
						11.0			Boring Log SB-07 Terminated at a Depth of 11.0 Feet Below Ground Surface	
						15.0				
						20.0				
						25.0				

APPENDIX B
Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	9.1	9.0	42.3	25.6	14.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	92.3		
#4	90.9		
#10	81.9		
#20	57.9		
#40	39.6		
#60	30.5		
#140	17.7		
#200	14.0		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits

PL= NP LL= NP PI= NP

Coefficients

D_{90}= 3.7343 D_{85}= 2.3664 D_{60}= 0.9112
D_{50}= 0.6492 D_{30}= 0.2421 D_{15}= 0.0827
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Remarks

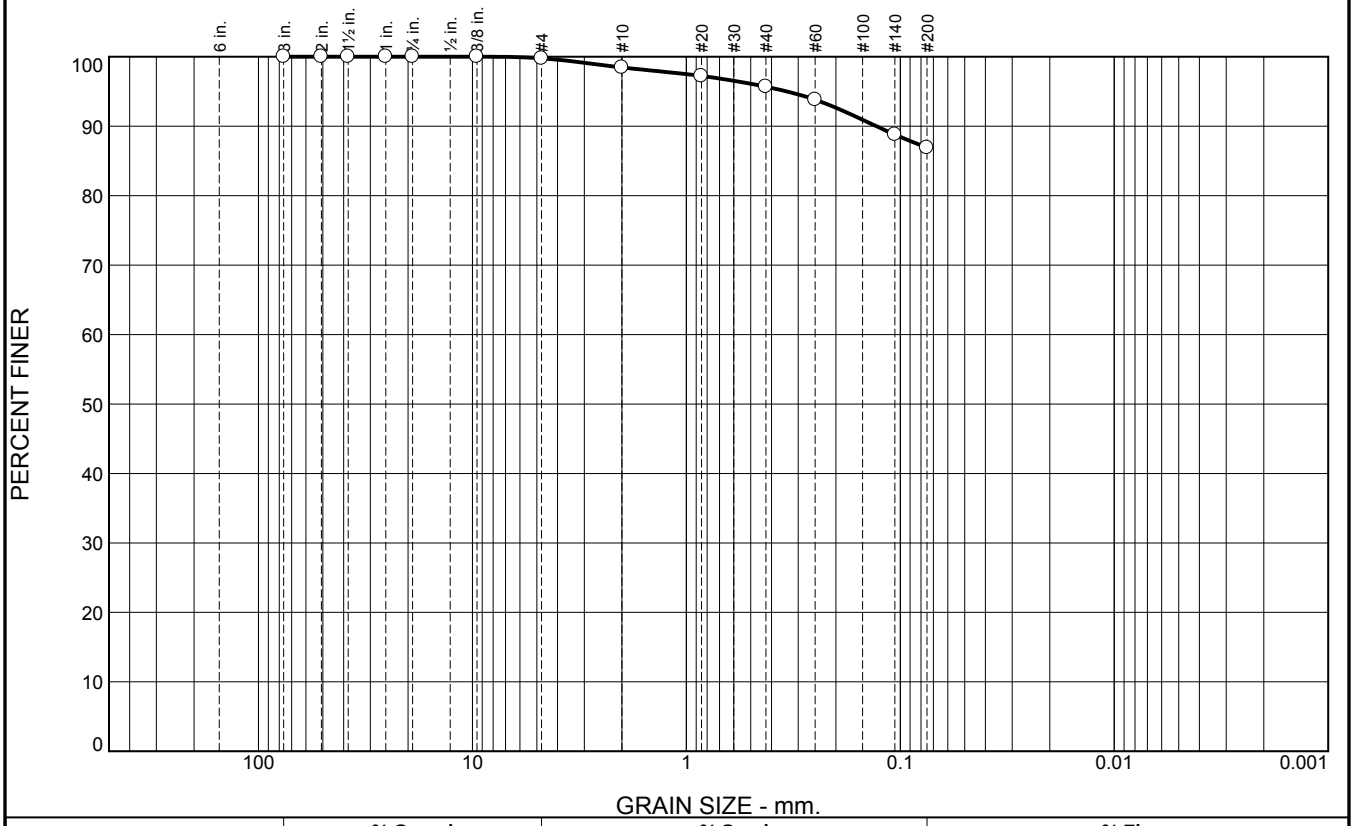
W_n = 13.1 %

Source of Sample: SB-2 **Depth:** 6.0' - 8.0'
Sample Number: S-4 **Date:** 07/19/2017

WHITESTONE ASSOCIATES, INC.
Warren, New Jersey

Client: The Autowash Group
Project: Proposed Wawa Food Market and Fueling Station
Lancaster Ave & Aberdeen Ave, Radnor Twp, Chester Co, PA
Project No: GP1714612.000 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.2	1.3	2.8	8.8	86.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3	100.0		
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.375	100.0		
#4	99.8		
#10	98.5		
#20	97.2		
#40	95.7		
#60	93.8		
#140	88.8		
#200	86.9		

* (no specification provided)

Material Description

Lean Clay

Atterberg Limits

PL= 20 LL= 40 PI= 20

Coefficients

D_{90}= 0.1296 D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(18)

Remarks

W_n = 24.0 %

Source of Sample: SB-4 **Depth:** 3.0' - 5.0'
Sample Number: S-2

Date: 07/19/2017

WHITESTONE ASSOCIATES, INC.
Warren, New Jersey

Client: The Autowash Group
Project: Proposed Wawa Food Market and Fueling Station
Lancaster Ave & Aberdeen Ave, Radnor Twp, Chester Co, PA
Project No: GP1714612.000 **Figure**

APPENDIX C
Supplemental Information (USCS, Terms and Symbols)

UNIFIED SOIL CLASSIFICATION SYSTEM

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMITS LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMITS GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS FOR SAMPLES WITH 5% TO 12% FINES

GRADATION*

% FINER BY WEIGHT

TRACE..... 1% TO 10%
LITTLE..... 10% TO 20%
SOME..... 20% TO 35%
AND..... 35% TO 50%

COMPACTNESS*
Sand and/or Gravel

RELATIVE DENSITY

LOOSE. ..... 0% TO 40%
MEDIUM DENSE.... 40% TO 70%
DENSE..... 70% TO 90%
VERY DENSE..... 90% TO 100%

CONSISTENCY*
Clay and/or Silt

RANGE OF SHEARING STRENGTH IN POUNDS PER SQUARE FOOT

VERY SOFT..... LESS THAN 250
SOFT..... ..... 250 TO 500
MEDIUM..... 500 TO 1000
STIFF..... 1000 TO 2000
VERY STIFF..... 2000 TO 4000
HARD..... GREATER THAN 4000

** VALUES ARE FROM LABORATORY OR FIELD TEST DATA, WHERE APPLICABLE. WHEN NO TESTING WAS PERFORMED, VALUES ARE ESTIMATED.*

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GEOTECHNICAL TERMS AND SYMBOLS

SAMPLE IDENTIFICATION

The Unified Soil Classification System is used to identify the soil unless otherwise noted.

SOIL PROPERTY SYMBOLS

N: Standard Penetration Value: Blows per ft. of a 140 lb. hammer falling 30" on a 2" O.D. split-spoon.
Qu: Unconfined compressive strength, TSF.
Qp: Penetrometer value, unconfined compressive strength, TSF.
Mc: Moisture content, %.
LL: Liquid limit, %.
PI: Plasticity index, %.
δd: Natural dry density, PCF.
▼: Apparent groundwater level at time noted after completion of boring.

DRILLING AND SAMPLING SYMBOLS

NE: Not Encountered (Groundwater was not encountered).
SS: Split-Spoon - 1 ⅜" I.D., 2" O.D., except where noted.
ST: Shelby Tube - 3" O.D., except where noted.
AU: Auger Sample.
OB: Diamond Bit.
CB: Carbide Bit
WS: Washed Sample.

