

NATIONAL GRID

STORMWATER MANAGEMENT STUDY

HILLSIDE AVE. SUBSTATION NO.66

PROJECT NO. 137032

REVISION 1
JANUARY 20, 2025

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List of Abbreviations

Abbreviation	Term/Phrase/Name
AC	Acre
BMP	Best Management Practice
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
CFS	Cubic Feet per Second
CN	Curve Number
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
EDA	Existing Drainage Area
GIS	Geographic Information System
HSG	Hydrologic Soil Group
IN	Inches
kV	Kilovolt
MassDEP	Massachusetts Department of Environmental Protection
MIN	Minute
NAVD88	Total Phosphorous
NO	Number
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
PDA	Proposed Drainage Area
SCS	Soil Conservation Service
SF	Square Foot
SMS	Stormwater Management Study
Tc	Time of Concentration
TP	Total Phosphorus
TR-55	Technical Release 55 Urban Hydrology for Small Watersheds
TSS	Total Suspended Solid
YR	Year

Index and Certification

National Grid

Stormwater Management Study

Project No. 137032

Report Index

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Certification

I hereby certify, as a Professional Engineer in the state of Massachusetts, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by the National Grid or others without specific verification or adaptation by the Engineer.

Brendan W. Maurer, P.E. (MA 52922)

Date: June 11, 2024

Reference information provided by others and not certified by the above sealing Engineer:

Appendix A	Site Location Map
Appendix B	FEMA FIRM
Appendix C	Soil Data

1.0 Project Overview

1.1 Location & Project Description

Burns & McDonnell has prepared this Stormwater Management Study (“SMS”) on behalf of National Grid in support of the Hillside 66 Station Rebuild project (“Project”). The Project is located in the City of Amesbury, Essex County, Massachusetts (“Site”). A site location map is included for reference in Appendix A. The Project will require the demolition of the existing substation and the construction of the proposed, with an expanded yard, new control house, and new fence surrounding the station. Furthermore, two permanent access roads are proposed off Allenclair Drive and two permanent gravel pads are included to the south of the station to allow for access to the existing transmission lines.

The Site is bounded on the north by Allenclair Drive and on the east, west and south by adjoining residential properties. A series of existing 23kV transmission lines are located on the south end of the parcel. Elevations within the area of interest range from 117 to 94 referenced to the North American Vertical Datum of 1988 (“NAVD 88”). The Site is bisected by overhead lines, underground electric lines, and gas lines.

1.2 Floodplain

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) Map No.25009C0102F for Essex County, Massachusetts, Effective Date 7/3/2012, the project site is located within “Zone X”, an “area of minimum flood hazard”, which represents areas outside the 500-year floodplain. The FEMA FIRM is located in Appendix B.

1.3 Soils

The National Resource Conservation Service (NRCS) Web Soil Survey describes the soil on the project site as “pits, gravel”. This classification has no hydrologic soil group (HSG). NRCS Web Soil Survey information can be found in Appendix C.

Additional soils information was provided by National Grid in a *Geotechnical Engineering Report* by GZA GeoEnvironmental, Inc. dated February 21, 2024 for the Hillside 66 Substation. Three test borings were completed on-site and ranged from 35.5-47 foot termination depth. GZA determined that the top of existing grade consisted of approximately 4 to 13 feet of fill material. This material primarily consisted of fine to medium sand with 10-49% gravel and 1-35% silt. Below this a layer of outwash was encountered primarily made up of fine to coarse sand with 1-20% silt and 1-35% gravel. This stratum extended approximately 28-37 feet below grade. The final layer of material encountered was identified as glacial till consisting of dense sand with 1-50+% gravel and 10-49% silt content. Groundwater was encountered in all test borings between 31-35.5 feet below existing grade. The GZA *Geotechnical Engineering Report* is found in Appendix C.

1.4 Pre-Development Site Conditions

Site pre-development conditions consist of the existing Hillside 66 Substation, a gravel access road, and some grassed areas. Most of the Site is relatively flat with a steeper slope to the south of the parcel. All of the Site currently drains to an existing dry well along Allenclair Drive or collects in small depressions along the Site. There is no discharge to any wetlands, streams, or drainage systems. There is no evidence or history of flooding in the neighborhood, which is evidence that the soils infiltrate runoff effectively.

As evident in Appendix D, the area of hydrologic analysis, termed as a “watershed” or “drainage area”, was limited to the project parcel and up to the existing roadway. The watershed, EDA-1, which accounts for the entire site (approximately 1.208 acres), conveys runoff towards the existing drywell along Allencclair Drive, Analysis Point 1. According to local and state public GIS data, this Analysis Point receives runoff from the majority of the surrounding neighborhood. The contributing off-site watershed is so large that analyzing the entire watershed would not be a good representation of the decrease in peak flow rates. A refined watershed boundary therefore more clearly assesses the impact of improving the Site. This is especially true considering that the site development represents a proportionally greater component of the indicated watershed compared to the full watershed. The corresponding results provide a qualitative indication of how development will affect site hydrology, in comparing the change between pre-development and post-development peak stormwater flow rates. This refined watershed consists of 0.945 acres of grass – good conditions with a curve number of 39 and 0.078 acres of existing gravel driveway with a curve number of 96.

A sub watershed, EDA-1.1 was included in the hydrologic analysis of this site and accounts for the runoff held within the substation yard stone. This sub watershed contains the impervious areas on-site including the existing Hillside 66 Substation with approximately 0.160 acres of substation gravel and 0.025 acres of foundations. All impervious surfaces have a curve number of 98.

A Pre-Development Watershed Map is included in Appendix D.

1.5 Post-Development Site Conditions

Post-development conditions propose a new, expanded station yard with several new slab foundations to support electrical equipment, two new gravel access roads connected to Allencclair Drive, a new control house, two permanent gravel pads, and a new stormwater management system comprised of vegetated swales and the existing dry well, along with ancillary grading consisting of grassed slopes to existing grade. The station yard will be expanded, corresponding to an increase in yard stone of approximately 9,977 square feet and an increase in roof area of 2,097 square feet. New equipment will be placed within the substation yard on foundations with a total coverage of approximately 1,050 square feet. This is a decrease from the existing amount of foundation cover of approximately 1,080 square feet.

Similar to the existing conditions, the entire site is encompassed in a watershed, PDA-1, which conveys water to the existing dry well along Allencclair Drive, Analysis Point 1, and consists of 0.691 acres of grass – good condition and 0.056 acres of gravel driveway. A sub watershed, PDA-1.1 accounts for the runoff held within the substation yard stone and consists of the proposed Hillside 66 Substation. This sub watershed holds 0.389 acres of substation gravel, 0.024 acres of proposed foundations, and 0.048 acres of roofs. The proposed substation yard and access road drain to grass-lined swales that outlet to the existing dry-well along Allencclair Drive. The same overall hydrologic area, as described in the section above, was analyzed for both pre-development and post-development conditions and all the same curve numbers were used for the corresponding cover types between the existing and proposed analysis.

A Post-Development Watershed Map is included in Appendix D.

2.0 MassDEP Stormwater Management Compliance

This Stormwater Management Study has been developed to validate compliance with state and local regulations to mitigate downstream effects of site development. Primarily, the requirements set forth by the Massachusetts Department of Environmental Protection (MassDEP) in the Massachusetts Stormwater Handbook (“Handbook”), dated February 2008, were followed to the maximum extent practical as described herein. Additionally, more stringent local requirements for drainage outlined in the City of Amesbury Massachusetts Subdivision Rules and Regulations, dated June 2020, have also been outlined herein where appropriate and followed to the maximum extent practical.

2.1 Rainfall Data

NOAA Atlas 14, Precipitation-Frequency Atlas of the United States, Volume 10, Version 3 published in 2019 provides rainfall intensity information. Type-III 24-hour rainfall depths for the Site were obtained from NOAA’s online precipitation frequency data server (<https://hdsc.nws.noaa.gov/pfds/>). Pertinent rainfall data is summarized in Table 2-1. Full NOAA precipitation frequency data is provided in Appendix E.

Table 2-1: Type-III Design Storm Frequency-Depth

Return Frequency (yr)	24-Hour Depth (in)
2	3.38
10	5.34
25	6.57
100	8.46

2.2 Runoff Data

Runoff calculations were completed using the NRCS/SCS TR-55 runoff curve number method in HydroCAD version 10.20-2g modeling software. The input values used in the HydroCAD model are presented in Tables 2-2 and 2-3.

Table 2-2: Standard Runoff Curve Numbers

Land Cover Type	Soil Type	Curve Number
Substation Yard	A	98
Gravel Driveway	A	96
Grass – Good Condition	A	39
Foundations	-	98
Roof	-	98

Table 2-3: Pre- and Post-Development Model Data

Watershed ID	Area (ac)	Curve Number	Time of Concentration (min)
EDA-1	1.023	43	14.1
EDA-1.1	0.184	98	6.0
PDA-1	0.747	43	16.3
PDA-1.1	0.461	98	6.0

A minimum time of concentration (T_c) of 6.0 minutes was applied to watersheds with calculated time of concentrations below 6.0 minutes, in compliance with TR-55. The Watershed maps of the pre-development and post-development conditions are included in Appendix D.

2.3 Standards

The *Massachusetts Stormwater Handbook* sets forth several standards to combat the adverse effects of new development on existing drainage features, wetlands, and water bodies. “The Stormwater Management Standards address water quality (pollutants) and water quantity (flooding, low base flow and recharge) by establishing standards that require the implementation of a wide variety of stormwater management strategies.”

(*Massachusetts Stormwater Handbook* Vol. 1, Ch. 1, pg. 1). Numbered standards applicable to this project include 1, 2, 3, 4, 8, and 9. The Project meets or exceeds the requirements for each standard.

2.3.1 Standard 1 – No New Untreated Stormwater Discharges

Standard 1 requires that “no new stormwater conveyances (e.g. outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth” (*Massachusetts Stormwater Handbook* Vol. 1, Ch. 1, pg. 4).

All runoff accumulated on-site is also infiltrated on-site; therefore, no stormwater is discharged off-site or into any wetlands or waters of the Commonwealth, and the proposed conditions comply with Standard 1.

2.3.2 Standard 2 – Post Development Peak Discharge Rates

Standard 2 requires that post-development peak discharge rates do not exceed pre-development peak discharge rates for the 2-year and 10-year, 24-hour storm events. Additionally, the *City of Amesbury Massachusetts Subdivision Rules and Regulations* state that, “peak stream and channel flows and overland runoff at the boundaries of the development in the twenty-five (25) and one hundred (100) year frequency storm shall be no higher following development than prior to development”.

The proposed condition stormwater runoff peak flow rate will be reduced versus existing conditions due to the increase in storage volume under the station yard stone.

The pre- and post-development conditions were modeled in HydroCAD to determine the associated peak flowrates according to the watershed maps. Table 2-4 summarizes the peak flowrates for the entire site and the reduction of flow achieved. The existing substation yard was modeled as storage for the rainfall onto the existing yard. The composition of the existing yard was estimated to be 3 inches of crushed stone with 40% voids over 12 inches of subbase. To be conservative, the subbase was assumed to contain 15% voids. This existing yard composition is based on existing station record drawings. The proposed substation yard was also modeled as storage for the rainfall onto the proposed yard. The composition of the proposed yard was accounted for, consisting of 6 inches of

crushed quarry stone with 40% voids overlaying 2 feet of subbase with 15% voids. The substation yard stone is modeled with a curve number of 98 to simulate the entire runoff volume being routed into the available yard storage volume, however the yard stone is a pervious surface and is not considered in the water quality calculations.

Section 1.3 and Appendix C describe the existing soil conditions. Existing soils are classified as “pits, gravel” according to NRCS with no associated hydrologic soil group (HSG). Additionally, the geotechnical report conducted on the Site concludes that the soil primarily consists of sand with varying degrees of coarseness and density. An on-site infiltration rate of 2.41 inches per hour was assumed and used as the exfiltration velocity within the HydroCAD model. This was determined using Table 2.3.3., 1982 Rawls Rates, noted in Volume 3 of the Massachusetts Stormwater Management Standards with the assumption that the soil classified as “loamy sand” with a NRCS hydrologic group (HSG) “A”. Refer to Appendix E for the comprehensive HydroCAD modeling results.

Table 2-4: Site Analysis Point Peak Flowrates

Return Frequency (yr)	Pre-Development Flow (cfs)	Post-Development Flow (cfs)	Net Change (cfs)
2	0.00	0.00	0.00
10	0.19	0.13	-0.06
25	0.51	0.36	-0.15
100	1.34	0.93	-0.41

Per Table 2-4, the peak discharge rates in post-development conditions are reduced from the existing conditions and therefore comply with Standard 2 of the *Massachusetts Stormwater Handbook* and the regulations set forth in the *City of Amesbury Massachusetts Subdivision Rules and Regulations*.

2.3.3 Standard 3 – Recharge to Groundwater

The infiltration volume for groundwater recharge required by the *Massachusetts Stormwater Handbook* is determined by the soil type, infiltration rate, and the increase in impervious area to the Site. At a minimum, the annual recharge from the post-development Site shall approximate the annual recharge from pre-development conditions based on soil type. The existing Site is partially developed and includes features such as concrete, grassed, and gravel areas with existing underground and overhead utilities. The recharge system currently on-site consists of the existing drywell along Allenclair Drive. All existing groundwater recharge occurs within this drywell or through the Site’s existing gravel and vegetated surfaces.

According to the site-specific geotechnical report provided by GZA, located in Appendix C, the existing groundwater level located during test borings was between 31-35.5 feet below existing grade; therefore, groundwater mounding is not a concern.

The proposed Site will act in the same manner as existing conditions with all runoff either infiltrating within the existing drywell or through the proposed gravel and vegetated areas. With no change in the existing soil types located on Site, the proposed conditions should recharge groundwater as sufficiently as the existing conditions and meet the requirements for Standard 3 of the *Massachusetts Stormwater Handbook*.

2.3.4 Standard 4 – Water Quality Treatment

The *Massachusetts Stormwater Handbook* requires that the stormwater system be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). As defined in Volume 1 of the *Massachusetts Stormwater Handbook*, the Site does qualify as an area with a rapid infiltration rate (greater than 2.4 inches per hour), thus the required water quality volume for treatment equals 1.0 inch of runoff times the total impervious area of the post-development.

Additionally, the *City of Amesbury Massachusetts Subdivision Rules and Regulations* states that all stormwater management systems on new development sites must be design to “retain the volume of runoff equivalent to, or greater than, one (1.0) inch multiplied by the total post-construction impervious surface area on site and/or remove 90% of the average annual load of Total Suspended Solids (TSS) generated from the total post-construction impervious area on site and 60% of the annual load of Total Phosphorus (TP) generated from the total post-construction impervious surface area on the site”.

According to the proposed Site conditions and the existing soil composition, all runoff generated on-site is intended to either infiltrate within the existing dry-well or infiltrate through the proposed gravel and vegetated surfaces. The impervious area on-site is anticipated to increase by approximately 1,094 sf. See Table 2-5 for a summary of impervious areas on-site.

Table 2-5: Existing vs Proposed Impervious Areas

Impervious Cover Type	Pre-Development Areas (sf)	Post-Development Areas (sf)	Net Change (sf)
Foundations	1,079	1,050	-29
Roofs	0	2,097	+2,097
Gravel Driveway	3,408	2,434	-974
Total	4,487	5,581	+1,094

The proposed Site contains several large depressions intended to provided storage for runoff in additional to the storage volume of the substation yard. These depressions alone are large enough to hold the required water quality volume to be treated on-site. The required water quality volume for the Site is 1 inch multiplied by the post-construction impervious area. In this case, as any impervious area within the substation is being treated by the yard itself, the additional impervious area to be treated consists of the proposed gravel driveways and pads, totaling approximately 2,434 sf. The required water quality volume is 203 cf. The proposed depressions on-site may hold a volume of approximately 875 cf, more than is required for water quality treatment. The proposed vegetated swale has a gradual slope and long drainage path to allow for maximum infiltration before runoff reaches the dry well. Additionally, pretreatment is provided for all the runoff on-site. Rainfall within the substation yard will be pretreated by the yard stone and subbase prior to infiltration. Areas outside of the substation yard will sheet flow over vegetated areas as pretreatment prior to infiltrating. There will be no discharge of stormwater off-site and all runoff will be completely treated meeting the requirements of Standard 4 of the *Massachusetts Stormwater Handbook* and complying with the regulations outlined in the *City of Amesbury Massachusetts Subdivision Rules and Regulations*.

2.3.5 Standard 5 – Land Uses with Higher Pollutant Loading

This Site does not have a use type or on-site materials that would qualify it for high pollutant load; therefore, this standard does not apply to the proposed construction.

2.3.6 Standard 6 – Discharges to Critical Areas

According to the *Massachusetts Stormwater Handbook*, critical areas are defined as Outstanding Resource Waters, Special Resource Waters, recharge areas for public water supplies, bathing beaches, and shellfish growing areas. Based on a review of publicly available GIS data, the Site is not part of and does not discharge into a critical area; therefore, this standard does not apply to the proposed construction.

2.3.7 Standard 7 – Redevelopment

The Site does not qualify as a redevelopment as defined in Volume 2 of the *Massachusetts Stormwater Handbook*.

2.3.8 Standard 8 – Erosion and Sediment Controls

Erosion and sediment control BMPs are to be implemented at the Site prior to construction and land disturbance. BMPs are to remain in working order until construction activities cease, and the Site is stabilized. All erosion and sediment controls at the Site will be required to comply with the *Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: A Guide for Planners, Designers, and Municipal Officials* dated May 2003, National Grid standards, and contract documents. The erosion control measures to be utilized are shown in Appendix F. The *Erosion and Sediment Control Plan* implements the following BMPs:

- Silt fence shall be installed at the perimeter of the Site before commencing earthwork activities.
- Vehicle construction entrances shall be installed where construction vehicles enter onto public roadways.
- Silt sack temporary inlet protection will be installed on every inlet within the adjoining roadway along the Site.
- Sedimentation and erosion controls shall be inspected weekly and after storm events.

2.3.9 Standard 9 – Long Term Operation and Maintenance Plan

The Project's stormwater-related *Operation and Maintenance Plan* is located in Appendix G. The *Operation and Maintenance Plan* defines the responsibilities that the owner of the property must undertake to comply with required inspections and maintenance to ensure the long-term functionality of the Site's stormwater BMPs.

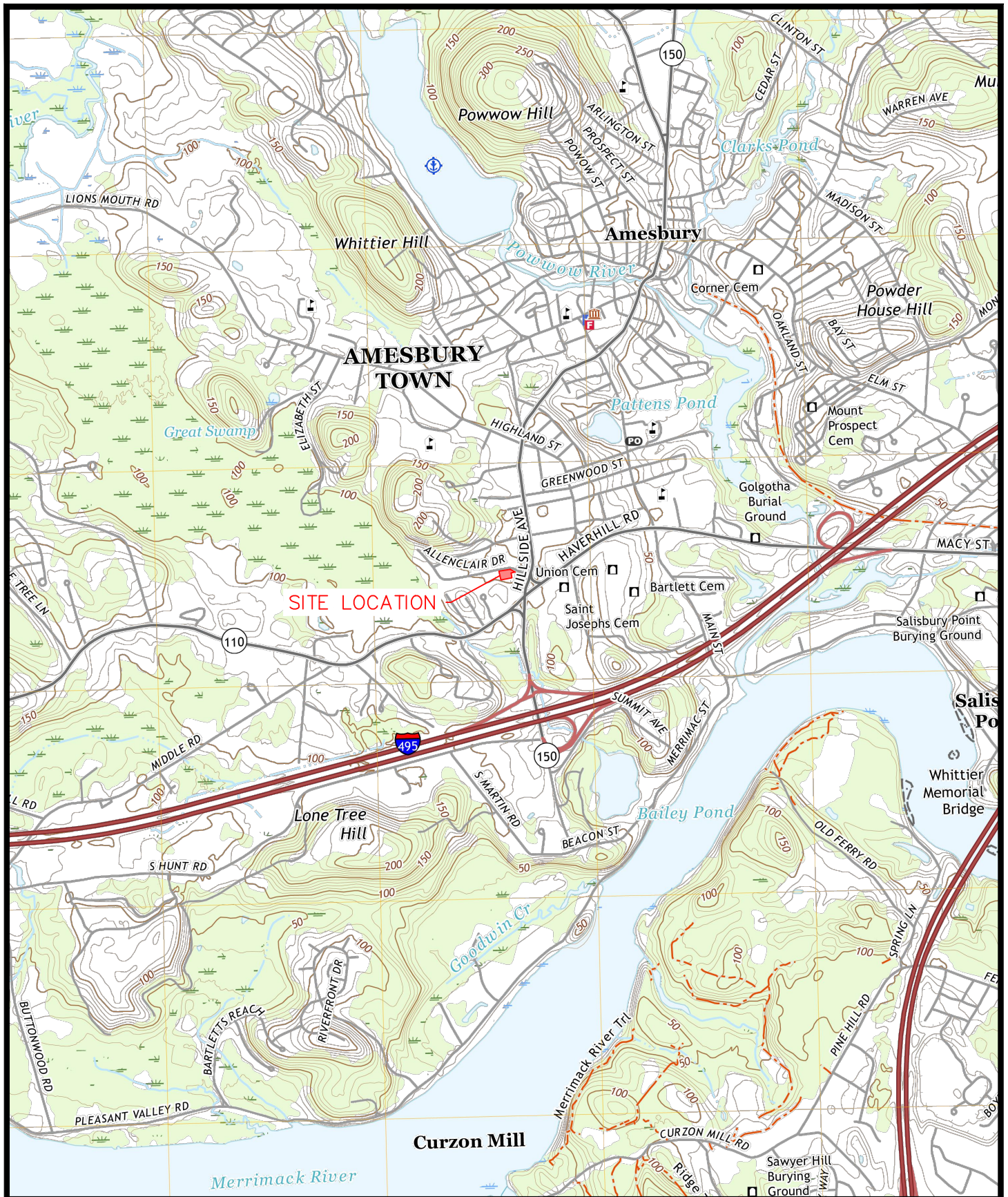
2.3.10 Standard 10 – Illicit Discharges

Illicit discharges to the stormwater management system are discharges that are not entirely comprised of stormwater. According to the *Massachusetts Stormwater Handbook*, an illicit discharge does not include discharges from the following activities or facilities; firefighting, water line flushing, landscape irrigation, uncontaminated groundwater, potable water sources, foundation or footing drains, water used for street washing and water used to clean residential buildings without detergents. The proposed site layout, grading, and stormwater system design ensures that no illicit discharges will occur on-site.

3.0 Conclusion

The proposed substation development has been designed to fully comply with the *Massachusetts Stormwater Handbook* and the *City of Amesbury Massachusetts Subdivision Rules and Regulations*. No new untreated stormwater discharges are added to the Site. The stormwater management system includes a dry well and the post-development conditions do not result in an increase in the stormwater runoff peak discharge rate when compared to pre-development conditions. The Site is proposed to meet requirements for infiltration in accordance with the *Massachusetts Stormwater Handbook*. Water quality treatment is provided for the post-development conditions by ensuring complete infiltration of all generated runoff. The Project does not constitute a use with higher pollutant loads and there are no critical areas identified at the Site. Temporary erosion and sediment controls will be employed during construction to minimize construction impacts to the downstream waters. As always, post-development operations and maintenance is imperative to the functionality of the post-construction stormwater management system.

APPENDIX A – SITE LOCATION MAP



0 2000' 4000'
SCALE IN FEET

**BURNS
& MCDONNELL**

HILLSIDE 66

**US TOPO MAP
AMESBURY TOWN
QUADRANGLE**

APPENDIX B – FEMA FIRM

National Flood Hazard Layer FIRMMette



70°56'37"W 42°50'57"N



0 250 500 1,000 1,500 2,000 Feet

1:6,000

70°55'59"W 42°50'30"N

Basemap Imagery Source: USGS National Map 2023

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) Zone A, V, A99
		With BFE or Depth Zone AE, AO, AH, VE, AR
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
		Future Conditions 1% Annual Chance Flood Hazard Zone X
		Area with Reduced Flood Risk due to Levee. See Notes. Zone X
		Area with Flood Risk due to Levee Zone D
OTHER AREAS		NO SCREEN Area of Minimal Flood Hazard Zone X
		Effective LOMRs
GENERAL STRUCTURES		Area of Undetermined Flood Hazard Zone D
		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
MAP PANELS		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
		Digital Data Available
		No Digital Data Available
		Unmapped



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on **12/26/2023 at 1:18 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

APPENDIX C – SOIL DATA

Soil Map—Essex County, Massachusetts, Northern Part



Soil Map may not be valid at this scale.

Map Scale: 1:1,270 if printed on A landscape (11" x 8.5") sheet.

0 15 30 60 90 Meters

0 50 100 200 300 Feet

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



Natural Resources
Conservation Service

Web Soil Survey
National Cooperative Soil Survey

3/7/2024
Page 1 of 3

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 19, Sep 10, 2023

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

Date(s) aerial images were photographed: May 22, 2022—Jun 5, 2022

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
253B	Hinckley loamy sand, 3 to 8 percent slopes	1.5	22.4%
260B	Sudbury fine sandy loam, 3 to 8 percent slopes	1.0	13.9%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	0.7	10.5%
600	Pits, gravel	3.6	53.2%
Totals for Area of Interest		6.9	100.0%

Essex County, Massachusetts, Northern Part

600—Pits, gravel

Map Unit Setting

National map unit symbol: vjq2

Frost-free period: 125 to 165 days

Farmland classification: Not prime farmland

Map Unit Composition

Pits: 100 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pits

Setting

Parent material: Loose sandy and gravelly glaciofluvial deposits

Data Source Information

Soil Survey Area: Essex County, Massachusetts, Northern Part

Survey Area Data: Version 19, Sep 10, 2023



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GEOTECHNICAL ENGINEERING REPORT

NATIONAL GRID

HILLSIDE 66 SUBSTATION

9 Allencclair Drive
Amesbury, Massachusetts

February 21, 2024
File No. 04.0191648.00



PREPARED FOR:
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40 Sylvan Road
Waltham, Massachusetts 02451

Re: Geotechnical Engineering Report
Hillside No. 66 Substation
9 Allenclair Drive
Amesbury, Massachusetts 01913

Dear Ms. Gavin:

GZA GeoEnvironmental, Inc. (GZA) is pleased to submit this geotechnical engineering report to National Grid for the design and construction of the proposed rebuild of Hillside No. 66 Substation located at 9 Allenclair Drive in Amesbury, Massachusetts (Site).

SCOPE OF SERVICES

GZA's scope of services consisted of subsurface explorations, laboratory testing, geotechnical evaluation, and this report, which summarizes our findings and presents our geotechnical design and construction recommendations for the proposed substation expansion.

This study was completed pursuant to National Grid Purchase Order Nos. 6200039584 and 6200039411. The contents of this report are subject to the Limitations contained in **Appendix A**. Unless indicated otherwise, elevations presented herein are in feet and are assumed to reference the 1988 North American Vertical Datum (NAVD 88).

BACKGROUND

Our understanding of the project is based on our observations made during the field activities completed as noted herein, and our review of plans provided by National Grid, entitled:

- Hillside Ave. No. 66 Substation Rebuild, Preliminary Grading Plan, Prepared by Burns and McDonnell, dated December 12, 2023;
- Hillside Substation No. 66, Sheet No. 1 of 1, EX-1, prepared by BL Companies, dated September 23, 2021;
- Existing Conditions Plan of Land, Hillside Avenue (Route 150), Amesbury, Massachusetts, Prepared by GPI, dated June 14, 2022.

SITE LOCATION AND EXTENT

The Site is defined as a 1.14-acre parcel of land located at 9 Allencclair Drive in Amesbury, Massachusetts, as shown on **Figure 1, Locus Plan** and **Figure 2, Exploration Location Plan**.

SITE HISTORY

GZA reviewed historic aerial maps, historic USGS topographic maps and Google Earth historic satellite imagery to evaluate the Site history. According to the historic maps, Hillside Road was constructed prior to 1888 and rerouted between 1934 and 1944. It is unclear whether this construction resulted in significant cuts and fills on the Site. A former structure was noted near the site on topographic maps prior to 1888 and removed by 1944. Winkley Street was constructed between 1934 and 1944 and extended in 1952. Allencclair Drive was partially constructed west of the Site between 1952 and 1968, though the roadway did not extend to Hillside Road at that time. Between 1968 and 1986, Allencclair Drive was completed and extended to Hillside Road. This resulted in a topographical change west of the site as noted on 1985 topographical maps. It is unclear if the topographical change occurred within the Site bounds. The powerline right of way was observed on historical aerals starting around 1962. The existing substation at the Site was constructed between 1971 and 1973. No water bodies were observed within the Site in historical topographic maps, historical aerals, or Google Earth imagery.

The USGS maps also indicate that the site was located within a topographic depression, At El. 90 or below. At that time, the USGS topographic maps referenced vertical datum NGVD29, roughly mean sea level, and in this region is typically within approximately 1 foot of NAVD88.



Detail 1: Historical Topographic maps of 1968 (left) and 1985 (right) showing topographical change (Source: USGS)

BACKGROUND SUBSURFACE INFORMATION

The USGS soil survey maps the area of the site as gravel pit, which is consistent with the topographic depression noted on the USGS topo maps and the upward slope along the southern property line noted on the survey. Adjacent properties are mapped as sandy and gravelly glaciofluvial deposits derived from gneiss and/or granite and/or schist. The USGS surficial and bedrock geologic maps indicate that the Site is underlain by coarse deposits over porphyritic granite as part of the Newburyport Complex.



FLOOD INSURANCE MAP

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for the Site area was reviewed to assess whether the proposed development will be located within a Special Flood Hazard Area (SFHA) and if so, determine the Base Flood Elevation (BFE) from the FIRM, if available. The FIRM for the Site area is 25009C0102F, effective July 3, 2012. Based on the FIRM, the Site is located outside of the SFHA and in an area of Minimal flood hazard (Zone X).

OBSERVED CONDITIONS

At the time of the subsurface exploration the Site was observed to be developed with a small electrical substation. The substation generally consists of transformers and switchgear. Within the substation the ground surface is covered with crushed stone. A chain link fence surrounds the substation. The transmission right-of-way containing overhead lines are located to the south of the Site. Trees are located around the exterior of the fence and the surrounding ground surface is generally grass covered. Access to the Site is provided by a gravel driveway on the eastern site of the Site. The ground surface is flat throughout most of the Site ranging from approximately El. 93 to El. 96 and slopes upward along the southern boundary. Residential development surrounds the Site on each side.

PROPOSED CONSTRUCTION

Our understanding of the proposed layout at the time of this report is shown on **Figure 2**. The proposed yard area will be approximately 18,300 square feet and will include a control house, two (2) transformers, switches, breakers, bus structures, electrical manholes, and dead-end terminal structures. The proposed grading for the substation will include cuts and fills of approximately +/- 2 feet. The yard will slope from the center at approximately 0.6% east and west, and approximately 0.8% north and south. The Site will be accessed from Allenclair Drive by two gravel driveways of approximately 50 feet in length.

We assume the proposed switches and bus structures will be supported on small diameter drilled piers or spread footings bearing below the design frost depth. Light weight ancillary equipment is anticipated to be pad-mounted and bearing at depths of 1 to 2 feet below the planned yard grade on non-frost-susceptible soil. Foundations for support of the terminal structures are anticipated to be typical National Grid FP-2S drilled shafts (caissons), with a minimum diameter of 5 feet in order to accommodate the anchor bolt assembly and limit plan dimensions of the foundations. Transformers and heavy equipment are assumed to be supported on mat foundations bearing below the frost depth and integrated into a dielectric fluid containment system.

The prefabricated 54-foot by 28-foot control building is anticipated to be supported on perimeter column foundations with wall-load-bearing grade beams that also support the floor span. If the control building is a steel-frame structure, we anticipate it will be supported on perimeter column foundations with wall-load-bearing grade beams and concrete slab-on-grade.

SUBSURFACE EXPLORATIONS

SUBSURFACE UTILITY LOCATION

In 2021, National Grid retained BL Companies (BL) of Melville, New York to perform a geophysical survey in the existing substation area to assess for the presence of potential buried utilities. BL utilized ground penetrating radar and precision utility location methods to detect for anomalies beneath the ground surface (bgs). Potential utilities were recorded on a plan entitled "Sue Markout Locations" dated September 23, 2021 and presented in BL's



September 2021 “Utility Investigation Summary” report. BL noted the detected utilities where at similar locations as depicted in the utility and grounding plan entitled “Conduit & Grounding” by New England Power Service Company dated December 1st, 1971. Subsequent survey of the conduits and grounding were not requested or completed as part of GZA’s scope of work.

EXPLORATION LOCATIONS AND ELEVATIONS

Four proposed test boring locations were laid out in the field using fiberglass tape and line-of-sight methods referencing existing site features. Minor modifications were made to the locations prior to the vacuum excavations to reduce potential conflicts with access constraints and potential underground utility locations. One test boring, GZ-3, was not completed at the request of National Grid due to proximity to underground utilities. The completed test boring locations were measured using the same methods as above and are illustrated on **Figure 2**.

The ground surface elevations at each test boring are based on interpolation of topographic contours shown on the Exploration Location Plan, rounded to the nearest 0.5 foot. The locations and elevations should be considered accurate to the degree implied by the method used.

PRE-EXCAVATION

GZA retained Drilex Environmental of Auburn, Massachusetts to pre-excavate the three test boring locations using vacuum methods and observed and logged the excavations. The vacuum excavation extended to a desired depth of 5 feet bgs. The vacuum excavations were backfilled with the spoils upon completion.

PROXIMITY TO ENERGIZED EQUIPMENT / CONDUCTORS

The Site is located near a right-of-way occupied by overhead 23kV transmission lines. Field observations made in advance of mobilizing the equipment indicated the test boring equipment could safely operate outside of the minimum approach distance for Qualifying Non-electrical Workers. A Qualified Electrical Worker was retained by Drilex as a safety observer and to ground the drilling equipment.

TEST BORINGS

The test borings, designated as GZ-1, GZ-2, and GZ-4, were completed as summarized below. GZA personnel collected soil samples for geotechnical testing during the exploration program. Test boring GZ-3 was planned to be drilled on the east side of the substation area and within the fence line. During the vacuum excavation program, NGRID elected to not complete GZ-3 due to the near proximity of underground electric and communication lines and GZ-3 was eliminated from the program.

Test Boring	Location	Test Boring Termination	Termination Depth (Feet, approx.)
GZ-1	Proposed Transformer	Proposed depth achieved	36.4
GZ-2	Near Proposed Control Building	Proposed depth achieved	35.5
GZ-4	Proposed Yard Area	Proposed depth achieved	47.0

Drilex Environmental Inc. (Drilex) of Auburn, Massachusetts drilled the test borings between January 23 and January 24, 2024. The test borings were advanced using 4.25-inch-inside-diameter hollow stem auger drilling methods to depths ranging from 35.5 to 47.0 feet below ground surface (bgs). The test borings were pre-excavated using vacuum methods to depths of 4 to 5 feet bgs prior to mechanical drilling.



Split spoon sampling and Standard Penetration Tests (SPTs) were performed beginning at the depths of the vacuum excavations and at 5-foot intervals thereafter. The split-spoon soil samples were classified according to the Modified Burmister System and assigned a symbol corresponding to the Unified Soil Classification System (USCS). The test borings were backfilled to the ground surface with drill cuttings upon completion. The SPT N-values presented on the borings are uncorrected. As part of the engineering analyses, the N-values were corrected for hammer efficiency, drill equipment, and overburden stresses.

The test borings were extended to the minimum proposed depths. Groundwater observations are noted on the test boring logs. Refer to the test boring logs in **Appendix B** for specific conditions encountered in each test boring. Refer to **Table 1** for a summary of test boring information.

