LINDEN Engineering Partners, LLC

100 TradCenter, Suite G700
Woburn, MA 01801
Tel: (781) 933-3711 Fax: (781) 287-1277
Email:lep@lindeneng.com

STORMWATER REPORT

Proposed Redevelopment
Building 1
1 Corporate Drive, Andover, MA

January 26, 2022

Owners & Applicants:
IQHQ-1 Corporate, LLC and
IQHQ-4 Corporate, LLC
ATTN: Mr. William Ashton
c/o IQHQ Real Estate Investment Trust
One Boston Place, 201 Washington St., Ste 3920
Boston, Massachusetts 02108
Tel: (617) 314-7951

Prepared by:
LINDEN ENGINEERING PARTNERS, LLC
100 TradeCenter, Suite G700
Woburn, MA 01801

Civil – Environmental Engineering including Storm water, Wastewater, Water Supply, Highway & Infrastructure Design
Land Planning, Land Subdivision, Site Design, Environmental Permitting, Wetlands Permitting & Land Development Permitting

TABLE OF CONTENTS

This report details the existing and proposed hydrological and hydraulic conditions for the Redevelopment of the One Corporate Drive building in Andover, MA. This report has been prepared in conformance with the requirements of the Massachusetts Department of Environmental Protection (MADEP) 2008 Stormwater Handbook and the 2008 amendments to 310 CMR 10.00 et. seq. (Massachusetts Wetlands Act Regulations (MAWPA Regs)) and the Town of Andover Stormwater Bylaw. The report has been organized to follow the MADEP Stormwater Checklist.

Site Description:

The project which is the subject of this report is located at One Corporate Drive on the eastern side of Shattuck Road in Andover, MA. The One Corporate Drive building is a portion of a larger property which also contains the Four Corporate Drive building. The property is shown on the Town of Andover Assessor's Map 166 as Lots 23E (old Lot 1) and 12 (old Lot 2). An Approval Not Required Plan to combine the properties into one lot was recently endorsed by the Andover Planning Board. It is the intention of the lot owners (which are entities of IQHQ Real Estate Investment Trust) to convey title to the respective properties to a single, to-be-formed affiliated entity that will own the fee to all of Lot A (the "Lot A Owner").

Existing Conditions:

The portion of the site which is the subject of the proposed work is located just to the east of Shattuck Road on the western portion of the 24 acre site. The area is presently occupied by the One Corporate Drive building and the surrounding parking area, lawn areas and some wooded areas. Drainage from the project area either flows overland to the drainage ditch adjacent to Shattuck Road, overland to the drainage system in Corporate Drive or is collected in the existing on site drainage system which is connected to the drainage system on the property which collects drainage from Corporate Drive, other driveways and parking areas.

Drainage from the area of the proposed work and other portions of the site flows to the onsite stormwater basin located to the east of the Four Corporate Drive building on the east side of the property adjacent to Interstate Route 93.

Proposed Conditions:

The redevelopment of the site consists of the renovation of the existing One Corporate Drive building and the construction of a two story addition to the existing building along with reconfiguration of the surrounding parking area.

Drainage from the project area will continue to flow either overland to the drainage ditch adjacent to Shattuck Road, overland to the drainage system in Corporate Drive and through the site or is collected in the proposed stormwater management system which is connected to the main site drainage system and conveyed to the existing stormwater basin on the site.

Stormwater Standard 1: No New Untreated Discharges

The proposed project does not include any new discharges as the runoff will flow through the existing drainage system to the stormwater basin on the site which discharges through an existing discharge to the drainage ditch adjacent to Interstate Route 93. In addition, all of the runoff from the redeveloped site will be treated with deep sump catch basins, subsurface infiltration systems and stormwater treatment units and the peak rates of runoff from the project area will be reduced when compared to the existing conditions.

Since no new discharges are proposed and stormwater treatment is being provided for the redeveloped site, Standard 1 has been fully met by the proposed project.

Stormwater Standard 2: Peak Rate Attenuation

The proposed project involves the redevelopment of an existing developed site. As such, compliance with Stormwater Standard 2 is required only to the maximum extent practicable and measures must be taken to improve existing conditions.

As part of this study our firm prepared existing and proposed runoff calculations for the project for the 2, 10, 25 and 100 year storms. To reduce the volume of paperwork we have attached to this report a print out of the modelling results for the existing and site developed 25 year storm. The printouts for the 2, 10 and 100 year storm can be provided if requested. All of the stormwater modeling calculations were prepared using SCS Methods consistent with the requirements of the Regulations. The calculations were prepared using HydroCAD software, Version 10.00 by Applied Microcomputers Systems.

Soils data for the stormwater study was obtained from the National Resource Conservation Service Soil Map for the Town of Andover as well as on-site test pits by a Massachusetts Licensed Soil Evaluator. Our firm analyzed that data and made our determination of what Hydrologic Soils Groups to use for the calculations.

Ground cover data is based on the existing and proposed site conditions using on the ground survey and observations of the site. Times of concentration are based on the tributary watershed characteristics and SCS Methodology with a minimum time of concentration of 6 minutes as prescribed by the methodology. Rainfall data for the study is based on the latest NOAA Atlas 14 Point Precipitation Frequency Estimates.

Stormwater mitigation for the proposed project is provided by the installation of subsurface infiltration systems throughout the site. These subsurface structures will infiltrate the required portion of the runoff and the additional volume will allow mitigation of the peak runoff from the redeveloped site.

A summary of the peak rate of runoff calculations from the project area through the discharge pipe is as follows:

RUNOFF TO SHATTUCK ROAD DRAINAGE DITCH			
Storm Return Period (years)	Existing Peak Rate of Runoff (c.f.s.) (REACH 1EX)	Proposed (Site Developed) Peak Rate of Runoff (c.f.s.) (REACH 1D)	Difference c.f.s. (%)
2	0.20	0.19	-0.01 (-5.0%)
10	0.53	0.49	-0.04 (-7.5%)
25	0.76	0.70	-0.06 (-7.8%)
100	1.13	1.04	-0.09 (-7.9%)

OVERLAND RUNOFF TO CORP. DRIVE/BUILDING 4 DRIVE			
Storm Return Period (years)	Existing Peak Rate of Runoff (c.f.s.) (REACH 2EX)	Proposed (Site Developed) Peak Rate of Runoff (c.f.s.)	Difference c.f.s. (%)
2	0.85	0.68	-0.17 (-20.0%)
10	2.09	1.65	-30.44 (-21.0%)
25	2.94	2.29	-0.65 (-22.1%)
100	4.34	3.35	-0.99 (-22.8%)

RUNOFF FROM MEADOW TO BUILDING 4 DRIVE DRAIN			
Storm Return Period (years)	Existing Peak Rate of Runoff (c.f.s.) (REACH 3EX)	Proposed (Site Developed) Peak Rate of Runoff (c.f.s.)	Difference c.f.s. (%)
2	1.07	1.10	+0.03 (+2.8%)
10	2.87	2.87	-0.00 (-0.0%)
25	4.12	4.07	-0.05 (-1.2%)
100	6.21	6.09	-0.12 (-1.9%)

RUNOFF FROM MAIN BUILDING ONE SITE TO BUILDING 4 DRAIN			
Storm Return Period (years)	Existing Peak Rate of Runoff (c.f.s.) (REACH 4EX)	Proposed (Site Developed) Peak Rate of Runoff (c.f.s.)	Difference c.f.s. (%)
2	11.31	8.83	-2.48 (-21.9%)
10	20.08	18.33	-1.75 (-8.7%)
25	25.45	22.48	-2.97 (-12.1%)
100	34.03	29.38	-4.65 (-13.6%)

TOTAL RUNOFF FROM BUILDING 1 PROJECT TO BUILDING 4 DRIVE DRAIN AND ON SITE BASIN			
Storm Return Period (years)	Existing Peak Rate of Runoff (c.f.s.) (REACH 5EX)	Proposed (Site Developed) Peak Rate of Runoff (c.f.s.)	Difference c.f.s. (%)
2	12.90	10.29	-2.61 (-20.2%)
10	24.39	22.14	-2.25 (-9.2%)
25	31.63	27.88	-3.75 (-11.8%)
100	43.36	37.35	-6.01 (-13.8%)

A review of the above summaries indicates that the redevelopment of the site as proposed will not increase the peak runoff from the site to the Shattuck Road ditch, Corporate Drive or the main site drain to the existing Stormwater Basin.

Based on the results of the calculations we feel that Standard 2 has been met by the proposed project.

Stormwater Standard 3: Recharge

The proposed project involves the redevelopment of an existing developed site. As such, compliance with Stormwater Standard 3 is required only to the maximum extent practicable and measures must be taken to improve existing conditions. Test pits were conducted on the site by Haley and Aldrich to determine the Estimates Seasonal High Ground Water Table (ESHGWT) elevations and the infiltration capacity of the soils. This information was used along with the NRCS Soil Maps to determine that the soils are Hydrologic Soils Group C with an infiltration capacity of 0.21 inches/hour.

Given that the soils are HSG C the required infiltration is 0.25 inches x the impervious area. Since the subsurface infiltration structures have been designed to infiltrate the ½ inch water quality volume see Standard 4 below for the subsurface infiltration system design. All of the systems have been located 2 feet above the ESHGWT and infiltration was not used as a component of the peak runoff mitigation.

Based on the fact that the water quality volume is being infiltrated and this volume exceeds the required infiltration volume Standard 3 has been met by the proposed project.

Stormwater Standard 4: Water Quality

The proposed project involves the redevelopment of an existing developed site. As such, compliance with Stormwater Standard 4 is required only to the maximum extent practicable and measures must be taken to improve existing conditions. Treatment for the runoff from the impervious surfaces is provided by new deep sump catch basins with hooded outlets, Subsurface Infiltration Structures and Cascade Stormwater Treatment Units. Calculations for these systems are as follows:

Infiltration Structure #1:

Tributary Impervious Area = 45,920 s.f.
Water Quality Volume = 45,920 s.f. x ½" = 1,913.3 c.f.
Captured Volume at the Overflow Depth = 3,659 c.f. which is > 1,913.3 c.f.
Time to Empty = 1.2 ft. deep x 12 in./ft.*0.21 in./hr. = 68.57 hrs < 72 hrs

Infiltration Structure #2:

Tributary Impervious Area = 91,941 s.f.
Water Quality Volume = 91,941 s.f. x ½" = 3,830.9 c.f.
Captured Volume at the Overflow Depth = 4,312 c.f. which is > 3,830.9 c.f.
Time to Empty = 1.2 ft. deep x 12 in./ft.*0.21 in./hr. = 68.57 hrs < 72 hrs

Infiltration Structure #3:

Tributary Impervious Area = 48,900 s.f.
Water Quality Volume = 48,900 s.f. x ½" = 2,037.5 c.f.
Captured Volume at the Overflow Depth = 2,221 c.f. which is > 2,037.5 c.f.
Time to Empty = 1.2 ft. deep x 12 in./ft.*0.21 in./hr. = 68.57 hrs < 72 hrs

Infiltration Structure #4:

Tributary Impervious Area = 34,882 s.f.
Water Quality Volume = 34,882 s.f. x ½" = 1,453.4 c.f.
Captured Volume at the Overflow Depth = 2,395 c.f. which is > 1,453.4 c.f.
Time to Empty = 1.2 ft. deep x 12 in./ft.*0.21 in./hr. = 68.57 hrs < 72 hrs

Note that due to the soils all of the infiltration structures were designed to retain 1.2 feet of water so that they would drain in less than 72 hours and treat the required water quality volume as required.

TSS and Phosphorous Removal

Runoff from the proposed impervious surfaces is being treated by a combination of deep sump catch basins, subsurface infiltration structures and Cascade Stormwater Treatment Units. The combination of the deep sump catch basins and subsurface infiltration structures removes 80% of the Total Suspended Solids (TSS) and 60% of the Total Phosphorous. The runoff from the subsurface structures is then treated using Contech Cascade CS-4 Stormwater Treatment Units. These units have been tested and shown to remove 80% of the TSS.

Calculations for these units are as follows:

Unit #1:
Impervious Area = 137,861 s.f. (3.165 acres), time of concentration = 0.12 hours
WQF = (qu)(A)(WQV)
WQF = (755 csm/in)(3.165 acres)(0.0015625 mi2/acre)(1/2 in)
WQF ≈ 1.87 CFS Note: The chosen Unit can treat 2.00 c.f.s.

Unit #2:
Impervious Area = 83,782 s.f. (1.923 acres), time of concentration = 0.12 hours
WQF = (qu)(A)(WQV)
WQF = (755 csm/in)(1.923 acres)(0.0015625 mi2/acre)(1/2 in)
WQF ≈ 1.134 CFS Note: The chosen Unit can treat 2.00 c.f.s.

By using the specified treatment units, the residual TSS load of 20% is further reduced to 4% for a total TSS Removal of 94%. Note that further treatment is provided by the existing stormwater basin on the site.

The runoff quality from the proposed redevelopment represents a significant improvement compared to existing conditions therefore, Standard 4 has been met by the proposed project.

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

The portion of the site where the work will be conducted does not contain any activities that are classified as Land Uses with Higher Potential Pollutant Loads as defined by the 2008 MADEP Stormwater Handbook and the 2008 amendments to 310 CMR 10.00 et. seq. (MAWPA Regs). Therefore Standard 5 has been met by the proposed project to the extent practicable.

Stormwater Standard 6: Critical Areas

The proposed project does not discharge stormwater runoff to a critical area as defined by the 2008 MADEP Stormwater Handbook and the 2008 amendments to 310 CMR 10.00 et. seq. (MAWPA Regs). Therefore Standard 6 has been fully met by the proposed project.

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

The proposed project involves the redevelopment of an existing developed site. As such, compliance with Stormwater Standards 2, 3, 4, 5, and 6 is required only to the maximum extent practicable and measures must be taken to improve existing conditions. Throughout this report we have listed the areas of compliance with the standards in the 2008 MADEP Stormwater Handbook. The proposed project has been carefully thought through and designed to meet the requirements of stormwater standards 1, 2, 3, 4, 5 & 6.

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

Erosion Control and Construction Sequencing

With regard to work proposed on the project and erosion and siltation control, the sequence of activities will generally take place as follows:

1. Prior to general pavement removal, or topsoil stripping, place all erosion controls (straw wattles and silt sacks) in the locations specified on the drawings.

2. Damaged or loose siltation controls shall be replaced as necessary to maintain their function of controlling erosion and siltation. Silt sacks in catch basins shall be replaced as necessary to maintain its function of controlling erosion and siltation.

3. Remove any accumulation of silt or soil build-up behind the straw wattles as it occurs.

4. Throughout excavation, and grading operations the Contractor shall take other necessary precautions, including installation of temporary drainage swales, siltation sumps/filtration dams, check dams, straw bales, straw wattles and temporary pipe, to direct and control drainage from disturbed areas on the site so that erosion and siltation is minimal. In addition, no erosion or discharge of silt or larger particles shall occur in wetland areas or onto adjacent properties.

5. Remove all erosion control measures, including the straw wattles only when construction is completed, upland surfaces are stabilized, and the piped drainage system is fully operational, and the removal of the devices has been approved by the Architect/Civil Engineer and the Town of Andover.

If the Contractor anticipates deviations from the above procedures, he shall obtain written approval from the Architect/Civil Engineer prior to proceeding.

Erosion and Sediment Control BMP’s

The Erosion and Sediment Controls represent the suggested best management practices proposed for the project. The Contractor's approach to controlling stormwater runoff from the site may vary however he must implement appropriate corresponding erosion control measures.

The use of erosion and sediment controls are mandatory and must be employed to minimize impacts to adjacent areas during construction. If sediment escapes the construction site, off-site accumulations of sediment must be removed at a frequency sufficient to minimize off-site impacts.

The control practices which are required to minimize stormwater pollution during construction must remain functional until disturbed areas have been stabilized. Erosion control products are to be installed and maintained in accordance with manufacturer's specifications and good engineering practices.

The most important aspects of controlling erosion and sedimentation are limiting the extent of drainage structures. These fundamental principles will be the key factors in the contractor's control of erosion on the project site. If appropriate, the contractor will construct temporary diversion swales and settling basins or use a settling tank. If additional drainage or erosion control measures are needed, they will be located up-gradient from the straw bales and silt fences.

The contractor is responsible for the maintenance and repair of all erosion control devices on-site. All erosion control devices will be regularly inspected. At no time will silt-laden water be allowed to enter sensitive areas (wetlands, streams, and drainage systems). Any runoff from disturbed surfaces will be directed through a sedimentation process prior to being discharged to the existing on site drainage system.

The contractor will establish a staging area for the overnight storage of equipment and stockpiling of materials. In the staging area, the contractor will have a stockpile of materials required to control erosion on-site to be used to supplement or repair erosion control devices. These materials will include, but are not limited to straw bales, straw wattles, siltation control fence, stakes, erosion control matting, and crushed stone. As mentioned previously, erosion and sedimentation controls will be employed to minimize the erosion and transport of sediment into resource areas during the earthwork and construction phases of the Project. Erosion and sedimentation control measures will be installed prior to site excavation or disturbance and will be maintained throughout the construction period.

The contractor is responsible for erosion control on the site and will utilize supplemental erosion control measures to supplement the erosion controls shown on the plans prepared for this project to work with his day to day operations at the site.

Primary erosion control techniques proposed include compost filled filtrexx soxx, siltation control fence with straw bale barriers and silt sacks, inlet sediment traps, siltation control dikes, a stabilized construction entrance, temporary diversion channels, and temporary sedimentation ponds when applicable. A detailed description of each technique is discussed below. During the growing season, slope stabilization will be achieved by applying topsoil followed by seeding and mulching as soon as final grades are achieved. Organic mulching, jute netting, geo-textiles, or a combination will be used to stabilize slopes completed outside of the growing season.

Best Management Practices (BMPs)

Straw Wattles/Straw bales

Erosion control barriers (straw wattles) will be installed in the locations shown on the drawings or as directed in the field by the Architect/Civil Engineer prior to the start of construction. These barriers will remain in place until all tributary surfaces have been fully stabilized.

The barriers will be placed to trap sediment transported by runoff before it reaches the drainage system or leaves the construction site. In areas where high runoff velocities or high sediment loads are expected, silt fencing may be installed adjacent to the straw wattle barriers. This semi-permeable barrier made of a synthetic porous fabric will provide additional protection. The straw wattle barrier will be replaced as determined by periodic field inspection. The underside of the wattle will be kept in close contact with the earth and reset as necessary. Straw wattles will be maintained and cleaned until slopes have healthy stands of grass and all proposed paved areas have been paved with the binder course of pavement.

Drain System Protection

Silt Sack sediment traps supplemented with straw bale erosion checks will be installed at drainage structures and maintained and cleaned until slopes have healthy stands of grass. Catch basins, drain inlets, stormwater treatment units and storm drain pipes will be cleaned of sediment and debris after the completion of construction. Sediment collected in structures will be disposed of properly and covered, if stored on-site.

- Until tributary areas are stabilized, catch basin inlets will be fitted with Silt Sacks. If intense rainfall is predicted before all tributary areas are stabilized, erosion control measures will be reinforced for the duration of the storm. Downstream areas will be inspected, and any sediment removed at the end of the storm.

- Unfiltered water will not be allowed to enter pipes from unstabilized surfaces.

- Trench excavation will be limited to the minimum length required for daily pipe installation. All trenches will be backfilled as soon as possible. The ends of pipes will be closed nightly with plywood

- During construction of the site, silt-laden waters should be intercepted prior to reaching catch basins. Any gross depositions of materials on paved surfaces will be removed by sweeping.

- All paved areas will be swept on a weekly basis, as permitted by weather, during the construction period.

- Catch basins should be inspected monthly and cleaned in anticipation of the winter season in November and at the same time the roads are swept in the spring.

Utility Construction

The Contractor will construct utility trenches in a manner that will not direct runoff toward wetlands or to drainage system structures.

Stabilization Activities

All disturbed surfaces will be stabilized within 14 days after construction in any portion of the project site is completed or is temporarily halted, unless additional construction is intended to be initiated within 14 days. The Contractor will not disturb more area than can be stabilized within 14 days unless the area is to remain active. The Contractor will not disturb more area than can be stabilized within the same construction season.

Slope Stabilization

The smallest practicable area of land will be exposed at a time. Slopes greater than three-to-one (horizontal to vertical) will be stabilized with seed, organic mulch, jute fabric, or rip-rap, as appropriate, to prevent erosion during construction. After disturbed areas have been stabilized, the temporary erosion control measures will be removed, and accumulated sediment will be removed and disposed of in an appropriate location. Disturbed areas will be stabilized with appropriate ground cover as soon as possible. After the removal of temporary erosion control measures, disturbed areas will receive a layer of topsoil for stabilization.

Stabilized Construction Entrance

Temporary stabilized construction entrance or entrances will be installed at the project site. The purpose of the construction entrance is to remove sediment attached to vehicle tires and to minimize sediment transport and deposition onto public road surfaces. The construction entrance or entrances will be composed of crushed stone which will be replenished as necessary to maintain their proper function.

Inspections

The Contractor shall perform the following inspections in accordance with the 2022 EPA Construction General Permit Conditions which require routine inspections of the site and careful documentation of events and conditions. The following inspection activities will be completed by a qualified, designated site monitor.

- Erosion control, sedimentation prevention, and stormwater management measures will be inspected at least once per week throughout the construction period.

- All controls, outfalls, and potential problem areas will also be inspected within 24 hours of any storm exceeding 0.25 inches of precipitation.

A log of inspection results will be maintained on-site and will include the name of the inspector, date, major observations, and necessary corrective measures.

Built up sediment will be removed when it has reached one-third the height of the straw wattle.

All needed repairs or modifications will be reported to the contractors to permit the timely implementation of required actions. Where necessary repairs do not pose an immediate concern, repairs or modifications will be implemented within two (2) days of inspection.

A report summarizing the scope of the inspection, name(s) and qualifications of personnel making the inspection, the date(s) of the inspection, major observations relating to the implementation of this CPPPP, and actions taken will be made and retained as part of the CPPPP.

Maintenance

The following maintenance practices will be used by the Contractor to maintain erosion and sediment controls. Maintenance activities will be documented on his Inspection Report.

Erosion and sediment control measures and other protective measures must be maintained in effective operating condition.

- If site inspections indicate that the BMPs are not operating effectively, maintenance must be performed as soon as possible and before the next storm event whenever practicable to maintain the continued effectiveness of the BMPs.
- If existing BMPs need to be modified or if additional BMPs are necessary for any reason, implementation must be completed before next storm event whenever practicable.
- Pollution prevention measures must be maintained in good working order. If a repair is necessary, it will be initiated, if practicable, within 24 hours of report.
- Accumulated sediment within the catch basin inlet protection must be removed on a weekly basis.
- Maintenance and inspection of pollution prevention measures must be continued on the site for as long as a portion of the site remains disturbed.
- Stabilization measures will be initiated as soon as practicable on portions of the site where construction has temporarily or permanently ceased. This will occur in NO CASE more than 14 days after construction activities have temporarily or permanently ceased.
- If issues are identified at hazardous materials storage areas, corrective actions will be implemented immediately. If leaks or spills are identified procedures outlined in Standard 9 will be followed.

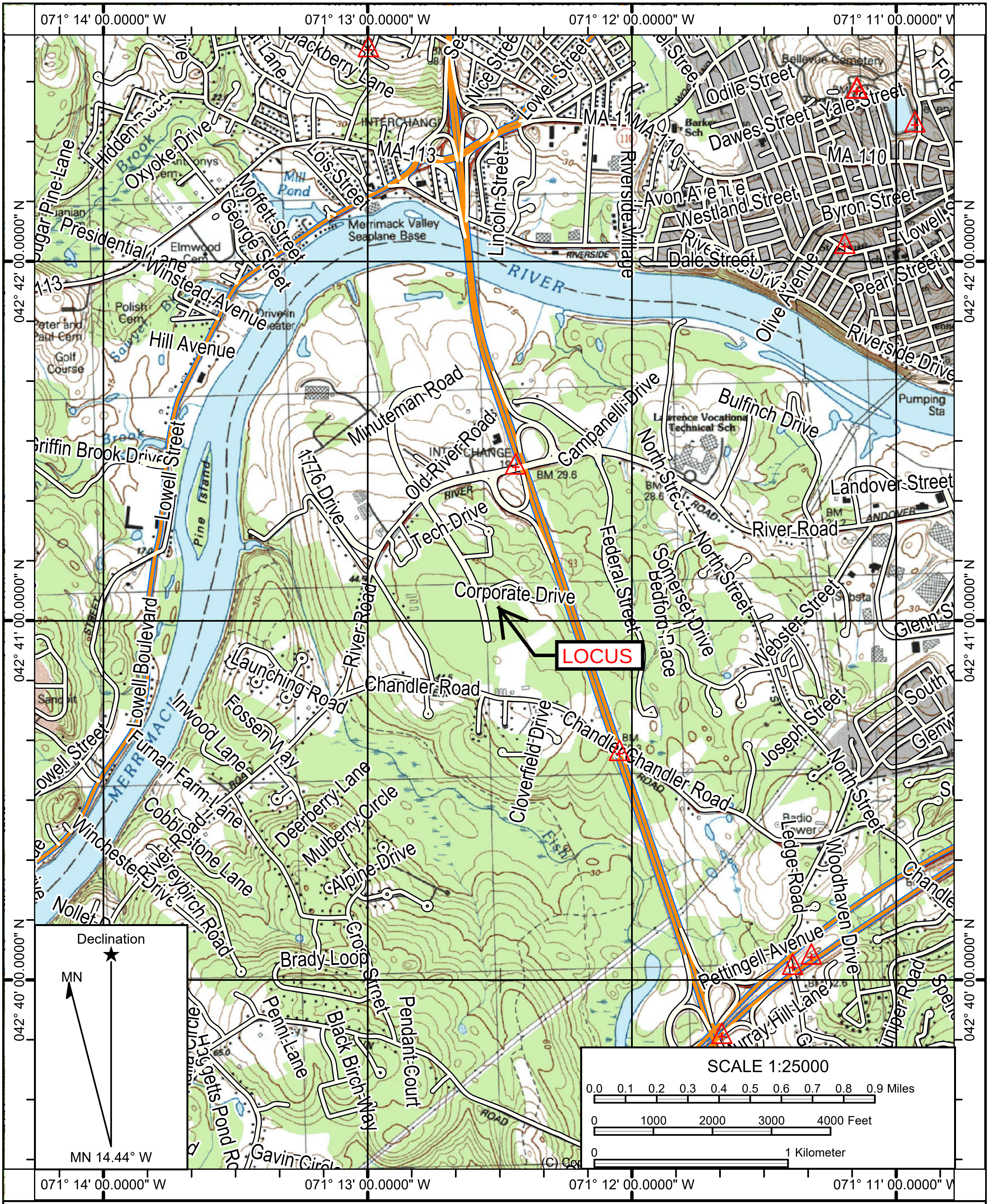
Stormwater Standard 9: Operation and Maintenance Plan

Attached to this report is an updated Operation and Maintenance Plan which is an update of the O&M Plan approved by the Town of Andover Conservation Commission for the property in 2021. The updated to the plan include is summarized below and will be incorporated into the construction documents for this project.

Stormwater Standard 10: Prohibition of Illicit Discharges

A signed Illicit Discharge Compliance Statement is attached to this Stormwater Report. The project has been designed to avoid illicit discharges.

LOCUS MAP



Name: IQHQ
Date: 1/26/2022

Location: 1 CORPORATE DRIVE, ANDOVER, MA
Caption: IQHQ

Scale: 1" = 2,083'

Datum: NAD27

NRCS SOIL DATA
TEST PIT DATA

United States Department of Agriculture

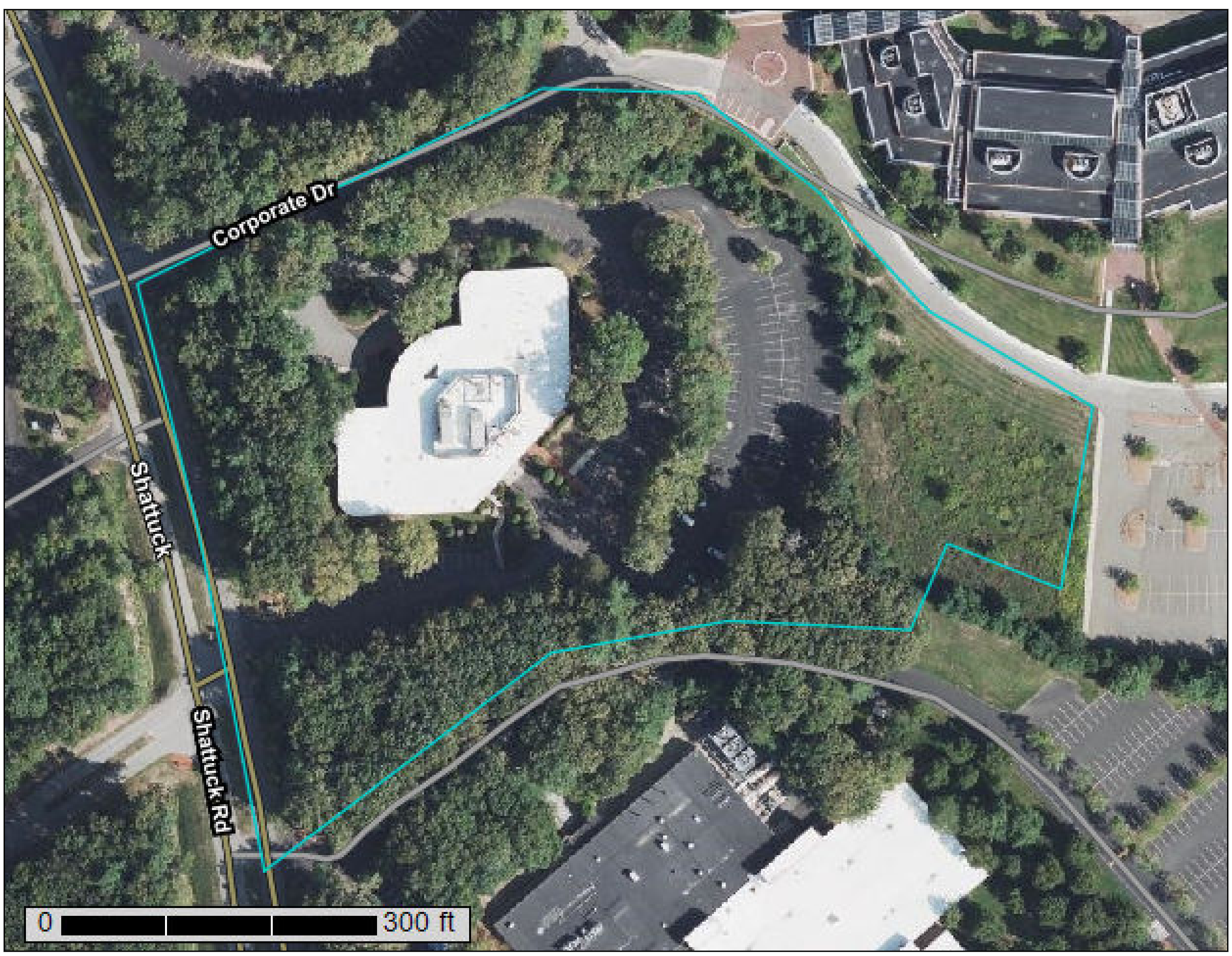
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Essex County, Massachusetts, Northern Part



January 20, 2022

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

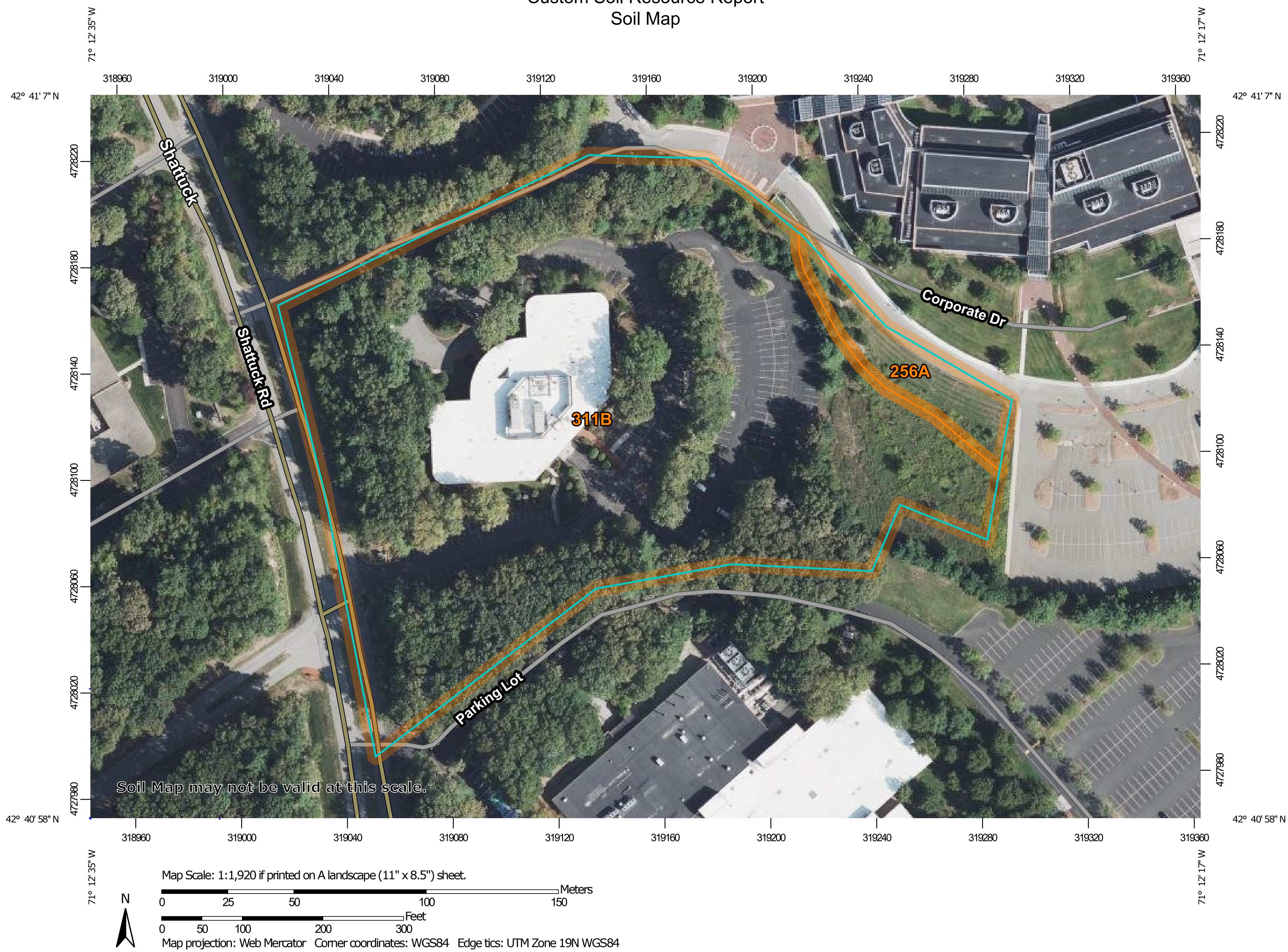
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


71° 12' 35" W
71° 12' 17" W
42° 41' 7" N
42° 40' 58" N
318960
319000
319040
319080
319120
319160
319200
319240
319280
319320
319360
4728220
4728180
4728140
4728100
4728060
4728020
4727980
Shattuck
Shattuck Rd
Corporate Dr
Parking Lot
256A
311B
Soil Map may not be valid at this scale.
N
Map Scale: 1:1,920 if printed on A landscape (11" x 8.5") sheet.
Meters
0
25
50
100
150
Feet
0
50
100
200
300
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N 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 1:15,800.

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: Essex County, Massachusetts, Northern Part
Survey Area Data: Version 17, Sep 2, 2021

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

Date(s) aerial images were photographed: Aug 13, 2020—Sep 15, 2020

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
256A	Deerfield loamy fine sand, 0 to 3 percent slopes	0.4	5.1%
311B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	8.4	94.9%
Totals for Area of Interest		**8.8**	**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.

Essex County, Massachusetts, Northern Part

256A—Deerfield loamy fine sand, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2xfg8
Elevation: 0 to 1,100 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Deerfield

Setting

Landform: Outwash terraces, outwash deltas, outwash plains, kame terraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave, convex, linear
Across-slope shape: Convex, linear, concave
Parent material: Sandy outwash derived from granite, gneiss, and/or quartzite

Typical profile

Ap - 0 to 9 inches: loamy fine sand
Bw - 9 to 25 inches: loamy fine sand
BC - 25 to 33 inches: fine sand
Cg - 33 to 60 inches: sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: About 15 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Sodium adsorption ratio, maximum: 11.0
Available water supply, 0 to 60 inches: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: A
Ecological site: F144AY027MA - Moist Sandy Outwash
Hydric soil rating: No

Minor Components

Windsor

Percent of map unit: 7 percent
Landform: Outwash terraces, kame terraces, outwash deltas, outwash plains
Landform position (three-dimensional): Tread
Down-slope shape: Concave, convex, linear
Across-slope shape: Convex, linear, concave
Hydric soil rating: No

Wareham

Percent of map unit: 5 percent
Landform: Drainageways, depressions
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Sudbury

Percent of map unit: 2 percent
Landform: Outwash plains, kame terraces, outwash deltas, outwash terraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave, convex, linear
Across-slope shape: Convex, linear, concave
Hydric soil rating: No

Ninigret

Percent of map unit: 1 percent
Landform: Kame terraces, outwash plains, outwash terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex, linear
Across-slope shape: Convex, concave
Hydric soil rating: No

311B—Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony

Map Unit Setting

National map unit symbol: 2t2qr
Elevation: 0 to 1,440 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Woodbridge, very stony, and similar soils: 82 percent
Minor components: 18 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodbridge, Very Stony

Setting

Landform: Ground moraines, hills, drumlins
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 9 inches: fine sandy loam
Bw1 - 9 to 20 inches: fine sandy loam
Bw2 - 20 to 32 inches: fine sandy loam
Cd - 32 to 67 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 8 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 20 to 43 inches to densic material
Drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 19 to 27 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C/D
Ecological site: F144AY037MA - Moist Dense Till Uplands
Hydric soil rating: No

Minor Components

Paxton, very stony

Percent of map unit: 10 percent
Landform: Ground moraines, hills, drumlins
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Ridgebury, very stony

Percent of map unit: 8 percent
Landform: Hills, drainageways, drumlins, depressions, ground moraines
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Head slope, base slope
Down-slope shape: Concave

Across-slope shape: Concave
Hydric soil rating: Yes

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Map—Hydrologic Soil Group

Map Scale: 1:1,920 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 25, 50, 100, 150

Feet: 0, 50, 100, 200, 300

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

MAP LEGEND

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

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

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 1:15,800.

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: Essex County, Massachusetts, Northern Part
Survey Area Data: Version 17, Sep 2, 2021

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

Date(s) aerial images were photographed: Aug 13, 2020—Sep 15, 2020

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.

Table—Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
256A	Deerfield loamy fine sand, 0 to 3 percent slopes	A	0.4	5.1%
311B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	C/D	8.4	94.9%
Totals for Area of Interest			**8.8**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

HALEY & ALDRICH, INC.
465 Medford St.
Suite 2200
Boston, MA 02129
617.886.7400

MEMORANDUM

6 December 2021
File No. 0203691-000

TO:	IQHQ-One Corporate, LLC Bryan Gubbins Matt Formicola David Surette
C:	Linden Engineering; William Jones Ellenzweig; James Blount EBI Consulting; Brian Hasemann
FROM:	Haley & Aldrich, Inc. Kyle Block, LSP; Mark Haley, P.E. (MA); Mark Kelley, P.E. (MA), SE (SE# 1195)
SUBJECT:	Preliminary Stormwater Infiltration Design Recommendations Proposed Building Addition One Corporate Drive Andover, Massachusetts

The purpose of this memorandum is to provide preliminary stormwater infiltration design recommendations for the proposed Building Addition located at One Corporate Drive in Andover, Massachusetts. These preliminary design recommendations are based on field explorations and in-situ hydraulic conductivity testing recently completed at the site and is intended to aid Linden Engineering in design of the stormwater infiltration systems for the project. The results of laboratory grain size distribution analyses for soils representative of the in-situ hydraulic conductivity testing intervals are currently pending and will be used to confirm the preliminary hydraulic conductivity estimates provided herein. The recommendations provided herein will be reviewed and updated recommendations provided in our forthcoming Geotechnical Report, as necessary.

Recent Subsurface Explorations

During the period 10 to 16 November 2021, Earthwork Industries, Inc., under the observation of Haley & Aldrich, Inc. (Haley & Aldrich), excavated 14 test pits, designated as HA21-TP1 through HA21-TP8 and HA21-TP10 through HA21-TP15. Due to site constraints that limited access, HA21-TP9 was not completed and was omitted from the exploration program. The test pits were excavated to depths ranging from 5.5 to 11.6 ft below ground surface (bgs). The ground surface elevation at the test pit locations ranged from elevation (El.) 161.7 to El. 141.5[1] with site grades generally sloping downward from the highest ground surface elevation to the southwest of the existing One Corporate Drive building at test pit HA21-TP11 down to the bottom of the existing slope at the location of test pit HA21-TP8. Refer to the attached DRAFT Figure 1 for the locations of the test pits. DRAFT test pit logs are attached for reference.

Soil Conditions

Generally, the subsurface explorations encountered fill above Glacial Deposits as described below:

- Fill: A layer of heterogeneous fill material was encountered at each test pit location ranging from about 1.5 to 7.5 ft in thickness. In paved areas of the site, a 0.3- to 0.4-ft thick layer of asphalt pavement was encountered above the fill. The fill generally consisted of SAND with varying amounts of silt, gravel and cobbles or SILT with varying amounts of sand, gravel, cobbles and boulders. Deleterious materials, including roots, wood, organic soils, and scrap building materials, were encountered within the fill. At test pit locations HA21-TP2 through HA21-TP5, HA21-TP7, HA21-TP11 and HA21-TP13, remnant topsoil and subsoil were observed at the bottom of the fill layer and above the naturally deposited Glacial Deposits.
- Glacial Deposits: Glacial Deposits were encountered beneath the fill at each test pit location at depths ranging from approximately 1.5 to 7.5 ft bgs, corresponding to about El. 159.2 to El. 139.1. The Glacial Deposits were described as either Glacial Till or Glacial Outwash and generally consisted of silty SAND with varying amounts of gravel, cobbles and boulders.

Groundwater Conditions

Groundwater levels observed during excavation of the recent test pit explorations ranged from approximately 7.4 to 11.0 ft bgs, corresponding to about El. 153.2 to El. 134.1, and were determined by observing seepage into the test pit excavations. The estimated seasonal high groundwater table was observed to range from about 5.5 to 10.0 ft bgs, corresponding to El. 154.9 to El. 136.0, based on redoximorphic features observed within the test pits. The bottom of proposed infiltration systems should be set a minimum of 2 ft above seasonal high groundwater.