RELATIVE DENSITY AND CONSISTENCY CLASSIFICATION

Term (Non-Cohesive Soils)	Standard Penetration Resistance
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	Over 50

Term (Cohesive Soils)	Qu (TSF)
Very Soft	0 - 0.25
Soft	0.25 - 0.50
Firm (Medium)	0.50 - 1.00
Stiff	1.00 - 2.00
Very Stiff	2.00 - 4.00
Hard	4.00+

PARTICLE SIZE

Boulders	8 in.+	Coarse Sand	5mm-0.6mm	Silt	0.074mm-0.005mm
Cobbles	8 in.-3 in.	Medium Sand	0.6mm-0.2mm	Clay	-0.005mm
Gravel	3 in.-5mm	Fine Sand	0.2mm-0.074mm		

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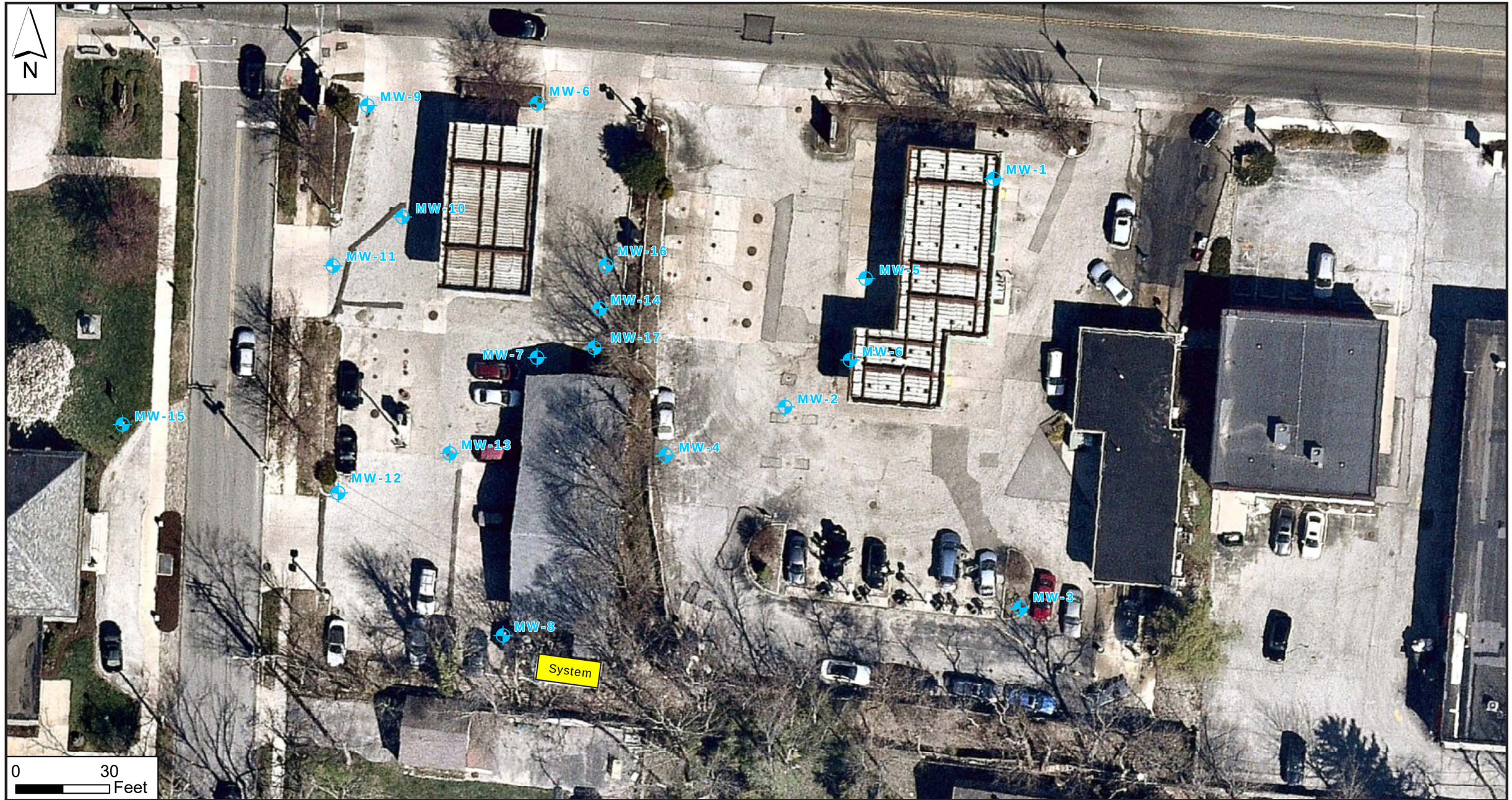
APPENDIX D

Table Summary of Soil Boring Location Coordinates

TABLE SUMMARY OF SOIL BORING LOCATION COORDINATES			
Soil Boring Number	**Latitude**	**Longitude**	**Elevation (feet above msl)***
SB-01	40° 02' 35.779" N	75° 22' 55.732" W	365.59
SB-02	40° 02' 36.415" N	75° 22' 52.302" W	364.32
SB-03	40° 02' 36.303" N	75° 22' 51.474" W	368.41
SB-04	40° 02' 36.707" N	75° 22' 50.410" W	369.85
SB-05	40° 02' 35.838" N	75° 22' 49.952" W	364.08
SB-06	40° 02' 35.339" N	75° 22' 49.538" W	367.11
SB-07	40° 02' 36.665" N	75° 22' 49.259" W	368.95

* msl: mean sea level



JK Environmental
PROFESSIONAL ENVIRONMENTAL ENGINEERING

P.O. Box 509
Lafayette Hill, PA 19444
610-387-6930

MONITORING WELL LOCATIONS
ABERDEEN SUNOCO & WAYNE BP
306 E. LANCASTER AVENUE
WAYNE, PENNSYLVANIA

Sources: nearmap

Notes:

Figure: 1
Drawn: MB
Checked: BD
2/27/2018

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TABLE 1

ABERDEEN SUNOCO
PADEP FACILITY ID #23-41203
302 E. LANCASTER AVENUE
RADNOR TOWNSHIP, DELAWARE COUNTY

Groundwater Level Measurements

Monitoring Well	Date	Top of Casing Elevation (ftmsl)[1]	Depth to Product (feet)	Product Thickness (feet)	Depth to Water (ftbtoc)	Groundwater Elevation (ftmsl)
Former MW-3	2/25/2014	365.70	NP	0.00	5.74	359.96
	3/25/2014		---	---	---	---
	5/19/2014		NP	0.00	6.25	359.45
	8/6/2014		NP	0.00	6.82	358.88
MW-6	2/25/2014	364.60	NP	0.00	4.15	360.45
	3/25/2014		NP	0.00	4.56	360.04
	5/19/2014		NP	0.00	4.29	360.31
	8/6/2014		NP	0.00	4.65	359.95
	11/6/2014		NP	0.00	4.83	359.77
	2/19/2015		NP	0.00	5.00	359.60
	5/8/2015		NP	0.00	4.82	359.78
	5/20/2015		NP	0.00	4.95	359.65
	8/6/2015		NP	0.00	5.02	359.58
	11/5/2015		NP	0.00	5.38	359.22
	2/24/2016		NP	0.00	4.34	360.26
	5/25/2016		NP	0.00	4.70	359.90
	8/8/2016		NP	0.00	5.03	359.57
	11/7/2016		NP	0.00	5.63	358.97
	2/6/2017		NP	0.00	5.50	359.10
	5/4/2017		NP	0.00	5.15	359.45
	8/7/2017		NP	0.00	5.13	359.47
	11/20/2017		NP	0.00	5.50	359.10
	2/8/2018		NP	0.00	4.97	359.63
	5/2/2018		NP	0.00	4.67	359.93
MW-7	2/25/2014	362.29	NP	0.00	2.72	359.57
	3/25/2014		NP	0.00	---	---
	5/19/2014		NP	0.00	3.19	359.10
	8/6/2014		NP	0.00	3.68	358.61
	11/6/2014		NP	0.00	3.70	358.59
	2/19/2015		NP	0.00	3.82	358.47
	5/8/2015		NP	0.00	3.75	358.54
	5/20/2015		NP	0.00	3.89	358.40
	8/6/2015		NP	0.00	3.89	358.40
	11/5/2015		NP	0.00	4.11	358.18
	2/24/2016		NP	0.00	3.28	359.01
	5/25/2016		NP	0.00	3.28	359.01
	8/8/2016		NP	0.00	3.86	358.43
	11/7/2016		NP	0.00	4.05	358.24
	2/6/2017		NP	0.00	3.97	358.32
	5/4/2017		NP	0.00	3.93	358.36
	8/7/2017		NP	0.00	3.85	358.44
	11/20/2017		NP	0.00	3.83	358.46
	2/8/2018		NP	0.00	3.26	359.03
	5/2/2018		NP	0.00	3.52	358.77
MW-8	2/25/2014	364.24	NP	0.00	3.17	361.07
	3/25/2014		NP	0.00	3.73	360.51
	5/19/2014		NP	0.00	3.49	360.75
	8/6/2014		NP	0.00	4.07	360.17
	11/6/2014		NP	0.00	4.11	360.13
	2/19/2015		NP	0.00	4.16	360.08
	5/8/2015		NP	0.00	4.13	360.11
	5/20/2015		NP	0.00	4.27	359.97
	8/6/2015		NP	0.00	4.38	359.86
	11/5/2015		NP	0.00	4.49	359.75
	2/24/2016		NP	0.00	3.59	360.65
	5/25/2016		NP	0.00	3.97	360.27
	8/8/2016		NP	0.00	4.34	359.90
	11/7/2016		NP	0.00	4.72	359.52
	2/6/2017		NP	0.00	4.50	359.74
	5/4/2017		NP	0.00	4.27	359.97
	8/7/2017		NP	0.00	4.41	359.83
	11/20/2017		NP	0.00	4.42	359.82
	2/8/2018		NP	0.00	3.78	360.46
	5/2/2018		NP	0.00	3.85	360.39

TABLE 1

ABERDEEN SUNOCO
PADEP FACILITY ID #23-41203
302 E. LANCASTER AVENUE
RADNOR TOWNSHIP, DELAWARE COUNTY

Groundwater Level Measurements

Monitoring Well	Date	Top of Casing Elevation (ftmsl)[1]	Depth to Product (feet)	Product Thickness (feet)	Depth to Water (ftbtoc)	Groundwater Elevation (ftmsl)
MW-9	2/25/2014	364.36	NP	0.00	5.96	358.40
	3/25/2014		NP	0.00	4.32	360.04
	5/19/2014		NP	0.00	6.19	358.17
	8/6/2014		NP	0.00	6.52	357.84
	11/6/2014		NP	0.00	6.62	357.74
	2/19/2015		NP	0.00	6.80	357.56
	5/8/2015		NP	0.00	6.60	357.76
	5/20/2015		NP	0.00	6.77	357.59
	8/6/2015		NP	0.00	6.74	357.62
	11/5/2015		NP	0.00	6.94	357.42
	2/24/2016		NP	0.00	6.14	358.22
	5/25/2016		NP	0.00	6.45	357.91
	8/8/2016		NP	0.00	6.71	357.65
	11/7/2016		NP	0.00	7.11	357.25
	2/6/2017		NP	0.00	6.95	357.41
	5/4/2017		NP	0.00	6.73	357.63
	8/7/2017		NP	0.00	6.75	357.61
	11/20/2017		NP	0.00	6.88	357.48
	2/8/2018		NP	0.00	6.49	357.87
	5/2/2018		NP	0.00	6.44	357.92
MW-10	2/25/2014	362.91	3.58	0.27	3.85	359.27
	3/25/2014		Film	Film	4.61	358.30
	5/19/2014		Film	0.01	4.01	358.90
	8/6/2014		Film	0.01	4.45	358.46
	11/6/2014		Film	Film	4.11	358.80
	2/19/2015		Film	Film	4.80	358.11
	5/8/2015		NP	0.00	4.55	358.36
	5/20/2015		NP	0.00	4.65	358.26
	8/6/2015		NP	0.00	4.72	358.19
	11/5/2015		NP	0.00	4.91	358.00
	2/24/2016		NP	0.00	3.91	359.00
	5/25/2016		NP	0.00	4.30	358.61
	8/8/2016		NP	0.00	4.58	358.33
	11/7/2016		NP	0.00	5.02	357.89
	2/6/2017		NP	0.00	4.87	358.04
	5/4/2017		NP	0.00	4.61	358.30
	8/7/2017		NP	0.00	4.59	358.32
	11/20/2017		NP	0.00	4.70	358.21
	2/8/2018		NP	0.00	4.17	358.74
	5/2/2018		NP	0.00	4.13	358.78
MW-11	2/25/2014	361.72	NP	0.00	3.12	358.60
	3/25/2014		NP	0.00	3.17	358.55
	5/19/2014		NP	0.00	3.02	358.70
	8/6/2014		NP	0.00	3.40	358.32
	11/6/2014		NP	0.00	3.45	358.27
	2/19/2015		NP	0.00	3.57	358.15
	5/8/2015		NP	0.00	3.49	358.23
	5/20/2015		NP	0.00	3.57	358.15
	8/6/2015		NP	0.00	3.68	358.04
	11/5/2015		NP	0.00	3.82	357.90
	2/24/2016		NP	0.00	2.91	358.81
	5/25/2016		NP	0.00	3.44	358.28
	8/8/2016		NP	0.00	3.66	358.06
	11/7/2016		NP	0.00	4.06	357.66
	2/6/2017		NP	0.00	4.03	357.69
	5/4/2017		NP	0.00	3.87	357.85
	8/7/2017		NP	0.00	3.90	357.82
	11/20/2017		NP	0.00	3.79	357.93
	2/8/2018		NP	0.00	3.18	358.54
	5/2/2018		NP	0.00	3.37	358.35