GEOTECHNICAL LABORATORY TESTING

GZA completed a laboratory testing program, consisting of six gradation analyses on selected representative soil samples to confirm visual-manual field classifications, to evaluate the suitability of on-site materials for reuse, and for use in our engineering analyses. Results of the laboratory tests are included as **Appendix C**. A summary of the laboratory testing follows:

Test Boring No.	Depth Below Grade (ft)	Stratum (USCS Symbol)	Test Performed
GZ-1	2-2.5	Fill (SM)	Index (Gradation)
GZ-1	35-36.4	Glacial Till (GM)	Index (Gradation)
GZ-2	5-7	Fill (SM)	Index (Gradation)
GZ-2	15-17	Outwash (SM)	Index (Gradation)
GZ-4	5-7	Outwash (SP-SM)	Index (Gradation)
GZ-4	20-22	Outwash (SP-SM)	Index (Gradation)

SUBSURFACE CONDITIONS

A general description of the subsurface strata encountered in the explorations is presented below, in order of increasing depth. Refer to the test boring logs in **Appendix B** for conditions encountered in each exploration. A summary of subsurface conditions is provided in **Table 1**.

Fill Material – Approximately 4 to 13 feet of fill material was encountered at the ground surface at test boring locations GZ-1, GZ-2 and GZ-4. This stratum consisted primarily of fine to medium SAND with 10% to 49% Gravel, and 1% to 35% Silt (USCS: SP-SM, SM). Based on vacuum excavation and test boring observations, Cobbles are anticipated to be present within this stratum.

At the location of GZ-1 approximately 4 inches of topsoil at the ground surface, classified as fine to medium SAND, some Silt, trace Organics, trace Gravel. At the location of GZ-2 approximately 8 inches of gravel was encountered at the ground surface at GZ-2.

Laboratory testing on one sample within the stratum was predominantly fine to medium SAND with a Silt content of 31% and a Gravel content of 20% (USCS: SM).

Outwash – This stratum was encountered in each exploration immediately beneath the fill material. The stratum consisted primarily of fine to coarse SAND with 1% to 20% Silt, and 1% to 35% Gravel (USCS: SM, SP-SM,).



The SPT N-values ranged from 7 to 40 and averaged 21 blows per foot, indicating a loose to dense relative density. However, the N-values greater of 40 may be artificially high to the presence of Gravel, and not necessarily indicative of the soil relative density. The stratum was observed to extend to a depth of between 28 to 37 feet bgs.

Laboratory testing on the samples summarized above indicated the stratum was predominantly fine to medium SAND, with a Gravel content ranging from 2% to 23%, and a Silt content ranging from 8% to 20% (USCS: SM, SP-SM).

Glacial Till – The test borings encountered a dense SAND with varying angular Gravel and Silt content beneath the SAND stratum. This layer was observed to be distinct from the SAND by the increase in Gravel and Silt, and the increased relative density. The Glacial Till consisted primarily of fine to coarse SAND with 1% to 50+% Gravel, and 10% to 49% Silt (USCS: SM, GM). Based on test boring observations, Cobbles and/or Boulders are anticipated to be present within this stratum.

The SPT N-values ranged from 41 to greater than 50 blows per foot, indicating a dense to very dense relative density. However, the N-values greater than 50 may be high to the presence of Gravel, Cobbles, and/or Boulders, and not necessarily indicative of the soil relative density. Each boring was terminated in this stratum at depths ranging from 35.5 to 47.

Laboratory testing on one sample within the stratum was predominantly GRAVEL, with a fine to coarse Sand content of 30%, and a Silt content of 18% (USCS: GM).

Bedrock – Bedrock was not encountered in the explorations.

Groundwater – Groundwater was encountered in the test borings at a depth ranging from 31 to 35.5 feet bgs. The measurements were taken immediately following the end of drilling and within the hollow stem augers.

Groundwater observations have been made at the times and under the conditions stated in the test borings logs. Groundwater measurements made during drilling may not represent stabilized groundwater conditions. Fluctuations in groundwater levels will occur due to variations in seasonal influences, precipitation amounts, and other factors different from those existing at the time the observations were made.

IMPLICATIONS OF SUBSURFACE CONDITIONS

Based on our explorations, the anticipated Site development and the foundation types described above appear technically feasible for the proposed construction, using the geotechnical design recommendations presented herein. The primary geotechnical issues impacting the design and construction of the proposed yard and foundations include:

- **Loose Soil.** The top approximately 15 feet of soil in the explorations is medium dense to very loose relative density, providing relatively low bearing capacity for support of shallow foundations and low side resistance for shallow drilled shafts.
- **Existing Fill.** The existing fill found in GZ-2 and GZ-4 exhibited a low and variable density. Although not encountered in the test borings, considering the apparent use of the site as a gravel pit, the Site may be underlain by buried unsuitable bearing materials including organics, rubble or other foreign debris, or cobbles and boulders. These materials pose foundation design and material re-use challenges. Additional subgrade



preparation including over-excavation of fill, is recommended herein. The existing fill was encountered approximately to depth of approximately 4 feet below the anticipated final yard grade.

- **Cobbles & Boulders.** Cobbles were observed in the vacuum excavation sidewalls and during the test borings and are anticipated at depth, which pose excavation and material re-use challenges. Boulders may also be present within the outwash and till.

RECOMMENDATIONS

The geotechnical design and construction recommendations presented below are based on our evaluation of the available data and design concepts provided to GZA and are subject to the limitations contained in **Appendix A**.

These recommendations are based on the conceptual site development plan understood at the time of this report. Additional subsurface investigations and additional or revised geotechnical recommendations may be needed following a more detailed Site development and structure layout.

It is recommended that construction follow National Grid's "Electric Substation Construction Specification", Sections II and III, (Specification) and State Code. References herein to the State Code refer to the Massachusetts State Building Code 9th Edition (Current) and 10th Edition (Draft), with amendments referencing the 2015 and 2021 International Building Codes, respectively. The 10th Edition is currently in draft form and the effective date has not been established. The 9th Edition of the code should be used for design unless the 10th Edition becomes effective during the design process.

FOUNDATIONS - GENERAL

The proposed structures and anticipated foundation types are summarized under the PROPOSED CONSTRUCTION section above. Based on the explorations, the anticipated foundations described above appear to be technically and economically feasible for the project and are the basis for the recommendations that follow. If it is found that the structure location, orientation, or loading change significantly, or that National Grid wishes to consider alternative foundation types, it is recommended that GZA review the changes and revise these recommendations, as necessary.

Foundation Design Parameters - Recommended generalized subsurface profiles for foundation design with the strata and respective depths at the test boring locations were prepared to consistent with the Subsurface Investigation requirements for Substations, ST.03.01.002 and are provided in **Table 2**. Recommended geotechnical soil design parameters corresponding to the generalized strata are presented in **Table 3**.

SUBGRADE CONDITIONS

The geotechnical recommendations herein are predicated on the base of excavations encountering the subgrade conditions summarized herein. Any difference from these anticipated subgrade conditions should be brought to the attention of the Geotechnical Engineer for re-evaluation of these recommendations.

Following demolition of existing structures, clearing and grubbing vegetation, stripping of surficial materials (topsoil, pavements, crushed stone, etc.) and cutting to proposed subgrade elevations, the following subgrade conditions are anticipated to be encountered within structural areas:



Pavement and Yard Section – The proposed yard and access road areas at a depth 3 feet below final grade are anticipated to consist of Existing Fill. Surface compaction is recommended prior to pavement and yard section construction.

Shallow Foundations – Subgrade condition at depths of approximately 4 to 6 feet below final yard grades is anticipated to consist of Existing Fill and loose Outwash deposit. The following is recommended below foundations and within bearing zones prior to foundation construction:

- Strip surficial materials and remove existing structures and utilities.
- Remove disturbed soil resulting from buried foundation / utility removal.
- Over-excavate to a depth of 2 feet below the bottom of the proposed footing.
- Remove any disturbed soil with smooth-edge bucket;
- Surface-compact the subgrade surface;
- Replace with compacted Structural Fill to bottom of footing.

Floor Slabs (if used) – The subgrade at depths of approximately 2 to 3 feet below final yard and building floor slab grades is anticipated to consist of Existing Fill. The same subgrade preparation is recommended as for shallow foundations. Alternatively:

- Strip surficial materials and remove existing structures and utilities.
- Remove Existing Fill to top of natural subgrade or depth of 2 feet below bottom of pad / floor slab, whichever is encountered first;
- Surface-compact;
- If subgrade is deemed acceptable to the Engineer, replace with compacted Structural Fill to bottom of pad/slab.

Shallow Drilled Shafts – Subgrade condition at depths of 5 to 15 feet below final yard grade is anticipated to consist of loose sand (Upper Sand) or loose Sand and Silt. Conventional bottom clean out is recommended.

Deep Drilled Shafts – Subgrade condition at depths of 15 to 30 feet below final yard grade is anticipated to consist of medium dense to dense soils. Conventional bottom clean out is recommended.

Surface compaction is recommended for the loose natural soil subgrades within the structural areas and bearing zones. Structural areas include areas of proposed pavements, yards, shallow foundations, pads, floor slabs, retaining walls, and steep (i.e., 3H:1V or steeper) slopes. The bearing zone includes the structural areas and the underlying area encompassed by 1 horizontal to 1 vertical (1H:1V) line extending downward and outward from one foot beyond the bottom edge of the structural areas. Proof compaction is recommended within the remaining cut areas. Any weak, soft, loose, saturated unstable, pumping, or weaving areas should be allowed to dry and later re-evaluated or removed with a smooth-edge bucket, proof-compacted, and replace with Structural Fill.

FOUNDATIONS – DRILLED SHAFTS (CAISSONS)

Drilled shaft design and construction should be consistent with Section II-10.0 of National Grid Specifications SP.08.00.001 for Substations and SP.06.01.301 for Transmission Structures, ACI 336.3R-14, and the following recommendations. The Contractor's proposed installation plan should be submitted for review and approval and should address procedures and contingencies for achieving the design depth; protecting sidewall and base stability;



installing reinforcement and concrete; and meeting specifications and tolerances consistent with National Grid requirements, the code, and these recommendations, and be reviewed and approved by the Engineer prior to mobilization.

Site-Specific Design and Construction Considerations – The drilled shafts are expected to be entirely within soil and should derive their axial geotechnical resistance within the soil profile using the soil profiles and design parameters provided in the Tables. Lateral resistance may be derived from within the soil profile depth.

Advancing the shaft excavation to design depth while maintaining sidewall and base stability are necessary in order to meet the design intent of the foundations. Significant sidewall collapse, sloughing, and or bottom heave can disturb and weaken the base and sidewall strength and stiffness conditions below that recommended herein and relied upon for foundation design. The recommended design parameters are therefore based upon constructing the drilled shafts consistent with the assumptions and construction considerations herein.

Slotted Caissons – If sufficient space allows, shallow caissons (i.e., 8 to 10 feet deep or shallower) can feasibly be installed by “slotting” as opposed to drilling methods. Slotted excavations can be used where trench boxes are sufficient for support of excavation, and conventional sump pumping methods are sufficient to maintain a dry and stable shaft bottom. Recommendations for slotting are provided in the permanent casing and shallow foundation recommendations below.

Geotechnical Design Parameters – The geotechnical design parameters recommended in **Table 3** include either ultimate strength values with respective factors of safety for use in allowable stress design (ASD), or allowable resistances with respective anticipated deflections. It is recommended that the designer contact GZA for the recommended resistance factors if limit state design is planned. In calculating axial resistance, the applied working load should include the effective weight of the drilled shaft.

Lateral Resistance – The generalized strata encountered in the test borings are provided in **Table 2**. Recommended geotechnical design parameters for the generalized strata are presented in **Table 3**. The individual geotechnical lateral resistant of closely-spaced caissons subject to lateral loads applied in the same direction at the same time should be reduced using the recommended stiffness response factors presented in the table below. It is recommended that the top 2 feet of soil below the ground surface be neglected for resistance of lateral loads due to the potential for future construction disturbance and freeze-thaw weakening.

RECOMMENDED STIFFNESS RESPONSE FACTORS FOR LATERAL SHAFT DESIGN			
Shaft Center-to-Center Spacing	P-multipliers		
	Row 1	Row 2	Rows 3 or More
6B	1.0	1.0	1.0
5B	1.0	0.85	0.70
4B	0.85	0.65	0.50
3B	0.70	0.50	0.35
2B	0.55	0.35	0.20

Notes:

1. These values may be interpolated for interim center-to-center spacing.
2. “B” corresponds to shaft diameter, e.g., 5B indicates center-to-center spacing of 5 diameters.
3. Row 1 is the leading shaft or row of shafts, which corresponds to that side of a shaft group that derives the principal soil resistance. Rows 2 and higher correspond to trailing shafts or rows of shafts, numbered sequentially behind the leading row.
4. Reduction factors should be applied as directed in LPILE (p-multiplier) or MFAD software.



Axial Compression Resistance – Recommended side friction and end bearing design parameters for soil are provided in **Table 3**.

It is recommended that axial compression resistance in soil rely on shaft (friction) only, with a factor of safety of 3. Total settlements are anticipated to be 0.5% of the shaft diameter or less (i.e., approximately ½-inch for a 5-foot diameter shaft). At these deflections, only a relatively small amount of base resistance will be mobilized, and base resistance may be neglected for practical purposes. Further, relying only on shaft friction relaxes the requirements for base cleaning during construction.

If additional axial compression resistance is required, combining the total end bearing with side friction resistance to calculate total compression axial resistance should consider the strain behavior of the shaft in both end bearing and skin friction. GZA is pleased to review this procedure, if requested.

Axial Uplift Resistance – Uplift resistance is derived from side friction using the values presented in **Table 3** with a factor of safety of 4, plus the dead weight of the shaft. Buoyant conditions should be considered in developing estimates of dead weight, and resistance due to base suction should be neglected.

Design Considerations of Installation Method – The means of shaft excavation, permanent casing, and drill fluid are important considerations in the shaft design.

Temporary Casing – Shafts should be constructed by installing temporary casing to the proposed bottom to provide a stable shaft excavation. Excavations in soil *above* the groundwater level should not extend below the bottom of the casing unless it can be illustrated that the sidewalls are stable and that proper excavation safety measures are employed and allow access to the shaft by workers and the geotechnical engineer to make observations and measurements.

Excavations extending below the bottom of temporary casing when working *below* the groundwater level increases the risk of significant sidewall collapse as well as mobilization and weakening of the overlying sidewall soils within the cased section. In certain cases, this can result in voids and ground subsidence. Excavating below the temporary casing should be limited to only that required to remove obstructions necessary to advance the casing. In such cases, continuous depth measurements along with evaluation of excavation soil volume, along with close observation of the ground surface grades is necessary to monitor for subsidence. In the event of sidewall collapse and/or ground subsidence, drilling should be ceased, the shaft temporarily backfilled to stabilize the sidewalls, and the excavation procedures evaluated with the Engineer.

Drill Fluid – Drill fluid consists of maintaining a positive head of either water or slurry within the excavation to resist sidewall caving and bottom heave, particularly when working below the groundwater level. Water alone can immediately weaken the apparent cohesion in granular soils, and over hours or days soften silty and clayey soils, and should be used with caution. In these cases, and in cases of irregular sidewalls caused by removal of cobbles and boulders, slurry is recommended to provide a caking effect to increase the resistance to sidewall weakening and caving.

The slurry, if used, consists of a suspension of either bentonite or polymer in water. Selection of the slurry material should factor environmental and disposal considerations and be approved by National Grid. It is recommended that the slurry be mixed, circulated, and cleaned in tanks and not mixed directly in the excavation. Addition of fresh slurry may be required not only to provide a manageable consistency during excavation, but also to replace



possible loss of slurry into the ground. The design parameters recommended in this report assume that if slurry is used, proper slurry methods are followed, and the slurry meets the parameters and is tested per ACI 336.3. Construction of the shafts should meet the proper slurry methods per ACI 336.3.

Excavation – The actual excavation method used to construct the drilled shafts will be determined by the drilled shaft contractor based on the anticipated subsurface conditions, and specifications should require that an installation plan be submitted to the Engineer for review and comment. Methods of construction as described by ACI 336.3 are recommended and should be referred to in the project specifications and the Contractor's installation plan. The installation plan should be consistent with ACI construction procedures, should include contingencies for repairing sidewall and base instability, and be submitted to the Engineer for review.

Drilling should proceed continuously to the specified tip elevations. The bottoms of drilled shafts should be measured and sounded in the presence of the geotechnical engineer to verify that soil and other debris have been removed from the shafts prior to the placement of concrete.

Obstructions and Excavation Difficulty – Obstructions, such as cobbles and boulders, should be pre-excavated where feasible from the drilled shaft locations in a manner that either protects or restores the design sidewall soils to the pre-existing condition described herein and assumed for design. The method of advancing the drilled shaft excavation should be capable of efficiently penetrating through obstructions to the required bottom elevations with minimal excavation below the temporary casing and minimizing sidewall weakening or caving. It is recommended that the contract documents include definitions for obstructions, including corresponding pay items and methods of measurement to account for specialized tooling and reduced production rates. The depth intervals where difficult test boring drilling occurred are noted on the test boring logs.

Permanent Casing – Casing not removed during concrete placement should be considered permanent. Permanent casing will require that the annulus between the permanent casing and sidewall soils either be backfilled to create the minimum concrete-soil interface assumed in the shaft design, or alternatively, both lateral and axial sidewall resistance will need to be reduced or neglected within the cased zone.

It is recommended that permanent casing, if used, consist of corrugated galvanized metal or single-wall HDPE pipe, provided that the casing be properly sized, centered, plumb, and backfilled with material that meets or exceeds the soil parameters assumed for design. Degradable materials (i.e., paper-based forms such as Sonotube) are not recommended for use as permanent casing. Concrete or flowable fill with a compressive strength of at least 150 pounds per square inch, placed on all sides of the casing using tremie methods consistent with ACI practices, may be used as permanent casing backfill without requiring an adjustment in soil design parameters provided the placement uses tremie or other methods to ensure backfill of the full length and perimeter without allowing any sidewall caving. Use of crushed stone may also be considered on a case-by-case basis, following the geotechnical engineer's review of the material gradation, annular space size, depth of backfill, and filter compatibility with the sidewall soils. Alternatively, the design parameters should be reduced to reflect the engineering properties of the backfill material and method of placement and compaction used.

Concrete – Concrete should be placed continuously and without cold joints from the bottom to the top of the shaft using methods approved by the structural engineer. Properly selected retarder additives are recommended for use in the approved mix design to allow greater time for casing removal, adjusting the reinforcing and anchor bolts, and forming the shaft top before setting begins.



Restoration – Upon completion of drilled shaft installations, disturbed soils around the tops of the shafts should be recompacted to a stable condition and to the relative density assumed in the design using compaction equipment and methods acceptable to the geotechnical engineer. However, it is recommended that the top 2 feet of soil below the ground surface be neglected for resistance of axial and lateral loads due to the potential for future disturbance and erosion.

Load Testing – It is our opinion that with proper inspection, load testing is not necessary for the drilled shaft foundations. It should be noted, however, that the factor of safety with a load test can be reduced to 2 for both compression and uplift, potentially resulting in construction cost savings if the shaft length is controlled by axial loading. If, in the opinion of the geotechnical engineer, questionable conditions are encountered during installation, integrity testing of the concrete or other testing depending on the situation encountered may be required.

Inspection – Construction of the drilled shafts should be performed for compliance with the verification and inspection tasks indicated on 1705.8 of the IBC, the recommendations of the geotechnical report, contract documents, and approved construction submittals. The engineer should observe critical aspects to confirm that geotechnical recommendations and design assumptions are met including, but not limited to:

- Excavation minimum dimensions, and sidewall and base conditions are consistent;
- The excavation is dry or, if not, that wet installation methods are consistent with proper procedures;
- Anchor bolts and reinforcing steel is consistent with the design, and are clean and properly placed; and
- Concrete is tested and placed continuously while casing is retracted in a method to maintain sidewall stability and integrity of the concrete.

SHALLOW FOUNDATIONS

Subgrades – Shallow foundations are anticipated to encounter the conditions summarized in the SUBGRADE CONDITIONS section of the report above. The subgrades are recommended to be prepared as outlined in the SUBGRADE CONDITIONS section above, and further described in the CONSTRUCTION section below.

The bearing zone includes the area encompassed by 1 horizontal to 1 vertical (1H:1V) line extending downward and outward from one foot beyond the bottom edge of the foundations to a suitable bearing soils. Structural backfill materials (i.e., Sub-base Fill, Subgrade Fill, and/or Crushed Stone) should be in accordance with the FILL MATERIALS, PLACEMENT, COMPACTION section below. Subgrade preparation includes protection of the subgrade from construction and moisture disturbance until foundations are constructed.

Spread Footings – Following the subgrade preparation above, the recommended maximum net allowable bearing pressures for shallow foundations bearing on 2 feet of compacted Structural Fill placed over the naturally deposited soil, are indicated in **Table 3**.

Soil Subgrades - The recommended bearing pressure is based on a post construction settlement of less than 1 inch and differential settlements of less than 1/400 between adjacent column footings. Much of this settlement is expected to occur during construction as dead load is added to the structures.

The allowable bearing pressure for footings smaller than 3 feet in the least lateral dimension should be reduced to one-third of the values listed in **Table 3**, multiplied by the least lateral footing dimension in feet. Continuous wall footings should be at least 18 inches wide; isolated footings at least 24 inches wide.



For frost protection, all exterior footings and interior footings in unheated areas should be placed at least 4 feet below final grade. For interior footings in heated areas, the bottom of the footing should be at least 18 inches below the lowest ground surface or floor slab immediately adjacent to the footing.

Slab-on-Grade and Pads – Following the subgrade preparations and structural fill placement recommended in this report, it is recommended that the control building slab be supported on a minimum 8-inch-thick Sub-Base Fill or crushed stone base course. Selection and installation of a vapor barrier, if used, is recommended in accordance with ACI 360R-10. The recommended modulus of subgrade reaction, assuming a 1-foot square plate at the ground surface and that subgrades are evaluated and prepared as recommended in this report is provided in **Table 3**.

Lateral Loads – Shallow foundations and retaining structures subjected to unbalanced earth-loading should be designed to resist sliding, overturning, and lateral earth pressures. The recommended friction angles between soil and concrete for sliding resistance are included in **Table 3**. In cases where insulation or vapor barriers are used beneath the foundation element, the base shear should be either neglected or further evaluated at the soil/insulation interface based on published friction factors for the selected product.

Recommended earth pressure coefficients are provided in **Table 3**. These coefficients may be multiplied by the unit weight (total or buoyant as appropriate) for each respective stratum. These coefficients are based on horizontal or 2H:1V sloped backfill, vertical soil/concrete interfaces and the walls are backfilled with free-draining material and provided with back drains (i.e., no hydrostatic pressure).

It is recommended that passive resistance of the top foot of soil below ground surface be neglected, due to possible disturbance of soil. Because larger deflections are required to mobilize passive resistance, a reduced passive earth pressure coefficient is recommended in **Table 3** for calculating sliding resistance.

Where the calculated earth pressure behind the wall is less than 250 pounds per square foot (psf), it should be increased to 250 psf to account for stresses created by compaction of soils behind the wall. Walls should also be designed for appropriate temporary and permanent surcharges, and for sloping backfill, if applicable.

Where required by code, design for lateral earth pressures should also include seismic forces added to the static forces. The total static and seismic resultant force acts on the wall at a distance of no less than one third of the wall height from the bottom of the wall footing. The recommended seismic active earth pressure coefficient is provided in **Table 3**.

SEISMIC DESIGN CONSIDERATIONS

It is understood that a Risk Category IV will be used for design. Based on the subsurface conditions encountered, a Site Class D (Stiff Soil) is recommended for design. Recommended seismic design parameters for the project are provided below.

Seismic Design Parameter	9 th Edition (Current) ASCE/SEI 7-10 IBC 2015	10 th Edition (Draft) ASCE/SEI 7-16 IBC 2018
Mapped short-period spectral response acceleration, S_s	0.267	0.356
Mapped long-period spectral response acceleration, S_1	0.078	0.077
Short-period site coefficient, F_a	1.59	1.52
Long-period site coefficient, F_v	2.4	2.4



The subsurface conditions were assessed for liquefaction potential. The term "liquefaction" describes a phenomenon in which saturated, cohesionless soil experiences a substantial reduction in effective stress during a design earthquake and acquires a degree of temporary mobility sufficient to permit substantial settlement and/or loss of bearing capacity. Based on the observed relative density and gradation of the Site soils below the groundwater level, it is our opinion that liquefaction under a design seismic event is **not** anticipated to result in a significant loss in bearing capacity or result in significant seismic-induced settlement.

In Massachusetts, the State code design for lateral earth pressures should also include seismic forces added to the static forces. For horizontal backfill, foundation and retaining walls should be designed to resist an earthquake force, F_w , as defined below. The seismic resultant force should be distributed over the height of the wall as an inverted triangle.

$$F_w = 0.1(S_s)(F_a)(\gamma_t)(H)^2$$

Where:

S_s and F_a are seismic parameters provided above;

γ_t is the total unit weight of the soil behind the wall, provided in **Table 3**, and

H is the height of the wall, measured from the grade in front of the wall to the top of the wall.

GRAVEL DRIVEWAY AND YARD AREAS

Following subgrade preparation described in the SUBGRADE CONDITIONS section above, the access road subgrade is anticipated to consist of existing fill. The planned gravel driveways and the yard expansion areas are structural areas. Prior to placement of Sub-Base Fill, gravel driveways, and Crushed Stone yard surface material, excavation and subgrade preparation should be consistent with the recommendations provided in the SUBGRADE CONDITIONS and CONSTRUCTION sections of this report.

PERMANENT GROUNDWATER CONTROL

Groundwater was encountered within 30 to 35 feet of the yard grade at the time of the exploration and may rise seasonally. Perimeter foundation drains may be installed to reduce water-related concerns surrounding the building consistent with the building code. However, given the flat yard grade and lack of below-grade open space, and with subgrade preparation and backfill as recommended herein, a perimeter drain is not considered necessary to meet the intended performance of the foundation.

FILL MATERIALS, PLACEMENT, COMPACTION

For the purposes of this report, the term Structural Fill is fill material placed and compacted with fill areas which can include the materials described below. Rip Rap and Ordinary Fill are not considered Structural Fill. We recommend the following materials and their respective recommended applications for use on this project, consistent with National Grid's "Standard Construction Specification for Electric Stations". Reference is made to acceptable materials described in the Commonwealth of Massachusetts Department of Transportation (MassDOT) Standard Specifications for Highways and Bridges, as appropriate.



¾" Crushed Stone

This Structural Fill material is recommended for use in the following applications:

- As subdrain backfill, and
- As a subgrade stabilization layer

¾" Crushed Stone should be separated from all subgrade and fill soils with the use of a non-woven geotextile in all drainage or wet applications and below the seasonal high groundwater table. Filter fabric is also recommended in dry applications where fill is placed directly over Crushed Stone. When used as a stabilization layer, the geotextile should consist of Mirafi 1120N (or equivalent), and when used only as part of a drainage system, the geotextile should consist of Mirafi 140N (or equivalent). Crushed Stone should consist of durable crushed rock or durable crushed gravel stone, free of organics, deleterious materials, clay, ice, snow, and waste of any kind and meet the gradation tabulated herein. Material meeting MassDOT Section M2.01.4 (¾ in.) is recommended for use as Crushed Stone.

1-½" Crushed Stone

This Structural Fill material is recommended for use in the following applications:

- Yard Surfacing, and
- As a subgrade stabilization layer.

1-½" Crushed Stone should be separated from all subgrade and fill soils with the use of a non-woven geotextile in all drainage or wet applications and below the seasonal high groundwater table. Filter fabric is also recommended in dry applications where fill is placed directly over Crushed Stone. When used as a stabilization layer, the geotextile should consist of Mirafi 1120N (or equivalent), and when used only as part of a drainage system, the geotextile should consist of Mirafi 140N (or equivalent). Crushed Stone should consist of durable crushed rock or durable crushed gravel stone, free of organics, deleterious materials, clay, ice, snow, and waste of any kind and meet the gradation tabulated herein. In New England, material meeting ASTM C-33, Type 4 is recommended for use as 1-½" Crushed Stone.

Sub-Base Fill

This Structural Fill material is recommended for use in the following applications:

- Within 0.5 and 2.5 feet below final yard grade,
- As backfill for foundation and retaining walls,
- As base course beneath floor slabs, and
- In other free-draining, potentially frost susceptible applications where Crushed Stone is not required.

Sub-base Fill should consist of clean sand, gravel and/or aggregate, free of concrete, brick, asphalt, cinder, organics, deleterious materials, ice, snow, and waste of any kind. The fine fraction should NOT consist of Clayey Silt, Silty Clay, Clay, Organic Silt, Organic Clay, or Peat. Water content by weight during compaction should not exceed ±2 percent of optimum moisture as determined by ASTM D 1557. Material meeting MassDOT Gravel Borrow, Section M1.03.0-1 with a maximum particle size of 1-inch is recommended for use as Sub-Base Fill.



Sub-Grade Fill

This Structural Fill material is recommended for use in the following applications:

- Within the yard below a depth of 2.5 feet below final yard grade;
- Within the bearing zone of footings;
- Below slab-on-grade base course; and
- In all other Structural Fill applications where Crushed Stone or Sub-base Fill are not required.

Sub-grade Fill should consist of clean sand, gravel and/or aggregate, free of concrete, brick, asphalt, cinder, organics, deleterious materials, ice, snow, and waste of any kind. The fine fraction should NOT consist of Clayey Silt, Silty Clay, Clay, Organic Silt, Organic Clay or Peat. Water content by weight during compaction should not exceed ± 2 percent of optimum moisture as determined by ASTM D 1557. Material meeting MassDOT Gravel Borrow, Section M1.03.0-1, Type b is recommended for use as Sub-grade Fill.

The following on-site soil may be used as an alternative to imported Subgrade Fill provided it meets the following criteria:

- Granular (i.e., < 35% silt / clay content)
- Within all pavement and yard areas is used only below the frost depth noted herein.
- Screened to remove particle sizes over 4 inches.
- Moisture conditioned to within 3% of optimum moisture content.
- Can be placed and compacted to create a consistent, stable and uniform lift thickness, compacted to 95% of modified Proctor.
- On-site mineral material, free of concrete, brick, asphalt, cinder, organics, deleterious materials, ice, snow, and waste of any kind.

Road Base Course

This Structural Fill material is recommended for direct support of the bituminous concrete in new pavement sections. Road Base Course should consist of a combination of hard durable stone coarse aggregate and natural sand or crushed stone fine aggregate free of any concrete, brick, asphalt, cinder, with a Los Angeles Abrasion Test wear of no more than 40. Water content by weight during compaction should not exceed ± 2 percent of optimum moisture as determined by ASTM D 1557. Material meeting MassDOT Section M2.01.7, Dense Graded Crushed Stone for Sub-base, is recommended for use as Road Base Course.

Ordinary Fill

On-site soil that does not meet any of the above Structural Fill requirements is defined herein as Ordinary Fill can potentially be used on-site as fill to minimize the export of excess on-site soils.

Ordinary Fill may be considered for use in the following applications:

- Below a depth of 5 feet within pavement areas;
- Below a depth of 5 feet in yard areas;
- Outside of the bearing zone of foundations, pads, and floors;
- Within slopes shallower than 2H:1V;
- Screened to remove particle sizes over 10 inches.;



- Moisture conditioned to within 3% of optimum moisture content;
- Can be placed and compacted to create a consistent, stable and uniform lift thickness, compacted to 92% of modified Proctor; and
- On-site mineral material, free of concrete, brick, asphalt, cinder, organics, deleterious materials, ice, snow, and waste of any kind.

Rip Rap

Rip Rap is recommended for all soil slopes steeper than 4H:1V and where slope cover is not required to be permanent vegetation cover. It is recommended that the minimum rip rap cover thickness be 12 to 18 inches and the rip rap be sized using a material with maximum stone size of 75% of the total cover thickness.

Material meeting MassDOT Section M2.02.4 “Modified Rockfill” is recommended for use as Rip Rap cover thickness of 12 to 18 inches, Material meeting MassDOT Section M2.02.3 “Stone for Pipe Ends” is recommended for use as Rip Rap cover thickness of 18 to 30 inches, and material meeting MassDOT Section M2.02.2 “Dumped Rip Rap” or M2.06.0 “Slope Paving” is recommended for use as Rip Rap with slope cover thicknesses of 30 inches and greater.

Placement and Compaction

Prior to placing new fills, all existing subgrades steeper than 5H:1V should be benched to roughly horizontal to facilitate equipment travel and to avoid sloped material interfaces. Fill operations should start at the lowest bench. In addition, all loose materials and slough created at the edges of compacted lifts should be cut during placement of adjacent lifts to ensure uniform compaction. Fill slopes are recommended to be over-built horizontally, and then cut back to finish slope grade to remove the uncompacted edges of each lift.

Representative samples of existing fills planned for reuse as Structural Fill should be obtained by the Geotechnical Engineer and tested for gradation prior to use. Representative samples of all fills and backfills for use on the project should be tested using the Modified Proctor method (ASTM D1557 and D4718) to determine maximum dry density and optimum moisture content. Field compaction should be measured prior to placing subsequent lifts. The following minimum compaction criteria are recommended:

Location and Depth of Fill	Percent of Maximum Dry Density (ASTM D1557)
Beneath Foundations and Slabs ⁽¹⁾	95
Adjacent to exterior foundation walls	92
Pavement and Yard Area within 4 feet of finished grade ⁽²⁾	95
Pavement and Yard Area greater than 4 feet below finished grade	92
Non-structural areas	90

1. Includes area within bearing zone (1H:1V slope) of bottom of footings.
2. The following paragraph regarding gravel fills does not apply to crushed stone or rip rap.
3. The maximum loose lift thickness should be 12 inches for vibratory rollers and 6 inches for hand-operated equipment.

Gravel fills containing greater than 30% coarse gravel (>3/4-inch size) may not be reliably tested in the field for compaction using conventional methods. A procedural compaction assessment method may be appropriate in the cases under the direction of the Geotechnical Engineer.



EXCAVATED MATERIAL RE-USE AND DISPOSAL

The project is predicated on re-use of the suitable portions of the on-site soils. Recommendations for on-site material re-use is addressed in the Ordinary Fill and Subgrade Fill sections above.

Due to the high fines content, re-use of these soils will require careful planning and extra care, adjust, and maintain moisture content to near the optimum moisture when stockpiled, and protect from wet weather with proper sloping and sealing during and following placement and compaction.

The excavated materials should be regularly assessed by the Geotechnical Engineer to ensure conformance with the intent of gradation specifications prior to reuse of any on-site materials as fill. Excavated material may be utilized on-site in the applications as described above at the discretion of the Geotechnical Engineer, provided that the material can be properly moisture conditioned and compacted to the recommended percent of the maximum dry density.

Due to the anticipated oversized content (i.e., cobbles and boulders), screening of oversized materials (i.e., cobbles and boulders) should be planned and budgeted to meet the required gradations described above. Protecting exposed soil from moisture and freezing will also be necessary. Covering stockpiles, diverting stormwater, and potentially aerated or watering overly moist or dry soil should also be planned and budgeted to meet the recommended range of optimum moisture content prior to placement and compaction.

Excess material from the site that cannot be reused on site should be transported off-site in accordance with local, State, and federal regulations. GZA's Scope of Services did not include chemical screening or testing. Evidence of stained or environmentally-impacted soil and water was not observed during the explorations. It is recommended that characterization and disposal or discharge of soil and water originating from the work area be performed in accordance with National Grid's Environmental Procedure, EP-1 – Waste Management; Environmental Guidance Document, EG-119 – Excavated Fill Materials and C&D Debris Management, and EG-1701 – Projects at Existing Substations, and in a manner acceptable to National Grid, as well as per applicable local, State, and Federal regulations.