Infiltration Considerations

Haley & Aldrich conducted in-situ hydraulic conductivity testing using a Guelph Permeameter in accordance with standard testing methods specified in ASTM D5126 at three test pits (HA21-TP2, HA21-TP7 and HA21-TP11) located in areas of proposed stormwater systems. The Guelph Permeameter is an in-hole constant-head permeameter which operates on the Mariotte siphon principle. The method involves measuring the steady-state rate of water recharge into unsaturated soil from a cylinder hole in which a constant depth or head of water is maintained. The rate of this constant outflow of water, together with the diameter of the hole, can be used to determine the field saturated hydraulic

1 Elevations are in feet and reference the National Geodetic Vertical Datum of 1929 (NGVD 29).

conductivity of the soil. The Guelph Permeameter was installed in the test pits to measure the in-situ hydraulic conductivity at the depths and elevations indicated below. DRAFT Guelph Permeameter calculations are attached for reference. The results are as follows:

- HA21-TP2, 4.7 to 5.2 ft (El. 147.6 to El. 147.1): Infiltration Rate = 1.4×10^{-3} centimeters per second (cm/s) (2.0 in/hr)
- HA21-TP7, 3.5 to 4 ft (El. 150.3 to El. 149.8): Infiltration Rate = 3.0×10^{-4} cm/s (0.43 in/hr)
- HA21-TP11, 4.3 to 4.8 ft (El. 157.4 to El. 156.9): Infiltration Rate = 7.6×10^{-4} cm/s (1.1 in/hr)

For application in the design of the proposed stormwater infiltration systems, a factor of safety of 2 should be applied to the field-measured hydraulic conductivity results. Based on these results, the Glacial Deposits are in Hydrologic Soil Group B.

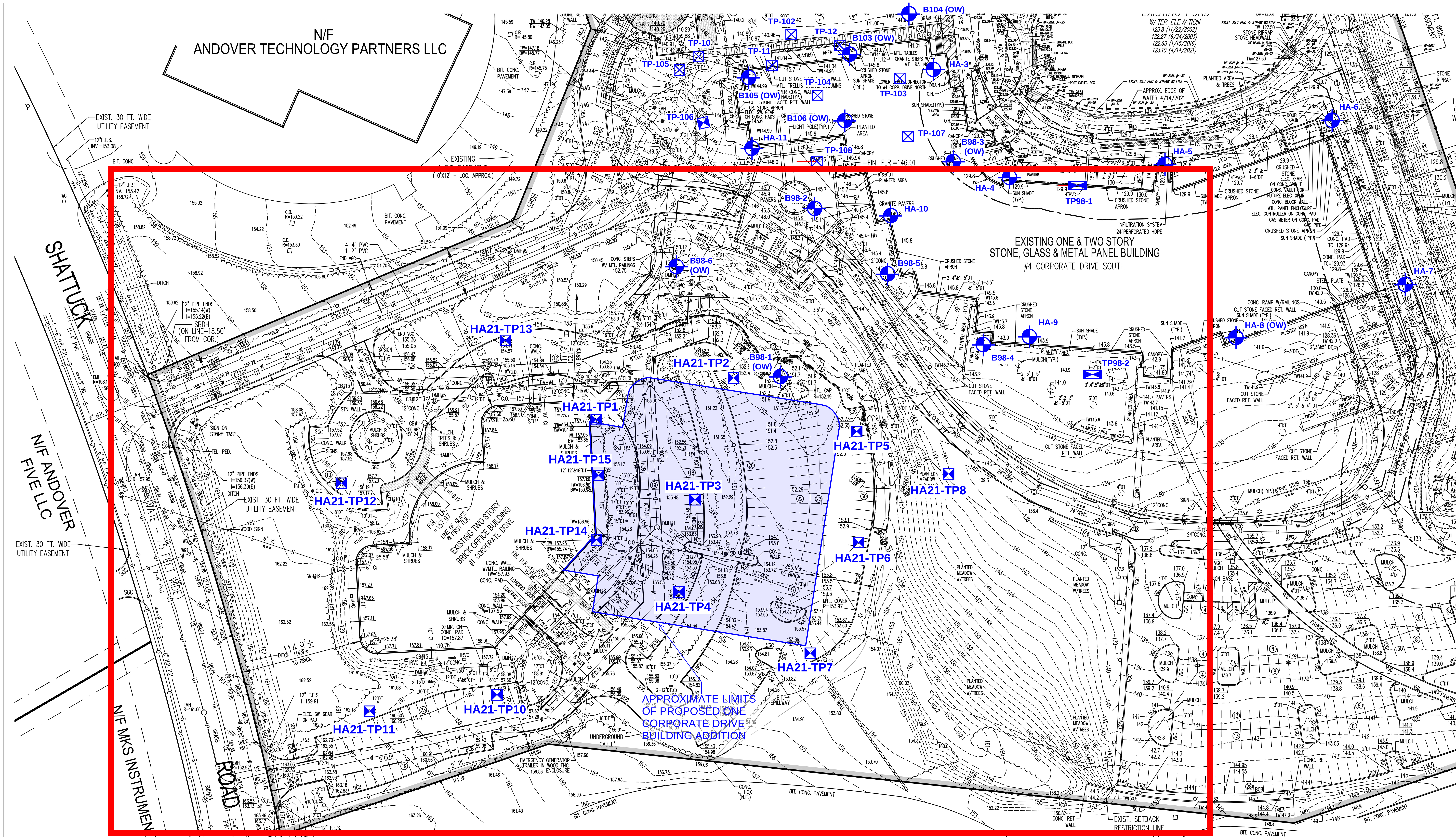
Additionally, at the request of Linden Engineering and in accordance with Town of Andover stormwater regulations, Haley & Aldrich provided a Soil Evaluator to observe test pits conducted at potential locations of stormwater infiltration systems including HA21-TP2, HA21-TP5, HA21-TP6, HA21-TP7, HA21-TP8, HA21-TP11 and HA21-TP12. The Soil Evaluator prepared Form 11 – Soil Suitability Assessments for these test pit locations. DRAFT forms are attached for reference and include United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soil classifications and estimated seasonal high groundwater table observations, among other details.

Attachments:

DRAFT Figure 1 – Site and Subsurface Exploration Location Plan
DRAFT Test Pit Logs
DRAFT Guelph Permeameter Calculations
DRAFT Form 11 – Soil Suitability Assessments

\\haleyaldrich.com\share\CF\Projects\0203691\Transmittals\Infiltration\2021-1206-HAI-One Corporate-Infiltration Memo-D4.docx

DRAFT FIGURE



NOTES

1. BASE PLAN OBTAINED FROM DRAWING TITLED "SV-1 SITE SURVEY", PREPARED BY LINDEN ENGINEERING AND DATED 1 OCTOBER 2021

2. ELEVATIONS ARE IN FEET AND REFERENCE THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29).

4. TECHNICAL MONITORING OF THE TEST PITS AND TEST BORINGS WAS PERFORMED BY HALEY & ALDRICH, INC.; THE LOCATIONS OF THE EXPLORATIONS IN 2021 WERE ESTIMATED BY TAPING TO EXISTING SITE FEATURES IN THE FIELD AND SHOULD BE CONSIDERED APPROXIMATE.

5. FOR ADDITIONAL INFORMATION ON CONDITIONS ENCOUNTERED IN TEST PITS, REFER TO ANNOTATED PHOTOS INCLUDED IN APPENDIX D.

LEGEND

B-1	DESIGNATION AND APPROXIMATE LOCATION OF HISTORICAL TEST BORING EXPLORATIONS BETWEEN 1988 AND 2003 AND OBSERVED BY HALEY & ALDRICH, INC.
TP1	DESIGNATION AND APPROXIMATE LOCATION OF TEST PIT EXCAVATED BY J. MARCHESE & SONS, INC. IN 1987 OR CROSSROADS CONSTRUCTION, INC. IN 1988 AND OBSERVED BY HALEY & ALDRICH, INC.
TP98-1	DESIGNATION AND APPROXIMATE LOCATION OF TEST PIT EXCAVATED BY NEW HAMPSHIRE BORING ON 7 MAY 1998 AND OBSERVED BY HALEY & ALDRICH, INC.
HA21-TP1	DESIGNATION AND APPROXIMATE LOCATION OF TEST PIT EXCAVATED BY EARTHWORK INDUSTRIES, INC. BETWEEN 10 AND 16 NOVEMBER 2021 AND OBSERVED BY HALEY & ALDRICH, INC.
(OW)	INDICATES GROUNDWATER OBSERVATION WELL INSTALLED IN COMPLETED BOREHOLE

HALEY ALDRICH
ONE CORPORATE DRIVE
ANDOVER, MASSACHUSETTS

DRAFT SITE AND SUBSURFACE EXPLORATION LOCATION PLAN

SCALE: AS SHOWN
DECEMBER 2021

FIGURE 1

IQHQ Giving progress a home

ONE CORPORATE DRIVE
ANDOVER, MA 01810

Ellenzweig Architecture | Planning	230 Congress Street Boston MA 02110 T 617 491-5575
EBI Consulting Owner Project Manager	21B Street Burlington, MA 01803 T 781 273-2500
McNamara Salvia Structural Engineer	101 Federal Street Boston, MA 02110 T 617 737-0040
Hallam-ICS HVAC, FP, Plumbing & Process/ GMP Consulting Engineers	525 West Street, Suite 220 Mansfield, MA 02048 T 508 821-9759
Hastings Consulting Building Fire & Access Code Consultant	142 Hanlon Street Holliston, MA 01746 T 508 397-8417
Linden Engineering Site/ Civil & Parking Engineer	15 Linden Street Woburn, MA 01801 T 781 933-3711
Copley Wolff Design Group Landscape Architect	10 Post Office Square, Suite 1315 Boston, MA 02109 T 617 654-9000
Haley-Aldrich Geotechnical Engineer	465 Medford Street, Suite 2200 Boston, MA 02129 T 617 886-7400
Goulston & Storrs Zoning & Permitting	400 Atlantic Avenue Boston, MA 02110 T 617 482-1776
The Green Engineer Sustainability Consultant	23 Bradford Street Concord, MA 01742 T 978 369-8978
The Friday Group Specifications Consultant	88 Mainelli Road Middlebury, VT 05753 T 802 369-8978

Notes:

Job Number 21055
Drawing By WAJ
Checked By WAJ/RGC
Date 01 October, 2021

Revisions

No.	Date	Description

Sheet Name

Site
Survey

Schematic Design
Scale: 1" = 40'-0"

SV-1

DRAFT Test Pit Logs

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP1

Project ONE CORPORATE DRIVE
Location ANDOVER, MA
Client IQHQ-One Corporate LLC
Contractor EARTHWORK INDUSTRIES, INC.
Equipment Used RUBBER TRACKED EXCAVATOR

File No. 0203691-000
H&A Rep M. Dodson
Date 12 Nov 2021
Weather

Ground El.: 157.9
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Toughness	Plasticity	Strength
0			ML	Dark brown sandy SILT (ML), no structure, no odor, moist, 15% of cobbles and roots, trace scrap building materials, trace oversized, mps 2 ft - LOAMY FILL -	5	5	5	10	25	50				
2		154.9 3.0												
4			SP	Yellow poorly-graded SAND (SP), no structure, no odor, moist - FILL -	5	5	10	50	25	5				
6		150.4 7.5												
8			SM	Gray-brown to tan silty SAND with gravel (SM), no structure, no odor, till becomes less gray brown and more tan with depth, possible remnant topsoil at stratum change, cuttings indicate possible leaching coloration on upper foot of till from removed topsoil above - GLACIAL TILL -	10	10	5	15	35	25				
		149.1 8.8		BOTTOM OF EXPLORATION 8.8 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 8.8

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HA TESTPIT-09 PLOG-HA-LIB09-BOS STANDARD ONLY.GLB HA-TP07-1.GDT \\HALEYALDRICH.COM\SHARE\CF\PROJECTS\0203691\GINT\0203691-000-TP.GPJ Dec 1, 21

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP2

Project ONE CORPORATE DRIVE
Location ANDOVER, MA
Client IQHQ-One Corporate LLC
Contractor EARTHWORK INDUSTRIES, INC.
Equipment Used RUBBER TRACKED EXCAVATOR

File No. 0203691-000
H&A Rep M. Dodson
Date 11 Nov 2021
Weather

Ground El.: 152.3
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0		151.9 / 0.4		-ASPHALT-										
			SP	Yellow poorly-graded SAND (SP), no structure, no odor, moist - FILL -	5	5	15	35	35	5				
2		150.6 / 1.7	SM	Light-brown to brown silty SAND (SM), no structure, no odor, moist, 10% pockets of dark brown organic soil, Mix of remnant topsoil, subsoil and fill above - FILL - PID = 0.0/0.0 ppm	5	5	10	25	35	20				
4 6 8		148.5 / 3.8	SM	Light-brown to tan silty SAND with gravel (SM), bonded, no odor, moist to wet, 5% cobbles, no oversized, slightly to occasionally moderately bonded, becomes more tan and slightly more silty/bonded with depth - GLACIAL TILL - PID = 0.0/0.0 ppm	5	10	10	10	45	20				
10		142.3 / 10.0		BOTTOM OF EXPLORATION 10.0 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 10.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP3

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	11 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 153.1
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0				-ASPHALT-										
		152.8 0.3	SP	Yellow-brown poorly-graded SAND (SP), no structure, no odor, moist - FILL -	5	5	10	35	40	5				
1														
2		151.3 1.8	SM	Yellow-brown to brown silty SAND (SM), no structure, no odor, moist, trace oversized, mps 1.2 ft, appears to be remnant subsoil, trace topsoil in pockets, disturbed with fill above - FILL -	5	5	5	20	45	20				
3		150.2 2.9	SM	Tan to olive-brown silty SAND (SM), trace cobbles, no oversized - GLACIAL TILL -	5	5	15	25	30	20				
4														
5														
		147.6 5.5		BOTTOM OF EXPLORATION 5.5 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)
Pit Depth (ft) 5.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP4

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	10 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 154.3 **El. Datum:**	**Location:**	**Groundwater depths/entry rates (in./min.):**

Depth (ft)	Sample ID	Stratum Change Elev./Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0		153.9 0.4		-ASPHALT-										
		153.3 1.0	SP	Yellow-brown poorly-graded SAND with gravel (SP), no structure, no odor, moist, no oversized	5	10	10	40	30	5				
				- FILL -	5	5	5	20	45	20				
		152.6 1.7	SM	Brown to gray-brown silty SAND (SM), no oversized, mps 3 in. - FILL -		5	5	10	40	40				
2		151.8 2.5	SM	Black to brown silty SAND (SM), Appears disturbed, remnant topsoil and subsoil, some subsoil may be undisturbed - FORMER TOPSOIL - PID = 0.0/0.0 ppm	5	5	15	15	40	20				
4–10			SM	Light-brown to tan silty SAND (SM), bonded, no odor, moist to moist, slight mottling below 5.5 ft, highest seepage 7.4 - GLACIAL TILL - PID = 0.0/0.0 ppm										
		143.8 10.5		BOTTOM OF EXPLORATION 10.5 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth ft

measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)

Pit Depth (ft) 10.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP5

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	10 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 152.4
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0		152.1 / 0.3		-ASPHALT-										
			SP	Yellow poorly-graded SAND (SP), no structure, no odor, moist - FILL -	5	5	15	45	30					
2		149.5 / 2.9	OL/OH	Black sandy ORGANIC SOIL (OL/OH), no structure, organic odor, moist, 10% roots - FORMER TOPSOIL -			5	5	30	60				
4		148.4 / 4.0	SM	Brown silty SAND (SM), no structure, no odor, moist, fines slightly organic - SUBSOIL -				10	50	40				
6, 8, 10		147.4 / 5.0	SM	Silty SAND with gravel (SM), bonded, 5% oversized, very slightly to unbonded, mottling, more silty below ~ 10.0 ft, possibly stratified or bedded - GLACIAL TILL -	5	10	5	20	45	15				
		141.1 / 11.3		BOTTOM OF EXPLORATION 11.6 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy R - Rapid S - Slow N - None
Toughness L - Low M - Medium H - High
Plasticity N - Nonplastic L - Low M - Medium H - High
Dry Strength N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 11.6

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP6

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	10 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 153.0
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Toughness	Plasticity	Strength
0				-ASPHALT-										
		152.7 0.3	SP	Yellow poorly-graded SAND (SP), no structure, no odor, no oversized - FILL -	5	5	10	45	30	5				
2		150.7 2.3	SM	PID = 0.0/0.0 ppm Black to gray-brown silty SAND with gravel (SM), no structure, no odor, trace wood debris - FILL -	10	10	10	15	35	20				
		150.3 2.7	SM	Dark brown to red-yellow silty SAND (SM), no structure, no odor, disturbed, higher fines % and organic content towards top, variable thickness - FILL -	5	5	10	20	35	25				
4		149.0 4.0	SM	Tan to light-brown silty SAND (SM), bonded, no odor, moist to wet, 5% oversized, mps 2.5 ft, slight red yellow oxidation below 7.5 ft, trace clayey pockets PID = 0.0/0.0 ppm PID = 0.0/0.0 ppm	10	5	5	20	40	20				
6														
8														
10		143.0 10.0		BOTTOM OF EXPLORATION 10.0 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 10.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP7

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	10 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 153.8
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Toughness	Plasticity	Strength
0				-ASPHALT-										
		153.5 0.3	SP	Yellow-brown to light-brown poorly-graded SAND (SP), layer, no odor, moist, no oversized -FILL-	5	5	10	45	30	5				
2		152.3 1.5	SM	Dark brown brown silty SAND (SM), no structure, no odor, moist, former topsoil and subsoil, partially excavated, disturbed, fines moderately organic - FORMER TOPSOIL - PID = 0.0/0.0 ppm		5	5	10	50	30				
4, 6, 8		151.6 2.2	SM	Tan to light-brown silty SAND (SM), bonded, no odor, moist, 10% oversized, mps 3 ft, boulder remained in sidewall at 8 ft, slightly to unbonded, moist to nearly wet below ~8 ft - GLACIAL TILL - PID = 0.0/0.0 ppm										
10		144.8 9.0	SM	Tan to olive-brown silty SAND with gravel (SM), no structure, no odor, moist to wet, trace oversized, mps 1.0 ft, lodgement till - GLACIAL TILL - PID = 0.0/0.0 ppm	5	10	5	10	35	35				
		142.3 11.5		BOTTOM OF EXPLORATION 11.5 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 11.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP8

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	11 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 141.5 **El. Datum:**	**Location:**	**Groundwater depths/entry rates (in./min.):**

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0			OL/OH	Black to dark brown sandy ORGANIC SOIL (OL/OH), no structure, no odor, moist, trace oversized - LOAMY FILL -	5		5	10	25	55				
		140.4 1.1	GP-GM	Tan to gray poorly-graded GRAVEL with silt and sand (GP-GM), no structure, no odor, moist, 25% cobbles, trace boulders, 10% oversized - FILL - PID = 0.0/0.0 ppm	40	20	5	10	15	10				
2		139.1 2.4	SM	Tan silty SAND with gravel (SM), bonded, no odor, moist to wet, highest seepage 7.4 ft, little seepage - GLACIAL TILL - PID = 0.0/0.0 ppm	10	10	10	10	20	40				
4														
6														
8														
		132.5 9.0		BOTTOM OF EXPLORATION 9.0 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth ft

measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)

Pit Depth (ft) 9.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HA TESTPIT-09 PLOG-HA-LIB09-BOS STANDARD ONLY.GLB HA-TP07-1.GDT \\HALEYALDRICH.COM\SHARE\CF\PROJECTS\0203691\GINT\0203691-000-TP.GPJ Dec 1, 21

TEST PIT LOG

HALEY ALDRICH

DRAFT

Test Pit No. HA21-TP10

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	15 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 158.0
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Toughness	Plasticity	Strength
0		157.7		-ASPHALT-										
		0.3	SP	Yellow-brown to dark brown poorly-graded SAND (SP), layer, no odor, moist, no oversized, mps 6 in, remnant former topsoil in lenses, more prevalent - FILL - PID = 0.0/0.0 ppm	5	5	5	30	50	5				
2														
		155.2 2.8	SM	Tan to olive-gray silty SAND (SM), bonded, no odor, moist, 5% cobbles, mps 8 in - GLACIAL TILL - PID = 0.0/0.0 ppm	5	5	5	15	40	30				
4														
6														
8														
		149.5 8.5	ML	Olive-brown to olive-gray sandy SILT (ML), bed, no odor, wet, bedded stratified horizontal but uneven and slightly folded				5	35	60				
10			SM	Olive-brown silty SAND with gravel (SM), bonded, no odor, wet - GLACIAL TILL - PID = 0.0/0.0 ppm	10	10	10	15	25	30				
		147.0 11.0		BOTTOM OF EXPLORATION 11.0 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)
Pit Depth (ft) 11.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP11

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	15 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 161.7
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0			ML	SILT with sand (ML), no structure, organic odor, moist, fines moderately organic - LOAMY FILL -										
		160.7 1.0	ML	Yellow-brown sandy SILT (ML), no structure, no odor, moist - SUBSOIL - PID = 0.0/0.0 ppm										
2		159.2 2.5	SM	Tan silty SAND with gravel (SM), bonded, no odor, moist to wet, trace oversized, mps 2.0 ft, wet below 8.5 ft PID = 0.0/0.0 ppm	5	5	5	10	45	30				
4														
6														
8														
		151.9 9.8		BOTTOM OF EXPLORATION 9.8 FT PID = 0.0/0.0 ppm										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)
Pit Depth (ft) 9.8

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP12

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	15 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 158.3
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0			SP	Yellow-brown poorly-graded SAND with gravel (SP), no structure, no odor, moist, no oversized, mps 8 in. - FILL -	5	5	5	30	50	5				
		156.8 1.5	SM	Tan silty SAND with gravel (SM), bonded PID = 0.0/0.0 ppm	10	5	10	15	35	25				
2														
4														
6														
8			SM	Yellow-brown to olive-brown silty SAND with gravel (SM), bonded, no odor, moist to wet, 10% cobbles, no oversized, moist to wet below highest seepage at 10.0 ft, lodgement till - GLACIAL TILL - PID = 0.0/0.0 ppm	15	10	10	10	20	35				
10		147.8 10.5		BOTTOM OF EXPLORATION 10.5 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)
Pit Depth (ft) 10.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP13

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	11 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 154.5
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0		154.2		-ASPHALT-										
		0.3	SP	Yellow poorly-graded SAND with gravel (SP), no structure, no odor, wet, 5% cobbles, trace oversized mps 2.5 ft from bottom of fill - FILL - PID = 0.0/0.0 ppm	10	5	10	45	25	5				
2														
4		150.1 4.4	SM	Yellow-brown to brown silty SAND with gravel (SM), no structure, no odor, moist, mix of remnant topsoil, subsoil and fill from above	10	10	10	30	25	15				
		149.0 5.5	SM	Light-brown to tan silty SAND with gravel (SM), bonded, no odor, moist to wet, becomes more tan/light gray with depth, mottling below est. 8.5 ft - GLACIAL TILL - PID = 0.0/0.0 ppm	10	5	10	20	30	25				
6														
8														
10														
		143.0 11.5		BOTTOM OF EXPLORATION 11.5 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 11.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP14

Project	**ONE CORPORATE DRIVE**	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	12 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 157.9
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0				Dark brown sandy SILT (ML), no structure, organic odor, moist, 15% roots, trace scrap building materials - LOAMY FILL -	5	5	10	10	20	50				
1			ML											
2		155.9 2.0		Yellow poorly-graded SAND (SP), no structure, no odor, moist - FILL - PID = 0.0/0.0 ppm	5	5	5	50	30	5				
3														
4			SP	PID = 0.0/0.0 ppm										
5														
6		151.9 6.0		BOTTOM OF EXPLORATION 6.0 FT PID = 0.0/0.0 ppm										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)

Pit Length x Width (ft)
Pit Depth (ft) 6.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

DRAFT

Test Pit No. HA21-TP15

Project	ONE CORPORATE DRIVE	**File No.**	0203691-000
Location	ANDOVER, MA	**H&A Rep**	M. Dodson
Client	IQHQ-One Corporate LLC	**Date**	16 Nov 2021
Contractor	EARTHWORK INDUSTRIES, INC.	**Weather**	
Equipment Used	RUBBER TRACKED EXCAVATOR		

Ground El.: 157.9
El. Datum:
Location:
Groundwater depths/entry rates (in./min.):

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0			ML	Dark brown sandy SILT (ML), trace building material debris, No oversized, fines moderately organic - LOAMY FILL - PID = 0.0/0.0 ppm										
2		155.4 2.5	SP	Yellow-brown poorly-graded SAND (SP) - FILL - PID = 0.0/0.0 ppm	5	5	15	30	40	5				
4														
6		151.6 6.3	SM	Tan to light-brown silty SAND (SM), no structure, no odor, moist - GLACIAL TILL - PID = 0.0/0.0 ppm	5	5	5	15	40	30				
8		149.9 8.0		BOTTOM OF EXPLORATION 8.0 FT										

Obstructions:

Remarks:

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit
at depth ft
measured after hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24		=
over 24		=

Test Pit Dimensions (ft)
Pit Length x Width (ft)
Pit Depth (ft) 8.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

DRAFT Guelph Permeameter Calculations

Guelph Permeameter Calculations

Input (green) — Result (yellow)

Single Head Method (1)

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16
Enter water Head Height ("H" in cm): 5
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 12.0000

Res Type	2.16
H	5
a	3
H/a	1.667
a*	0.12
C0.01	0.809
C0.04	0.842
C0.12	0.803
C0.36	0.803
C	0.803
R	#####
Q	0.432
pi	3.142

α*= 0.12 cm^{-1}

C = 0.803154
Q = 0.432

K_{fs} = 7.86E-04 cm/sec
4.71E-02 cm/min
7.86E-06 m/sec
1.86E-02 inch/min
3.09E-04 inch/sec

Φ_m = 6.55E-03 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 24.0000

Res Type	2.16
H	10
a	3
H/a	3.33333
a*	0.12
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.28754
R	24.000
Q	0.864
pi	3.1415

α*= 0.12 cm^{-1}

C = 1.287543
Q = 0.864

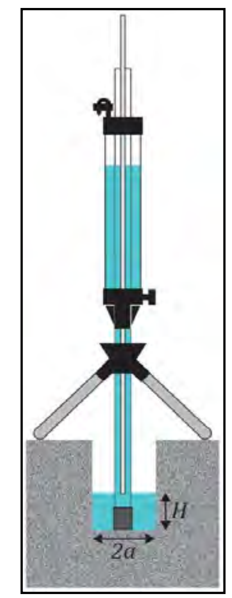
K_{fs} = 9.36E-04 cm/sec
5.62E-02 cm/min
9.36E-06 m/ses
2.21E-02 inch/min
3.69E-04 inch/sec

Φ_m = 7.80E-03 cm^2/min

Average

K_{fs} = 8.61E-04 cm/sec
5.17E-02 cm/min
8.61E-06 m/s
2.03E-02 inch/min
3.39E-04 inch/sec

Φ_m = 7.17E-03 cm^2/min



Double Head Method

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16

Enter the first water Head Height ("H1" in cm): 5
Enter the second water Head Height ("H2" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α*= 0.12 cm^{-1}

α= 0.4292

Steady State Rate of Water Level Change ("R1" in cm/min): 12.0000
Steady State Rate of Water Level Change ("R2" in cm/min): 24.0000

Q_1 = 0.432

Q_2 = 0.864

Res Type:	2.16
H1/a:	1.666667
H2/a:	3.333333
C1-0.01:	0.809485
C2-0.01:	1.21841
C1-0.04:	0.842059
C2-0.04:	1.290234
C1-0.12:	0.803154
C2-0.12:	1.287543
C1-0.36:	0.803154
C2-0.36:	1.287543
G-Denominator:	1525.687

C_1 = 0.803154257

C_2 = 1.287542759

G_1 = 0.005264214

G_2 = 0.004219551

G_3 = 0.055692198

G_4 = 0.024147811

K_{fs} = 1.37E-03 cm/sec
8.23E-02 cm/min
1.37E-05 m/sec
3.24E-02 inch/min
5.40E-04 inch/sec

Φ_m = 3.20E-03 cm^2/min

Θ_{fs} = 0.65 cm^3/cm^3
Θ_i = 0.4 cm^3/cm^3

Sorptivity = 0.0400 ($cm\ min^{-½}$)
Single Head Average Sorptivity = 0.0599 ($cm\ min^{-½}$)

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

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121(H_2/a)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

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

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	$\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	$G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$

Guelph Permeameter Calculations

Input (green) · Result (yellow)

Single Head Method (1)

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): **2.16**
Enter water Head Height ("H" in cm): **5**
Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **3**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **3.0000**

Res Type	2.16
H	5
a	3
H/a	1.667
a*	0.12
C0.01	0.809
C0.04	0.842
C0.12	0.803
C0.36	0.803
C	0.803
R	3.000
Q	0.108
pi	3.142

α^* = **0.12** cm^{-1}

C = 0.803154
Q = 0.108

K_{fs} = **1.96E-04** cm/sec
1.18E-02 cm/min
1.96E-06 m/sec
4.64E-03 inch/min
7.73E-05 inch/sec

Φ_m = **1.64E-03** cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): **2.16**
Enter water Head Height ("H" in cm): **15**
Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **3**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **9.0000**

Res Type	2.16
H	15
a	3
H/a	5
a*	0.12
C0.01	1.51827
C0.04	1.62914
C0.12	1.66689
C0.36	1.66689
C	1.66689
R	9.000
Q	0.324
pi	3.1415

α^* = **0.12** cm^{-1}

C = 1.666893
Q = 0.324

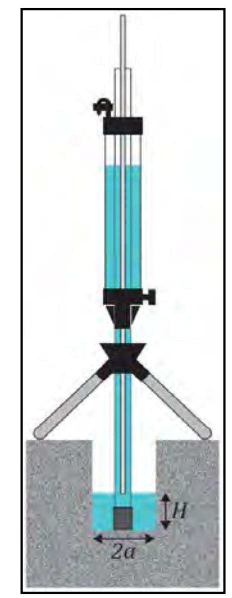
K_{fs} = **2.40E-04** cm/sec
1.44E-02 cm/min
2.40E-06 m/ses
5.68E-03 inch/min
9.47E-05 inch/sec

Φ_m = **2.00E-03** cm^2/min

Average

K_{fs} = **2.18E-04** cm/sec
1.31E-02 cm/min
2.18E-06 m/s
5.16E-03 inch/min
8.60E-05 inch/sec

Φ_m = **1.82E-03** cm^2/min



Double Head Method

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): **2.16**

Enter the first water Head Height ("H1" in cm): **5**
Enter the second water Head Height ("H2" in cm): **15**

Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **3**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α^* = **0.12** cm^{-1}

α = **0.2969**

Steady State Rate of Water Level Change ("R1" in cm/min): **3.0000**
Steady State Rate of Water Level Change ("R2" in cm/min): **9.0000**

Q_1 = 0.108

Q_2 = 0.324

Res Type:	2.16
H1/a:	1.666667
H2/a:	5
C1-0.01:	0.809485
C2-0.01:	1.518269
C1-0.04:	0.842059
C2-0.04:	1.629144
C1-0.12:	0.803154
C2-0.12:	1.666893
C1-0.36:	0.803154
C2-0.36:	1.666893
G-Denominator:	4607.275

C_1 = 0.803154257

C_2 = 1.666892939

G_1 = 0.002614846

G_2 = 0.001808979

G_3 = 0.04053029

G_4 = 0.010352497

K_{fs} = **3.04E-04** cm/sec
1.82E-02 cm/min
3.04E-06 m/sec
7.17E-03 inch/min
1.20E-04 inch/sec

Φ_m = **1.02E-03** cm^2/min

Θ_{fs} = **0.65** cm^3/cm^3
Θ_i = **0.4** cm^3/cm^3

Sorptivity = **0.0226** (cm min$^{-½}$)
Single Head Average Sorptivity = **0.0302** (cm min$^{-½}$)

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

Soil Texture-Structure Category	α^*(cm^{-1})	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121(H_2/a)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

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

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi\left(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1)\right)}$ $G_2 = \frac{H_1 C_2}{\pi\left(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1)\right)}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi\left(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1)\right)}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi\left(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1)\right)}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

SOILMOISTURE® Guelph Permeameter Calculations

Input (green)
Result (yellow)

Single Head Method (1)

Reservoir Cross-sectional area in cm²
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16
Enter water Head Height ("H" in cm): 5
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 8.0000

Res Type	2.16
H	5
a	3
H/a	1.667
a*	0.12
C0.01	0.809
C0.04	0.842
C0.12	0.803
C0.36	0.803
C	0.803
R	8.000
Q	0.288
pi	3.142

α^* = 0.12 cm^{-1}

C = 0.803154

Q = 0.288

K_{fs} = 5.24E-04 cm/sec
3.14E-02 cm/min
5.24E-06 m/sec
1.24E-02 inch/min
2.06E-04 inch/sec

Φ_m = 4.37E-03 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm²
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 15.0000

Res Type	2.16
H	10
a	3
H/a	3.33333
a*	0.12
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.28754
R	15.000
Q	0.54
pi	3.1415

α^* = 0.12 cm^{-1}

C = 1.287543

Q = 0.54

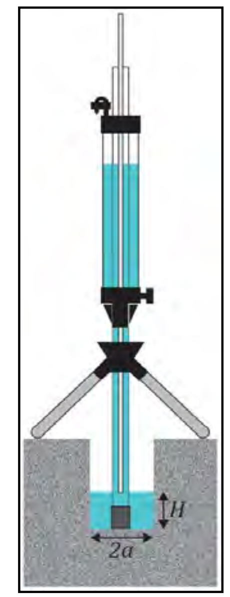
K_{fs} = 5.85E-04 cm/sec
3.51E-02 cm/min
5.85E-06 m/ses
1.38E-02 inch/min
2.30E-04 inch/sec

Φ_m = 4.88E-03 cm^2/min

Average

K_{fs} = 5.54E-04 cm/sec
3.33E-02 cm/min
5.54E-06 m/s
1.31E-02 inch/min
2.18E-04 inch/sec

Φ_m = 4.62E-03 cm^2/min



Double Head Method

Reservoir Cross-sectional area in cm²
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16

Enter the first water Head Height ("H1" in cm): 5
Enter the second water Head Height ("H2" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α^* = 0.12 cm^{-1}

α = 0.2542

Steady State Rate of Water Level Change ("R1" in cm/min): 8.0000
Steady State Rate of Water Level Change ("R2" in cm/min): 15.0000

Q_1 = 0.288

Q_2 = 0.54

Res Type:	2.16
H1/a:	1.666667
H2/a:	3.333333
C1-0.01:	0.809485
C2-0.01:	1.21841
C1-0.04:	0.842059
C2-0.04:	1.290234
C1-0.12:	0.803154
C2-0.12:	1.287543
C1-0.36:	0.803154
C2-0.36:	1.287543
G-Denominator:	1525.687

C_1 = 0.803154257

C_2 = 1.287542759

G_1 = 0.005264214

G_2 = 0.004219551

G_3 = 0.055692198

G_4 = 0.024147811

K_{fs} = 7.62E-04 cm/sec
4.57E-02 cm/min
7.62E-06 m/sec
1.80E-02 inch/min
3.00E-04 inch/sec

Φ_m = 3.00E-03 cm^2/min

Θ_{fs} = 0.65 cm^3/cm^3

Θ_i = 0.4 cm^3/cm^3

Sorptivity = 0.0387 $(cm\ min^{-1/2})$

Single Head Average Sorptivity = 0.0481 $(cm\ min^{-1/2})$

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

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121(H_2/a)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

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

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	$\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	$G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$

DRAFT Form 11 – Soil Suitability Assessments

HA21-TP2 11/11/2021

Commonwealth of Massachusetts
City/Town of

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

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

Deep Observation Hole Number: HA21-TP2 (Hole #) 11/11/2021 (Date) 1045 (Time) Sunny 40s (Weather) ____ (Latitude) ____ (Longitude:)

1. Land Use ____ (e.g., woodland, agricultural field, vacant lot, etc.) ____ Vegetation ____ Surface Stones (e.g., cobbles, stones, boulders, etc.) ____ Slope (%)

   Description of Location: ____

2. Soil Parent Material: Gl. Till   TILL Plateau (Landform)   ____ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ____ feet   Drainage Way ____ feet   Wetlands ____ feet

   Property Line ____ feet   Drinking Water Well ____ feet   Other ____ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No   If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No   If yes: ____ Depth Weeping from Pit   ____ Depth Standing Water in Hole

EL 152.5 HA21-TP2

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-5"	ASPHALT			—	—	—	—		-	—	
4"-1.7'	A/FILL	SAND	10YR 6/6 Brownish yellow							very friable	
1.7-3.8	B/FILL	Loam		—	—					friable	
3.8-10	C	Loamy SAND	Olive 5Y 5/3	8.5	Reddish Brn	10%				Single Grain/friable	

Additional Notes: Seepage @ 9.5' BOE 10 ft. ESHWT 8.5 ft

HA21-TP5

11/10/2021
1 CORPORATE DRIVE

Commonwealth of Massachusetts
City/Town of

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

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

Deep Observation Hole Number: HA21-TP5 (Hole #) 11/10/2021 (Date) 1030 (Time) ______ (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use ______ (e.g., woodland, agricultural field, vacant lot, etc.) ______ (Vegetation) ______ (Surface Stones (e.g., cobbles, stones, boulders, etc.)) ______ (Slope (%))

   Description of Location: ______

2. Soil Parent Material: Gl. Till / Outwash — 'Edge of Till Slope (Landform) ______ (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body ______ feet Drainage Way ______ feet Wetlands ______ feet
   Property Line ______ feet Drinking Water Well ______ feet Other ______ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No If yes: ______ Depth Weeping from Pit ______ Depth Standing Water in Hole

EL-152.4 HA21-TP5

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-4"	Asphalt			—	—	—	—		—	—	
4"-2.9	A/FILL	SAND	10YR 6/6 Brownish Yellow	—	—	—	—		—	—	
2.9'-4.0	A_b (Buried)	LOAM	Dk Brown							V. friable	
4-5	B_1 (Buried)	Loamy SAND	10 YR 4/3 Brown	—					Granular/weak	friable	
5-11.0	C_1	Loamy SAND	Light Brownish Gray 2.5Y 6/2	10'	Yellowish Red 5YR5/6	10%	5%	<10%	weak/Platy	friable	
11.0-11.6	C_2	SILT LOAM	Appears to be Interbedded w/ SILT LOAM @ 11.0+/-			20%			—		

Additional Notes: Appears to be GL. Till / OUTWASH - Ablation Till; Total depth 11.6 11.4 standing water
Seepage @ 11.0 ESHWT @ 10'

11/10/2021

Commonwealth of Massachusetts
City/Town of

HA21 - TP6

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

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

Deep Observation Hole Number: HA21-TP6 (Hole #) 11/10/21 (Date) 0900 (Time) ______ (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use: ______ (e.g., woodland, agricultural field, vacant lot, etc.) ______ Vegetation ______ Surface Stones (e.g., cobbles, stones, boulders, etc.) ______ Slope (%)

   Description of Location: ______

2. Soil Parent Material: Gl. Till ______ Landform ______ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Wetlands ____ feet

   Property Line ____ feet Drinking Water Well ____ feet Other ____ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No If yes: ____ Depth Weeping from Pit ____ Depth Standing Water in Hole

HA21 - TP6 EL. 153.0

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-4	Asphalt		—	—							
4"-2.3'	A/FILL	SAND	10YR 6/6 Brownish Yello	—					Single Grain		
2.3'-2.7'	A/FILL	LOAMY SAND	7.5YR 4/4 Brown						weak	Friable	
2.7-3.2	A/B	SANDY LOAM	7.5YR 5/8 Strong Brn.						weak	v. friable	
3.2-3.9'	B	LOAMY SAND	7.5YR 4/4 Brown						weak	friable	
3.9-10'	C1	SILT LOAM AND LOAMY SAND	2.5Y 6/3 Light Yellowish Brn	7.5'	Yellowish Red 5YR 5/6	10%	15%	5%	massive	~~moist~~	
10-10.5	C2	SILT LOAM	2.5Y 5/3 Light olive Brn	10.0	5YR 5/6	30% and Light Gray 2.5Y 7.2					

Additional Notes: Seepage @ 9' Total Depth = 10.5'
ESHWT @ 7.5'

HA-21 - TP7
11/10/2021

Commonwealth of Massachusetts
City/Town of

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

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

Deep Observation Hole Number: TP7 (Hole #) ______ Date ______ Time ______ Weather ______ Latitude ______ Longitude:

1. Land Use ______ (e.g., woodland, agricultural field, vacant lot, etc.) ______ Vegetation ______ Surface Stones (e.g., cobbles, stones, boulders, etc.) ______ Slope (%)

   Description of Location: ______

2. Soil Parent Material: ______ Landform ______ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ______ feet Drainage Way ______ feet Wetlands ______ feet
   Property Line ______ feet Drinking Water Well ______ feet Other ______ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No If yes: ______ Depth Weeping from Pit ______ Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-4"	Parent										
4-1.5'	B/FILL	SAND	'						weak	v. friable	
1.5-2.2	B/FILL	LOAM/SANDY LOAM							weak	friable	
2.2-9	C_1	LOAM	Olive 5Y 5/4	6.5	Reddish Brn 5YR 4/4	10%			massive	"	
9-10.5	Cd	SILT LOAM	Olive brn 2.5Y 5/3	7.5	Reddish Brn and Gray	20%			Massive	"	

Additional Notes: Seepage @ 7.5 ft ESHWT @ 6.5'

Test @ 3.5-4.0

HA21 - TP8 11/11/2021 0915 - 1015 0203691 -000 One Corporate Drive, Andover, MA

Commonwealth of Massachusetts
City/Town of

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

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

Deep Observation Hole Number: HA21-TP8 (Hole #) 11/11 (Date) 10:00 (Time) Sunny (Weather) ____ (Latitude) ____ (Longitude:)

1. Land Use: Commercial Development (e.g., woodland, agricultural field, vacant lot, etc.) Field Edge (Vegetation) SOD (Surface Stones (e.g., cobbles, stones, boulders, etc.)) ~5% (Slope (%))

   Description of Location: Grass landscape edge of field slope

2. Soil Parent Material: GLACIAL TILL ____ (Landform) ____ (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Wetlands ____ feet

   Property Line ____ feet Drinking Water Well ____ feet Other 250 feet Catch Basin

4. Unsuitable Materials Present: ☐ Yes ☐ No If Yes: ☑ Disturbed Soil ☑ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☑ Yes ☐ No If yes: 7.4 Depth Weeping from Pit — Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-1'	A/Fill	Loam	Dk Brn 7.5 YR 3/3						weak	V-friable	
1-2.5	B/Fill	Loam	2.5Y 6/3 Light Yellowish Brn	—	—		—	10%	weak	Friable	
2.5-3.2	C1	Silt Loam	5Y 5/3 Olive	4.5	Reddish Yellow 7.5YR 6/8	<5%	20%	40%	Blocky		
3.2-9'	Cd	Silt Loam	5Y 5/3 Olive	5.5	5Y 7/3 Pale Yellow and 7.5YR 6/8 Reddish Yellow	15%	20%	10%	Blocky	Firm	

Additional Notes: Seepage @ 7.4' BOE 9.0ft

ESHWT @ 5.5 ft.