TABLE 1

ABERDEEN SUNOCO
PADEP FACILITY ID #23-41203
302 E. LANCASTER AVENUE
RADNOR TOWNSHIP, DELAWARE COUNTY

Groundwater Level Measurements

Monitoring Well	Date	Top of Casing Elevation (ftmsl)[1]	Depth to Product (feet)	Product Thickness (feet)	Depth to Water (ftbtoc)	Groundwater Elevation (ftmsl)
MW-12	2/25/2014	360.26	NP	0.00	1.33	358.93
	3/25/2014		NP	0.00	1.94	358.32
	5/19/2014		NP	0.00	1.72	358.54
	8/6/2014		NP	0.00	2.16	358.10
	11/6/2014		NP	0.00	1.20	359.06
	2/19/2015		NP	0.00	2.35	357.91
	5/8/2015		NP	0.00	2.26	358.00
	5/20/2015		NP	0.00	2.37	357.89
	8/6/2015		NP	0.00	2.43	357.83
	11/5/2015		NP	0.00	2.42	357.84
	2/24/2016		NP	0.00	1.76	358.50
	5/25/2016		NP	0.00	2.04	358.22
	8/8/2016		NP	0.00	2.44	357.82
	11/7/2016		NP	0.00	2.75	357.51
	2/6/2017		NP	0.00	2.61	357.65
	5/4/2017		NP	0.00	2.39	357.87
	8/7/2017		NP	0.00	2.58	357.68
	11/20/2017		NP	0.00	2.50	357.76
	2/8/2018		NP	0.00	1.96	358.30
	5/2/2018		NP	0.00	2.12	358.14
MW-13	2/25/2014	361.71	NP	0.00	2.57	359.14
	3/25/2014		NP	0.00	3.23	358.48
	5/19/2014		NP	0.00	3.05	358.66
	8/6/2014		NP	0.00	3.53	358.18
	11/6/2014		NP	0.00	3.52	358.19
	2/19/2015		NP	0.00	3.68	358.03
	5/8/2015		NP	0.00	3.62	358.09
	5/20/2015		NP	0.00	3.78	357.93
	8/6/2015		NP	0.00	3.82	357.89
	11/5/2015		NP	0.00	3.94	357.77
	2/24/2016		NP	0.00	3.10	358.61
	5/25/2016		NP	0.00	3.44	358.27
	8/8/2016		NP	0.00	3.82	357.89
	11/7/2016		NP	0.00	4.20	357.51
	2/6/2017		NP	0.00	3.69	358.02
	5/4/2017		NP	0.00	3.81	357.90
	8/7/2017		NP	0.00	3.89	357.82
	11/20/2017		NP	0.00	3.84	357.87
	2/8/2018		NP	0.00	3.23	358.48
	5/2/2018		NP	0.00	3.39	358.32
MW-14	2/25/2014	362.72	---	---	---	---
	3/25/2014		NP	0.00	3.74	358.98
	5/19/2014		NP	0.00	3.65	359.07
	8/6/2014		NP	0.00	4.03	358.69
	11/6/2014		NP	0.00	4.05	358.67
	2/19/2015		NP	0.00	4.27	358.45
	5/8/2015		NP	0.00	4.18	358.54
	5/20/2015		NP	0.00	4.33	358.39
	8/6/2015		NP	0.00	4.42	358.30
	11/5/2015		NP	0.00	4.60	358.12
	2/24/2016		NP	0.00	3.68	359.04
	5/25/2016		NP	0.00	4.05	358.67
	8/8/2016		NP	0.00	4.38	358.34
	11/7/2016		NP	0.00	4.86	357.86
	2/6/2017		NP	0.00	4.61	358.11
	5/4/2017		NP	0.00	4.40	358.32
	8/7/2017		NP	0.00	4.44	358.28
	11/20/2017		NP	0.00	4.51	358.21
	2/8/2018		NP	0.00	3.85	358.87
	5/2/2018		NP	0.00	3.88	358.84

TABLE 1

ABERDEEN SUNOCO
PADEP FACILITY ID #23-41203
302 E. LANCASTER AVENUE
RADNOR TOWNSHIP, DELAWARE COUNTY

Groundwater Level Measurements

Monitoring Well	Date	Top of Casing Elevation (ftmsl)[1]	Depth to Product (feet)	Product Thickness (feet)	Depth to Water (ftbtoc)	Groundwater Elevation (ftmsl)
MW-15	2/25/2014	360.87	---	---	---	---
	3/25/2014		NP	0.00	3.70	357.17
	5/19/2014		NP	0.00	3.69	357.18
	8/6/2014		NP	0.00	3.88	356.99
	11/6/2014		NP	0.00	3.85	357.02
	2/19/2015		NP	0.00	3.95	356.92
	5/8/2015		NP	0.00	3.92	356.95
	5/20/2015		NP	0.00	4.06	356.81
	8/6/2015		NP	0.00	4.07	356.80
	11/5/2015		NP	0.00	4.16	356.71
	2/24/2016		NP	0.00	3.52	357.35
	5/25/2016		NP	0.00	3.85	357.02
	8/8/2016		NP	0.00	4.03	356.84
	11/7/2016		NP	0.00	4.31	356.56
	2/6/2017		NP	0.00	4.14	356.73
	5/4/2017		NP	0.00	4.04	356.83
	8/7/2017		NP	0.00	3.98	356.89
	11/20/2017		NP	0.00	3.86	357.01
	2/8/2018		NP	0.00	3.44	357.43
	5/2/2018		NP	0.00	3.50	357.37
MW-16	5/8/2015	362.86	NP	0.00	4.60	358.26
	5/20/2015		NP	0.00	4.78	358.08
	8/6/2015		NP	0.00	4.86	358.00
	8/7/2015		NP	0.00	4.89	357.97
	11/5/2015		NP	0.00	5.06	357.80
	2/24/2016		NP	0.00	4.30	358.56
	5/25/2016		NP	0.00	4.49	358.37
	8/8/2016		NP	0.00	4.82	358.04
	11/7/2016		NP	0.00	5.25	357.61
	2/6/2017		NP	0.00	5.06	357.80
	5/4/2017		NP	0.00	4.82	358.04
	8/7/2017		NP	0.00	4.84	358.02
	11/20/2017		NP	0.00	4.96	357.90
	2/8/2018		NP	0.00	4.37	358.49
	5/2/2018		NP	0.00	4.33	358.53
MW-17	5/8/2015	363.38	NP	0.00	4.39	358.99
	5/20/2015		NP	0.00	4.53	358.85
	8/6/2015		NP	0.00	4.63	358.75
	8/7/2015		NP	0.00	4.64	358.74
	11/5/2015		NP	0.00	4.79	358.59
	2/24/2016		NP	0.00	3.81	359.57
	5/25/2016		NP	0.00	4.27	359.11
	8/8/2016		NP	0.00	4.59	358.79
	11/7/2016		NP	0.00	5.02	358.36
	2/6/2017		NP	0.00	4.79	358.59
	5/4/2017		NP	0.00	4.58	358.80
	8/7/2017		NP	0.00	4.63	358.75
	11/20/2017		NP	0.00	4.68	358.70
	2/8/2018		NP	0.00	4.01	359.37
	5/2/2018		NP	0.00	4.23	359.15

Notes:

ftmsl = feet above mean sea level

ftbtoc = feet below top of casing

NP = No product

film = producted detected by interface probe less than 0.01 feet thick.

[1] = Top of casing elevations surveyed by Chester Valley Engineers in March 2014.

Corrected groundwater elevation = Top of casing elevation - depth to water

TABLE 1

BP WAYNE
306 E. LANCASTER AVENUE
RADNOR TOWNSHIP, DELAWARE COUNTY
FACILITY ID #23-29806

Groundwater Level Measurements

Monitor Well	Date	Top of Casing Elevation (feet)[1]	Depth to Product (feet)	Product Thickness (feet)	Depth to Water (ftbtoc)	Corrected Groundwater Elevation (ftMSL)
MW-1	2/6/2017	365.60	NP	0.00	6.34	359.26
	5/4/2017		NP	0.00	5.83	359.77
	8/7/2017		NP	0.00	5.83	359.77
	11/20/2017		NP	0.00	6.23	359.37
	2/5/2018		NP	0.00	5.84	359.76
	5/1/2018		NP	0.00	5.30	360.30
MW-2	2/6/2017	365.28	NP	0.00	7.16	358.12
	5/4/2017		NP	0.00	6.85	358.43
	8/7/2017		NP	0.00	7.08	358.20
	11/20/2017		NP	0.00	7.02	358.26
	2/5/2018		NP	0.00	6.60	358.68
	5/1/2018		NP	0.00	6.33	358.95
MW-3	2/6/2017	366.36	NP	0.00	8.13	358.23
	5/4/2017		NP	0.00	7.83	358.53
	8/7/2017		NP	0.00	7.98	358.38
	11/20/2017		NP	0.00	8.09	358.27
	2/5/2018		NP	0.00	7.05	359.31
	5/1/2018		NP	0.00	7.19	359.17
MW-4	2/6/2017	365.31	NP	0.00	7.49	357.82
	5/4/2017		NP	0.00	7.19	358.12
	8/7/2017		NP	0.00	7.31	358.00
	11/20/2017		NP	0.00	7.31	358.00
	2/5/2018		NP	0.00	6.89	358.42
	5/1/2018		NP	0.00	6.70	358.61
MW-5	5/4/2017	365.61	NP	0.00	6.56	359.05
	8/7/2017		NP	0.00	6.65	358.96
	11/20/2017		NP	0.00	6.82	358.79
	2/5/2018		NP	0.00	6.38	359.23
	5/1/2018		NP	0.00	5.99	359.62
MW-6	5/4/2017	364.98	NP	0.00	6.47	358.51
	8/7/2017		NP	0.00	6.56	358.42
	11/20/2017		NP	0.00	6.64	358.34
	2/5/2018		NP	0.00	6.25	358.73
	5/1/2018		NP	0.00	5.95	359.03