CONSTRUCTION

It is recommended that construction follow National Grid's January 2019 "Standard Construction Specification for Electric Stations", Section II, (Specification). Additional recommendations and considerations are provided below.

SUBGRADE PREPARATION

The geotechnical recommendations herein are predicated upon completion of the minimum subgrade preparation presented in SUBGRADE CONDITIONS section of this report.

Subgrade preparation serves to:

- Replace unsuitable bearing materials;
- Improve otherwise suitable subgrade soils that become loosened or disturbed during excavations;
- Assist the geotechnical engineer in assessing the suitability of the subgrades for their intended use; and
- Identify additional weak, unstable, deleterious, or otherwise unsuitable subsurface conditions.



Removal of Existing Materials

The minimum recommended depth and extent of subgrade removal within planned structural areas are presented in the SUBGRADE CONDITIONS section of this report. Where excavations for removal of anticipated unsuitable bearing soils is recommended, this removal should occur:

- Following site clearing of vegetation, grubbing of stumps and root balls, and stripping of topsoil and surficial materials;
- Prior to placing fills and installing duct banks, underground utilities, grounding grids, and foundations;
- Extend to the minimum depths recommended herein or to the top of natural undisturbed, suitable bearing soils described herein and as observed and approved in the field by the Geotechnical Engineer, whichever is encountered first; and
- Extend laterally to include the bearing zone beneath foundations as defined in the SHALLOW FOUNDATIONS section.

Surface-Compaction

Following the removals described above, surface compaction is recommended to improve the relative density of Existing Fill soils. When performed as recommended, surface compaction is a high-intensity compaction procedure anticipated to improve the relative density of loose granular soils to a depth of 2 to 3 feet. Surface compaction is a ground improvement method to improve the relative density of granular soils to a depth of 2 to 3 feet, when recommended. Surface compaction also accomplishes the goal of proof-compaction as described below. Following the above removal, all exposed yard and access road subgrades should be tracked and back-bladed, and surface compacted with a minimum of 6 passes of a 10,000-pound or heavier smooth drum roller operating with full vibration. Surface compaction should be performed with the roller operating a maximum 2 miles per hour (3 feet per second). Surface-compaction should be completed under the full-time observation of, and acceptance of the subgrade by, the Geotechnical Engineer.

The Geotechnical Engineer should provide full-time observation and evaluation of all surface compaction to confirm that the content, gradation, and relative density of the subgrade are consistent with the conditions described in the test boring logs and the foundation design parameters recommended in **Table 3** and is sufficiently stable to support subsequent fills and foundations. Based on the Geotechnical Engineer's assessment, either the subgrades will be approved, or further removal and evaluation of the fill subgrade will be required prior to approval of the subgrade for direct and indirect support of structural fills and foundations.

Exceptions to the above recommendations should be upon the observation of the field conditions and recommendation of the Geotechnical Engineer and include:

- Saturated subgrades: In the event that vibratory compaction is observed to weaken or un-stabilize otherwise suitable subgrades, static compaction methods may be employed.
- Deep subgrades: In the event that stable subgrades are not encountered within practical depths of excavation, subgrade stabilization may be employed.
- Roadways: The following may remain below a depth of 4 feet below finish grade provided no future foundations or underground utilities are planned in these areas:
 - Buried structures not susceptible to crushing or collapse or containing voids allowing raveling of soil;
 - Topsoil that is relatively thin, firm, and stable; and
 - Root balls that remain undisturbed.



- Frozen subgrades: As an alternative to removal and replacement with Structural Fill, frozen subgrades which were otherwise suitable bearing and stable may be thawed by means approved by the Geotechnical Engineer, scarified, and re-compacted.

Subgrade Stabilization

Once exposed, the otherwise suitable and stable natural subgrade materials may become weakened by weather and construction traffic disturbance. Subgrade stabilization, if required, may consist of over-excavation to a deeper stable subgrade and replacement with structural fill and/or placement of coarse-graded aggregate or crushed stone wrapped in non-woven geotextile or placement of a lean concrete working slab. The extent of subgrade stabilization can likely be reduced if the Contractor constructs a haul road of granular soil prior to initiation of heavy construction traffic or if the Contractor waits to excavate to the final subgrade surface until immediately before new fills or foundations are constructed.

Subgrade Protection

Following subgrade preparation and/or stabilization, the Contractor should employ means to protect the otherwise suitable bearing and stable subgrades. The exposed subgrade should be graded to promote positive runoff to a suitable drainage feature at all times during construction. The degree of subgrade disturbance will be dependent on the Contractor's means and methods, such as coordinating site activities around anticipated precipitation and protecting exposed subgrades due to disturbance from excess moisture and construction equipment traffic.

Prior to fill placement or foundation construction, subgrades should be covered and protected from freezing, either by blankets or excess fill material. Recommendations for frozen subgrades are provided under the Proof-compaction section above.

EXCAVATION DIFFICULTY

The fill and natural soils underlying the site are anticipated to be practically removed with conventional excavation equipment capable of reaching the required depths. Buried structures such as utilities, conduits, pits, sumps, and foundations, and cobbles and boulders within the fill and sand and gravel deposits, may be anticipated during the excavations, requiring specialized excavation equipment and/or disposal procedures.

EXCAVATION SUPPORT

Excavation slopes should be flattened or braced to maintain stability. All excavations should be performed in accordance with current OSHA requirements under the observation and responsibility of the project contractors. Construction site safety generally is the sole responsibility of the Contractor, who shall also be solely responsible for the means, methods, and sequencing of construction operations.

Based on the granular nature of the soils within planned excavation depths, it is anticipated that the soil exposed in excavation would generally be classified as Type C soil in accordance with OSHA regulations, with a maximum slope inclination of 1.5H:1V.

Excavation slopes should be checked regularly for signs of instability and should be shored or flattened as required. Temporary slopes should be protected from surface run-off erosion by means of berms and swales located along the top of the slope and by means of plastic sheeting placed over the slope.



It is recommended that if additional excavation support is required, the support of excavation (SOE) system should be designed by a Professional Engineer registered in the state of Massachusetts for any excavation deeper than 8 feet.

CONSTRUCTION DEWATERING

Temporary construction dewatering is not anticipated during foundation excavation. However, the contractor should be prepared to dewater as necessary to allow excavation, observation of the subgrade, and footing construction in-the-dry. In general, we anticipate that pumping from localized sumps should be sufficient for construction dewatering. Dewatering efforts must satisfy the Site-specific Soil Management Plan and the requirements of local, State, and federal environmental and conservation authorities.

It is also recommended that temporary control measures be implemented to reduce the amount of surface water (from rainfall runoff) from potentially entering and ponding in the excavations. Temporary measures should include, but not be limited to, construction of drainage ditches to divert and/or reduce the amount of surface water flowing over exposed subgrades during construction. Precipitation that results in standing water in the excavation should be removed immediately.

The degree of moisture and construction disturbance will be dependent on the Contractor's means and methods, such as coordinating site activities around anticipated precipitation, and protecting exposed subgrades due to disturbance from excess moisture and construction equipment traffic. Additional time and expense should be planned and budgeted to protect moisture condition and stabilize the exposed sensitive subgrades.

PROTECTION OF EXISTING STRUCTURES

The proposed excavations for footings, slabs-on-grade, may be close to existing above- and below-ground structures. Particular care should be made to avoid undermining of these features to remain.

All excavation should be restricted from encroaching into the 2H:1V line extending downward and outward from the bottom of existing footings/foundation walls/slabs. Temporary cut slopes adjacent to existing footings/foundation walls/slabs should be protected from erosion and stormwater runoff.

Vibration monitoring may be warranted to monitor potential disturbance to energized facilities. Vibration monitoring should establish a low-level warning and a higher-level stop work vibration threshold, real-time reporting, and a contingency plan in the event that construction activities create unacceptable vibrations.



FINAL DESIGN AND CONSTRUCTION PHASE SERVICES

We look forward to continuing working with National Grid during the upcoming planning, design, and construction phases of this project. Integrating these geotechnical recommendations into the contract documents and the final construction can be facilitated by GZA providing design, design review, value engineering, procurement support, submittal review, QA/QC, and construction control for the site development, stormwater, foundation, and other civil components of the project.

CLOSURE

We appreciate the opportunity to work with you on this project. Please call us with any questions.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

A handwritten signature in black ink, appearing to read 'Trey Dykstra'.

Trey A. Dykstra, P.E.
Project Manager

A handwritten signature in black ink, appearing to read 'Jay L. Hodkinson'.

Jay L. Hodkinson, P.E.
Consultant/Reviewer

A handwritten signature in black ink, appearing to read 'Gary McAllister'.

Gary R. McAllister, P.E.
Principal-in-Charge

TAD/GRM/JLH:jlh

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Attachments: **Table 1** – Summary of Subsurface Conditions
Table 2 – Recommended Generalized Subsurface Profiles
Table 3 – Recommended Foundation Design Parameters – Granular Soils
Figure 1– Locus Plan
Figure 2 – Exploration Location Plan
Appendix A – Limitations
Appendix B – Test Boring Logs
Appendix C – Results of Geotechnical Laboratory Testing

Tables

TABLE 1 - SUMMARY OF SUBSURFACE CONDITIONS

Hillside 66 Substation

Amesbury, Massachusetts

Project No. 04.0191648.00

Test Boring	Lon (Deg)	Lat (Deg)	X Coordinate (Massachusetts State plane)	Y Coordinate (Massachusetts State Plane)	Approximate Existing Ground Surface Elevation	Soil and Groundwater Conditions								Bottom of Exploration (ft)		
						Groundwater	Bottom of Fill Material (ft)		Top of Outwash		Top of Glacial Till					
							Depth BGS	ELEV	Depth BGS	ELEV	Depth BGS	ELEV	Depth BGS	ELEV	Depth BGS	ELEV
GZ-1	-70.938524	42.845468	806753	3133637	96.0	33.6	62	8.0	88	8.0	88	28.0	68	36.4	60	
GZ-2	-70.938408	42.845580	806784	3133678	95.5	31.0	65	13.0	83	13.0	83	31.5	64	35.5	60	
GZ-4	-70.938339	42.845311	806803	3133580	95.5	35.5	60	4.0	92	4.0	92	37.0	59	47.0	49	

NOTES:

- 1 All depths are measured in feet below ground surface (bgs). Depths were estimated to the nearest 0.1 feet during drilling as presented on the boring logs. The accuracy of these values depends on drilling conditions and sample recovery and is on the order of ±1 foot. Elevations are rounded to the nearest 1 foot.
- 2 "NE" indicates stratum not encountered in exploration. "NM" indicates groundwater not measured.
- 3 See test boring logs in Appendix B for additional information.

TABLE 2 - RECOMMENDED GENERALIZED SUBSURFACE PROFILE OF EXISTING CONDITIONS

**Hillside 66 Substation
Amesbury, Massachusetts
Project No. 04.0191648.00**

GZ-1				GZ-2				GZ-4						
Depth (ft)	Elev (ft)	Rec'd Design Strata	Hydrostatic Condition	Depth (ft)	Elev (ft)	Rec'd Design Strata	Hydrostatic Condition	Depth (ft)	Elev (ft)	Rec'd Design Strata	Hydrostatic Condition			
0	96	G1	UNSAT	0	95.5	G1	UNSAT	0	95.5	G1	UNSAT			
1	95			1	94.5			1	94.5					
2	94			2	93.5			2	93.5	G2				
3	93			3	92.5			3	92.5					
4	92	G2		4	91.5	G2								
5	91			5	90.5			5	90.5					
6	90			6	89.5			6	89.5					
7	89			7	88.5			7	88.5					
8	88			8	87.5			8	87.5					
9	87			9	86.5			9	86.5					
10	86			10	85.5			10	85.5					
11	85			11	84.5			11	84.5					
12	84			12	83.5			12	83.5					
13	83			13	82.5	G3		13	82.5					
14	82			14	81.5			14	81.5					
15	81			15	80.5			15	80.5					
16	80			16	79.5			16	79.5					
17	79			17	78.5			17	78.5					
18	78			18	77.5			18	77.5					
19	77			19	76.5			19	76.5					
20	76			20	75.5			20	75.5					
21	75			21	74.5			21	74.5					
22	74			22	73.5			22	73.5					
23	73			23	72.5			23	72.5					
24	72			24	71.5			24	71.5					
25	71			25	70.5			25	70.5					
26	70			26	69.5			26	69.5					
27	69			27	68.5			27	68.5					
28	68	G3		28	67.5			28	67.5					
29	67			29	66.5			29	66.5					
30	66			30	65.5			30	65.5					
31	65			31	64.5	SAT	31	64.5						
32	64			32	63.5		G3		32			63.5		
33	63			33	62.5				33			62.5		
34	62			34	61.5				34			61.5		
35	61			35	60.5				35			60.5		
36	60							36	59.5	G3	SAT			
								37	58.5					
								38	57.5					
								39	56.5					
								40	55.5					
								41	54.5					
								42	53.5					
								43	52.5					
								44	51.5					
								45	50.5					
								46	49.5					

NOTES:

- 1 Refer to Notes on Table 1. Strata elevations are rounded to the nearest 1 foot.
- 2 The above profiles represent a recommended interpretation of subsurface conditions at the time of the explorations for application of the recommended parameters in the design of foundations located at the respective test boring locations. Foundations located between two or more test borings are recommended to be designed based upon the most geotechnically conservative profile of the surrounding test borings.
- 3 Site development and ground modifications may result in changes to the above subsurface conditions FOLLOWING RECOMMENDED SUBGRADE PREPARATION. Recommended generalized soil conditions for new fills recommended in the geotechnical report are provided in Table 3.

TABLE 3 - RECOMMENDED FOUNDATION DESIGN PARAMETERS - GRANULAR SOIL

Hillside 66 Substation
Amesbury, Massachusetts
Project No. 04.0191648.00

		G1	G2	G3
Parameter	Units	Existing Fill	Outwash	Glacial Till
Interpreted Index Parameters				
USCS	Symbol	SMg	SM-SP	GM
Presumed corrected SPT (N'60)	bpf	8	10	40
Presumed Relative Density	unitless	Loose	Medium Dense	Dense
Unit Weight, dry, g_d	pcf	120	120	135
Unit Weight, Total (Moist, Unsaturated), g_m	pcf	125	130	145
Unit Weight, Total (Saturated), g_t	pcf	135	135	145
Unit Weight, Effective / Buoyant (Saturated), g_e	pcf	73	73	83
Internal friction angle, f'	deg	31	32	37
Recommended Pier / Pile Lateral Design Parameters Using MFAD		Existing Fill	Outwash	Glacial Till
Unit Weight, Total (Moist, Unsaturated), g_m	pcf	125	130	145
Unit Weight, Total (Saturated), g_t	pcf	135	135	145
Internal friction angle, f'	deg	31	32	37
Deformation Modulus, E_p	ksi	0.8	1.0	4.8
Horizontal Stress Coefficient / At-Rest Earth Pressure Coefficient, K_o	unitless	0.50	0.45	0.40
Recommended Pier / Pile Lateral Design Parameters Using LPILE		Existing Fill	Outwash	Glacial Till
Recommended Soil Type for p-y Curve Model		Sand (Reese)	Sand (Reese)	Sand (Reese)
Unit Weight, Total (Moist, Unsaturated), g_m	pcf	125	130	145
Unit Weight, Effective / Buoyant (Saturated), g_e	pcf	73	73	83
Internal friction angle, f'	deg	31	32	37
Horz. Modulus, Unsaturated, k_h	pci	55	70	185
Horz. Modulus, Saturated, $k_{h, sat}$	pci	40	45	105
Recommended Pier / Pile Axial Design Parameters ($D_f > 8'$, $D_f / B > 3$)		Existing Fill	Outwash	Glacial Till
Friction Against Uncased Shaft (Rough Mass Concrete)	deg	31	32	37
Friction Against Corrugated HDPE / Steel Permanent Casing	deg	23	24	28
Friction Against Smooth Steel Permanent Casing	deg	19	19	22
Ultimate Side Friction, f (linear increase with depth up to f_{max})	psf/ft	30	35	55
Ultimate Maximum Friction, f_{max}	psf	640	800	1,500
Factor of Safety Friction in Compression, FS_{id}	unitless	3.0	3.0	3.0
Factor of Safety Friction in Uplift, FS_{iu}	unitless	4.0	4.0	4.0
Ultimate Unit End Bearing, q_{BN} 4.0%	psf	7,000	8,500	34,000
Factor of Safety Bearing, FS_b	unitless	3.0	2.0	3.0
Recommended Shallow Fdn Design Parameters ($4' \leq D_f < 8'$, $D_f / B \leq 2$) and Retaining Structures		See Report for Subgrade Preparation Recommendations Applicable to the Use of the Following Design Values		
Net Allow. Bearing, $S \leq 1'$, q_{all} ($3' < B < 8'$)	psf	2,500	2,500	5,500
Net Allow. Bearing, $S \leq 1'$, q_{all} ($8' < B < 20'$)	psf	2,000	2,000	4,000
Net Allow. Bearing, short-duration live load ($3' < B < 8'$)	psf	3,500	3,500	7,500
Vertical Modulus of Subgrade Reaction, k_{v1} (unsaturated subgrade)	tcf	60	70	230
Vertical Modulus of Subgrade Reaction, k_{v1} (saturated subgrade)	tcf	30	35	115
Earth Pressure Coef. - Active - Horz. Backslope	unitless	0.32	0.30	0.24
Earth Pressure Coef. - Active - 3H:1V Backslope	unitless	0.40	0.38	0.30
Earth Pressure Coef. - Active - 2H:1V Backslope	unitless	0.50	0.47	0.34
Earth Pressure Coef. - At-Rest - Horz. Backslope	unitless	0.50	0.45	0.40
Earth Pressure Coef. - Passive - Horz. Backslope	unitless	3.10	3.30	4.20
Earth Pressure Coef. - Passive - Horz. Backslope - Rec'd for Use in Sliding Resistance	unitless	1.20	1.30	1.70
Friction Against Unformed (mass) Concrete	deg	31	32	37
Friction Against Formed Concrete	deg	19	19	22

NOTES:

- Foundation parameters assume design performed based on Ultimate (Unfactored Nominal) Strength Limit State unless noted otherwise.
- Bearing capacity G1 and G2 assume partial overexcavation and recompaction as outlined in the "Subgrade Conditions" section of this report.
- Values provided above assume that subgrades are prepared as recommended in the geotechnical report and not weakened or disturbed during construction.
- If settlements within the compressible strata (fill, organics, etc.) are deemed excessive for the project, side friction within these strata should be neglected in calculating compression resistance. The compressible strata may be relied upon for calculating lateral and uplift resistance, where parameters are provided.

N/A = not applicable or not recommended for use in design

Pcf = pounds per cubic foot

Psf = pounds per square foot

Pci = pounds per cubic inch

Psi = pounds per square inch

Tcf = tons per cubic foot

Ksi = kips (1,000 pounds) per square inch

Ksf = kips per square foot

Bpf = blows per foot

Ft = feet

Df = depth of foundation below ground surface

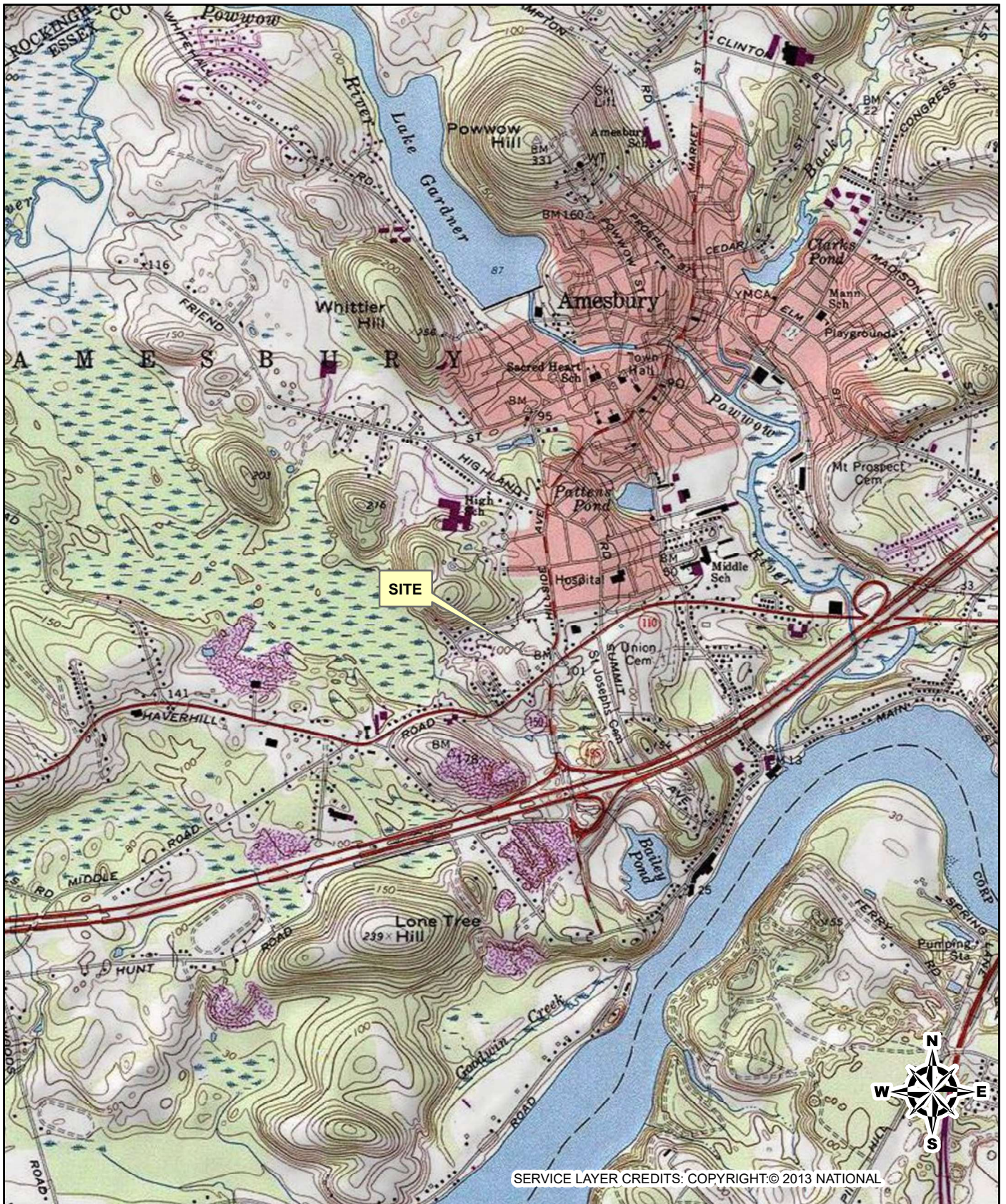
B = narrowest foundation width or diameter

S = foundation-induced settlement

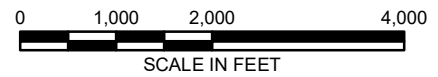
Deg = degrees

Figures

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\\GZA Bedford\Jobs\04\Jobs\04\0191648\04_0191648.mxd - NGrid Amesbury_Report\Figures\GIS\04\0191648\00_Figure_1_Locus_Plan.mxd, February 20, 2024 - 11:36:15 AM, dylan.shaffer



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HILLSIDE 66 SUBSTATION
9 ALLENCLAIR DRIVE
AMESBURY, MASSACHUSETTS

PREPARED BY:
 GZA GeoEnvironmental, Inc.
www.gza.com

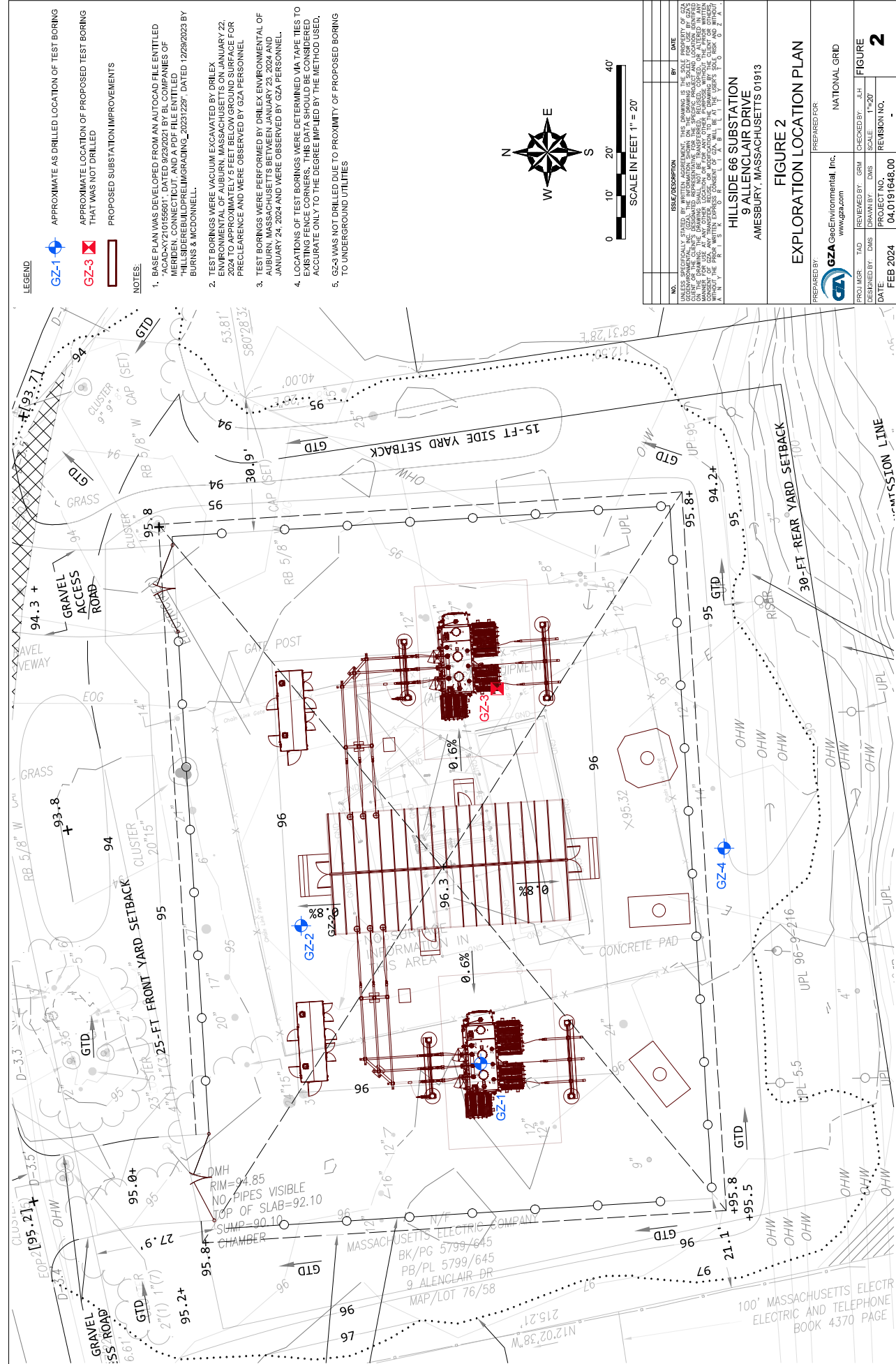
PREPARED FOR:
NATIONAL GRID

FIGURE 1
LOCUS PLAN

PROJ MGR: TAD	REVIEWED BY: TAD
DESIGNED BY: DMS	DRAWN BY: DMS
DATE: 02/20/2024	PROJECT NO: 04.0191648.00

CHECKED BY: GRM
SCALE: 1" = 2,000 FEET
REVISION NO: -

FIGURE
1



Appendix A – Limitations



USE OF REPORT

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the contract documents, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

STANDARD OF CARE

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in Proposal for Services and/or Report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions .
3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.
4. In conducting our work, GZA relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the Report.

SUBSURFACE CONDITIONS

5. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then become evident, it will be necessary to reevaluate the conclusions and recommendations of this report.
6. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.
7. Water level readings have been made in test holes (as described in this Report) and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.
8. GZA's services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities, or the use of structures on the property.



9. Recommendations for foundation drainage, waterproofing, and moisture control address the conventional geotechnical engineering aspects of seepage control. These recommendations may not preclude an environment that allows the infestation of mold or other biological pollutants.

COMPLIANCE WITH CODES AND REGULATIONS

10. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

COST ESTIMATES

11. Unless otherwise stated, our cost estimates are only for comparative and general planning purposes. These estimates may involve approximate quantity evaluations. Note that these quantity estimates are not intended to be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over either when the work will take place or the labor and material costs required to plan and execute the anticipated work, our cost estimates were made by relying on our experience, the experience of others, and other sources of readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

ADDITIONAL SERVICES

12. GZA recommends that we be retained to provide services during any future: site observations, design, implementation activities, construction and/or property development/redevelopment. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

Appendix B – Test Boring Logs

GZA TEMPLATE TEST BORING - GZA GINT DATA TEMPLATE 10-27-20.GDT - 2/20/24 11:58 - P:\04JOBS\GINT PROJECT DATABASES\04.0191648.00 NGRID AMESBURY 66 SUBSTATION.GPJ

TEST BORING LOG												
 GZA GeoEnvironmental, Inc. <i>Engineers and Scientists</i>				National Grid Hillside #66 Substation 9 Allencair Drive Amesbury, Massachusetts				EXPLORATION NO.: GZ-1 SHEET: 1 of 2 PROJECT NO: 04.0191648.00 REVIEWED BY: T. Dykstra				
Logged By: K. Ashe Drilling Co.: Drilex Environmental Foreman: J. Hastings				Type of Rig: ATV Rig Model: CME 55 Drilling Method: HSA		Boring Location: See Plan Ground Surface Elev. (ft.): 96.0 Final Boring Depth (ft.): 36.4 Date Start - Finish: 1/23/2024 - 1/23/2024				H. Datum: NAD83 MA Mainland V. Datum: NAVD88		
Hammer Type: Automatic Hammer Hammer Weight (lb.): 140 Hammer Fall (in.): 30 Auger or Casing O.D./I.D Dia (in.): 4.25				Sampler Type: SS Sampler O.D. (in.): 2.0 Sampler Length (in.): 24 Rock Core Size: Not Applicable				Groundwater Depth (ft.)				
								Date	Time	Stab. Time	Water	Casing
								1/23/2024	10:44	0	33.6	36.4
Depth (ft)	Casing Blows/ (Core Rate)	No.	Depth (ft.)	Pen. (in)	Rec. (in)	Blows (per 6 in.)	SPT Value	Sample Description (Modified Burmister Classification)	Remark	Depth (ft.)	Stratum Description	Elev. (ft.)
5		G-1	2.0-2.5					4 inches of Topsoil.	1			
								G-1: Brown, fine to medium SAND, some Silt, little Gravel, trace Organics, dry. (SM)	2		FILL	
		G-2	4.0-4.5					G-2: Brown, fine to medium SAND and Gravel, some Silt, dry. (SM)				
		S-1	5.0-7.0	24	7	2 1 3 3	4	S-1: Loose to very loose, brown, fine to medium SAND, some Silt, dry. (SM)				
									8	88.0		
10		S-2	10.0-12.0	24	7	1 2 6 5	8	S-2: Loose, brown, fine to medium SAND and Silt, trace Gravel, moist. (SM)				
15		S-3	15.0-17.0	24	17	5 8 10 18	18	S-3: Medium dense, brown, fine to coarse SAND, little Gravel, trace Silt, moist. (SP-SM)				
20		S-4	20.0-22.0	24	13	5 5 4 5	9	S-4: Loose, brown/tan, fine to coarse SAND, little Silt, trace Gravel, moist. (SM)				
25		S-5	25.0-27.0	24	14	3 8 14 18	22	S-5: Medium dense, brown, fine to coarse SAND, some Gravel, little Silt, moist. (SM)				
30									3	28	68.0	
											GLACIAL TILL	
REMARKS 1 - Vacuum excavated boring to approximately 5 feet below existing ground surface (b.e.g.s.). 2 - Cobble encountered at approximately 2 feet b.e.g.s. 3 - Driller noted increased resistance at approximately 28 feet b.e.g.s. 4 - Increase in Gravel in auger flights at approximately 30 feet b.e.g.s.												
See Log Key for exploration of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.										Exploration No.: GZ-1		

GZA TEMPLATE TEST BORING - GZA GINT DATA TEMPLATE 10-27-20.GDT - 2/20/24 11:58 - P:\04JOBS\GINT PROJECT DATABASES\04.0191648.00 NGRID AMESBURY 66 SUBSTATION.GPJ

TEST BORING LOG														
 GZA GeoEnvironmental, Inc. <i>Engineers and Scientists</i>				National Grid Hillside #66 Substation 9 Allencclair Drive Amesbury, Massachusetts				EXPLORATION NO.: GZ-1 SHEET: 2 of 2 PROJECT NO: 04.0191648.00 REVIEWED BY: T. Dykstra						
Logged By: K. Ashe Drilling Co.: Drilex Environmental Foreman: J. Hastings				Type of Rig: ATV Rig Model: CME 55 Drilling Method: HSA		Boring Location: See Plan Ground Surface Elev. (ft.): 96.0 Final Boring Depth (ft.): 36.4 Date Start - Finish: 1/23/2024 - 1/23/2024				H. Datum: NAD83 MA Mainland V. Datum: NAVD88				
Hammer Type: Automatic Hammer Hammer Weight (lb.): 140 Hammer Fall (in.): 30 Auger or Casing O.D./I.D Dia (in.): 4.25				Sampler Type: SS Sampler O.D. (in.): 2.0 Sampler Length (in.): 24 Rock Core Size: Not Applicable			Groundwater Depth (ft.)							
							Date	Time	Stab. Time	Water	Casing			
							1/23/2024	10:44	0	33.6	36.4			
Depth (ft)	Casing Blows/ (Core Rate)	No.	Depth (ft.)	Pen. (in)	Rec. (in)	Blows (per 6 in.)	SPT Value	Sample Description (Modified Burmister Classification)			Remark	Depth (ft.)	Stratum Description	Elev. (ft.)
35		S-6	30.0-30.4	5	2	40 /5"		S-6: Very dense, brown, fine to coarse SAND, some Gravel, little Silt, moist. Gravel in spoon tip. (SM)			4	GLACIAL TILL		
		S-7	35.0-36.4	16	12	19 21 50 /4"	71	S-7: Very dense, gray/brown, GRAVEL, some fine to medium Sand, little Silt, wet. (GM)						
	40								End of exploration at 36.4 feet			5		
45														
50														
55														
60														
REMARKS 5 - Boring backfilled with auger cuttings														
See Log Key for exploration of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.												Exploration No.: GZ-1		

GZA TEMPLATE TEST BORING - GZA GINT DATA TEMPLATE 10-27-20.GDT - 2/20/24 11:58 - P:\04JOBS\GINT PROJECT DATABASES\04.0191648.00 NGRID AMESBURY 66 SUBSTATION.GPJ