Commonwealth of Massachusetts
City/Town of

11/15/2021
HA21-TP11

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

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

Deep Observation Hole Number: TP11 (Hole #) 11/15/2021 (Date) ______ (Time) ______ (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use ______ (e.g., woodland, agricultural field, vacant lot, etc.) ______ Vegetation ______ Surface Stones (e.g., cobbles, stones, boulders, etc.) ______ Slope (%)

   Description of Location: ______

2. Soil Parent Material: ______ ______ Landform ______ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Wetlands ____ feet
   Property Line ____ feet Drinking Water Well ____ feet Other ____ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☐ Yes ☐ No If yes: ____ Depth Weeping from Pit ____ Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0 - 1 ft	A/Fill	Loam	Brown 10YR 4/3						weak	V friable	Root mat/Forest mat landscaped Area
1-3.0	B/Fill	Sandy Loam	Brownish Yellow 10YR 6/6						weak	v. friable	
3.0-6.0	C1	Loam	Light Yellowish Brown 2.5Y 6/3			<5%	5%		Platy	friable	
6.0-9.5	Cd	Loam/Loamy Sand	Light Yellowish Gray 2.5Y 6/2	6.8'	Reddish Brn and Gray	15%			Firm/massive	friable	
					5YR 4/4 / 5YR 6/1						

Additional Notes: Seepage @ 8.5 ESHWT @ 6.8' Test 4.3 - 4.8 w/ Guelph
Standing Water 9.3

Commonwealth of Massachusetts
City/Town of

11/15/2021
HA21-TP12

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

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

Deep Observation Hole Number: TP-12 (Hole #) ______ Date ______ Time ______ Weather ______ Latitude ______ Longitude:

1. Land Use ______ (e.g., woodland, agricultural field, vacant lot, etc.) ______ Vegetation ______ Surface Stones (e.g., cobbles, stones, boulders, etc.) ______ Slope (%)

   Description of Location: ______

2. Soil Parent Material: ______ ______ Landform ______ Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body ______ feet Drainage Way ______ feet Wetlands ______ feet

   Property Line ______ feet Drinking Water Well ______ feet Other ______ feet

4. Unsuitable Materials Present: ☐ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

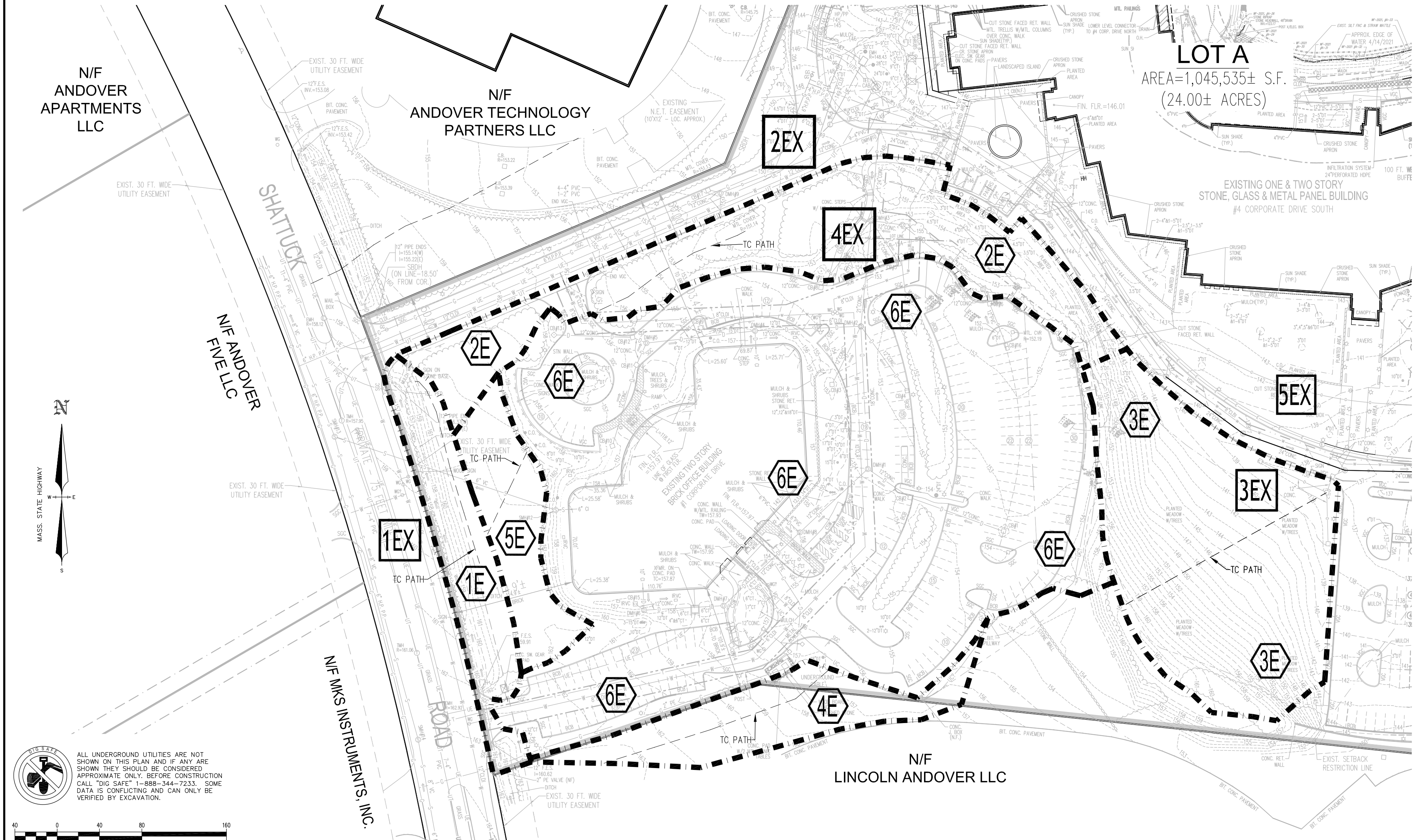
5. Groundwater Observed: ☐ Yes ☐ No If yes: ______ Depth Weeping from Pit ______ Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-5"	Asphalt								—	—	
5"-1.5	B/Fill	Sand	Yellowish Brn. 10YR 6/8						weak	v. friable	
1.5-8'	C1	Loam	Light Yellowish Brn. 2.5Y 6/4						Platy	friable	
8-10.5	Cd	Silt Loam	Olive 5Y 5/3	9.5	Reddish Brn 5YR 4/4	10%			Massive	friable	

Additional Notes: BOE 10.5' Seepage @ 10.0 ESHWT 9.5

EXISTING CONDITIONS
RUNOFF CALCULATIONS
(25 YEAR STORM PRINTOUT ONLY)



				CALC. BY:	WAJ
				DR. BY:	WAJ
				CKD. BY:	RGC/WAJ
				APPD. BY:	RGC
				JOB NO.:	21055
1/26/2022	RGC	⚠	ISSUED FOR PERMITTING	SCALE:	1" = 40'
DATE	BY	REV#	REVISIONS	DATE:	JAN. 26, 2022

RICHARD G. CUTTS
REG. PROF. ENGINEER

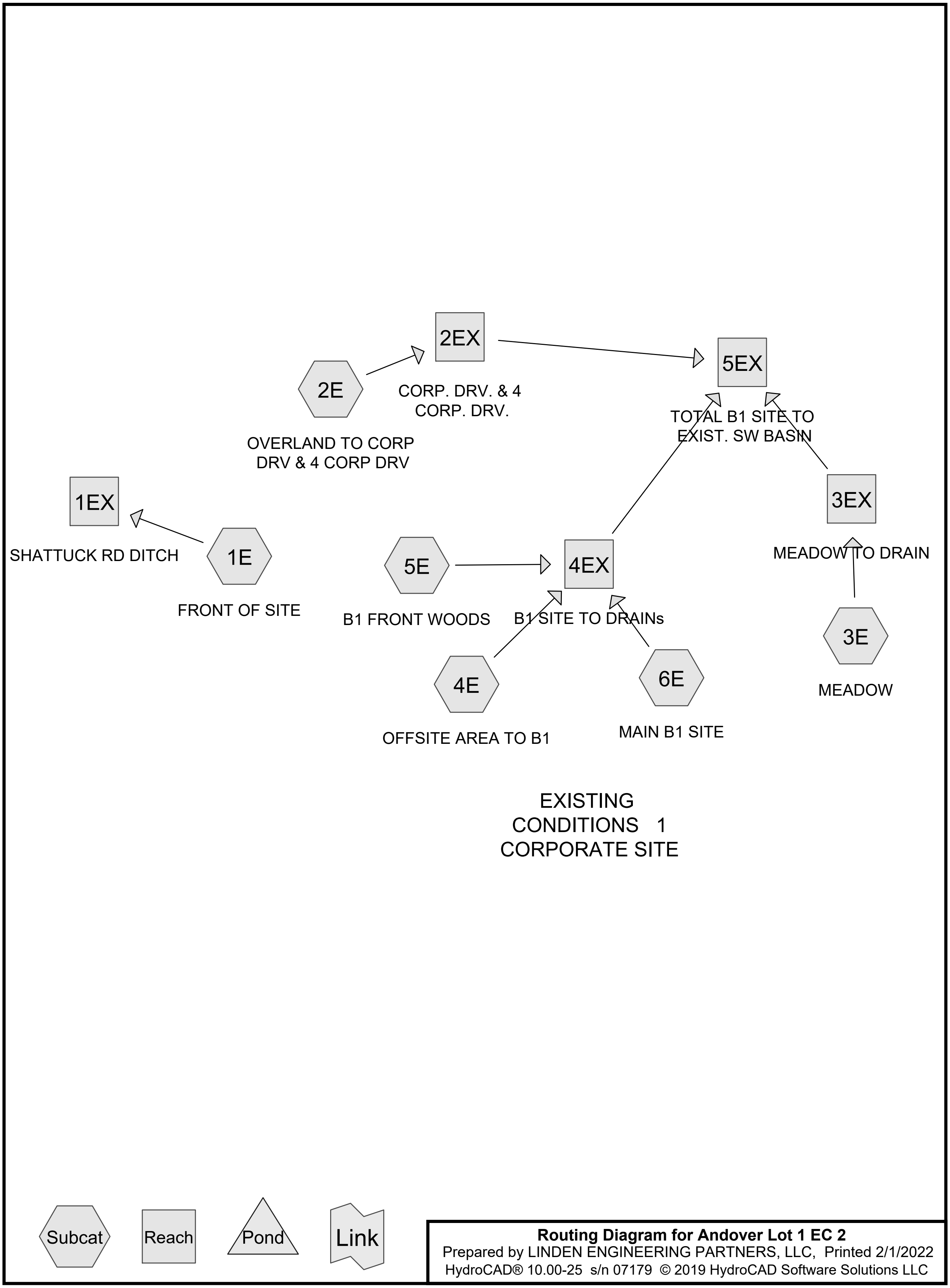
LINDEN ENGINEERING PARTNERS LLC
100 TradeCenter Suite G700
Woburn, MA 01801-1851
Tel: (781) 933-3711
Fax: (781) 287-1277

Civil - Environmental Engineering including Storm water, Wastewater, Water Supply, Highway & Infrastructure Design, Land Planning, Land Subdivision, Site Design, Environmental Permitting, Wetlands Permitting & Land Development Permitting

PREPARED FOR:
IQHQ-1 CORPORATE, LLC AND IQHQ-4 CORPORATE, LLC
ATTN: MR. WILLIAM ASHTON
ONE BOSTON PLACE, 201 WASHINGTON STREET, SUITE 3920
BOSTON, MASSACHUSETTS 02108
TEL: (617) 314-7951

EXISTING WATERSHED PLAN
PROPOSED RENOVATION AND ADDITION
ONE AND FOUR CORPORATE DRIVE
ANDOVER, MASSACHUSETTS

SHEET
WS-1



Routing Diagram for Andover Lot 1 EC 2
Prepared by LINDEN ENGINEERING PARTNERS, LLC, Printed 2/1/2022
HydroCAD® 10.00-25 s/n 07179 © 2019 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.750	74	>75% Grass cover, Good, HSG C (1E, 2E, 6E)
0.017	65	Brush, Good, HSG C (1E)
1.214	71	Meadow, non-grazed, HSG C (3E)
3.313	98	Paved parking, HSG C (1E, 2E, 6E)
1.571	70	Woods, Good, HSG C (1E, 2E, 3E, 4E, 5E, 6E)
7.865	**83**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
7.865	HSG C	1E, 2E, 3E, 4E, 5E, 6E
0.000	HSG D	
0.000	Other	
7.865		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	1.750	0.000	0.000	1.750	>75% Grass cover, Good	1E, 2E, 6E
0.000	0.000	0.017	0.000	0.000	0.017	Brush, Good	1E
0.000	0.000	1.214	0.000	0.000	1.214	Meadow, non-grazed	3E
0.000	0.000	3.313	0.000	0.000	3.313	Paved parking	1E, 2E, 6E
0.000	0.000	1.571	0.000	0.000	1.571	Woods, Good	1E, 2E, 3E, 4E, 5E, 6E
0.000	**0.000**	**7.865**	**0.000**	**0.000**	**7.865**	**TOTAL AREA**	

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1E: FRONT OF SITE Runoff Area=17,379 sf 3.61% Impervious Runoff Depth=3.01"
Flow Length=185' Tc=33.2 min CN=72 Runoff=0.76 cfs 0.100 af

Subcatchment 2E: OVERLAND TO CORP Runoff Area=45,130 sf 5.60% Impervious Runoff Depth=3.20"
Flow Length=305' Tc=14.9 min CN=74 Runoff=2.94 cfs 0.276 af

Subcatchment 3E: MEADOW Runoff Area=53,653 sf 0.00% Impervious Runoff Depth=2.91"
Flow Length=216' Tc=6.0 min CN=71 Runoff=4.12 cfs 0.299 af

Subcatchment 4E: OFFSITE AREA TO B1 Runoff Area=17,916 sf 0.00% Impervious Runoff Depth=2.82"
Flow Length=235' Slope=0.0300 '/' Tc=14.2 min CN=70 Runoff=1.04 cfs 0.097 af

Subcatchment 5E: B1 FRONT WOODS Runoff Area=13,858 sf 0.00% Impervious Runoff Depth=2.82"
Flow Length=87' Slope=0.0230 '/' Tc=12.6 min CN=70 Runoff=0.83 cfs 0.075 af

Subcatchment 6E: MAIN B1 SITE Runoff Area=194,667 sf 72.51% Impervious Runoff Depth=4.98"
Tc=6.0 min CN=91 Runoff=24.09 cfs 1.853 af

Reach 1EX: SHATTUCK RD DITCH Inflow=0.76 cfs 0.100 af
Outflow=0.76 cfs 0.100 af

Reach 2EX: CORP. DRV. & 4 CORP. DRV. Inflow=2.94 cfs 0.276 af
Outflow=2.94 cfs 0.276 af

Reach 3EX: MEADOW TO DRAIN Inflow=4.12 cfs 0.299 af
Outflow=4.12 cfs 0.299 af

Reach 4EX: B1 SITE TO DRAINs Inflow=25.45 cfs 2.025 af
Outflow=25.45 cfs 2.025 af

Reach 5EX: TOTAL B1 SITE TO EXIST. SW BASIN Inflow=31.63 cfs 2.601 af
Outflow=31.63 cfs 2.601 af

Total Runoff Area = 7.865 ac Runoff Volume = 2.701 af Average Runoff Depth = 4.12"
57.88% Pervious = 4.552 ac 42.12% Impervious = 3.313 ac

Summary for Subcatchment 1E: FRONT OF SITE

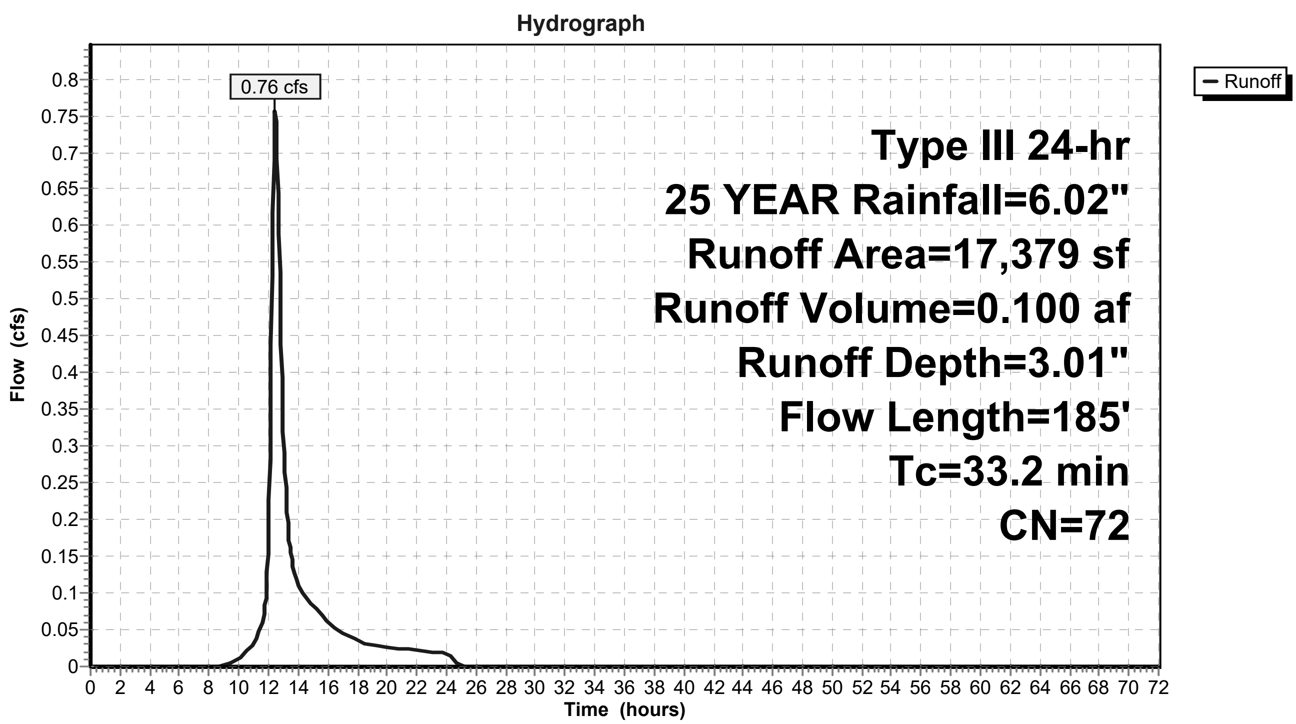
Runoff = 0.76 cfs @ 12.47 hrs, Volume= 0.100 af, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
720	65	Brush, Good, HSG C
3,805	74	>75% Grass cover, Good, HSG C
627	98	Paved parking, HSG C
12,227	70	Woods, Good, HSG C
17,379	72	Weighted Average
16,752		96.39% Pervious Area
627		3.61% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.7	50	0.0025	0.03		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.12"
4.5	135	0.0100	0.50		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
33.2	185	Total			

Subcatchment 1E: FRONT OF SITE



Summary for Subcatchment 2E: OVERLAND TO CORP DRV & 4 CORP DRV

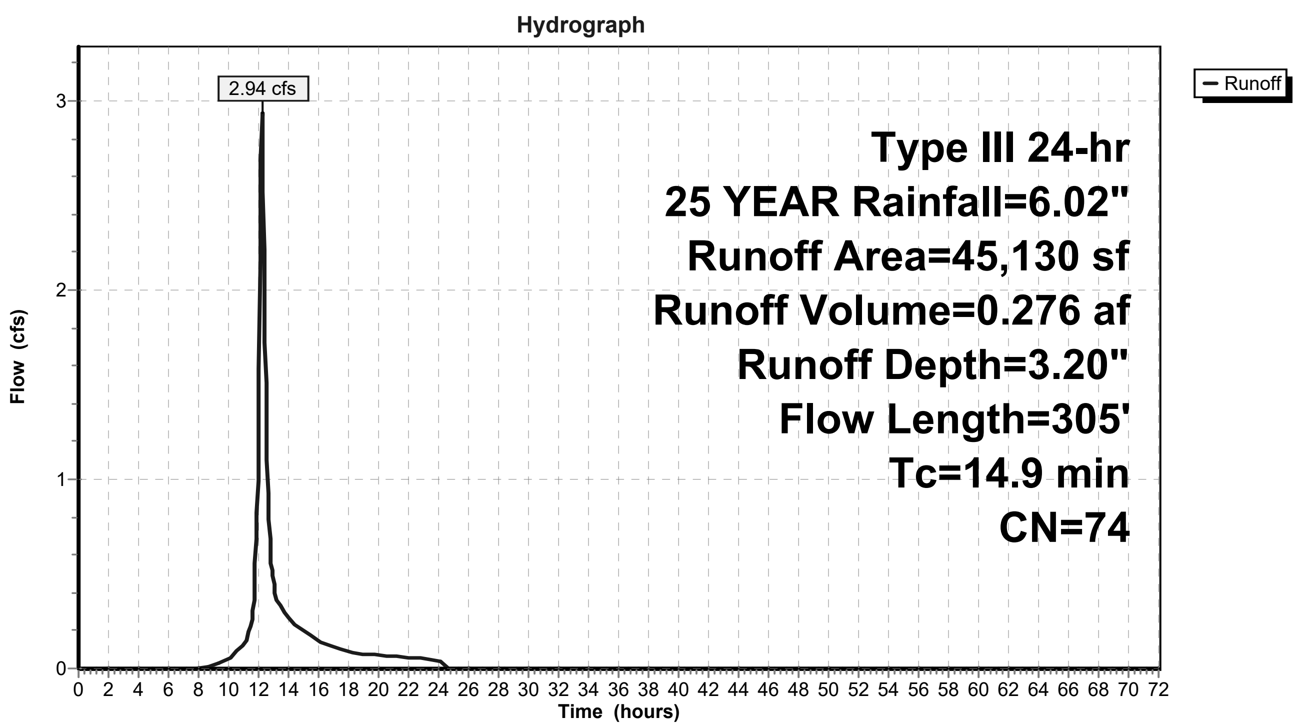
Runoff = 2.94 cfs @ 12.21 hrs, Volume= 0.276 af, Depth= 3.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
21,936	74	>75% Grass cover, Good, HSG C
2,529	98	Paved parking, HSG C
20,665	70	Woods, Good, HSG C
45,130	74	Weighted Average
42,601		94.40% Pervious Area
2,529		5.60% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	50	0.0400	0.09		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.12"
5.4	255	0.0245	0.78		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
14.9	305	Total			

Subcatchment 2E: OVERLAND TO CORP DRV & 4 CORP DRV



Summary for Subcatchment 3E: MEADOW

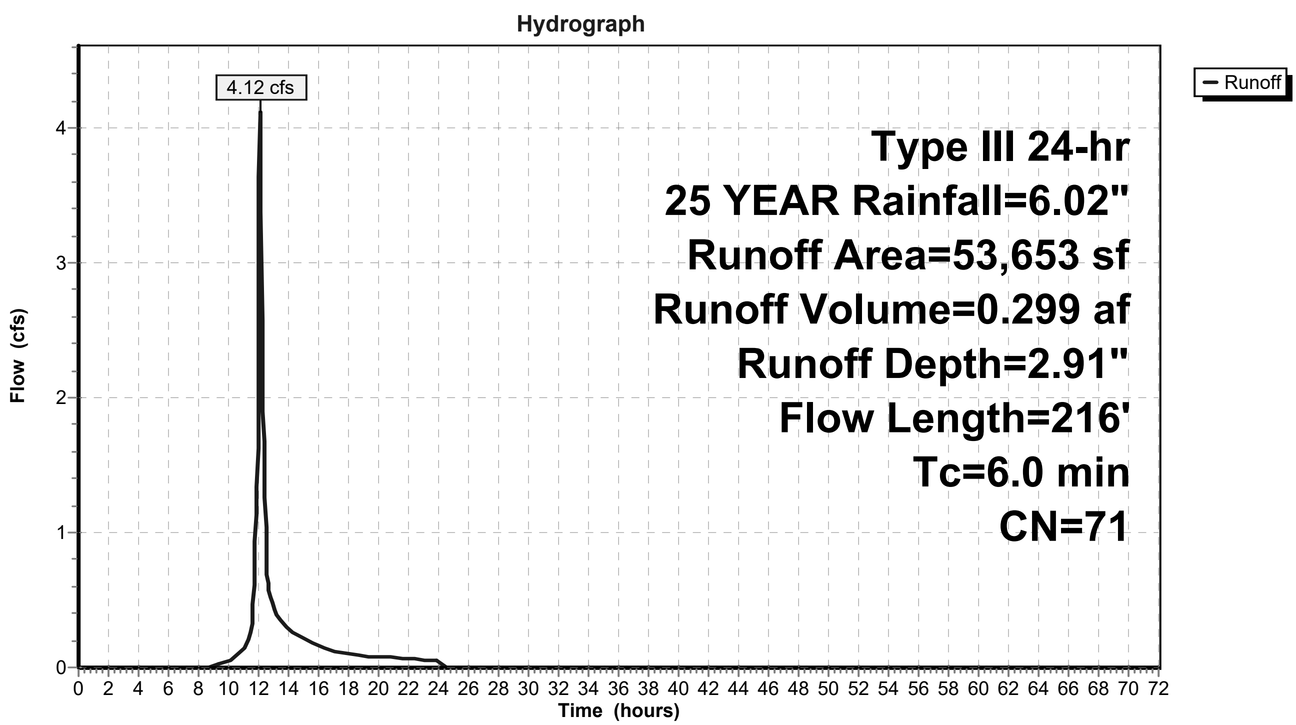
Runoff = 4.12 cfs @ 12.09 hrs, Volume= 0.299 af, Depth= 2.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
765	70	Woods, Good, HSG C
52,888	71	Meadow, non-grazed, HSG C
53,653	71	Weighted Average
53,653		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.3	50	0.1900	0.36		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.12"
1.3	166	0.0900	2.10		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.6	216	Total, Increased to minimum Tc = 6.0 min			

Subcatchment 3E: MEADOW



Summary for Subcatchment 4E: OFFSITE AREA TO B1

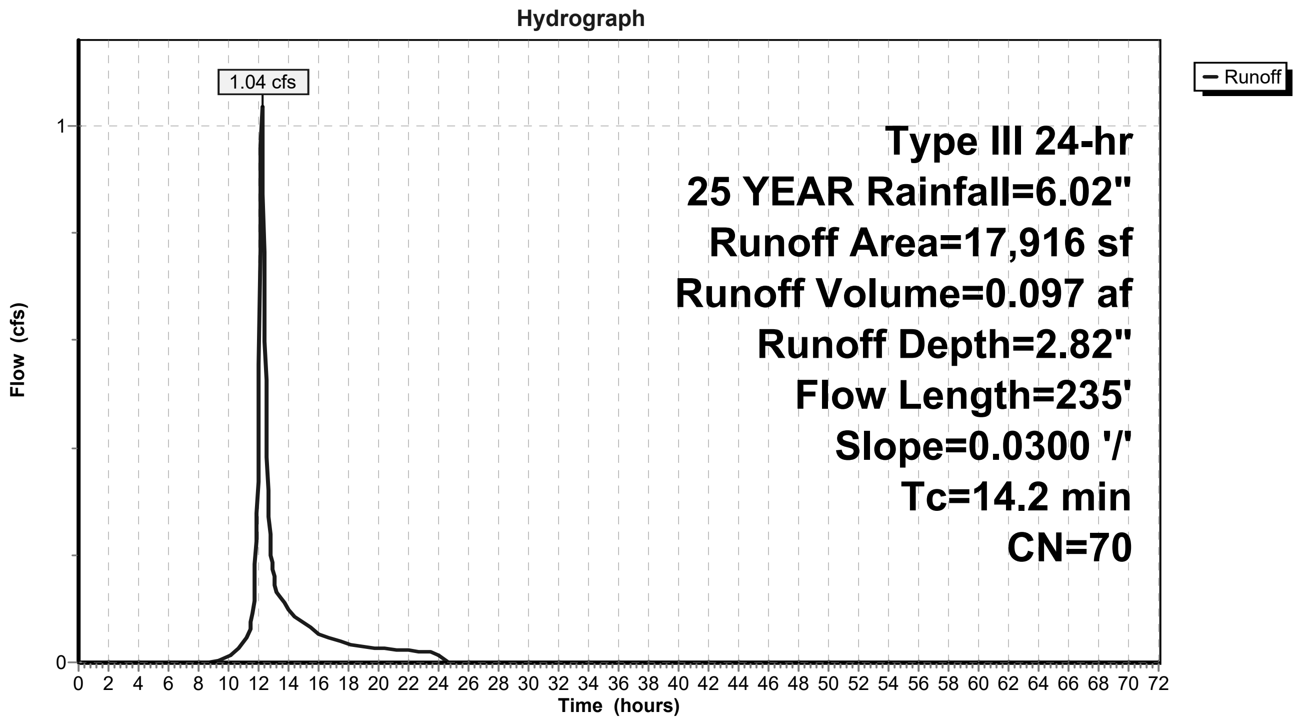
Runoff = 1.04 cfs @ 12.20 hrs, Volume= 0.097 af, Depth= 2.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
17,916	70	Woods, Good, HSG C
17,916		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.6	50	0.0300	0.08		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.12"
3.6	185	0.0300	0.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
14.2	235	Total			

Subcatchment 4E: OFFSITE AREA TO B1



Summary for Subcatchment 5E: B1 FRONT WOODS

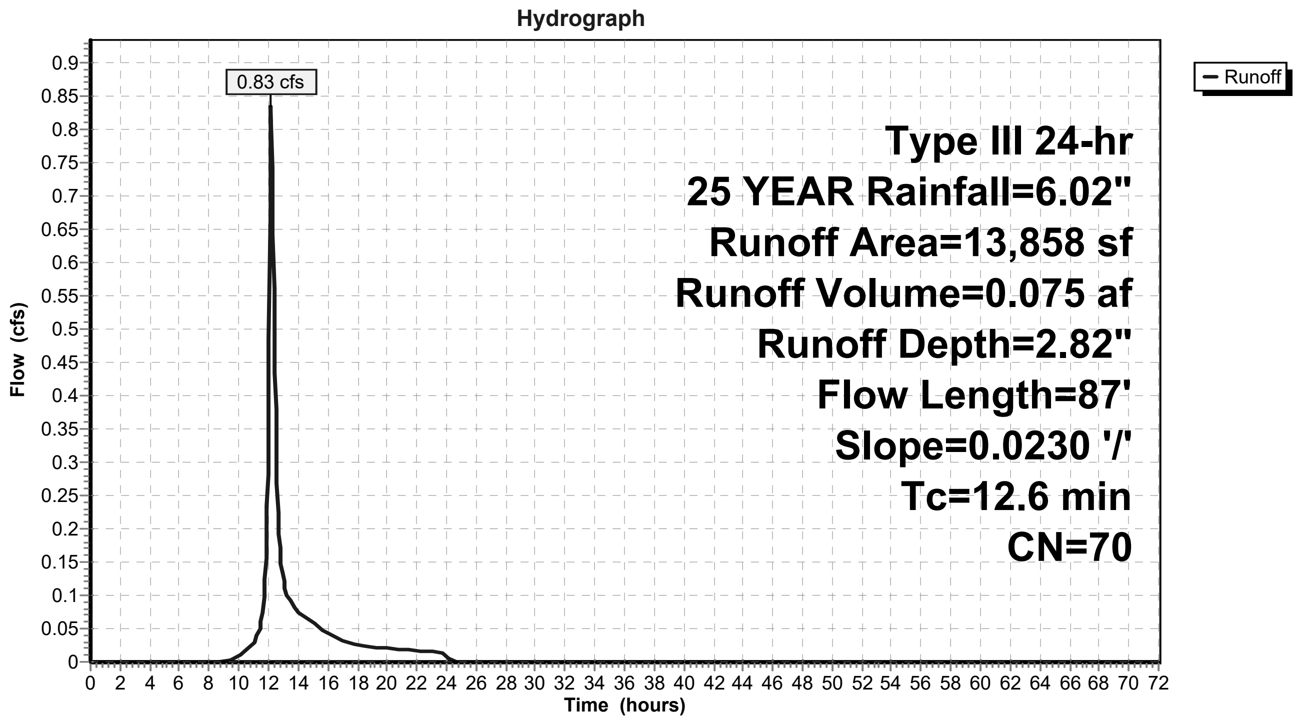
Runoff = 0.83 cfs @ 12.18 hrs, Volume= 0.075 af, Depth= 2.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
13,858	70	Woods, Good, HSG C
13,858		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.8	50	0.0230	0.07		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.12"
0.8	37	0.0230	0.76		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
12.6	87	Total			

Subcatchment 5E: B1 FRONT WOODS



Summary for Subcatchment 6E: MAIN B1 SITE

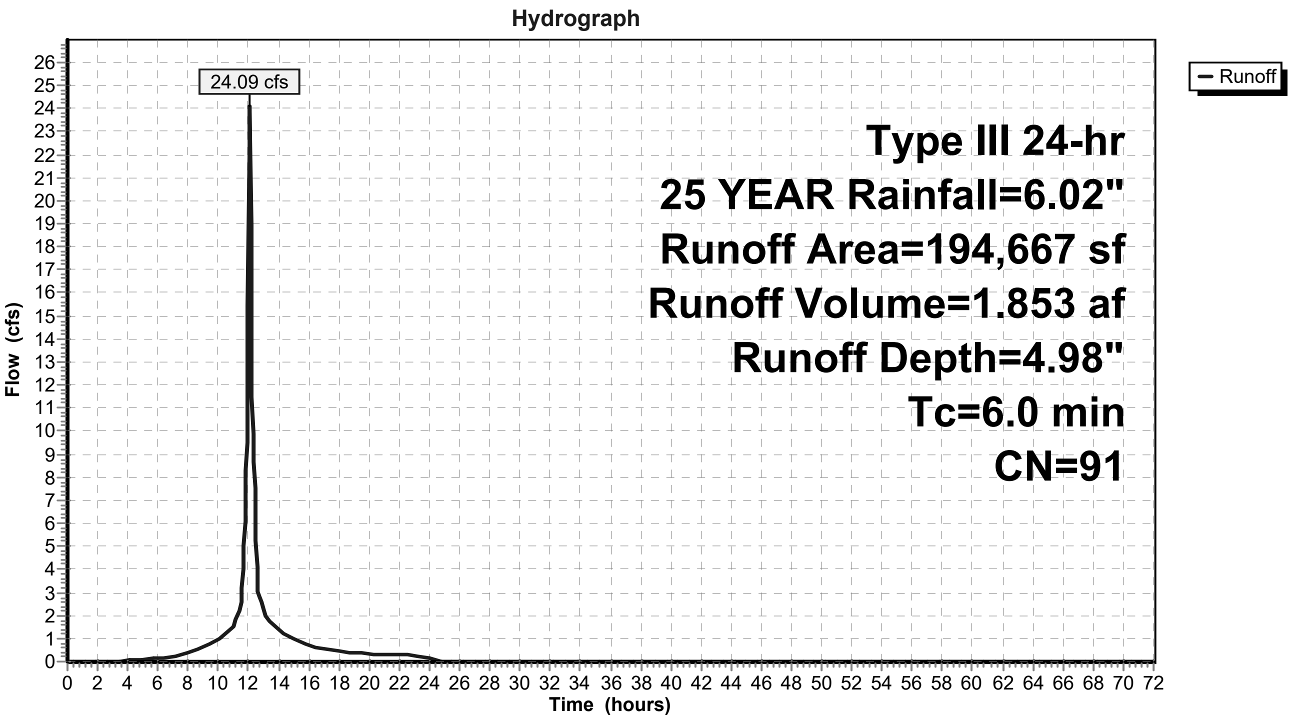
Runoff = 24.09 cfs @ 12.09 hrs, Volume= 1.853 af, Depth= 4.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
3,000	70	Woods, Good, HSG C
141,158	98	Paved parking, HSG C
50,509	74	>75% Grass cover, Good, HSG C
194,667	91	Weighted Average
53,509		27.49% Pervious Area
141,158		72.51% Impervious Area

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

Subcatchment 6E: MAIN B1 SITE

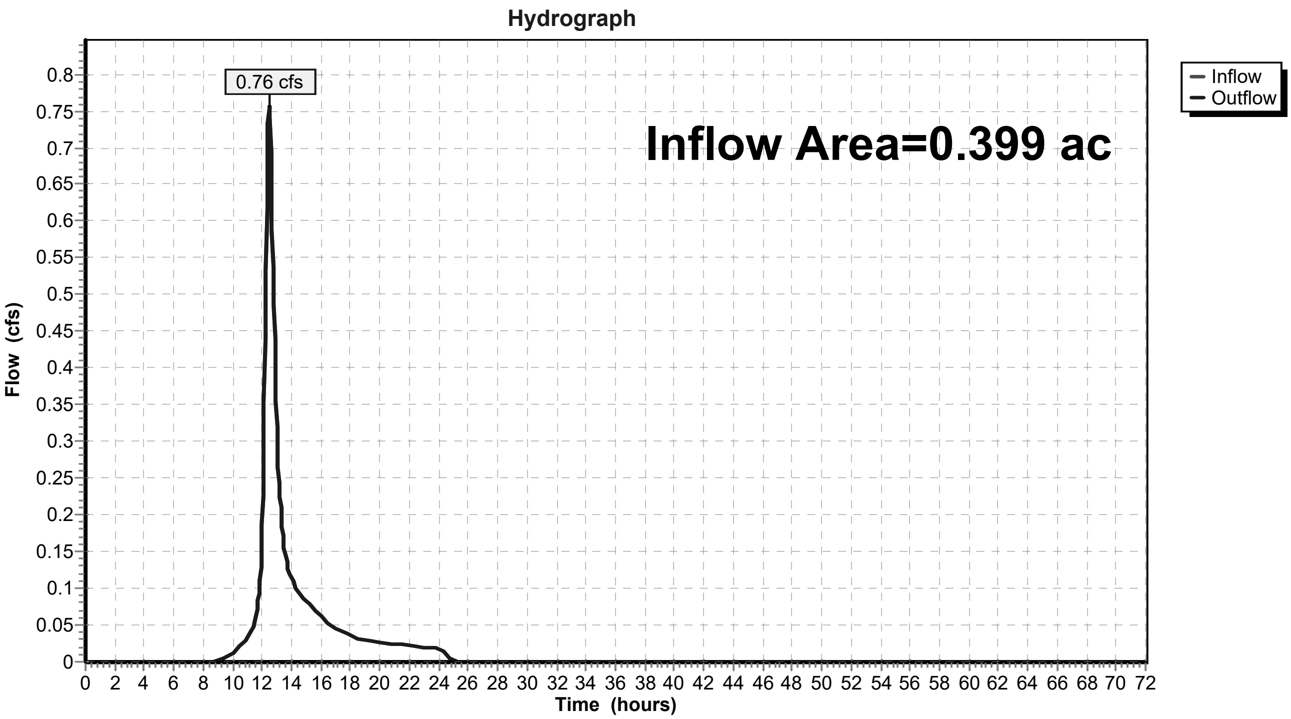


Summary for Reach 1EX: SHATTUCK RD DITCH

Inflow Area =	0.399 ac,	3.61% Impervious, Inflow Depth = 3.01"	for 25 YEAR event
Inflow =	0.76 cfs @	12.47 hrs, Volume=	0.100 af
Outflow =	0.76 cfs @	12.47 hrs, Volume=	0.100 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 1EX: SHATTUCK RD DITCH

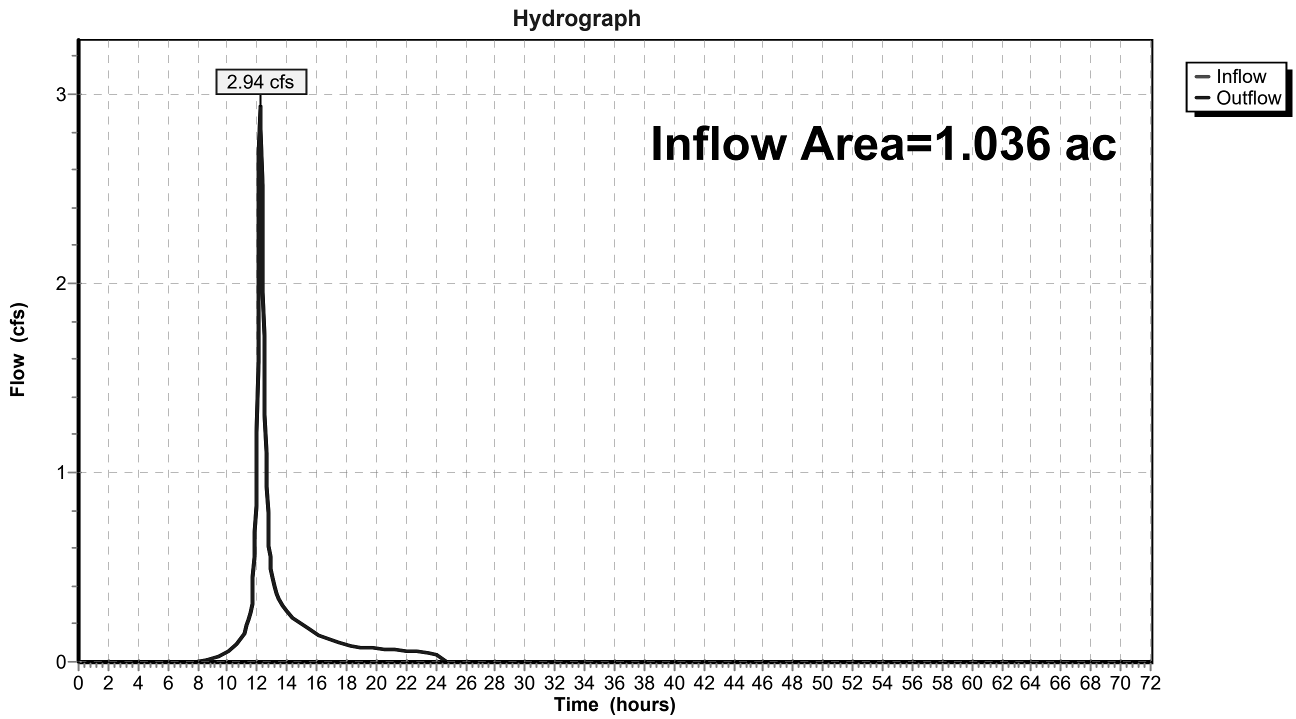


Summary for Reach 2EX: CORP. DRV. & 4 CORP. DRV.