Notes:

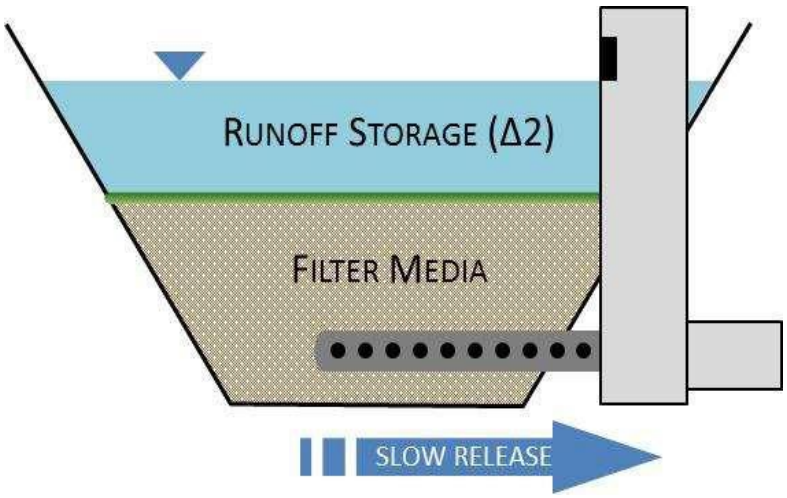
[1] *Top of casing elevation measured by E&LP, Inc. in February 2017*

ftboc = feet below top of casing

ftMSL= feet above Mean Sea Level

NP = No product

BMP 6.4.11: Slow Release Concept



The Slow Release Concept (SRC) is a stormwater strategy used to manage the increase in the pre vs. post development runoff volume through attenuation and discharge of storm events up to and including the 2-year 24-hour storm (Δ2 volume). The goal of the SRC is to mimic the normal baseflow hydrology in the receiving stream. The SRC can be used in tandem with volume management measures such as infiltration and evapotranspiration. This concept can be used in either above-ground or underground storage systems – though underground systems will be more challenging and costly.

- This BMP follows Title 25, Chapter 102.11(b) for Alternative BMP and design standards.
- Maintain a minimum 1-foot separation to the seasonally high water table which should be verified by bore pit analysis. Minimum thickness for amended soil/ filter media is 2 feet (24") to ensure adequate pollutant removal.
- Infiltration Guidelines and Soil Testing Protocols apply to show that standard infiltration is not viable or not fully achievable. Justification and documentation is required including an analysis of which volume reducing BMPs were considered as not feasible and why.
- Design to hold and slowly release the difference in the pre vs post development runoff volume of the 2-yr 24-hour storm (Δ2)
- Maximize non-structural BMPs on-site. The BMP manual allows volume credit up to 25% of the Δ2.
- Must utilize soil amendments and restoration (per BMP 6.7.3) on all disturbed areas to be revegetated – as feasible.
- Provide positive stormwater overflow through engineered outlet structure. (as depicted)
- Above ground storage systems will typically utilize an underdrain system. (as depicted)

Commercial: Yes
Ultra Urban: Yes
Industrial: Yes
Retrofit: Yes
Highway/Road: Yes

Stormwater Functions

Volume Mgmt: High
Recharge: Low
Peak Rate Control: Low-High
Water Quality: High

Water Quality Functions

TSS: 85%
TP: 85%
NO3: 30%

Other Considerations

- **The Slow Release Concept (SRC) can be used when a volume increase still remains only after all other volume management BMPs have been utilized and/or exhausted including structural and non-structural BMPs. Justification and documentation are required including an analysis of which volume reducing BMPs were considered as not feasible and the reasons why.**

- **Protocol 1. Site Evaluation and Soil Infiltration Testing** and **Protocol 2. Infiltration Systems Guidelines** should be followed to clearly demonstrate a lack of infiltration capability on site, see Appendix C.

- **Hydraulic Loading is an important consideration. Sizing Criteria for these BMPs are discussed in the Design Considerations below.**

- **Pollutant Loading is also an important consideration. Water Quality Treatment, including pretreatment, is vital to the success of this BMP.**

Description

The Slow Release Concept (SRC) is a volume management strategy that collects, stores, and filters captured runoff through a water quality media/device, and slowly releases the treated volume to an on-site or off-site surface water. The SRC utilizes a storage area, either above-ground or underground, that temporarily impounds the captured runoff from storm events up to and including the 2-year 24-hour storm. The runoff is then filtered through a water quality media or equivalent water quality treatment device prior to slowly discharging the treated volume. As previously noted, the storage area can either be an above ground basin or an underground storage area, i.e., stone trench, vaults, chambers, etc. For above ground storage, shading is highly recommended to reduce thermal impacts.

SRC may be confused with extended detention, however it differs for the following reasons:

- The slow release concept manages the volume for all storms up to and including the 2-year/24-hour storm when the collected rain drains through the 2 feet of amended soils. This follows 102.8(g)(2). After draining through the amended soils, the runoff is discharged through an underdrain and dewatered between 24 to 72 hours. (Equivalent Water Quality BMP(s) and drain set up would be needed for underground systems using SRC and documented using Worksheets 12 and 13) The size (stream order) and the physical condition of the stream needs to be taken into account when determining the appropriate drain time. Low order streams which may be more susceptible to erosion should maximize drain time to 72 hours. Research supports that this approach is acceptable and helps "mimic" baseflow. (or rather the interflow portion of the stream hydrograph) The objective of slow release is provide volume management for the "stream bank protection" stage of the basin **and** to provide water quality treatment.

- The extended detention (ED) volume is for storms events greater than the 2-year (up to the 100 year) which is much greater in magnitude and is discharged though higher orifice(s) on a multi-stage outlet structure. The objective of ED is to provide peak rate control and to hold the "flood protection" stage of the basin for as long as possible and to safely convey the discharge to the receiving stream.

The system can incorporate infiltration and evapotranspiration as site conditions allow. The outflow

should be designed to mimic normal baseflow conditions in the receiving waters and help support aquatic habitat. The quality of the runoff is treated by the natural cleansing processes of soil media (including any infiltration that may occur). Additional water quality is treated through the vegetation planted in the above ground systems. The keys to this slow release process are to minimize the height of the water stored and discharge in a manner to minimize its duration so that the captured volume do not lead to plant mortality or stagnant water issues in the basin; and not lead to any erosion issues after being discharged out of the basin. The designer shall demonstrate through their design and plant selection that ponding time will not adversely affect vegetation.

Slow release is typically incorporated into a multi-stage detention facility with the upper portions of the facility providing flow attenuation for storm events greater than a 2-year 24-hour storm – up to an including the 100-year 24-hour storm. In the absence of a multi-stage system, an engineered overflow structure should be provided to provide safe conveyance for the 100-year storm. As previously noted the drain time is project-specific and receiving-stream dependent and hence can vary – but will typically be between 24 and 72 hours after the 2-year/24-hour storm event in accordance with Chapter 3 of this manual. Stream channel protection may also be a design consideration.

Applications

- This concept can be utilized with various BMPs. The designer would need to determine proper suitability and can adapt various elements to achieve project goals.
- This concept can be used for both new construction and retrofit projects.
- Other applications of SRC may be determined by the Design Professional, as appropriate, with DEP approval.

Design Considerations

1. Follow design considerations for BMP and associated volume management approach. This strategy would need to be affirmatively analyzed by a person trained in PCSM design. This strategy should only be considered after all other volume management BMPs have been utilized and/or exhausted[1] including structural and non-structural BMPs. **Justification and documentation is required including an analysis of which volume reducing BMPs were considered as not feasible and the reasons why**. This analysis is even more crucial in special protection watersheds and need to be incorporated into the Antidegradation Analysis.
2. Soil testing and evaluation is one of the important steps in this process. Adequate soils testing and evaluation must be performed to demonstrate to the satisfaction of DEP or other reviewing authority that infiltration is not feasible on the entire project site and that at least one foot of separation distance exists between seasonal high water table and bottom of BMP.
    a. The designer should go through each BMP in Chapters 5 and 6 of this Manual (or other acceptable reference), and incorporate each BMP into their design to manage the proposed increase in volume. Chapter 3 of the BMP Manual is also a good reference for sites with limited infiltration capacity.
    b. The designer should maximize Infiltration BMPs strategies.
3. When there is a deficit between the amount of infiltration achievable and the amount required (i.e. through Worksheets #4 and 5), the designer can incorporate this slow release volume mitigation strategy.
    a. After determining the deficit runoff volume to be managed, BMP(s) should be designed to manage this runoff volume through a slow release device. Slow release devices can

have various design elements. (e.g. above-ground, subsurface, etc.) Samples are included in this document. These samples show a minimum 2-foot depth of amended soils/filter media for Water Quality (WQ) with an underdrain system.

b. The volume is managed by setting the invert of the lowest orifice or weir at the maximum elevation of the $\Delta 2$ Volume – which should be clearly shown on the outlet detail. This low orifice would be in addition to any other orifice(s) or control structures for managing larger storm events.

c. Another option (not shown) for a subsurface basin would be to utilize a smaller orifice to manage this volume for storms up to and including the 2-year/24-hour storm event with a non-clogging device and then incorporate adequate WQ BMP(s)[2]. This strategy would need to be consistent with Chapter 3 of the PA BMP Manual which states "retention and detention facilities should be designed to completely drain water quality volumes including both the permanently removed volume and the extended detention volume over a period of time not less than 24 hours and not more than 72 hours from the end of the design storm." Subsurface systems that incorporate other WQ BMPs and do not utilize the minimum 2 feet of soil media will need to complete Worksheets 12 and 13 to demonstrate water quality compliance.

4. Ultimately, the designer's analysis should clearly demonstrate what BMPs are being proposed for **each point of discharge**, and how much volume is being managed by each BMP (when comparing the pre- and post-construction runoff volume from a 2-year/24-hour storm event). **As noted in Design Considerations Item No. 1, the analysis should also include which BMPs were considered as not feasible and the reasons why.**

5. Specifications for the amended soil or filter media – The soil mix or filter media should be site-specific depending on the anticipated pollutants (gradation) at the proposed site. The maximum soil texture is course sand. The minimum depth is 2 feet (24 inches) which is consistent with Appendix C Protocol 2 of the PA BMP Manual to assure adequate pollutant removal. Please reference BMP 6.4.7 Constructed Filter in the PA BMP Manual for more information.

[1] Exhausting all options for infiltration would include looking at all infiltration BMP options and conducting soil

evaluations/testing at multiple locations and multiple depths at each location.

[2] In this case, preference for "WQ BMP" would be a constructed filter (BMP 6.4.7) or other BMP(s) with similar WQ functions. Pretreatment BMPs at all major inflow points should be designed as well – similar to an infiltration basin.

6. Sizing Criteria. Similar to the loading ratio concept for infiltration BMPs, sizing consideration also needs to be given to this BMP strategy to avoid either hydraulic or pollutant overloading[1]. Sizing of this BMP can be achieved in different ways. The simplest way is to follow the table below which was adapted from PWD's Manual version 3.0 (Table 4.1-4) which is based on a maximum loading ratio of 16:1 and a release rate of 0.05 cfs/acre.

Table 1. Slow Release Concept – Sizing Table

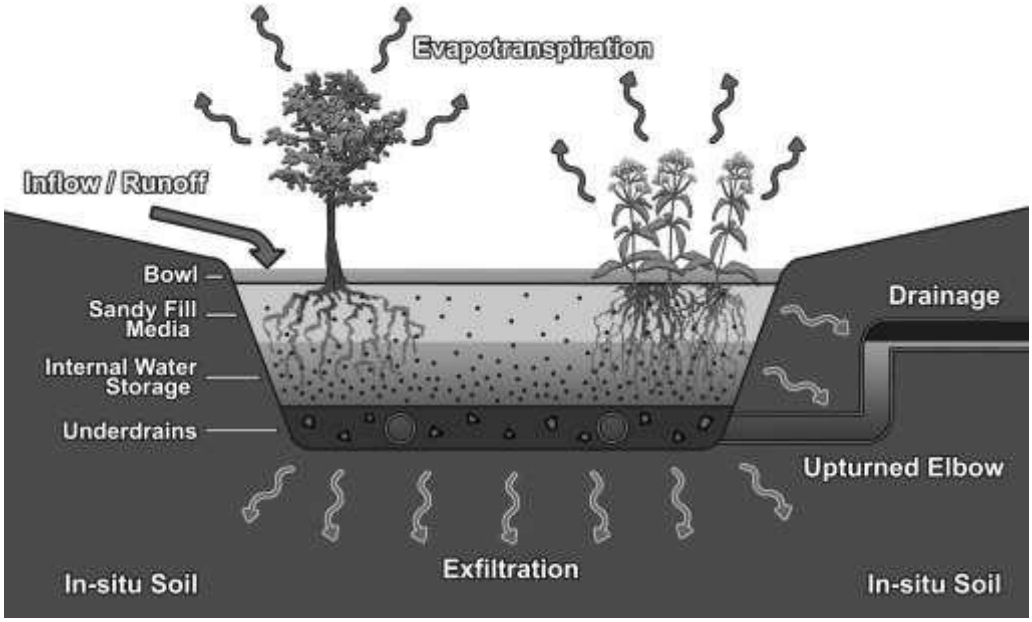
Drainage Area (sq. ft.)	Minimum BMP Area (sq. ft.)	Orifice Diameter (inches)
0-17,000	1,063	1/2"
17,000-24,000	1,500	5/8"
24,000-33,000	2,063	3/4"
33,000-43,560	2,723	7/8"
43,460-68,000	4,250	1"
68,000-96,000	6,000	1 ¼"
96,000-132,000	8,250	1 ½"
132,000-174,240	10,890	1 ¾"

In lieu of this simplified approach, the designer may perform their own analysis which would need to be reviewed and approved by the reviewing entity. This may be necessary for a number of reasons – for instance, to prolong the drain time as long as possible due to the size/condition of the receiving stream. (e.g. headwater streams warrant max. drain time of 72 hours). It should be noted that undersizing of these BMPs are a significant concern of the Department –especially if these BMPs promote any level of infiltration.

7. Drainage characteristics of Soil Media. Please note that the designer will have to exercise caution when selecting a soil media. As noted in Appendix C Protocol 2 of the PA BMP Manual, soil infiltration rate can be between 0.1 inches per hour and 10 inches per hour per. **The designer will need to select a soil media that possesses the proper characteristics that address infiltration rate and water quality.** To maximize water quality treatment and achieve the listed water quality functions (85%/85%/30%) – the residence time within the soil should be maximized within the established parameters. For this reason, the maximum soil texture is course sand. In addition per Appendix C, "Soils with rates in excess of 6.0 inches per hour may require an additional soil buffer (such as an organic layer over the bed bottom) if the Cation Exchange Capacity (CEC) is less than 5 and pollutant loading is expected to be significant."
8. Calculating flows through the perforated underdrains – Please reference PennDOT Publication 408 Section 610 for specifications of underdrains. This section specifies a minimum rate of 10 gallons (1.34 cubic feet) per minute per linear foot of pipe. There may need to be multiple underdrains or longer underdrains to provide adequate design capacity to drain within 72 hours after the storm. In addition, the section BMP 6.4.7 Constructed Filter in the PA BMP Manual has recommended specifications for lateral spacing of multiple underdrains.

[1] This BMP incorporates water quality treatment – typically an amended soil layer designed to provide pollutant reduction.

9. Underdrain aggregate envelope – Please reference PennDOT Roadway Construction details RC-30M for underdrain bedding and aggregate envelope options. The aggregate selected for the underdrain bedding and envelope should be clean washed stone for water quality reasons.
10. Cleanout for underdrain – The underdrain(s) should be equipped with a cleanout for future maintenance. Caution should be used so that a riser pipe from the u-drain is not allowed to take in surface waters. The u-drain maintenance could be done from inside the riser instead of stand pipes that all too frequently do not specify a water tight top cap or at least the pipe extended up past any standing water elevations.
11. Capped Underdrain and/or Control Valve – Underdrains should be capped within the outlet structure. The cap should be drilled for an appropriately sized orifice to manage release rates. (See Table 1 for orifice sizes) Also see Underdrain Connection Standard Detail in Philadelphia Water Department (PWD) Guidance Manual. (Fig. 4.1-5) Control valve may also be included for maintenance reasons and to better manage the discharge rate if the other design components are not functioning as planned (turn the valve to slow the discharge to the desired release rate). Due to issues with control valves being misused and/or inappropriately maintained and/or freezing during winter months, the reviewing entity has the discretion to prohibit their use.
12. Vegetation - The native vegetation for the above ground concept should be selected so that the vegetation can grow and sustain under the design conditions. The vegetation should be able to grow and sustain based on the depth of stored water in the slow release storage basin and the length of time that the depth is sustained prior to the slow release.
13. Design Variations – The underdrain can include an upturned elbow towards its outlet and is **highly recommended**. Future iterations of this BMP may make this a requirement. The upturned elbow creates a zone within the amended soils or filter media named the "internal water storage (IWS)". This zone has been researched and studied to show that this IWS can improve runoff volume reduction and water quality treatment. (Davis et al, 2009) (Davis, Hunt & Traver, 2011) The upturned elbow can also aid if site conditions present daylighting issues with the underdrain's discharge elevation. Please see figure below with upturned elbow.



(Image by Shawn Kennedy, NC State University)

Detailed Stormwater Functions

Volume Management Calculations
Full volume management credit up to the ∆2 volume for dead or static storage that is slow released. (Keeping in mind that all attempts must be exhausted to maximize volume reductions with non-structural BMPS (up to 25%of ∆2) and other structural BMPs such as capture & reuse; and soil restoration.) The Department reserves the right to deny the use of the slow release concept for projects that threaten the integrity of the receiving stream by producing excessive amounts of volume runoff not implementing the above-mentioned volume reduction practices. Additional BMPs may be necessary.

Peak Rate Mitigation Calculations: See Chapter 8 for Peak Rate Mitigation methodology which addresses link between volume reduction and peak rate control.

Water Quality Improvement: Based on type and depth (min. 24") of amended soil/filter media or other water quality BMP placed in series with slow release concept. The designer may utilize Worksheet #10 or Worksheets 12 & 13 to demonstrate nitrate compliance as currently shown in Chapter 8 of BMP Manual, Flow Chart D – Water Quality Process.

The Department reserves the right to deny the use of the slow release concept for projects that threaten the water quality of the receiving stream. Additional BMPs may be necessary.

Construction Sequence

1. Follow sequencing for BMP. This will be project specific per the design engineer's recommendation.

Maintenance and Inspection Issues

1. Follow recommended maintenance and inspection schedule for BMP. This will be project specific per the design engineer's recommendation.

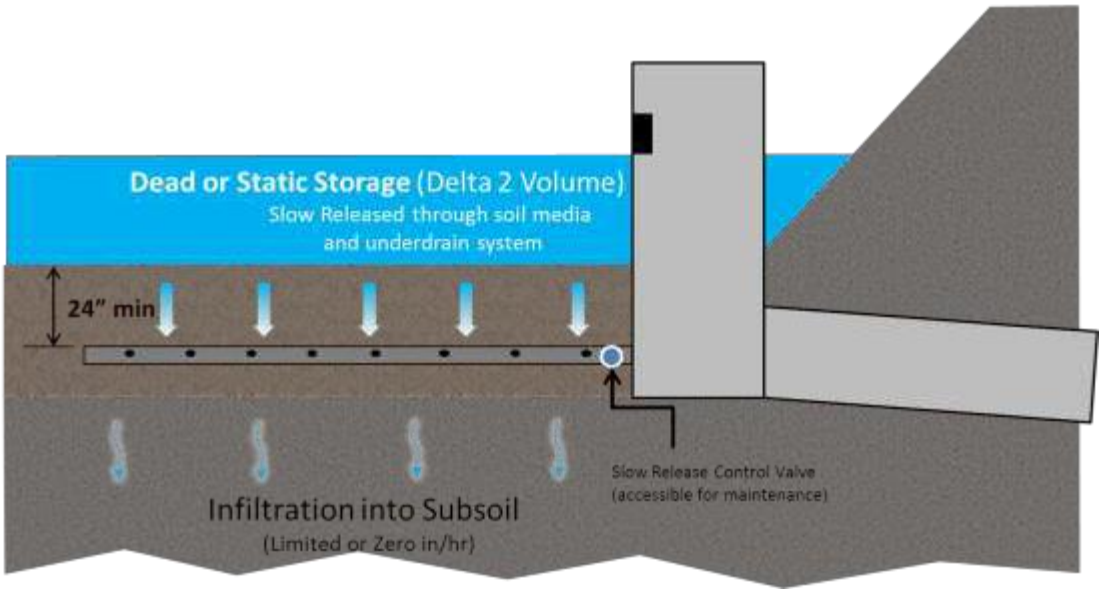
References

PWD Stormwater Management Guidance Manual v3.0, 4.1 Bioinfiltration/Bioretention

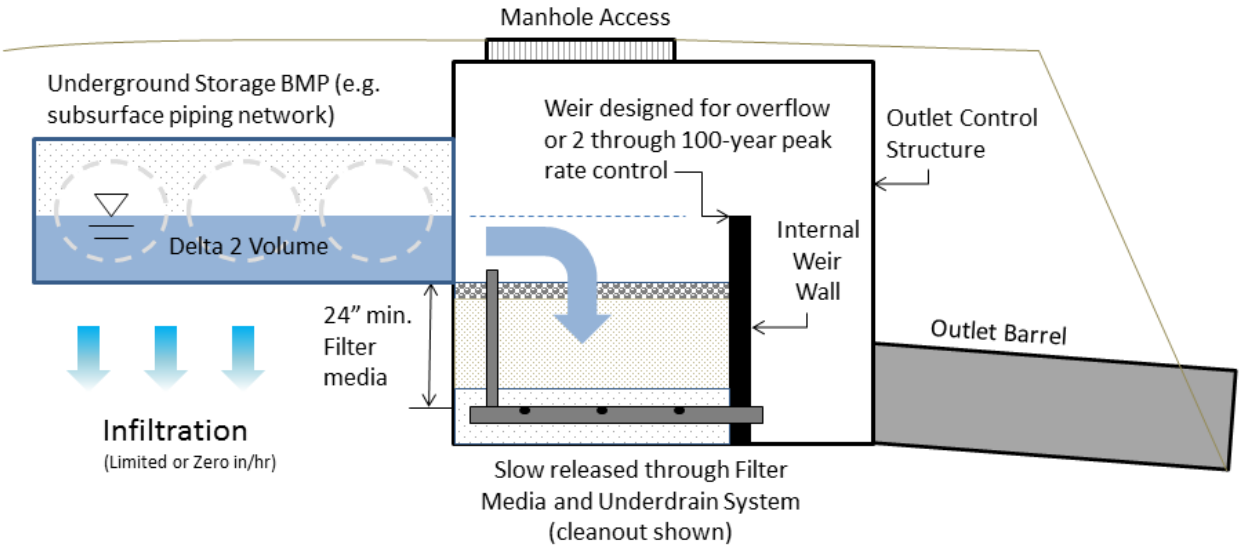
PennDOT Publication 408 Section 610 for specifications of underdrains

Journal Publications:
Bioretention Tech: Overview of Current Practice & Future Needs; (Davis et al, ASCE Journal of Environmental Engineering March 2009)
Bioretention Outflow: Does it Mimic Nonurban Watershed Shallow Interflow?; (DeBusk et al, Low Impact Development 2010 ASCE)
Hydrologic Performance of Bioretention Stormwater Control Measures (Davis et al, draft 2011)
Field Performance of Bioretention: Hydrology Impacts (Davis) Journal of Hydrologic Engineering February 2008
Meeting Hydrologic and Water Quality Goals through Targeted Bioretention Design (Hunt et al) Journal of Environmental Engineering June 2012

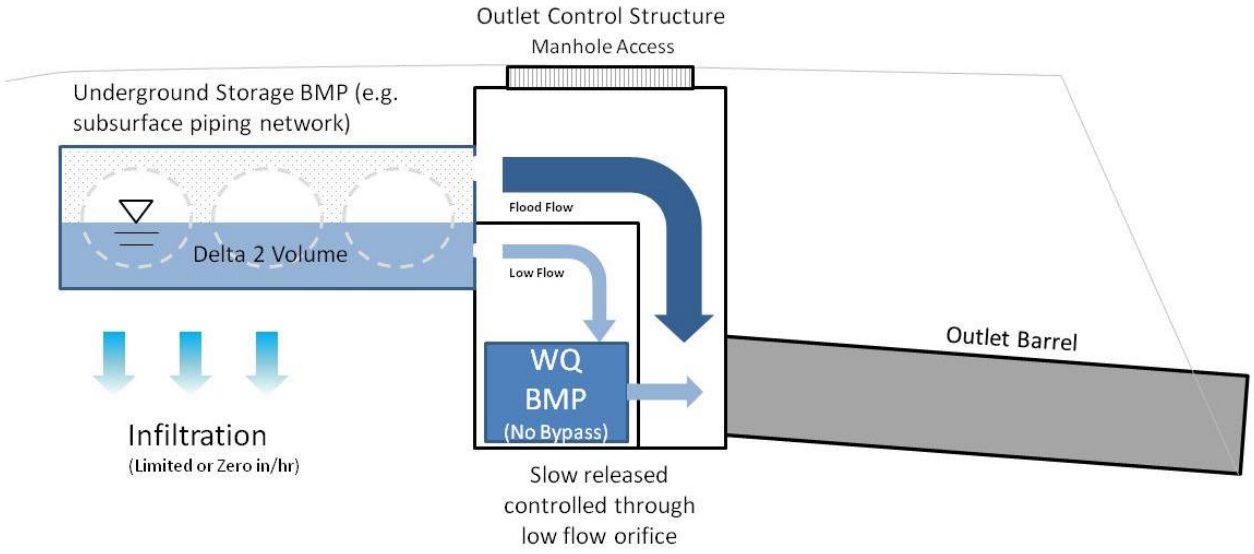
Example 1: Slow Release Concept. Above Ground Storage (Preferred)



Example 2: Slow Release Concept. Underground Storage w/ Filter Media:



Example 3: Slow Release Concept. Underground Storage w/ WQ BMP:



Example 4: Slow Release Concept. Underground Storage w/ WQ BMP:

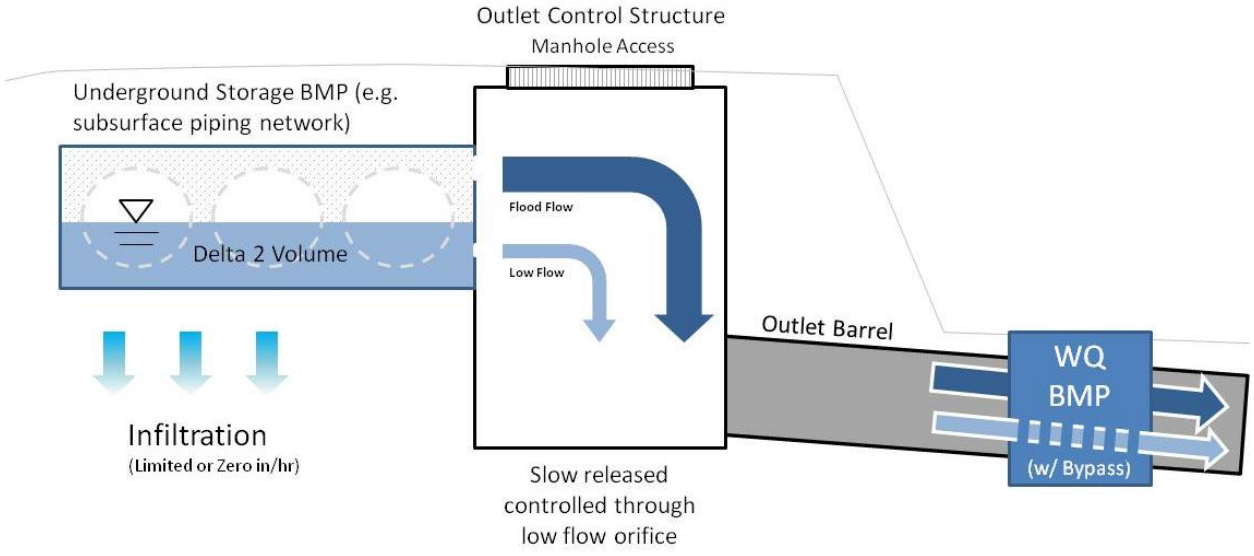


Table 7A.6(a) Five (5) minute through twenty-four (24) hour storm totals for Region 5 (Metric).

Region 5								
Rainfall Total								
	1-Yr Storm	2-Yr Storm	5-Yr Storm	10-Yr Storm	25-Yr Storm	50-Yr Storm	100-Yr Storm	500-Yr Storm
Duration (Min)	cm	cm	cm	cm	cm	cm	cm	cm
5	0.95	1.13	1.32	1.48	1.72	1.91	2.11	
10	1.47	1.76	2.06	2.29	2.64	2.91	3.19	
15	1.81	2.16	2.53	2.82	3.27	3.61	3.96	
30	2.40	2.90	3.49	3.97	4.63	5.18	5.76	
60	2.96	3.61	4.47	5.15	6.06	6.84	7.72	
120	3.54	4.30	5.39	6.26	7.45	8.48	9.90	
180	3.90	4.71	5.92	6.89	8.25	9.51	11.03	
360	4.84	5.87	7.40	8.65	10.46	11.95	13.56	
720	6.02	7.25	9.04	10.66	13.07	15.14	17.42	
1440	7.20	8.64	10.73	12.57	15.49	18.19	21.40	31.49

Table 7A.6(b). Five (5) minute through twenty-four (24) hour storm totals for Region 5 (U.S. Customary).

Region 5								
Rainfall Total								
	1-Yr Storm	2-Yr Storm	5-Yr Storm	10-Yr Storm	25-Yr Storm	50-Yr Storm	100-Yr Storm	500-Yr Storm
Duration (Min)	in	in	in	in	in	in	in	in
5	0.37	0.45	0.52	0.58	0.68	0.75	0.83	
10	0.58	0.69	0.81	0.90	1.04	1.15	1.26	
15	0.71	0.85	1.00	1.11	1.29	1.42	1.56	
30	0.94	1.14	1.37	1.56	1.82	2.04	2.27	
60	1.17	1.42	1.76	2.03	2.39	2.69	3.04	
120	1.39	1.69	2.12	2.46	2.93	3.34	3.90	
180	1.53	1.86	2.33	2.71	3.25	3.75	4.34	
360	1.91	2.31	2.91	3.40	4.12	4.70	5.34	
720	2.37	2.86	3.56	4.20	5.15	5.96	6.86	
1440	2.83	3.40	4.22	4.95	6.10	7.16	8.43	12.40

Drainage Area Maps