TEST BORING LOG												
 GZA GeoEnvironmental, Inc. <i>Engineers and Scientists</i>				National Grid Hillside #66 Substation 9 Allencclair Drive Amesbury, Massachusetts				EXPLORATION NO.: GZ-2 SHEET: 1 of 2 PROJECT NO: 04.0191648.00 REVIEWED BY: T. Dykstra				
Logged By: K. Ashe Drilling Co.: Drilex Environmental Foreman: J. Hastings				Type of Rig: ATV Rig Model: CME 55 Drilling Method: HSA		Boring Location: See Plan Ground Surface Elev. (ft.): 95.5 Final Boring Depth (ft.): 35.5 Date Start - Finish: 1/23/2024 - 1/24/2024				H. Datum: NAD83 MA Mainland V. Datum: NAVD88		
Hammer Type: Automatic Hammer Hammer Weight (lb.): 140 Hammer Fall (in.): 30 Auger or Casing O.D./I.D Dia (in.): 4.25				Sampler Type: SS Sampler O.D. (in.): 2.0 Sampler Length (in.): 24 Rock Core Size: Not Applicable				Groundwater Depth (ft.)				
								Date	Time	Stab. Time	Water	Casing
								1/24/2024	9:55	0	31.0	35.5
Depth (ft)	Casing Blows/ (Core Rate)	No.	Depth (ft.)	Pen. (in)	Rec. (in)	Blows (per 6 in.)	SPT Value	Sample Description (Modified Burmister Classification)	Remark	Depth (ft.)	Stratum Description	Elev. (ft.)
5		G-1	2.0-2.5					8 inches of Gravel.	1			
								G-1: Brown, GRAVEL, some fine to medium Sand, little Silt, dry. (GM)	2			
		G-2	4.0-4.5					G-2: Brown, fine to medium SAND, some Silt, little Gravel, dry. (SM)	3			
		S-1	5.0-7.0	24	7	6 6 3 4	9	S-1: Loose, brown, GRAVEL and fine to medium Sand, little Silt, moist. (GM)			FILL	
10		S-2	10.0-12.0	24	5	2 1 2 3	3	S-2: Very loose, brown, fine to medium SAND, some Gravel, little Silt, moist. (SM)				
15		S-3	15.0-17.0	24	3	11 17 14 15	31	S-3: Dense, brown, fine to coarse SAND, some Gravel, little Silt, moist. (SM)				
20		S-4	20.0-22.0	24	11	6 7 8 11	15	S-4: Medium dense, tan, fine to medium SAND, little Silt, moist. (SM)				
											OUTWASH	
25		S-5	25.0-27.0	24	11	7 15 16 22	31	S-5: Dense, brown, fine to medium SAND and Gravel, little Silt, moist. (SM)				
30												
REMARKS 1 - Vacuum excavated boring to approximately 5 feet below existing ground surface (b.e.g.s.). 2 - Cobble and Gravel encountered at approximately 1.5 feet b.e.g.s. 3 - Cobble encountered at approximately 4 feet b.e.g.s.												
See Log Key for exploration of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.										Exploration No.: GZ-2		

GZA TEMPLATE TEST BORING - GZA GINT DATA TEMPLATE 10-27-20.GDT - 2/20/24 11:58 - P:\04JOBS\GINT PROJECT DATABASES\04.0191648.00 NGRID AMESBURY 66 SUBSTATION.GPJ

TEST BORING LOG														
 GZA GeoEnvironmental, Inc. <i>Engineers and Scientists</i>				National Grid Hillside #66 Substation 9 Allencclair Drive Amesbury, Massachusetts				EXPLORATION NO.: GZ-2 SHEET: 2 of 2 PROJECT NO: 04.0191648.00 REVIEWED BY: T. Dykstra						
Logged By: K. Ashe Drilling Co.: Drilex Environmental Foreman: J. Hastings				Type of Rig: ATV Rig Model: CME 55 Drilling Method: HSA		Boring Location: See Plan Ground Surface Elev. (ft.): 95.5 Final Boring Depth (ft.): 35.5 Date Start - Finish: 1/23/2024 - 1/24/2024				H. Datum: NAD83 MA Mainland V. Datum: NAVD88				
Hammer Type: Automatic Hammer Hammer Weight (lb.): 140 Hammer Fall (in.): 30 Auger or Casing O.D./I.D Dia (in.): 4.25				Sampler Type: SS Sampler O.D. (in.): 2.0 Sampler Length (in.): 24 Rock Core Size: Not Applicable				Groundwater Depth (ft.)						
								Date	Time	Stab. Time	Water	Casing		
								1/24/2024	9:55	0	31.0	35.5		
Depth (ft)	Casing Blows/ (Core Rate)	No.	Depth (ft.)	Pen. (in)	Rec. (in)	Blows (per 6 in.)	SPT Value	Sample Description (Modified Burmister Classification)		Remark	Depth (ft.)	Stratum Description	Elev. (ft.)	
35		S-6	30.0-32.0	5	12	14 17 20 22/0"	37	S-6: Dense, brown, fine to coarse SAND and Gravel, little Silt, wet. (SM)			31.5	OUTWASH	64.0	
		S-7	35.0-35.4	4	2	50 /4"		S-7: Very dense, brown/gray, GRAVEL, some fine to medium Sand, little silt, wet. (GM)			4		60.0	
		End of exploration at 35.5 feet									5			
40														
45														
50														
55														
60														
REMARKS 4 - Auger refusal at approximately 35.5 feet b.e.g.s. 5 - Boring backfilled with auger cuttings														
See Log Key for exploration of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.											Exploration No.: GZ-2			

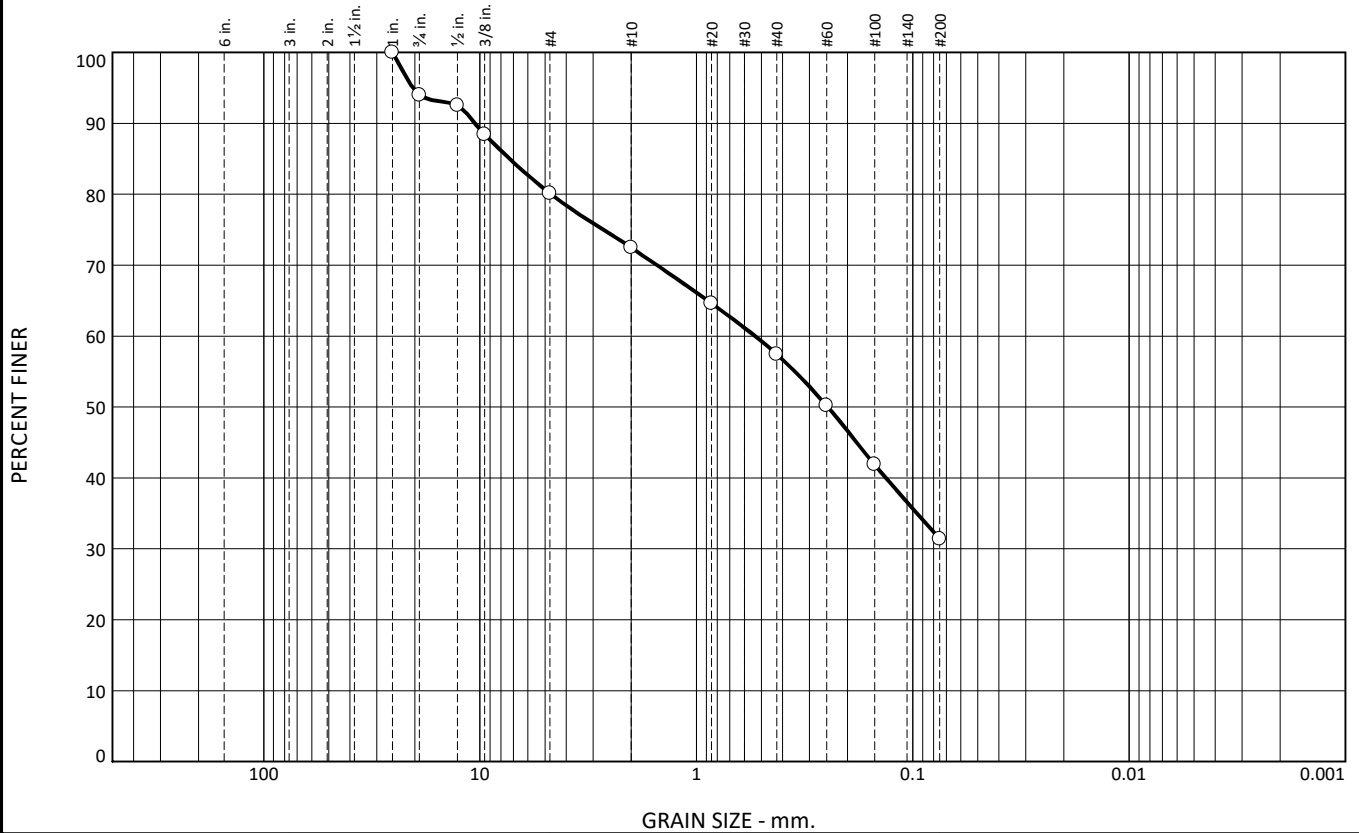
TEST BORING LOG														
GZA GeoEnvironmental, Inc. <i>Engineers and Scientists</i>					National Grid Hillside #66 Substation 9 Allencclair Drive Amesbury, Massachusetts					EXPLORATION NO.: GZ-4 SHEET: 2 of 2 PROJECT NO: 04.0191648.00 REVIEWED BY: T. Dykstra				
Logged By: K. Ashe Drilling Co.: Drillex Environmental Foreman: J. Hastings					Type of Rig: ATV Rig Model: CME 55 Drilling Method: HSA			Boring Location: See Plan Ground Surface Elev. (ft.): 95.5 Final Boring Depth (ft.): 47 Date Start - Finish: 1/23/2024 - 1/23/2024				H. Datum: NAD83 MA Mainland V. Datum: NAVD88		
Hammer Type: Automatic Hammer Hammer Weight (lb.): 140 Hammer Fall (in.): 30 Auger or Casing O.D./I.D Dia (in.): 4.25					Sampler Type: SS Sampler O.D. (in.): 2.0 Sampler Length (in.): 24 Rock Core Size: Not Applicable			Groundwater Depth (ft.)						
								Date	Time	Stab. Time	Water	Casing		
								1/23/2024	13:30	0	35.5	47		
Depth (ft)	Casing Blows/ (Core Rate)	Sample						Sample Description (Modified Burmister Classification)	Remark	Depth (ft.)	Stratum Description	Elev. (ft.)		
		No.	Depth (ft.)	Pen. (in)	Rec. (in)	Blows (per 6 in.)	SPT Value							
35		S-6	30.0-32.0	24	17	6 11 11 14	22	S-6: Medium dense, brown/tan, fine to coarse SAND, little Gravel, little Silt, moist. (SM)						
		S-7	35.0-37.0	24	17	5 9 12 19	21	S-7: Medium dense, brown, fine to coarse SAND, little Silt, trace Gravel, moist. (SM)		37	58.5			
		S-8	40.0-42.0	24	17	20 31 28 64	59	S-8: Very dense, brown, fine to coarse SAND and Gravel, little Silt, wet. (SM)						
		S-9	45.0-47.0	24	12	8 13 28 33	41	S-9: Dense, brown, fine to coarse SAND and Silt, trace Gravel, moist. (SM)		47	48.5			
								End of exploration at 47 feet	2					
2 - Boring backfilled with auger cuttings														
See Log Key for exploration of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.														
Exploration No.: GZ-4														

GZA TEMPLATE TEST BORING - GZA GINT DATA TEMPLATE 10-27-20.GDT - 2/20/24 11:58 - P:\04JOBS\GINT PROJECT DATABASES\04 0191648.00 NGRID AMESBURY 66 SUBSTATION GPJ

Appendix C – Results of Geotechnical Laboratory Testing

These results are for the exclusive use of the client for whom they were obtained. This report only relates to items inspected and/or tested. No warranty, expressed or implied, is made.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	6.0	13.9	7.6	15.1	26.0	31.4	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	94.0		
1/2"	92.5		
3/8"	88.4		
#4	80.1		
#10	72.5		
#20	64.6		
#40	57.4		
#60	50.2		
#100	41.9		
#200	31.4		

* (no specification provided)

Soil Description

Brown f-m SAND, some Silt, little Gravel

PL= NP

Atterberg Limits

LL= NV

PI= NP

Coefficients

D₉₀= 10.5506

D₈₅= 7.2826

D₆₀= 0.5343

D₅₀= 0.2468

D₃₀=

D₁₅=

D₁₀=

C_u=

C_c=

Classification

USCS= SM

AASHTO= A-2-4(0)

Remarks

Sample visually classified as non-plastic.

Source of Sample: Boring Depth: 2-2.5'
Sample Number: GZ-1 / Cuttings

Date: 01.31.24

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental

Project: NGRID Amesbury #66 Substation Hillside
Amesbury, MA

Project No: 04.0191648.00

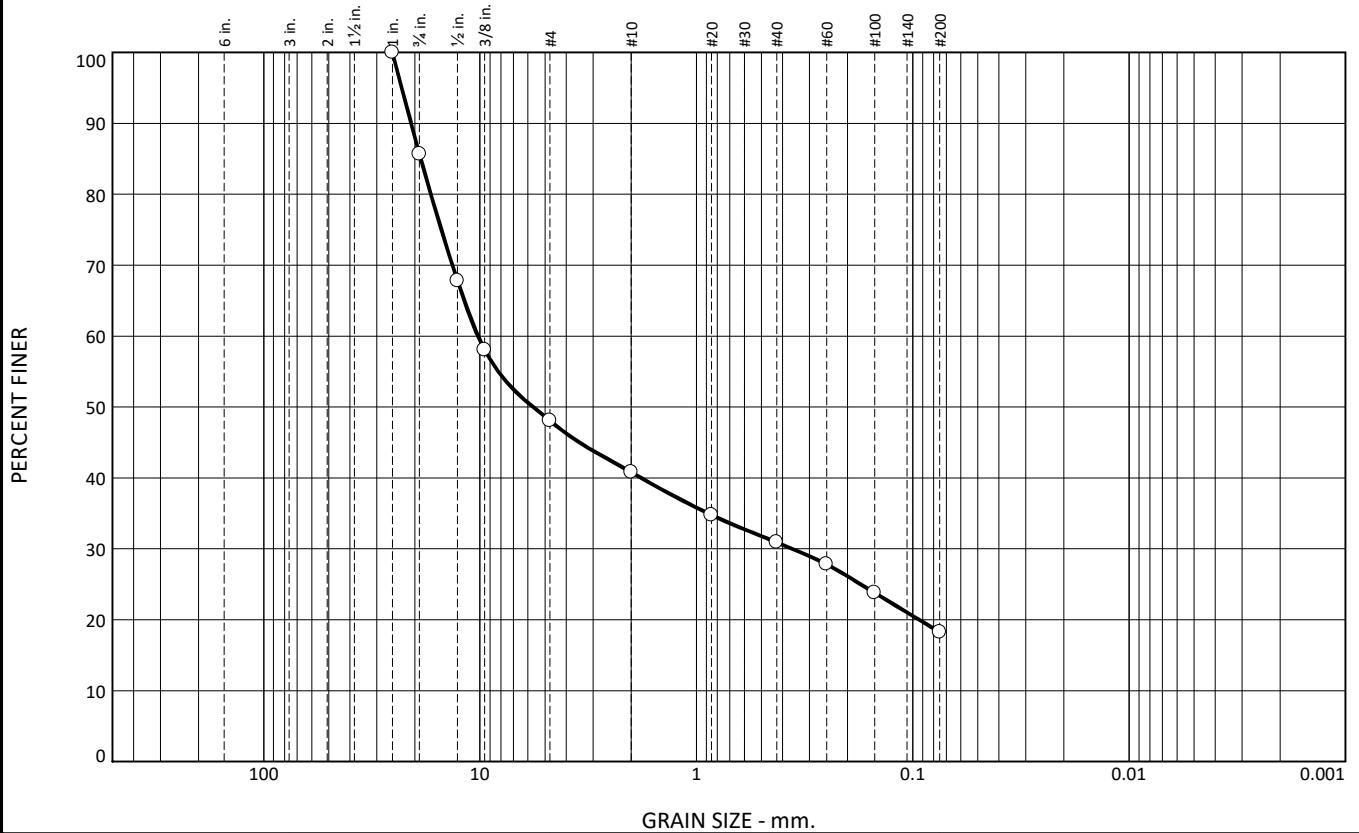
Figure 24-S-B207

Tested By: AF / SF

Checked By: Andrew Flanagan

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	14.4	37.5	7.3	9.9	12.7	18.2	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	85.6		
1/2"	67.8		
3/8"	58.0		
#4	48.1		
#10	40.8		
#20	34.8		
#40	30.9		
#60	27.8		
#100	23.8		
#200	18.2		

* (no specification provided)

Soil Description

Brown GRAVEL, some f-m Sand, little Silt

PL= NP

Atterberg Limits

LL= NV

PI= NP

Coefficients

D₉₀= 20.8380

D₈₅= 18.7888

D₆₀= 10.2291

D₅₀= 5.6756

D₃₀= 0.3610

D₁₅=

D₁₀=

C_u=

C_c=

Classification

USCS= GM

AASHTO= A-1-b

Remarks

Source of Sample: Boring Depth: 35-36.4'
Sample Number: GZ-1 / S-7

Date: 01.31.24

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental

Project: NGRID Amesbury #66 Substation Hillside
Amesbury, MA

Project No: 04.0191648.00

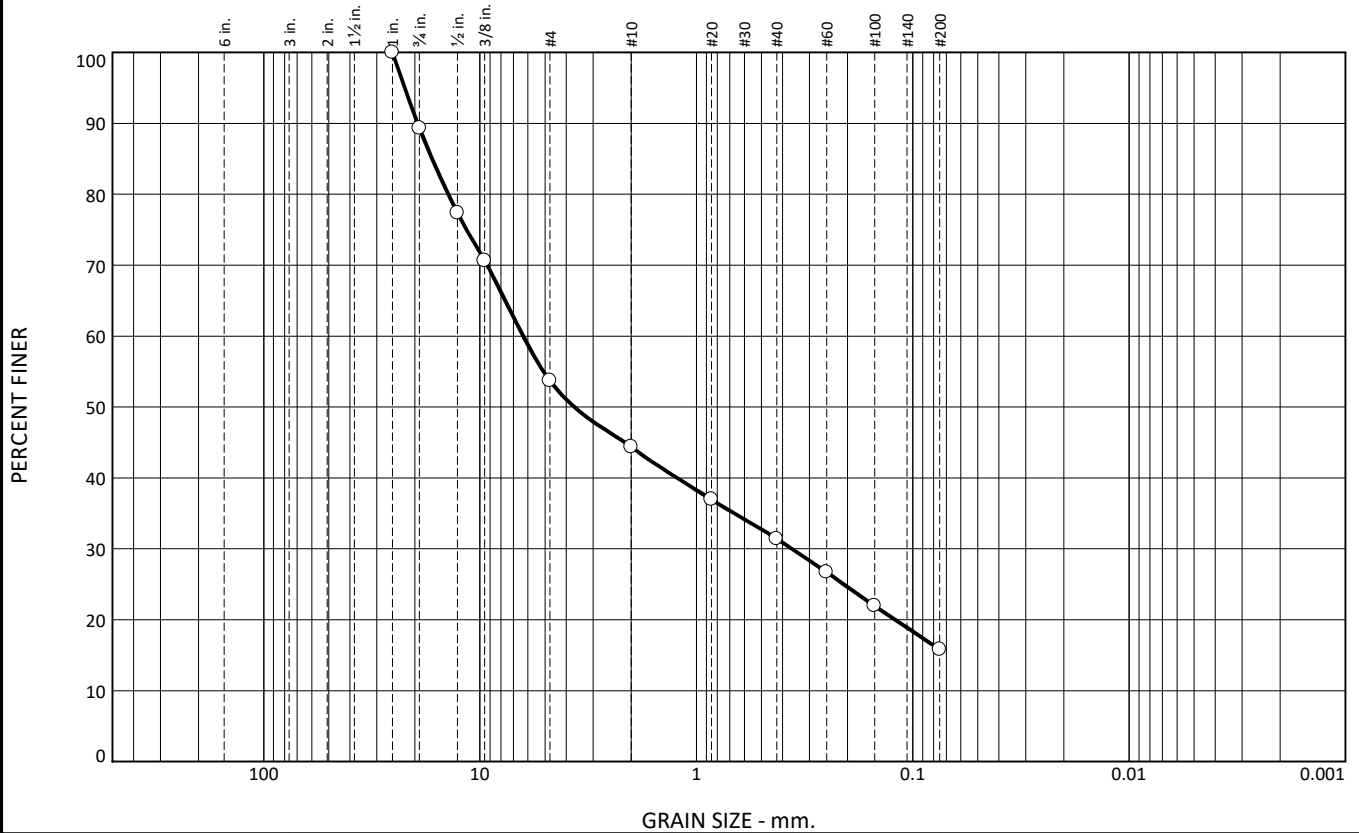
Figure 24-S-B208

Tested By: AF / SF

Checked By: Andrew Flanagan

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	10.7	35.6	9.3	13.0	15.6	15.8	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	89.3		
1/2"	77.3		
3/8"	70.6		
#4	53.7		
#10	44.4		
#20	36.9		
#40	31.4		
#60	26.7		
#100	22.0		
#200	15.8		

* (no specification provided)

Soil Description
Brown GRAVEL and f-m SAND, little Silt

PL= NP **Atterberg Limits** LL= NV PI= NP
Coefficients
D₉₀= 19.4499 D₈₅= 16.6481 D₆₀= 6.3160
D₅₀= 3.6704 D₃₀= 0.3612 D₁₅=
D₁₀= C_u= C_c=
Classification
USCS= GM AASHTO= A-1-b
Remarks

Source of Sample: Boring Depth: 5-7'
Sample Number: GZ-2 / S-1

Date: 01.31.24

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental
Project: NGRID Amesbury #66 Substation Hillside
Amesbury, MA

Project No: 04.0191648.00

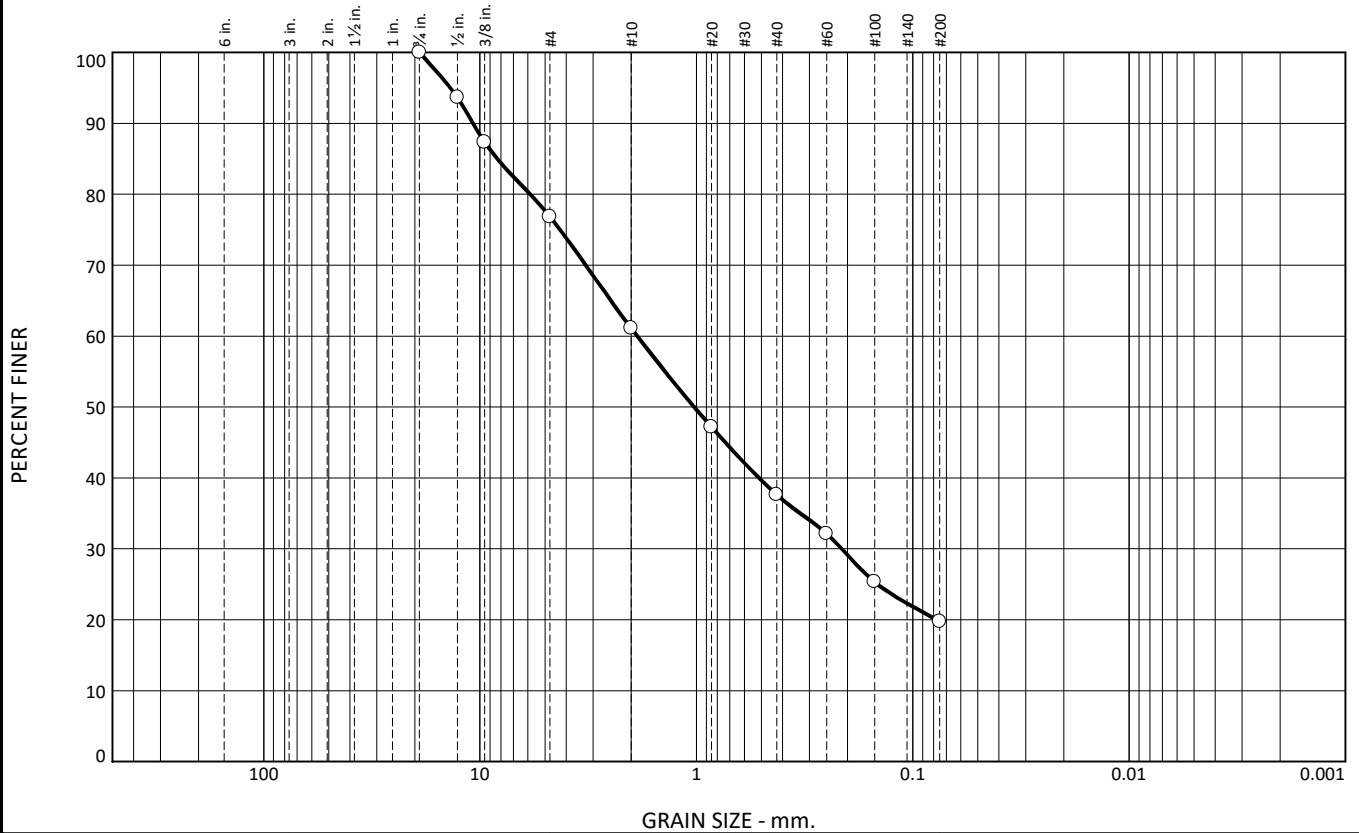
Figure 24-S-B209

Tested By: AF / SF

Checked By: Andrew Flanagan

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	23.2	15.7	23.5	17.9	19.7	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	93.6		
3/8"	87.3		
#4	76.8		
#10	61.1		
#20	47.1		
#40	37.6		
#60	32.1		
#100	25.3		
#200	19.7		

* (no specification provided)

Soil Description

Brown f-c SAND, some Gravel, little Silt

PL= NP

Atterberg Limits

LL= NV

PI= NP

Coefficients

D₉₀= 10.7805

D₈₅= 8.3145

D₆₀= 1.8746

D₅₀= 1.0233

D₃₀= 0.2128

D₁₅=

D₁₀=

C_u=

C_c=

Classification

USCS= SM

AASHTO= A-1-b

Remarks

Source of Sample: Boring Depth: 15-17'
Sample Number: GZ-2 / S-3

Date: 01.31.24

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental

Project: NGRID Amesbury #66 Substation Hillside
Amesbury, MA

Project No: 04.0191648.00

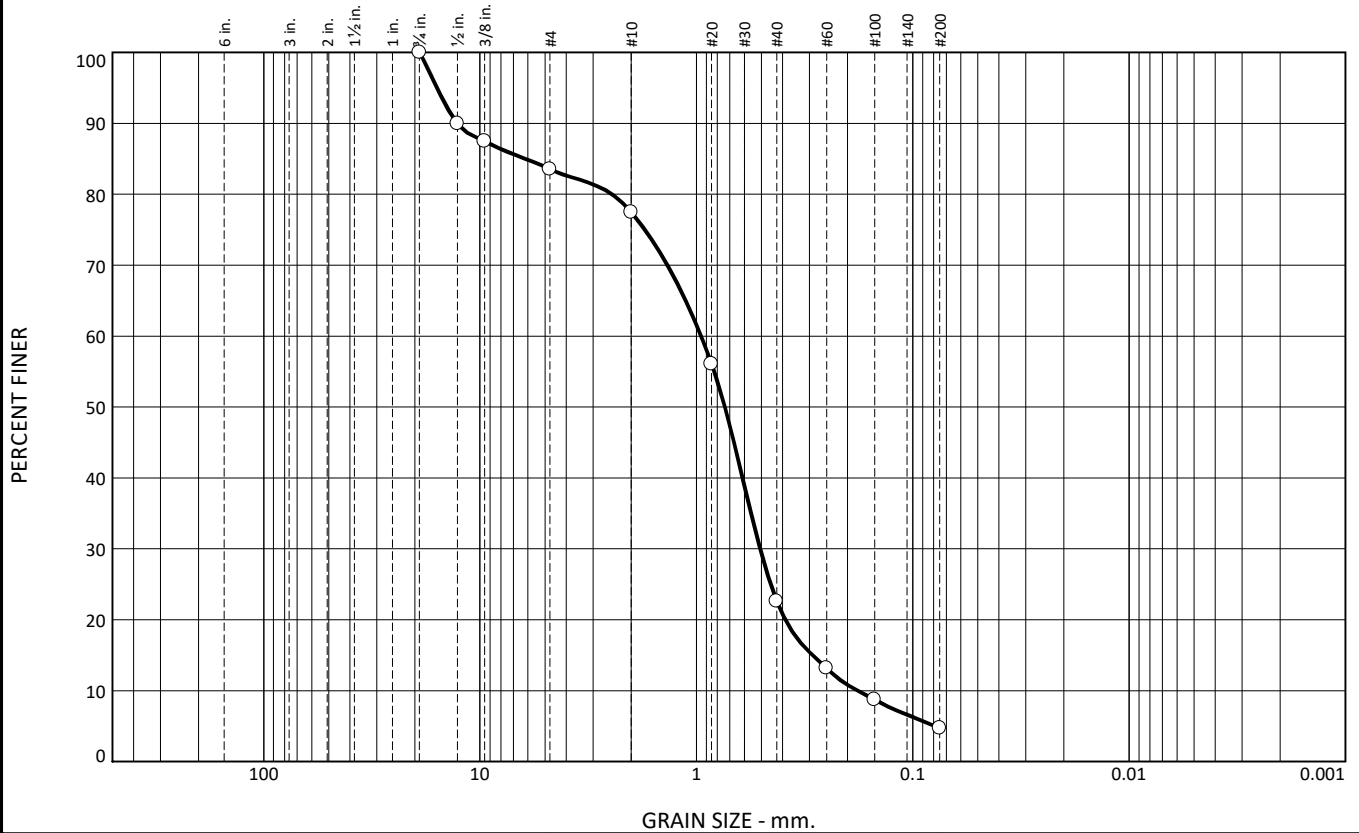
Figure 24-S-B210

Tested By: AF

Checked By: Andrew Flanagan

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	16.5	6.0	54.9	17.9	4.7	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	90.0		
3/8"	87.5		
#4	83.5		
#10	77.5		
#20	56.1		
#40	22.6		
#60	13.2		
#100	8.7		
#200	4.7		

* (no specification provided)

Soil Description

Brown f-m SAND, little Gravel, trace Silt

PL= NP

Atterberg Limits

LL= NV

PI= NP

Coefficients

D₉₀= 12.7354

D₈₅= 6.1807

D₆₀= 0.9513

D₅₀= 0.7388

D₃₀= 0.5067

D₁₅= 0.2900

D₁₀= 0.1799

C_u= 5.29

C_c= 1.50

Classification

USCS= SP

AASHTO= A-1-b

Remarks

Source of Sample: Boring Depth: 5-7'
Sample Number: GZ-4 / S-1

Date: 01.31.24

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental

Project: NGRID Amesbury #66 Substation Hillside
Amesbury, MA

Project No: 04.0191648.00

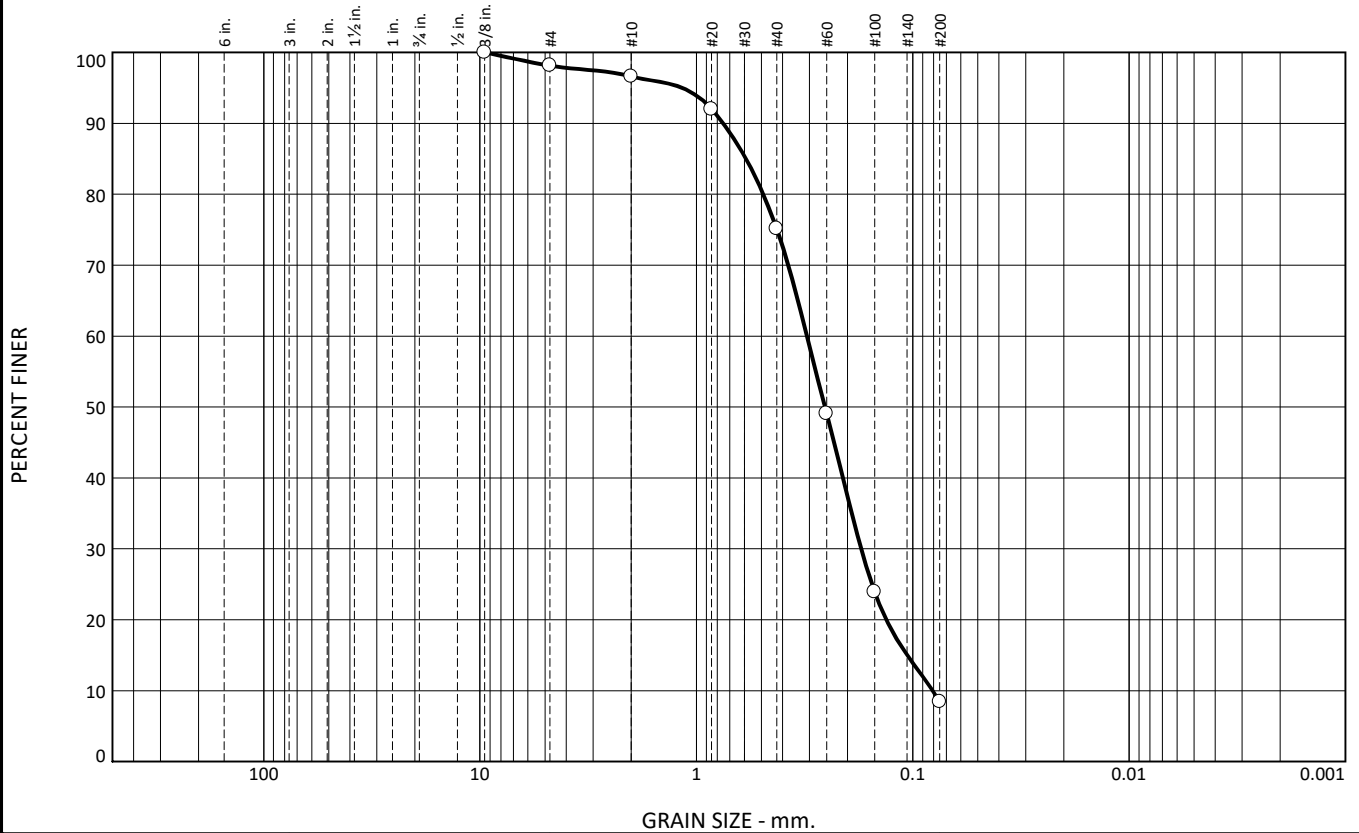
Figure 24-S-B211

Tested By: AF

Checked By: Andrew Flanagan

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.9	1.5	21.5	66.7	8.4	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8"	100.0		
#4	98.1		
#10	96.6		
#20	92.0		
#40	75.1		
#60	49.1		
#100	23.9		
#200	8.4		

* (no specification provided)

Soil Description

Brown f-m SAND, trace Silt, trace Gravel

PL= NP

Atterberg Limits

LL= NV

PI= NP

Coefficients

D₉₀= 0.7511

D₈₅= 0.5897

D₆₀= 0.3084

D₅₀= 0.2548

D₃₀= 0.1732

D₁₅= 0.1060

D₁₀= 0.0808

C_u= 3.82

C_c= 1.20

Classification

USCS= SP-SM

AASHTO= A-3

Remarks

Source of Sample: Boring Depth: 20-22'
Sample Number: GZ-4 / S-4

Date: 01.31.24

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental

Project: NGRID Amesbury #66 Substation Hillside
Amesbury, MA

Project No: 04.0191648.00

Figure 24-S-B212

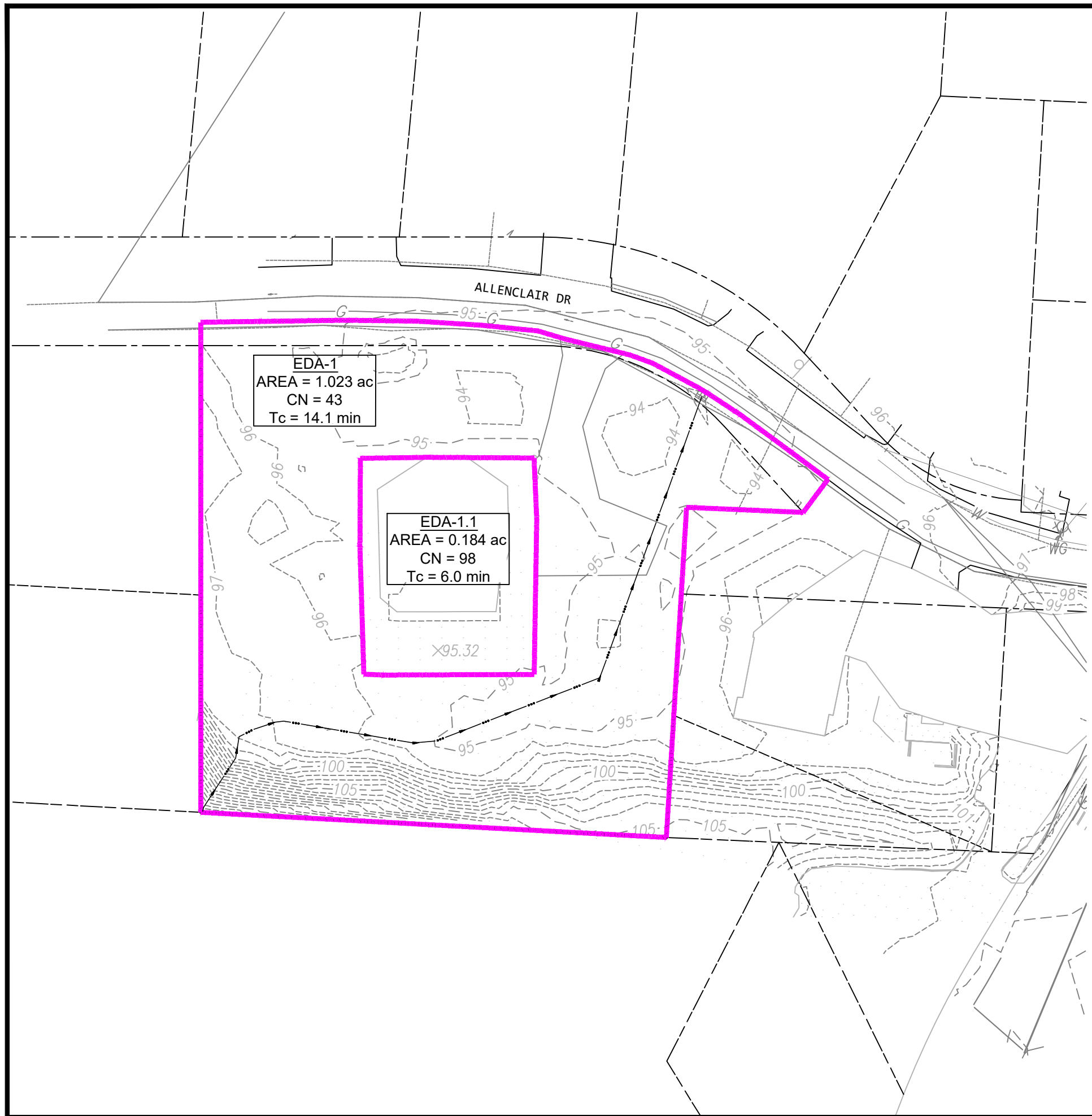
Tested By: AF / SF

Checked By: Andrew Flanagan



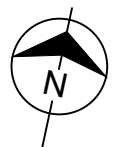
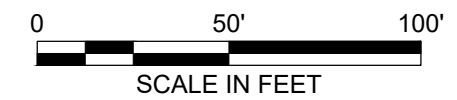
GZA GeoEnvironmental, Inc.