Inflow Area = 1.036 ac, 5.60% Impervious, Inflow Depth = 3.20" for 25 YEAR event
Inflow = 2.94 cfs @ 12.21 hrs, Volume= 0.276 af
Outflow = 2.94 cfs @ 12.21 hrs, Volume= 0.276 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 2EX: CORP. DRV. & 4 CORP. DRV.

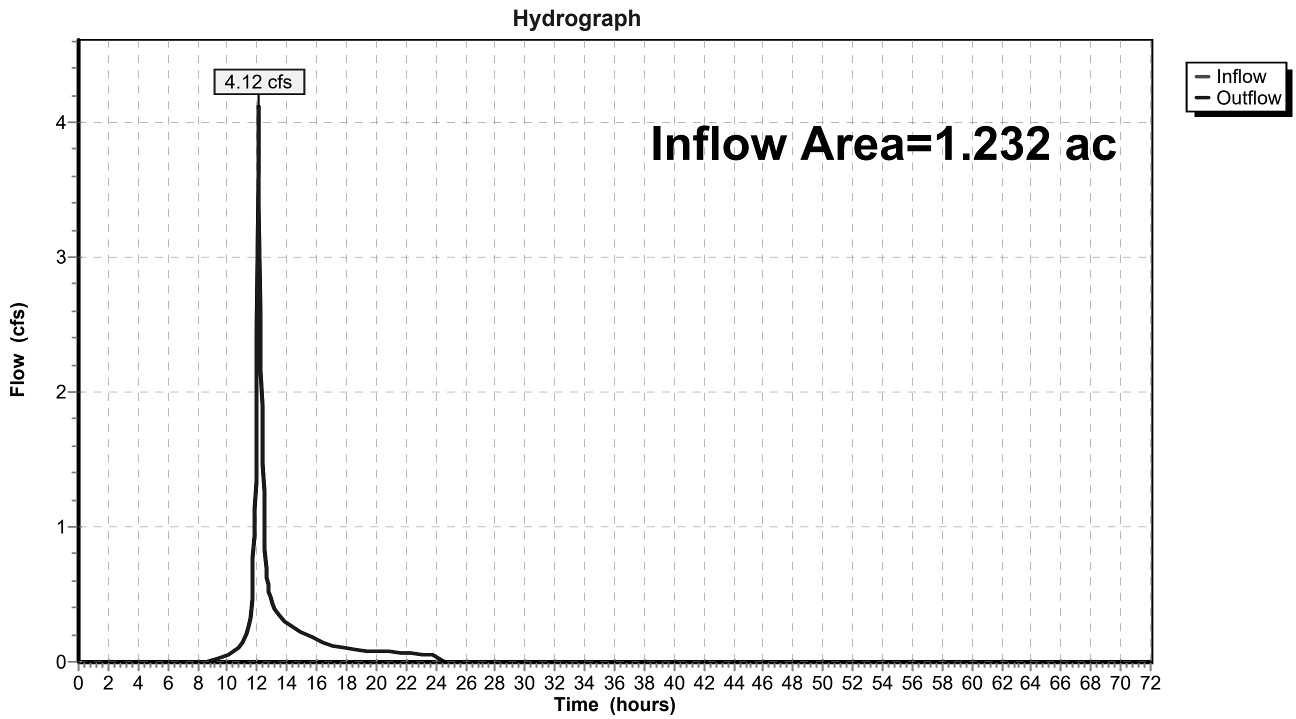


Summary for Reach 3EX: MEADOW TO DRAIN

Inflow Area =	1.232 ac,	0.00% Impervious, Inflow Depth = 2.91"		for 25 YEAR event
Inflow =	4.12 cfs @	12.09 hrs, Volume=	0.299 af	
Outflow =	4.12 cfs @	12.09 hrs, Volume=	0.299 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 3EX: MEADOW TO DRAIN

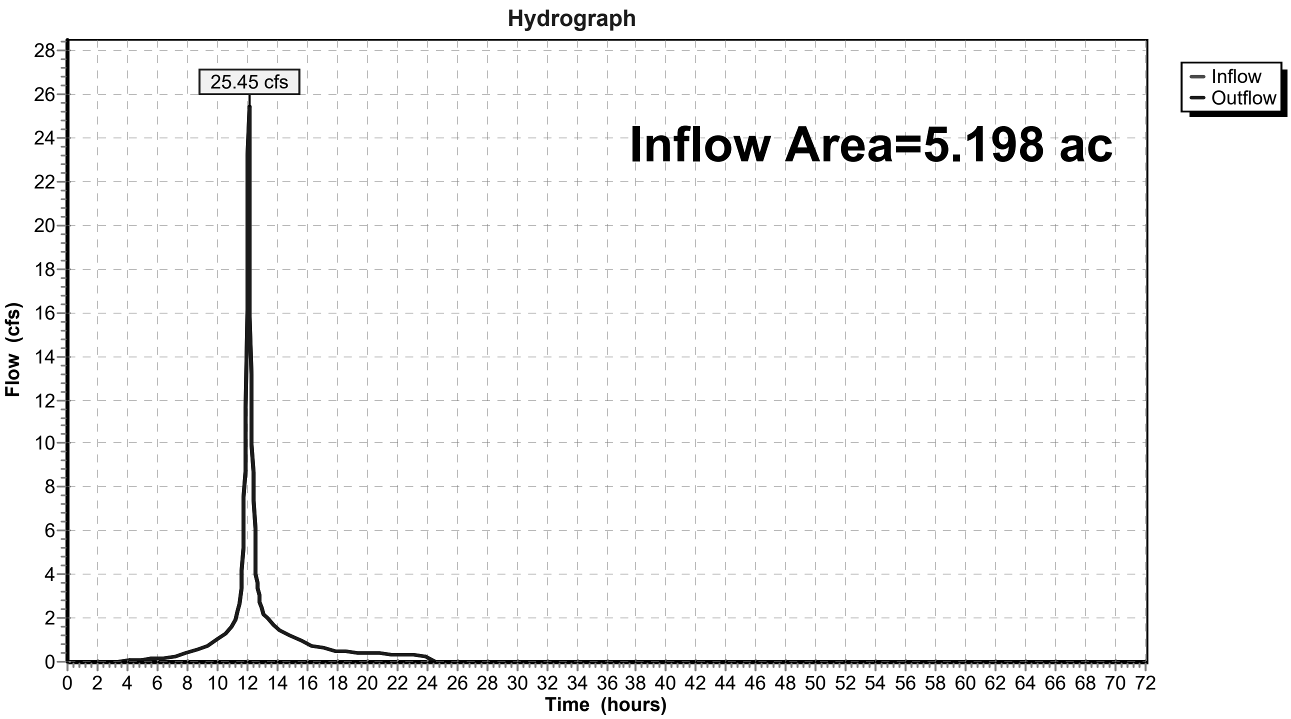


Summary for Reach 4EX: B1 SITE TO DRAINs

Inflow Area = 5.198 ac, 62.34% Impervious, Inflow Depth = 4.67" for 25 YEAR event
Inflow = 25.45 cfs @ 12.09 hrs, Volume= 2.025 af
Outflow = 25.45 cfs @ 12.09 hrs, Volume= 2.025 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 4EX: B1 SITE TO DRAINs

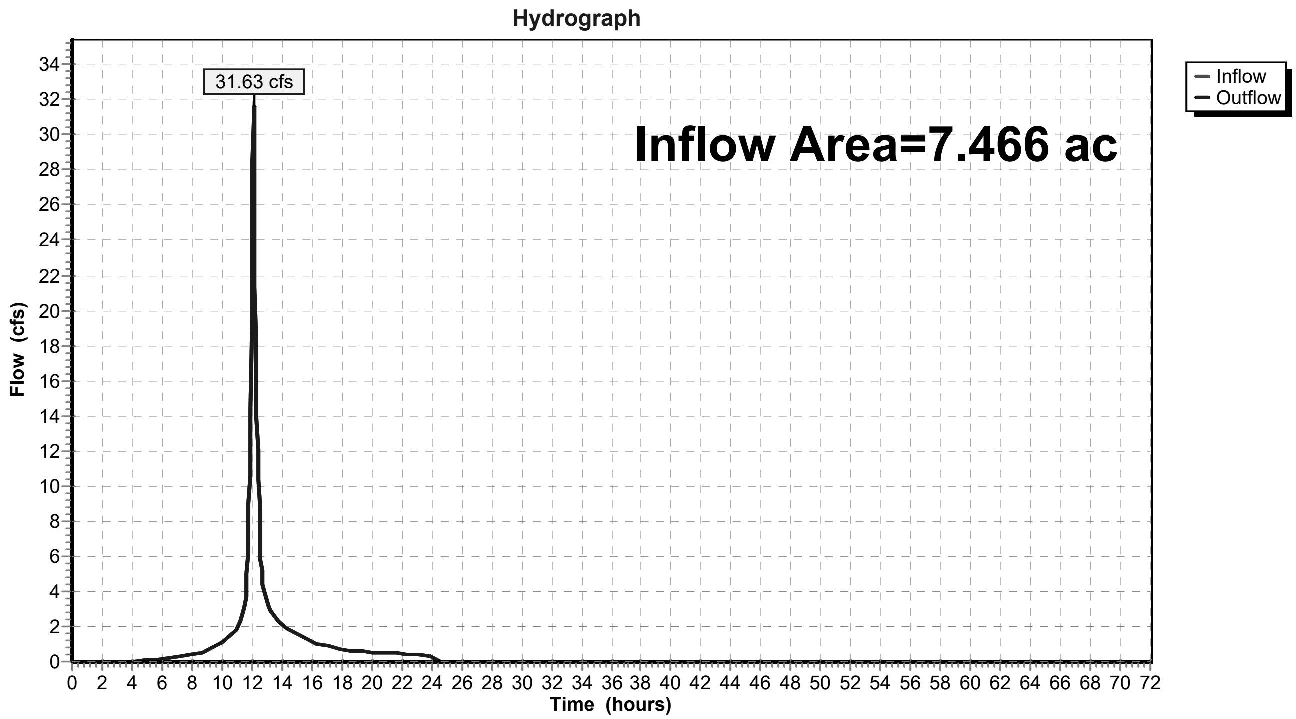


Summary for Reach 5EX: TOTAL B1 SITE TO EXIST. SW BASIN

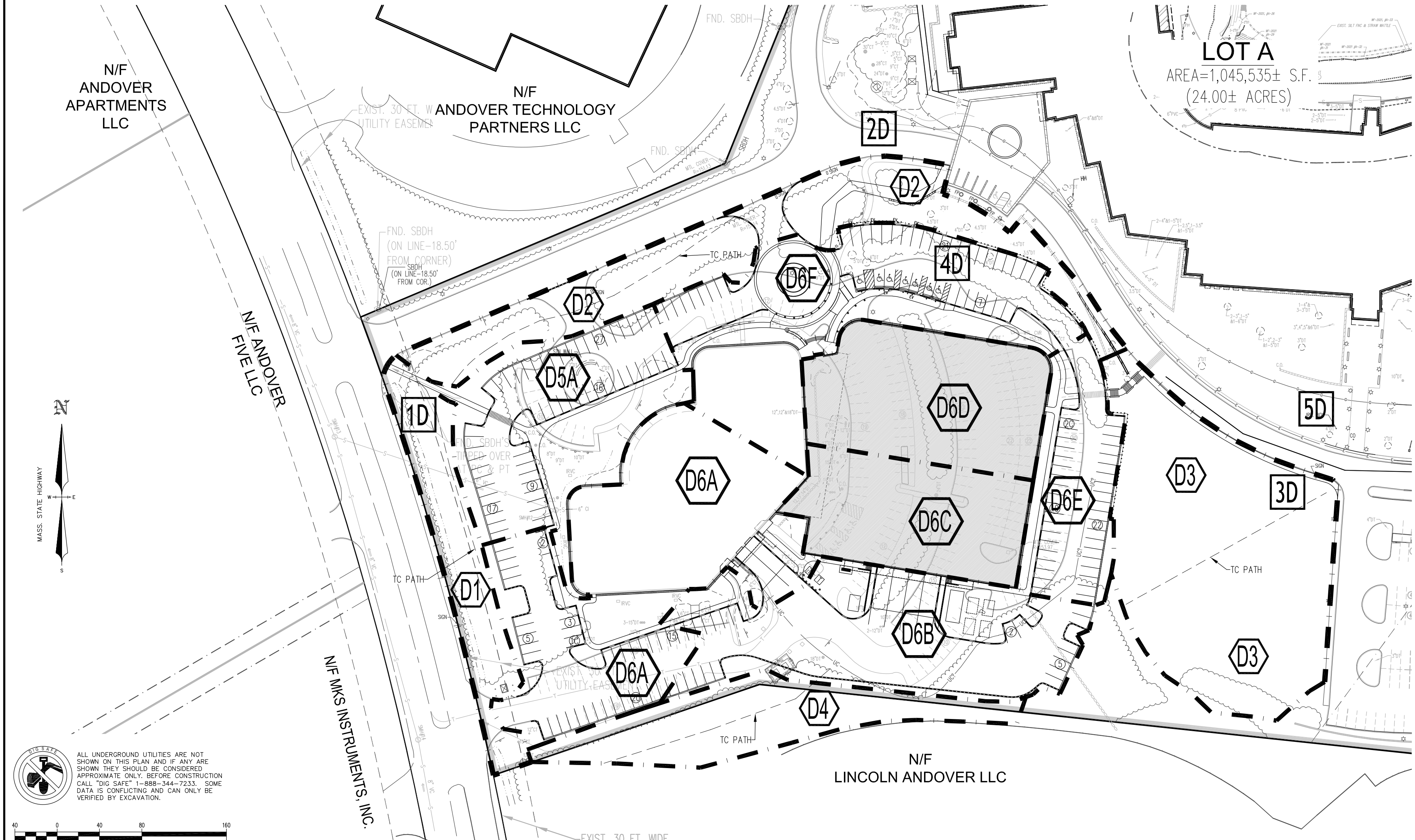
Inflow Area = 7.466 ac, 44.18% Impervious, Inflow Depth = 4.18" for 25 YEAR event
Inflow = 31.63 cfs @ 12.09 hrs, Volume= 2.601 af
Outflow = 31.63 cfs @ 12.09 hrs, Volume= 2.601 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 5EX: TOTAL B1 SITE TO EXIST. SW BASIN



PROPOSED CONDITIONS
RUNOFF CALCULATIONS
(25 YEAR STORM PRINTOUT ONLY)



1/26/2022	RGC	⚠	ISSUED FOR PERMITTING	CALC. BY:	WAJ
DATE	BY	REV#	REVISIONS	DR. BY:	WAJ
				CKD. BY:	RGC/WAJ
				APPD. BY:	RGC
				JOB NO.:	21055
				SCALE:	1" = 40'
				DATE:	JAN. 26, 2022

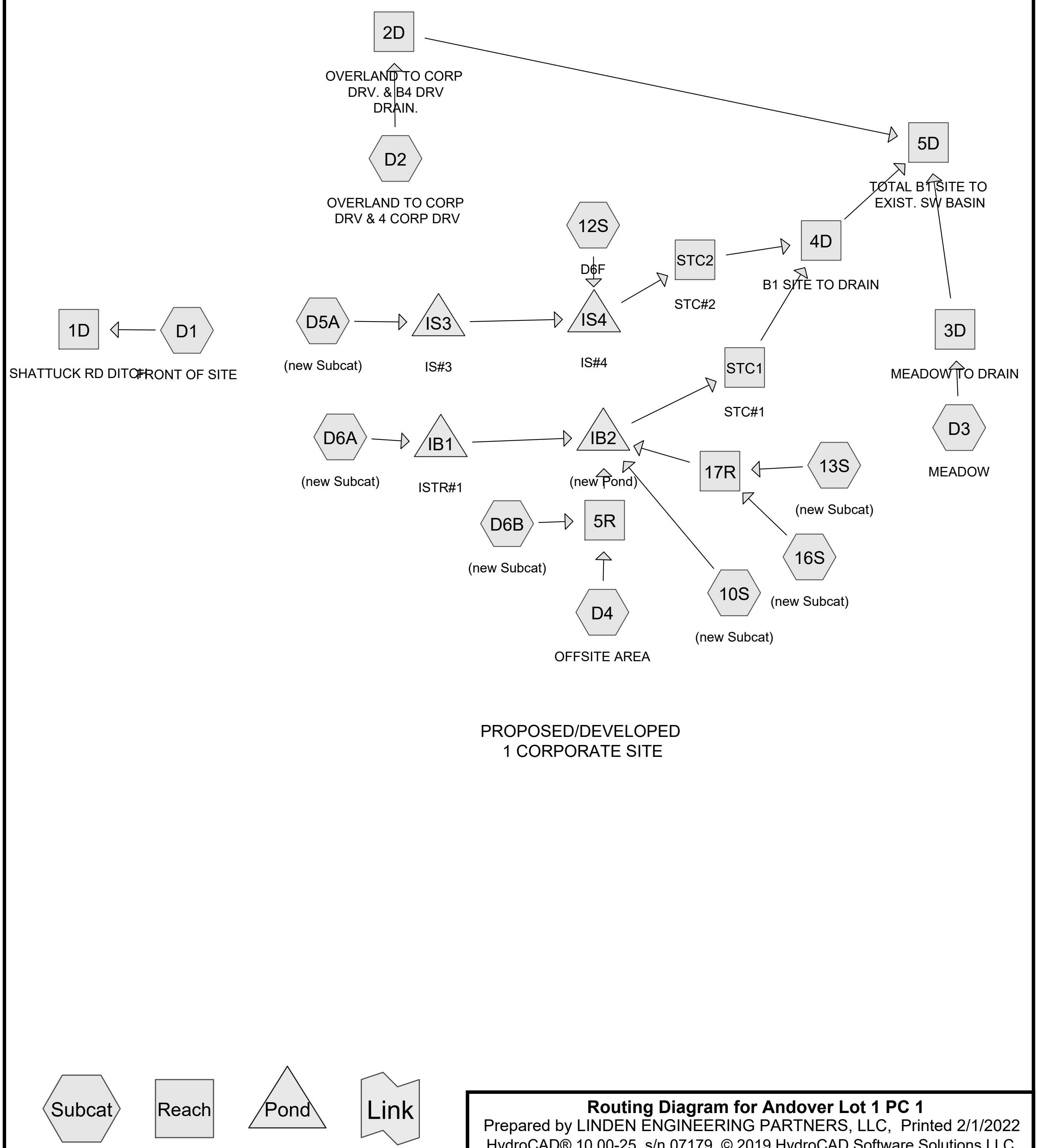
RICHARD G. CUTTS
REG. PROF. ENGINEER

LINDEN ENGINEERING PARTNERS LLC
100 TradeCenter Suite G700
Woburn, MA 01801-1851
Tel: (781) 933-3711
Fax: (781) 287-1277
Civil - Environmental Engineering including Storm water, Wastewater, Water Supply, Highway & Infrastructure Design, Land Planning, Land Subdivision, Site Design, Environmental Permitting, Wetlands Permitting & Land Development Permitting

PREPARED FOR:
IQHQ-1 CORPORATE, LLC AND IQHQ-4 CORPORATE, LLC
ATTN: MR. WILLIAM ASHTON
ONE BOSTON PLACE, 201 WASHINGTON STREET, SUITE 3920
BOSTON, MASSACHUSETTS 02108
TEL: (617) 314-7951

PROPOSED WATERSHED PLAN
PROPOSED RENOVATION AND ADDITION
ONE AND FOUR CORPORATE DRIVE
ANDOVER, MASSACHUSETTS

SHEET
WS-2



Routing Diagram for Andover Lot 1 PC 1
Prepared by LINDEN ENGINEERING PARTNERS, LLC, Printed 2/1/2022
HydroCAD® 10.00-25 s/n 07179 © 2019 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.200	86	<50% Grass cover, Poor, HSG C (D6A)
1.453	74	>75% Grass cover, Good, HSG C (12S, 16S, D1, D2, D3, D5A, D6B)
0.017	65	Brush, Good, HSG C (D1)
1.021	71	Meadow, non-grazed, HSG C (D3)
2.342	98	Paved parking, HSG C (12S, 16S, D1, D2, D3, D5A, D6B)
1.054	98	Paved parking, Roof, HSG C (D6A)
1.133	98	Roofs, HSG C (10S, 13S)
0.915	70	Woods, Good, HSG C (D1, D2, D3, D4)
8.134	**87**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
8.134	HSG C	10S, 12S, 13S, 16S, D1, D2, D3, D4, D5A, D6A, D6B
0.000	HSG D	
0.000	Other	
8.134		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.200	0.000	0.000	0.200	<50% Grass cover, Poor	D6A
0.000	0.000	1.453	0.000	0.000	1.453	>75% Grass cover, Good	12S, 16S, D1, D2, D3, D5A, D6B
0.000	0.000	0.017	0.000	0.000	0.017	Brush, Good	D1
0.000	0.000	1.021	0.000	0.000	1.021	Meadow, non-grazed	D3
0.000	0.000	2.342	0.000	0.000	2.342	Paved parking	12S, 16S, D1, D2, D3, D5A, D6B
0.000	0.000	1.054	0.000	0.000	1.054	Paved parking, Roof	D6A
0.000	0.000	1.133	0.000	0.000	1.133	Roofs	10S, 13S
0.000	0.000	0.915	0.000	0.000	0.915	Woods, Good	D1, D2, D3, D4
0.000	**0.000**	**8.134**	**0.000**	**0.000**	**8.134**	**TOTAL AREA**	

Summary for Subcatchment 10S: (new Subcat)

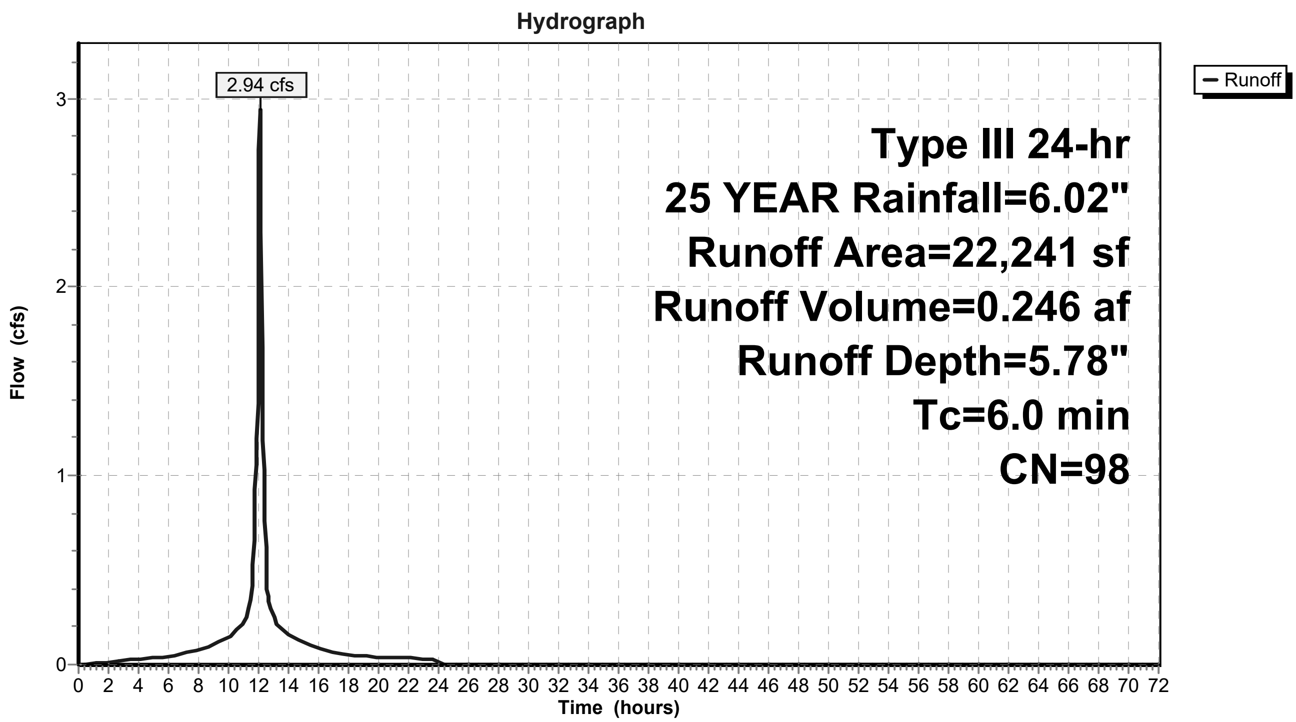
Runoff = 2.94 cfs @ 12.09 hrs, Volume= 0.246 af, Depth= 5.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
22,241	98	Roofs, HSG C
22,241		100.00% Impervious Area

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

Subcatchment 10S: (new Subcat)



Summary for Subcatchment 12S: D6F

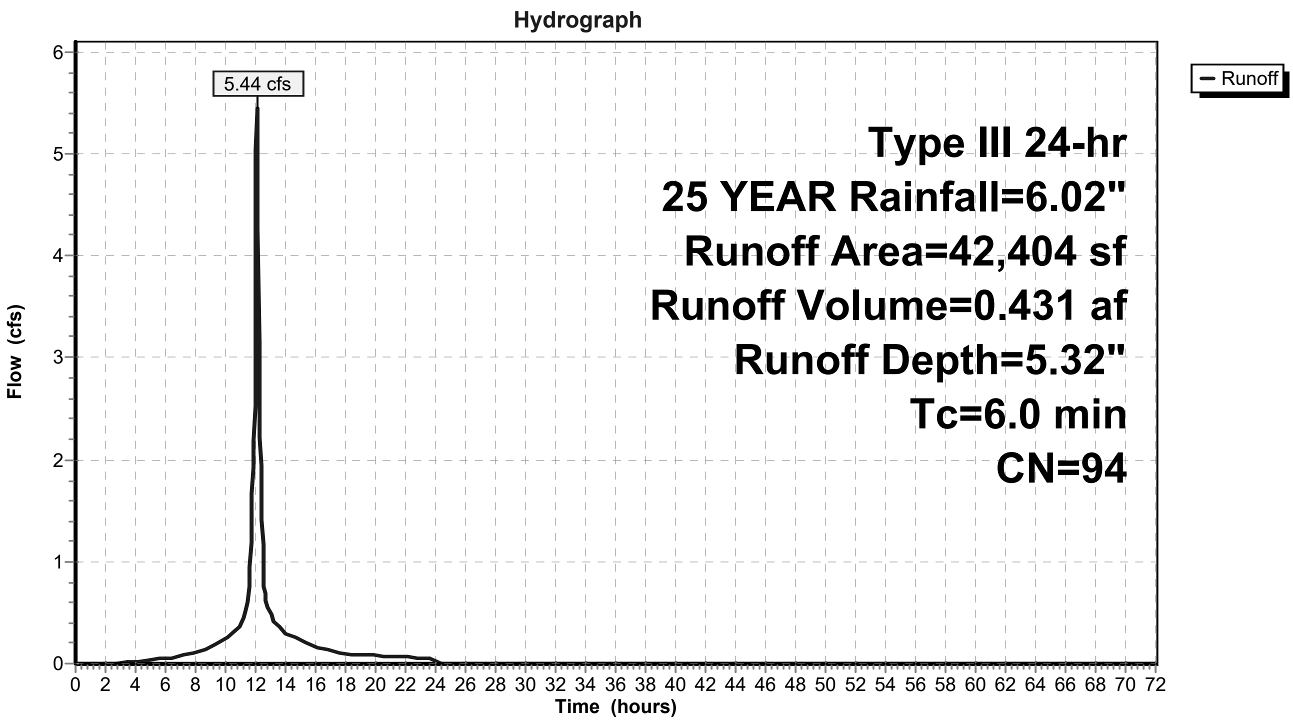
Runoff = 5.44 cfs @ 12.09 hrs, Volume= 0.431 af, Depth= 5.32"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
34,882	98	Paved parking, HSG C
7,522	74	>75% Grass cover, Good, HSG C
42,404	94	Weighted Average
7,522		17.74% Pervious Area
34,882		82.26% Impervious Area

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

Subcatchment 12S: D6F



Summary for Subcatchment 13S: (new Subcat)

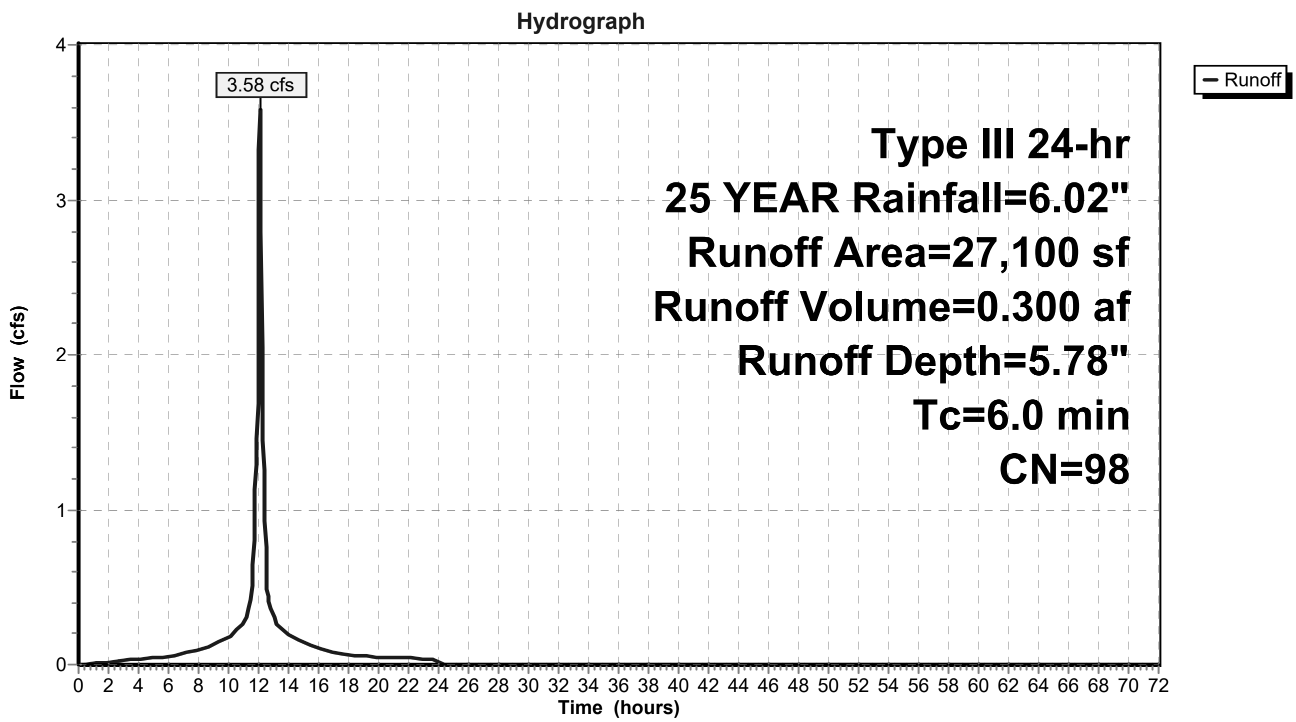
Runoff = 3.58 cfs @ 12.09 hrs, Volume= 0.300 af, Depth= 5.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
27,100	98	Roofs, HSG C
27,100		100.00% Impervious Area

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

Subcatchment 13S: (new Subcat)



Summary for Subcatchment 16S: (new Subcat)

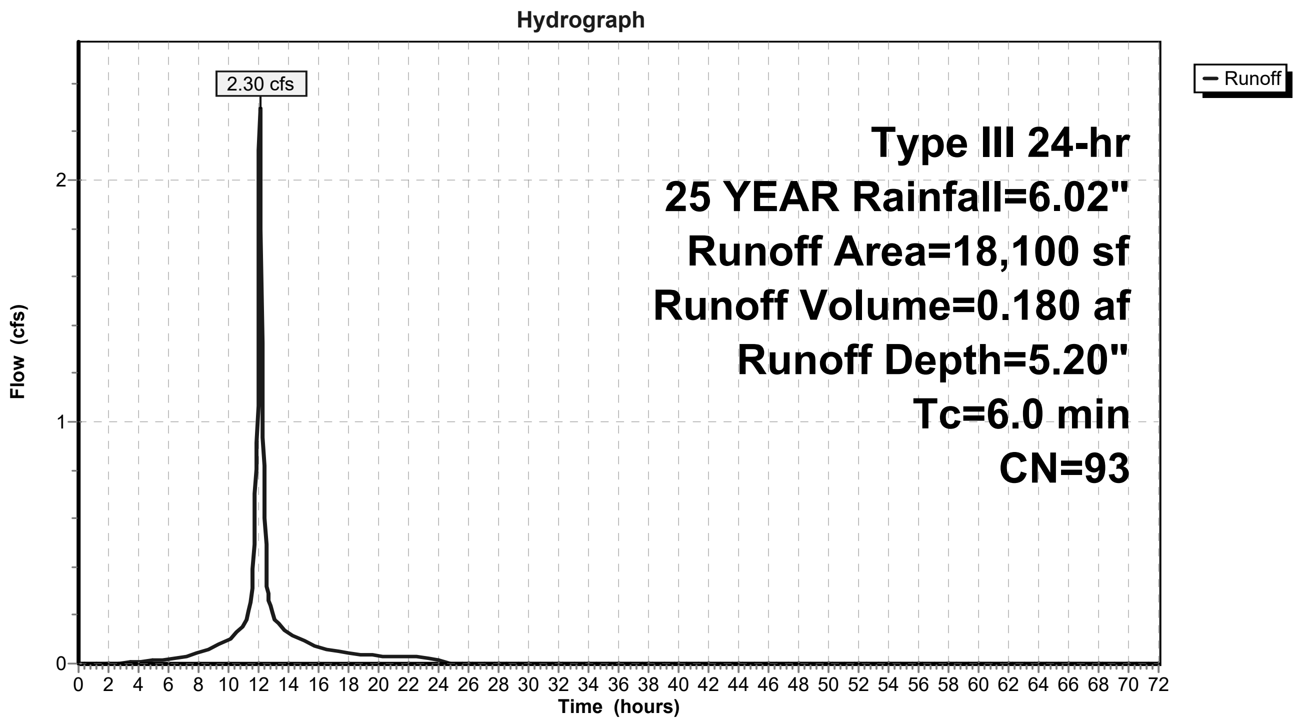
Runoff = 2.30 cfs @ 12.09 hrs, Volume= 0.180 af, Depth= 5.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
14,100	98	Paved parking, HSG C
4,000	74	>75% Grass cover, Good, HSG C
18,100	93	Weighted Average
4,000		22.10% Pervious Area
14,100		77.90% Impervious Area

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

Subcatchment 16S: (new Subcat)



Summary for Subcatchment D1: FRONT OF SITE

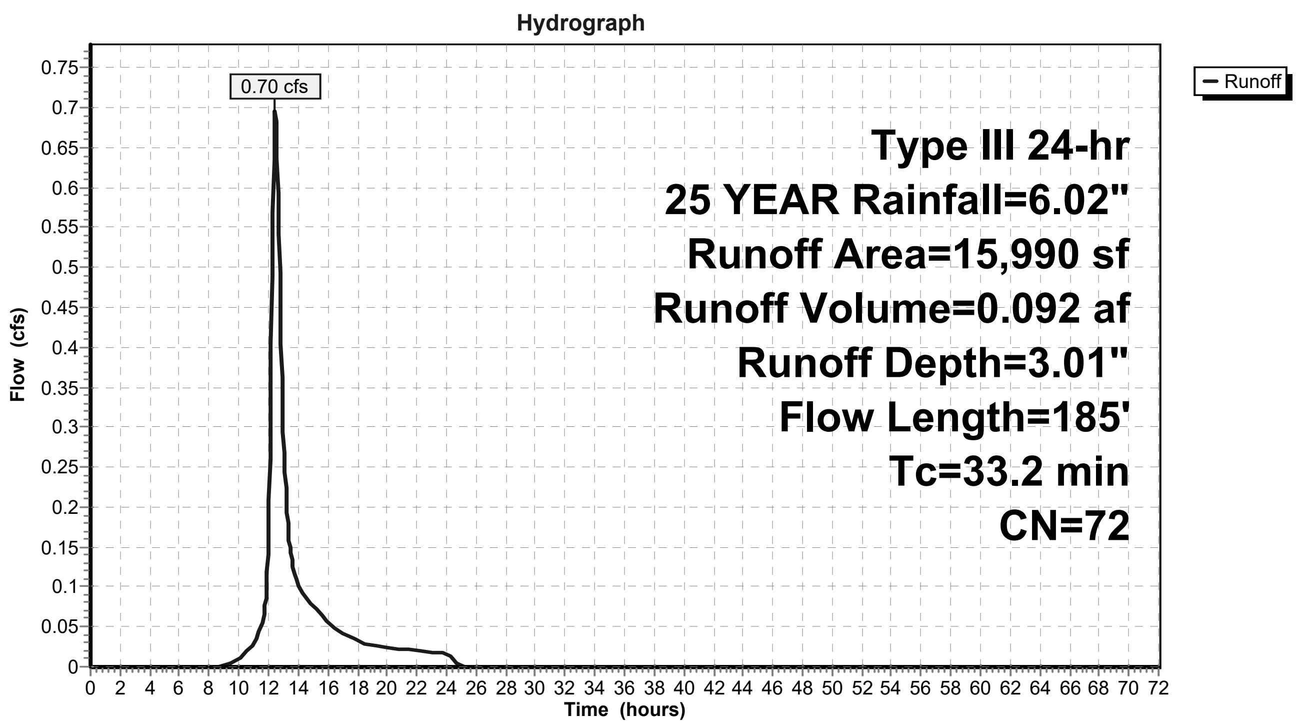
Runoff = 0.70 cfs @ 12.47 hrs, Volume= 0.092 af, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
720	65	Brush, Good, HSG C
3,805	74	>75% Grass cover, Good, HSG C
927	98	Paved parking, HSG C
10,238	70	Woods, Good, HSG C
300	74	>75% Grass cover, Good, HSG C
15,990	72	Weighted Average
15,063		94.20% Pervious Area
927		5.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.7	50	0.0025	0.03		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.12"
4.5	135	0.0100	0.50		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
33.2	185	Total			

Subcatchment D1: FRONT OF SITE



Summary for Subcatchment D2: OVERLAND TO CORP DRV & 4 CORP DRV

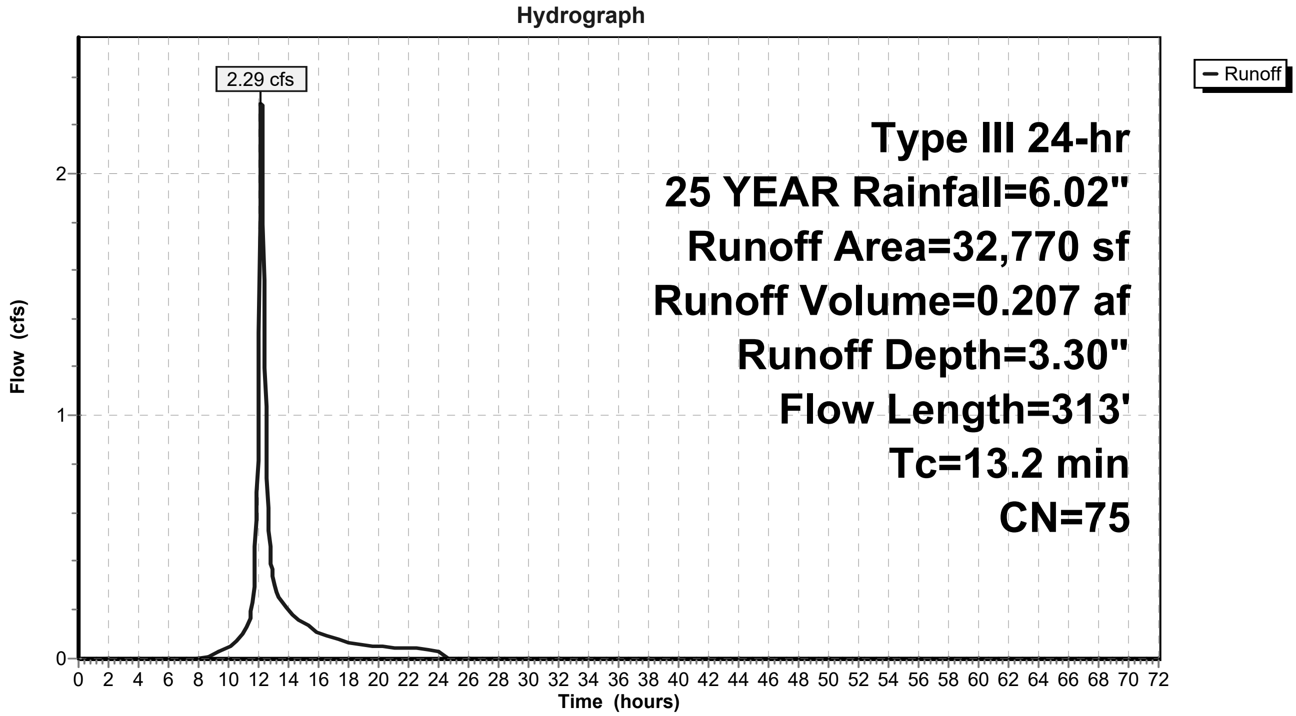
Runoff = 2.29 cfs @ 12.19 hrs, Volume= 0.207 af, Depth= 3.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
9,975	74	>75% Grass cover, Good, HSG C
9,856	74	>75% Grass cover, Good, HSG C
3,379	98	Paved parking, HSG C
9,560	70	Woods, Good, HSG C
32,770	75	Weighted Average
29,391		89.69% Pervious Area
3,379		10.31% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.5	50	0.0520	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.12"
1.2	58	0.0280	0.84		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.7	50	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
2.8	155	0.0350	0.94		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
13.2	313	Total			

Subcatchment D2: OVERLAND TO CORP DRV & 4 CORP DRV



Summary for Subcatchment D3: MEADOW

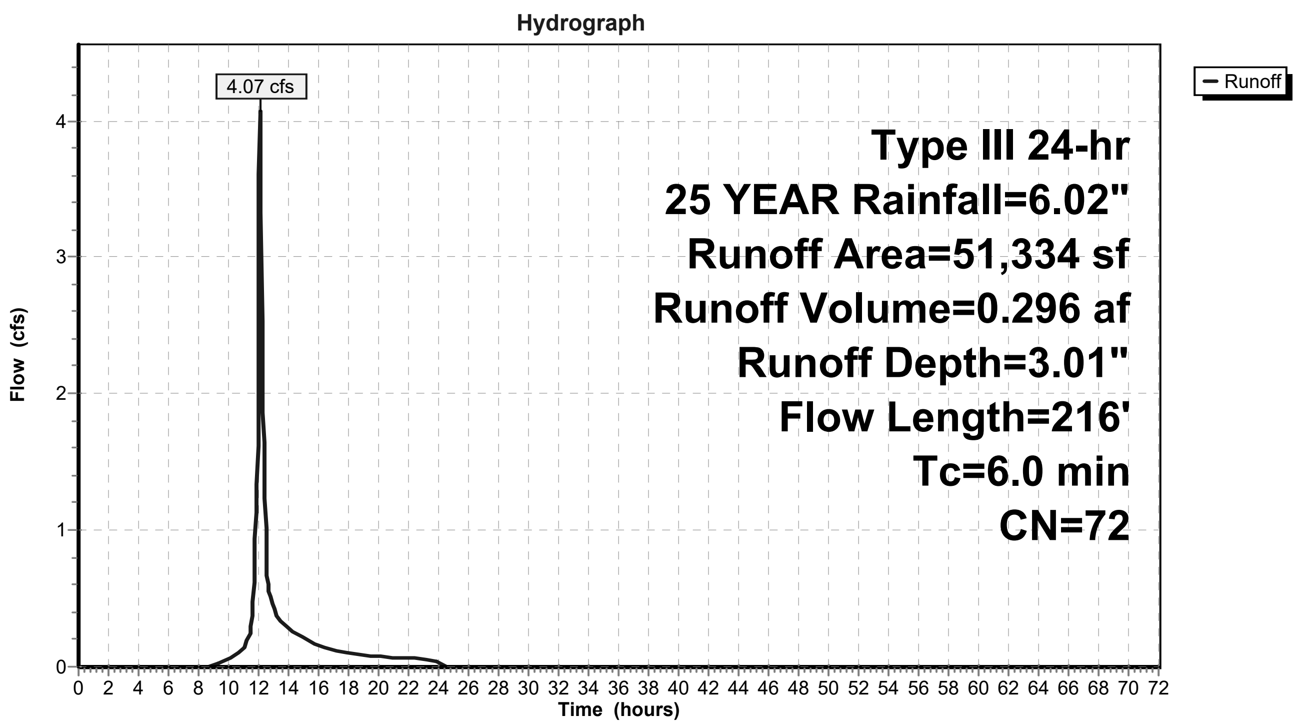
Runoff = 4.07 cfs @ 12.09 hrs, Volume= 0.296 af, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
765	70	Woods, Good, HSG C
38,528	71	Meadow, non-grazed, HSG C
5,930	71	Meadow, non-grazed, HSG C
4,761	74	>75% Grass cover, Good, HSG C
1,350	98	Paved parking, HSG C
51,334	72	Weighted Average
49,984		97.37% Pervious Area
1,350		2.63% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.3	50	0.1900	0.36		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.12"
1.3	166	0.0900	2.10		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.6	216	Total, Increased to minimum Tc = 6.0 min			

Subcatchment D3: MEADOW



Summary for Subcatchment D4: OFFSITE AREA

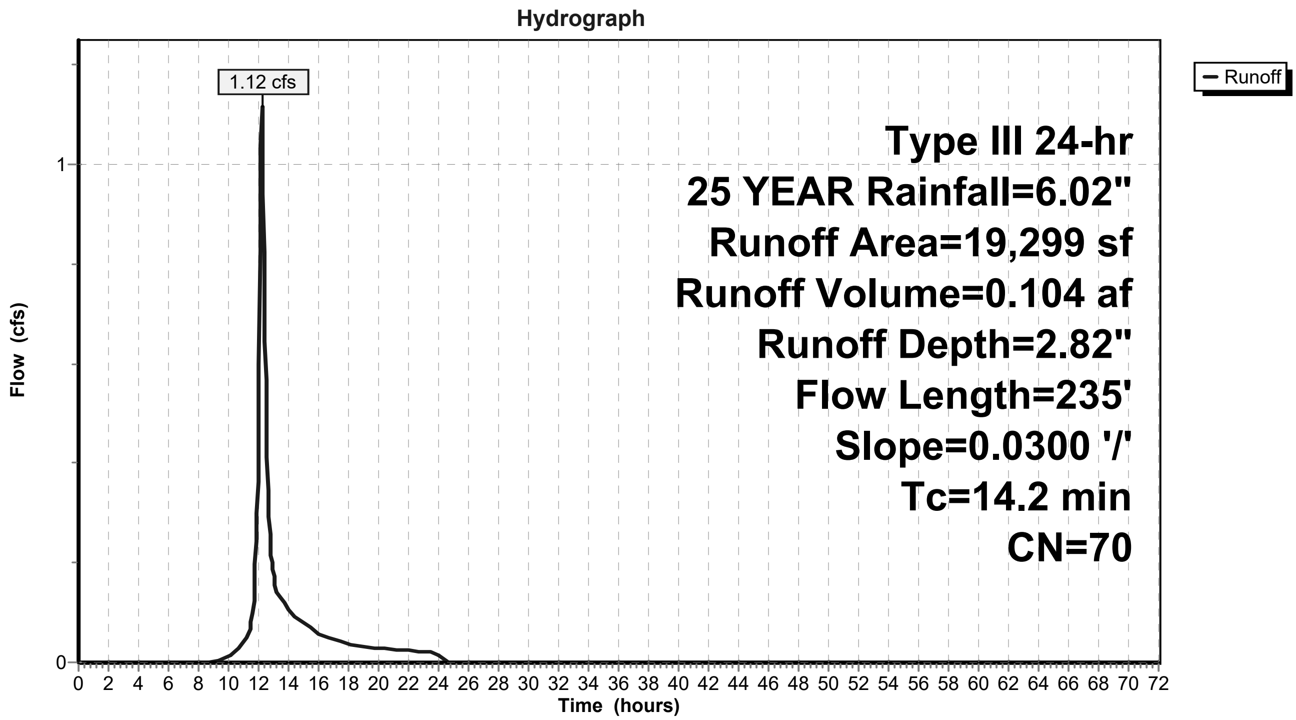
Runoff = 1.12 cfs @ 12.20 hrs, Volume= 0.104 af, Depth= 2.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
19,299	70	Woods, Good, HSG C
19,299		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.6	50	0.0300	0.08		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.12"
3.6	185	0.0300	0.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
14.2	235	Total			

Subcatchment D4: OFFSITE AREA



Summary for Subcatchment D5A: (new Subcat)

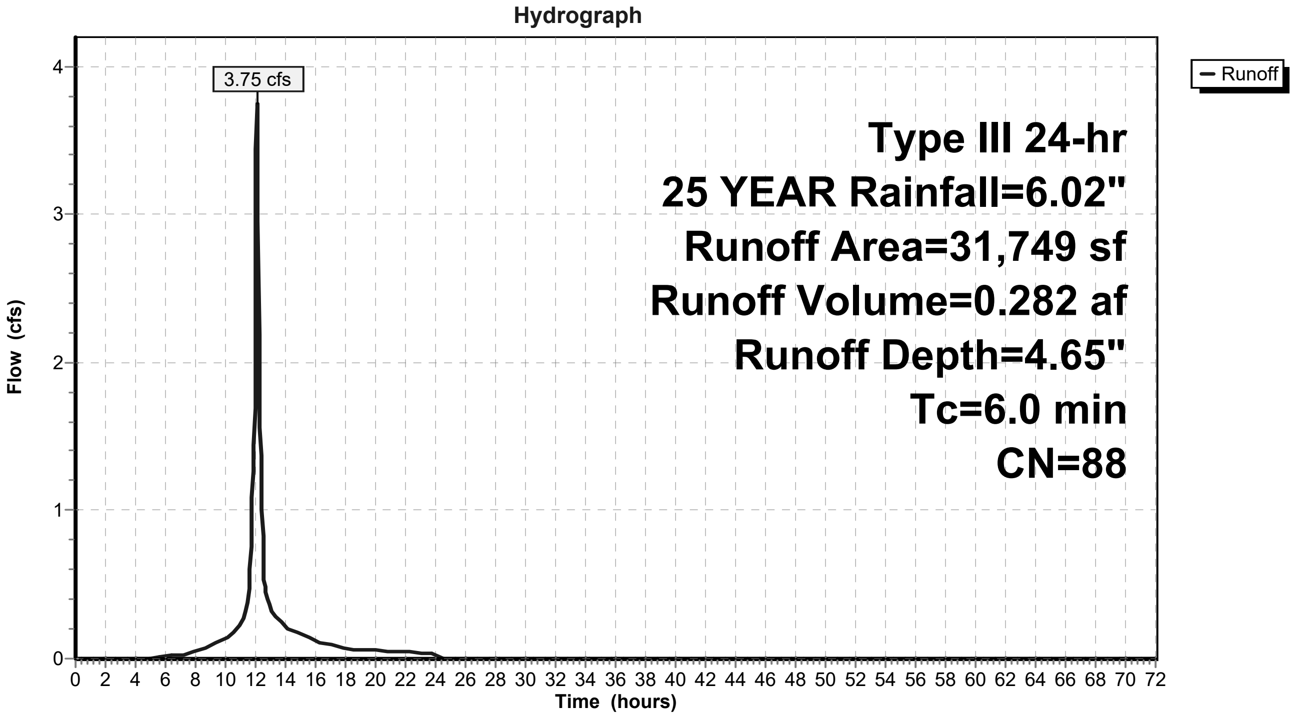
Runoff = 3.75 cfs @ 12.09 hrs, Volume= 0.282 af, Depth= 4.65"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
18,900	98	Paved parking, HSG C
12,849	74	>75% Grass cover, Good, HSG C
31,749	88	Weighted Average
12,849		40.47% Pervious Area
18,900		59.53% Impervious Area

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

Subcatchment D5A: (new Subcat)



Summary for Subcatchment D6A: (new Subcat)

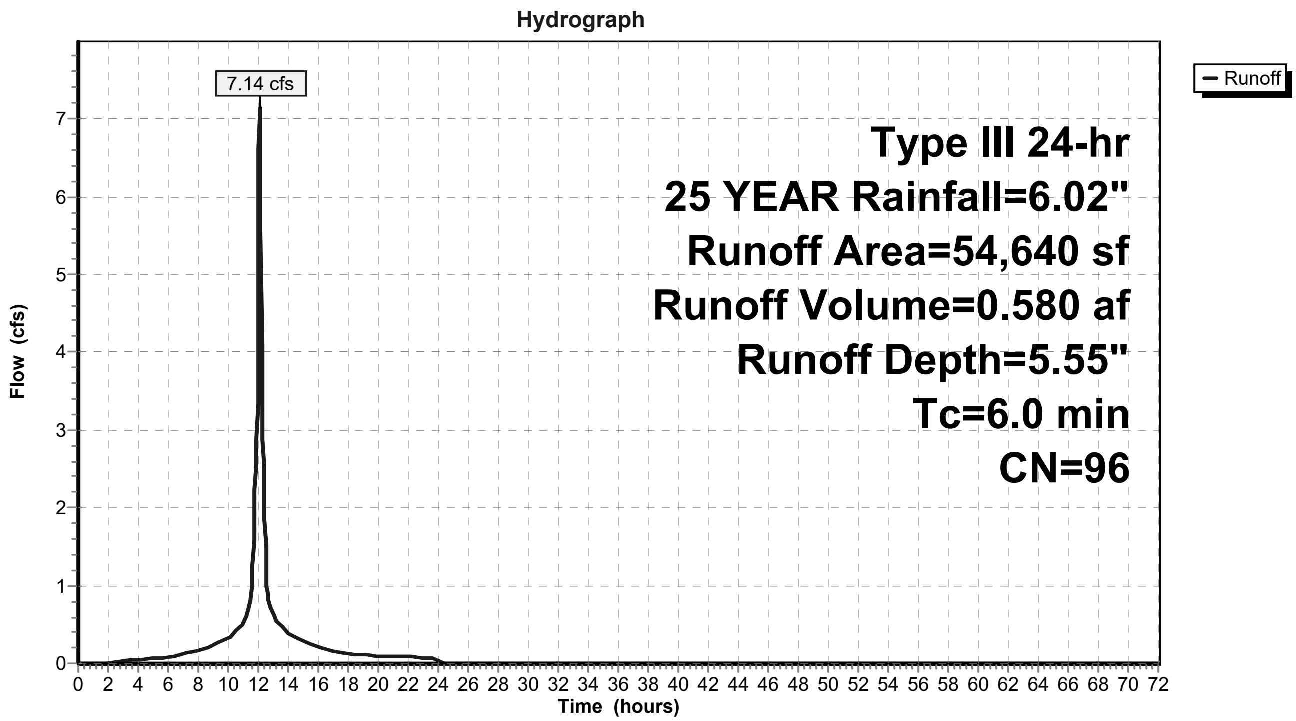
Runoff = 7.14 cfs @ 12.09 hrs, Volume= 0.580 af, Depth= 5.55"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

	Area (sf)	CN	Description
*	45,920	98	Paved parking, Roof, HSG C
	8,720	86	<50% Grass cover, Poor, HSG C
	54,640	96	Weighted Average
	8,720		15.96% Pervious Area
	45,920		84.04% Impervious Area

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

Subcatchment D6A: (new Subcat)



Summary for Subcatchment D6B: (new Subcat)

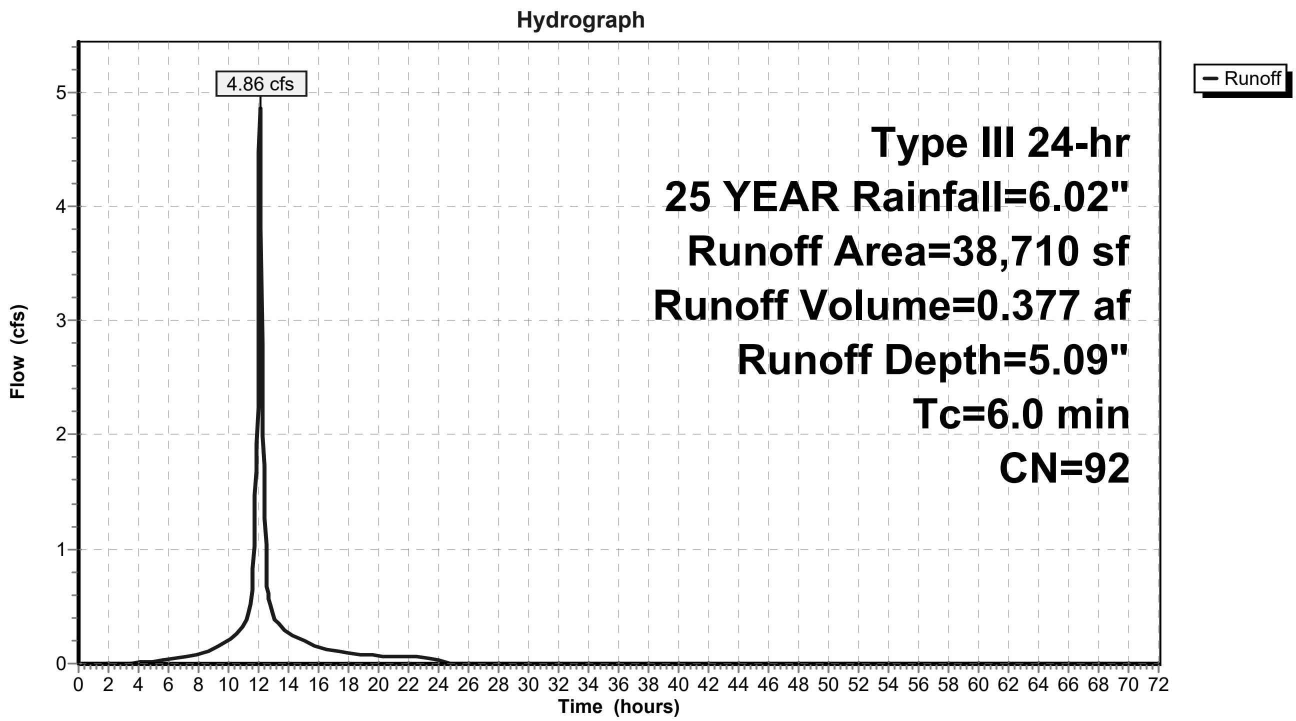
Runoff = 4.86 cfs @ 12.09 hrs, Volume= 0.377 af, Depth= 5.09"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 YEAR Rainfall=6.02"

Area (sf)	CN	Description
28,500	98	Paved parking, HSG C
10,210	74	>75% Grass cover, Good, HSG C
38,710	92	Weighted Average
10,210		26.38% Pervious Area
28,500		73.62% Impervious Area

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

Subcatchment D6B: (new Subcat)

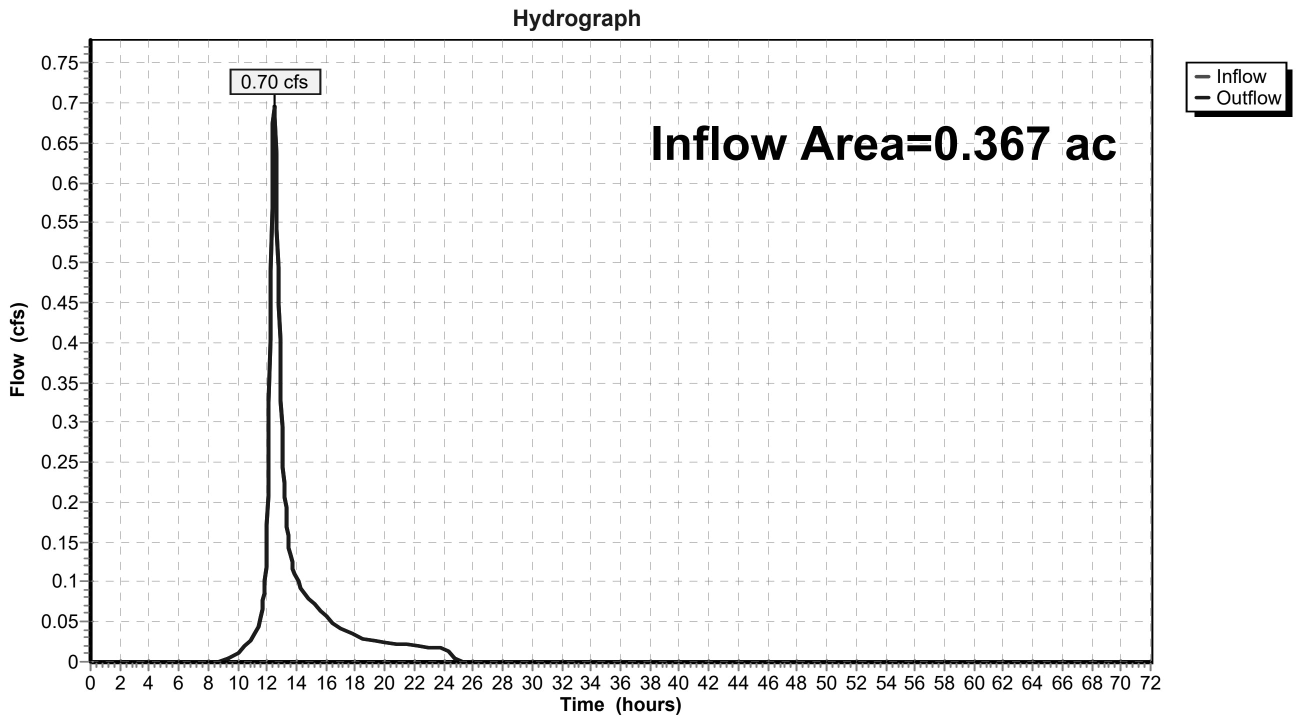


Summary for Reach 1D: SHATTUCK RD DITCH

Inflow Area =	0.367 ac,	5.80% Impervious, Inflow Depth = 3.01"	for 25 YEAR event
Inflow =	0.70 cfs @	12.47 hrs, Volume=	0.092 af
Outflow =	0.70 cfs @	12.47 hrs, Volume=	0.092 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 1D: SHATTUCK RD DITCH

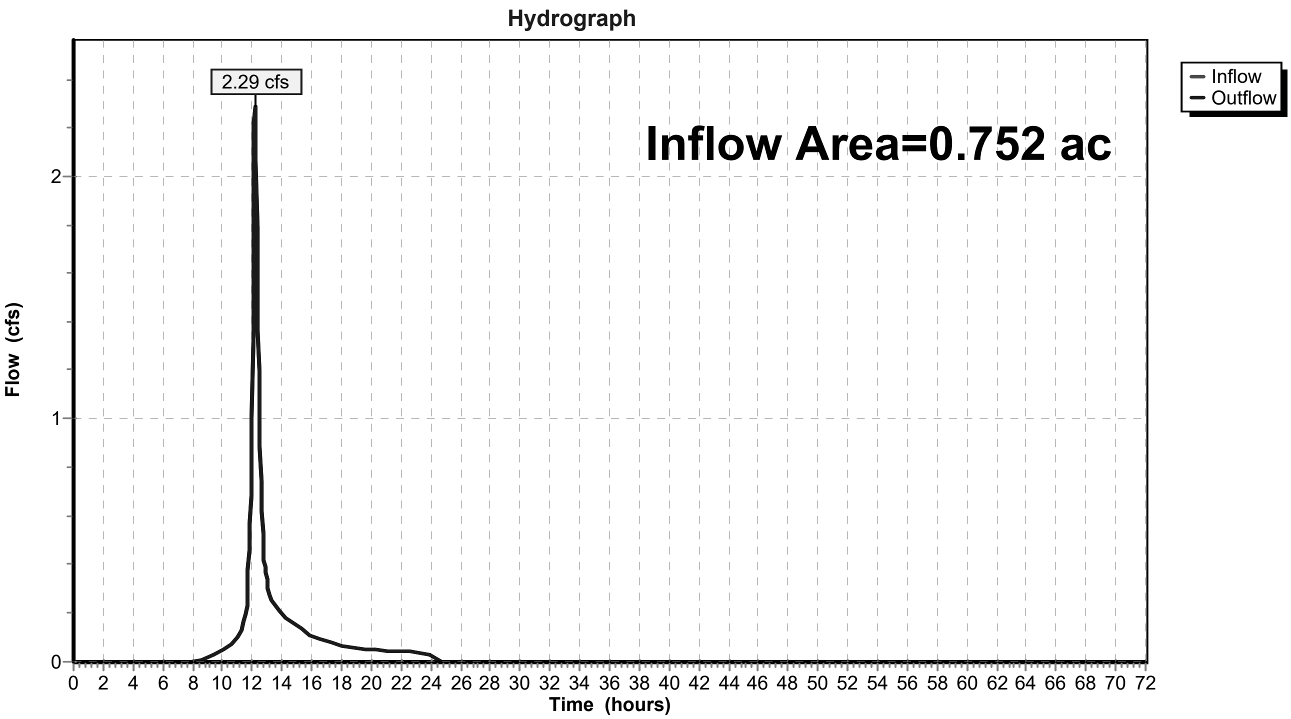


Summary for Reach 2D: OVERLAND TO CORP DRV. & B4 DRV DRAIN.

Inflow Area = 0.752 ac, 10.31% Impervious, Inflow Depth = 3.30" for 25 YEAR event
Inflow = 2.29 cfs @ 12.19 hrs, Volume= 0.207 af
Outflow = 2.29 cfs @ 12.19 hrs, Volume= 0.207 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 2D: OVERLAND TO CORP DRV. & B4 DRV DRAIN.

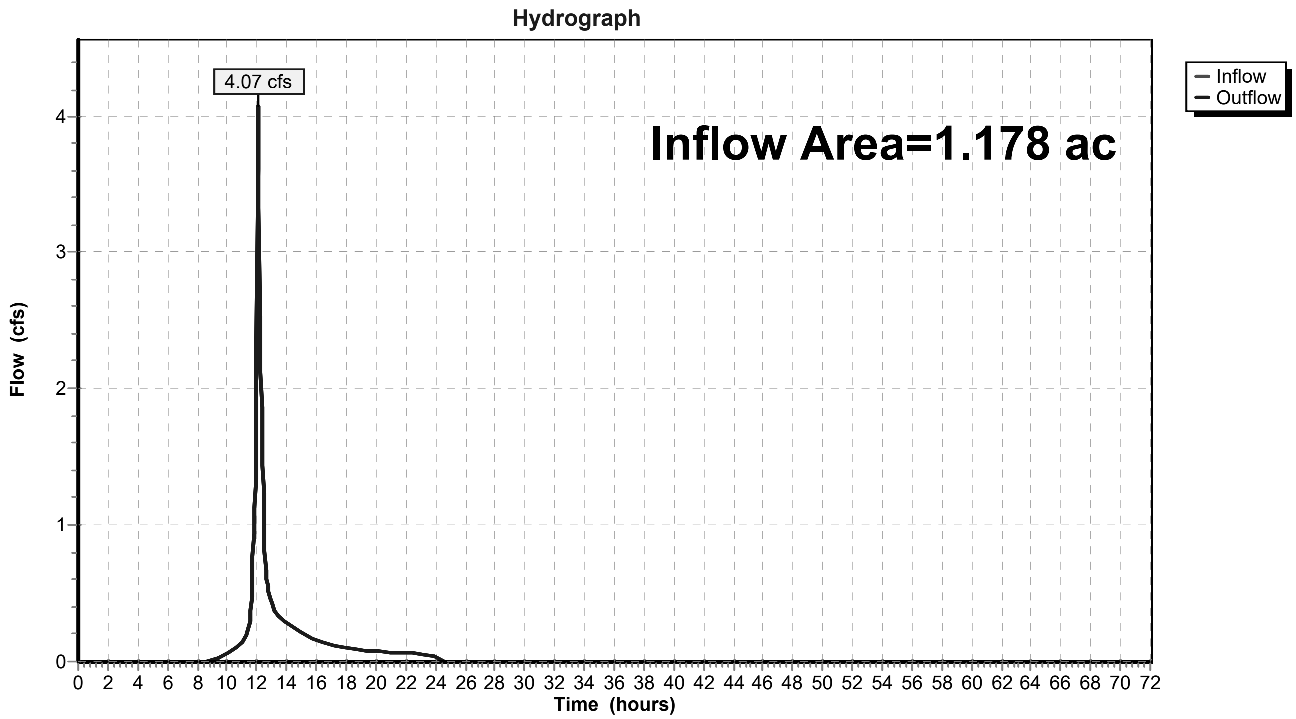


Summary for Reach 3D: MEADOW TO DRAIN

Inflow Area = 1.178 ac, 2.63% Impervious, Inflow Depth = 3.01" for 25 YEAR event
Inflow = 4.07 cfs @ 12.09 hrs, Volume= 0.296 af
Outflow = 4.07 cfs @ 12.09 hrs, Volume= 0.296 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 3D: MEADOW TO DRAIN

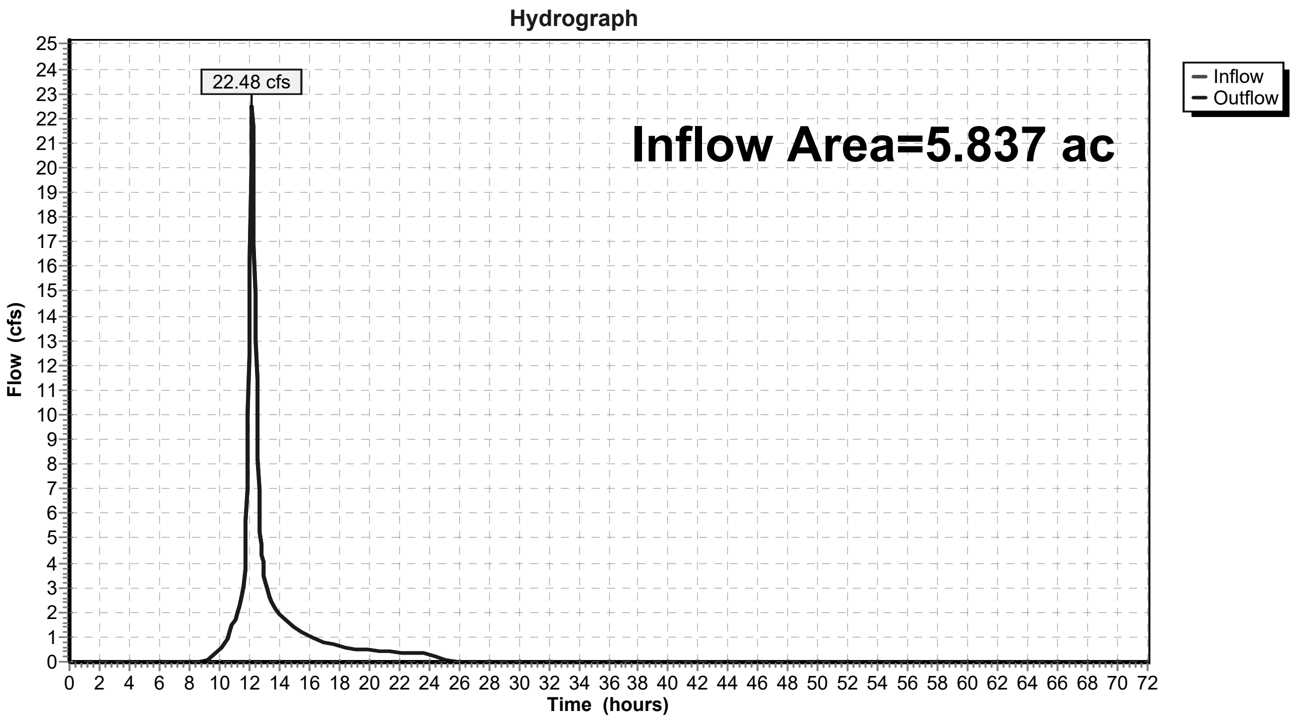


Summary for Reach 4D: B1 SITE TO DRAIN

Inflow Area = 5.837 ac, 75.38% Impervious, Inflow Depth = 4.54" for 25 YEAR event
Inflow = 22.48 cfs @ 12.18 hrs, Volume= 2.210 af
Outflow = 22.48 cfs @ 12.18 hrs, Volume= 2.210 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 4D: B1 SITE TO DRAIN

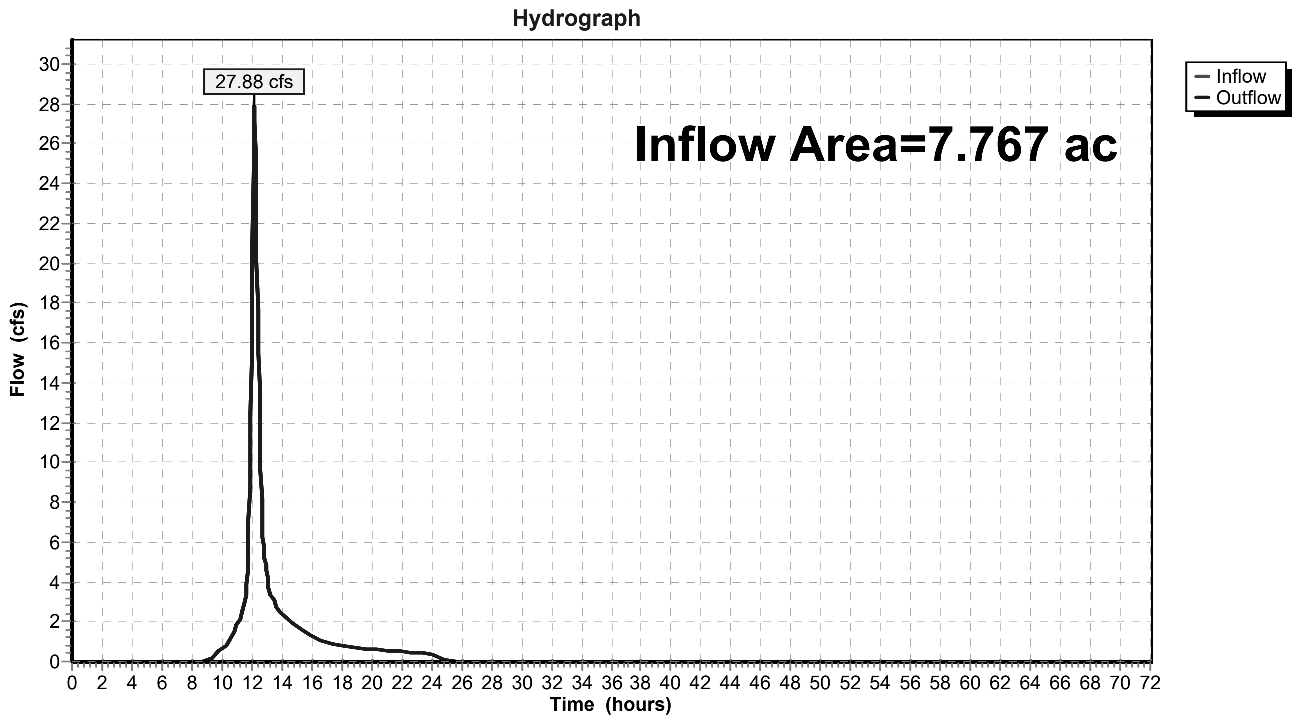


Summary for Reach 5D: TOTAL B1 SITE TO EXIST. SW BASIN

Inflow Area = 7.767 ac, 58.04% Impervious, Inflow Depth = 4.19" for 25 YEAR event
Inflow = 27.88 cfs @ 12.16 hrs, Volume= 2.712 af
Outflow = 27.88 cfs @ 12.16 hrs, Volume= 2.712 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 5D: TOTAL B1 SITE TO EXIST. SW BASIN

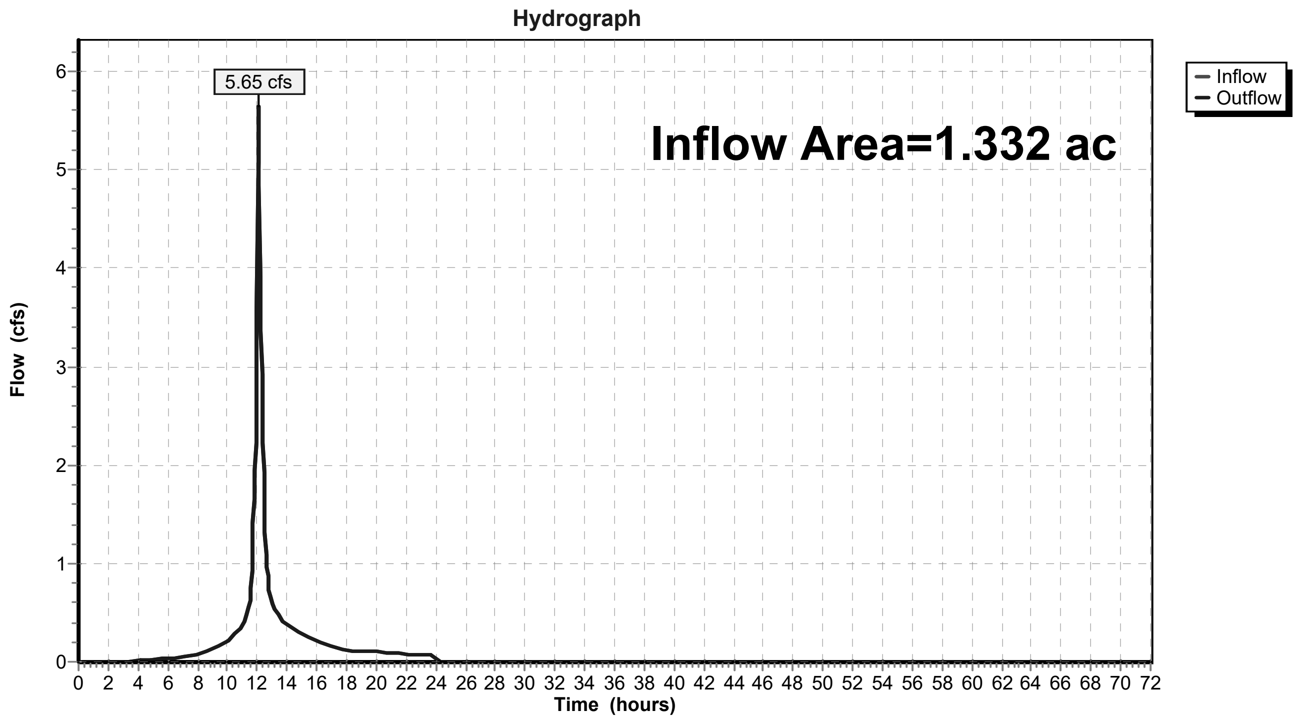


Summary for Reach 5R:

Inflow Area = 1.332 ac, 49.13% Impervious, Inflow Depth = 4.33" for 25 YEAR event
Inflow = 5.65 cfs @ 12.10 hrs, Volume= 0.481 af
Outflow = 5.65 cfs @ 12.10 hrs, Volume= 0.481 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 5R:

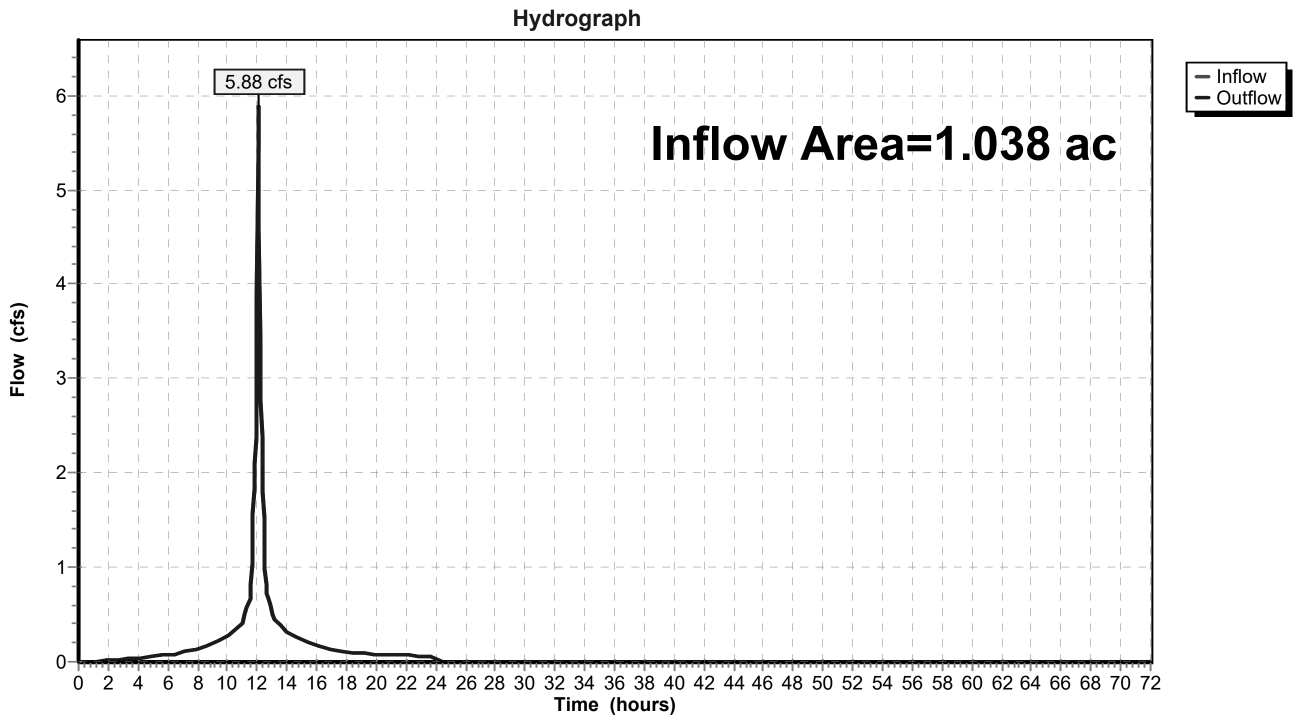


Summary for Reach 17R:

Inflow Area = 1.038 ac, 91.15% Impervious, Inflow Depth = 5.55" for 25 YEAR event
Inflow = 5.88 cfs @ 12.09 hrs, Volume= 0.480 af
Outflow = 5.88 cfs @ 12.09 hrs, Volume= 0.480 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach 17R:

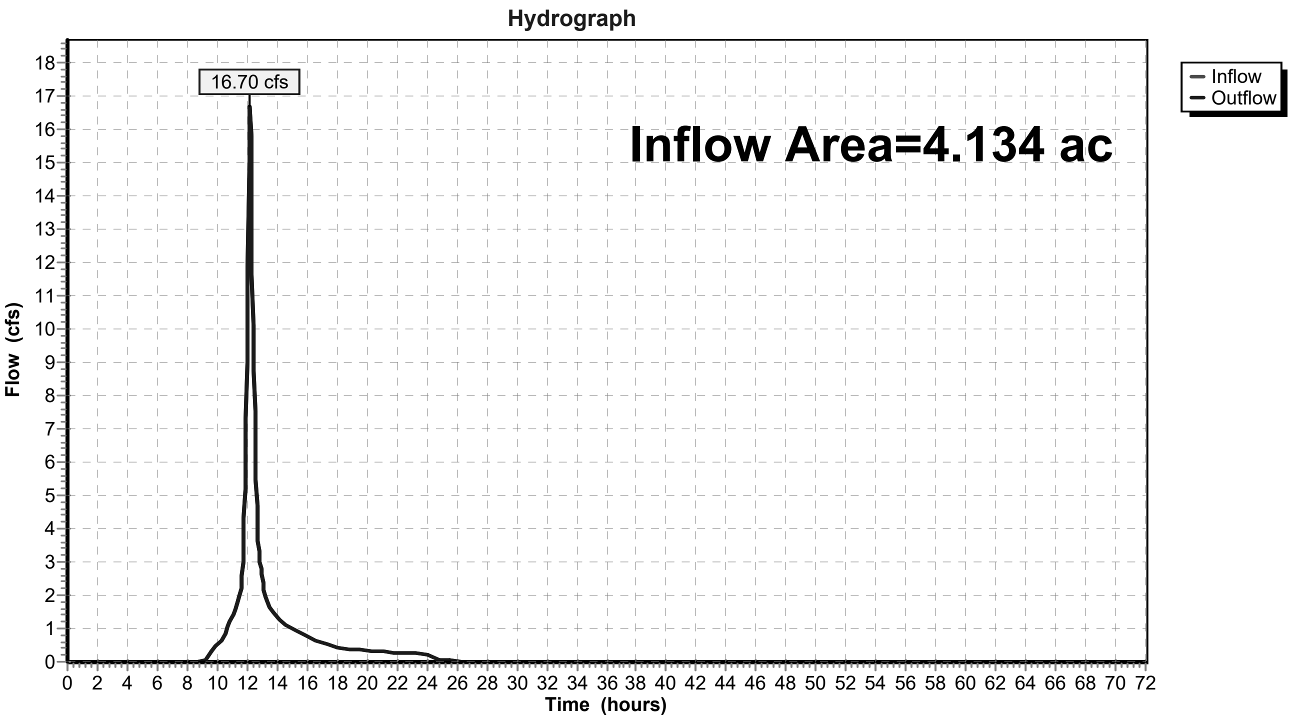


Summary for Reach STC1: STC#1

Inflow Area = 4.134 ac, 76.55% Impervious, Inflow Depth = 4.65" for 25 YEAR event
Inflow = 16.70 cfs @ 12.17 hrs, Volume= 1.603 af
Outflow = 16.70 cfs @ 12.17 hrs, Volume= 1.603 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach STC1: STC#1

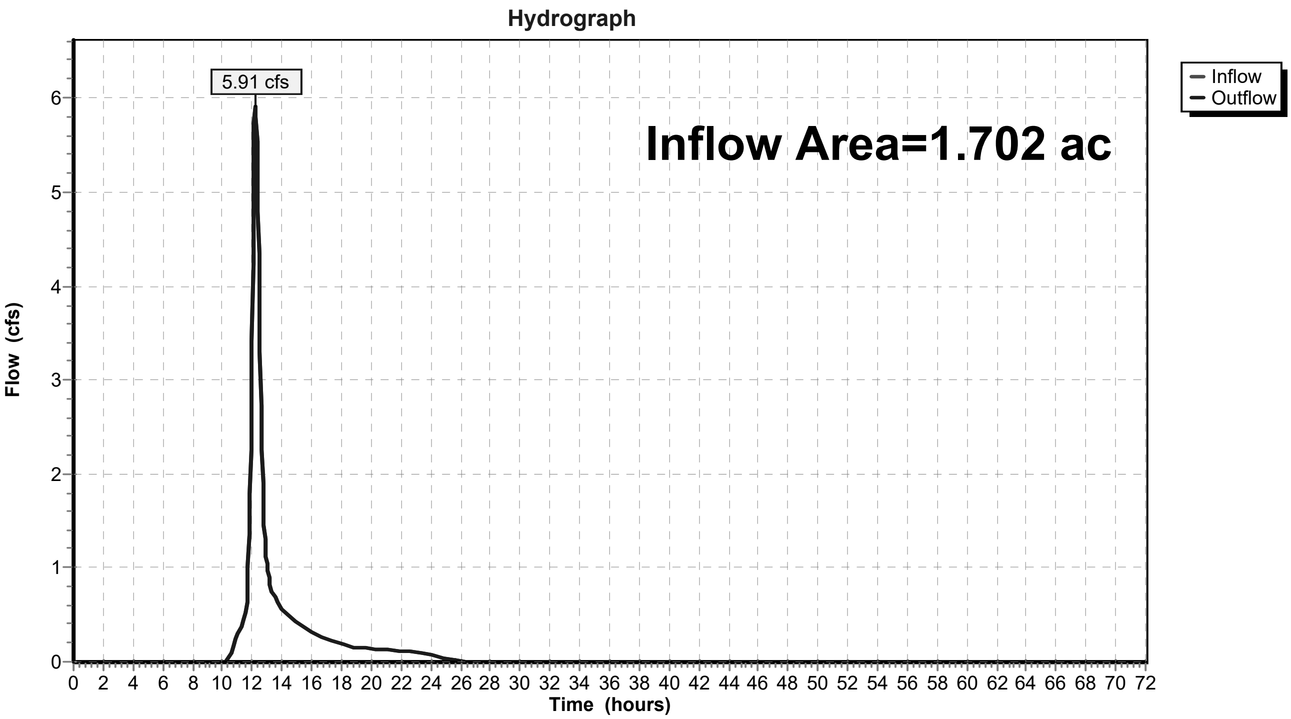


Summary for Reach STC2: STC#2

Inflow Area = 1.702 ac, 72.53% Impervious, Inflow Depth = 4.28" for 25 YEAR event
Inflow = 5.91 cfs @ 12.21 hrs, Volume= 0.607 af
Outflow = 5.91 cfs @ 12.21 hrs, Volume= 0.607 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Reach STC2: STC#2



Summary for Pond IB1: ISTR#1

Inflow Area = 1.254 ac, 84.04% Impervious, Inflow Depth = 5.55" for 25 YEAR event
Inflow = 7.14 cfs @ 12.09 hrs, Volume= 0.580 af
Outflow = 6.22 cfs @ 12.14 hrs, Volume= 0.495 af, Atten= 13%, Lag= 3.0 min
Primary = 6.22 cfs @ 12.14 hrs, Volume= 0.495 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 151.81' @ 12.14 hrs Surf.Area= 0.064 ac Storage= 0.127 af

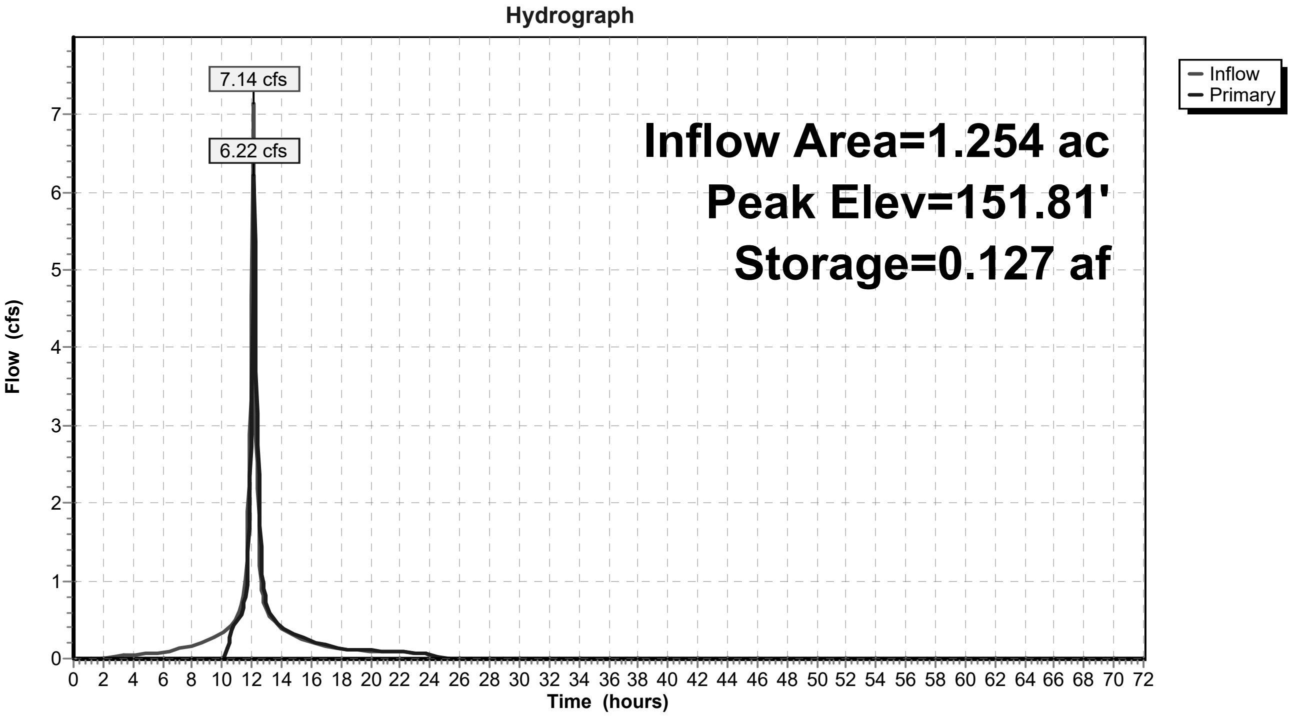
Plug-Flow detention time= 121.9 min calculated for 0.495 af (85% of inflow)
Center-of-Mass det. time= 59.1 min (817.2 - 758.2)

Volume	Invert	Avail.Storage	Storage Description
#1	150.00'	0.141 af	**Shea Leaching Chamber 8x14x2.7 @ 13.00' L** x 33 Inside= 84.0"W x 24.0"H => 15.38 sf x 12.07'L = 185.7 cf Outside= 96.0"W x 32.0"H => 21.36 sf x 13.00'L = 277.7 cf

Device	Routing	Invert	Outlet Devices
#1	Device 2	151.20'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 2.7' Crest Height
#2	Primary	148.50'	**18.0" Round Culvert** L= 50.0' Ke= 0.500 Inlet / Outlet Invert= 148.50' / 148.30' S= 0.0040 '/' Cc= 0.900 n= 0.013, Flow Area= 1.77 sf

Primary OutFlow Max=6.11 cfs @ 12.14 hrs HW=151.80' TW=150.08' (Dynamic Tailwater)
└─**2=Culvert** (Passes 6.11 cfs of 11.18 cfs potential flow)
  └─**1=Sharp-Crested Rectangular Weir** (Weir Controls 6.11 cfs @ 2.61 fps)

Pond IB1: ISTR#1



Summary for Pond IB2: (new Pond)

Inflow Area = 4.134 ac, 76.55% Impervious, Inflow Depth = 4.94" for 25 YEAR event
Inflow = 20.33 cfs @ 12.10 hrs, Volume= 1.702 af
Outflow = 16.70 cfs @ 12.17 hrs, Volume= 1.603 af, Atten= 18%, Lag= 4.2 min
Primary = 16.70 cfs @ 12.17 hrs, Volume= 1.603 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 150.14' @ 12.17 hrs Surf.Area= 0.075 ac Storage= 0.260 af

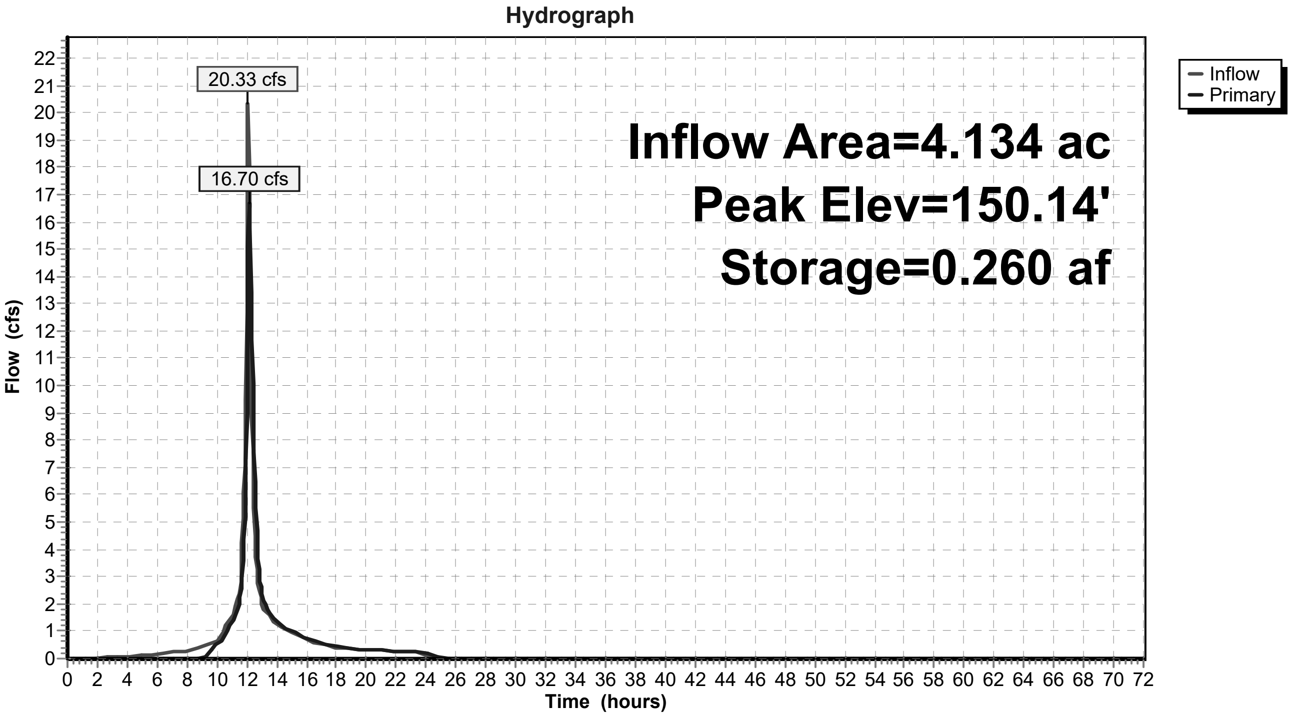
Plug-Flow detention time= 71.8 min calculated for 1.602 af (94% of inflow)
Center-of-Mass det. time= 40.1 min (822.4 - 782.3)

Volume	Invert	Avail.Storage	Storage Description
#1	147.00'	0.331 af	**Shea Leaching Chamber 8x14x4.7** x 36 Inside= 84.0"W x 48.0"H => 30.77 sf x 13.00'L = 400.0 cf Outside= 96.0"W x 56.0"H => 37.36 sf x 14.00'L = 523.0 cf

Device	Routing	Invert	Outlet Devices
#1	Primary	148.20'	**18.0" Round Culvert** L= 5.0' Ke= 0.500 Inlet / Outlet Invert= 148.20' / 148.13' S= 0.0140 '/' Cc= 0.900 n= 0.012, Flow Area= 1.77 sf
#2	Primary	148.20'	**18.0" Round Culvert** L= 7.0' Ke= 0.500 Inlet / Outlet Invert= 148.20' / 148.13' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 1.77 sf

Primary OutFlow Max=16.50 cfs @ 12.17 hrs HW=150.12' TW=0.00' (Dynamic Tailwater)
1=Culvert (Barrel Controls 8.28 cfs @ 4.75 fps)
2=Culvert (Barrel Controls 8.22 cfs @ 4.71 fps)

Pond IB2: (new Pond)



Summary for Pond IS3: IS#3

Inflow Area = 0.729 ac, 59.53% Impervious, Inflow Depth = 4.65" for 25 YEAR event
Inflow = 3.75 cfs @ 12.09 hrs, Volume= 0.282 af
Outflow = 3.40 cfs @ 12.13 hrs, Volume= 0.231 af, Atten= 9%, Lag= 2.3 min
Primary = 3.40 cfs @ 12.13 hrs, Volume= 0.231 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 153.10' @ 12.13 hrs Surf.Area= 0.039 ac Storage= 0.068 af

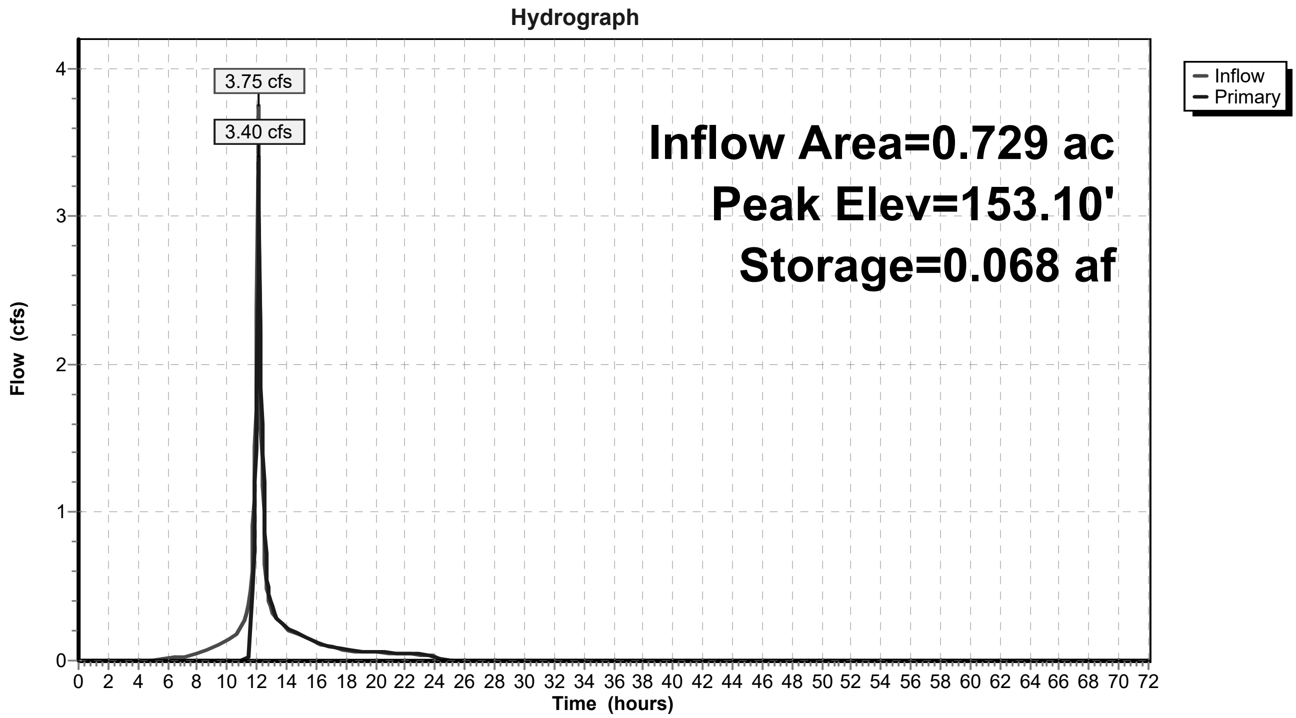
Plug-Flow detention time= 121.2 min calculated for 0.231 af (82% of inflow)
Center-of-Mass det. time= 49.2 min (840.5 - 791.4)

Volume	Invert	Avail.Storage	Storage Description
#1	151.50'	0.085 af	**Shea Leaching Chamber 8x14x2.7 @ 13.00' L** x 20 Inside= 84.0"W x 24.0"H => 15.38 sf x 12.07'L = 185.7 cf Outside= 96.0"W x 32.0"H => 21.36 sf x 13.00'L = 277.7 cf

Device	Routing	Invert	Outlet Devices
#1	Device 2	152.70'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.2' Crest Height
#2	Primary	150.00'	**15.0" Round Culvert** L= 60.0' Ke= 0.500 Inlet / Outlet Invert= 150.00' / 149.40' S= 0.0100 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=3.33 cfs @ 12.13 hrs HW=153.10' TW=149.40' (Dynamic Tailwater)
└─**2=Culvert** (Passes 3.33 cfs of 9.05 cfs potential flow)
  └─**1=Sharp-Crested Rectangular Weir** (Weir Controls 3.33 cfs @ 2.14 fps)

Pond IS3: IS#3


Hydrograph
3.75 cfs
3.40 cfs
Inflow Area=0.729 ac
Peak Elev=153.10'
Storage=0.068 af
Inflow
Primary
Flow (cfs)
Time (hours)
0
1
2
3
4
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72

Summary for Pond IS4: IS#4

Inflow Area = 1.702 ac, 72.53% Impervious, Inflow Depth = 4.67" for 25 YEAR event
Inflow = 8.72 cfs @ 12.10 hrs, Volume= 0.662 af
Outflow = 5.91 cfs @ 12.21 hrs, Volume= 0.607 af, Atten= 32%, Lag= 6.4 min
Primary = 5.91 cfs @ 12.21 hrs, Volume= 0.607 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 149.60' @ 12.21 hrs Surf.Area= 0.042 ac Storage= 0.142 af

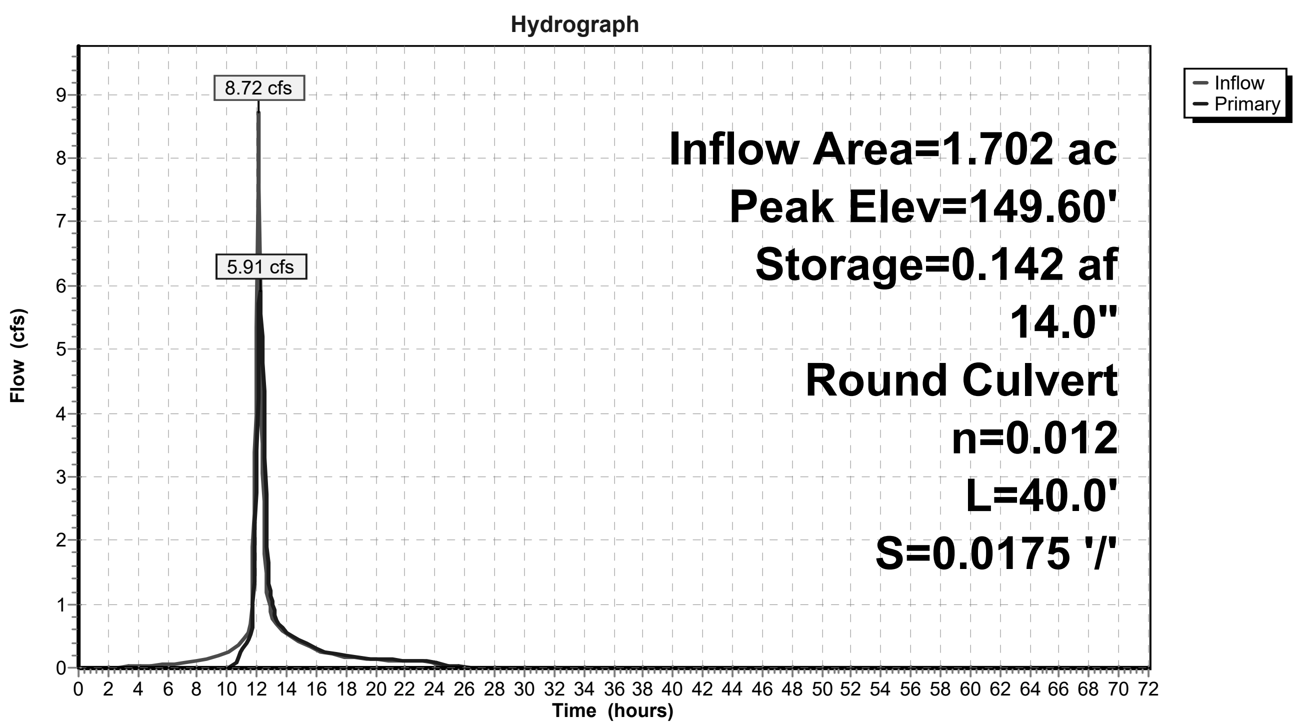
Plug-Flow detention time= 91.1 min calculated for 0.607 af (92% of inflow)
Center-of-Mass det. time= 47.7 min (841.3 - 793.6)

Volume	Invert	Avail.Storage	Storage Description
#1	146.50'	0.184 af	**Shea Leaching Chamber 8x14x4.7** x 20 Inside= 84.0"W x 48.0"H => 30.77 sf x 13.00'L = 400.0 cf Outside= 96.0"W x 56.0"H => 37.36 sf x 14.00'L = 523.0 cf

Device	Routing	Invert	Outlet Devices
#1	Primary	147.70'	**14.0" Round Culvert** L= 40.0' Ke= 0.500 Inlet / Outlet Invert= 147.70' / 147.00' S= 0.0175 '/' Cc= 0.900 n= 0.012, Flow Area= 1.07 sf

Primary OutFlow Max=5.90 cfs @ 12.21 hrs HW=149.60' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 5.90 cfs @ 5.52 fps)

Pond IS4: IS#4



MADEP CHECKLIST FOR STORMWATER REPORT

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

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

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

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

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

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

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

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

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

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature

COMMONWEALTH OF MASSACHUSETTS
RICHARD
GEORGE
CUTTS
CIVIL
No. 29034
REGISTERED
PROFESSIONAL ENGINEER

Jan. 26, 2022
Signature and Date

Checklist

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

☐ New development

☒ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

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

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

Standard 1: No New Untreated Discharges

- ☒ No new untreated discharges (Project uses recently approved outlet with reduced flow)
- ☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- ☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☒ Soil Analysis provided.

☐ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☒ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☒ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

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

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

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

- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☒ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

- ☐ is within the Zone II or Interim Wellhead Protection Area
- ☐ is near or to other critical areas
- ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
- ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist (continued)

Standard 4: Water Quality (continued)

☒ The BMP is sized (and calculations provided) based on:

- ☒ The ½" or 1" Water Quality Volume or
- ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☒ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

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

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist (continued)

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

☒ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☒ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☒ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

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

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

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist (continued)

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

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☒ Name of the stormwater management system owners;
- ☒ Party responsible for operation and maintenance;
- ☒ Schedule for implementation of routine and non-routine maintenance tasks;
- ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☒ Description and delineation of public safety features;
- ☒ Estimated operation and maintenance budget; and
- ☒ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☒ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

OPERATION AND MAINTENANCE PLAN

Property Description:

The property which is the subject of this O & M Manual is located at 1 and 4 Corporate Drive in Andover, MA. The land area of the property consists of 24.0± acres and the land is located to the east of Shattuck Road and to the west of Interstate Route 93.

Stormwater from the improvements on the land is collected in a series of catch basins and conveyed by drainage pipes to a stormwater management basin located on the east side of the property near Interstate Route 93. The discharge from this basin is conveyed via a constructed drainage channel in a utility and drainage easement north to a culvert under River Road and subsequently to the Merrimac River.

Operation and Maintenance Plan

In accordance with the Stormwater Management Regulations issued by the Department of Environmental Protection (DEP) and the Town of Andover Stormwater Management Bylaw, Linden Engineering Partners, LLC has prepared the following Operation and Maintenance Plan for the 1 and 4 Corporate Drive property.

This plan is broken into two major sections. The first section describes operational management practices. The second section is devoted to the operation and maintenance plan.

<u>Basic Information</u>

Property Owner & Financially Responsible Party:

IQHQ-1 Corporate, KKC and IQHQ-4 Corporate, LLC
c/o Mr. Will Ashton, IQHQ
One Boston Place, 201 Washington St, Suite 3920, Boston, MA 02108
Tel: 617-314-9620; Mobile 617-992-1930
Email: washton@iqhqreit.com

Property Manager and Person Responsible for Maintenance and Repairs:

Stacy Browne, Senior Real Estate Manager
CBRE, Property Management
One Tech Drive, Andover, MA 01810

Tel: 1 978 683 5224; Cell: 1 617 594 8883
Email: Stacy.Browne@cbre.com

Good Housekeeping BMP's (Construction and Post Construction Periods)

The following good housekeeping practices will be followed onsite during and after the construction project:

- An effort will be made to store only enough product required to do a particular job. All materials stored onsite will be stored in a neat, orderly manner in their appropriate containers and, if possible under a roof or other enclosure.
- Products will be kept in their original containers with the original manufacturer's label.
- Substances will not be mixed with one another unless recommended by the manufacturer.
- Whenever possible, all of a product will be used up before disposing of the container.
- Manufacturer's recommendations for proper use and disposal will be followed.

Material Handling and Waste Management

Hazardous Products:

These practices will be used to reduce the risks associated with hazardous materials. Material Safety Data Sheets (MSDSs) for each substance with hazardous properties that is used on the property will be obtained and used for the proper management of potential wastes that may result from these products. An MSDS will be posted in the immediate area where such product is stored and/or used and another copy of each MSDS will be maintained in the property management office. Each employee who must handle a substance with hazardous properties will be instructed on the use of MSDS sheets and the specific information in the applicable MSDS for the product they are using, particularly regarding spill control techniques.

- Products will be kept in original containers unless they are not re-sealable.
- Original labels and material safety data will be retained; they contain important product information.

- If surplus product must be disposed of, manufacture's or local and State recommended methods for proper disposal will be followed.

Hazardous Waste

All hazardous waste material will be disposed of in the manner specified by local, state, and/or federal regulations and by the manufacturer of such products. Site personnel will be instructed in these practices by the job site superintendent, who will also be responsible for seeing that these practices are followed.

Sanitary Wastes

All sanitary waste will be disposed of by means of the municipal sewer system connected to the buildings on the property

Equipment Fueling

No fuel shall be stored on the property except for fuel stored in approved containers as part of equipment. All fueling areas will be inspected and cleaned weekly as necessary.

Spill Prevention and Control Plan

The property manager will train all personnel in the proper handling and cleanup of spilled materials. No spilled hazardous materials or hazardous wastes will be allowed to come in contact with storm water discharges. If such contact occurs, the storm water discharge will be contained on site until appropriate measures in compliance with state and federal regulations are taken to dispose of such contaminated storm water. It shall be the responsibility of the job site superintendent to properly train all personnel in spill prevention and clean up procedures.

In order to minimize the potential for a spill of hazardous materials to come into contact with storm water, the following steps will be implemented:

1. All materials with hazardous properties (such as pesticides, petroleum products, fertilizers, detergents, chemicals, acids, paints, paint solvents, cleaning solvents will be stored in a secure location, with their lids on, under cover, when not in use.

2. The minimum practical quantity of all such materials will be kept on the property at all times.

3. A spill control and containment kit (containing, for example, absorbent materials, acid neutralizing powder, brooms, dust pans, mops, rags, gloves, goggles, plastic and metal trash containers, etc.) will be provided at the storage site. Catch basin inlet cover blankets and inflatable pipe plugs will be used to seal the openings in the outlet control structure and isolate product in the wet basin should a spill occur.

4. Manufacturer’s recommended methods for spill cleanup will be clearly posted and site personnel will be trained regarding these procedures and the location of the information and cleanup supplies.

In the event of a spill, the following procedures should be followed:

1. All spills will be cleaned up immediately after discovery.

2. The spill area will be kept well ventilated and personnel will wear appropriate protective clothing to prevent injury from contact with the hazardous substances.

3. The property manager will be notified immediately.

4. Spills of toxic or hazardous materials will be reported to the appropriate federal, state, and/or local government agency, regardless of the size of the spill.

The property manager will be the spill prevention and response coordinator. He/she will designate the individuals who will receive spill prevention and response training. These individuals will each become responsible for a particular phase of prevention and response. The names of these personnel will be posted in the property management office.

Allowable Non-Stormwater Discharge Management

Certain types of discharges are allowed under the NPDES Permit System, and it is the intent of this O & M Plan to allow such discharges. These types of discharges will be allowed under the conditions that no pollutants will be allowed to come into contact with the water prior to or after its discharge. The control measures that have been outlined previously in this O & M Plan will be strictly followed to ensure that no contamination of these non-stormwater discharges takes place. The following non-stormwater discharges that may occur from the job site include:

- Discharges from fire-fighting activities
- Fire Hydrant flushings
- Waters used to wash vehicles where detergents are not used
- Water used to control dust in accordance with off-site vehicle tracking
- Potable water including uncontaminated water line flushings
- Routine external building wash down that does not use detergents
- Pavement wash waters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled material has been removed) and where detergents are not used
- Uncontaminated air conditioner compressor condensate
- Uncontaminated ground water or spring water
- Foundation or footing drains where flows are not contaminated with process materials such as solvents
- Uncontaminated excavation dewatering
- Landscape irrigation

STORMWATER MANAGEMENT SYSTEM MAINTENANCE

Stormwater BMP’s

Several types of structural and non-structural water quality controls in various combinations are proposed to treat stormwater generated on the site. These measures include deep sump catch basins, stormwater treatment units, underground infiltration systems and a wet basin. These Water quality treatment measures will result in the removal of most of the total suspended solids (TSS) load in runoff prior to discharge from the site, consistent with DEP's TSS removal standards.

The following best management practices are specified in the proposed development program to mitigate the increase in stormwater runoff from the site.

BMPs Used

- Deep Sump Catch basins – 50 Catch basins
- Trench Drains – 2 Trench Drains
- Stormwater Treatment Units – 1 Stormceptor STC 900, 2 Contech Cascade CS-4
- Underground Infiltration Structures – 5 Systems Total
- Wet Basin – 1 Basin

Post-Development Activities

1. Paved Areas: Paved Areas shall be mechanically swept during the dry weather to remove excess sediments, thereby reducing the amount of sediments that the drainage system will have to remove from the runoff. Paved areas shall be mechanically swept a minimum of two times each year (in the spring after all snow and ice have melted and late in the fall prior to snowfall).

2. The use of salt or chemicals for de-icing on the paved areas during the winter months shall be limited to the minimum amount necessary to maintain pedestrian and vehicle safety. Alternative measures to sodium chloride are encouraged for use at the site.

3. Deep Sump Catch Basins: All Catch basins shall be inspected at least four times/year (once in the spring at the end of snowfall and once at the end of the fall foliage season and two other times spaced throughout the year) to verify that the inlet openings are not clogged by debris and to determine if the sump needs to be cleaned). Any debris shall be removed from the inlet grates and disposed of properly. The catch basin sumps shall be inspected and cleaned whenever the depth of the sediment is 25% or more of the sump depth or cleaned a minimum of twice annually. Material shall be removed from the catch basins and disposed of in accordance with all applicable regulations.

4. Trench Drains: All Trench Drains shall be inspected at least four times/year (once in the spring at the end of snowfall and once at the end of the fall foliage season and two other times spaced throughout the year) to verify that the inlet and outlet openings are not clogged by debris and to determine if they need to be cleaned). Any debris shall be removed from

the inlet grates and disposed of properly. The trench drains shall be inspected and cleaned whenever the depth of the sediment is 25% or more of the depth or cleaned a minimum of twice annually. Material shall be removed from the trench drains and disposed of in accordance with all applicable regulations.

5. The Stormwater Treatment Units (Stormceptor & Cascade): Stormwater Treatment Units shall be cleaned and inspected a minimum of four times per year for the first year and twice per year thereafter if the silt trap is not full in six months . Cleaning shall be in strict conformance with the manufacturer's written instructions which are attached to this Operations and Maintenance Plan.

6. The Subsurface (Underground) Infiltration Structures and the inlet/outlet pipes shall be inspected a minimum of twice/year for signs of accumulated water, debris and rodent activity. Remove any debris that is observed. Implement appropriate corrective action if any issues are discovered during the inspections.

7. Inspect the Wet Basin at least once per year to ensure the basin is operating as designed. Inspect the outlet pipes and structure for evidence of clogging or excessive outflow releases. Potential problems to check include: subsidence, erosion, cracking or tree growth on the embankment, damage to the emergency spillway, sediment accumulation around the outlet, inadequacy of the inlet/outlet channel erosion control measures, changes in the condition of the pilot channel, erosion within the basin and banks, and the emergence of invasive species. Make any necessary repairs immediately. During inspections, note any changes to the wet basin or the contributing watershed area because these may affect basin performance. At least twice a year, mow the upper-stage, side slopes, embankment and emergency spillway. Remove sediment from the basin as necessary, and at least once every 10 years.

8. All sediments removed from the site drainage facilities shall be disposed of properly and in accordance with all applicable local and state regulations.

9. All vegetated slope areas on the site shall be stabilized following completion of construction and maintained to control erosion. Any

disturbed areas shall be re-seeded and stabilized by the application of jute mesh if the slope exceeds 3 feet horizontal to 1 foot vertical.

10. Maintenance Responsibilities: All post-construction maintenance activities shall be documented and kept on file and made available to the Town of Andover Conservation Commission. Post-construction maintenance shall be the responsibility of the Property Owner.

All structural BMP's and maintenance responsibilities as identified on the site plans and within this document will be owned and maintained by the owner of the property and shall run with the title of the property.

Annual Reporting Form

The Owner of the facility shall keep complete records of all BMP maintenance activities. Annual reports shall be made to the Andover Conservation Commission using the following form:

OPERATION AND MAINTENANCE PLAN
Project: 1 and 4 Corporate Drive
Location: 1 and 4 Corporate Drive, Andover, MA **Date: January 26, 2021**

Structure or Task	Inspection Schedule	Inspection Performed		Method	Notes/Remarks
		Date	By:		
Street Sweeping	April / May			Power broom or vacuum walks and pavement	
Catch Basins & Trench Drains, Total 50 CB's, 2 Trench Drains	March			Clam shell or vacuum sumps, vacuum trench drains	Clean when sediment is 12" deep in catch basins or 25% of deep in trench drains or at least twice annually
	June				
	September				
	December				
TSS Removal Systems (Stormceptor Units, Contech Cascade Units) Total 3 Units	March			Remove debris in accordance with manufacturer's recommendations vacuum sumps	Reduce to bi-annual inspections after first year of operations
	June				
	September				
	December				
Subsurface Infiltration Systems Total 5 Systems	April / May			Inspect Units through observation manholes	Remove any debris and correct any problems observed
	Sept. / Oct.				
Wet Basin	April / May			Inspect banks and bottoms	Remove accumulated debris and silt
	Sept. / Oct.				

Party responsible for O & M Plan:

Name IQHQ-1 Corporate, LLC & IQHQ-4 Corporate, LLC
Address: One Boston Place, 201 Washington Street Suite 3920, Boston, MA 02108
Contact: Mr. Will Ashton
Phone: (617) 314-7906

NOTE: This form must be submitted to the Andover Conservation Commission yearly by November 1st.

Annual Operating Budget

The estimated annual operating budget for the O & M Plan for the 1 and 4 Corporate Drive property is $10,000.

Plan of BMP's

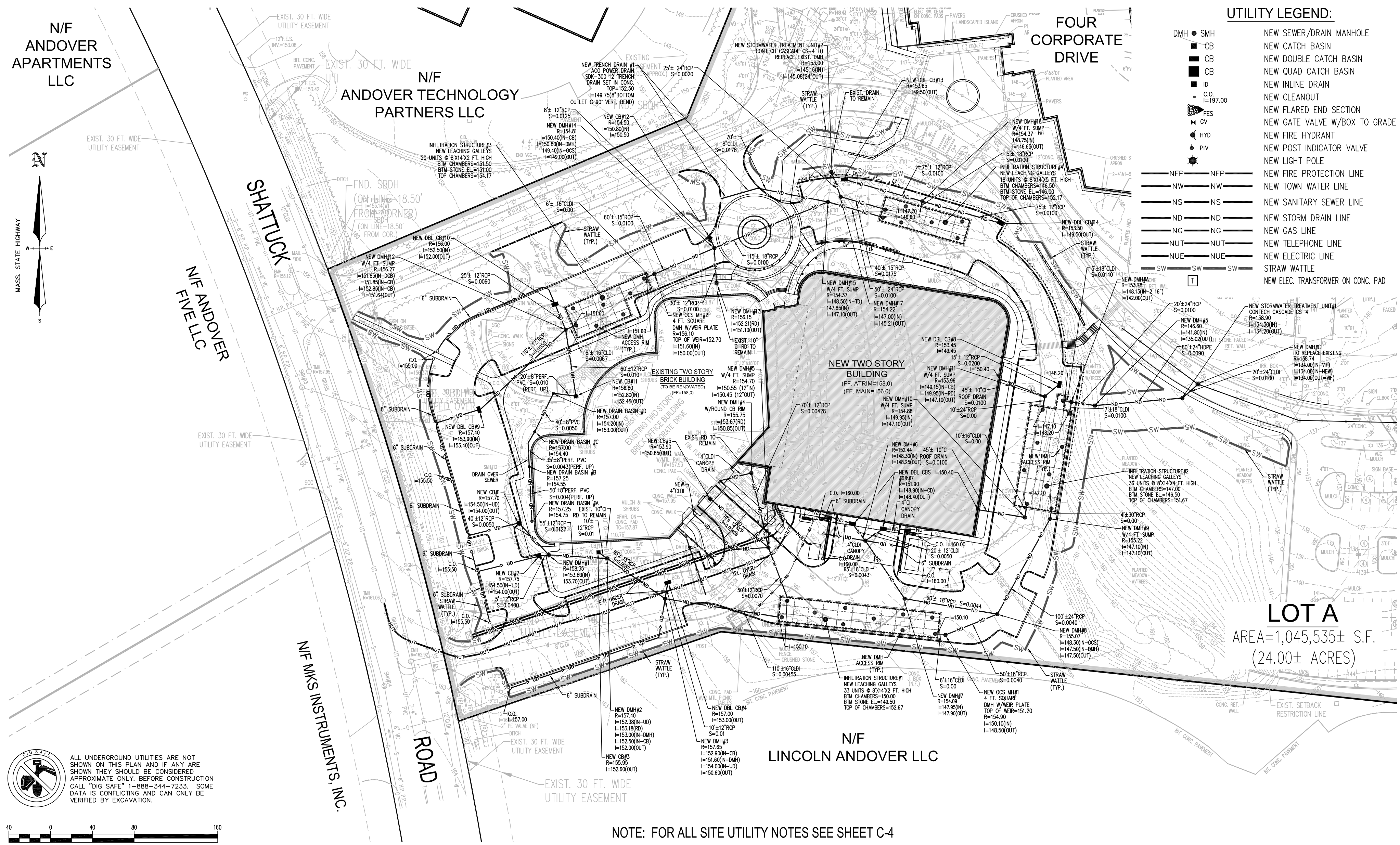
Reference is made to the As-Built Plan to be prepared upon completion of the 1 Corporate Drive Redevelopment Project for the location of all BMP's.

Conclusion

The construction of the proposed site development as proposed will provide runoff control for the completed development as required by the MADEP Stormwater Regulations.

DRAIN SYSTEM PLANS

THE PLANS OF THE DRAINAGE SYSTEM ATTACHED HERETO WILL BE REPIACED WITH NEW UP TO DATE AS-BUILT PLANS OF THE SITE UPON COMPLETION OG THE BUILDING 1 REDEVELOPMENT. FULL SIZE PLANS WILL BE PROVIDED TO THE MAINTENANCE PERSONNEL AT THE SITE.