APPENDIX D – WATERSHED MAPS



LEGEND:

-  EXISTING PROPERTY LINE
-  EXISTING CONTOUR
-  EXISTING FENCE
-  WATERSHED BOUNDARY
-  TIME OF CONCENTRATION

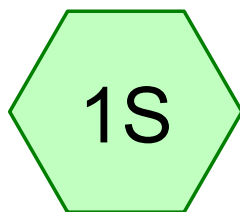


06/11/2024

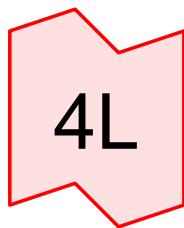


FIGURE D-1
HILLSIDE 66 SUBSTATION
PRE-DEVELOPMENT
WATERSHED MAP

APPENDIX E – HYDROLOGIC CALCULATIONS

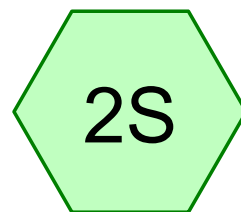


EDA-1

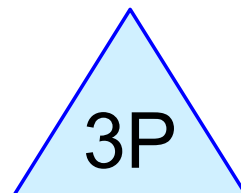


4L

Analysis Point 1

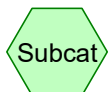


EDA-1.1



3P

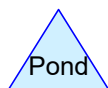
Existing Substation Yard
Stone



Subcat



Reach



Pond



Link

Routing Diagram for HillsideRebuild

Prepared by Burns & McDonnell, Printed 1/20/2025

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HillsideRebuild

Prepared by Burns & McDonnell

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Page 2

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.945	39	>75% Grass cover, Good, HSG A (1S)
0.025	98	Foundations (2S)
0.078	96	Gravel surface, HSG A (1S)
0.160	98	Substation Yard (2S)

HillsideRebuild

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Type III 24-hr 2-yr Rainfall=3.38"

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Page 3

Time span=0.00-28.00 hrs, dt=0.01 hrs, 2801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: EDA-1

Runoff Area=44,593 sf 0.00% Impervious Runoff Depth=0.04"
Flow Length=352' Tc=14.1 min CN=43 Runoff=0.00 cfs 0.003 af

Subcatchment2S: EDA-1.1

Runoff Area=8,041 sf 100.00% Impervious Runoff Depth=3.15"
Tc=6.0 min CN=98 Runoff=0.61 cfs 0.048 af

Pond 3P: Existing Substation Yard Stone

Peak Elev=94.09' Storage=90 cf Inflow=0.61 cfs 0.048 af
Discarded=0.39 cfs 0.048 af Primary=0.00 cfs 0.000 af Outflow=0.39 cfs 0.048 af

Link 4L: Analysis Point 1

Inflow=0.00 cfs 0.003 af
Primary=0.00 cfs 0.003 af

HillsideRebuild

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Type III 24-hr 2-yr Rainfall=3.38"
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Page 4

Summary for Subcatchment 1S: EDA-1

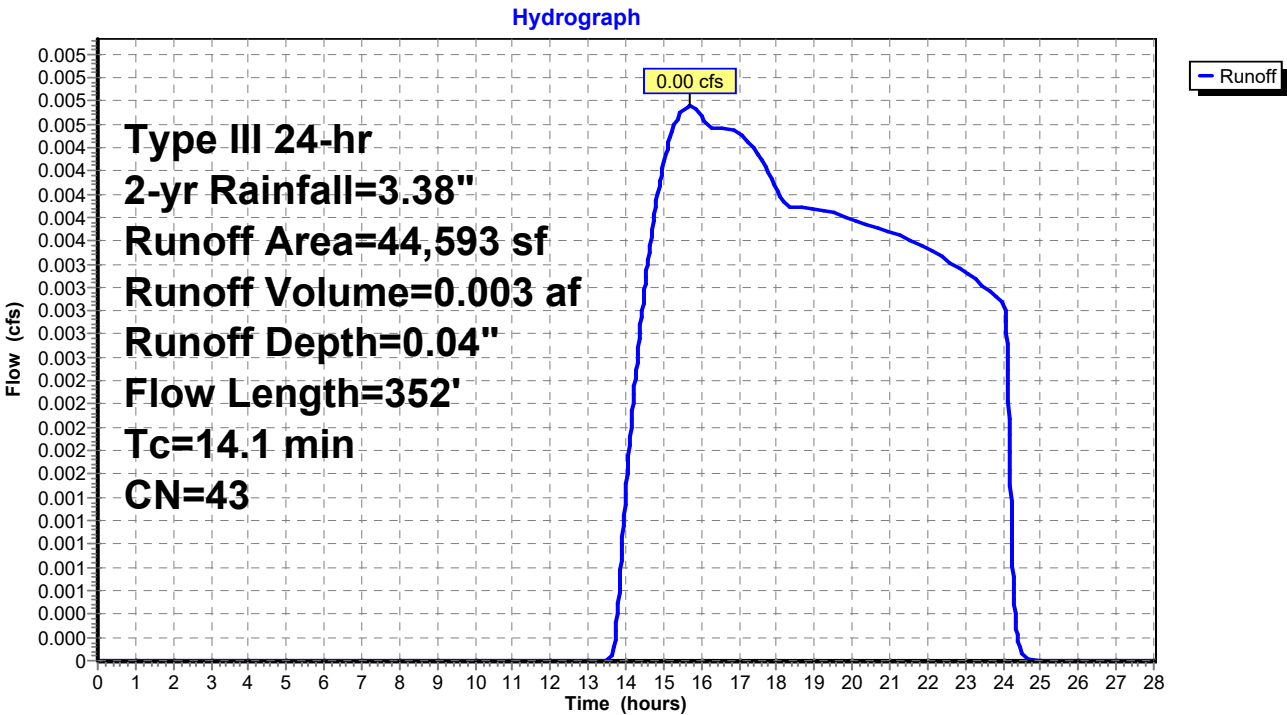
Runoff = 0.00 cfs @ 15.68 hrs, Volume= 0.003 af, Depth= 0.04"
Routed to Link 4L : Analysis Point 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.38"

Area (sf)	CN	Description
41,185	39	>75% Grass cover, Good, HSG A
3,408	96	Gravel surface, HSG A
44,593	43	Weighted Average
44,593		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	30	0.6250	0.54		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
5.0	70	0.0500	0.23		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
8.2	252	0.0010	0.51		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
14.1	352	Total			

Subcatchment 1S: EDA-1



HillsideRebuild

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Type III 24-hr 2-yr Rainfall=3.38"

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Summary for Subcatchment 2S: EDA-1.1

Runoff = 0.61 cfs @ 12.08 hrs, Volume= 0.048 af, Depth= 3.15"

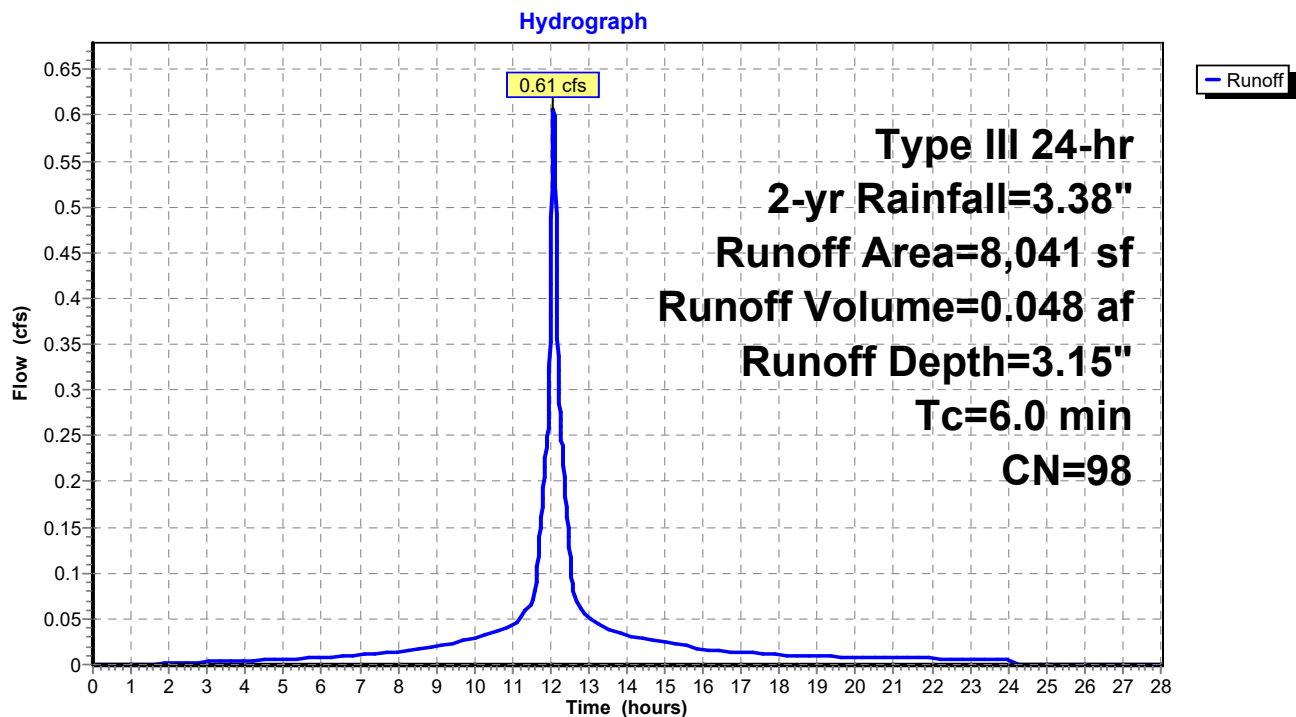
Routed to Pond 3P : Existing Substation Yard Stone

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.38"

	Area (sf)	CN	Description
*	6,962	98	Substation Yard
*	1,079	98	Foundations
	8,041	98	Weighted Average
	8,041		100.00% Impervious Area

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

Subcatchment 2S: EDA-1.1



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Type III 24-hr 2-yr Rainfall=3.38"

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Summary for Pond 3P: Existing Substation Yard Stone

Inflow Area = 0.185 ac, 100.00% Impervious, Inflow Depth = 3.15" for 2-yr event
 Inflow = 0.61 cfs @ 12.08 hrs, Volume= 0.048 af
 Outflow = 0.39 cfs @ 12.01 hrs, Volume= 0.048 af, Atten= 36%, Lag= 0.0 min
 Discarded = 0.39 cfs @ 12.01 hrs, Volume= 0.048 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Routed to Link 4L : Analysis Point 1

Routing by Stor-Ind method, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
 Peak Elev= 94.09' @ 12.18 hrs Surf.Area= 6,980 sf Storage= 90 cf

Plug-Flow detention time= 0.9 min calculated for 0.048 af (100% of inflow)
 Center-of-Mass det. time= 0.9 min (756.2 - 755.3)

Volume	Invert	Avail.Storage	Storage Description
#1	94.00'	2,809 cf	Substation Yard Storage (Prismatic) , listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
94.00	6,980	0.0	0	0
94.01	6,980	15.0	10	10
94.99	6,980	15.0	1,026	1,037
95.00	6,980	40.0	28	1,064
95.25	6,980	40.0	698	1,762
95.40	6,980	100.0	1,047	2,809

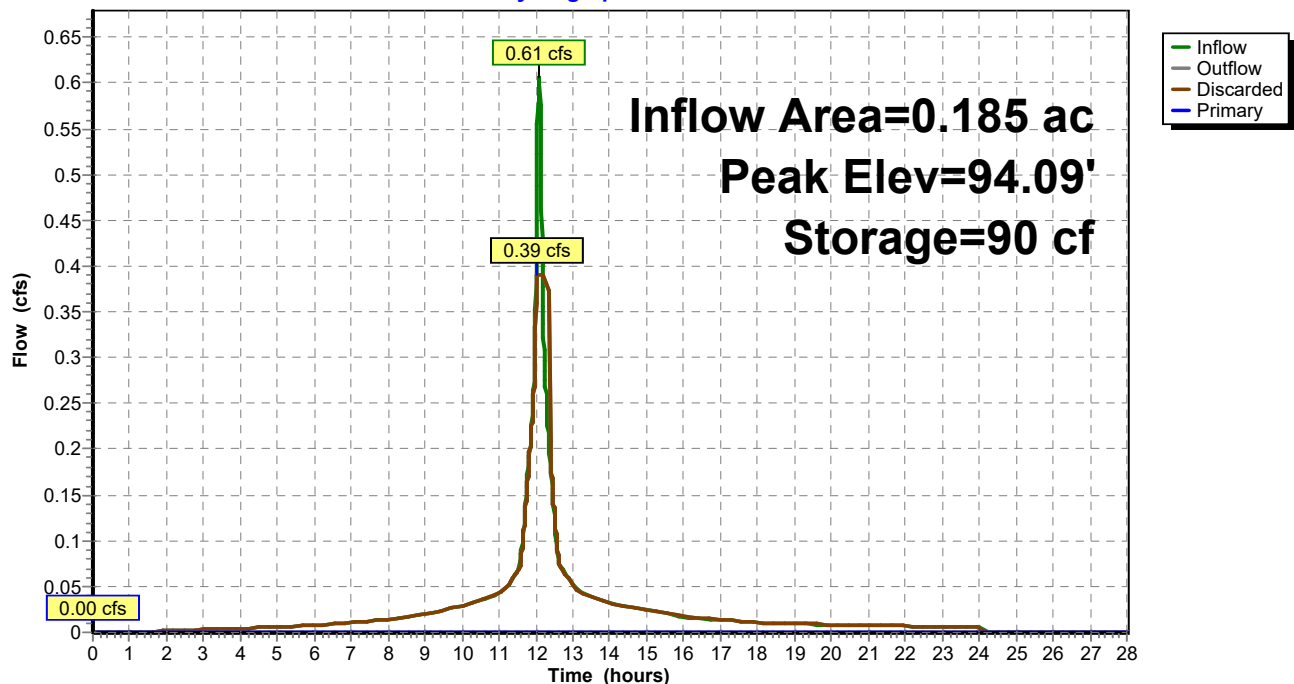
Device	Routing	Invert	Outlet Devices
#1	Discarded	94.00'	2.410 in/hr Exfiltration over Surface area
#2	Primary	95.25'	Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
			Head (feet) 0.00 0.20
			Width (feet) 376.00 376.00

Discarded OutFlow Max=0.39 cfs @ 12.01 hrs HW=94.01' (Free Discharge)
 ↑ **1=Exfiltration** (Exfiltration Controls 0.39 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=94.00' (Free Discharge)
 ↑ **2=Custom Weir/Orifice** (Controls 0.00 cfs)

Pond 3P: Existing Substation Yard Stone

Hydrograph



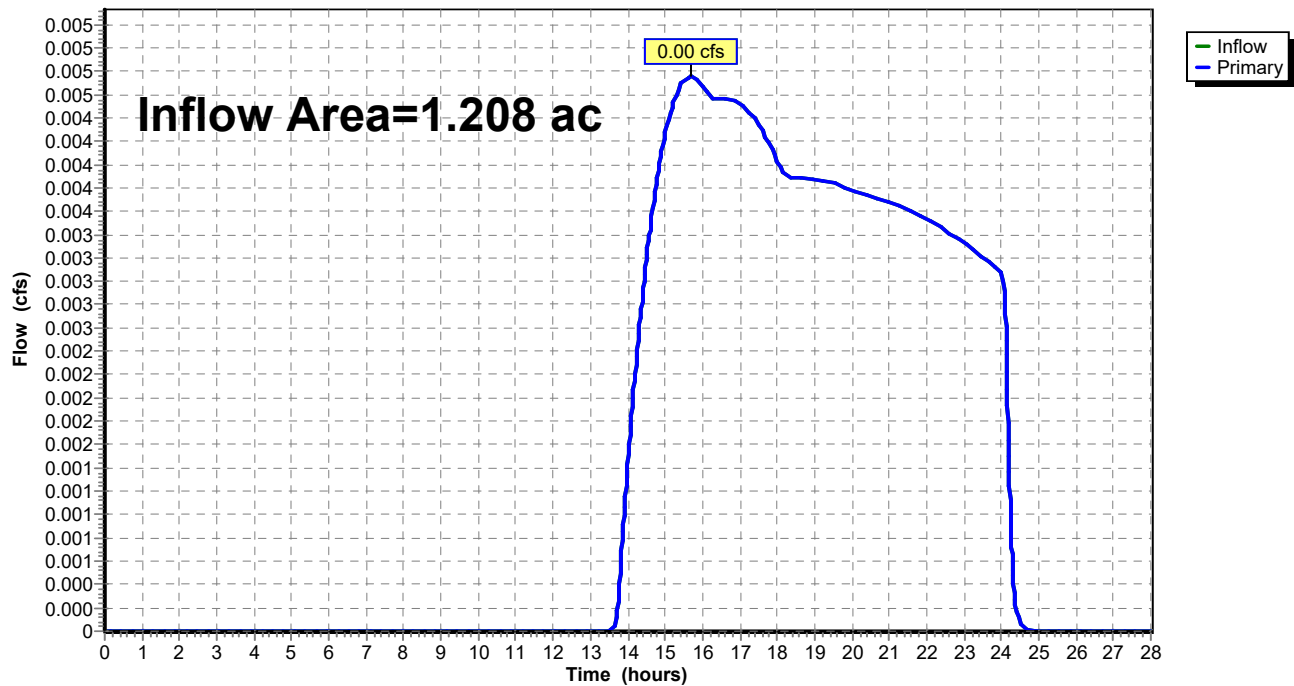
Summary for Link 4L: Analysis Point 1

Inflow Area = 1.208 ac, 15.28% Impervious, Inflow Depth = 0.03" for 2-yr event
Inflow = 0.00 cfs @ 15.68 hrs, Volume= 0.003 af
Primary = 0.00 cfs @ 15.68 hrs, Volume= 0.003 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs

Link 4L: Analysis Point 1

Hydrograph



HillsideRebuild

Type III 24-hr 10-yr Rainfall=5.34"

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Time span=0.00-28.00 hrs, dt=0.01 hrs, 2801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: EDA-1

Runoff Area=44,593 sf 0.00% Impervious Runoff Depth=0.45"
Flow Length=352' Tc=14.1 min CN=43 Runoff=0.19 cfs 0.039 af

Subcatchment2S: EDA-1.1

Runoff Area=8,041 sf 100.00% Impervious Runoff Depth=5.10"
Tc=6.0 min CN=98 Runoff=0.97 cfs 0.078 af

Pond 3P: Existing Substation Yard Stone

Peak Elev=94.33' Storage=345 cf Inflow=0.97 cfs 0.078 af
Discarded=0.39 cfs 0.078 af Primary=0.00 cfs 0.000 af Outflow=0.39 cfs 0.078 af

Link 4L: Analysis Point 1

Inflow=0.19 cfs 0.039 af
Primary=0.19 cfs 0.039 af

HillsideRebuild

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Type III 24-hr 10-yr Rainfall=5.34"

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Summary for Subcatchment 1S: EDA-1

Runoff = 0.19 cfs @ 12.45 hrs, Volume= 0.039 af, Depth= 0.45"

Routed to Link 4L : Analysis Point 1

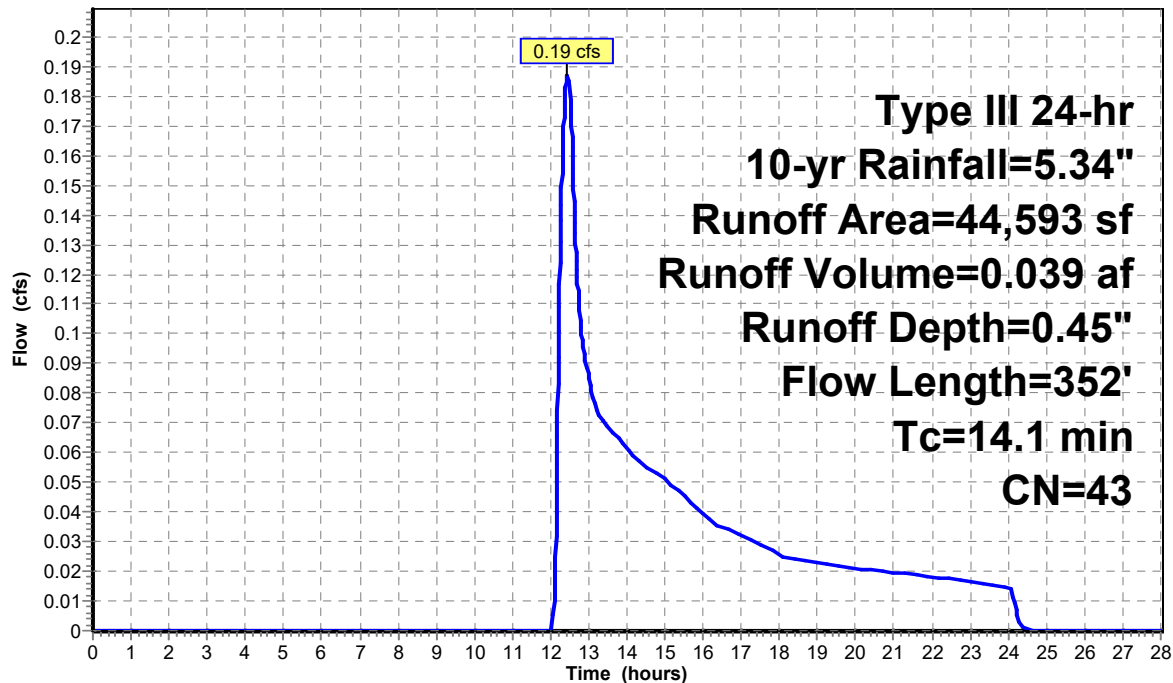
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=5.34"

Area (sf)	CN	Description
41,185	39	>75% Grass cover, Good, HSG A
3,408	96	Gravel surface, HSG A
44,593	43	Weighted Average
44,593		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	30	0.6250	0.54		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
5.0	70	0.0500	0.23		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
8.2	252	0.0010	0.51		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
14.1	352	Total			

Subcatchment 1S: EDA-1

Hydrograph



HillsideRebuild

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Type III 24-hr 10-yr Rainfall=5.34"
Printed 1/20/2025
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Summary for Subcatchment 2S: EDA-1.1

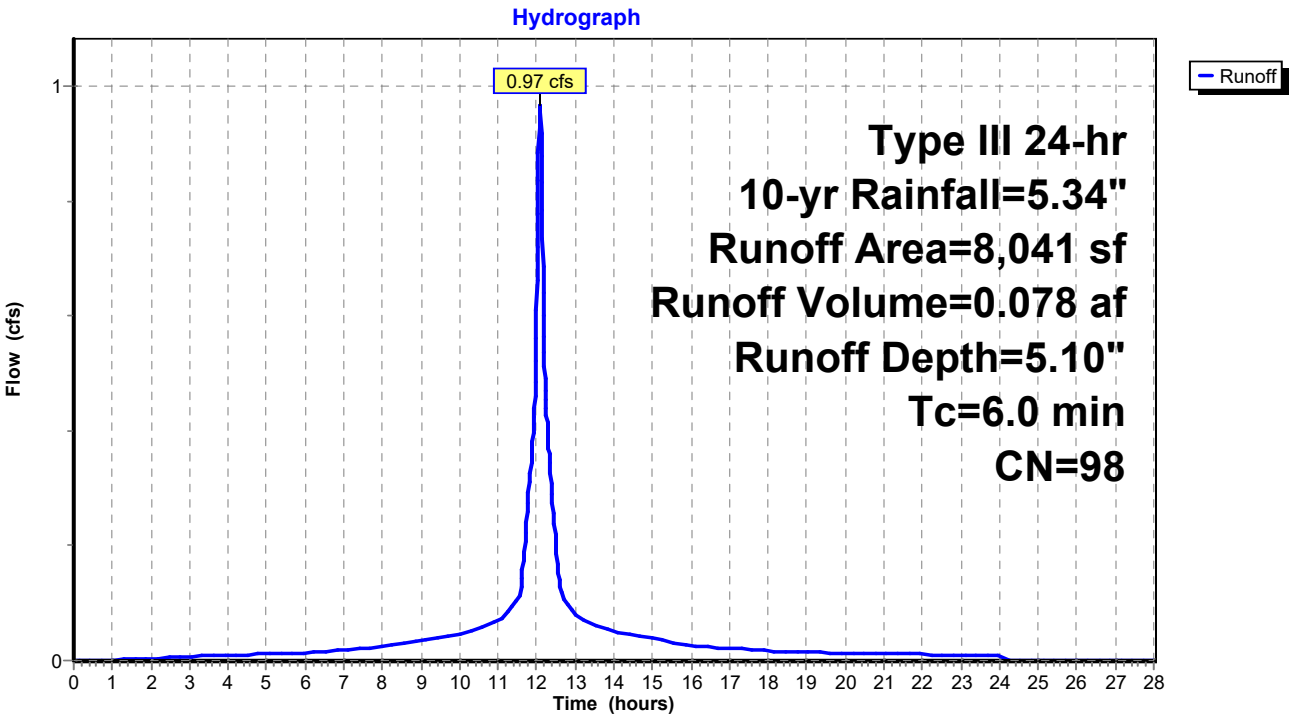
Runoff = 0.97 cfs @ 12.08 hrs, Volume= 0.078 af, Depth= 5.10"
Routed to Pond 3P : Existing Substation Yard Stone

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=5.34"

	Area (sf)	CN	Description
*	6,962	98	Substation Yard
*	1,079	98	Foundations
	8,041	98	Weighted Average
	8,041		100.00% Impervious Area

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

Subcatchment 2S: EDA-1.1



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Type III 24-hr 10-yr Rainfall=5.34"

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Summary for Pond 3P: Existing Substation Yard Stone

Inflow Area = 0.185 ac, 100.00% Impervious, Inflow Depth = 5.10" for 10-yr event
 Inflow = 0.97 cfs @ 12.08 hrs, Volume= 0.078 af
 Outflow = 0.39 cfs @ 11.92 hrs, Volume= 0.078 af, Atten= 60%, Lag= 0.0 min
 Discarded = 0.39 cfs @ 11.92 hrs, Volume= 0.078 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Routed to Link 4L : Analysis Point 1

Routing by Stor-Ind method, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
 Peak Elev= 94.33' @ 12.29 hrs Surf.Area= 6,980 sf Storage= 345 cf

Plug-Flow detention time= 3.4 min calculated for 0.078 af (100% of inflow)
 Center-of-Mass det. time= 3.4 min (750.4 - 746.9)

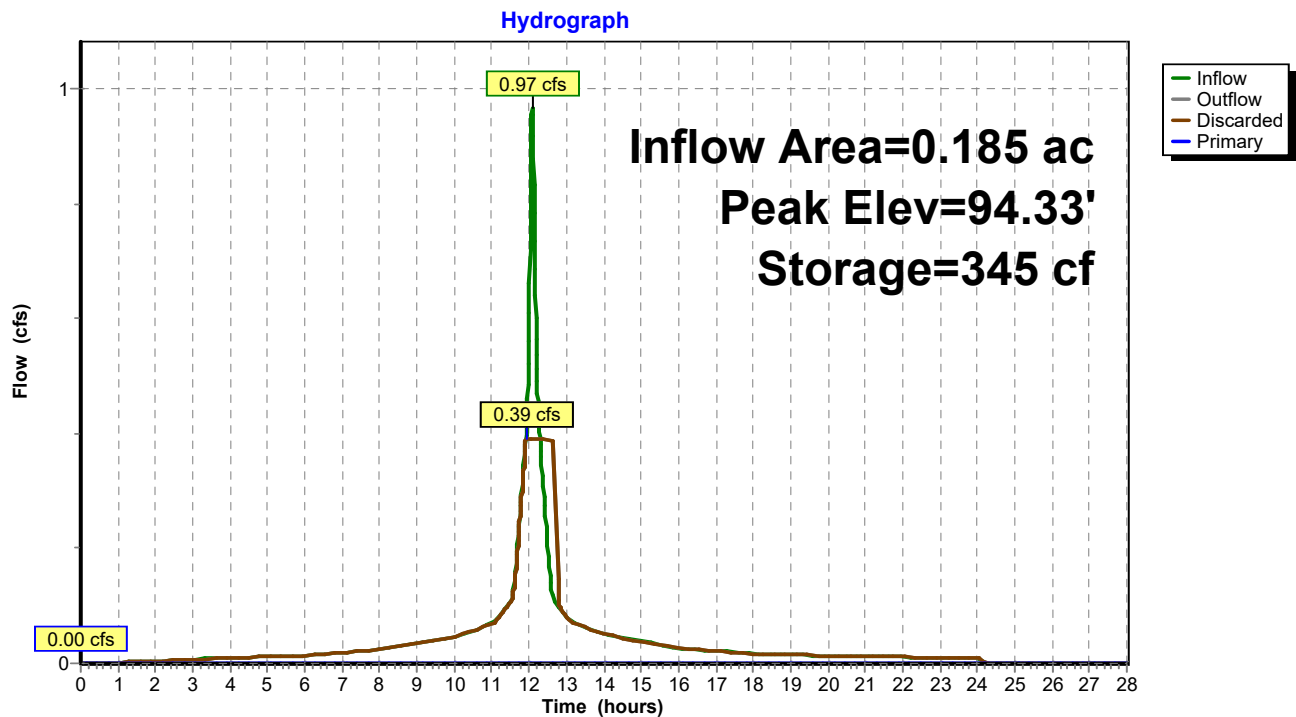
Volume	Invert	Avail.Storage	Storage Description	
#1	94.00'	2,809 cf	Substation Yard Storage (Prismatic) listed below (Recalc)	
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
94.00	6,980	0.0	0	0
94.01	6,980	15.0	10	10
94.99	6,980	15.0	1,026	1,037
95.00	6,980	40.0	28	1,064
95.25	6,980	40.0	698	1,762
95.40	6,980	100.0	1,047	2,809

Device	Routing	Invert	Outlet Devices
#1	Discarded	94.00'	2.410 in/hr Exfiltration over Surface area
#2	Primary	95.25'	Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
			Head (feet) 0.00 0.20
			Width (feet) 376.00 376.00

Discarded OutFlow Max=0.39 cfs @ 11.92 hrs HW=94.01' (Free Discharge)
 ↑ **1=Exfiltration** (Exfiltration Controls 0.39 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=94.00' (Free Discharge)
 ↑ **2=Custom Weir/Orifice** (Controls 0.00 cfs)

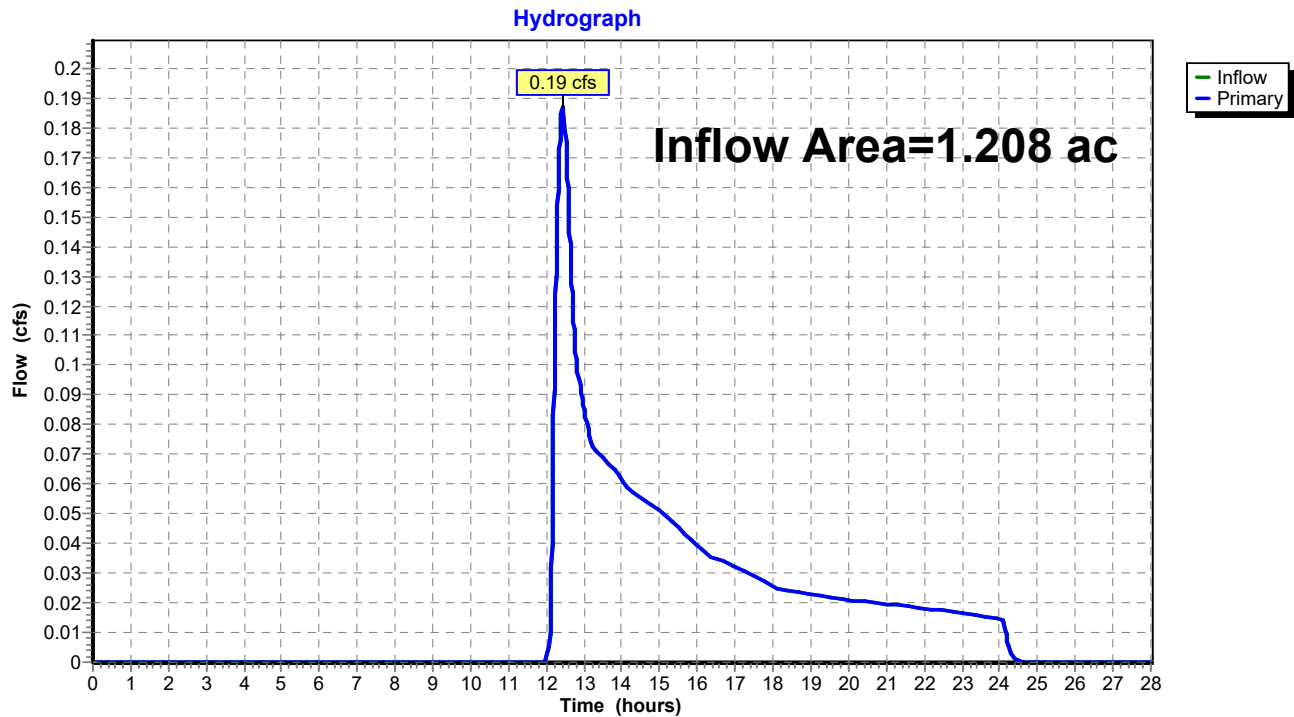
Pond 3P: Existing Substation Yard Stone



Summary for Link 4L: Analysis Point 1

Inflow Area = 1.208 ac, 15.28% Impervious, Inflow Depth = 0.38" for 10-yr event
Inflow = 0.19 cfs @ 12.45 hrs, Volume= 0.039 af
Primary = 0.19 cfs @ 12.45 hrs, Volume= 0.039 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs

Link 4L: Analysis Point 1

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Type III 24-hr 25-yr Rainfall=6.57"

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Time span=0.00-28.00 hrs, dt=0.01 hrs, 2801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: EDA-1

Runoff Area=44,593 sf 0.00% Impervious Runoff Depth=0.89"
Flow Length=352' Tc=14.1 min CN=43 Runoff=0.51 cfs 0.076 af

Subcatchment2S: EDA-1.1

Runoff Area=8,041 sf 100.00% Impervious Runoff Depth=6.33"
Tc=6.0 min CN=98 Runoff=1.19 cfs 0.097 af

Pond 3P: Existing Substation Yard Stone

Peak Elev=94.55' Storage=573 cf Inflow=1.19 cfs 0.097 af
Discarded=0.39 cfs 0.097 af Primary=0.00 cfs 0.000 af Outflow=0.39 cfs 0.097 af

Link 4L: Analysis Point 1

Inflow=0.51 cfs 0.076 af
Primary=0.51 cfs 0.076 af

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Type III 24-hr 25-yr Rainfall=6.57"

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Summary for Subcatchment 1S: EDA-1

Runoff = 0.51 cfs @ 12.28 hrs, Volume= 0.076 af, Depth= 0.89"

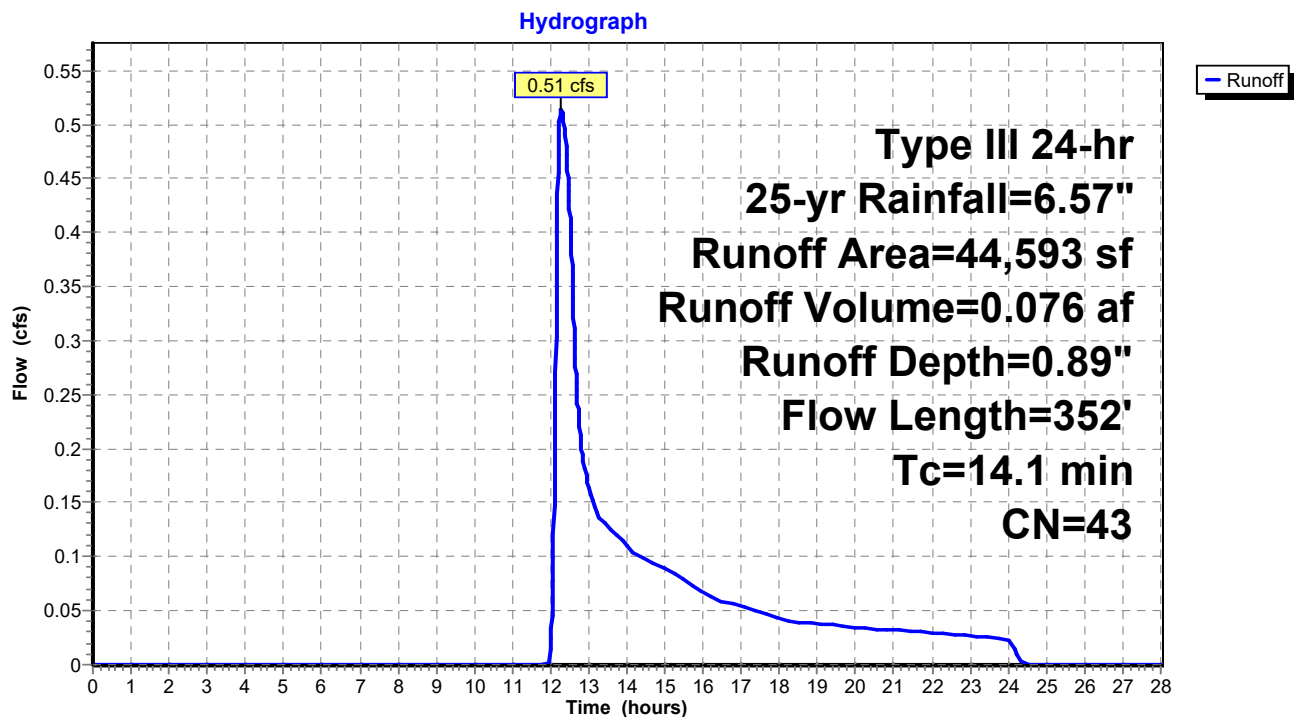
Routed to Link 4L : Analysis Point 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.57"

Area (sf)	CN	Description
41,185	39	>75% Grass cover, Good, HSG A
3,408	96	Gravel surface, HSG A
44,593	43	Weighted Average
44,593		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	30	0.6250	0.54		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
5.0	70	0.0500	0.23		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
8.2	252	0.0010	0.51		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
14.1	352	Total			

Subcatchment 1S: EDA-1



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Type III 24-hr 25-yr Rainfall=6.57"

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Summary for Subcatchment 2S: EDA-1.1

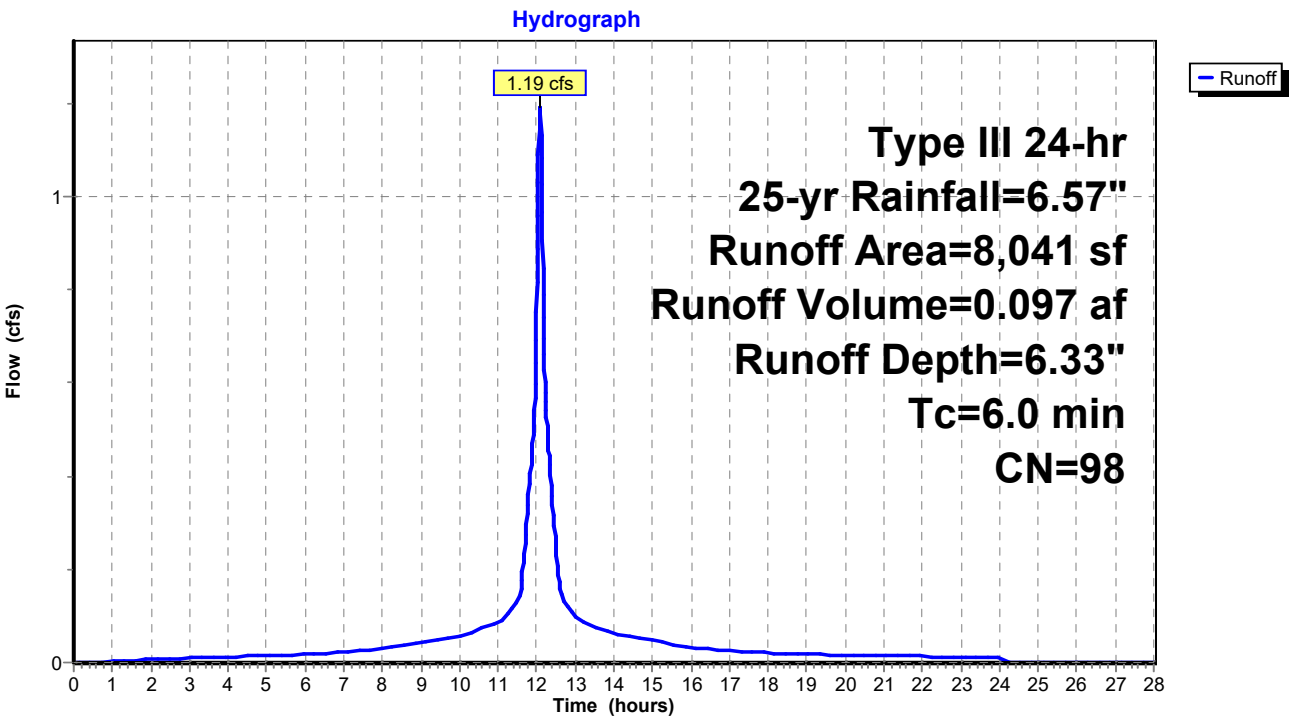
Runoff = 1.19 cfs @ 12.08 hrs, Volume= 0.097 af, Depth= 6.33"
Routed to Pond 3P : Existing Substation Yard Stone

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.57"

	Area (sf)	CN	Description
*	6,962	98	Substation Yard
*	1,079	98	Foundations
	8,041	98	Weighted Average
	8,041		100.00% Impervious Area

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

Subcatchment 2S: EDA-1.1



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Type III 24-hr 25-yr Rainfall=6.57"

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Summary for Pond 3P: Existing Substation Yard Stone

Inflow Area = 0.185 ac, 100.00% Impervious, Inflow Depth = 6.33" for 25-yr event
 Inflow = 1.19 cfs @ 12.08 hrs, Volume= 0.097 af
 Outflow = 0.39 cfs @ 11.83 hrs, Volume= 0.097 af, Atten= 67%, Lag= 0.0 min
 Discarded = 0.39 cfs @ 11.83 hrs, Volume= 0.097 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Routed to Link 4L : Analysis Point 1

Routing by Stor-Ind method, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
 Peak Elev= 94.55' @ 12.37 hrs Surf.Area= 6,980 sf Storage= 573 cf

Plug-Flow detention time= 5.9 min calculated for 0.097 af (100% of inflow)
 Center-of-Mass det. time= 5.9 min (749.8 - 743.8)

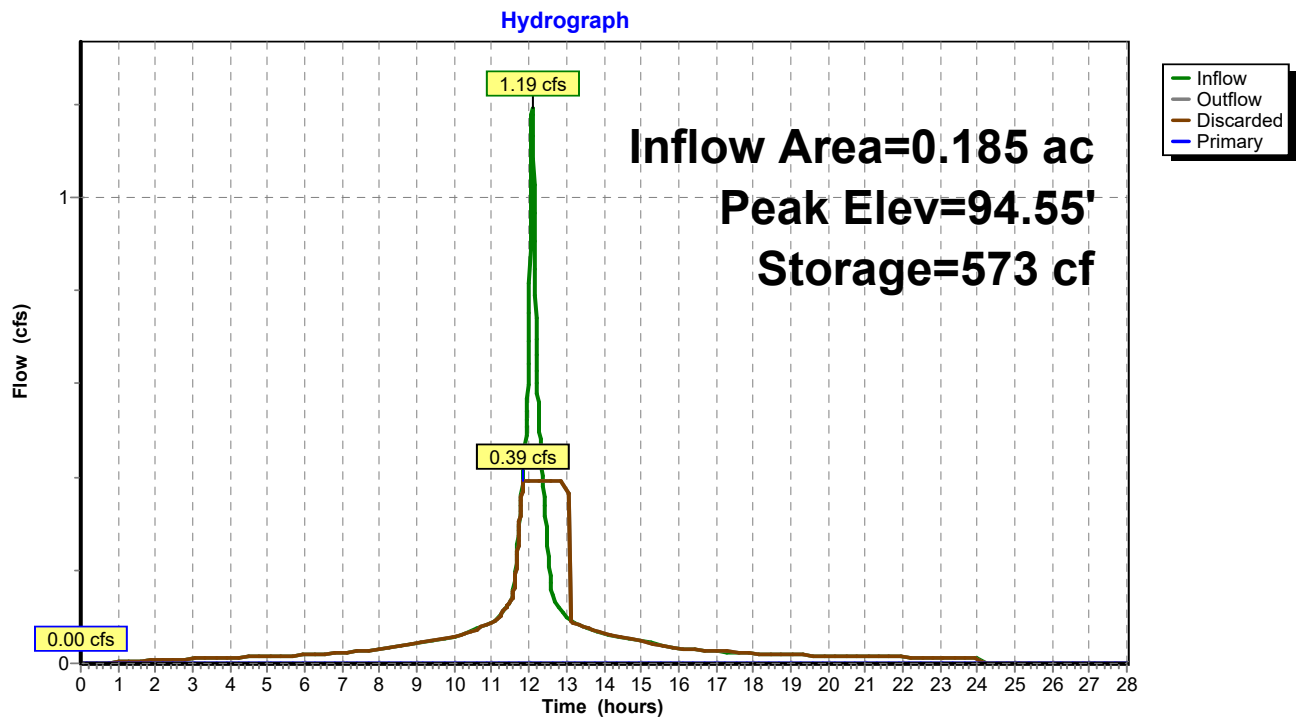
Volume	Invert	Avail.Storage	Storage Description	
#1	94.00'	2,809 cf	Substation Yard Storage (Prismatic) listed below (Recalc)	
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
94.00	6,980	0.0	0	0
94.01	6,980	15.0	10	10
94.99	6,980	15.0	1,026	1,037
95.00	6,980	40.0	28	1,064
95.25	6,980	40.0	698	1,762
95.40	6,980	100.0	1,047	2,809

Device	Routing	Invert	Outlet Devices
#1	Discarded	94.00'	2.410 in/hr Exfiltration over Surface area
#2	Primary	95.25'	Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
			Head (feet) 0.00 0.20
			Width (feet) 376.00 376.00

Discarded OutFlow Max=0.39 cfs @ 11.83 hrs HW=94.01' (Free Discharge)
 ↑ **1=Exfiltration** (Exfiltration Controls 0.39 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=94.00' (Free Discharge)
 ↑ **2=Custom Weir/Orifice** (Controls 0.00 cfs)

Pond 3P: Existing Substation Yard Stone

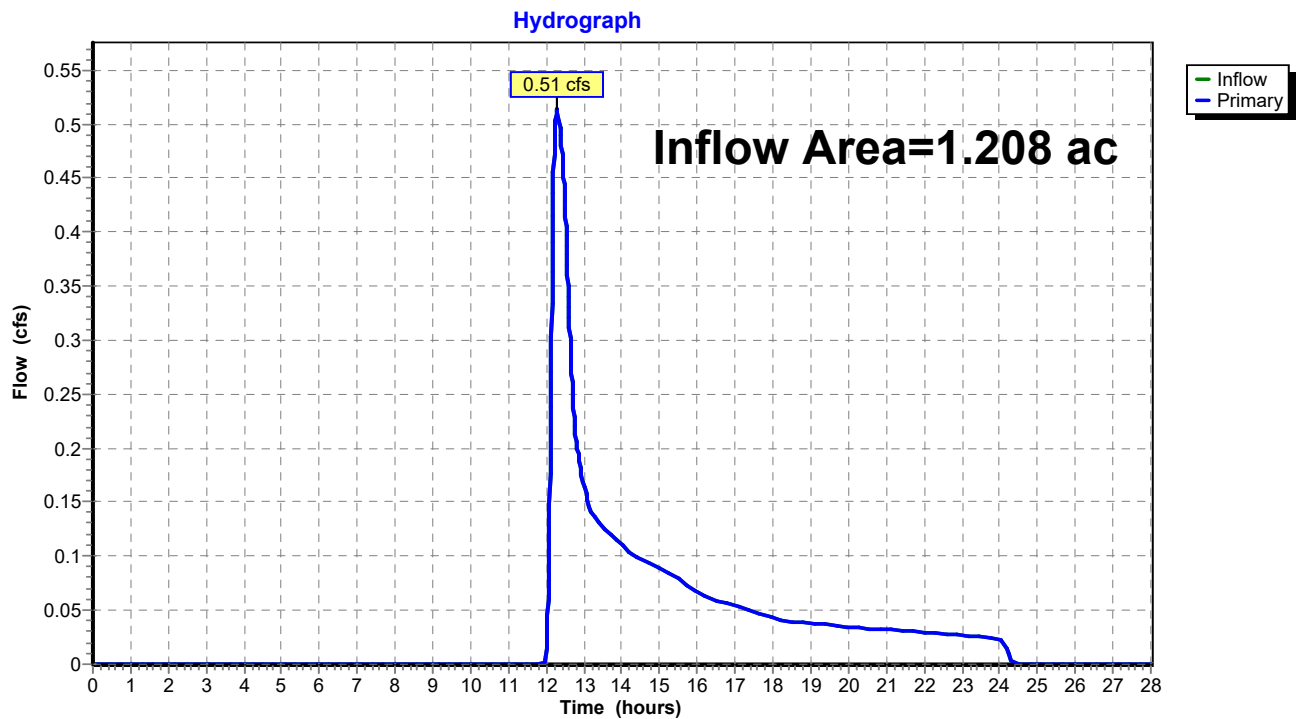


Summary for Link 4L: Analysis Point 1

Inflow Area = 1.208 ac, 15.28% Impervious, Inflow Depth = 0.76" for 25-yr event
 Inflow = 0.51 cfs @ 12.28 hrs, Volume= 0.076 af
 Primary = 0.51 cfs @ 12.28 hrs, Volume= 0.076 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs

Link 4L: Analysis Point 1



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Type III 24-hr 100-yr Rainfall=8.46"

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Time span=0.00-28.00 hrs, dt=0.01 hrs, 2801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: EDA-1

Runoff Area=44,593 sf 0.00% Impervious Runoff Depth=1.77"
Flow Length=352' Tc=14.1 min CN=43 Runoff=1.34 cfs 0.151 af

Subcatchment2S: EDA-1.1

Runoff Area=8,041 sf 100.00% Impervious Runoff Depth=8.22"
Tc=6.0 min CN=98 Runoff=1.53 cfs 0.126 af

Pond 3P: Existing Substation Yard Stone

Peak Elev=94.95' Storage=990 cf Inflow=1.53 cfs 0.126 af
Discarded=0.39 cfs 0.126 af Primary=0.00 cfs 0.000 af Outflow=0.39 cfs 0.126 af

Link 4L: Analysis Point 1

Inflow=1.34 cfs 0.151 af
Primary=1.34 cfs 0.151 af

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Type III 24-hr 100-yr Rainfall=8.46"

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Summary for Subcatchment 1S: EDA-1

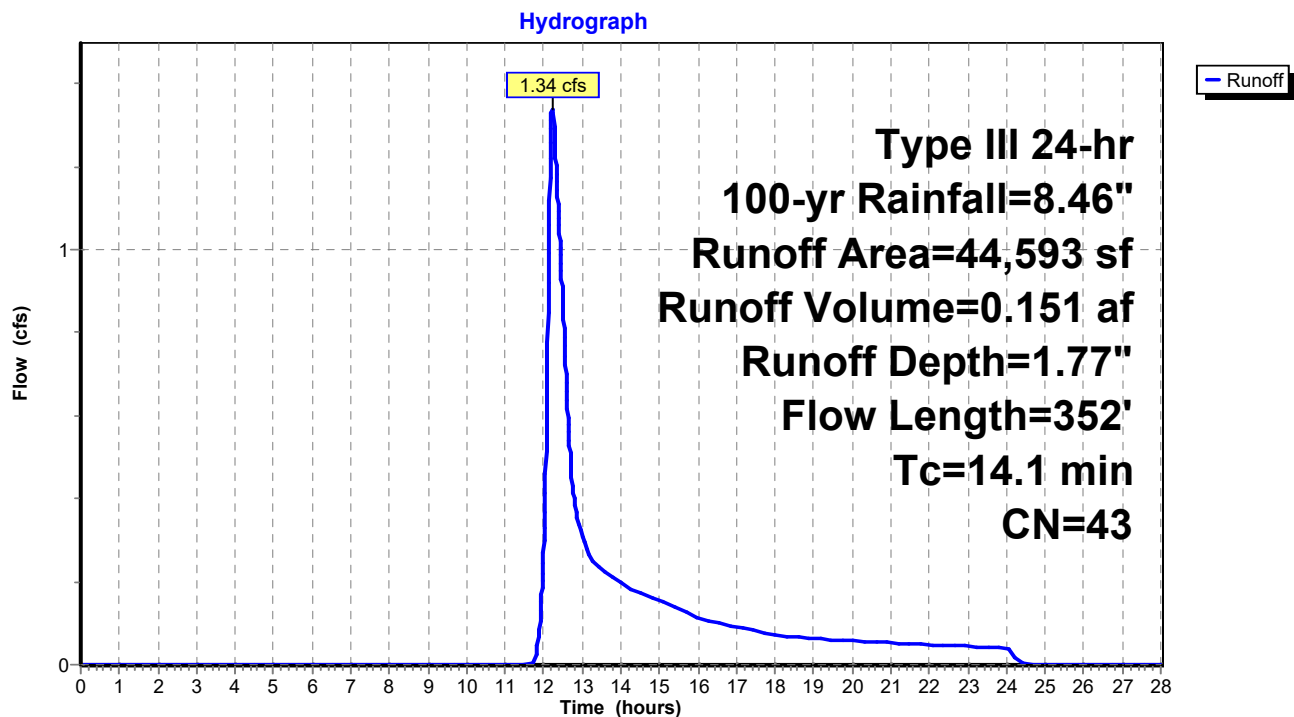
Runoff = 1.34 cfs @ 12.23 hrs, Volume= 0.151 af, Depth= 1.77"

Routed to Link 4L : Analysis Point 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.46"

Area (sf)	CN	Description
41,185	39	>75% Grass cover, Good, HSG A
3,408	96	Gravel surface, HSG A
44,593	43	Weighted Average
44,593		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	30	0.6250	0.54		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
5.0	70	0.0500	0.23		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
8.2	252	0.0010	0.51		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
14.1	352	Total			

Subcatchment 1S: EDA-1

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Type III 24-hr 100-yr Rainfall=8.46"

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Summary for Subcatchment 2S: EDA-1.1

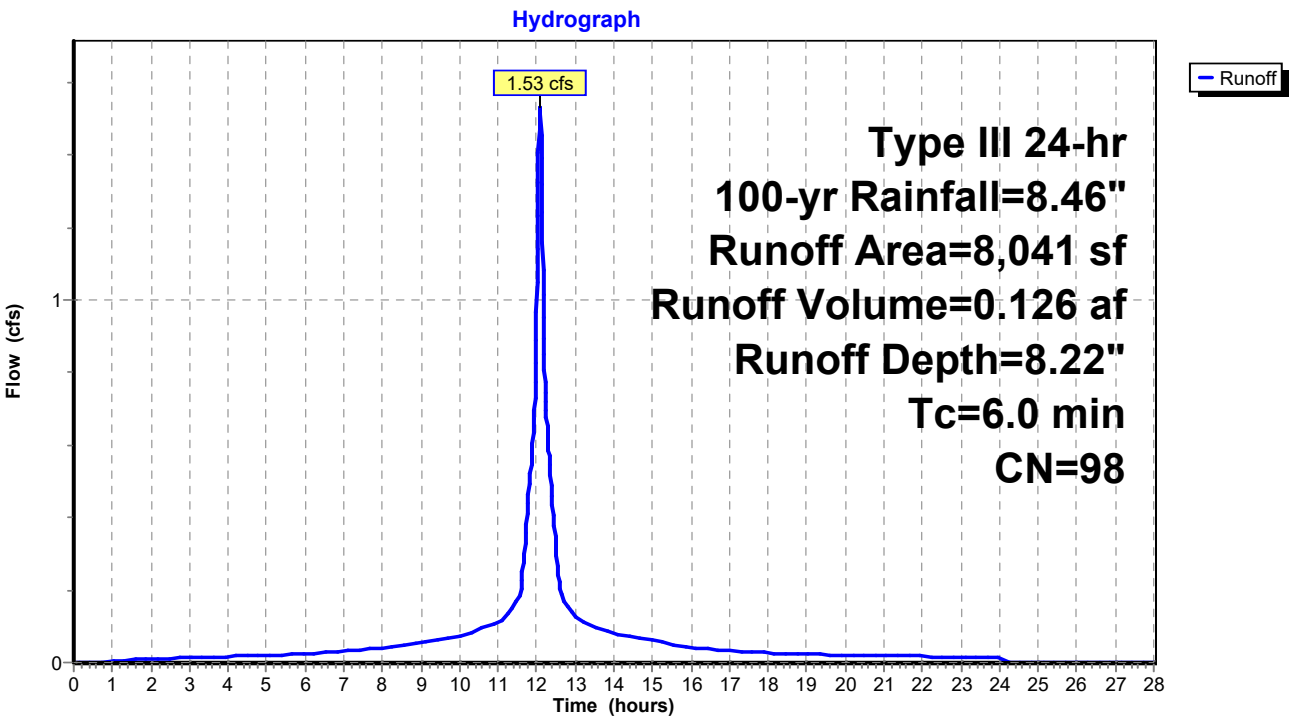
Runoff = 1.53 cfs @ 12.08 hrs, Volume= 0.126 af, Depth= 8.22"
Routed to Pond 3P : Existing Substation Yard Stone

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.46"

	Area (sf)	CN	Description
*	6,962	98	Substation Yard
*	1,079	98	Foundations
	8,041	98	Weighted Average
	8,041		100.00% Impervious Area

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

Subcatchment 2S: EDA-1.1



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Type III 24-hr 100-yr Rainfall=8.46"

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Summary for Pond 3P: Existing Substation Yard Stone

Inflow Area = 0.185 ac, 100.00% Impervious, Inflow Depth = 8.22" for 100-yr event
 Inflow = 1.53 cfs @ 12.08 hrs, Volume= 0.126 af
 Outflow = 0.39 cfs @ 11.75 hrs, Volume= 0.126 af, Atten= 75%, Lag= 0.0 min
 Discarded = 0.39 cfs @ 11.75 hrs, Volume= 0.126 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Routed to Link 4L : Analysis Point 1

Routing by Stor-Ind method, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
 Peak Elev= 94.95' @ 12.45 hrs Surf.Area= 6,980 sf Storage= 990 cf

Plug-Flow detention time= 11.1 min calculated for 0.126 af (100% of inflow)
 Center-of-Mass det. time= 11.1 min (751.6 - 740.5)

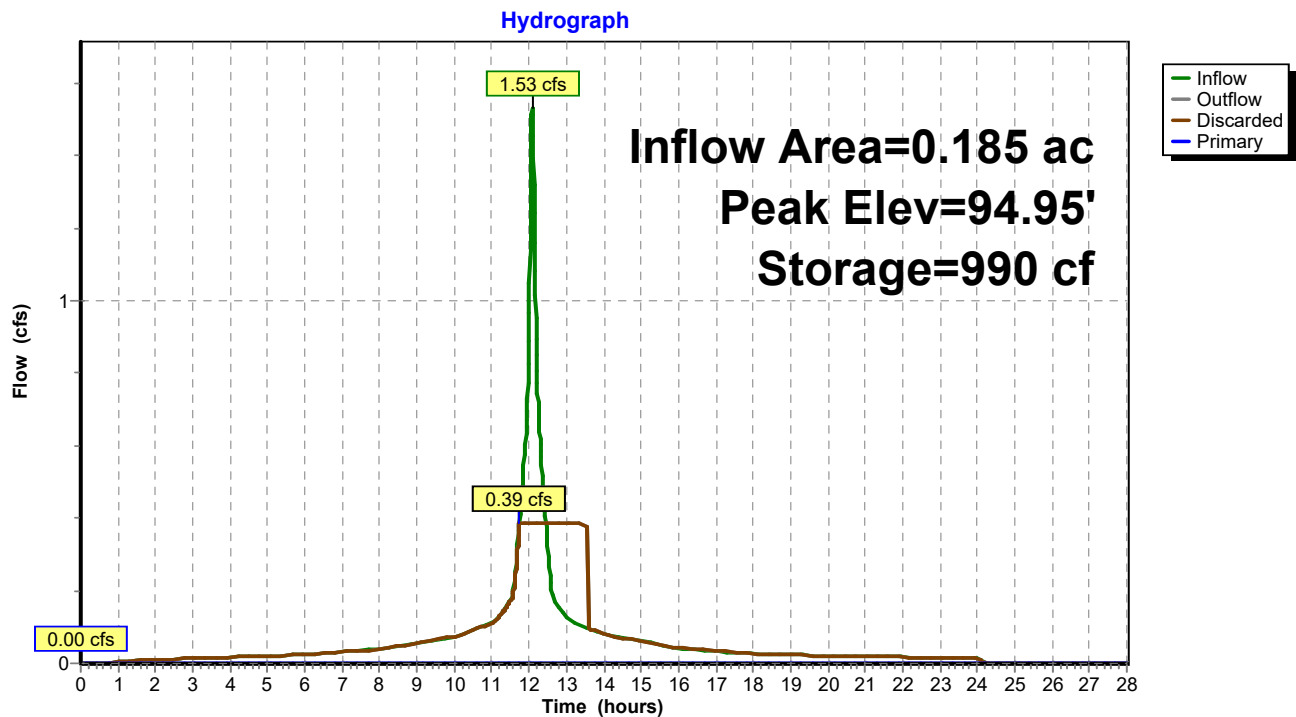
Volume	Invert	Avail.Storage	Storage Description	
#1	94.00'	2,809 cf	Substation Yard Storage (Prismatic) listed below (Recalc)	
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
94.00	6,980	0.0	0	0
94.01	6,980	15.0	10	10
94.99	6,980	15.0	1,026	1,037
95.00	6,980	40.0	28	1,064
95.25	6,980	40.0	698	1,762
95.40	6,980	100.0	1,047	2,809

Device	Routing	Invert	Outlet Devices
#1	Discarded	94.00'	2.410 in/hr Exfiltration over Surface area
#2	Primary	95.25'	Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
			Head (feet) 0.00 0.20
			Width (feet) 376.00 376.00

Discarded OutFlow Max=0.39 cfs @ 11.75 hrs HW=94.01' (Free Discharge)
 ↑ **1=Exfiltration** (Exfiltration Controls 0.39 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=94.00' (Free Discharge)
 ↑ **2=Custom Weir/Orifice** (Controls 0.00 cfs)

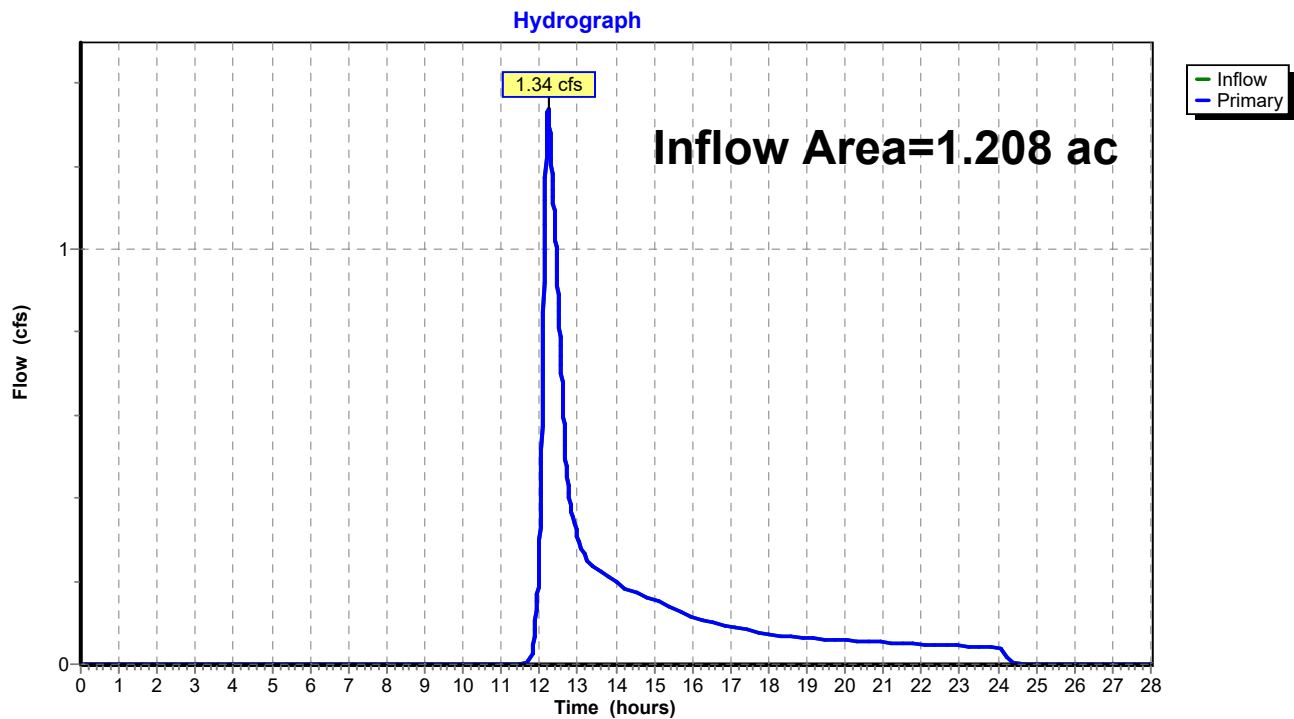
Pond 3P: Existing Substation Yard Stone

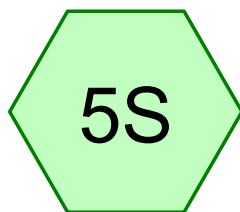


Summary for Link 4L: Analysis Point 1

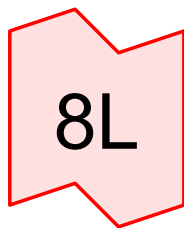
Inflow Area = 1.208 ac, 15.28% Impervious, Inflow Depth = 1.50" for 100-yr event
Inflow = 1.34 cfs @ 12.23 hrs, Volume= 0.151 af
Primary = 1.34 cfs @ 12.23 hrs, Volume= 0.151 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs

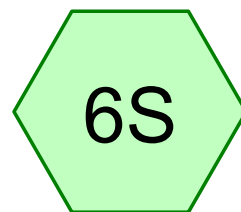
Link 4L: Analysis Point 1



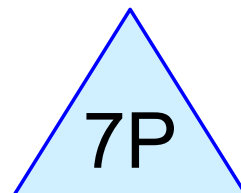
PDA-1



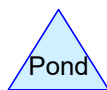
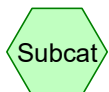
Analysis Point 1



PDA-1.1



Proposed Substation
Yard Stone



Routing Diagram for HillsideRebuild

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Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.691	39	>75% Grass cover, Good, HSG A (5S)
0.024	98	Foundations (6S)
0.056	96	Gravel surface, HSG A (5S)
0.048	98	Roof (6S)
0.389	98	Substation Yard (6S)

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Type III 24-hr 2-yr Rainfall=3.38"

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Time span=0.00-28.00 hrs, dt=0.01 hrs, 2801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment5S: PDA-1

Runoff Area=32,548 sf 0.00% Impervious Runoff Depth=0.04"
Flow Length=386' Tc=16.3 min CN=43 Runoff=0.00 cfs 0.002 af

Subcatchment6S: PDA-1.1

Runoff Area=20,086 sf 100.00% Impervious Runoff Depth=3.15"
Tc=6.0 min CN=98 Runoff=1.51 cfs 0.121 af

Pond 7P: Proposed Substation Yard Stone

Peak Elev=93.40' Storage=243 cf Inflow=1.51 cfs 0.121 af
Discarded=0.94 cfs 0.121 af Primary=0.00 cfs 0.000 af Outflow=0.94 cfs 0.121 af

Link 8L: Analysis Point 1

Inflow=0.00 cfs 0.002 af
Primary=0.00 cfs 0.002 af

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Type III 24-hr 2-yr Rainfall=3.38"

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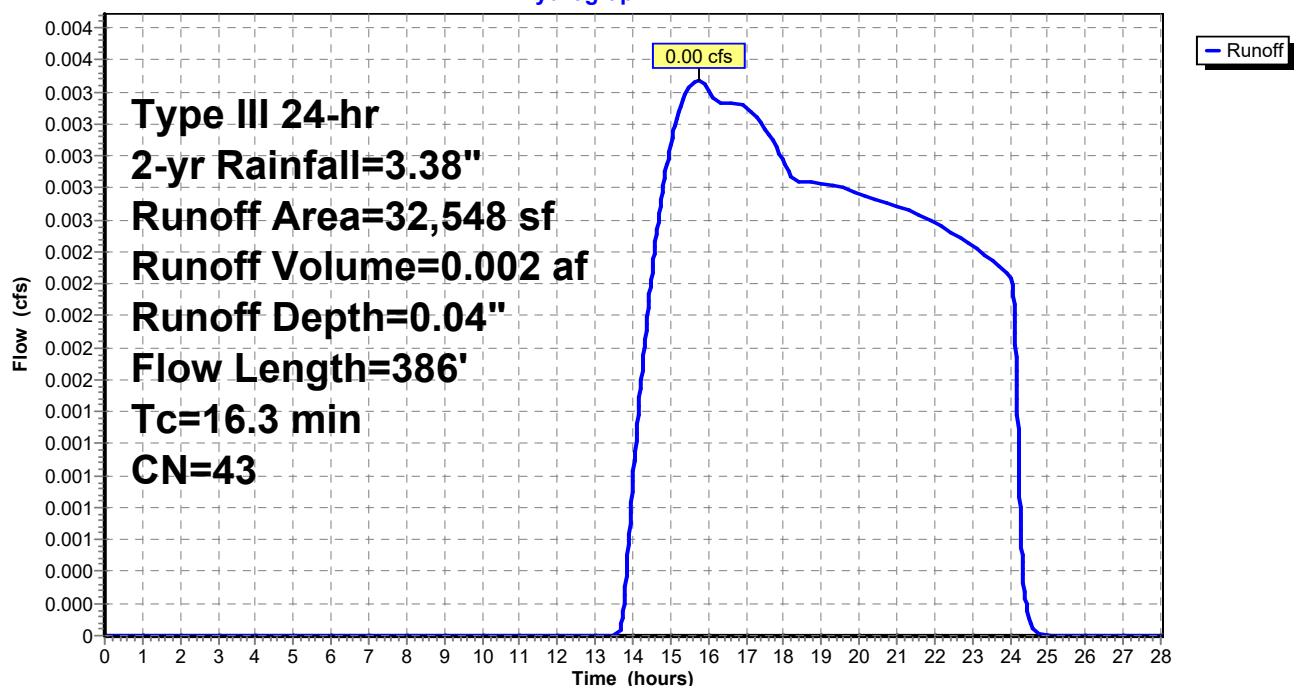
Summary for Subcatchment 5S: PDA-1

Runoff = 0.00 cfs @ 15.74 hrs, Volume= 0.002 af, Depth= 0.04"
Routed to Link 8L : Analysis Point 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.38"

Area (sf)	CN	Description
30,114	39	>75% Grass cover, Good, HSG A
2,434	96	Gravel surface, HSG A
32,548	43	Weighted Average
32,548		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	30	0.6250	0.54		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
3.4	42	0.0450	0.20		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
5.5	28	0.0063	0.09		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
6.5	286	0.0024	0.73		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
16.3	386	Total			

Subcatchment 5S: PDA-1**Hydrograph**

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Type III 24-hr 2-yr Rainfall=3.38"

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Summary for Subcatchment 6S: PDA-1.1

Runoff = 1.51 cfs @ 12.08 hrs, Volume= 0.121 af, Depth= 3.15"

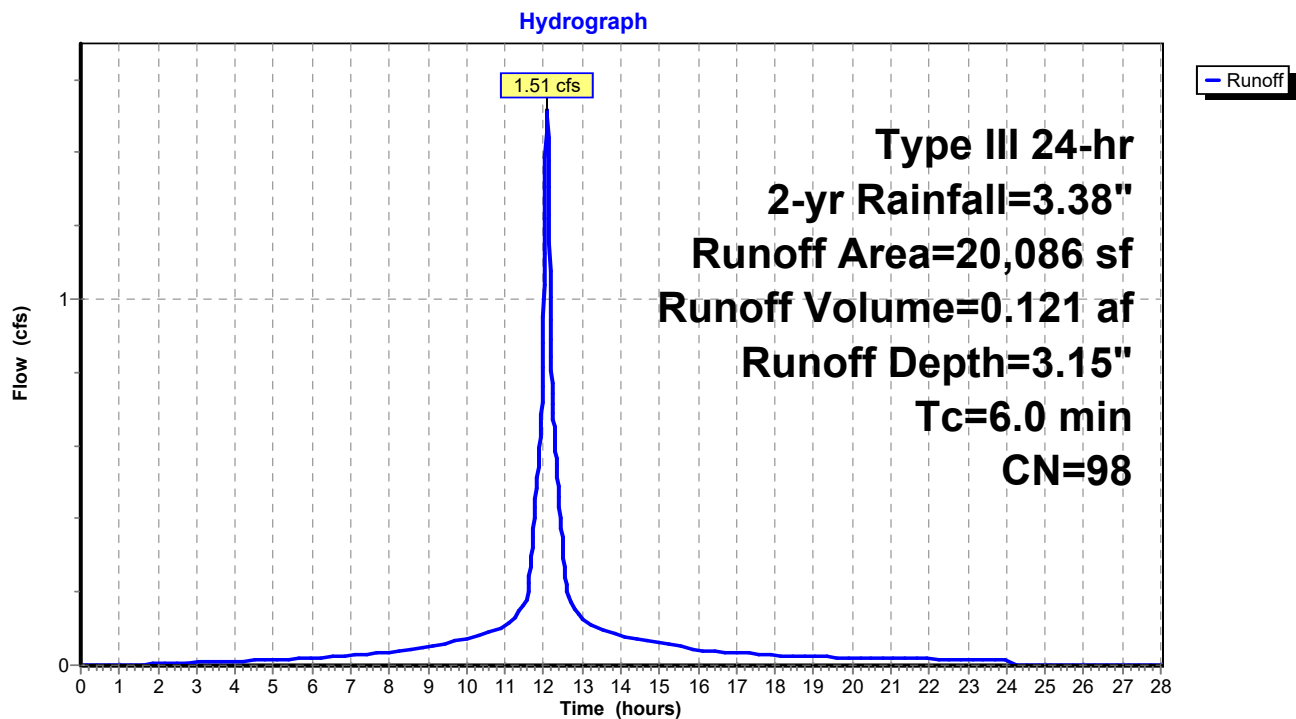
Routed to Pond 7P : Proposed Substation Yard Stone

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.38"

	Area (sf)	CN	Description
*	16,939	98	Substation Yard
*	1,050	98	Foundations
*	2,097	98	Roof
	20,086	98	Weighted Average
	20,086		100.00% Impervious Area

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

Subcatchment 6S: PDA-1.1



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Type III 24-hr 2-yr Rainfall=3.38"

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Summary for Pond 7P: Proposed Substation Yard Stone

Inflow Area = 0.461 ac, 100.00% Impervious, Inflow Depth = 3.15" for 2-yr event
 Inflow = 1.51 cfs @ 12.08 hrs, Volume= 0.121 af
 Outflow = 0.94 cfs @ 12.01 hrs, Volume= 0.121 af, Atten= 38%, Lag= 0.0 min
 Discarded = 0.94 cfs @ 12.01 hrs, Volume= 0.121 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Routed to Link 8L : Analysis Point 1

Routing by Stor-Ind method, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
 Peak Elev= 93.40' @ 12.18 hrs Surf.Area= 16,939 sf Storage= 243 cf

Plug-Flow detention time= 1.0 min calculated for 0.121 af (100% of inflow)
 Center-of-Mass det. time= 1.0 min (756.3 - 755.3)

Volume	Invert	Avail.Storage	Storage Description	
#1	93.30'	11,857 cf	Substation Yard (Prismatic) Listed below (Recalc)	
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
93.30	16,939	0.0	0	0
93.31	16,939	15.0	25	25
95.30	16,939	15.0	5,056	5,082
95.31	16,939	40.0	68	5,149
95.80	16,939	40.0	3,320	8,470
95.81	16,939	100.0	169	8,639
96.00	16,939	100.0	3,218	11,857

Device	Routing	Invert	Outlet Devices
#1	Discarded	93.30'	2.410 in/hr Exfiltration over Surface area
#2	Primary	95.80'	Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
			Head (feet) 0.00 0.20
			Width (feet) 574.00 574.00

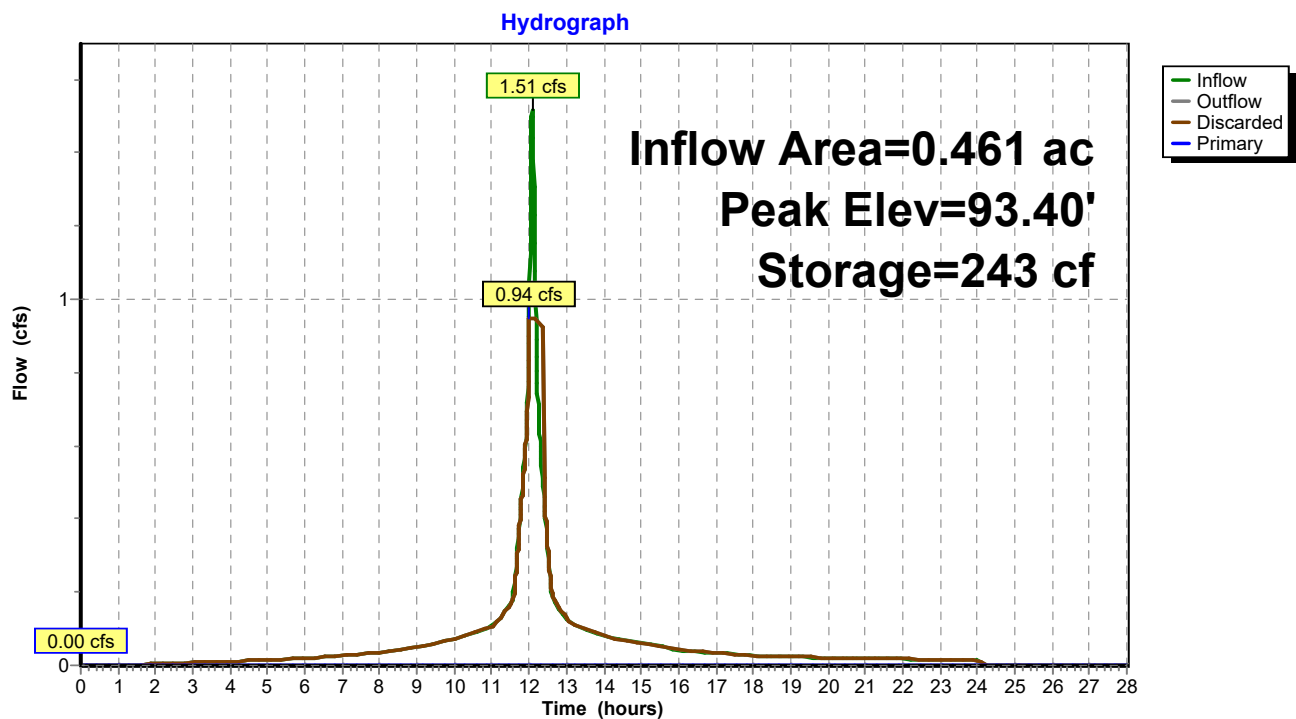
Discarded OutFlow Max=0.94 cfs @ 12.01 hrs HW=93.31' (Free Discharge)

↑ **1=Exfiltration** (Exfiltration Controls 0.94 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=93.30' (Free Discharge)

↑ **2=Custom Weir/Orifice** (Controls 0.00 cfs)

Pond 7P: Proposed Substation Yard Stone



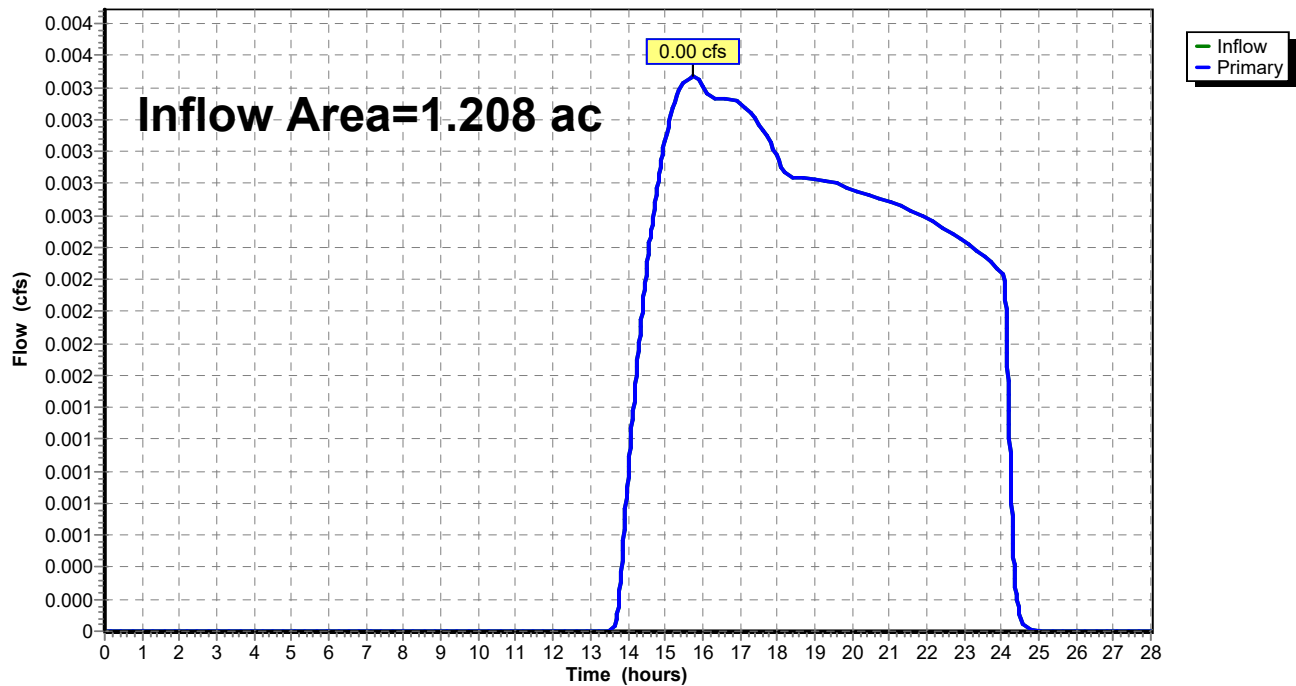
Summary for Link 8L: Analysis Point 1

Inflow Area = 1.208 ac, 38.16% Impervious, Inflow Depth = 0.02" for 2-yr event
 Inflow = 0.00 cfs @ 15.74 hrs, Volume= 0.002 af
 Primary = 0.00 cfs @ 15.74 hrs, Volume= 0.002 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs

Link 8L: Analysis Point 1

Hydrograph



HillsideRebuild

Type III 24-hr 10-yr Rainfall=5.34"

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Time span=0.00-28.00 hrs, dt=0.01 hrs, 2801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment5S: PDA-1

Runoff Area=32,548 sf 0.00% Impervious Runoff Depth=0.45"
Flow Length=386' Tc=16.3 min CN=43 Runoff=0.13 cfs 0.028 af

Subcatchment6S: PDA-1.1

Runoff Area=20,086 sf 100.00% Impervious Runoff Depth=5.10"
Tc=6.0 min CN=98 Runoff=2.41 cfs 0.196 af

Pond 7P: Proposed Substation Yard Stone

Peak Elev=93.65' Storage=899 cf Inflow=2.41 cfs 0.196 af
Discarded=0.94 cfs 0.196 af Primary=0.00 cfs 0.000 af Outflow=0.94 cfs 0.196 af

Link 8L: Analysis Point 1

Inflow=0.13 cfs 0.028 af
Primary=0.13 cfs 0.028 af

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Type III 24-hr 10-yr Rainfall=5.34"

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Summary for Subcatchment 5S: PDA-1

Runoff = 0.13 cfs @ 12.48 hrs, Volume= 0.028 af, Depth= 0.45"

Routed to Link 8L : Analysis Point 1

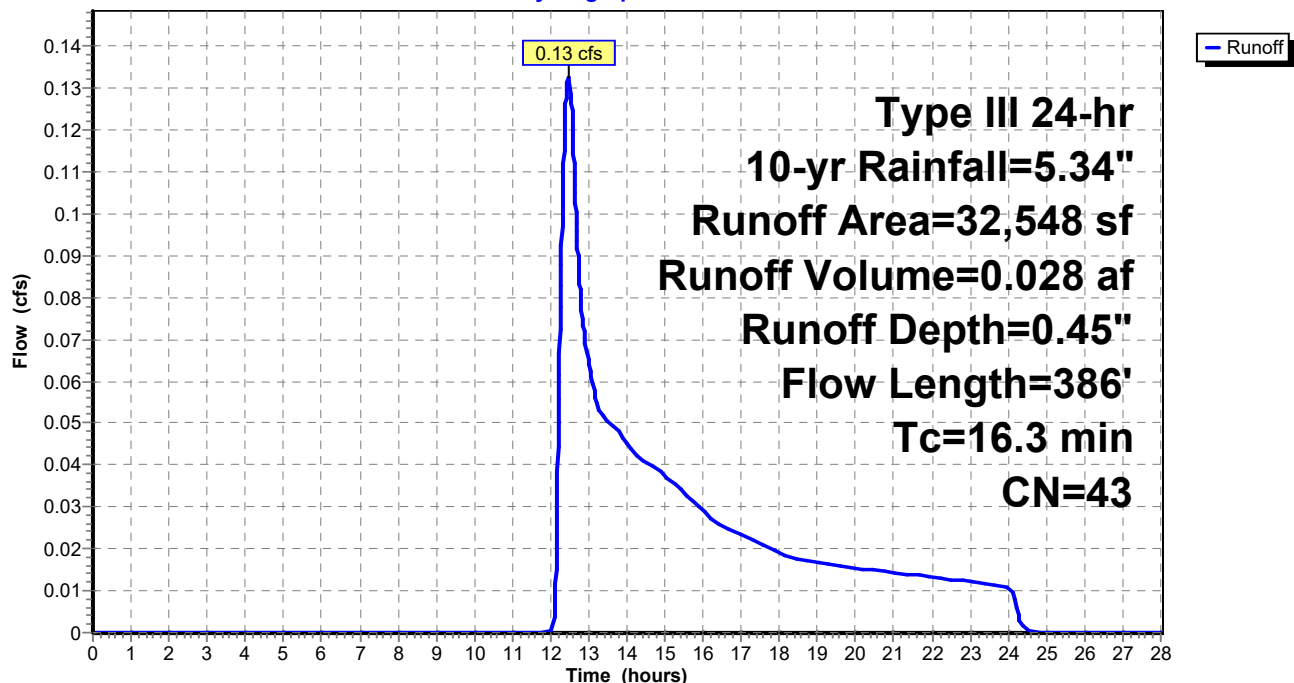
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=5.34"

Area (sf)	CN	Description
30,114	39	>75% Grass cover, Good, HSG A
2,434	96	Gravel surface, HSG A
32,548	43	Weighted Average
32,548		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	30	0.6250	0.54		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
3.4	42	0.0450	0.20		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
5.5	28	0.0063	0.09		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
6.5	286	0.0024	0.73		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
16.3	386	Total			

Subcatchment 5S: PDA-1

Hydrograph



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Type III 24-hr 10-yr Rainfall=5.34"

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Summary for Subcatchment 6S: PDA-1.1

Runoff = 2.41 cfs @ 12.08 hrs, Volume= 0.196 af, Depth= 5.10"

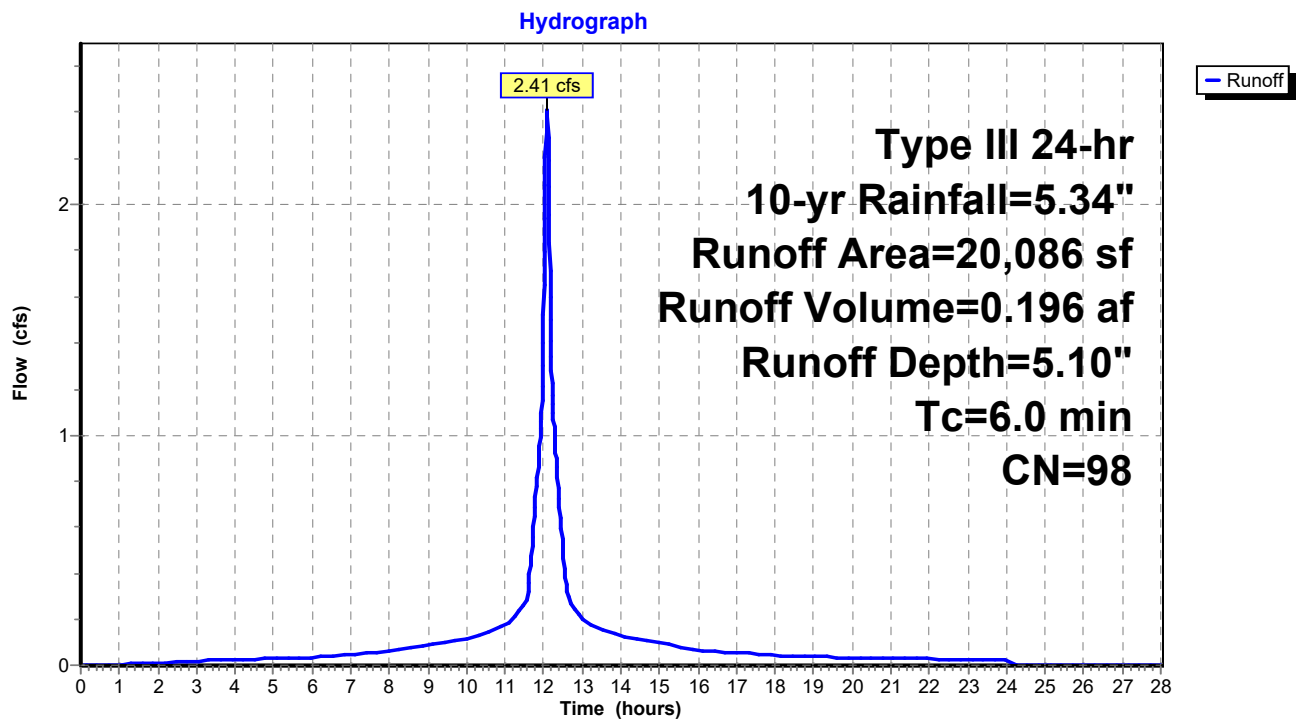
Routed to Pond 7P : Proposed Substation Yard Stone

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=5.34"

	Area (sf)	CN	Description
*	16,939	98	Substation Yard
*	1,050	98	Foundations
*	2,097	98	Roof
	20,086	98	Weighted Average
	20,086		100.00% Impervious Area

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

Subcatchment 6S: PDA-1.1



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Type III 24-hr 10-yr Rainfall=5.34"

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Summary for Pond 7P: Proposed Substation Yard Stone

Inflow Area = 0.461 ac, 100.00% Impervious, Inflow Depth = 5.10" for 10-yr event
 Inflow = 2.41 cfs @ 12.08 hrs, Volume= 0.196 af
 Outflow = 0.94 cfs @ 11.91 hrs, Volume= 0.196 af, Atten= 61%, Lag= 0.0 min
 Discarded = 0.94 cfs @ 11.91 hrs, Volume= 0.196 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Routed to Link 8L : Analysis Point 1

Routing by Stor-Ind method, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
 Peak Elev= 93.65' @ 12.30 hrs Surf.Area= 16,939 sf Storage= 899 cf

Plug-Flow detention time= 3.7 min calculated for 0.196 af (100% of inflow)
 Center-of-Mass det. time= 3.7 min (750.6 - 746.9)

Volume	Invert	Avail.Storage	Storage Description	
#1	93.30'	11,857 cf	Substation Yard (Prismatic) Listed below (Recalc)	
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
93.30	16,939	0.0	0	0
93.31	16,939	15.0	25	25
95.30	16,939	15.0	5,056	5,082
95.31	16,939	40.0	68	5,149
95.80	16,939	40.0	3,320	8,470
95.81	16,939	100.0	169	8,639
96.00	16,939	100.0	3,218	11,857

Device	Routing	Invert	Outlet Devices
#1	Discarded	93.30'	2.410 in/hr Exfiltration over Surface area
#2	Primary	95.80'	Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
			Head (feet) 0.00 0.20
			Width (feet) 574.00 574.00

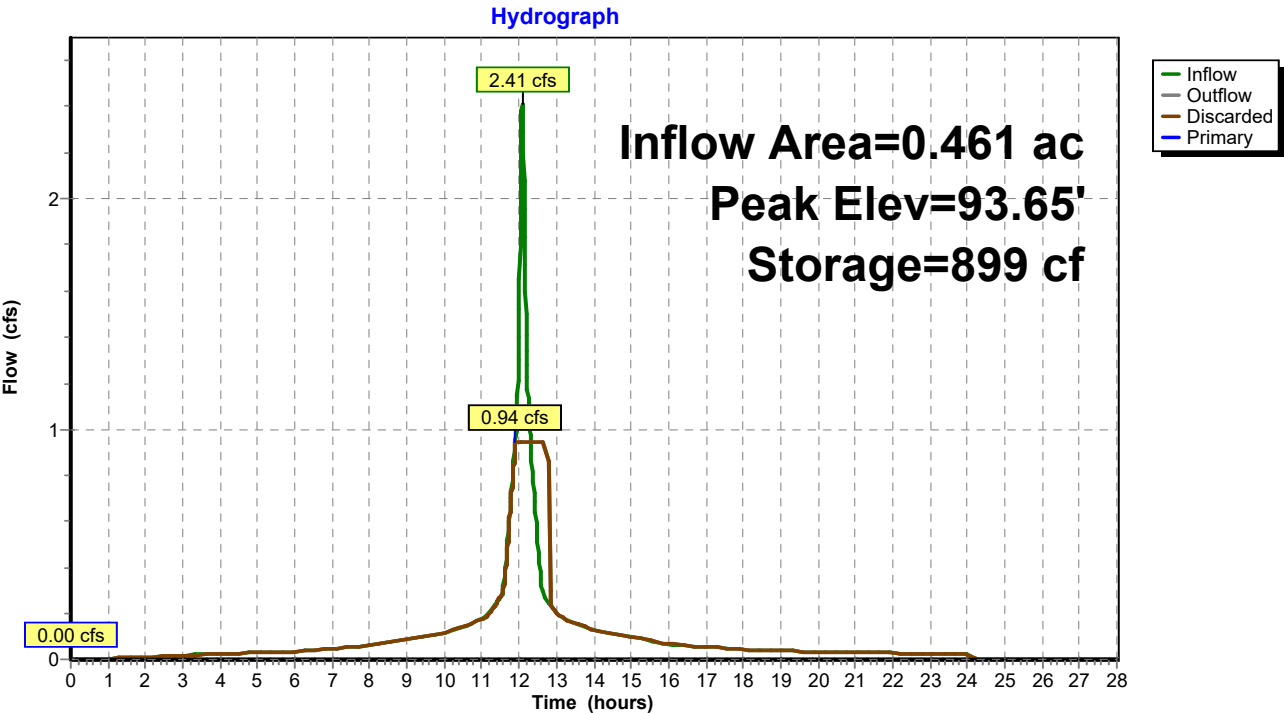
Discarded OutFlow Max=0.94 cfs @ 11.91 hrs HW=93.31' (Free Discharge)

↑1=**Exfiltration** (Exfiltration Controls 0.94 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=93.30' (Free Discharge)

↑2=**Custom Weir/Orifice** (Controls 0.00 cfs)

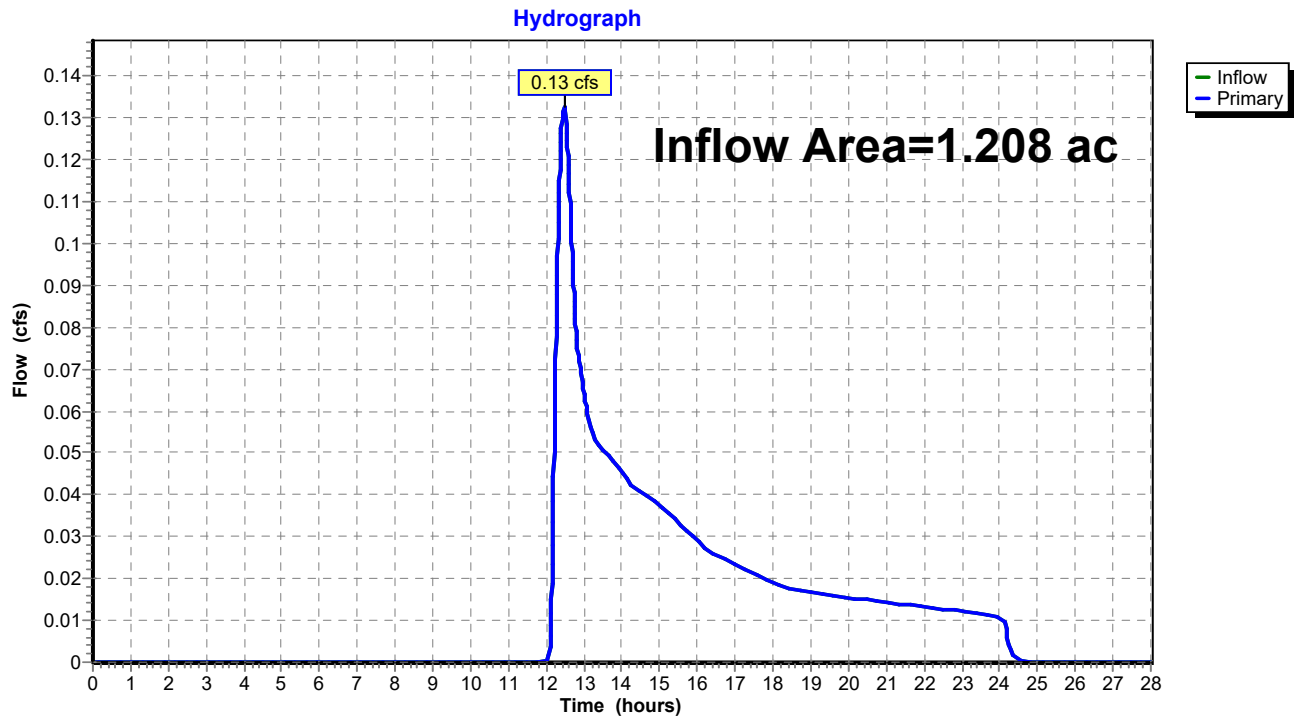
Pond 7P: Proposed Substation Yard Stone



Summary for Link 8L: Analysis Point 1

Inflow Area = 1.208 ac, 38.16% Impervious, Inflow Depth = 0.28" for 10-yr event
Inflow = 0.13 cfs @ 12.48 hrs, Volume= 0.028 af
Primary = 0.13 cfs @ 12.48 hrs, Volume= 0.028 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs

Link 8L: Analysis Point 1

HillsideRebuild

Type III 24-hr 25-yr Rainfall=6.57"

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Time span=0.00-28.00 hrs, dt=0.01 hrs, 2801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment5S: PDA-1

Runoff Area=32,548 sf 0.00% Impervious Runoff Depth=0.89"
Flow Length=386' Tc=16.3 min CN=43 Runoff=0.36 cfs 0.056 af

Subcatchment6S: PDA-1.1

Runoff Area=20,086 sf 100.00% Impervious Runoff Depth=6.33"
Tc=6.0 min CN=98 Runoff=2.97 cfs 0.243 af

Pond 7P: Proposed Substation Yard Stone

Peak Elev=93.88' Storage=1,486 cf Inflow=2.97 cfs 0.243 af
Discarded=0.94 cfs 0.243 af Primary=0.00 cfs 0.000 af Outflow=0.94 cfs 0.243 af

Link 8L: Analysis Point 1

Inflow=0.36 cfs 0.056 af
Primary=0.36 cfs 0.056 af

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Type III 24-hr 25-yr Rainfall=6.57"

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Summary for Subcatchment 5S: PDA-1

Runoff = 0.36 cfs @ 12.33 hrs, Volume= 0.056 af, Depth= 0.89"

Routed to Link 8L : Analysis Point 1

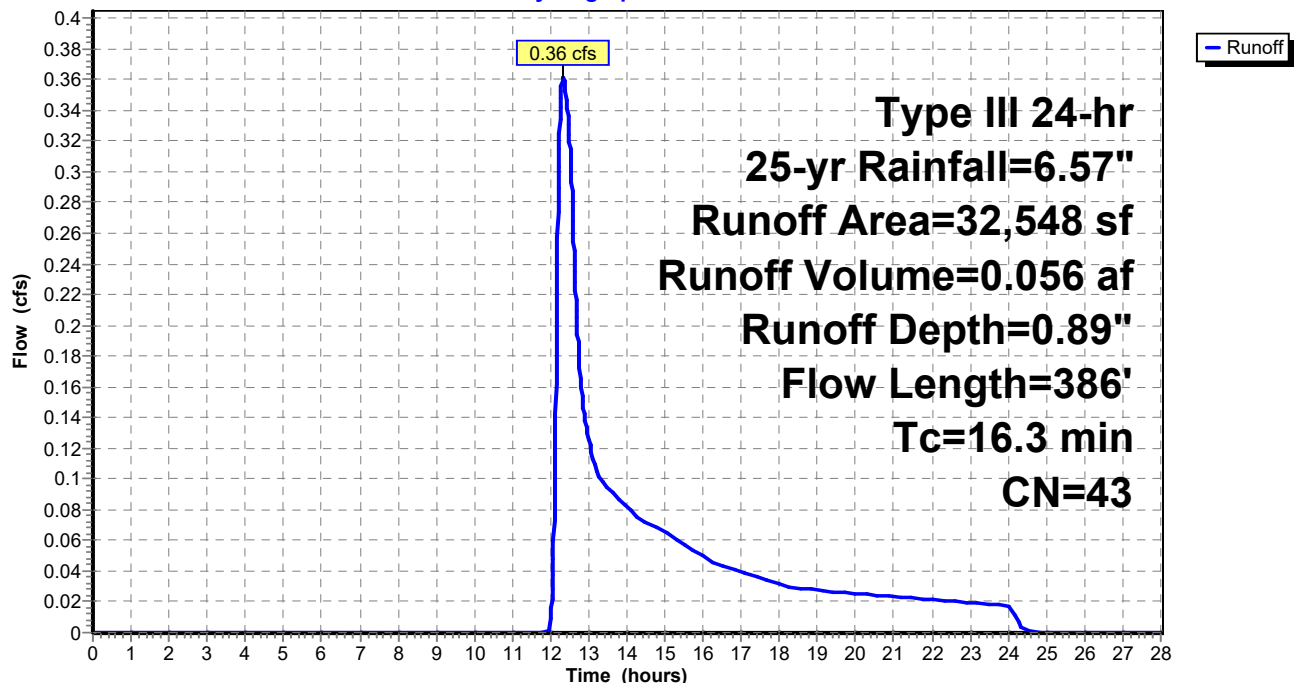
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.57"