NOTE: FOR ALL SITE UTILITY NOTES SEE SHEET C-4

DATE	BY	REV#	REVISIONS
1/26/2022	RGC	⚠	ISSUED FOR PERMITTING

CALC. BY:	WAJ
DR. BY:	WAJ
CKD. BY:	RGC/WAJ
APPD. BY:	RGC
JOB NO.:	21055
SCALE:	1" = 40'
DATE:	JAN. 26, 2022

RICHARD GEORGE CUTTS CIVIL No. 29034 REGISTERED PROFESSIONAL ENGINEER

RICHARD G. CUTTS
REG. PROF. ENGINEER

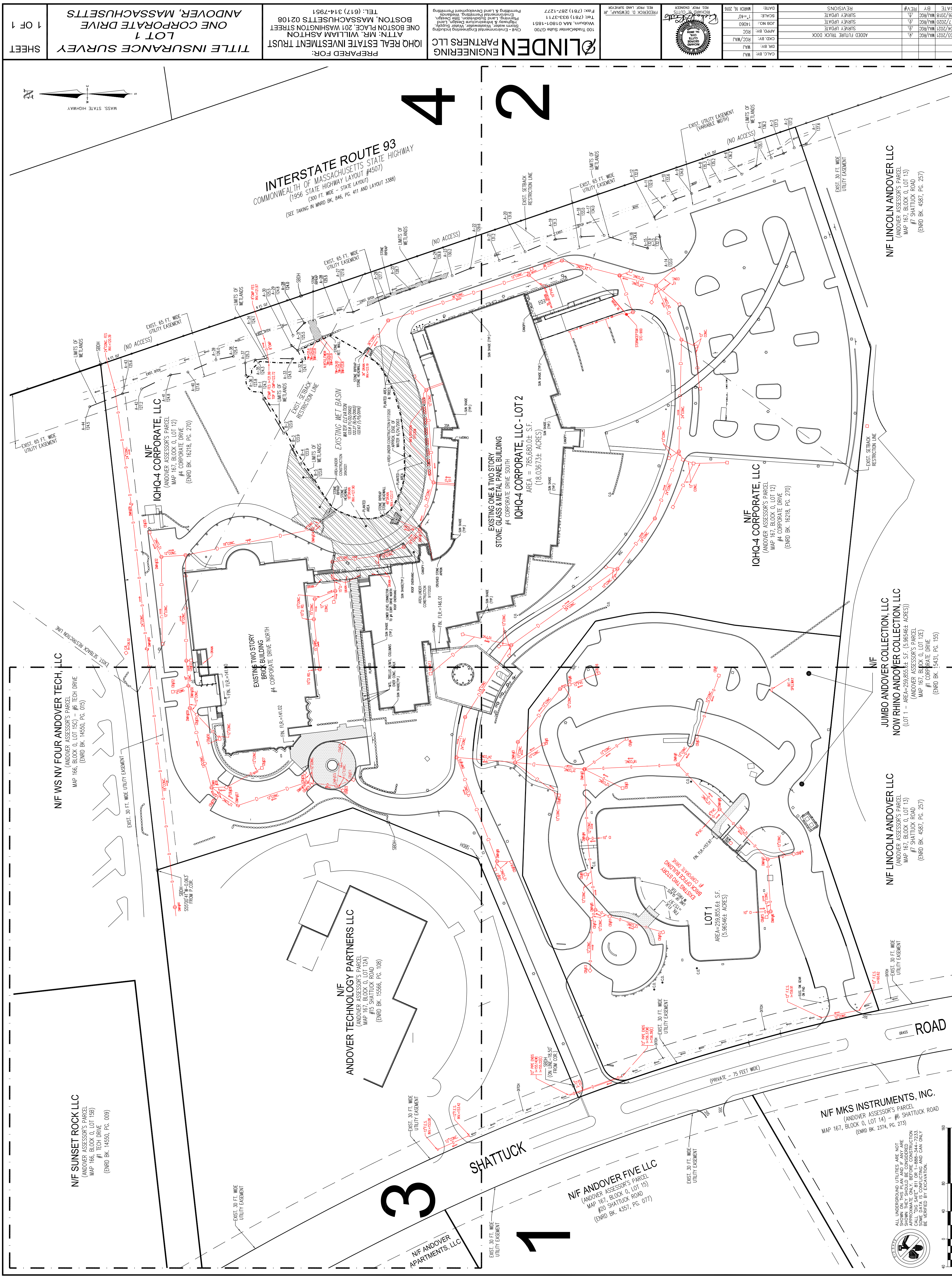
LINDEN ENGINEERING PARTNERS LLC
100 TradeCenter Suite G700
Woburn, MA 01801-1851
Tel: (781) 933-3711
Fax: (781) 287-1277

Civil - Environmental Engineering including Storm water, Wastewater, Water Supply, Highway & Infrastructure Design, Land Planning, Land Subdivision, Site Design, Environmental Permitting, Wetlands Permitting & Land Development Permitting

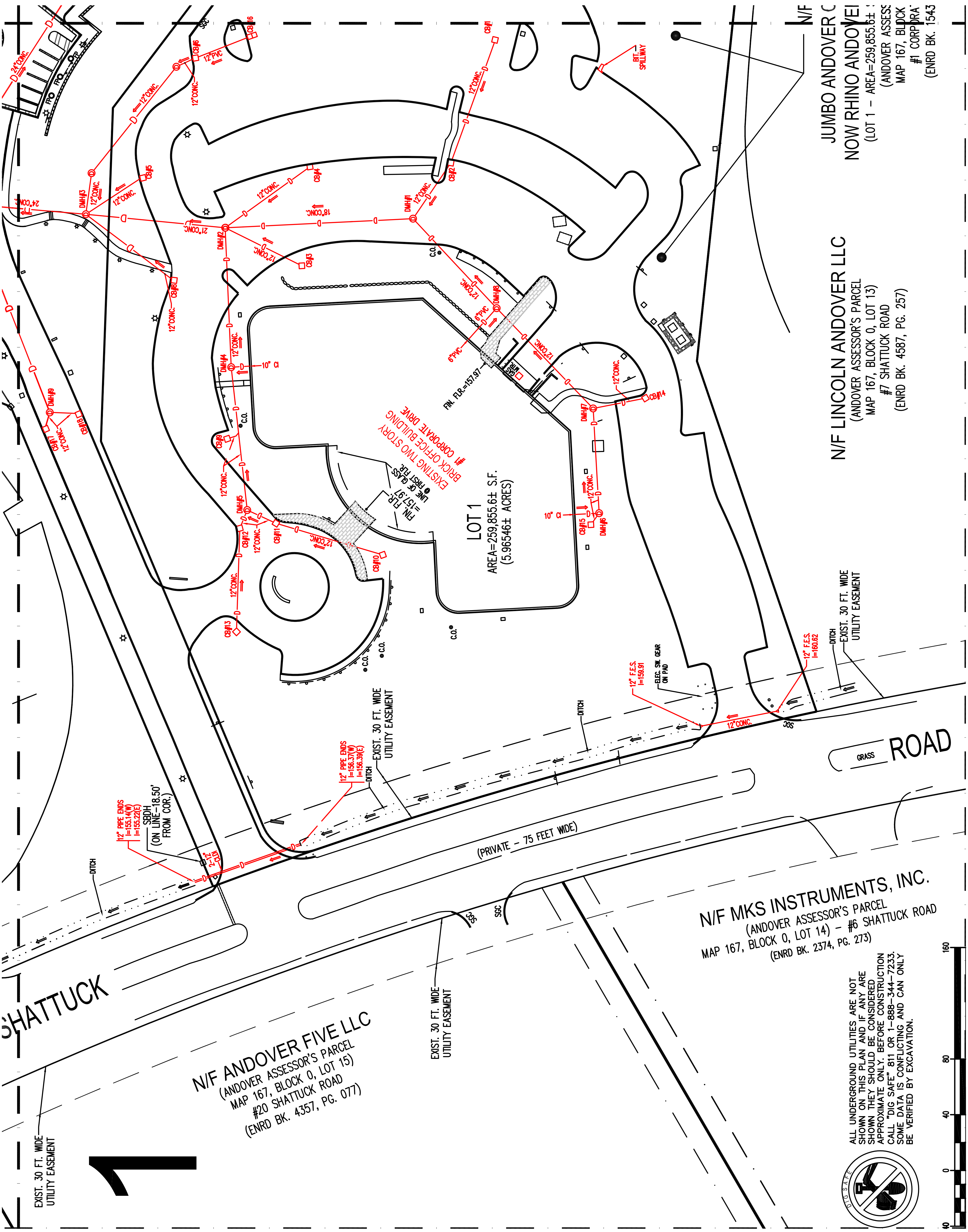
PREPARED FOR:
IQHQ-1 CORPORATE, LLC AND IQHQ-4 CORPORATE, LLC
ATTN: MR. WILLIAM ASHTON
ONE BOSTON PLACE, 201 WASHINGTON STREET, SUITE 3920
BOSTON, MASSACHUSETTS 02108
TEL: (617) 314-7951

SITE UTILITY PLAN
PROPOSED RENOVATION AND ADDITION
ONE AND FOUR CORPORATE DRIVE
ANDOVER, MASSACHUSETTS

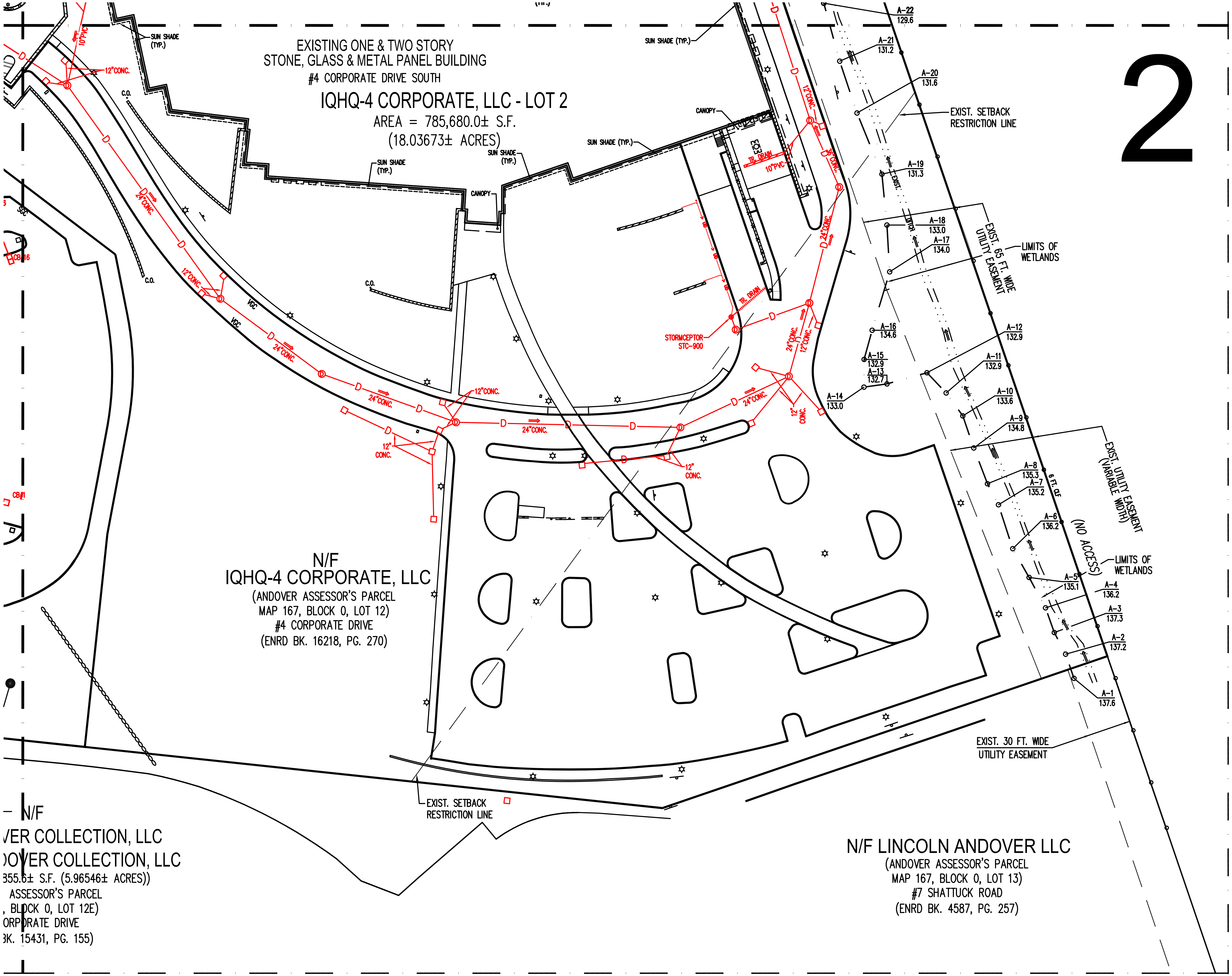
SHEET



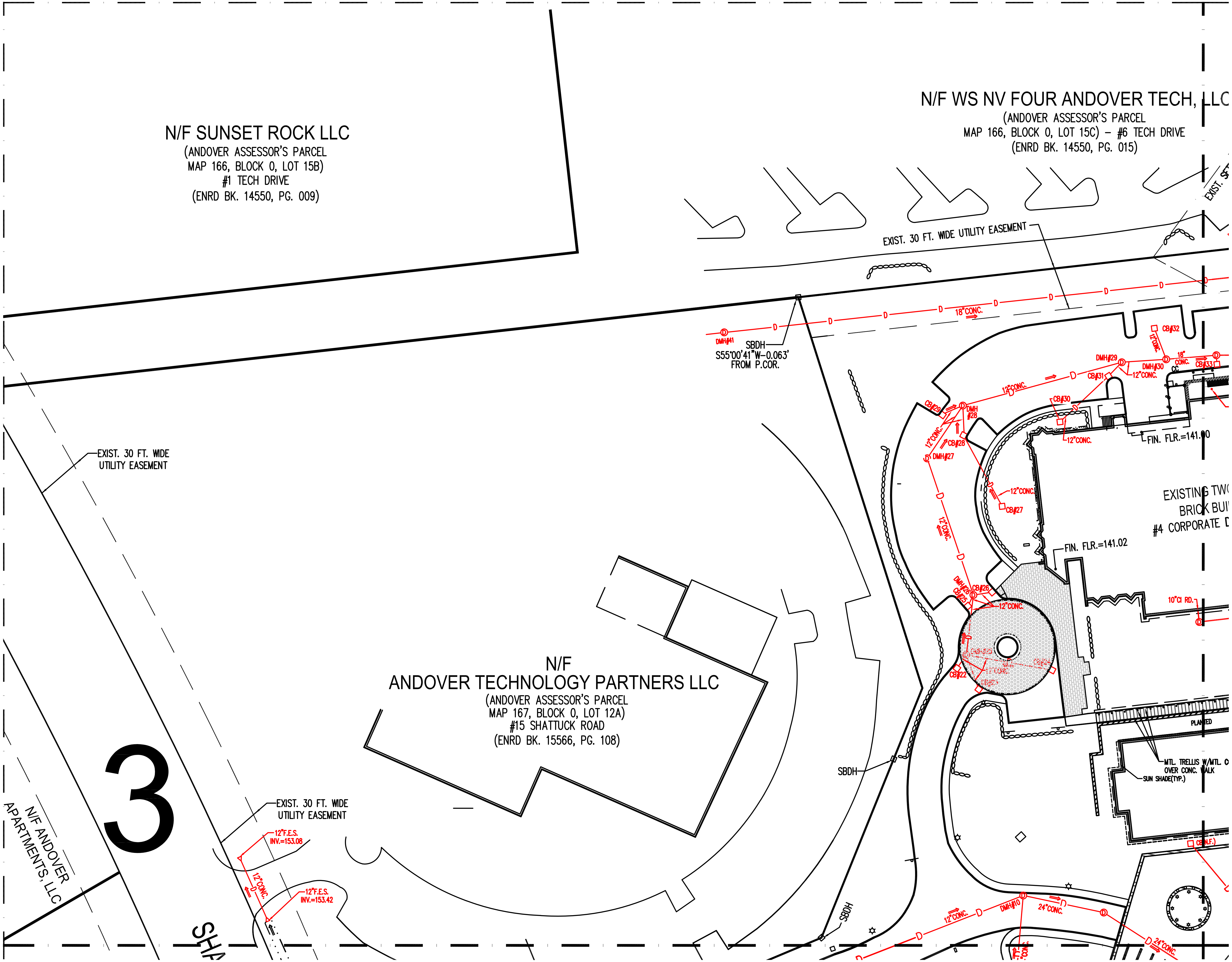
TITLE INSURANCE SURVEY
LOT 1
ONE CORPORATE DRIVE
ANDOVER, MASSACHUSETTS
SHEET
1 OF 1
PREPARED FOR:
IQHQ REAL ESTATE INVESTMENT TRUST
ONE BOSTON PLACE, 201 WASHINGTON STREET
BOSTON, MASSACHUSETTS 02108
ATTN: MR. WILLIAM ASHTON
TEL: (617) 314-7951
LINDEN ENGINEERING PARTNERS LLC
100 TradeCenter Suite G700
Woburn, MA 01801-1851
Tel: (781) 933-3711
Fax: (781) 287-1277
REVISIONS
ADDED FUTURE TRUCK DOCK
SURVEY UPDATE
INTERSTATE ROUTE 93
COMMONWEALTH OF MASSACHUSETTS STATE HIGHWAY
(1956 STATE HIGHWAY LAYOUT #4507)
(300 FT. WIDE - STATE LAYOUT)
EXISTING WET BASIN
N/F IQHQ-4 CORPORATE, LLC
(ANDOVER ASSESSOR'S PARCEL MAP 167, BLOCK 0, LOT 12)
#4 CORPORATE DRIVE
(ENRD BK. 16218, PG. 270)
EXISTING TWO STORY BRICK BUILDING
#4 CORPORATE DRIVE NORTH
EXISTING ONE & TWO STORY STONE, GLASS & METAL PANEL BUILDING
#4 CORPORATE DRIVE SOUTH
IQHQ-4 CORPORATE, LLC - LOT 2
AREA = 785,680.0± S.F.
(18.03673± ACRES)
N/F LINCOLN ANDOVER LLC
(ANDOVER ASSESSOR'S PARCEL MAP 167, BLOCK 0, LOT 13)
#7 SHATTUCK ROAD
(ENRD BK. 4587, PG. 257)
N/F JUMBO ANDOVER COLLECTION, LLC
NOW RHINO ANDOVER COLLECTION, LLC
(LOT 1 - AREA=259,855.6± S.F. (5.96546± ACRES))
N/F WS NV FOUR ANDOVER TECH, LLC
(ANDOVER ASSESSOR'S PARCEL MAP 166, BLOCK 0, LOT 15C) - #6 TECH DRIVE
(ENRD BK. 14550, PG. 015)
N/F ANDOVER TECHNOLOGY PARTNERS LLC
(ANDOVER ASSESSOR'S PARCEL MAP 167, BLOCK 0, LOT 12A)
#15 SHATTUCK ROAD
(ENRD BK. 15566, PG. 108)
LOT 1
AREA=259,855.6± S.F.
(5.96546± ACRES)
N/F SUNSET ROCK LLC
(ANDOVER ASSESSOR'S PARCEL MAP 166, BLOCK 0, LOT 15B)
#1 TECH DRIVE
(ENRD BK. 14550, PG. 009)
SHATTUCK ROAD
(PRIVATE - 75 FEET WIDE)
N/F MKS INSTRUMENTS, INC.
(ANDOVER ASSESSOR'S PARCEL MAP 167, BLOCK 0, LOT 14) - #6 SHATTUCK ROAD
(ENRD BK. 2374, PG. 273)
N/F ANDOVER FIVE LLC
(ANDOVER ASSESSOR'S PARCEL MAP 167, BLOCK 0, LOT 15)
#20 SHATTUCK ROAD
(ENRD BK. 4357, PG. 077)
N/F ANDOVER APARTMENTS, LLC
EXIST. 30 FT. WIDE UTILITY EASEMENT
EXIST. 65 FT. WIDE UTILITY EASEMENT
EXIST. SETBACK RESTRICTION LINE
LIMITS OF WETLANDS
(NO ACCESS)
1
2
3
4

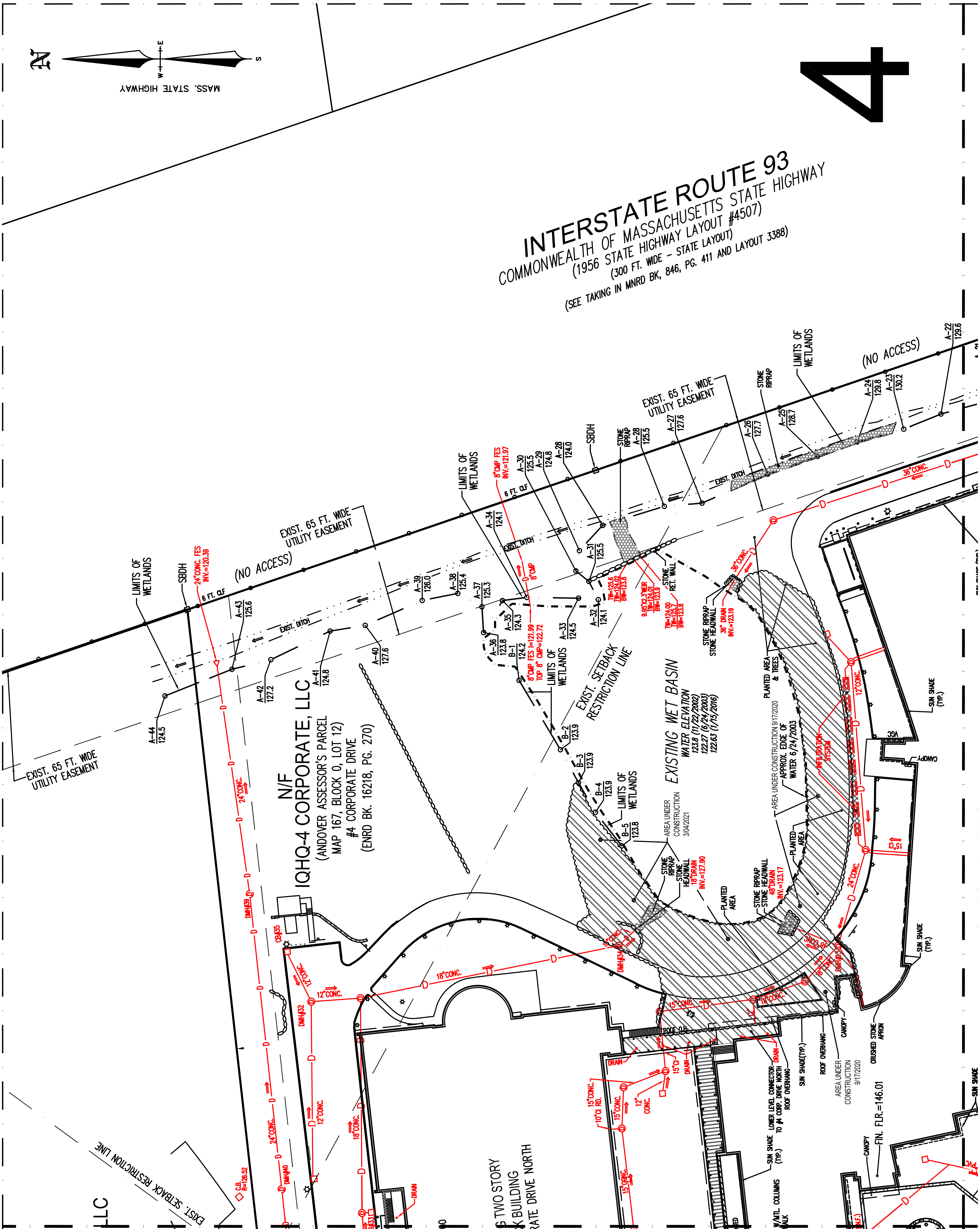


JUMBO ANDOVER
NOW RHINO ANDOVER
(LOT 1 - AREA=259,855.6±
(ANDOVER ASSES
MAP 167, BLOCK
#1 CORPORA
(ENRD BK. 1543
N/F LINCOLN ANDOVER LLC
(ANDOVER ASSESSOR'S PARCEL
MAP 167, BLOCK 0, LOT 13)
#7 SHATTUCK ROAD
(ENRD BK. 4587, PG. 257)
LOT 1
AREA=259,855.6± S.F.
(5.96546± ACRES)
EXISTING TWO STORY
BRICK OFFICE BUILDING
#1 CORPORATE DRIVE
FIN. FLR.=157.97
FIN. FLR.=157.91
LINE OF GLASS FIRST FLR.
EXIST. 30 FT. WIDE
UTILITY EASEMENT
ROAD
GRASS
(PRIVATE - 75 FEET WIDE)
SHATTUCK
N/F MKS INSTRUMENTS, INC.
(ANDOVER ASSESSOR'S PARCEL
MAP 167, BLOCK 0, LOT 14) - #6 SHATTUCK ROAD
(ENRD BK. 2374, PG. 273)
N/F ANDOVER FIVE LLC
(ANDOVER ASSESSOR'S PARCEL
MAP 167, BLOCK 0, LOT 15)
#20 SHATTUCK ROAD
(ENRD BK. 4357, PG. 077)
SBDH
(ON LINE-18.50'
FROM COR.)
12" PIPE ENDS
I=155.14(W)
I=155.22(E)
12" PIPE ENDS
I=156.37(W)
I=156.39(E)
12" F.E.S.
I=159.91
12" F.E.S.
I=160.62
ELEC. SW. GEAR ON PAD
DITCH
12"CONC.
18"CONC.
21"CONC.
24"CONC.
12"PVC
6"PVC
10" CI
C.O.
SGC
RIP. SPILLWAY
ALL UNDERGROUND UTILITIES ARE NOT
SHOWN ON THIS PLAN AND IF ANY ARE
SHOWN THEY SHOULD BE CONSIDERED
APPROXIMATE ONLY. BEFORE CONSTRUCTION
CALL "DIG SAFE" 811 OR 1-888-344-7233.
SOME DATA IS CONFLICTING AND CAN ONLY
BE VERIFIED BY EXCAVATION.
DIG SAFE
0
40
80
160
1



EXISTING ONE & TWO STORY
STONE, GLASS & METAL PANEL BUILDING
#4 CORPORATE DRIVE SOUTH
IQHQ-4 CORPORATE, LLC - LOT 2
AREA = 785,680.0± S.F.
(18.03673± ACRES)
N/F
IQHQ-4 CORPORATE, LLC
(ANDOVER ASSESSOR'S PARCEL
MAP 167, BLOCK 0, LOT 12)
#4 CORPORATE DRIVE
(ENRD BK. 16218, PG. 270)
N/F LINCOLN ANDOVER LLC
(ANDOVER ASSESSOR'S PARCEL
MAP 167, BLOCK 0, LOT 13)
#7 SHATTUCK ROAD
(ENRD BK. 4587, PG. 257)
N/F
VER COLLECTION, LLC
OVER COLLECTION, LLC
355.6± S.F. (5.96546± ACRES))
ASSESSOR'S PARCEL
, BLOCK 0, LOT 12E)
ORPORATE DRIVE
BK. 15431, PG. 155)
EXIST. SETBACK RESTRICTION LINE
EXIST. 65 FT. WIDE UTILITY EASEMENT
LIMITS OF WETLANDS
EXIST. UTILITY EASEMENT (VARIABLE WIDTH)
(NO ACCESS)
EXIST. 30 FT. WIDE UTILITY EASEMENT
STORMCEPTOR STC-900
SUN SHADE (TYP.)
CANOPY
24"CONC.
12"CONC.
10"PVC
TR. DRAIN
C.O.
VGC
A-1 137.6
A-2 137.2
A-3 137.3
A-4 136.2
A-5 135.1
A-6 136.2
A-7 135.2
A-8 135.3
A-9 134.8
A-10 133.6
A-11 132.9
A-12 132.9
A-13 132.7
A-14 133.0
A-15 132.9
A-16 134.6
A-17 134.0
A-18 133.0
A-19 131.3
A-20 131.6
A-21 131.2
A-22 129.6
2

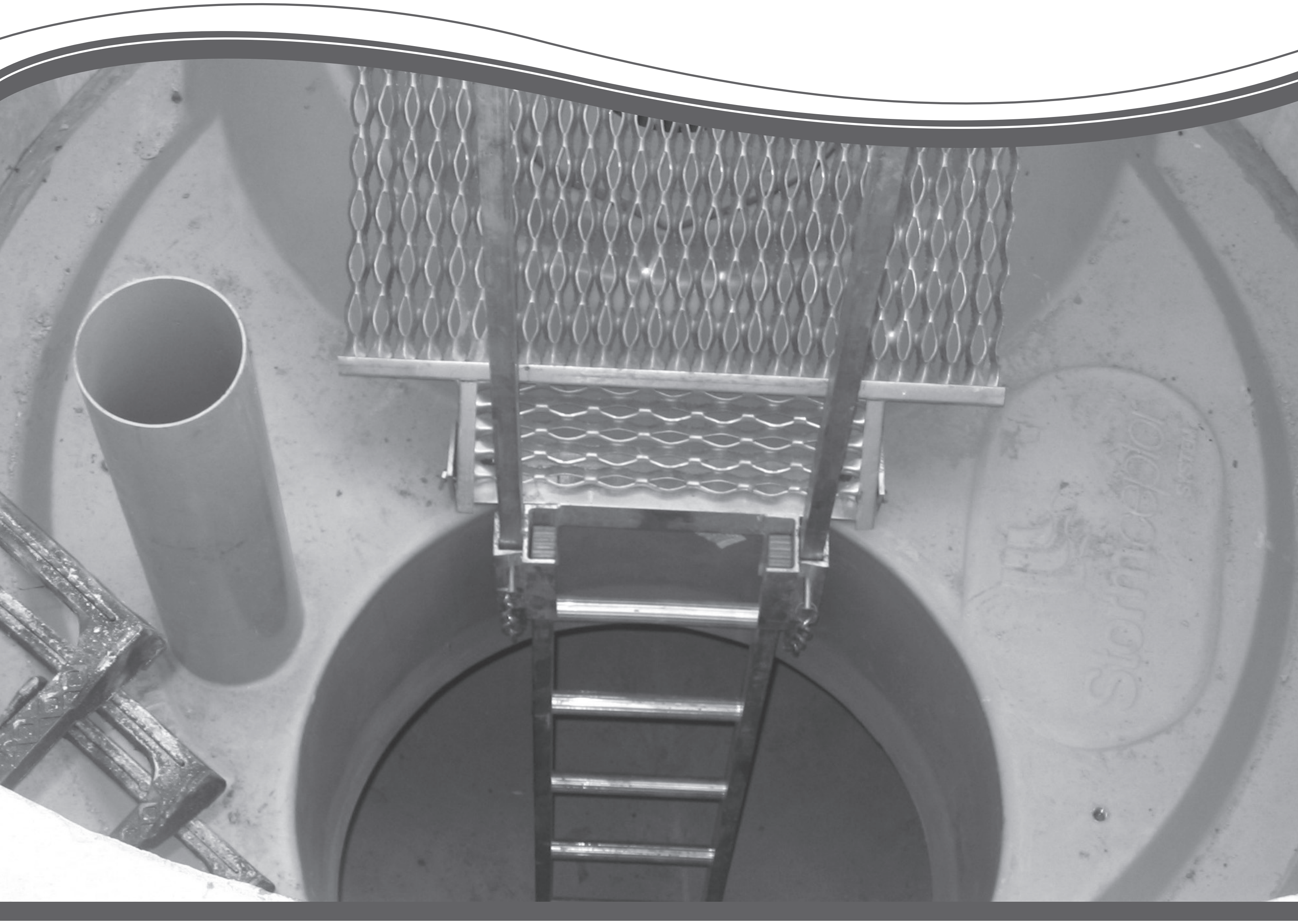

N/F SUNSET ROCK LLC
(ANDOVER ASSESSOR'S PARCEL
MAP 166, BLOCK 0, LOT 15B)
#1 TECH DRIVE
(ENRD BK. 14550, PG. 009)
N/F WS NV FOUR ANDOVER TECH, LLC
(ANDOVER ASSESSOR'S PARCEL
MAP 166, BLOCK 0, LOT 15C) – #6 TECH DRIVE
(ENRD BK. 14550, PG. 015)
EXIST. 30 FT. WIDE UTILITY EASEMENT
SBDH
S55°00'41"W–0.063'
FROM P.COR.
18"CONC.
12"CONC.
DMH#29
DMH#30
CB#31
CB#32
CB#33
CB#30
CB#29
DMH #28
CB#28
DMH#27
CB#27
DMH#26
CB#26
CB#25
CB#22
FIN. FLR.=141.00
FIN. FLR.=141.02
EXISTING TW
BRICK BUI
#4 CORPORATE D
10"CI RD.
PLANTED
MTL. TRELLIS W/MTL. C
OVER CONC. WALK
SUN SHADE(TYP.)
EXIST. 30 FT. WIDE
UTILITY EASEMENT
N/F
ANDOVER TECHNOLOGY PARTNERS LLC
(ANDOVER ASSESSOR'S PARCEL
MAP 167, BLOCK 0, LOT 12A)
#15 SHATTUCK ROAD
(ENRD BK. 15566, PG. 108)
SBDH
EXIST. 30 FT. WIDE
UTILITY EASEMENT
12"F.E.S.
INV.=153.08
12"F.E.S.
INV.=153.42
DMH#10
24"CONC.
3
N/F ANDOVER
APARTMENTS, LLC
SHA



4
MASS. STATE HIGHWAY
INTERSTATE ROUTE 93
COMMONWEALTH OF MASSACHUSETTS STATE HIGHWAY
(1956 STATE HIGHWAY LAYOUT #4507)
(300 FT. WIDE - STATE LAYOUT)
(SEE TAKING IN MNRD BK, 846, PG. 411 AND LAYOUT 3388)
(NO ACCESS)
EXIST. 65 FT. WIDE UTILITY EASEMENT
LIMITS OF WETLANDS
SBDH
6 FT. CLF
EXIST. DITCH
STONE RIPRAP
24"CONC. FES INV.=120.39
8"CMP FES INV.=121.97
N/F
IQHQ-4 CORPORATE, LLC
(ANDOVER ASSESSOR'S PARCEL MAP 167, BLOCK 0, LOT 12)
#4 CORPORATE DRIVE
(ENRD BK. 16218, PG. 270)
EXIST. SETBACK RESTRICTION LINE
EXISTING WET BASIN
WATER ELEVATION
123.8 (11/22/2002)
122.27 (6/24/2003)
122.63 (1/15/2016)
AREA UNDER CONSTRUCTION 3/04/2021
AREA UNDER CONSTRUCTION 9/17/2020
APPROX. EDGE OF WATER 6/24/2003
PLANTED AREA
PLANTED AREA & TREES
STONE HEADWALL
INFILTRATION SYSTEM
SUN SHADE (TYP.)
CANOPY
ROOF OVERHANG
CRUSHED STONE APRON
FIN. FLR.=146.01
LOWER LEVEL CONNECTOR TO #4 CORP. DRIVE NORTH ROOF OVERHANG
EXISTING TWO STORY BRICK BUILDING CORPORATE DRIVE NORTH

STORMCEPTOR MAINTENANCE INSTRUCTIONS

Stormceptor® STC
Operation and Maintenance Guide



Stormceptor Design Notes

- Only the STC 450i is adaptable to function with a catch basin inlet and/or inline pipes.
- Only the Stormceptor models STC 450i to STC 7200 may accommodate multiple inlet pipes.

Inlet and outlet invert elevation differences are as follows:

Inlet and Outlet Pipe Invert Elevations Differences			
Inlet Pipe Configuration	STC 450i	STC 900 to STC 7200	STC 11000 to STC 16000
Single inlet pipe	3 in. (75 mm)	1 in. (25 mm)	3 in. (75 mm)
Multiple inlet pipes	3 in. (75 mm)	3 in. (75 mm)	Only one inlet pipe.

Maximum inlet and outlet pipe diameters:

Inlet/Outlet Configuration	Inlet Unit STC 450i	In-Line Unit STC 900 to STC 7200	Series* STC 11000 to STC 16000
Straight Through	24 inch (600 mm)	42 inch (1050 mm)	60 inch (1500 mm)
Bend (90 degrees)	18 inch (450 mm)	33 inch (825 mm)	33 inch (825 mm)

- The inlet and in-line Stormceptor units can accommodate turns to a maximum of 90 degrees.
- Minimum distance from top of grade to crown is 2 feet (0.6 m)
- Submerged conditions. A unit is submerged when the standing water elevation at the proposed location of the Stormceptor unit is greater than the outlet invert elevation during zero flow conditions. In these cases, please contact your local Stormceptor representative and provide the following information:
- Top of grade elevation
- Stormceptor inlet and outlet pipe diameters and invert elevations
- Standing water elevation
- Stormceptor head loss, K = 1.3 (for submerged condition, K = 4)

Stormceptor® STC

OPERATION AND MAINTENANCE GUIDE
Table of Content

1. About Stormceptor

The Stormceptor® STC (Standard Treatment Cell) was developed by Imbrium™ Systems to address the growing need to remove and isolate pollution from the storm drain system before it enters the environment. The Stormceptor STC targets hydrocarbons and total suspended solids (TSS) in stormwater runoff. It improves water quality by removing contaminants through the gravitational settling of fine sediments and floatation of hydrocarbons while preventing the re-suspension or scour of previously captured pollutants.

The development of the Stormceptor STC revolutionized stormwater treatment, and created an entirely new category of environmental technology. Protecting thousands of waterways around the world, the Stormceptor System has set the standard for effective stormwater treatment.

1.1. Patent Information

The Stormceptor technology is protected by the following patents:

- Australia Patent No. 693,164 • 693,164 • 707,133 • 729,096 • 779401
- Austrian Patent No. 289647
- Canadian Patent No 2,009,208 •2,137,942 • 2,175,277 • 2,180,305 • 2,180,383 • 2,206,338 • 2,327,768 (Pending)
- China Patent No 1168439
- Denmark DK 711879
- German DE 69534021
- Indonesian Patent No 16688
- Japan Patent No 9-11476 (Pending)
- Korea 10-2000-0026101 (Pending)
- Malaysia Patent No PI9701737 (Pending)
- New Zealand Patent No 314646
- United States Patent No 4,985,148 • 5,498,331 • 5,725,760 • 5,753,115 • 5,849,181 • 6,068,765 • 6,371,690
- Stormceptor OSR Patent Pending • Stormceptor LCS Patent Pending

2. Stormceptor Design Overview

2.1. Design Philosophy

The patented Stormceptor System has been designed to focus on the environmental objective of providing long-term pollution control. The unique and innovative Stormceptor design allows for continuous positive treatment of runoff during all rainfall events, while ensuring that all captured pollutants are retained within the system, even during intense storm events.

An integral part of the Stormceptor design is PCSWMM for Stormceptor - sizing software developed in conjunction with Computational Hydraulics Inc. (CHI) and internationally acclaimed expert, Dr. Bill James. Using local historical rainfall data and continuous simulation modeling, this software allows a Stormceptor unit to be designed for each individual site and the corresponding water quality objectives.

By using PCSWMM for Stormceptor, the Stormceptor System can be designed to remove a wide range of particles (typically from 20 to 2,000 microns), and can also be customized to remove a specific particle size distribution (PSD). The specified PSD should accurately reflect what is in the stormwater runoff to ensure the device is achieving the desired water quality objective. Since stormwater runoff contains small particles (less than 75 microns), it is important to design a treatment system to remove smaller particles in addition to coarse particles.

2.2. Benefits

The Stormceptor System removes free oil and suspended solids from stormwater, preventing spills and non-point source pollution from entering downstream lakes and rivers. The key benefits, capabilities and applications of the Stormceptor System are as follows:

- Provides continuous positive treatment during all rainfall events
- Can be designed to remove over 80% of the annual sediment load
- Removes a wide range of particles
- Can be designed to remove a specific particle size distribution (PSD)
- Captures free oil from stormwater
- Prevents scouring or re-suspension of trapped pollutants
- Pre-treatment to reduce maintenance costs for downstream treatment measures (ponds, swales, detention basins, filters)
- Groundwater recharge protection
- Spills capture and mitigation
- Simple to design and specify
- Designed to your local watershed conditions
- Small footprint to allow for easy retrofit installations
- Easy to maintain (vacuum truck)
- Multiple inlets can connect to a single unit
- Suitable as a bend structure
- Pre-engineered for traffic loading (minimum AASHTO HS-20)
- Minimal elevation drop between inlet and outlet pipes
- Small head loss
- Additional protection provided by an 18” (457 mm) fiberglass skirt below the top of the insert, for the containment of hydrocarbons in the event of a spill.

2.3. Environmental Benefit

Freshwater resources are vital to the health and welfare of their surrounding communities. There is increasing public awareness, government regulations and corporate commitment to reducing the pollution entering our waterways. A major source of this pollution originates from stormwater runoff from urban areas. Rainfall runoff carries oils, sediment and other contaminants from roads and parking lots discharging directly into our streams, lakes and coastal waterways.

The Stormceptor System is designed to isolate contaminants from getting into the natural environment. The Stormceptor technology provides protection for the environment from spills that occur at service stations and vehicle accident sites, while also removing contaminated sediment in runoff that washes from roads and parking lots.

3. Key Operation Features

3.1. Scour Prevention

A key feature of the Stormceptor System is its patented scour prevention technology. This innovation ensures pollutants are captured and retained during all rainfall events, even extreme storms. The Stormceptor System provides continuous positive treatment for all rainfall events, including intense storms. Stormceptor slows incoming runoff, controlling and reducing velocities in the lower chamber to create a non-turbulent environment that promotes free oils and floatable debris to rise and sediment to settle.

The patented scour prevention technology, the fiberglass insert, regulates flows into the lower chamber through a combination of a weir and orifice while diverting high energy flows away through the upper chamber to prevent scouring. Laboratory testing demonstrated no scouring when tested up to 125% of the unit's operating rate, with the unit loaded to 100% sediment capacity (NJDEP, 2005). Second, the depth of the lower chamber ensures the sediment storage zone is adequately separated from the path of flow in the lower chamber to prevent scouring.

3.2. Operational Hydraulic Loading Rate

Designers and regulators need to evaluate the treatment capacity and performance of manufactured stormwater treatment systems. A commonly used parameter is the "operational hydraulic loading rate" which originated as a design methodology for wastewater treatment devices.

Operational hydraulic loading rate may be calculated by dividing the flow rate into a device by its settling area. This represents the critical settling velocity that is the prime determinant to quantify the influent particle size and density captured by the device. PCSWMM for Stormceptor uses a similar parameter that is calculated by dividing the hydraulic detention time in the device by the fall distance of the sediment.

$$v_{SC} = \frac{H}{6_H} = \frac{Q}{A_S}$$

Where:

v_{SC} = critical settling velocity, ft/s (m/s)

H = tank depth, ft (m)

$Ø_H$ = hydraulic detention time, ft/s (m/s)

Q = volumetric flow rate, ft3/s (m3/s)

A_S = surface area, ft^2 (m^2)

(Tchobanoglous, G. and Schroeder, E.D. 1987. Water Quality. Addison Wesley.)

Unlike designing typical wastewater devices, stormwater systems are designed for highly variable flow rates including intense peak flows. PCSWMM for Stormceptor incorporates all of the flows into its calculations, ensuring that the operational hydraulic loading rate is considered not only for one flow rate, but for all flows including extreme events.

3.3. Double Wall Containment

The Stormceptor System was conceived as a pollution identifier to assist with identifying illicit discharges. The fiberglass insert has a continuous skirt that lines the concrete barrel wall for a depth of 18 inches (457 mm) that provides double wall containment for hydrocarbons storage. This protective barrier ensures that toxic floatables do not migrate through the concrete wall into the surrounding soils.

4. Stormceptor Product Line

4.1. Stormceptor Models

A summary of Stormceptor models and capacities are listed in Table 1.

Table 1. Stormceptor Models

Stormceptor Model	Total Storage Volume U.S. Gal (L)	Hydrocarbon Storage Capacity U.S. Gal (L)	Maximum Sediment Capacity ft³ (L)
STC 450i	470 (1,780)	86 (330)	46 (1,302)
STC 900	952 (3,600)	251 (950)	89 (2,520)
STC 1200	1,234 (4,670)	251 (950)	127 (3,596)
STC 1800	1,833 (6,940)	251 (950)	207 (5,861)
STC 2400	2,462 (9,320)	840 (3,180)	205 (5,805)
STC 3600	3,715 (1,406)	840 (3,180)	373 (10,562)
STC 4800	5,059 (1,950)	909 (3,440)	543 (15,376)
STC 6000	6,136 (23,230)	909 (3,440)	687 (19,453)
STC 7200	7,420 (28,090)	1,059 (4,010)	839 (23,757)
STC 11000	11,194 (42,370)	2,797 (10, 590)	1,086 (30,752)
STC 13000	13,348 (50,530)	2,797 (10, 590)	1,374 (38,907)
STC 16000	15,918 (60,260)	3,055 (11, 560)	1,677 (47,487)

NOTE: Storage volumes may vary slightly from region to region. For detailed information, contact your local Stormceptor representative.

4.2. Inline Stormceptor

The Inline Stormceptor, Figure 1, is the standard design for most stormwater treatment applications. The patented Stormceptor design allows the Inline unit to maintain continuous positive treatment of total suspended solids (TSS) year-round, regardless of flow rate. The Inline Stormceptor is composed of a precast concrete tank with a fiberglass insert situated at the invert of the storm sewer pipe, creating an upper chamber above the insert and a lower chamber below the insert.

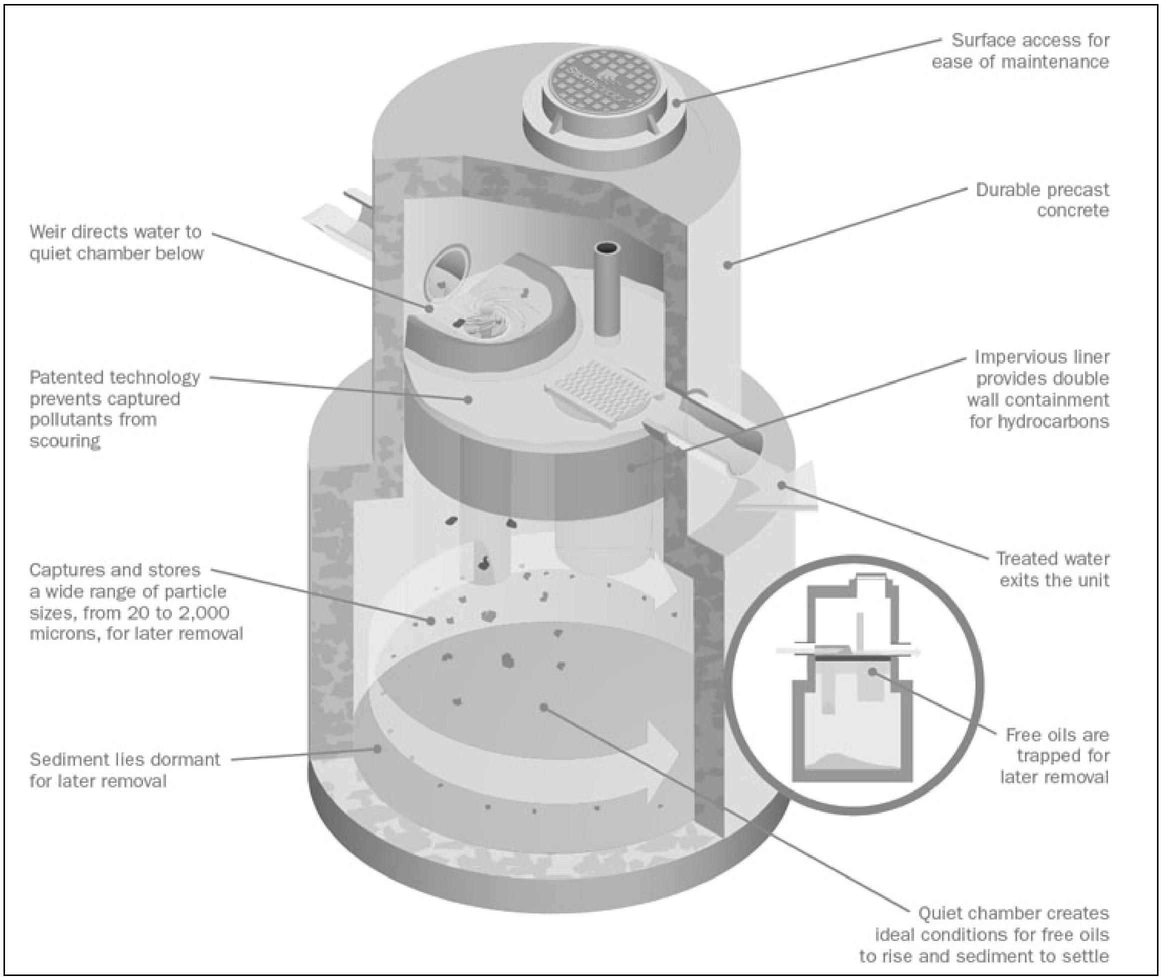


Figure 1. Inline Stormceptor

Operation

As water flows into the Stormceptor unit, it is slowed and directed to the lower chamber by a weir and drop tee. The stormwater enters the lower chamber, a non-turbulent environment, allowing free oils to rise and sediment to settle. The oil is captured underneath the fiberglass insert and shielded from exposure to the concrete walls by a fiberglass skirt. After the pollutants separate, treated water continues up a riser pipe, and exits the lower chamber on the downstream side of the weir before leaving the unit. During high flow events, the Stormceptor System's patented scour prevention technology ensures continuous pollutant removal and prevents re-suspension of previously captured pollutants.

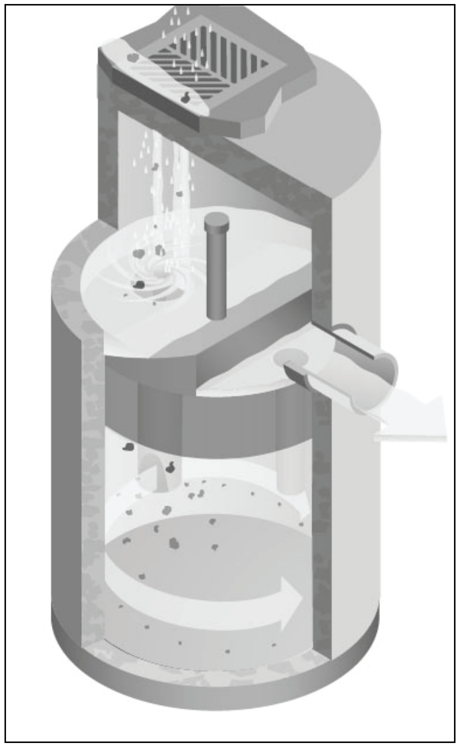


Figure 2. Inlet Stormceptor

4.3. Inlet Stormceptor

The Inlet Stormceptor System, Figure 2, was designed to provide protection for parking lots, loading bays, gas stations and other spill-prone areas. The Inlet Stormceptor is designed to remove sediment from stormwater introduced through a grated inlet, a storm sewer pipe, or both.

The Inlet Stormceptor design operates in the same manner as the Inline unit, providing continuous positive treatment, and ensuring that captured material is not re-suspended.

4.4. Series Stormceptor

Designed to treat larger drainage areas, the Series Stormceptor System, Figure 3, consists of two adjacent Stormceptor models that function in parallel. This design eliminates the need for additional structures and piping to reduce installation costs.

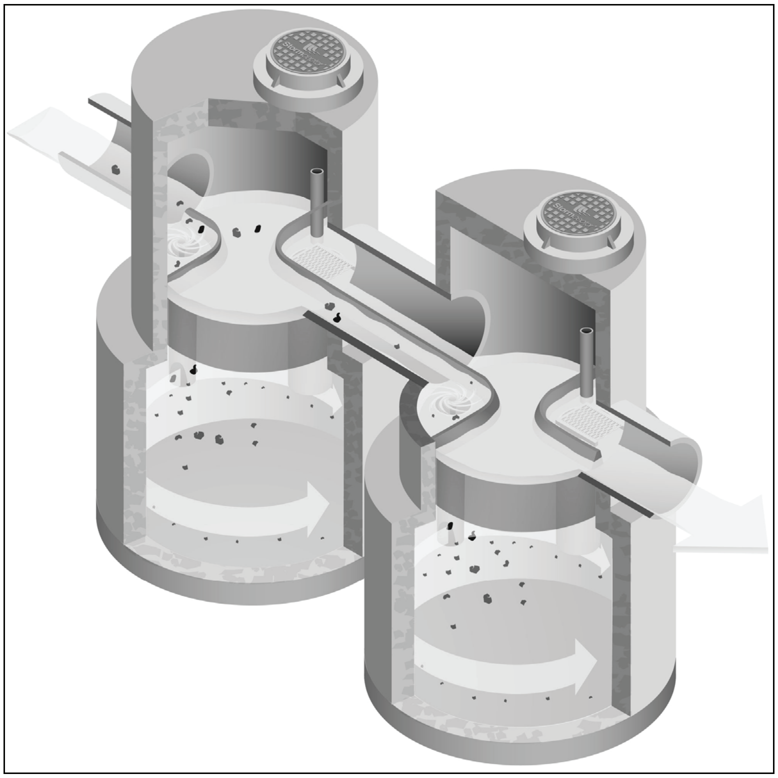


Figure 3. Series System

The Series Stormceptor design operates in the same manner as the Inline unit, providing continuous positive treatment, and ensuring that captured material is not re-suspended.

5. Sizing the Stormceptor System

The Stormceptor System is a versatile product that can be used for many different aspects of water quality improvement. While addressing these needs, there are conditions that the designer needs to be aware of in order to size the Stormceptor model to meet the demands of each individual site in an efficient and cost-effective manner.

PCSWMM for Stormceptor is the support tool used for identifying the appropriate Stormceptor model. In order to size a unit, it is recommended the user follow the seven design steps in the program. The steps are as follows:

STEP 1 – Project Details

The first step prior to sizing the Stormceptor System is to clearly identify the water quality objective for the development. It is recommended that a level of annual sediment (TSS) removal be identified and defined by a particle size distribution.

STEP 2 – Site Details

Identify the site development by the drainage area and the level of imperviousness. It is recommended that imperviousness be calculated based on the actual area of imperviousness based on paved surfaces, sidewalks and rooftops.

STEP 3 – Upstream Attenuation

The Stormceptor System is designed as a water quality device and is sometimes used in conjunction with onsite water quantity control devices such as ponds or underground detention systems. When possible, a greater benefit is typically achieved when installing a Stormceptor unit upstream of a detention facility. By placing the Stormceptor unit upstream of a detention structure, a benefit of less maintenance of the detention facility is realized.

STEP 4 – Particle Size Distribution

It is critical that the PSD be defined as part of the water quality objective. PSD is critical for the design of treatment system for a unit process of gravity settling and governs the size of a treatment system. A range of particle sizes has been provided and it is recommended that clays and silt-sized particles be considered in addition to sand and gravel-sized particles. Options and sample PSDs are provided in PCSWMM for Stormceptor. The default particle size distribution is the Fine Distribution, Table 2, option.

Table 2. Fine Distribution

Particle Size	Distribution	Specific Gravity
20	20%	1.3
60	20%	1.8
150	20%	2.2
400	20%	2.65
2000	20%	2.65

If the objective is the long-term removal of 80% of the total suspended solids on a given site, the PSD should be representative of the expected sediment on the site. For example, a system designed to remove 80% of coarse particles (greater than 75 microns) would provide relatively poor removal efficiency of finer particles that may be naturally prevalent in runoff from the site.

Since the small particle fraction contributes a disproportionately large amount of the total available particle surface area for pollutant adsorption, a system designed primarily for coarse particle capture will compromise water quality objectives.

STEP 5 – Rainfall Records

Local historical rainfall has been acquired from the U.S. National Oceanic and Atmospheric Administration, Environment Canada and regulatory agencies across North America. The rainfall data provided with PCSMM for Stormceptor provides an accurate estimation of small storm hydrology by modeling actual historical storm events including duration, intensities and peaks.

STEP 6 – Summary

At this point, the program may be executed to predict the level of TSS removal from the site. Once the simulation has completed, a table shall be generated identifying the TSS removal of each Stormceptor unit.

STEP 7 – Sizing Summary

Performance estimates of all Stormceptor units for the given site parameters will be displayed in a tabular format. The unit that meets the water quality objective, identified in Step 1, will be highlighted.

5.1. PCSWMM for Stormceptor

The Stormceptor System has been developed in conjunction with PCSWMM for Stormceptor as a technological solution to achieve water quality goals. Together, these two innovations model, simulate, predict and calculate the water quality objectives desired by a design engineer for TSS removal.

PCSWMM for Stormceptor is a proprietary sizing program which uses site specific inputs to a computer model to simulate sediment accumulation, hydrology and long-term total suspended solids removal. The model has been calibrated to field monitoring results from Stormceptor units that have been monitored in North America. The sizing methodology can be described by three processes:

1. Determination of real time hydrology
2. Buildup and wash off of TSS from impervious land areas
3. TSS transport through the Stormceptor (settling and discharge). The use of a calibrated model is the preferred method for sizing stormwater quality structures for the following reasons:
    - The hydrology of the local area is properly and accurately incorporated in the sizing (distribution of flows, flow rate ranges and peaks, back-to-back storms, inter-event times)
    - The distribution of TSS with the hydrology is properly and accurately considered in the sizing
    - Particle size distribution is properly considered in the sizing
    - The sizing can be optimized for TSS removal
    - The cost benefit of alternate TSS removal criteria can be easily assessed
    - The program assesses the performance of all Stormceptor models. Sizing may be selected based on a specific water quality outcome or based on the Maximum Extent Practicable

For more information regarding PCSWMM for Stormceptor, contact your local Stormceptor representative, or visit www.imbriumsystems.com to download a free copy of the program.

5.2. Sediment Loading Characteristics

The way in which sediment is transferred to stormwater can have a considerable effect on which type of system is implemented. On typical impervious surfaces (e.g. parking lots) sediment will build over time and wash off with the next rainfall. When rainfall patterns are examined, a short intense storm will have a higher concentration of sediment than a long slow drizzle. Together with rainfall data representing the site's typical rainfall patterns, sediment loading characteristics play a part in the correct sizing of a stormwater quality device.

Typical Sites

For standard site design of the Stormceptor System, PCSWMM for Stormceptor is utilized to accurately assess the unit's performance. As an integral part of the product's design, the program can be used to meet local requirements for total suspended solid removal. Typical installations of manufactured stormwater treatment devices would occur on areas such as paved parking lots or paved roads. These are considered "stable" surfaces which have non – erodible surfaces.

Unstable Sites

While standard sites consist of stable concrete or asphalt surfaces, sites such as gravel parking lots, or maintenance yards with stockpiles of sediment would be classified as "unstable". These types of sites do not exhibit first flush characteristics, are highly erodible and exhibit atypical sediment loading characteristics and must therefore be sized more carefully. Contact your local Stormceptor representative for assistance in selecting a proper unit sized for such unstable sites.

6. Spill Controls

When considering the removal of total petroleum hydrocarbons (TPH) from a storm sewer system there are two functions of the system: oil removal, and spill capture.

'Oil Removal' describes the capture of the minute volumes of free oil mobilized from impervious surfaces. In this instance relatively low concentrations, volumes and flow rates are considered. While the Stormceptor unit will still provide an appreciable oil removal function during higher flow events and/or with higher TPH concentrations, desired effluent limits may be exceeded under these conditions.

‘Spill Capture’ describes a manner of TPH removal more appropriate to recovery of a relatively high volume of a single phase deleterious liquid that is introduced to the storm sewer system over a relatively short duration. The two design criteria involved when considering this manner of introduction are overall volume and the specific gravity of the material. A standard Stormceptor unit will be able to capture and retain a maximum spill volume and a minimum specific gravity.

For spill characteristics that fall outside these limits, unit modifications are required. Contact your local Stormceptor Representative for more information.

One of the key features of the Stormceptor technology is its ability to capture and retain spills. While the standard Stormceptor System provides excellent protection for spill control, there are additional options to enhance spill protection if desired.

6.1. Oil Level Alarm

The oil level alarm is an electronic monitoring system designed to trigger a visual and audible alarm when a pre-set level of oil is reached within the lower chamber. As a standard, the oil

level alarm is designed to trigger at approximately 85% of the unit’s available depth level for oil capture. The feature acts as a safeguard against spills caused by exceeding the oil storage capacity of the separator and eliminates the need for manual oil level inspection.

The oil level alarm installed on the Stormceptor insert is illustrated in Figure 4.

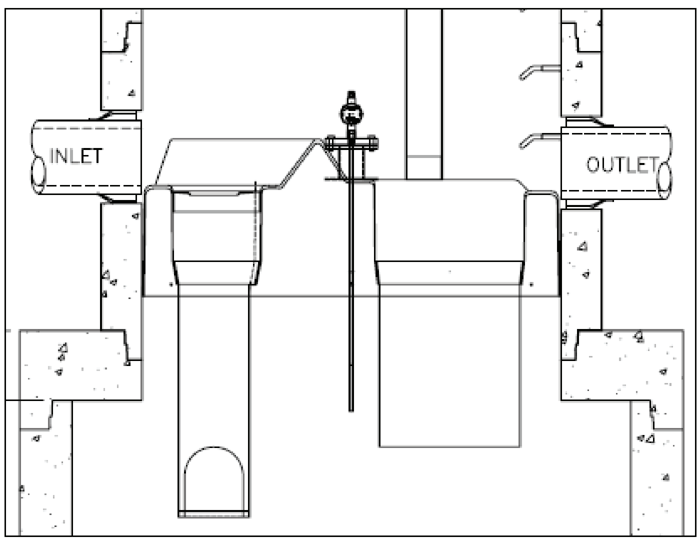


Figure 4. Oil level alarm

6.2. Increased Volume Storage Capacity

The Stormceptor unit may be modified to store a greater spill volume than is typically available. Under such a scenario, instead of installing a larger than required unit, modifications can be made to the recommended Stormceptor model to accommodate larger volumes. Contact your local Stormceptor representative for additional information and assistance for modifications.

7. Stormceptor Options

The Stormceptor System allows flexibility to incorporate to existing and new storm drainage infrastructure. The following section identifies considerations that should be reviewed when installing the system into a drainage network. For conditions that fall outside of the recommendations in this section, please contact your local Stormceptor representative for further guidance.

7.1. Installation Depth Minimum Cover

The minimum distance from the top of grade to the crown of the inlet pipe is 24 inches (600 mm). For situations that have a lower minimum distance, contact your local Stormceptor representative.

7.2. Maximum Inlet and Outlet Pipe Diameters

Maximum inlet and outlet pipe diameters are illustrated in Figure 5. Contact your local Stormceptor representative for larger pipe diameters

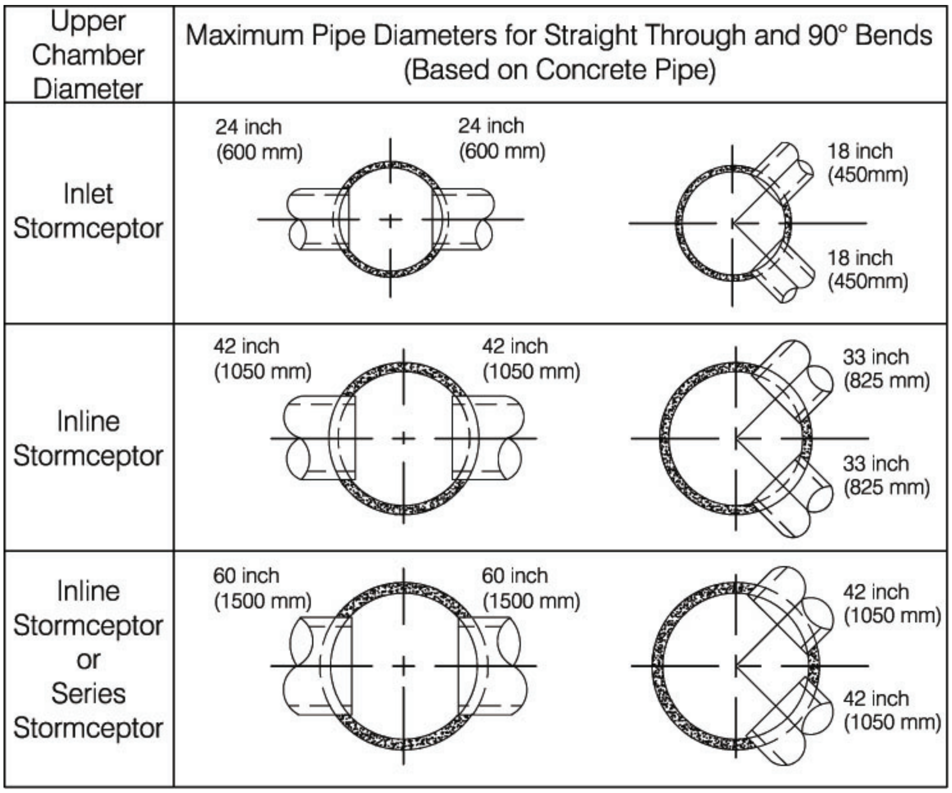


Figure 5. Maximum pipe diameters for straight through and bend applications

*The bend should only be incorporated into the second structure (downstream structure) of the Series Stormceptor System

7.3. Bends

The Stormceptor System can be used to change horizontal alignment in the storm drain network up to a maximum of 90 degrees. Figure 6 illustrates the typical bend situations of the Stormceptor System. Bends should only be applied to the second structure (downstream structure) of the Series Stormceptor System.

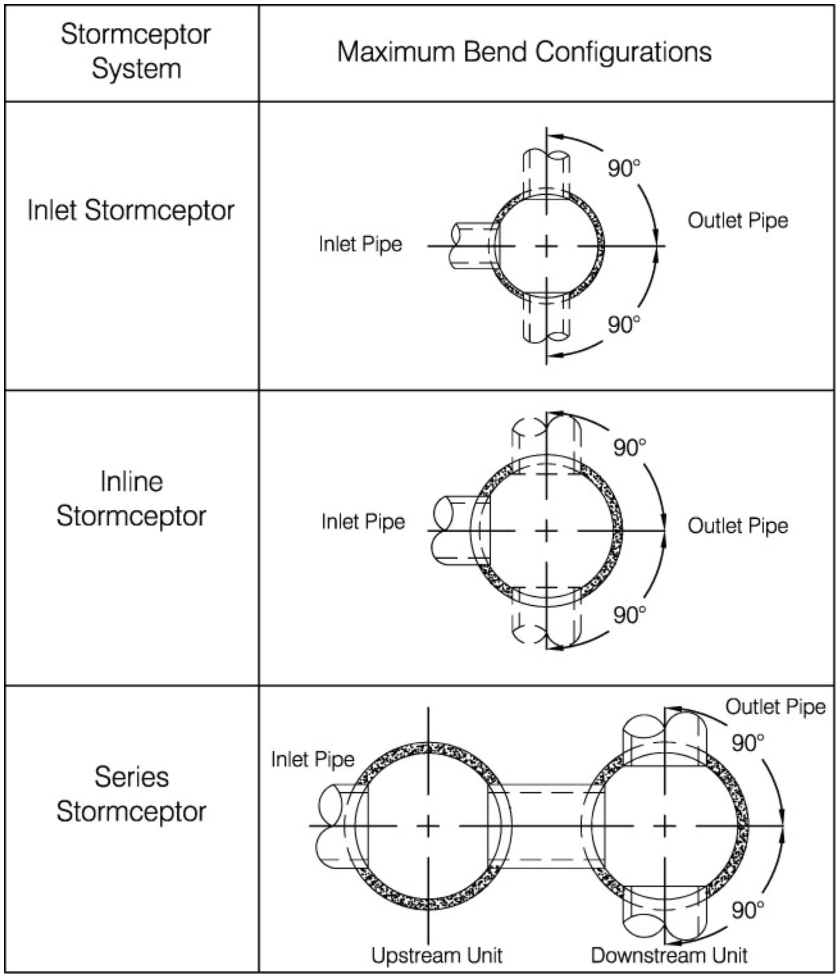


Figure 6. Maximum bend angles

7.4. Multiple Inlet Pipes

The Inlet and Inline Stormceptor System can accommodate two or more inlet pipes. The maximum number of inlet pipes that can be accommodated into a Stormceptor unit is a function of the number, alignment and diameter of the pipes and its effects on the structural integrity of the precast concrete. When multiple inlet pipes are used for new developments, each inlet pipe shall have an invert elevation 3 inches (75 mm) higher than the outlet pipe invert elevation.

7.5. Inlet/Outlet Pipe Invert Elevations

Recommended inlet and outlet pipe invert differences are listed in Table 3.

Table 3. Recommended Drops Between Inlet and Outlet Pipe Inverts

Number of Inlet Pipes	Inlet System	In-Line System	Series System
1	3 inches (75 mm)	1 inch (25 mm)	3 inches (75 mm)
>1	3 inches (75 mm)	3 inches (75 mm)	Not Applicable

7.6. Shallow Stormceptor

In cases where there may be restrictions to the depth of burial of storm sewer systems. In this situation, for selected Stormceptor models, the lower chamber components may be increased in diameter to reduce the overall depth of excavation required.

7.7. Customized Live Load

The Stormceptor system is typically designed for local highway truck loading (AASHTO HS- 20). When the project requires live loads greater than HS-20, the Stormceptor System may be customized structurally for a pre-specified live load. Contact your local Stormceptor representative for customized loading conditions.

7.8. Pre-treatment

The Stormceptor System may be sized to remove sediment and for spills control in conjunction with other stormwater BMPs to meet the water quality objective. For pretreatment applications, the Stormceptor System should be the first unit in a treatment train. The benefits of pre-treatment include the extension of the operational life (extension of maintenance frequency) of large stormwater management facilities, prevention of spills and lower total life- cycle maintenance cost.

7.9. Head loss

The head loss through the Stormceptor System is similar to a 60 degree bend at a manhole. The K value for calculating minor losses is approximately 1.3 (minor loss = k*1.3v2/2g).

However, when a Submerged modification is applied to a Stormceptor unit, the corresponding K value is 4.

7.10. Submerged

The Submerged modification, Figure 7, allows the Stormceptor System to operate in submerged or partially submerged storm sewers. This configuration can be installed on all models of the Stormceptor System by modifying the fiberglass insert. A customized weir height and a secondary drop tee are added.

Submerged instances are defined as standing water in the storm drain system during zero flow conditions. In these instances, the following information is necessary for the proper design and application of submerged modifications:

- Stormceptor top of grade elevation
- Stormceptor outlet pipe invert elevation
- Standing water elevation

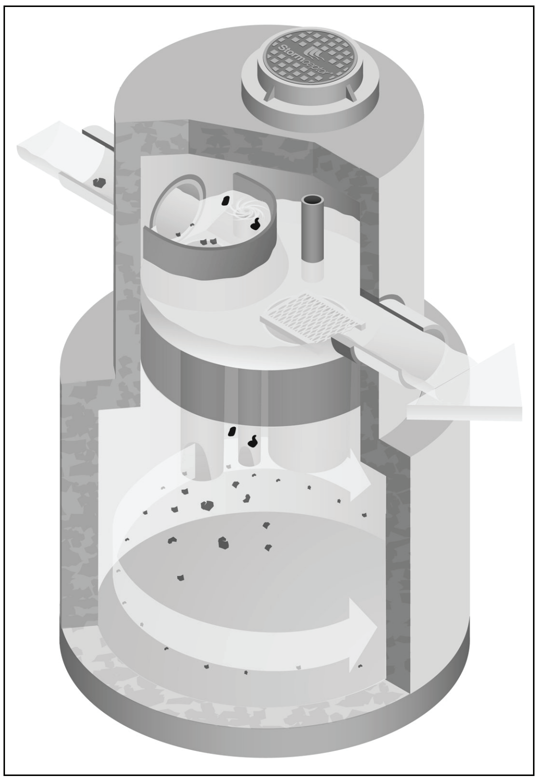


Figure 7. Submerged Stormceptor

8. Comparing Technologies

Designers have many choices available to achieve water quality goals in the treatment of stormwater runoff. Since many alternatives are available for use in stormwater quality treatment it is important to consider how to make an appropriate comparison between “approved alternatives”. The following is a guide to assist with the accurate comparison of differing technologies and performance claims.

8.1. Particle Size Distribution (PSD)

The most sensitive parameter to the design of a stormwater quality device is the selection of the design particle size. While it is recommended that the actual particle size distribution (PSD) for sites be measured prior to sizing, alternative values for particle size should be selected to represent what is likely to occur naturally on the site. A reasonable estimate of a particle size distribution likely to be found on parking lots or other impervious surfaces should consist of a wide range of particles such as 20 microns to 2,000 microns (Ontario MOE, 1994).

There is no absolute right particle size distribution or specific gravity and the user is cautioned to review the site location, characteristics, material handling practices and regulatory requirements when selecting a particle size distribution. When comparing technologies, designs using different PSDs will result in incomparable TSS removal efficiencies. The PSD of the TSS removed needs to be standard between two products to allow for an accurate comparison.

8.2. Scour Prevention

In order to accurately predict the performance of a manufactured treatment device, there must be confidence that it will perform under all conditions. Since rainfall patterns cannot be predicted, stormwater quality devices placed in storm sewer systems must be able to withstand extreme events, and ensure that all pollutants previously captured are retained in the system.

In order to have confidence in a system's performance under extreme conditions, independent validation of scour prevention is essential when examining different technologies. Lack of independent verification of scour prevention should make a designer wary of accepting any product's performance claims.

8.3. Hydraulics

Full scale laboratory testing has been used to confirm the hydraulics of the Stormceptor System. Results of lab testing have been used to physically design the Stormceptor System and the sewer pipes entering and leaving the unit. Key benefits of Stormceptor are:

- Low head loss (typical k value of 1.3)
- Minimal inlet/outlet invert elevation drop across the structure
- Use as a bend structure
- Accommodates multiple inlets

The adaptability of the treatment device to the storm sewer design infrastructure can affect the overall performance and cost of the site.

8.4. Hydrology

Stormwater quality treatment technologies need to perform under varying climatic conditions. These can vary from long low intensity rainfall to short duration, high intensity storms. Since a treatment device is expected to perform under all these conditions, it makes sense that any system's design should accommodate those conditions as well.

Long-term continuous simulation evaluates the performance of a technology under the varying conditions expected in the climate of the subject site. Single, peak event design does not provide this information and is not equivalent to long-term simulation. Designers should request long-term simulation performance to ensure the technology can meet the long-term water quality objective.

9. Testing

The Stormceptor System has been the most widely monitored stormwater treatment technology in the world. Performance verification and monitoring programs are completed to the strictest standards and integrity. Since its introduction in 1990, numerous independent field tests and studies detailing the effectiveness of the Stormceptor System have been completed.

- Coventry University, UK – 97% removal of oil, 83% removal of sand and 73% removal of peat
- National Water Research Institute, Canada, - scaled testing for the development of the Stormceptor System identifying both TSS removal and scour prevention.
- New Jersey TARP Program – full scale testing of an STC 900 demonstrating 75% TSS removal of particles from 1 to 1000 microns. Scour testing completed demonstrated that the system does not scour. The New Jersey Department of Environmental Protection was followed.
- City of Indianapolis – full scale testing of an STC 900 demonstrating over 80% TSS removal of particles from 50 microns to 300 microns at 130% of the unit's operating rate. Scour testing completed demonstrated that the system does not scour.
- Westwood Massachusetts (1997), demonstrated >80% TSS removal
- Como Park (1997), demonstrated 76% TSS removal
- Ontario MOE SWAMP Program – 57% removal of 1 to 25 micron particles
- Laval Quebec – 50% removal of 1 to 25 micron particles

10. Installation

The installation of the concrete Stormceptor should conform in general to state highway, or local specifications for the installation of manholes. Selected sections of a general specification that are applicable are summarized in the following sections.

10.1. Excavation

Excavation for the installation of the Stormceptor should conform to state highway, or local specifications. Topsoil removed during the excavation for the Stormceptor should be stockpiled in designated areas and should not be mixed with subsoil or other materials.

Topsoil stockpiles and the general site preparation for the installation of the Stormceptor should conform to state highway or local specifications.

The Stormceptor should not be installed on frozen ground. Excavation should extend a minimum of 12 inches (300 mm) from the precast concrete surfaces plus an allowance for shoring and bracing where required. If the bottom of the excavation provides an unsuitable foundation additional excavation may be required.

In areas with a high water table, continuous dewatering may be required to ensure that the excavation is stable and free of water.

10.2. Backfilling

Backfill material should conform to state highway or local specifications. Backfill material should be placed in uniform layers not exceeding 12 inches (300mm) in depth and compacted to state highway or local specifications.

11. Stormceptor Construction Sequence

The concrete Stormceptor is installed in sections in the following sequence:

1. Aggregate base
2. Base slab
3. Lower chamber sections
4. Upper chamber section with fiberglass insert
5. Connect inlet and outlet pipes
6. Assembly of fiberglass insert components (drop tee, riser pipe, oil cleanout port and orifice plate
7. Remainder of upper chamber
8. Frame and access cover

The precast base should be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, should be installed in accordance with the precast concrete manufacturer's recommendations.

Adjustment of the Stormceptor can be performed by lifting the upper sections free of the excavated area, re-leveling the base and re-installing the sections. Damaged sections and gaskets should be repaired or replaced as necessary. Once the Stormceptor has been constructed, any lift holes must be plugged with mortar.

12. Maintenance

12.1. Health and Safety

The Stormceptor System has been designed considering safety first. It is recommended that confined space entry protocols be followed if entry to the unit is required. In addition, the fiberglass insert has the following health and safety features:

- Designed to withstand the weight of personnel
- A safety grate is located over the 24 inch (600 mm) riser pipe opening
- Ladder rungs can be provided for entry into the unit, if required

12.2. Maintenance Procedures

Maintenance of the Stormceptor system is performed using vacuum trucks. No entry into the unit is required for maintenance (in most cases). The vacuum service industry is a well- established sector of the service industry that cleans underground tanks, sewers and catch basins. Costs to clean a Stormceptor will vary based on the size of unit and transportation distances.

The need for maintenance can be determined easily by inspecting the unit from the surface. The depth of oil in the unit can be determined by inserting a dipstick in the oil inspection/cleanout port.

Similarly, the depth of sediment can be measured from the surface without entry into the Stormceptor via a dipstick tube equipped with a ball valve. This tube would be inserted through the riser pipe. Maintenance should be performed once the sediment depth exceeds the guideline values provided in the Table 4.

Table 4. Sediment Depths Indicating Required Servicing*

Particle Size	Specific Gravity
Model	Sediment Depth inches (mm)
450i	8 (200)
900	8 (200)
1200	10 (250)
1800	15 (381)
2400	12 (300)
3600	17 (430)
4800	15 (380)
6000	18 (460)
7200	15 (381)
11000	17 (380)
13000	20 (500)
16000	17 (380)
* based on 15% of the Stormceptor unit's total storage	

Although annual servicing is recommended, the frequency of maintenance may need to be increased or reduced based on local conditions (i.e. if the unit is filling up with sediment more quickly than projected, maintenance may be required semi-annually; conversely once the site has stabilized maintenance may only be required every two or three years).

Oil is removed through the oil inspection/cleanout port and sediment is removed through the riser pipe. Alternatively oil could be removed from the 24 inches (600 mm) opening if water is removed from the lower chamber to lower the oil level below the drop pipes.

The following procedures should be taken when cleaning out Stormceptor:

1. Check for oil through the oil cleanout port
2. Remove any oil separately using a small portable pump
3. Decant the water from the unit to the sanitary sewer, if permitted by the local regulating authority, or into a separate containment tank
4. Remove the sludge from the bottom of the unit using the vacuum truck
5. Re-fill Stormceptor with water where required by the local jurisdiction

12.3. Submerged Stormceptor

Careful attention should be paid to maintenance of the Submerged Stormceptor System. In cases where the storm drain system is submerged, there is a requirement to plug both the inlet and outlet pipes to economically clean out the unit.

12.4. Hydrocarbon Spills

The Stormceptor is often installed in areas where the potential for spills is great. The Stormceptor System should be cleaned immediately after a spill occurs by a licensed liquid waste hauler.

12.5. Disposal

Requirements for the disposal of material from the Stormceptor System are similar to that of any other stormwater Best Management Practice (BMP) where permitted. Disposal options for the sediment may range from disposal in a sanitary trunk sewer upstream of a sewage treatment plant, to disposal in a sanitary landfill site. Petroleum waste products collected in the Stormceptor (free oil/chemical/fuel spills) should be removed by a licensed waste management company.

12.6. Oil Sheens

With a steady influx of water with high concentrations of oil, a sheen may be noticeable at the Stormceptor outlet. This may occur because a rainbow or sheen can be seen at very small oil concentrations (<10 mg/L). Stormceptor will remove over 98% of all free oil spills from storm sewer systems for dry weather or frequently occurring runoff events.

The appearance of a sheen at the outlet with high influent oil concentrations does not mean the unit is not working to this level of removal. In addition, if the influent oil is emulsified the Stormceptor will not be able to remove it. The Stormceptor is designed for free oil removal and not emulsified conditions.

SUPPORT

Drawings and specifications are available at www.ContechES.com.
Site-specific design support is available from our engineers.

Contech Engineered Solutions LLC provides site solutions for the civil engineering industry. Contech's portfolio includes bridges, drainage, sanitary sewer, stormwater, and earth stabilization products. For information, visit www.ContechES.com or call 800.338.1122

CONTECH ENGINEERED SOLUTIONS
800-925-5240
www.ContechES.com

CONTECH CASCADE MAINTENANCE INSTRUCTIONS

CONTECH®
ENGINEERED SOLUTIONS

Cascade Separator® Inspection and Maintenance Guide

CASCADE
separator®

Maintenance

The Cascade Separator® system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects sediment and debris will depend upon on-site activities and site pollutant characteristics. For example, unstable soils or heavy winter sanding will cause the sediment storage sump to fill more quickly but regular sweeping of paved surfaces will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant transport and deposition may vary from year to year and regular inspections will help ensure that the system is cleaned out at the appropriate time. At a minimum, inspections should be performed twice per year (i.e. spring and fall). However, more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid accumulations, or in equipment wash-down areas. Installations should also be inspected more frequently where excessive amounts of trash are expected.

A visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions in the inlet chamber, flumes or outlet channel. The inspection should also quantify the accumulation of hydrocarbons, trash and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If absorbent material is used for enhanced removal of hydrocarbons, the level of discoloration of the sorbent material should also be identified during inspection. It is useful and often required as part of an operating permit to keep a record of each inspection. A simple form for doing so is provided in this Inspection and Maintenance Guide.

Access to the Cascade Separator unit is typically achieved through one manhole access cover. The opening allows for inspection and cleanout of the center chamber (cylinder) and sediment storage sump, as well as inspection of the inlet chamber and slanted skirt. For large units, multiple manhole covers allow access to the chambers and sump.

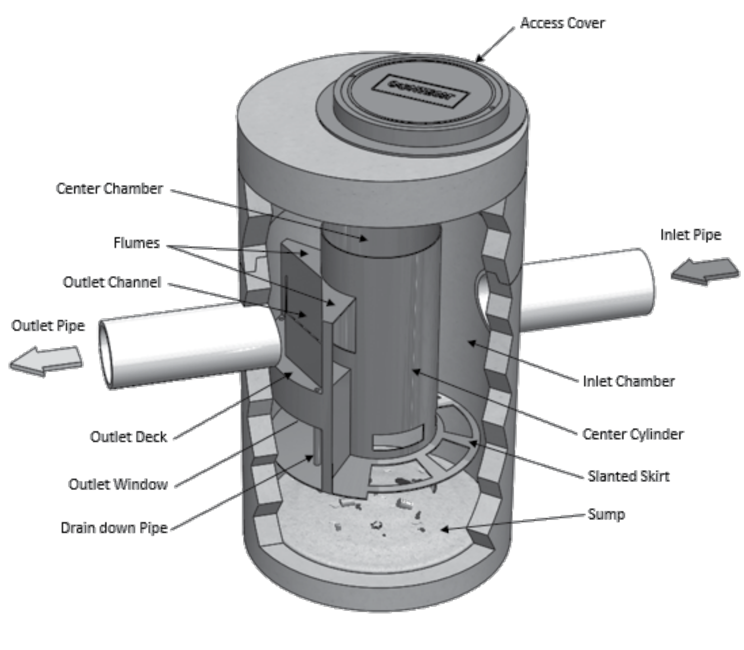
The Cascade Separator system should be cleaned before the level of sediment in the sump reaches the maximum sediment depth and/or when an appreciable level of hydrocarbons and trash has accumulated. If sorbent material is used, it must be replaced when significant discoloration has occurred. Performance may be impacted when maximum sediment storage capacity is exceeded. Contech recommends maintaining the system when sediment level reaches 50% of maximum storage volume. The level of sediment is easily determined by measuring the distance from the system outlet invert (standing water level) to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the chart in this document to determine if the height of the sediment pile off the bottom of the sump floor exceeds 50% of the maximum sediment storage.

Cleaning

Cleaning of a Cascade Separator system should be done during dry weather conditions when no flow is entering the system. The use of a vacuum truck is generally the most effective and convenient method of removing pollutants from the system. Simply remove the manhole cover and insert the vacuum tube down through the center chamber and into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The areas outside the center chamber and the slanted skirt should also be washed off if pollutant build-up exists in these areas.

In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, the system should be cleaned out immediately in the event of an oil or gasoline spill. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use absorbent pads since they are usually less expensive to dispose than the oil/water emulsion that may be created by vacuuming the oily layer. Trash and debris can be netted out to separate it from the other pollutants. Then the system should be power washed to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and to ensure proper safety precautions. Confined space entry procedures need to be followed if physical access is required. Disposal of all material removed from the Cascade Separator system must be done in accordance with local regulations. In many locations, disposal of evacuated sediments may be handled in the same manner as disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal. If any components are damaged, replacement parts can be ordered from the manufacturer.



Cascade Separator® Maintenance Indicators and Sediment Storage Capacities

Model Number	Diameter		Distance from Water Surface to Top of Sediment Pile		Sediment Storage Capacity	
	ft	m	ft	m	y^3	m^3
CS-3	3	0.9	1.5	0.5	0.4	0.3
CS-4	4	1.2	2.5	0.8	0.7	0.5
CS-5	5	1.3	3	0.9	1.1	0.8
CS-6	6	1.8	3.5	1	1.6	1.2
CS-8	8	2.4	4.8	1.4	2.8	2.1
CS-10	10	3.0	6.2	1.9	4.4	3.3
CS-12	12	3.6	7.5	2.3	6.3	4.8

Note: The information in the chart is for standard units. Units may have been designed with non-standard sediment storage depth.

A Cascade Separator unit can be easily cleaned in less than 30 minutes.

A vacuum truck excavates pollutants from the systems.

Cascade Separator® Inspection & Maintenance Log

Cascade Model:		Location:			
Date	Depth Below Invert to Top of Sediment[1]	Floatable Layer Thickness[2]	Describe Maintenance Performed	Maintenance Personnel	Comments

1. The depth to sediment is determined by taking a measurement from the manhole outlet invert (standing water level) to the top of the sediment pile. Once this measurement is recorded, it should be compared to the chart in the maintenance guide to determine if the height of the sediment pile off the bottom of the sump floor exceeds 50% of the maximum sediment storage. Note: to avoid underestimating the volume of sediment in the chamber, the measuring device must be carefully lowered to the top of the sediment pile.
2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of an oil spill, the system should be cleaned immediately.

SUPPORT

- Drawings and specifications are available at www.ContechES.com.
- Site-specific design support is available from our engineers.

CONTECH® ENGINEERED SOLUTIONS
800-925-5240
www.ContechES.com