Area (sf)	CN	Description
30,114	39	>75% Grass cover, Good, HSG A
2,434	96	Gravel surface, HSG A
32,548	43	Weighted Average
32,548		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	30	0.6250	0.54		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
3.4	42	0.0450	0.20		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
5.5	28	0.0063	0.09		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
6.5	286	0.0024	0.73		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
16.3	386	Total			

Subcatchment 5S: PDA-1

Hydrograph



HillsideRebuild

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Type III 24-hr 25-yr Rainfall=6.57"

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Summary for Subcatchment 6S: PDA-1.1

Runoff = 2.97 cfs @ 12.08 hrs, Volume= 0.243 af, Depth= 6.33"

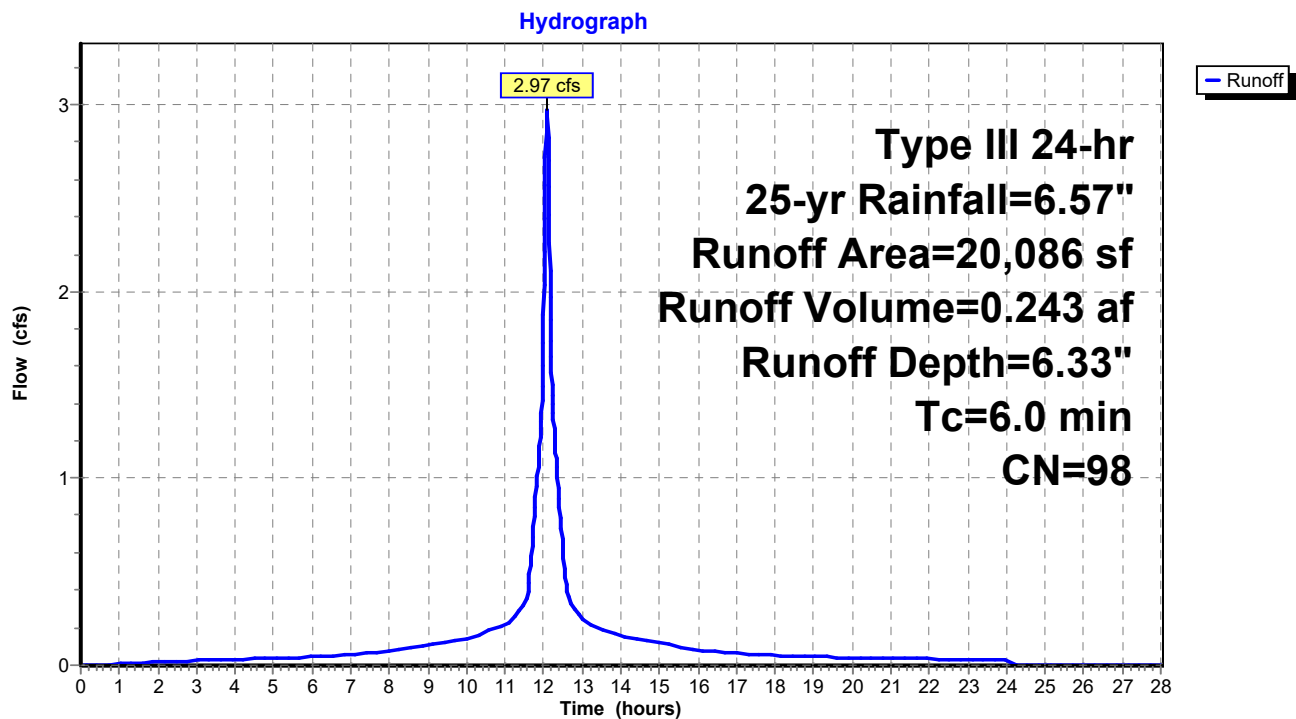
Routed to Pond 7P : Proposed Substation Yard Stone

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.57"

	Area (sf)	CN	Description
*	16,939	98	Substation Yard
*	1,050	98	Foundations
*	2,097	98	Roof
	20,086	98	Weighted Average
	20,086		100.00% Impervious Area

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

Subcatchment 6S: PDA-1.1



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Type III 24-hr 25-yr Rainfall=6.57"

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Summary for Pond 7P: Proposed Substation Yard Stone

Inflow Area = 0.461 ac, 100.00% Impervious, Inflow Depth = 6.33" for 25-yr event
 Inflow = 2.97 cfs @ 12.08 hrs, Volume= 0.243 af
 Outflow = 0.94 cfs @ 11.82 hrs, Volume= 0.243 af, Atten= 68%, Lag= 0.0 min
 Discarded = 0.94 cfs @ 11.82 hrs, Volume= 0.243 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Routed to Link 8L : Analysis Point 1

Routing by Stor-Ind method, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
 Peak Elev= 93.88' @ 12.38 hrs Surf.Area= 16,939 sf Storage= 1,486 cf

Plug-Flow detention time= 6.4 min calculated for 0.243 af (100% of inflow)
 Center-of-Mass det. time= 6.4 min (750.2 - 743.8)

Volume	Invert	Avail.Storage	Storage Description	
#1	93.30'	11,857 cf	Substation Yard (Prismatic) Listed below (Recalc)	
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
93.30	16,939	0.0	0	0
93.31	16,939	15.0	25	25
95.30	16,939	15.0	5,056	5,082
95.31	16,939	40.0	68	5,149
95.80	16,939	40.0	3,320	8,470
95.81	16,939	100.0	169	8,639
96.00	16,939	100.0	3,218	11,857

Device	Routing	Invert	Outlet Devices
#1	Discarded	93.30'	2.410 in/hr Exfiltration over Surface area
#2	Primary	95.80'	Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
			Head (feet) 0.00 0.20
			Width (feet) 574.00 574.00

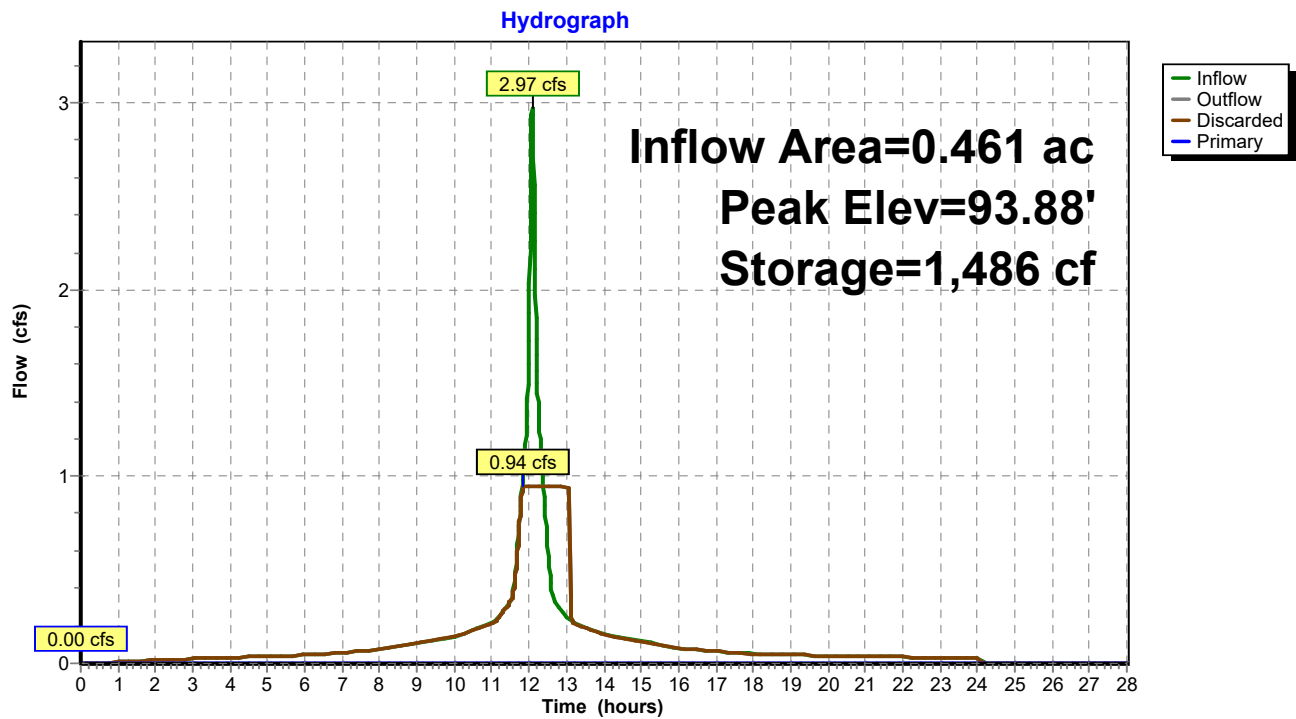
Discarded OutFlow Max=0.94 cfs @ 11.82 hrs HW=93.31' (Free Discharge)

↑**1=Exfiltration** (Exfiltration Controls 0.94 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=93.30' (Free Discharge)

↑**2=Custom Weir/Orifice** (Controls 0.00 cfs)

Pond 7P: Proposed Substation Yard Stone

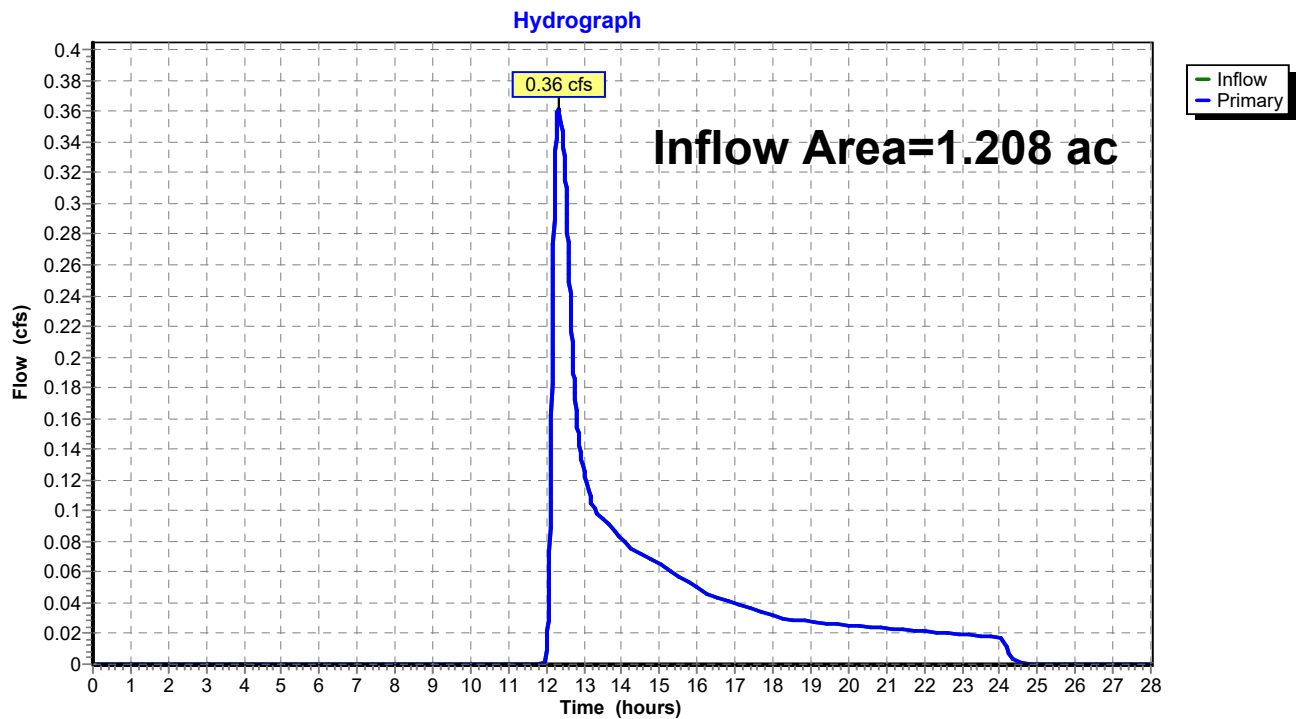


Summary for Link 8L: Analysis Point 1

Inflow Area = 1.208 ac, 38.16% Impervious, Inflow Depth = 0.55" for 25-yr event
 Inflow = 0.36 cfs @ 12.33 hrs, Volume= 0.056 af
 Primary = 0.36 cfs @ 12.33 hrs, Volume= 0.056 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs

Link 8L: Analysis Point 1



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Type III 24-hr 100-yr Rainfall=8.46"

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Time span=0.00-28.00 hrs, dt=0.01 hrs, 2801 points

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment5S: PDA-1

Runoff Area=32,548 sf 0.00% Impervious Runoff Depth=1.77"
Flow Length=386' Tc=16.3 min CN=43 Runoff=0.93 cfs 0.110 af

Subcatchment6S: PDA-1.1

Runoff Area=20,086 sf 100.00% Impervious Runoff Depth=8.22"
Tc=6.0 min CN=98 Runoff=3.83 cfs 0.316 af

Pond 7P: Proposed Substation Yard Stone

Peak Elev=94.30' Storage=2,544 cf Inflow=3.83 cfs 0.316 af
Discarded=0.94 cfs 0.316 af Primary=0.00 cfs 0.000 af Outflow=0.94 cfs 0.316 af

Link 8L: Analysis Point 1

Inflow=0.93 cfs 0.110 af
Primary=0.93 cfs 0.110 af

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Type III 24-hr 100-yr Rainfall=8.46"

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Summary for Subcatchment 5S: PDA-1

Runoff = 0.93 cfs @ 12.26 hrs, Volume= 0.110 af, Depth= 1.77"

Routed to Link 8L : Analysis Point 1

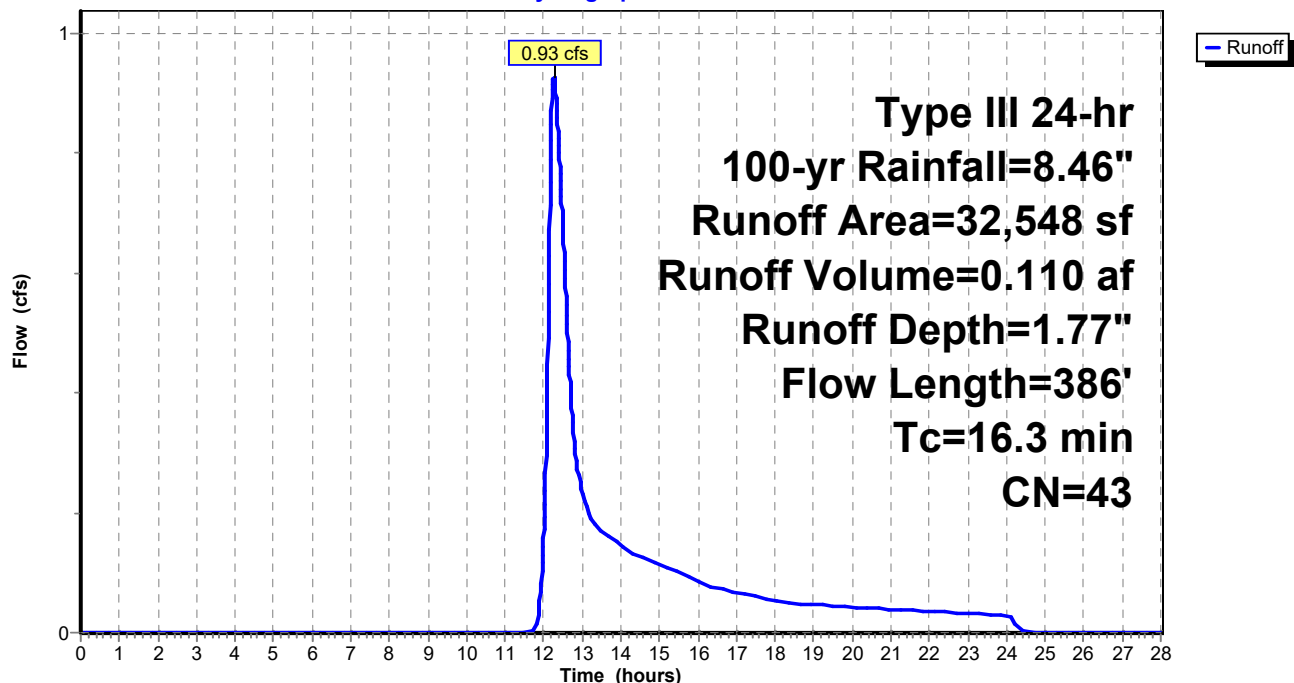
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.46"

Area (sf)	CN	Description
30,114	39	>75% Grass cover, Good, HSG A
2,434	96	Gravel surface, HSG A
32,548	43	Weighted Average
32,548		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	30	0.6250	0.54		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
3.4	42	0.0450	0.20		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
5.5	28	0.0063	0.09		Sheet Flow, Grass: Short n= 0.150 P2= 3.38"
6.5	286	0.0024	0.73		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
16.3	386	Total			

Subcatchment 5S: PDA-1

Hydrograph



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Type III 24-hr 100-yr Rainfall=8.46"

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Summary for Subcatchment 6S: PDA-1.1

Runoff = 3.83 cfs @ 12.08 hrs, Volume= 0.316 af, Depth= 8.22"

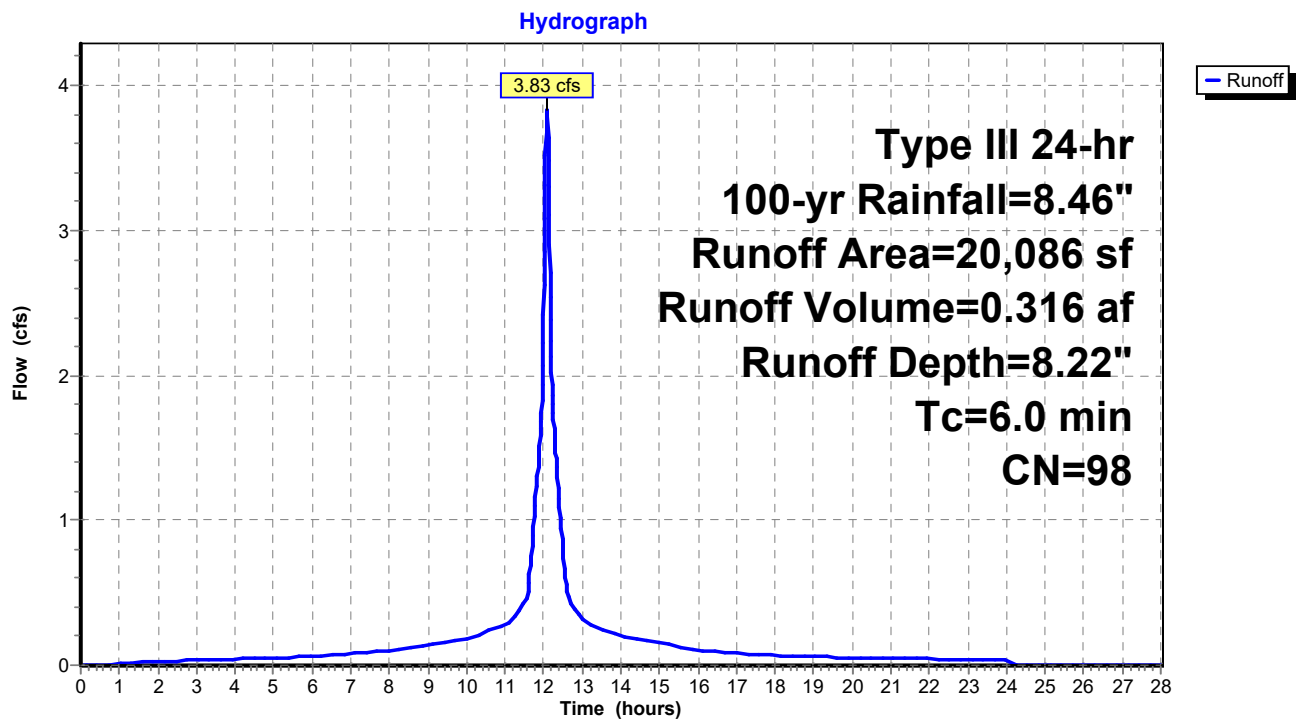
Routed to Pond 7P : Proposed Substation Yard Stone

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.46"

	Area (sf)	CN	Description
*	16,939	98	Substation Yard
*	1,050	98	Foundations
*	2,097	98	Roof
	20,086	98	Weighted Average
	20,086		100.00% Impervious Area

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

Subcatchment 6S: PDA-1.1



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Type III 24-hr 100-yr Rainfall=8.46"

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Summary for Pond 7P: Proposed Substation Yard Stone

Inflow Area = 0.461 ac, 100.00% Impervious, Inflow Depth = 8.22" for 100-yr event
 Inflow = 3.83 cfs @ 12.08 hrs, Volume= 0.316 af
 Outflow = 0.94 cfs @ 11.74 hrs, Volume= 0.316 af, Atten= 75%, Lag= 0.0 min
 Discarded = 0.94 cfs @ 11.74 hrs, Volume= 0.316 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Routed to Link 8L : Analysis Point 1

Routing by Stor-Ind method, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs
 Peak Elev= 94.30' @ 12.45 hrs Surf.Area= 16,939 sf Storage= 2,544 cf

Plug-Flow detention time= 11.8 min calculated for 0.316 af (100% of inflow)
 Center-of-Mass det. time= 11.8 min (752.4 - 740.5)

Volume	Invert	Avail.Storage	Storage Description	
#1	93.30'	11,857 cf	Substation Yard (Prismatic) Listed below (Recalc)	
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
93.30	16,939	0.0	0	0
93.31	16,939	15.0	25	25
95.30	16,939	15.0	5,056	5,082
95.31	16,939	40.0	68	5,149
95.80	16,939	40.0	3,320	8,470
95.81	16,939	100.0	169	8,639
96.00	16,939	100.0	3,218	11,857

Device	Routing	Invert	Outlet Devices
#1	Discarded	93.30'	2.410 in/hr Exfiltration over Surface area
#2	Primary	95.80'	Custom Weir/Orifice, Cv= 2.62 (C= 3.28)
			Head (feet) 0.00 0.20
			Width (feet) 574.00 574.00

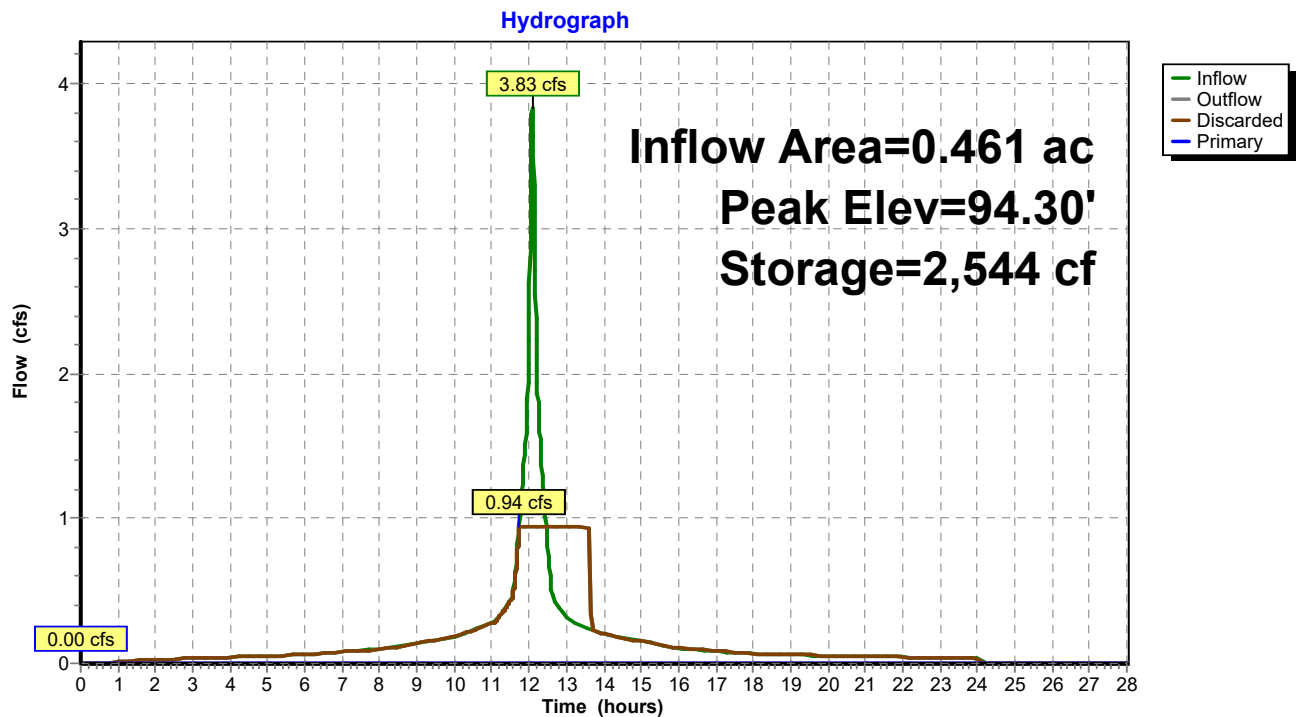
Discarded OutFlow Max=0.94 cfs @ 11.74 hrs HW=93.31' (Free Discharge)

↑ **1=Exfiltration** (Exfiltration Controls 0.94 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=93.30' (Free Discharge)

↑ **2=Custom Weir/Orifice** (Controls 0.00 cfs)

Pond 7P: Proposed Substation Yard Stone

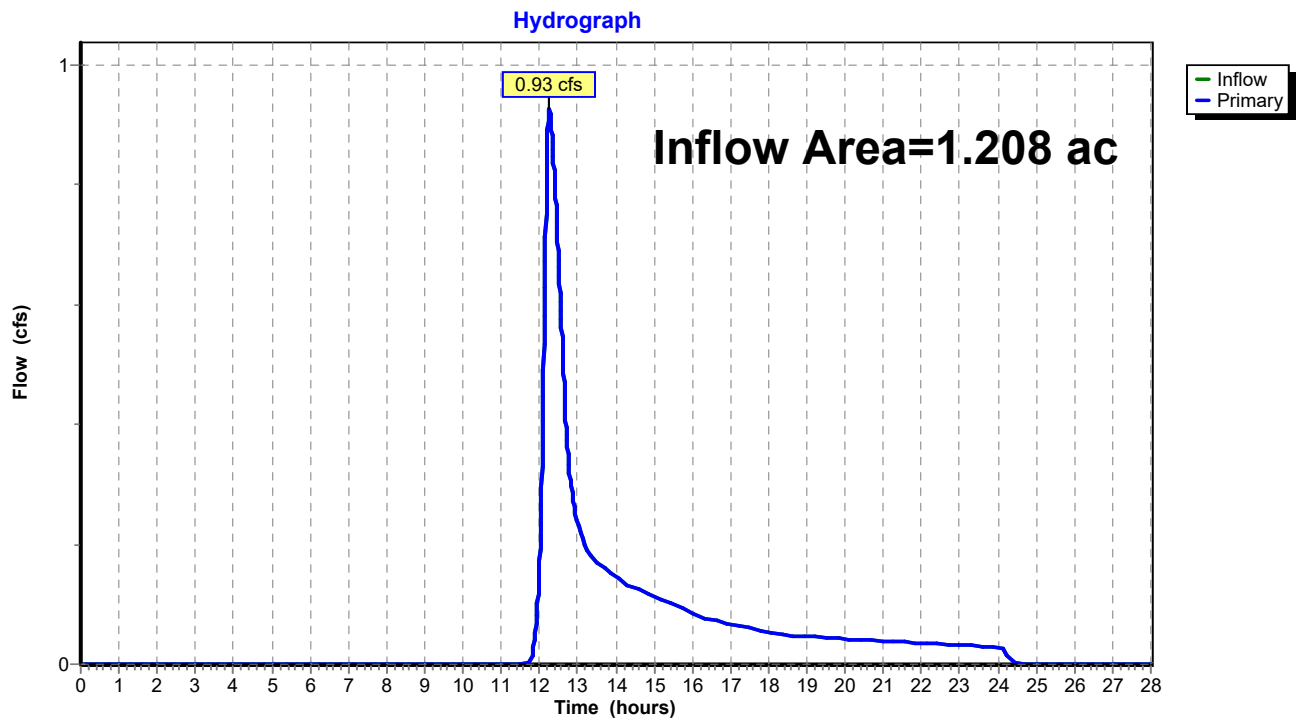


Summary for Link 8L: Analysis Point 1

Inflow Area = 1.208 ac, 38.16% Impervious, Inflow Depth = 1.09" for 100-yr event
 Inflow = 0.93 cfs @ 12.26 hrs, Volume= 0.110 af
 Primary = 0.93 cfs @ 12.26 hrs, Volume= 0.110 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-28.00 hrs, dt= 0.01 hrs

Link 8L: Analysis Point 1



APPENDIX F – EROSION AND SEDIMENT CONTROL PLAN AND DETAILS

- | | |
|---|-------------------------------------|
| <p><u>REFERENCE DRAWINGS:</u></p> <p>23/13.2KV BUS STRUCTURE ULTIMATE ARRANGEMENT
 LEIDOS ENGINEERING - CONDUIT GET-A-WAYS
 LAYOUT FOR HILLSIDE SUBSTATION SCREENING
 FOUNDATION PLAN</p> | <p>H-111325
 SK-201</p> |
|---|-------------------------------------|

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MASSACHUSETTS ELECTRIC COMPANY
HILLSIDE AVE. SUBSTATION NO.66
AMESBURY, MASSACHUSETTS

CIVIL-SITE PLANS
EROSION CONTROL PLAN

SCALE: 1"=20'

UNCONTROLLED
EXPOSURE

MA-9.6-H3 H-111358-A

APPENDIX G – OPERATION AND MAINTENANCE PLAN

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APPENDIX A – RECORDING KEEPING LOGS

1.0 General Overview

Burns & McDonnell has prepared this Operation and Maintenance (“O&M”) Plan on behalf of National Grid for the post-construction stormwater management system located at the Hillside 66 Station Rebuild in the City of Amesbury, Essex County, Massachusetts. The O&M Plan is in accordance with the Massachusetts Stormwater Handbook and will be implemented upon completion of construction as outlined below. Any required post construction stormwater management permits will be obtained and implemented by National Grid. Operation and maintenance procedures made part of this plan shall be in addition to any operation and maintenance procedures already in place at the facility.

1.1 Purpose and Goals

The purpose of this O&M Plan is to provide guidance for the implementation and documentation process of the facilities stormwater management system associated with the Hillside 66 Station to help conform with the corresponding regulatory agency approvals and permits. The guidance provided herein is the minimum required. The primary goal is to inform all the property managers of how the system operates and what maintenance items are necessary. The secondary goal is to provide a practical, efficient means of maintenance planning and record keeping to verify permit compliance.

1.2 Responsible Parties

National Grid is the owner of the stormwater system and will be responsible for implementing the O&M Plan.

Name: _____

Address: _____

Phone #: _____

Email: _____

1.3 Maintenance Logs and Checklists

Nation Grid will keep a record of all maintenance procedures performed, date of inspections, cleanings, etc. Copies of inspection reports and maintenance records shall be kept on-site.

1.4 Forms and Record Keeping

Inspection and maintenance procedures shall be logged and recorded. Copies of the logs shall be kept on site. The following forms are included herein for reference.

- Inspection and Maintenance Log for Vegetated Swales and Dry Well.

2.0 Training

Responsible operators, maintenance workers, and contractors will be trained with a basic description of the purpose and function of the on-site stormwater management system as well as safety protocols and procedures, with annual updates, to ensure that the workers tasked with maintaining the site do so in accordance with the approved permit conditions. All workers with maintenance duties will be adequately informed of their responsibilities. All sub-contractors will be informed of any special requirements or responsibilities.

3.0 Stormwater Management System

The on-site stormwater management system has several components that perform various functions in conveying and treating stormwater runoff. Refer to the Site Plans for locations and details for each of the stormwater system components. Regular operation and maintenance is critical to the long term success of the stormwater management system. The stormwater system components are:

- Vegetated Swales
- Dry Well

3.1 Vegetated Swales

Vegetated swales are vegetated open channels that are designed to provide stormwater conveyance with limited erosion. Within the first few months after construction inspect the swales regularly to ensure that the vegetation is adequate and there are no signs of gullying. After the first few months these inspections should occur twice a year. Conditions to take into consideration during inspection include slope integrity, soil moisture, vegetative health, soil stability, soil compaction, soil erosion, ponding, and sediment accumulation. If discovered, repair any gullies and replace any dead vegetation. Additional maintenance includes mowing at least once per year, removing sediment and debris manually at least once per year, and re-seeding periodically to maintain dense growth. Grass height should remain under six inches but be no lower than three to four inches.

3.2 Dry Well

Dry wells are a small, excavated pit backfilled with aggregate that are designed to collect and infiltrate stormwater. Dry wells are not designed to collect runoff from areas with high potential pollutant loads. When used for runoff other than that of residential rooftops clogging is possible and may cause failure. The dry well should be inspected after every major storm event (a storm that is equal to or greater than the 2-year, 24-hour storm) within the first few months after construction to ensure proper function. Afterwards, the dry well should be inspected annually. During inspection, the water depth should be noted at 24- and 48-hour intervals after the storm. Then the clearance rate of the dry well should be calculated by dividing the drop in water level (inches) by the time elapsed (hr). Any ponding 72-hours after a storm event should be noted and addressed.

3.3 Disposal

All sediment, debris, trash, etc. removed from the stormwater management system during operations and maintenance shall be disposed of properly and legally by a Massachusetts Licensed hauler.

4.0 Long-Term Pollution Prevention Plan

National Grid will employ good housekeeping measures to prevent pollution from the site. Specifically, National Grid shall:

- Perform routine inspections and maintenance duties per the Operations and Maintenance Plan;
- Repair, replace, or restore any damaged, deteriorated, or eroded components of the stormwater management system;
- Ensure that no illicit connections to the stormwater management system occur;
- Prohibit the excessive use of chemicals on the site above the manufacturer's recommendations;
- Prohibit the storage of oil and chemicals outside of appropriate containers specifically designed for the storage of said materials;
- National Grid maintenance staff will be trained to inspect and maintain the stormwater system.

APPENDIX A – RECORDING KEEPING LOGS

INSPECTION AND MAINTENANCE LOG

DATE OF INSPECTION: _____

PERSON PERFORMING INSPECTION: _____

VEGETATED SWALE:

Within the first few months after construction inspect the swales regularly to ensure that the vegetation is adequate and there are no signs of gullyng. After the first few months these inspections should occur twice a year.

☐ FIRST INSPECTION OF YEAR

☐ SECOND INSPECTION OF YEAR

DEPTH OF SEDIMENT	IS THE REMOVAL OF SED/DEBRIS REQUIRED?	IS MOWING REQUIRED?	DOES SWALE REQUIRE REPAIR?	IS RESEEDING REQUIRED?	METHOD OF CLEANING
	☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☐ NO	

ADDITIONAL NOTES:

INSPECTION AND MAINTENANCE LOG

DATE OF INSPECTION: _____

PERSON PERFORMING INSPECTION: _____

DRY WELL:

The dry well should be inspected after every major storm event (a storm that is equal to or greater than the 2-year, 24-hour storm) within the first few months after construction to ensure proper function. Afterwards, the dry well should be inspected annually.

☐ YEAR OF INSPECTION: _____

☐ INSPECTION AFTER MAJOR STORM EVENT

TIME FROM STORM EVENT	24-HOURS	48-HOURS	72-HOURS	CLEARANCE RATE	WAS PONDING NOTED AFTER 72-HOURS?
WATER LEVEL					☐ YES ☐ NO

ADDITIONAL NOTES:

