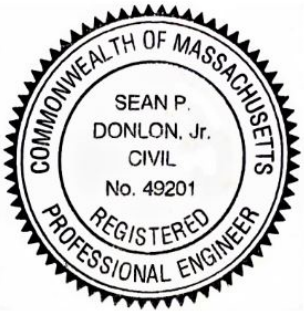
Stormwater Management Report

12 Farnsworth Street Repositioning

12 Farnsworth Street
Boston, MA 02210
16 February 2020

SGH Project 210659



Sean P Donlon Jr.

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DN: CN=Sean P Donlon Jr., OU=A01410D0000017668713086000066D, O=SIMPSON GUMPERTZ AND HEGER, C=US
Reason: I am the author of this document
Date: 2022.02.15 15:00:56-05'00'

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Table of Contents

Contents

Page

1. INTRODUCTION 1

2. OBJECTIVE 2

3. BACKGROUND 3

4. REVIEW OF DOCUMENTS 4

5. EXISTING SITE CONDITIONS 5

6. PROPOSED SITE CONDITIONS 7

7. ANALYSIS 10
   - 7.1 Method of Calculation 10
   - 7.2 Sources of Data 10
   - 7.3 Rainfall Depths 10
   - 7.4 Ground Cover 11
   - 7.5 Soil Conditions 11
   - 7.6 Recharge Volume Calculations 12
   - 7.7 Existing Site Conditions Runoff Calculations 13
   - 7.8 Proposed Site Conditions Runoff Calculations 14
   - 7.9 Water Quality Volume 14

8. MASSDEP STORMWATER MANAGEMENT STANDARDS 16
   - 8.1 Standard #1 – No New Untreated Discharges 16
   - 8.2 Standard #2 – Peak Rate Attenuation 16
   - 8.3 Standard #3 – Recharge 17
   - 8.4 Standard #4 – Water Quality 17
   - 8.5 Standard #5 – Land Uses with Higher Potential Pollutant Loads (LUHPPLs) 17
   - 8.6 Standard #6 – Stormwater Discharges within Zone II or Interim Wellhead Protection Area and Stormwater Discharges Near/to Critical Areas 17
   - 8.7 Standard #7 – Redevelopment 17
   - 8.8 Standard #8 – Stormwater Pollution Prevention and Erosion and Sedimentation Control 17
   - 8.9 Standard #9 – Operation and Maintenance Plan and Long-Term Pollution Prevention Plan 18
   - 8.10 Standard #10 – Prohibition of ILLICIT Discharges 18

FIGURES

Figure 1 – USGS Site Location Map
Figure 2 – Hydrologic Soil Group Plan
Figure 3 – Pre Development Catchment Areas Plan
Figure 4 – Post Development Catchment Areas Plan

APPENDICES

Appendix A Checklist for Stormwater Report
Appendix B Geotechnical Report / NRCS Data/ USGS Surficial Geology Map
Appendix C Northeast Regional Climate Center Extreme Precipitation Table
Appendix D HydroCAD Input/Output Data
Appendix E Recharge Calculations
Appendix F Operation and Maintenance Plan & Long-Term Pollution Prevention Plan

1. INTRODUCTION

Simpson Gumpertz & Heger Inc. (SGH) prepared this Stormwater Management Report on behalf of Phase 3 Real Estate Partners (P3RE) for its proposed building renovation (Project) located at 12 Farnsworth Street, Boston, Massachusetts (Site) and the related proposed exterior utility upgrades at the adjacent parcel, 11 Sleeper Street, Boston, Massachusetts. This report summarizes the proposed stormwater management plan and relevant analyses for the Project. Refer to the drawing set (attached under separate cover) titled "12 Farnsworth Street/11 Sleeper Street Notice of Intent Drawings," prepared by SGH and dated 16 February 2022 for the proposed scope of improvements.

2. OBJECTIVE

The objective of the proposed stormwater management improvements is to provide long-term protection of natural resources downstream of the Site from degradation as a result of stormwater discharges from the Site and to comply with the Massachusetts Stormwater Standards. The following sections describe the specific improvements to be implemented at the Site.

3. BACKGROUND

The existing building at 12 Farnsworth Street in South Boston is six stories and is currently being utilized as office space. The building encompasses much of the parcel, and the remaining parcel area consists of a concrete patio adjacent to Farnsworth Street. A private alleyway (Westerly Passageway) runs along the northwestern side of the property line. The Westerly Passageway is currently used for pedestrian access to the neighboring parcels and contains subsurface utilities that serve the building. The westerly passageway contains a narrow gravel curbed area that houses certain mechanical equipment that serve the building, as well as the loading and receiving dock. The building is currently served by a transformer that is located on 11 Sleeper Street, the adjacent property to the north of the site, and the westerly passageway.

The Project includes interior renovations to convert the all-office space to a mixed-use research and development and office space. In addition, the Project requires several utility upgrades to support the change of use, including new domestic water, fire protection water, sanitary sewer, storm drain, gas, and electric services. The Project also includes an upgraded transformer and concrete pad on the 11 Sleeper Street lot. Trenching within Farnsworth Street, the adjacent private alleyway, and the westerly passageway is required to construct the new services.

The Boston Water and Sewer Commission (BWSC) and Groundwater Conservation Overlay District (GCOD) require the first inch of Runoff from the 12 Farnsworth building area is captured and infiltrated within 72 hours. To fulfill this requirement, the Project includes a sub-surface recharge system within the building, below the existing building slab.

The site, including the 11 Sleeper Street parcel, is mapped within the 100-year floodplain, a regulated wetland resource, and is therefore under the jurisdiction of the City of Boston Conservation Commission. The Project does not include drainage improvements or additional scope of work outside of the project site and 11 Sleeper Street. The scope of this Stormwater Management Report is limited to drainage improvements within the proposed limits of construction for the Project as indicated on the NOI Drawings.

4. REVIEW OF DOCUMENTS

We reviewed the following record documents.

- Plan titled "ALTA/ACSM Land Title Survey, #22 Boston Wharf Road, #12, #17 & #29 Farnsworth Street & #11 Sleeper Street, Boston, Mass" prepared by Feldman Land Surveyors and dated 25 August 2015.
- Plan titled "Existing Conditions Plan, 11 Sleeper Steet, 12 Farnsworth Street, Boston, (South Boston) Mass" prepared by Feldman Geospatial and dated 17 October 2021.
- Plans titled "As-Built Plan (Z123-25 and Z123-26)" prepared by the Boston Water and Sewer Commission and dated 02 February 2010.
- Geotechnical report titled "Geotechnical Design Recommendations, Soil Quality Data for Disposal, and Construction Considerations, Proposed 12 Farnsworth Street Renovation, Boston, Massachusetts" prepared by Haley & Aldrich, Inc. and dated 18 January 2022.

5. EXISTING SITE CONDITIONS

We base our current understanding of the existing (current) site conditions on visual field observations, topography from a formal field survey, and review of available record drawings.

We delineated the existing site into three (3) watershed subcatchment areas designated as "Existing Watershed Area – 12 Farns" (EWA-12F), "Existing Watershed Area – 11 Sleeper" (EWA-11S), and "Existing Watershed Area – Westerly Passageway" (EWA-WP), as indicated on Figure 3. The existing subcatchments discharge to Design Point 1 (DP-1), an existing 18 in. PVC BWSC storm drain in Farnsworth Street, as indicated on Figure 3, and eventually discharge to the Fort Point Channel through the BWSC drainage infrastructure within Congress Street.

EWA-12F encompasses the entire 12 Farnsworth Street parcel. EWA-12F consists of impervious roof area, an impervious concrete patio area, and impervious brick sidewalk area. The Site is relatively flat around the building. Runoff from the roof area is conveyed via internal roof drains and other plumbing appurtenances and discharges directly to the existing 18 in. PVC main in Farnsworth Street via an existing storm drain service lateral. The remaining concrete patio and sidewalk area Runoff is conveyed via surface flow to Farnsworth Street, where it enters the storm drain system via existing BWSC catch basins.

EWA-11S consists of the northeastern portion of the 11 Sleeper Street parcel, where the existing transformer and appurtenances are located. This area consists of an impervious concrete transformer pad and a pervious mulched area. Runoff from EWA-11S is conveyed via surface flow from the Westerly Passageway to an existing catch basin located within the adjacent unnamed alleyway. Runoff is then conveyed through the BWSC storm drainage system.

EWA-WP consists of the partial area between EWA-12F and EWA-11S, located within the Westerly Passageway between both the 11 Sleeper and 12 Farnsworth parcels. EWA-WP

includes a curbed area directly adjacent to the building and generally consists of gravel, loose dirt, and existing mechanical equipment servicing the building. Runoff is conveyed via surface flow from the Westerly Passageway to an existing catch basin located with the adjacent unnamed alleyway. Runoff is then conveyed through the BWSC storm drainage system.

6. PROPOSED SITE CONDITIONS

The project includes interior renovations to convert the existing office use to a mixed-use facility and the accompanying exterior utility work required to support the proposed use. Existing subsurface utilities within Farnsworth Street and the Westerly Passageway will be cut and capped, and new utilities (e.g., gas, electric, storm drain, sewer, domestic/fire protection water) will be constructed to service the building. The Project includes trenching and the replacement of all surface materials in kind to install the proposed utilities.

BWSC and GCOD require a recharge system, which we are proposing to be constructed below the slab of the project site. The system is sized to store and infiltrate the first inch of rainfall over the building area within 72 hours per BWSC requirements and will overflow to the existing main in Farnsworth Street via a new service lateral for flows exceeding the required volume. A larger 8 ft by 8 ft concrete transformer pad will replace the existing 7-1/2 ft by 6-1/2 ft pad on the 11 Sleeper Street parcel.

The Boston Historical Commission requested new granite pavers surrounding the proposed transformer pad within the existing mulched area. A portion of the existing curbed area within the Westerly Passageway will also be modified to remove existing mechanical equipment and replace the surface material with granite pavers to match the area surrounding the transformer by request of the historical commission. The existing asphalt in the Westerly Passageway and adjacent parking spaces will be repaired as necessary after construction. The proposed granite pavers surrounding the transformer will extend approximately 2 ft into the existing parking area. Proposed pavers will be permeable with a reservoir course capable of storing and recharging the first inch of rainfall.

Other proposed stormwater management improvements for the Project include the groundwater recharge system, which will store and infiltrate the required recharge volume generated from approximately 10,700 sq ft of impervious roof area. The remaining site area will

continue to utilize the existing drainage patterns and infrastructure consisting of catch basins and subsurface piping. No additional impervious area will be added associated with the Project.

The proposed site consists of four (4) subcatchments designated as “Proposed Watershed Area – 12 Farns Roof” (PWA-12FR), “Proposed Watershed Area – 12 Farns Patio” (PWA-12FP), “Proposed Watershed Area – 11 Sleeper (PWA-11S), and “Proposed Watershed Area – Westerly Passageway” (PWA-WP), as indicated on Figure 4. All four proposed subcatchments ultimately discharge to Design Point 1 (DP-1), the existing 18 in. PVC storm drain in Farnsworth Street, as indicated on Figure 4, and eventually downstream to the Fort Point Channel.

PWA-12FR contains most of the site area and consists of the entire roof area of the 12 Farnsworth Street parcel. The roof area is conveyed via internal plumbing to the proposed recharge system, which is sized to store the first inch of rainfall over the roof area and infiltrate the volume within 72 hours. Flows in excess of the capacity of the recharge system will be conveyed to the storm drain main in Farnsworth Street via a proposed 10” storm drain service lateral.

PWA-12FP contains the existing concrete patio and sidewalk area adjacent to Farnsworth Street. No additional impervious area for this subcatchment is proposed; all surface materials removed during trenching operations will be replaced in kind. Runoff is conveyed via surface flow to the exiting BWSC storm drain infrastructure in Farnsworth Street.

PWA-11S contains the proposed transformer pad and granite paver system. Some existing paving and mulch areas are being replaced with pervious pavers, as requested by the historical commission, to facilitate the required utility construction within this subcatchment. Runoff from PWA-11S is conveyed via surface flow to the existing BWSC storm drain infrastructure.

PWA-WP contains the curbed area in the Westerly Passageway that is being modified to remove existing mechanical equipment. The existing gravel and dirt surface will be replaced with permeable pavers. Runoff from PWA-WP is conveyed via surface flow to an existing catch basin in the alleyway and into the existing BWSC storm drain piping infrastructure.

7. ANALYSIS

7.1 Method of Calculation

We utilized the Soil Conservation Service (SCS) Technical Release No. 20 (SCS Unit Hydrograph runoff procedure), SCS Technical Release No. 55 (Runoff Curve Numbers and calculating Time of Concentration), and rainfall data obtained from the Northeast Regional Climate Center to perform the hydrologic analysis for the site. The hydrologic model was created and calculated with HydroCAD, Version 10.0 software, developed by Applied Microcomputer Systems. We used synthetic Type III 24-hr storm for the calculations. The reach routing calculations were modeled using the Storage-Indication plus Translation Method, and the pond routing calculations were modeled using the Storage-Indication Method as applicable.

7.2 Sources of Data

- SCS Technical Release No. 20 (TR-20).
- SCS Technical Release No. 55 (TR-55).
- Northeast Regional Climate Center (NRCC); Extreme Precipitation in Massachusetts. (Appendix C).
- United States Geological Survey (USGS) Surficial Geology Maps. (Appendix B)
- Natural Resources Conservation Service (NRCS) Soil Survey of Suffolk County, Massachusetts. (Appendix B).
- January 2022 Site Specific Geotechnical Report (Performed by Haley & Aldrich). (Appendix B).

7.3 Rainfall Depths

In accordance with the DEP Stormwater Management Guidelines, we analyzed the 2, 10, 25, and 100-Year storm events. The following are the rainfall depths used for each storm event.

Table 1 - Rainfall Depths

Storm Event	24 Hour Rainfall
2-Year	3.26 in.
10-Year	4.90 in.
25-Year	6.19 in.
100-Year	8.81 in.

7.4 Ground Cover

The overall hydrologic study area for the proposed redevelopment is 21,500 square feet (0.49 acres). Table 2 below summarizes the ground cover distribution for the hydrologic study area for existing and proposed conditions.

Table 2 - Ground Cover Distribution - Hydrologic Area

Area	CN	Existing (sf)	Proposed (sf)
Hydrologic Soils Group B			
Concrete/Isolated Impervious	98	1,505	1,505
Gravel	96	202	73
Mulch	79	260	57
Roof	98	10,700	10,700
Permeable Paver	68[1]	0	358
Westerly Passageway Asphalt[2]	98	26	0
Total		**12,693**	**12,693**

7.5 Soil Conditions

Based on USGS publication "Surficial Materials Map of the Boston South Quadrangle, Massachusetts," compiled by Byron D. Stone and Mary L. DiGiacomo-Cohen, and dated 2018, the surficial soils at the Site are likely artificial fill deposits typically used in urban-development area. The artificial fill deposits are likely underlain by glacial deposits of coarse glaciofluvial and glaciodeltaic sediments that are graded to the glaciomarine sea level. Refer to Appendix B for more information.

[1] A composite curve number for the permeable pavers was calculated based on an assumed 12 in. stone base reservoir course with 40% voids.
[2] The proposed paver system extends into the existing parking area approximately 2 feet. Refer to the NOI drawings.

The subsurface soil investigation performed by Haley and Aldrich consisted of one soil boring and one test pit. The soil boring indicated marine deposits overlain with organic deposits overlain with fill. The fill soils generally consisted of very loose to loose silty sand with gravel and trace bricks and very soft organic soil and lean clay. The soil boring indicated that the fill layer is approximately 19 ft thick, underlain by 20 ft of organic deposits, which are underlain by marine deposits. Haley and Aldrich classified the existing fill materials on site as NRCS Hydrologic Soil Group (HSG) B for design purposes. Groundwater was found approximately 7.2 ft below the ground surface (El. 6.8 Boston City Base Datum [BCB]).

The site is predominantly covered by a mix of paved areas, gravel surfaces, mulched areas, and roof area and as described above has varying HSG designations based on the USDA National Cooperative Soil Survey. We assigned the following Natural Resources Conservation Service (NRCS) Curve Numbers (CN) for the different ground covers as follows:

- Impervious (i.e., pavement, concrete, & roofs):
  CN=98
- Mulch over HSG B Soil:
  CN=79
- Gravel Surface CN=96
- Permeable Granite Pavers: CN=68

7.6 Recharge Volume Calculations

The required recharge volume represents a depth of runoff equivalent to 1.0 in. of rainfall over the roof area in accordance with Article 32 of the Boston Zoning Code. The required recharge volume is calculated using Equation 1 below. Impervious area coverage, corresponding cover type, and corresponding target depth factors for each HSG for the post-development site are reported in Table 3.

Equation 1: Recharge Volume

$$R_v = F\ x\ impervious\ area$$

$$where,$$
$$R_v = Required\ Recharge\ Volume\ [cubic\ feet]$$
$$F\ = Target\ Depth\ Factor\ with\ each\ HS\text{G}$$

Table 3 - Required Recharge Volume[3]

Impervious Area & Corresponding Cover Type			
NRCS Hydrologic Soil Type	**Total Proposed Impervious Area over Soil Type (SF)**	**Target Factor (F) (in)**	**Required Recharge Volume (cf)**
Roof Area	10,700	1.0	892
Total Required Recharge Volume:			**892**

Haley and Aldrich performed a falling head is-situ permeability test within the test boring. Haley and Aldrich recommended an infiltration rate of 0.3 in./hour for design of the recharge system. See Appendix E for the Recharge System Storage Table and Recharge Calculations.

7.7 Existing Site Conditions Runoff Calculations

Figure 3 indicates the existing drainage sub-catchments and parameters we used in the analysis. We generated runoff hydrographs using SCS TR-20 and TR-55 methodology to determine the peak rate of discharge for existing conditions. See Appendix D for HydroCAD Input/Output Data. Table 4 below summarizes the existing peak rates of Runoff.

Table 4 - Existing Peak Runoff Rates

Peak Runoff (cubic feet per second)[4]				
Design Point	**2-Year Storm**	**10-Year Storm**	**25-Year Storm**	**100-Year Storm**
DP-1	0.95	1.44	1.82	2.60

[3] Refer to Appendix E for recharge calculations.

[4] The peak runoff rates only include flows generated from within the limit of work as shown on the NOI drawings. The provided runoff rates do not represent the total flow rate in the BWSC system generated from flows outside the limit of work.

7.8 Proposed Site Conditions Runoff Calculations

Figure 4 indicates the proposed drainage sub-catchments and parameters we used in the analysis. We generated runoff hydrographs using SCS TR-20 and TR-55 methodology to determine the peak rate of discharge for proposed conditions. See Appendix D for HydroCAD Input/Output Data. Table 5 below summarizes the proposed peak rates of Runoff.

Table 5 - Proposed Peak Runoff Rates

Peak Runoff (cubic feet per second)[3]				
Design Point	**2-Year Storm**	**10-Year Storm**	**25-Year Storm**	**100-Year Storm**
DP-1	0.91	1.40	1.79	2.56

7.9 Water Quality Volume

We calculated Water Quality Volume in accordance with the methodology described for Standard 4 in Chapter 1 of Volume 3 of the Massachusetts Stormwater Handbook, published in February 2008. The required water quality depth is 0.5 inches. We calculated the total water quality volume using Equation 2 and reported in Table 7 below using a water quality depth of 1.0 in. to be consistent with requirements of Article 32 of the Boston Zoning Code. The proposed runoff drainage patterns are consistent with the existing drainage patterns, and no added impervious area is proposed. The proposed permeable pavers do not require pretreatment because no impervious area is routed through the paver system.

Equation 2: Water Quality Treatment Volume

$$\boldsymbol{V_{WQ} = (D_{WQ}/inches/foot) * (A_{IMP} * 43,560\ square\ feet/acre)}$$

$where,$
$V_{WQ} = Required\ Water\ Quality\ Volume\ [cubic\ feet]$
$D_{WQ} = Water\ Quality\ Depth: 1\ inch$
$A_{IMP} = Impervious\ Area\ [acres]$

The proposed impervious area in PWA-11S and PWA-WP is routed into the permeable paver system, designed to capture and infiltrate the first inch of Runoff. The Runoff is treated via infiltration.

Table 6 - Ground Cover Distribution - Hydrologic Area to Permeable Paver

Area	Proposed (sf)
Permeable Pavers	358
Transformer Pad	64
Total	**422**

Table 7 - Water Quality Volume[5]

Water Quality Volume			
Area (sf)	Water Quality Runoff Depth (in.)	Water Quality Volume Required (cf)	Water Quality Volume Provided (cf)
422	**1.0**	**35**	**143**

[5] Refer to Appendix E.

8. MASSDEP STORMWATER MANAGEMENT STANDARDS

The ten standards contained in the DEP Stormwater Management policy relate to the protection of wetlands and water bodies, control of water quantity, recharge to groundwater, water quality and protection of critical areas, erosion/sedimentation control, and stormwater maintenance. The following summarizes the proposed Project's compliance with the Stormwater Management Standards.

8.1 Standard #1 – No New Untreated Discharges

The Project does not propose any new untreated discharges. The Project implements stormwater quality controls, including source controls, as part of the long-term pollution prevention plan, including groundwater recharge.

8.2 Standard #2 – Peak Rate Attenuation

Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development discharge rates.

We generated runoff hydrographs for 2, 10, 25, and 100-Year, 24-hour storm events using the SCS TR-20 Method and Type III rainfall distribution.

Table 11 below summarizes the pre- and post-development peak runoff discharge rates determined in the hydrologic/hydraulic analyses and show no increase in peak rates under proposed conditions.

Table 11 - Comparison of Peak Runoff Rates

Peak Runoff (cubic feet per second)												
Pre-Development Conditions vs. Proposed Conditions												
Design Point	2-Year Storm			10-Year Storm			25-Year Storm			100-Year Storm		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
DP-1	0.95	0.91	-0.04	1.44	1.40	-0.04	1.82	1.79	-0.03	2.60	2.56	-0.04

8.3 Standard #3 – Recharge

The sub-slab recharge system and exterior permeable pavers provide sufficient storage to accommodate the required recharge volume. This project complies with Standard #3.

8.4 Standard #4 – Water Quality

The proposed runoff drainage patterns are consistent with the existing drainage patterns on site. The proposed recharge system and the permeable pavers provide water quality treatment that improves the existing treatment of stormwater for the site.

8.5 Standard #5 – Land Uses with Higher Potential Pollutant Loads (LUHPPLs)

The site is not considered a land use with Higher Potential Pollutant Loads (LUHPPLs); therefore, the project complies with standard #5.

8.6 Standard #6 – Stormwater Discharges within Zone II or Interim Wellhead Protection Area and Stormwater Discharges Near/to Critical Areas

The proposed improvements are not located within a Zone II or an Interim Wellhead Protection Area.

8.7 Standard #7 – Redevelopment

Redevelopments include development, rehabilitation, expansion, and phased projects on previously developed sites, provided the redevelopment results in no net increase in impervious area and improves existing conditions. The proposed project does not increase overall impervious area and improves existing conditions. The project is considered a redevelopment project and complies with standard #7.

8.8 Standard #8 – Stormwater Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention Plan has not been included in the Stormwater Report but will be prepared by the Contractor and submitted before land disturbance begins. The NOI drawings (attached under separate cover) include provisions for erosion and sedimentation control that will be incorporated into the SWPPP.

The SWPPP will be prepared by the contractor describing the specific practices, installation methods, and inspection requirements for temporary and permanent erosion prevention and sediment control practices. The SWPPP will follow the template developed by the U.S. EPA. At a minimum, the SWPPP will include the following measures:

- Minimize the extent and time of exposed soils;
- Provide perimeter sediment control, including silt fence and/or compost filter tubes;
- Provide catch basin inlet protection, including geotextile filter fabric and gravel drop;
- Minimize sediment track out with stabilized construction exits;
- Control discharges from soil stockpiles include temporary erosion control measures and perimeter sediment controls;
- Minimize dust;
- Temporary stormwater management practices including basins, traps, and swales;
- Dewatering requirements;
- Temporary and permanent stabilization requirements, including seeding, mulching, and matting;
- Good housekeeping pollution prevention measures;
- Maintenance requirements; and
- Inspection, recordkeeping, and reporting requirements.

8.9 Standard #9 – Operation and Maintenance Plan and Long-Term Pollution Prevention Plan

Maintenance of the stormwater management system will be the responsibility of the Owner. A site-specific Operations and Maintenance Plan and Long-Term Pollution Prevention Plan is included in Appendix F.

8.10 Standard #10 – Prohibition of ILLICIT Discharges

To the best of the Owners and Engineer's knowledge, no illicit discharges exist at the Site.

Figures

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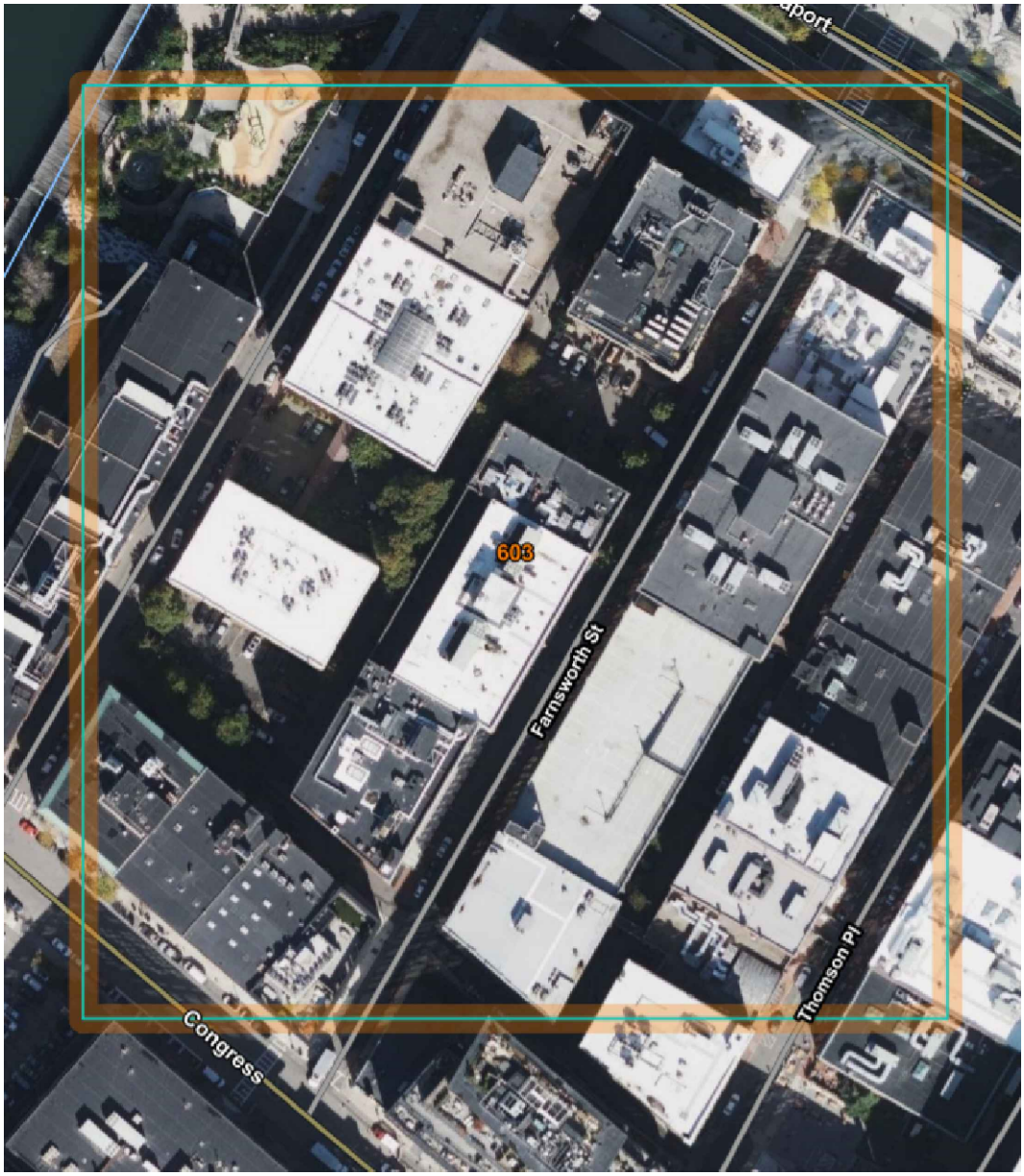
Project: 12 FARNSWORTH STREET, BOSTON, MA				Drawing No.: FIGURE 1
Title: USGS SITE LOCATION MAP				Scale: 1"=2,500'
Drawn: TK	Checked: EBT	Approved: SPD	Project No.: 210659.00	Date: 02/02/2022



Report — Hydrologic Soil Group and Surface Runoff

Absence of an entry indicates that the data were not estimated. The dash indicates no documented presence.

Norfolk and Suffolk Counties, Massachusetts

Map symbol and soil name	Pct. of map unit	Surface Runoff	Hydrologic Soil Group
603—Urban land, wet substratum, 0 to 3 percent slopes			
Urban land	85	—	—
Udorthents	13	—	—
Beaches	2	—	—

NOTE:

BASED ON THE UNITED STATES DEPARTMENT OF AGRICULTURE (USDA) WEBSITE, THE SOIL IN THIS AREA IS IDENTIFIED AS URBAN LAND. WE COULD NOT OBTAIN HYDROLOGIC SOIL GROUP DATA FOR THE SOIL IN THIS AREA.

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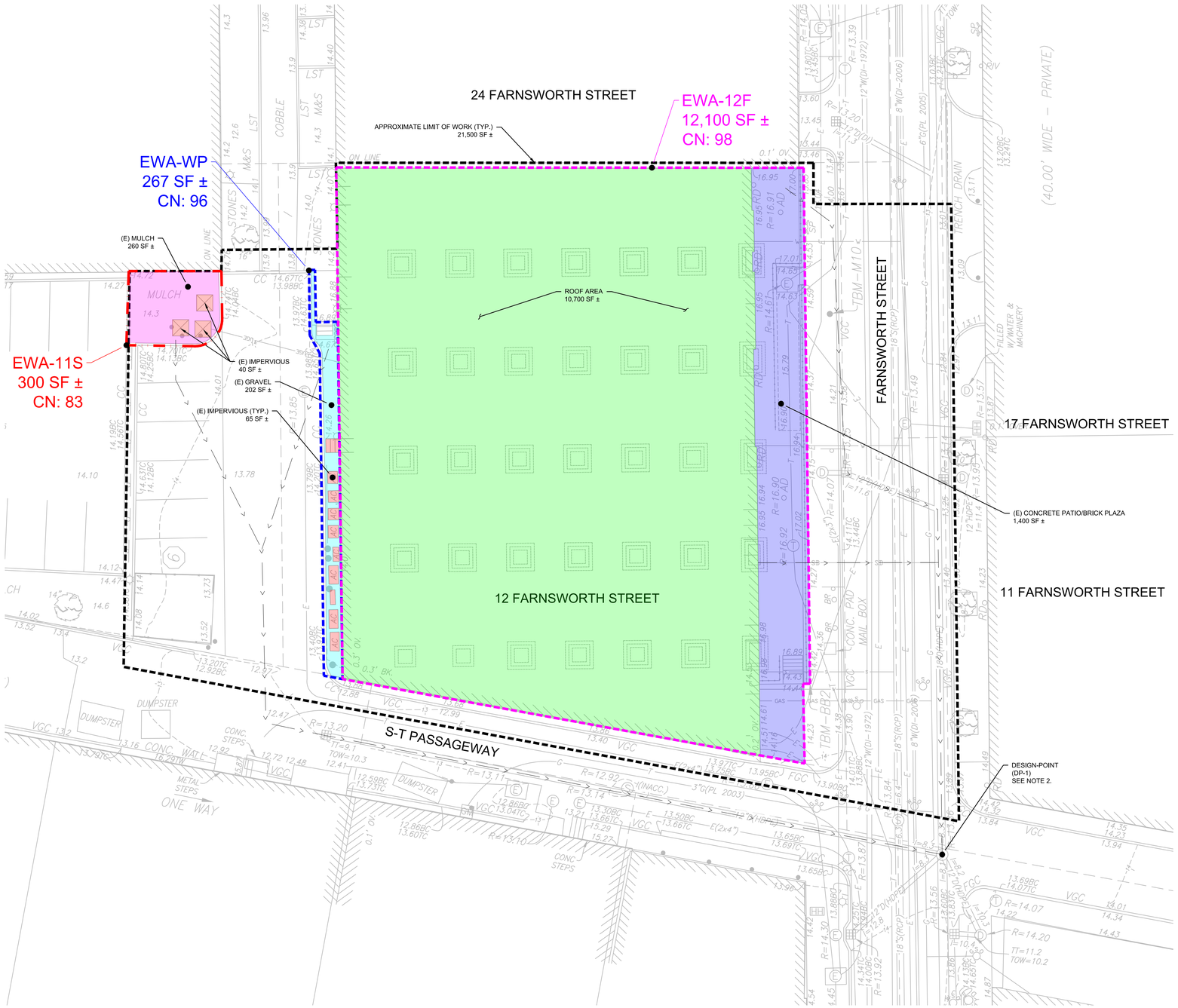
Project: 12 FARNSWORTH STREET, BOSTON, MA			Drawing No.: FIGURE 2
Title: HYDROLOGIC SOIL GROUP			Scale: NTS
Drawn: TK	Checked: EBT	Approved: SPD	Project No.: 210659.00	Date: 02/02/2022



12 FARNSWORTH STREET PLAN VIEW

1" = 10'

NOTES:

1. EXISTING CONDITIONS INFORMATION IS BASED ON A SURVEY PREPARED BY FELDMAN GEOSPATIAL TITLED "11 SLEEPER STREET, 12 FARNSWORTH STREET", DATED 17 OCTOBER 2021.
2. DESIGN-POINT 1 DOES NOT CONSIDER CATCHMENT AREAS OUTSIDE THE LIMIT OF WORK AS SHOWN ON THIS FIGURE.

0 10 20 30 40

SCALE: 1" = 10'

LEGEND

- (E) MULCH
- (E) GRAVEL
- (E) CONCRETE PATIO/BRICK SIDEWALK
- (E) IMPERVIOUS
- FLOW PATH

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Consultant

No.	Date	Description	By

12 FARNSWORTH REPOSITIONING

12 FARNSWORTH STREET BOSTON, MA

Project

PRE-DEVELOPMENT CATCHMENT AREAS

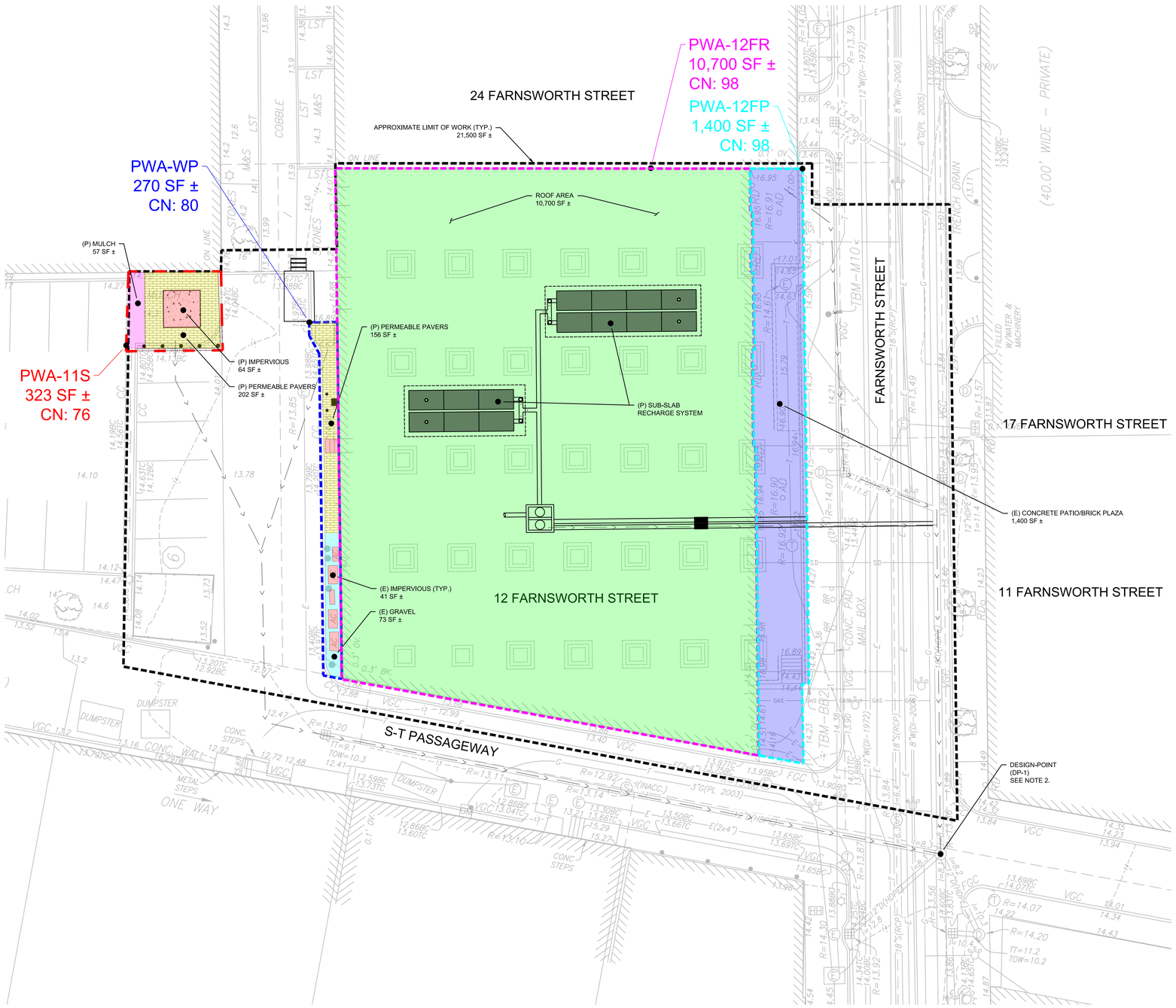
Drawing Title

Project No.	Checked	Date
210659.00	RJA	02/16/2022
Drawn	Approved	Scale
EBT	SPD	AS SHOWN

Drawing No.

FIG. 3

Seal



12 FARNSWORTH STREET PLAN VIEW

1" = 10'

0 10 20 30 40

SCALE: 1" = 10'

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2. DESIGN-POINT 1 DOES NOT CONSIDER CATCHMENT AREAS OUTSIDE THE LIMIT OF WORK AS SHOWN ON THIS FIGURE.

LEGEND

- MULCH
- GRAVEL
- CONCRETE PATIO/BRICK SIDEWALK
- IMPERVIOUS
- PERMEABLE PAVERS
- FLOW PATH

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No.	Date	Description	By

12 FARNSWORTH REPOSITIONING

12 FARNSWORTH STREET BOSTON, MA

Project

POST-DEVELOPMENT CATCHMENT AREAS

Drawing Title

Project No.	Checked	Date
210659.00	RJA	02/16/2022
Drawn	Approved	Scale
EBT	SPD	AS SHOWN

Drawing No.

FIG. 4

Seal

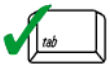
Appendix A
Checklist for Stormwater Report

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

Checklist for Stormwater Report

A. Introduction

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



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

The Stormwater Report must include:

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

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

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

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

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

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

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

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

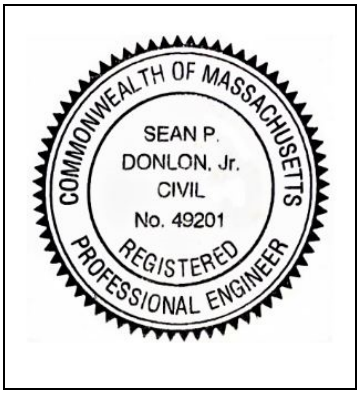
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature



Sean P Donlon Jr.

Digitally signed by Sean P Donlon Jr.
DN: CN=Sean P Donlon Jr., OU=A01410D0000017668713086000066 6D, O=SIMPSON GUMPERTZ AND HEGER, C=US
Reason: I am the author of this document
Date: 2022.02.15 15:03:52-05'00'

Signature and Date

Checklist

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

☐ New development

☒ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

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

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

Standard 1: No New Untreated Discharges

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

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☐ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

Standard 9: Operation and Maintenance Plan

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

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

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

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

Standard 10: Prohibition of Illicit Discharges

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

☒ An Illicit Discharge Compliance Statement is attached;

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

Appendix B

Geotechnical Report / NRCS Data/ USGS Surficial Geology Map

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

MEMORANDUM

18 January 2022
File No. 0201742-000

TO: BP3-BOS7 12 Farnsworth LLC; Phil Marcotty

C: Perkins+Will; Michael Boone
Simpson Gumpertz & Heger; Matt Gilbertson, Mike Hughes, Ned Taylor
Suffolk Construction; Kevin Chamberland

FROM: Haley & Aldrich, Inc.; Mark Balfe, Nate Sherwood, Keith Johnson, Shay Gerald

SUBJECT: Geotechnical Design Recommendations, Soil Quality Data for Disposal, and Construction Considerations
Proposed 12 Farnsworth Street Renovation
Boston, Massachusetts

The purpose of this memorandum is to provide geotechnical design recommendations, soil quality data for disposal, and construction considerations, in connection with the proposed renovation of the existing 12 Farnsworth building in Boston, Massachusetts. This work was performed in accordance with our proposal dated 5 November 2021, which was authorized by BP3-BOS7 12 Farnsworth LLC on 16 November 2021.

Existing Site and Building Conditions

The site is located at the corner of Farnsworth Street and a private alley. The site is an approximately 0.47-acre property developed with one commercial structure. The current building was constructed in 1917 but has since been renovated into office space. The building is approximately 58,000 square-foot (ft), six-story wood frame and brick commercial structure, with a partial basement. The building is currently occupied by various tenants and the surrounding area consists of commercial and office space structures. The surrounding street grades are at approximately El. 14[1]. The top of the existing basement slab is approximately at El. 8.

Proposed Renovation

We understand that the proposed renovations of the existing 12 Farnsworth Street building generally include: 1) removing current building systems and equipment in the basement to create added space for potential tenant storage, 2) adding a new lobby entry, mechanical space, storage, and amenities on the

[1] Elevations referenced herein are in feet (ft) and are based on the Boston City Base datum.

ground floor (Level 1), while the current tenant, Flour Bakery/Café, will remain operational during these renovations, and 3) demolishing interior walls in Levels 2 through 6, to open the space for anticipated office and research and development tenant fit-out work.

Subsurface Exploration Program

TEST BORING

One test boring designated as HA21-1 was drilled by Northern Drill Service, Inc. between 4 and 5 November 2021 at the location shown on Figure 1. The test boring was monitored and logged by a Haley & Aldrich, Inc. (Haley & Aldrich) geologist and was drilled to 124 ft below ground surface (bgs). The test boring log prepared by Haley & Aldrich is provided in Appendix A.

TEST PIT

One test pit designated HA21-TP-1 was hand excavated and backfilled by Chutehall Construction between 15 November 2021 and 1 December 2021. The location of the test pit is shown on Figure 1. The test pit excavation was documented by a Haley & Aldrich representative. The test pit was excavated to 8 ft below the top of the existing basement slab (El. 0). The tops of several existing timber piles supporting the granite block pile caps were documented. The test pit log and photographs are provided in Appendix B.

IN-SITU PERMEABILITY DATA

A falling head permeability test was conducted in test boring HA21-1. The test was performed to support the design of the proposed stormwater recharge systems. Our stormwater recharge analyses were based on the falling head permeability testing and our stormwater recharge recommendations were previously transmitted to the project Civil Engineer, Simpson Gumpertz & Heger (SGH), and are provided in this memorandum for completeness.

Subsurface Conditions

SOIL

Test boring HA21-1 generally indicate the following sequence and generalized descriptions of subsurface units encountered, listed in order of occurrence below ground surface, including estimated elevation of the top of each stratum, depth to top of stratum below ground surface, and thickness.

Generalized Subsurface Stratum	Top of Stratum Elevation (ft, BCB)	Depth to Top of Stratum Below Ground Surface (ft)	Stratum Thickness (ft)
Fill	El. 14.0	--	19.0
Organic Deposits	El. -5.0	19	20.0
Marine Deposits (Clay)	El. -25.0	39	>85.0 (BNE[2])

- Fill – A heterogeneous layer of Fill was encountered beneath a layer of asphalt. The Fill was typically described as very loose to loose, brown, silty SAND with gravel and trace brick, cinders, ash, and porcelain. The lower approximately 7 ft of the Fill layer consisted of very soft, gray to black, ORGANIC SOIL and soft gray lean CLAY from historic placement of hydraulic fill. The site was filled by Boston Wharf Company by 1873.

- Organic Deposits – The Organic Deposits was typically described as very soft, gray, ORGANIC SOIL with trace shell fragments and organic odors.

- Marine Deposits – The approximately 10-ft-thick upper layer of the Marine Deposits was typically described as medium stiff to stiff, gray, lean CLAY, with trace sand seams. This upper layer forms a "crust" over the softer clay in the Marine Deposit. The crust was created during a period when sea levels dropped, and the upper surface of the clay was exposed allowing oxidation, i.e., resulting in the sometimes yellow color, and desiccation, which in turn results in the medium stiff to stiff consistency. The lower layer of the Marine Deposit was typically described as very soft, gray, lean CLAY.

GROUNDWATER

Approximately 24 hours after drilling test boring HA21-1, we measured the groundwater to be approximately 7.2 ft bgs (El. 6.8). One Boston Groundwater Trust (BGwT) monitoring well, 23L-2422, is located relatively close to the site (adjacent to 338 Congress Street), and the recent groundwater measurement on 2 November 2021 indicated the groundwater level to be at El. 8.7.

Groundwater levels at the site should be anticipated to fluctuate with season, precipitation, nearby construction activities, nearby below-grade structures, and other environmental factors. Area groundwater levels will also be influenced by rainfall, local construction activity, surface runoff, leakage into and out of sewers, storms drains, and other below-grade structures, pumping of dewatering systems, season, temperature, the Fort Point channel tide, and other factors. As a result, groundwater levels observed during and following construction may vary from those reported in the test boring log and the BGwT monitoring well.

[2] BNE = Bottom Not Encountered.

Existing Basement Slab and Foundation Conditions

Although direct observation of all the timber piles supporting the 12 Farnsworth Street building is not practical, it is our opinion that the condition of the timber piles exposed during this foundation investigation program provides a reasonable representation of the conditions that would be expected to currently exist beneath the footprint of the building.

The groundwater was observed to be higher than the tops of the timber piles exposed. The observed groundwater elevation and saturated Fill surrounding the tops of the piles appear to be aiding in the preservation of the condition of the timber piles. The tops of the piles that were exposed for viewing were full diameter and in positive contact with the underside of the granite blocks; in addition, little to no penetration of the timber fabric around the perimeter of the pile was possible. As such, it is our opinion that the foundation system of the existing building is currently in satisfactory condition.

As indicated on the test pit log, we documented three distinct layers of remanent concrete basement floor slabs. The lowest slab was found to be 12-inch (in.)-thick and steel reinforced. In total, the slab thickness was 2 ft. While existing slab thickness and reinforcement information is not clear on the available historical foundation plans, we recommend that the Contractor assume the entire floor slab is at least 2-ft-thick and steel reinforced for pricing purposes.

Soil Quality Data and Soil Disposal Considerations

The environmental test results indicated no detectable levels of volatile organic carbons (VOCs), no polychlorinated biphenyl (PCBs), low levels of semi-volatile organic carbons (SVOCs), the presence of lead at a concentration of 393 mg/kg, and low levels of petroleum hydrocarbons. Results were below the applicable Reportable Concentrations (RCS-1), except for lead, which has a RCS-1 criteria of 200 mg/kg. However, the presence of ash and cinders was noted on the test boring HA21-1 log. Massachusetts Department of Environmental Protection (MassDEP) Background levels for lead in Fill with ash/cinders is 600 mg/kg; therefore, the levels of lead at the site are considered “background” and not subject to reporting under the MCP per 310 CMR 40.0317(9), due to the presence of coal ash or wood ash and due to definition of meeting background conditions.

The soil however must be managed as an exempt “remediation waste”. Typical of most Boston area soils; the soil meets Massachusetts landfill reuse criteria and will need to be shipped under a Bill-of-Lading to an in-state landfill if removed from the site.

A summary of soil chemical analytical data is provided in Table 1. Table 1 also includes the soil disposal group designations for each sample, based on the criteria described in the summary included in Appendix C. Laboratory analytical data reports are included in Appendix D.

For disposal purposes, we offer the following considerations:

- Depending on the soil receiving facilities proposed, pre-shipping soil screening in the field for the presence of volatile organics with a portable Photoionization Detector (PID) may be required. Elevated PIDs could pose an issue with Group I facilities with Administrative Consent Order (ACO) permits issued by MassDEP which limit PID readings to 5 parts per million volume

(ppmv) as monitored during excavation. Therefore, soils generated at the site should be disposed at an in-state unlined landfill, regardless of chemical testing results.

- Based on typical disposal facility sampling frequency requirements (1 sample for every 500 cy), it is expected that the testing conducted to-date would allow for disposition of up to 500 cy (850 tons) of soil. If soil inconsistent with the precharacterization data (based on visual and/or olfactory evidence and PID readings) is encountered during soil excavation, then this material must be stockpiled separately. Supplemental characterization of this material will need to be conducted to confirm its acceptably at the selected facility. Additional testing l may be required if more than 500 cy of soil is generated for off-site disposal.

Geotechnical Design Recommendations

The recommendations provided herein are in general accordance with the Ninth Edition of the Massachusetts State Building Code (Code).

GENERAL

The existing Fill and Organic Deposits are unsuitable foundation bearing strata for the proposed elevator shaft. We evaluated several foundation types for the proposed elevator shaft including helical piles and drilled micropiles (DMP). It is our recommendation that the proposed elevator shaft be supported on DMPs, which will derive axial resistance via frictional resistance in the Marine Deposits.

We considered the following factors during our evaluation:

- Due to the thickness of the Fill and Organic Deposits and the presence of existing utilities and economics, it is not practical to over-excavate and replace the Fill and Organic Deposits and support the elevator shaft on competent Marine Deposits.
- Site constraints for foundation construction (within limit space constraints of existing building) cause several foundation types to be infeasible (driven piles or pressure-injected footings).
- Helical piles will be difficult to advance due to the required depth to suitable bearing strata (i.e., Marine Deposits) and the potential presence of bricks/cobbles/granite blocks in the Fill.
- Helical piles will need to be load tested to confirm capacity (we used an estimated capacity of 25 kips for our evaluation). DMPs, if designed as outlined below, will not require a load test.
- Helical pile or DMP installation does not generate significant vibrations as compared to similar foundation types (i.e., pressure-injected footings and driven piles).
- Helical piles and DMPs can typically be installed in low overhead environments.

DMP DESIGN CRITERIA

- DMPs should be designed in accordance with Section 1810.3.10 of the Code.
- A minimum of three DMPs should be provided below the elevator shaft unless laterally braced/supported in accordance with the Code (1810.2.2).
- DMPs should be designed to extend through the Fill and Organic Deposits to support the structural loads in the Marine Deposits.
- DMPs should be reinforced with a centrally installed reinforcement bar (core steel) in a tremie-grouted hole. The core steel should extend the full length of the DMP. The core steel must have either 3 in. of concrete cover or a reduction in cross-sectional area to account for potential long-term corrosion.
- DMPs should have a permanent outer steel casing extending through the Fill and Organic Deposits and a minimum of 1 ft into the Marine Deposits.
- DMP diameters should be at least 6 in.
- Potential for corrosion of permanent steel casing in the Fill and Organic Deposits should be considered.
- DMP vertical capacity in compression should be determined using an allowable skin frictional resistance of 0.5 kips per square foot (ksf) at the pile perimeter in the Marine Deposits.
- No end bearing resistance should be assumed.
- No lateral resistance should be assumed.
- Uplift loads for DMPs should be limited to 75 percent of allowable compression design capacity.
- A static pile load test will need to be performed to verify geotechnical design parameters (e.g., allowable frictional resistance) IF an allowable frictional resistance greater than 0.5 ksf is used to design the DMPs in the Marine Deposits, per the Code.
- The bottoms of pile caps and grade beams should be constructed at least 4 ft below adjacent ground surfaces that will be exposed to freezing temperatures unless insulation or other comparable protection is provided.
- The minimum center-to-center spacing should be as required in Section 1810.3.14 of the Code, which we have interpreted as 30 in. or twice the DMP diameter, whichever is greater. The spacing/distance that new DMPs can be installed relative to existing structures depends in part on the Contractor's installation equipment. A distance of 2 ft from existing above-grade structures is considered a reasonable setback for drilling DMPs.
- Assuming a compressive load of 30 kips[3] acting on each DMP from the elevator shaft, the following table provides required socket/uncased lengths in the Marine Deposits and tip elevations corresponding to typical DMP diameters. This table can be used for pricing purposes.

[3] Preliminary DMP load estimates based on information received via email from Syska Hennessy Group on 12 January 2022. Estimated loads may change during design; therefore, estimated DMP lengths presented herein are for pricing purposes only.

DMP Diameter (in.)	Marine Deposits Socket/Uncased Length (ft)	Required Tip Elevation (ft, BCB)
6	39	-64
7	33	-58
8	29	-54
9	26	-51
10	23	-48

ELEVATOR SHAFT SETTLEMENT ESTIMATES

- Since the elevator shaft will be supported on the thick Marine Deposits (clay) stratum, it is necessary to determine the anticipated settlements of the structure resulting from consolidation of the Marine Deposits (clay) stratum under the superimposed stresses in the foundation system. Settlement calculations were made based on data available from other subsurface explorations conducted in the vicinity of the 12 Farnsworth Street project. No laboratory tests were undertaken during this study to define the consolidation characteristics and stress history of the clay underlying the site.
- In general, settlements of the proposed elevator shaft that will be supported on DMPs is expected to be within allowable limits. Following elastic shortening of the DMPs during the application of dead loads during construction, total settlement of the structure supported on the DMPs is anticipated to be less than ½-in. We estimate that differential settlements across the elevator shaft will be negligible.

LATERAL LOAD RESISTANCE

- The net (passive minus active) lateral resistance provided by compacted Structural Fill surrounding the DMP caps and/or grade beams can be calculated using an equivalent fluid unit weight of 200 pounds per cubic ft (pcf) above El. 9 and 125 pcf below El. 9. This value assumes that backfill is systematically compacted in lifts to a lateral distance of at least 5 ft from the structural element. The top of the assumed passive zone should be 6 in. below the top of adjacent soil or backfill surface. If the horizontal distance between DMP caps, or walls is less than twice the height of the subject structural element, the passive pressure should be discounted proportionately to the distance (full pressure at twice the height away) to accommodate interaction of the elements.
- The above lateral capacities assume an essentially fixed condition at the connection between the foundation element and the cap. If significant pre-excavation is required below the cap bottom elevation at DMP locations to clear obstructions, compacted Structural Fill should replace the excavated material to obtain the design lateral capacities.

DESIGN GROUNDWATER, FOUNDATION DRAINAGE, AND WATERPROOFING

- We recommend a design groundwater level at El. 9 for calculation of hydrostatic uplift pressures on below-grade structures.
- The replacement ground floor slab will be finished at, or slightly above, the exterior grade and at least 5 ft above the maximum groundwater level. Therefore, slab waterproofing or permanent underslab or foundation drainage are not required.
- Any below-grade pits should be waterproofed and designed for hydrostatic uplift based on design groundwater at El. 9.
- A moisture vapor retarder barrier should be considered if directly beneath the ground floor slabs in occupied and finished spaces.
- Surface runoff should be directed away from structures. In general, the ground surface within 10 ft immediately around the structures should be sloped downward away from the structures to divert surface runoff.

SEISMIC DESIGN

Under the Code, seismic design of structures is to be based on ASCE/SEI 7-05-Minimum Design Loads for Buildings and Other Structures as modified for Massachusetts. The Code requires classifying the site (Site Class A through F) depending on soil type within the top 100 ft of the soil profile. After determining the appropriate Site Class and the project location within Massachusetts, site-specific design parameters are selected for use in analyses to determine the "Seismic Design Category." Accordingly, we recommend the following parameters be utilized in accordance with the Code.

- Site Class D
- S_s = 0.217g (Note 1)
- S_1 = 0.069g (Note 1)
- F_a = 1.6 (Note 2)
- F_v = 2.4 (Note 2)

Notes:
1. Values determined from Table 1604.11 of the Code.
2. Values determined from Table 1613.3.3(1) and Table 1613.3.3(2) of the International Building Code, 2015.

STORMWATER MANAGEMENT

Based on plans provided by SGH, the project is planning to direct stormwater to stormwater recharge systems and an associated recharge outlet control structure. The recharge systems will be constructed beneath the ground floor slab (the ground finished floor elevation is El. 17 ±). The bottom of the proposed stormwater recharge systems will be at El. 11.

During the subsurface exploration program, a falling infiltration test was completed at test boring HA21-1. The infiltration test was performed above the groundwater table during drilling. The falling head test was performed by advancing a 4-in. inner diameter steel casing to the prescribed depths and cleaning (removing soil) out the casing. To test a 2 ft zone, pea gravel was added into the casing and the casing

was jacked out 2 ft to expose the test section of soil. The casing was then filled with water and the rate of water drop inside the casing was measured over time.

The falling head test data was reduced using an unsaturated infiltration testing method by International Livestock Research Institute (ILRI). The test was completed at a depth of 5 to 8 ft bgs at test boring HA21-1. The table below summarizes the data:

Test Boring No.	Test Date	Ground Surface Elevation (ft, BCB)	Top Elevation of Test Zone (ft, BCB)	Bottom Elevation of Test Zone (ft, BCB)	Soil Type of Test Zone	Coefficient of Permeability (k, cm/sec)
HA21-1	4 November 2021	14	9	6	Silty SAND	$4x10^{-4}$

- For purposes of stormwater infiltration, the recommended value of infiltration is 50 percent of the lowest measured value of infiltration. This would result in a recommended rate of 2.5x10-4 cm/sec, which is equivalent to 0.3 in./hour.
- Existing Fill (except for the lower hydraulic fill stratum below a depth of 12 ft bgs), for hydrologic purposes, may be classified as Soil Group B, per USDA Natural Resources Conservation Service (Part 630 Hydrology, National Engineering Handbook, Chapter 7 – Hydrologic Soil Groups).

UTILITIES

In general, we recommend that site utilities be soil-supported and constructed using conventional procedures. Utilities below structural slabs should be supported from the slab with corrosion-resistant pipe hangers. The hangers should be designed to support the weight of the utility, its contents, and the weight of soil within the zone defined by imaginary lines rising at a 1 horizontal:2 vertical slope drawn upward and outward from the spring line of the pipe (both sides) to the underside of the slab. A unit weight of 120 pcf should be assumed for the overlying soil.

Construction Considerations

The primary purpose of this section is to comment on the items related to earthwork, foundation construction, and related geotechnical engineering aspects of the proposed construction. Prospective Contractors for this project should evaluate potential construction issues based on their knowledge and experience with similar soils conditions in Boston, considering their own proposed construction methods.

In addition to the construction guidelines and recommendations made herein, construction should conform to the requirements of the Occupational Health and Safety Administration and all other applicable Municipal, State, and Federal regulations.

EARTHWORK

Reuse of On-site Excavated Fill

- Per the test boring HA21-1 log, the Fill to a depth of 12 ft generally consisted of very loose, brown, silty SAND with gravel. Granular existing Fill may be reusable as Common Fill outside the building if processed (culled, screened and/or crushed) to remove oversized and deleterious materials (wood, trash, scrap metal, etc.) and as backfill beneath structural slabs. The Fill will be very susceptible to placement difficulties when wet or in cold weather.
- Rainfall or melting snow can readily saturate stockpiled silty soils such as the existing Fill. Providing drainage from, and covering a stockpile, can help limit this potential problem. These soils will probably require considerable drying if left in an unprotected stockpile for an extended period.
- Organic Deposits or hydraulic fill are not suitable for reuse for any project application and would likely require off-site disposal.
- We should review and approve of all proposed cases of excavated Fill reuse.

Backfilling

- Compacted Structural Fill should be used for backfill surrounding foundation elements (pile caps and grade beams).
- Compacted Common Fill could be used beneath structurally supported slabs (i.e., slabs that do not rely on soils for support) and within utility trenches (provided this is acceptable with SGH). As noted above, we anticipate that selected on-site soils may be used as substitute for Compacted Common Fill, if they are judged suitable and can be placed and compacted in accordance with recommendations in this memorandum.

Structural Fill

Structural Fill placed around pile caps and grade beams, and within 5 ft of the backside of retaining walls, should consist of mineral, bank run sand and gravel, free of organic material, snow, ice, or other unsuitable materials and should be well graded within the following limits:

Sieve Size	Percent Finer by Weight
½ in.	35 to 80
¼ in.	25 to 65
No. 40	0 to 30
No. 200	0 to 8

Common Fill

Common Fill should consist of uncontaminated mineral sandy or gravelly soil, free from organic matter, plastic, metal, wood, ice, snow, debris, or other deleterious material and should have the characteristic that it can be readily placed and compacted. Common Fill imported to the site should have a maximum of 80 percent passing the No. 4 sieve and a maximum of 25 percent finer than the No. 200 sieve. Silty Common Fill soils may require moisture control during placement and compaction. As noted above, the Existing Fill soils *may* be acceptable to be used as Common Fill at the discretion of Haley & Aldrich.

Compaction Requirements

Recommended compaction requirements are as follows:

Location	Minimum Compaction Requirements
Around pile caps and grade beams	95%
Within 3 ft below parking, roadways, and sidewalks	95%
Deeper than 3 ft below parking, roadways, and sidewalks	92%
Landscaped areas	By Landscape Architect

Minimum compaction requirements refer to percentages of the maximum dry density determined in accordance with ASTM D1557.

Compacted fills should be placed in horizontal lifts not more than 12 in. thick prior to compaction. Compaction equipment should consist of a large, self-propelled vibratory roller. Where hand-guided compaction equipment such as a vibratory plate compactor is used in confined areas, the loose lift thickness should not exceed 8 in. Each layer of fill should receive at least four complete coverages with suitable compaction equipment. The maximum particle size should not exceed two-thirds of the loose lift thickness.

CONSTRUCTION DEWATERING

The excavation for the elevator pit will extend below groundwater; therefore, temporary construction dewatering will be required to allow this work to be conducted in-the-dry. If the dewatering effluent cannot be managed on-site through recharge from sump pumps, then a dewatering permit will likely be required to allow discharge of water to storm drainage features in a surrounding street (i.e., catch basins).

DMP INSTALLATION

- DMPs should be drilled through the Fill and Organic Deposits to the design tip elevation in the Marine Deposits with steel casing lengths.
- Following the completion of drilling, steel casing lengths within the Fill and Organic Deposits should be left in place. The steel casings should penetrate at least 1 ft into the Marine Deposit. The permanent steel casing will help prevent loss of ground, provide the required structural connection at the DMP top, and provide the required structural cross-section throughout the complete length of the DMP.
- To prevent loss of ground, only internal-flush methods of DMP installation should be permitted.
- Remnant foundations and other structures may be present within the Fill soils, and can include brick, concrete, wood, and any other miscellaneous debris.
- As explained above, if an allowable frictional resistance greater than 0.5 ksf is used to estimate the DMP length within the Marine Deposit, a static pile load test will be required to confirm allowable load bearing capacity of the DMP per the Code. The test pile should be loaded in compression to design capacity. Test loads and sequence should be in accordance with the Code.
- The Contractor will be responsible for augmentation and/or stabilization of spoils produced during DMP installation rendering them suitable for loading and off-site transportation in a condition acceptable to the selected disposal facility. Spoils will need to be managed in a way that prevents impacts to adjacent properties. DMP spoils should be handled as a separate waste stream from soil and groundwater for disposal purposes. DMP spoils will need to be sampled and tested for disposal parameters.

STRUCTURAL SLAB SUBGRADE PREPARATION

Per the project Structural Engineer, SGH, we understand all new slabs will be structurally supported and will not be relying on soil for support. For structural slab subgrade areas, following the excavation to desired elevation, the resulting subgrade should be proof compacted with several passes of a large vibratory compactor, to enable a stable working surface for slab construction.

Limitations

This memorandum has been prepared for specific application to the proposed 12 Farnsworth Street project in Boston, Massachusetts. If changes in the nature, design, or location of structures are planned, the conclusions and recommendations contained in this memorandum should not be considered valid unless the changes are reviewed, and conclusions of this memorandum modified or verified in writing. This memorandum is intended solely for the use of the project team in connection with the aspects of the project as described herein. The analyses and recommendations submitted in this memorandum are based in part upon data obtained from the referenced subsurface explorations. The nature and extent of the subsurface conditions across the site may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this memorandum.

As noted above, this memorandum provides data and represents the chemical properties of the soil retrieved from the subsurface explorations conducted to date. Physical properties of the materials are noted on the test boring log provided in Appendix A; however, the log describe observations and conditions encountered at the specific exploration location and time and may not be representative of the bulk soil requiring management. Variation in the materials in-place is expected. The Contractor must understand and accommodate both the chemical and physical acceptance criteria for each facility it proposes to use.

Some soil receiving facilities may conduct quality assurance/quality control (QA/QC) chemical testing of soils upon arrival at the receiving facility. Haley & Aldrich considers the results of the chemical analytical data obtained during the precharacterization program to be representative of the soil to be excavated, based on the standard of practice for soil precharacterization. However, QA/QC chemical testing results conducted by the receiving facility may differ from the precharacterization results obtained by Haley & Aldrich due to the heterogeneous nature of Fill soils. Should the receiving facility's QA/QC chemical testing results differ from Haley & Aldrich's precharacterization results and exceed the facility's acceptance criteria, the receiving facility may reject the material. Additional costs for handling, rehandling, loading, temporary storage and transportation of the material to another facility may be incurred.

Closure

We appreciate the opportunity to provide geotechnical and environmental consulting services on this project. Please do not hesitate to call if you have any questions or comments.

Attachments:

- Table 1 – Summary of Soil Quality Data
- Figure 1 – Site and Subsurface Exploration Location Plan
- Appendix A – Test Boring HA21-1 Log
- Appendix B – Test Pit HA21-TP-1 Log and Photographs
- Appendix C – Haley & Aldrich Soil Precharacterization Group Classification System
- Appendix D – Laboratory Analytical Data Reports

TABLE 1
SUMMARY OF SOIL QUALITY DATA
12 FARNSWORTH STREET
BOSTON, MASSACHUSETTS
FILE NO. 0201742-000

Precharacterization Grid	Action Level		
Location Name	MCP Reportable Concentration RCS-1 2014	TCLP	HA21-1
Sample Name			HA21-1-0-6
Sample Date			11/04/2021
Lab Sample ID			L2160886-01 L2161350-01
Sample Depth (bgs)			0 - 6 (ft)
Volatile Organic Compounds (mg/kg)			
Sum of Volatile Organic Compounds	NA	NA	ND
Semi-Volatile Organic Compounds (mg/kg)			
Anthracene	1000	NA	0.12
Benzo(a)anthracene	7	NA	0.24
Benzo(a)pyrene	2	NA	0.21
Benzo(b)fluoranthene	7	NA	0.23
Chrysene	70	NA	0.23
Fluoranthene	1000	NA	0.49
Phenanthrene	10	NA	0.5
Pyrene	1000	NA	0.43
Total Petroleum Hydrocarbons (mg/kg)			
Petroleum hydrocarbons	1000	NA	264
Inorganic Compounds (mg/kg)			
Antimony	20	NA	ND (2.38)
Arsenic	20	NA	5.51
Barium	1000	NA	48.1
Beryllium	90	NA	ND (0.238)
Cadmium	70	NA	ND (0.476)
Chromium	100	NA	7.86
Lead	200	NA	**393**
Mercury	20	NA	4.62
Nickel	600	NA	8.8
Selenium	400	NA	ND (2.38)
Silver	100	NA	ND (0.476)
Thallium	8	NA	ND (2.38)
Vanadium	400	NA	14.9
Zinc	1000	NA	147
TCLP Inorganic Compounds (mg/L)			
Lead	NA	5	ND (0.5)
Mercury	NA	0.2	ND (0.001)
PCBs (mg/kg)			
Aroclor-1016 (PCB-1016)	1	NA	ND (0.0389)
Aroclor-1221 (PCB-1221)	1	NA	ND (0.0389)
Aroclor-1232 (PCB-1232)	1	NA	ND (0.0389)
Aroclor-1242 (PCB-1242)	1	NA	ND (0.0389)
Aroclor-1248 (PCB-1248)	1	NA	ND (0.0389)
Aroclor-1254 (PCB-1254)	1	NA	ND (0.0389)
Aroclor-1260 (PCB-1260)	1	NA	ND (0.0389)
Aroclor-1262 (PCB-1262)	NA	NA	ND (0.0389)
Aroclor-1268 (PCB-1268)	NA	NA	ND (0.0389)
Polychlorinated biphenyls (PCBs)	1	NA	ND (0.0389)
Other			
Total Solids (%)	NA	NA	81.9
Reactive Cyanide (mg/kg)	NA	NA	ND (130)
Reactive Sulfide (mg/kg)	NA	NA	ND (250)
Ignitability (Flashpoint)	NA	NA	NI
pH (lab) (pH units)	NA	NA	7.8
Conductivity (umhos/cm)	NA	NA	140

ABBREVIATIONS:
mg/kg: milligram per kilogram
mg/L: milligram per liter
umhos/cm: micromhos per centimeter
bgs: below ground surface
ft: feet
MCP: 310 CMR 40.0000 Massachusetts Contingency Plan effective 25 April 2014; revisions 23 May 2014.
NA: Not Applicable
ND (2.5): Not detected, number in parentheses is the laboratory reporting limit
NI: Not Ignitable

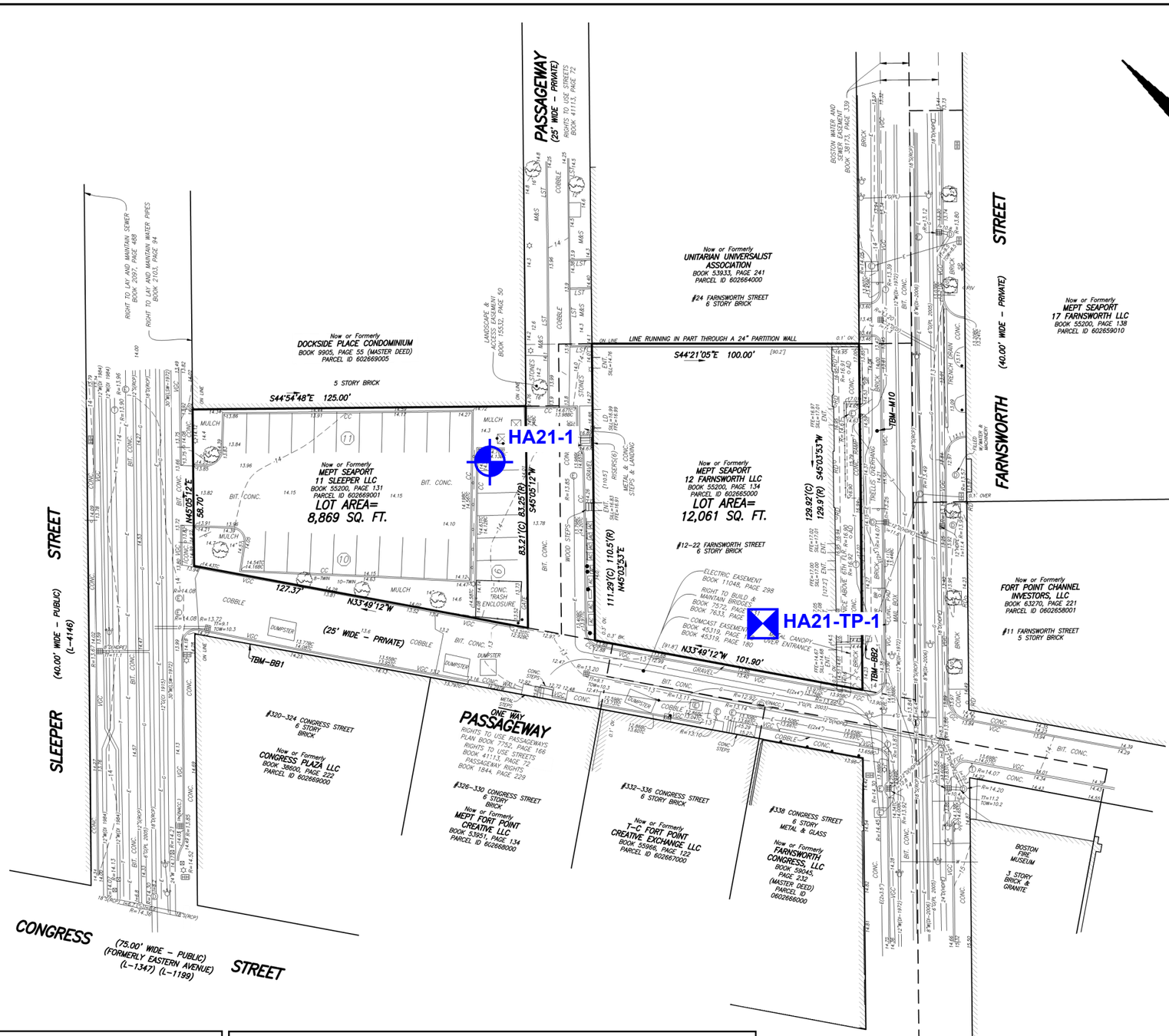
NOTES:
1. Analytes detected in Volatile and Semi-Volatile Organics for at least one sample are reported herein. For a complete list of analytes see the laboratory data sheets.
2. For test methods used, see the laboratory data sheets.
3. Bold values indicate an exceedance of the **RCS-1** or **TCLP** criteria.

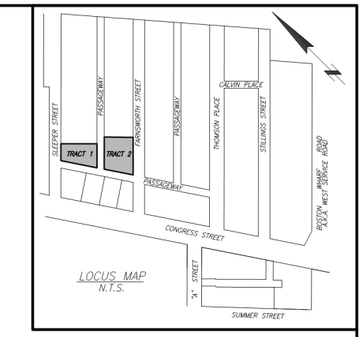
LEGEND

- SEWER MANHOLE
- DRAIN MANHOLE
- ELECTRIC MANHOLE
- TELEPHONE MANHOLE
- CABLE TELEVISION MANHOLE
- MANHOLE
- WATER SHUT OFF
- GAS SHUT OFF
- CATCH BASIN
- LIGHT POLE
- ELECTRIC HANDHOLE
- BOLLARD
- MAIL BOX
- SIGN
- SECURITY CAMERA
- STAND PIPE/SIAMESE CONNECTION
- TRANSFORMER
- BOLLARD
- AD ..... AREA DRAIN
- RD ..... ROOF DRAIN
- DECIDUOUS TREE

BH	BUILDING HEIGHT
BFA	BUILDING FOOTPRINT AREA
BIT	BITUMINOUS
BK	BACK
BR	BIKE RACK
[X.X']	BUILDING DIMENSION
(C)	CALCULATED
COB	COBBLESTONE
CONC	CONCRETE
CC	CONCRETE CURB
ENT	ENTRANCE
FFE	FINISH FLOOR ELEVATION
FGC	FLUSH GRANITE CURB
GD	GARAGE DOOR
I=	INVERT ELEVATION
INACC.	INACCESSIBLE
LD	LOADING DOCK
LST	LANDSCAPE TIMBER
MTL	METAL
OV	OVER
POB	POINT OF BEGINNING
POC	POINT OF COMMENCEMENT
(R)	RECORD
SQ. FT.	SQUARE FEET
TR	TRANSFORMER
TBM	TEMPORARY BENCH MARK
TOW	TOP OF WATER
TT=	TOP OF TRAP
LD	LOADING DOCK
VGC	VERTICAL GRANITE CURB
X	EXCEPTION NUMBER LISTED IN TITLE COMMITMENT
Z	INDICATES COMMON OWNERSHIP
X	NUMBER OF PARKING SPACES

- —X——X— METAL FENCE
- —D— DRAIN
- —E— ELECTRIC
- —G— GAS
- —S— SEWER
- —T— TELEPHONE
- —W— WATER
- —CI— CAST IRON
- —12"D(CI)— PIPE SIZE AND MATERIAL
- —RCP— REINFORCED CONCRETE PIPE
- METAL RAILING





NOTES:

1. BENCH MARK INFORMATION:
2. ELEVATIONS ESTABLISHED BY GPS.

   TEMPORARY BENCH MARKS SET:

   TBM–BB1: TOP OF WINDOW SILL OF #320–#324 CONGRESS STREET ON NORTH FACE OF BUILDING 20.5' FROM NORTHWESTERLY CORNER OF BUILDING, APPROXIMATELY 2.75' ABOVE SIDEWALK GRADE, AS SHOWN HEREON. ELEVATION=16.96

   TBM–M10: TOP OF MAG NAIL SET IN BRICK SIDEWALK ON NORTHWESTERLY SIDE OF FARNSWORTH STREET IN FRONT OF #12 FARNSWORTH STREET AND APPROXIMATELY 32' FROM THE MOST SOUTHERLY CORNER OF #24 FARNSWORTH STREET AS SHOWN HEREON. ELEVATION =14.40.
3. ELEVATIONS REFER TO BOSTON CITY BASE (BCB).
4. UTILITY INFORMATION SHOWN IS BASED ON BOTH A FIELD SURVEY AND PLANS OF RECORD. THE LOCATIONS OF UNDERGROUND PIPES AND CONDUITS HAVE BEEN DETERMINED FROM THE AFOREMENTIONED RECORD PLANS AND ARE APPROXIMATE ONLY. WE CANNOT ASSUME RESPONSIBILITY FOR DAMAGES INCURRED AS A RESULT OF UTILITIES THAT ARE OMITTED OR INACCURATELY SHOWN ON SAID RECORD PLANS, SINCE SUBSURFACE UTILITIES CANNOT BE VISIBLY VERIFIED. BEFORE PLANNING FUTURE CONNECTIONS, THE PROPER UTILITY ENGINEERING DEPARTMENT SHOULD BE CONSULTED AND THE ACTUAL LOCATION OF SUBSURFACE STRUCTURES SHOULD BE DETERMINED IN THE FIELD. CALL, TOLL FREE, THE DIG SAFE CALL CENTER AT 1–888–344–7233 SEVENTY–TWO HOURS PRIOR TO EXCAVATION.
5. THIS DOCUMENT IS AN INSTRUMENT OF SERVICE OF FELDMAN GEOSPATIAL ISSUED TO OUR CLIENT FOR PURPOSES RELATED DIRECTLY AND SOLELY TO FELDMAN GEOSPATIAL'S SCOPE OF SERVICES UNDER CONTRACT TO OUR CLIENT FOR THIS PROJECT. ANY USE OR REUSE OF THIS DOCUMENT FOR ANY REASON BY ANY PARTY FOR PURPOSES UNRELATED DIRECTLY AND SOLELY TO SAID CONTRACT SHALL BE AT THE USER'S SOLE AND EXCLUSIVE RISK AND LIABILITY, INCLUDING LIABILITY FOR VIOLATION OF COPYRIGHT LAWS, UNLESS WRITTEN CONSENT IS PROVIDED BY FELDMAN GEOSPATIAL.

COMMONWEALTH OF MASSACHUSETTS — TIMOTHY R. AGURKIS No.52782 — REGISTERED PROFESSIONAL LAND SURVEYOR

I CERTIFY THAT THIS PLAN IS BASED ON AN ACTUAL FIELD SURVEY AND THE LATEST PLANS AND DEEDS OF RECORD.

TIMOTHY R. AGURKIS, PLS (MA# 52782) — 10/17/21 DATE
TRA@FELDMANSURVEYORS.COM

EXISTING CONDITIONS PLAN

11 SLEEPER STREET
12 FARNSWORTH STREET
BOSTON, (SOUTH BOSTON) MASS.
(SUFFOLK COUNTY)

FELDMAN GEOSPATIAL
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OCTOBER 17, 2021
PHONE: (617)357–9740
www.feldmansurveyors.com

FELDMAN GEOSPATIAL

20 0 10 20 40 80
SCALE: 1"=20'

RESEARCH MJB	FIELD CHIEF BB	PROJ MGR TRA	APPROVED TRA	SHEET NO. 1 OF 1
CALC MJB	CADD SPP	FIELD CHECKED	CRD FILE 2100728	JOB NO. 2100728

FILENAME: S:\PROJECTS\2021\2100728\DWG\2100728–EC – C3D.dwg

HALEY ALDRICH

12 FARNSWORTH STREET
BOSTON, MASSACHUSETTS

SITE AND SUBSURFACE EXPLORATION LOCATION PLAN

SCALE: AS SHOWN
JANUARY 2022

FIGURE 1

LEGEND

HA21-1 — DESIGNATION AND APPROXIMATE LOCATION OF TEST BORING CONDUCTED BY NORTHERN DRILL SERVICE, INC. FROM 4 TO 5 NOVEMBER 2021.

HA21-TP-1 — DESIGNATION AND APPROXIMATE LOCATION OF TEST PIT CONDUCTED BY CHUTEHALL CONSTRUCTION FROM 15 NOVEMBER TO 1 DECEMBER 2021.

APPENDIX A

Test Boring HA21-1 Log

TEST BORING REPORT

HALEY ALDRICH

Boring No. HA21-1

Project	12 FARNSWORTH STREET, BOSTON, MA
Client	BP3-BOS7 12 FARNSWORTH LLC
Contractor	NORTHERN DRILL SERVICE, INC.

File No.	201742-000
Sheet No.	1 of 5
Start	November 4, 2021
Finish	November 5, 2021
Driller	C. Bierholm
H&A Rep.	A. Fleming
Elevation	14.0 (est.)
Datum	Boston City Base
Location	See Plan

	Casing	Sampler	Barrel
Type	HW	S	
Inside Diameter (in.)	4	1.4	
Hammer Weight (lb)	140	140	-
Hammer Fall (in.)	30	30	-

Drilling Equipment and Procedures

Rig Make & Model: Mobile Drill B57
Bit Type: Roller Bit
Drill Mud: None
Casing: Drive and wash
Hoist/Hammer: Winch / Automatic hammer
PID Make & Model: Tiger 10.6 eV

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0					SP	13.7	-ASPHALT-										
	7 8 5	S1 7	0.5 2.0	0.0		0.3	Medium dense light brown to brown poorly-graded SAND (SP), no structure, no odor, moist, trace pockets of silty sand, trace brick		5	5	25	60	5				
	4 5 2 3	S2 11	2.0 4.0	0.6	SM	12.0 2.0	Loose black to dark brown silty SAND with gravel (SM), no structure, no odor, moist, trace brick, cinders, ash and porcelain, trace pockets of lean clay	5	10	10	20	35	20				
							-FILL-										
5	5 2 6 6	S3 4	4.0 6.0	0.2	SM		Loose gray-brown to dark brown silty SAND with gravel (SM), no structure, no odor, moist, 15-20% pockets of lean clay, 5-10% ash, cinders and brick Falling head test performed from 5-8'.	5	10	15	30	20	20				
	8 4 2 1	S4 3	6.0 8.0	0.2	SM		Loose gray-brown to black silty SAND with gravel (SM), no structure, no odor, moist, 5-10% ash and cinders, trace pockets of lean clay	10	15	15	25	20	15				
	5 1 1 1	S5 3	8.0 10.0	0.0	SM		Very loose gray to gray-brown silty SAND with gravel (SM), no structure, no odor, wet, trace ash and cinders	5	10	15	35	20	15				
10	1 1 1 0	S6 3	10.0 12.0	0.0	SM		Very loose gray silty SAND with gravel (SM), no structure, no odor, wet, trace cinders and glass	5	10	15	30	25	15				
	1 1 1 1	S7 11	12.0 14.0	0.0	OL/OH	2.0 12.0	Very soft gray to black ORGANIC SOIL with sand (OL/OH), no structure, no odor, wet, trace wood, trace peat fibers					15	85				
							-FILL-										
15	1 1 1 1	S8 13	14.0 16.0	0.0	OL/OH		Very soft gray to black ORGANIC SOIL (OL/OH), no structure, no odor, wet					10	90				
	1 2 1 2	S9 10	16.0 18.0	0.0	CL	-1.8 15.8	Soft gray lean CLAY (CL), no structure, no odor, wet						100				
							-FILL-										
20	1 1	S10 22	19.0 21.0	0.0	OL/OH	-5.0 19.0	Very soft gray ORGANIC SOIL (OL/OH), no structure, organic odor, wet, trace fine sand seams					5	95				

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
11/05/21	07:18	24	24.0	45.0	7.2

Sample ID

O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Splitspoon Sample
G - Geoprobe

Well Diagram

Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary

Overburden (ft) 124.0
Rock Cored (ft)
Samples S23

Boring No. HA21-1

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

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

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

H&A-TEST BORING WITH PERM PID COLUMN PLOG-HA-LIB09-BOS STANDARD ONLY - COPY.GLB HA-TB+CORE+WELL-09 W FENCE.GDT \\HALEYALDRICH.COM\SHARE\CF\PROJECTS\0201742\GINT\0201742-000-TB.GPJ Dec 9, 21

TEST BORING REPORT

HALEY ALDRICH

Boring No. HA21-1

File No. 201742-000

Sheet No. 2 of 5

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
20	1 1						-ORGANIC DEPOSITS-										
25	WOH 1 1 1	S11 24	24.0 26.0	0.0	OL/OH		Very soft gray ORGANIC SOIL with sand (OL/OH), no structure, organic odor, wet					15	85				
30	1 1 1 1	S12 23	29.0 31.0	0.0	OL/OH		Very soft gray ORGANIC SOIL (OL/OH), no structure, organic odor, wet, trace shells					10	90				
35	WOR 1 1 1	S13 23	34.0 36.0	0.0	OL/OH		Very soft gray ORGANIC SOIL (OL/OH), no structure, organic odor, wet -ORGANIC DEPOSITS-					5	95				
40	10 6 5 6	S14 10	39.0 41.0	0.0	CL	-25.0 39.0	Stiff gray lean CLAY (CL), no structure, no odor, wet -MARINE DEPOSITS-					5	95				
45	2 3 4 3	S15 22	44.0 46.0	0.0	CL		Medium stiff gray lean CLAY (CL), no structure, no odor, wet, trace fine sand seams					5	95				
	1	S16	49.0	0.0	CL		Very soft gray lean CLAY (CL), no structure, no odor, wet, trace fine					5	95				

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

Boring No. HA21-1

H&A-TEST BORING WITH PERM PID COLUMN PLOG-HA-LIB09-BOS STANDARD ONLY - COPY.GLB HA-TB+CORE+WELL-09 W FENCE.GDT \\HALEYALDRICH.COM\SHARE\CF\PROJECTS\0201742\GINT\0201742-000-TB.GPJ Dec 9, 21

TEST BORING REPORT

HALEY ALDRICH

Boring No. HA21-1

File No. 201742-000

Sheet No. 3 of 5

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
50	1 1 3	24	51.0				sand seams										
55	1 1 1 2	S17 23	54.0 56.0	0.0	CL		Very soft gray lean CLAY (CL), no structure, no odor, wet, trace fine sand seams						100				
							-MARINE DEPOSITS-										
60	1 3 3 4	S18 5	59.0 61.0	0.0	CL		Medium stiff gray lean CLAY (CL), no structure, no odor, wet						100				
65																	
70	WOR 1 1 2	S19 24	69.0 71.0	0.0	CL		Very soft gray lean CLAY (CL), no structure, no odor, wet						100				
75																	
					CL												

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

Boring No. HA21-1

H&A-TEST BORING WITH PERM PID COLUMN PLOG-HA-LIB09-BOS STANDARD ONLY - COPY.GLB HA-TB+CORE+WELL-09 W FENCE.GDT \\HALEYALDRICH.COM\SHARE\CF\PROJECTS\0201742\GINT\0201742-000-TB.GPJ Dec 9, 21

TEST BORING REPORT

HALEY ALDRICH

Boring No. HA21-1

File No. 201742-000

Sheet No. 4 of 5

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
80	WOR WOR 2 2	S20 24	79.0 81.0	0.0			Very soft gray lean CLAY (CL), no structure, no odor, wet						100				
85							-MARINE DEPOSITS-										
90	WOR WOR 1 3	S21 24	89.0 91.0	0.0	CL		Very soft gray lean CLAY (CL), no structure, no odor, wet						100				
95																	
100	WOR WOR WOR WOR	S22 24	99.0 101.0	0.0	CL		Very soft gray lean CLAY (CL), no structure, no odor, wet						100				
105																	

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

Boring No. HA21-1

H&A-TEST BORING WITH PERM PID COLUMN PLOG-HA-LIB09-BOS STANDARD ONLY - COPY.GLB HA-TB+CORE+WELL-09 W FENCE.GDT \\HALEYALDRICH.COM\SHARE\CF\PROJECTS\0201742\GINT\0201742-000-TB.GPJ Dec 9, 21

TEST BORING REPORT

HALEY ALDRICH

Boring No. HA21-1

File No. 201742-000

Sheet No. 5 of 5

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
	WOR WOR WOR WOR	S23 24	109.0 111.0	0.0	CL		Very soft gray lean CLAY (CL), no structure, no odor, wet						100				
110							-MARINE DEPOSITS-										
115																	
120																	
						-110.0 124.0	BOTTOM OF EXPLORATION 124.0 FT Advanced roller bit to 124'. Drill action indicates soft lean clay. 124' B.O.E.										

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

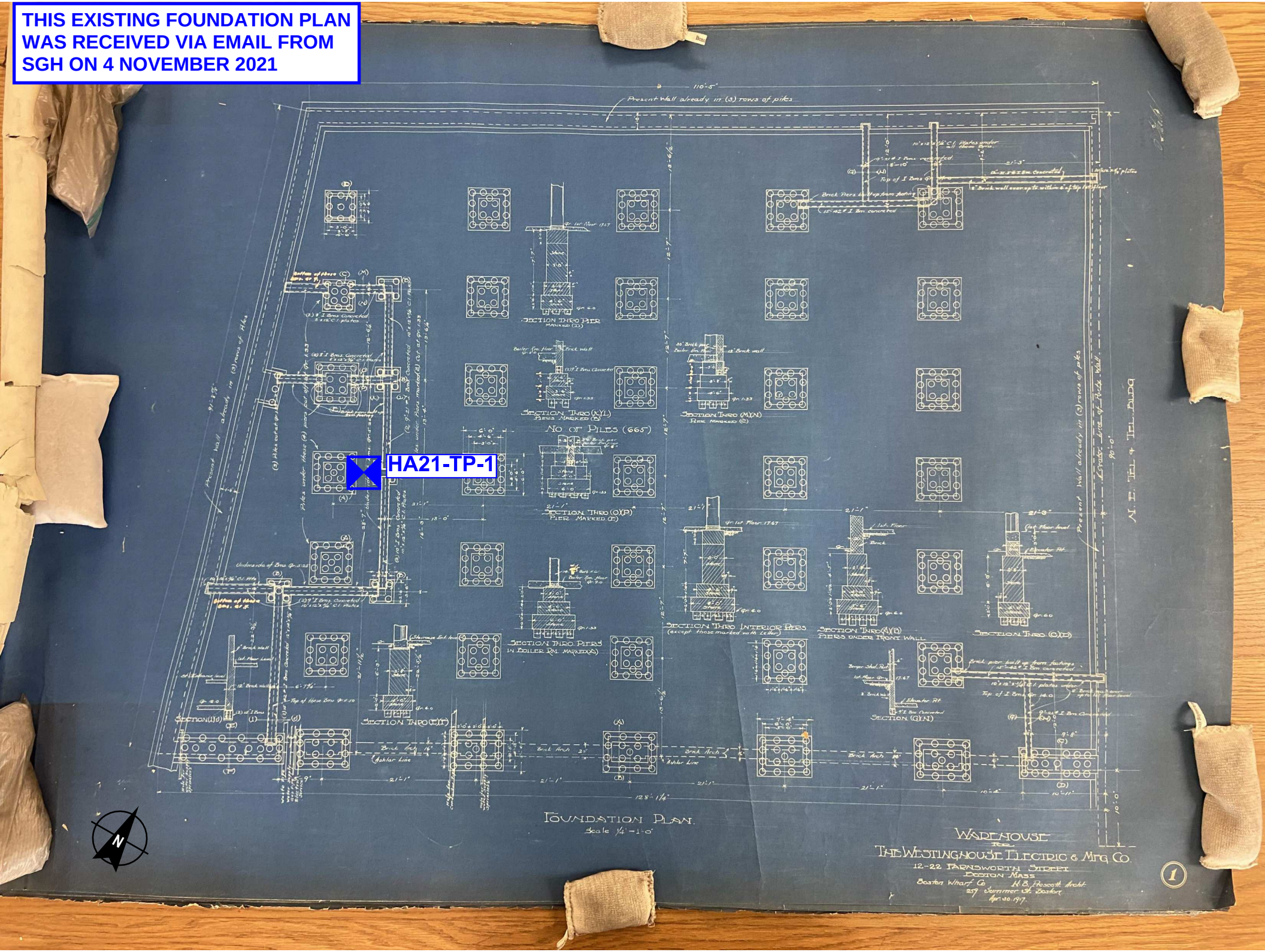
Boring No. HA21-1

H&A-TEST BORING WITH PERM PID COLUMN PLOG-HA-LIB09-BOS STANDARD ONLY - COPY.GLB HA-TB+CORE+WELL-09 W FENCE.GDT \\HALEYALDRICH.COM\SHARE\CF\PROJECTS\0201742\GINT\0201742-000-TB.GPJ Dec 9, 21

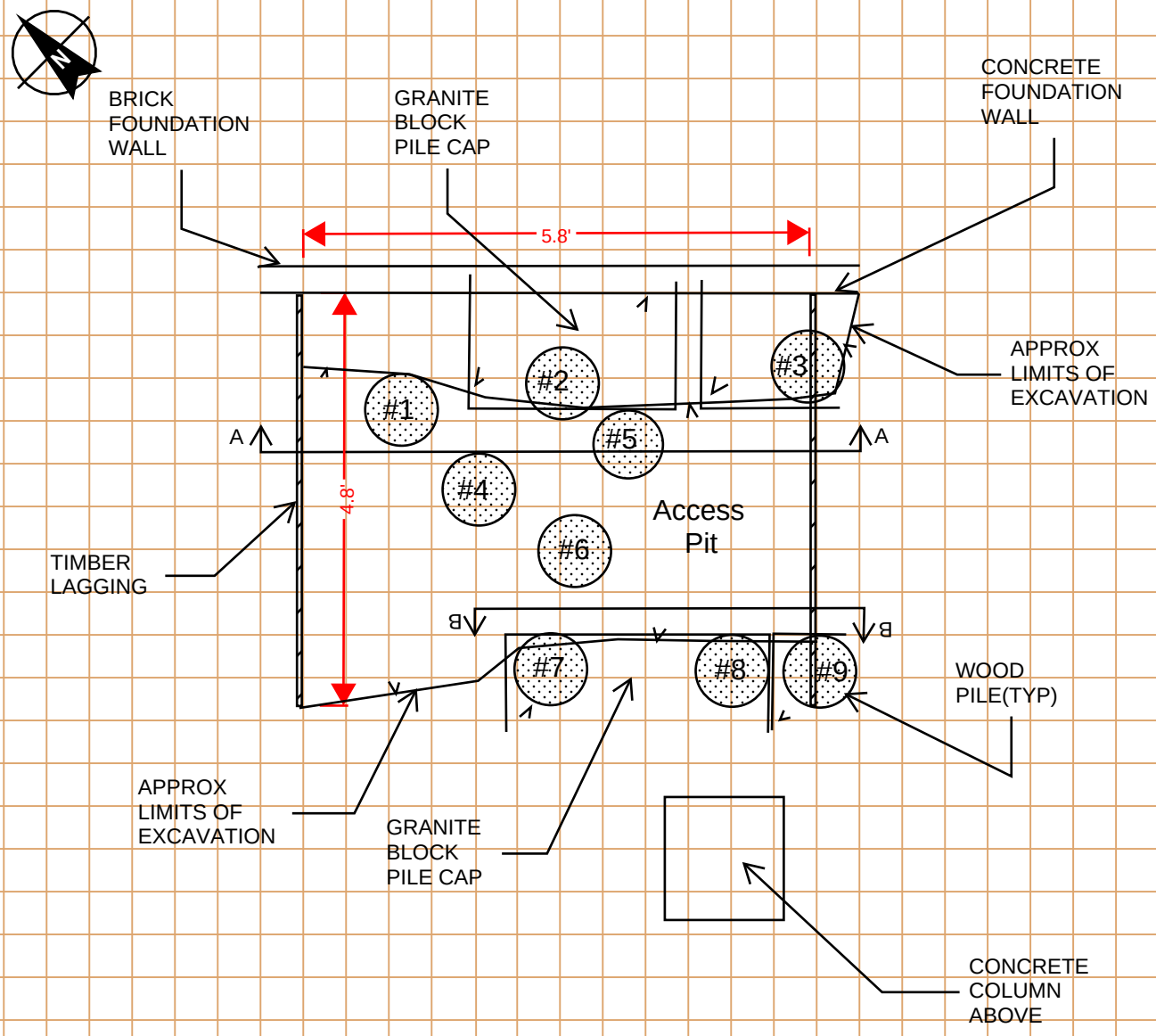
APPENDIX B

Test Pit HA21-TP-1 Log and Photographs

THIS EXISTING FOUNDATION PLAN WAS RECEIVED VIA EMAIL FROM SGH ON 4 NOVEMBER 2021



HALEY ALDRICH		File No.	0201742-000
		Sheet	1 of 3
Client	BP3-BOS 7 12 Farnsworth LLC	Date	12/1/2021
Project	12 Farnsworth Street, Boston, MA	Computed By	RPB
Subject	Existing Foundation Investigation	Checked By	NAS

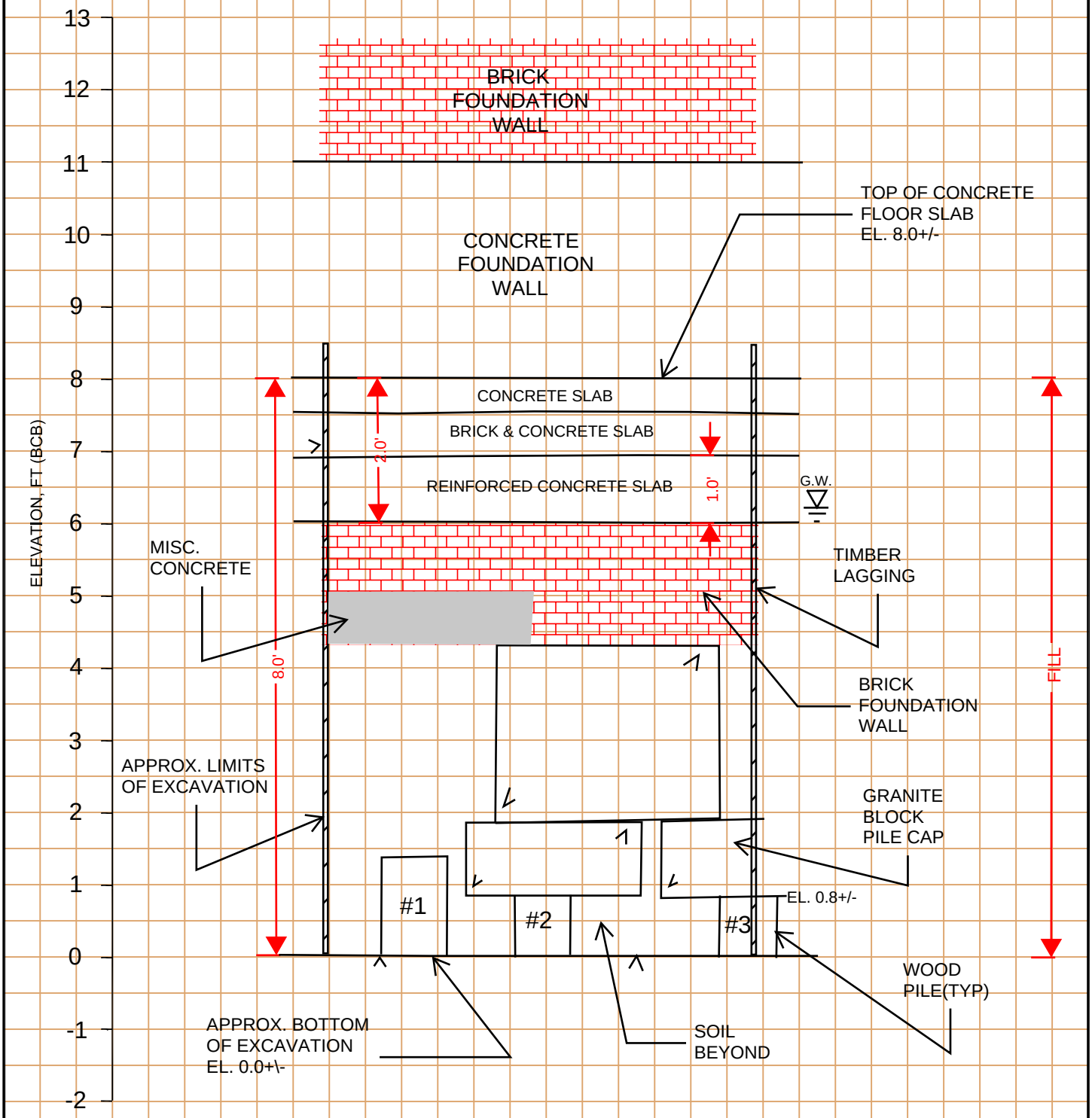


0 2
SCALE: 1 IN. = FT.

TEST PIT NO. HA21-TP-1

FIGURE 3

HALEY ALDRICH		File No.	0201742-000
		Sheet	2 of 3
Client	BP3-BOS 7 12 Farnsworth LLC	Date	12/1/2021
Project	12 Farnsworth Street, Boston, MA	Computed By	RPB
Subject	Existing Foundation Investigation	Checked By	NAS



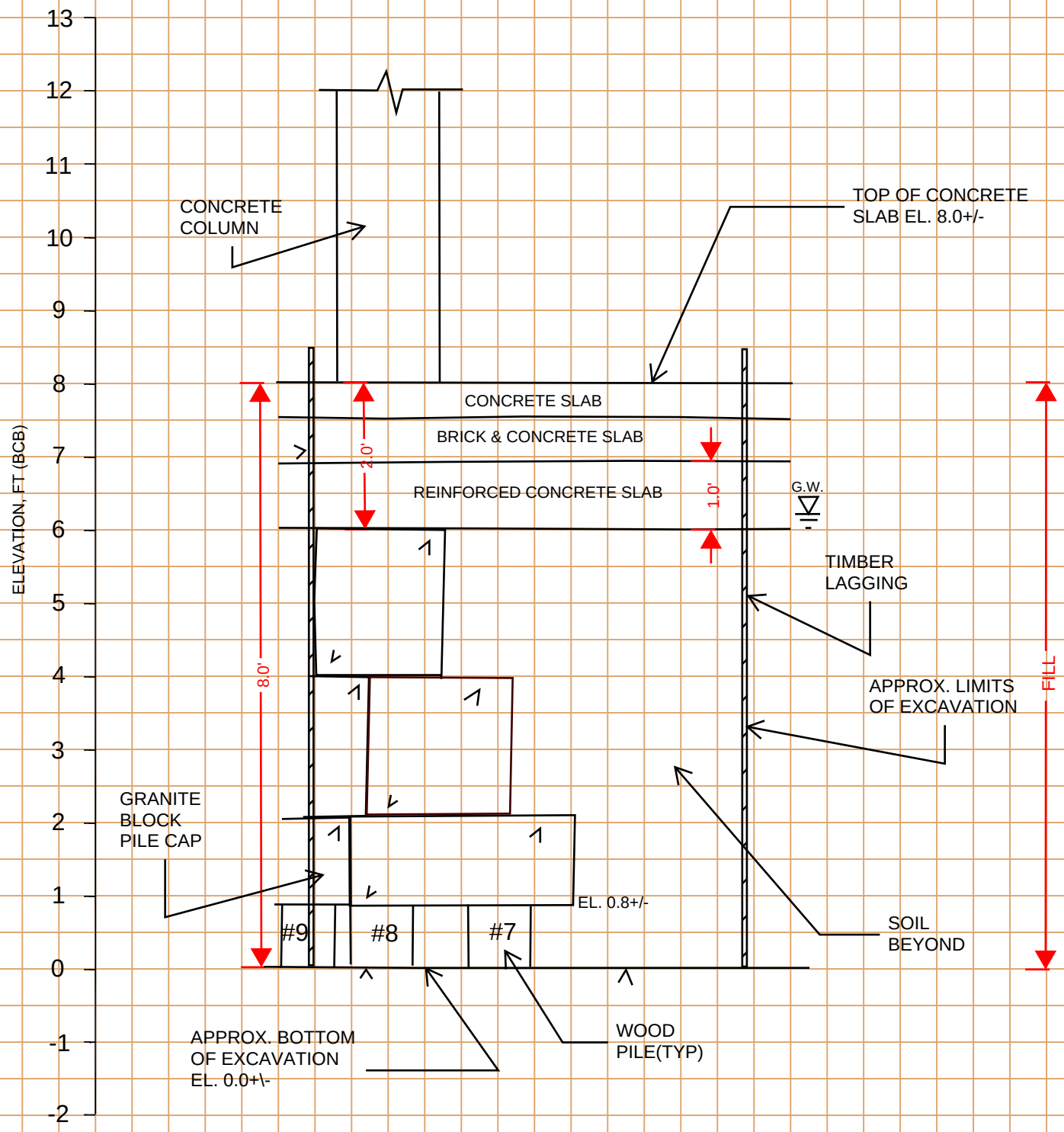
SECTION A-A
ELEVATION VIEW

0 2
SCALE: 1 IN. = FT.

TEST PIT NO. HA21-TP-1

FIGURE 4

HALEY ALDRICH		File No.	0201742-000
		Sheet	3 of 3
Client	BP3-BOS 7 12 Farnsworth LLC	Date	12/1/2021
Project	12 Farnsworth Street, Boston, MA	Computed By	RPB
Subject	Existing Foundation Investigation	Checked By	NAS



SECTION B-B
ELEVATION VIEW

0 2
SCALE: 1 IN. = FT.

TEST PIT NO. HA21-TP-1

FIGURE 5

Photograph No. 1: Facing east (note existing pile cap and timber piles #1, #2, #4, #5, and #6)

HALEY ALDRICH

12 FARNSWORTH STREET

BOSTON, MASSACHUSETTS

PHOTOGRAPH OF CONDITIONS OBSERVED AT TEST PIT HA21-TP-1

FILE NO. 0201742-000 JANUARY 2022

Photograph No. 2: Existing basement slabs totaling 2-ft-thick (note upper 6-in.-thick concrete topping slab, middle 6-in.-thick brick and concrete slab, and lower 1-ft-thick reinforced concrete slab)

HALEY ALDRICH

12 FARNSWORTH STREET

BOSTON, MASSACHUSETTS

PHOTOGRAPH OF CONDITIONS OBSERVED AT TEST PIT HA21-TP-1

FILE NO. 0201742-000 JANUARY 2022

Photograph No. 3: Facing east (note existing pile cap, timber piles #1, #2, #4, and #5, and saturated fill with debris)

HALEY ALDRICH

12 FARNSWORTH STREET

BOSTON, MASSACHUSETTS

PHOTOGRAPH OF CONDITIONS OBSERVED AT TEST PIT HA21-TP-1

FILE NO. 0201742-000 JANUARY 2022

Photograph No. 4: Existing timber pile #2 supporting granite block pile cap

HALEY ALDRICH

12 FARNSWORTH STREET

BOSTON, MASSACHUSETTS

PHOTOGRAPH OF CONDITIONS OBSERVED AT TEST PIT HA21-TP-1

FILE NO. 0201742-000 JANUARY 2022

Photograph No. 5: Facing southeast

HALEY ALDRICH

12 FARNSWORTH STREET

BOSTON, MASSACHUSETTS

PHOTOGRAPH OF CONDITIONS OBSERVED AT TEST PIT HA21-TP-1

FILE NO. 0201742-000 JANUARY 2022

APPENDIX C

Haley & Aldrich Soil Precharacterization Group Classification System

APPENDIX C
HALEY & ALDRICH SOIL PRECHARACTERIZATION GROUP CLASSIFICATION SYSTEM

Haley & Aldrich has developed the following Soil Precharacterization Group Classification System to describe soil quality with regards to both Massachusetts Contingency Plan (MCP) requirements and disposal facility requirements (COMM-97-001 and specific facility requirements):

GROUP I (NON-REPORTABLE SOILS; NON-REMEDIATION WASTE)

- Group I-1: Naturally deposited soils that contain no detectable contaminant concentrations above those included in Table I (Concentration in "Natural Soil") of DEP's Technical Update to WSC/ORS # 95-141 "Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil," dated May 2002 and naturally occurring metals that may be attributed to background (either above or below the DEP published background or applicable Reportable Concentrations) and not associated with a release and that are not otherwise a hazardous waste, as specified in DEP Policy.

- Group I-2: Naturally deposited soils that contain oil, waste oil, or hazardous materials at concentrations less than applicable RCS-1 Reportable Concentrations specified in 310 CMR 40.1600, and greater than DEP published background concentrations for Natural Soil, and that are not otherwise a hazardous waste, as specified in DEP Policy.

- Group I-3: Urban fill soils that contain oil, waste oil, or hazardous materials at concentrations less than applicable RCS-1 Reportable Concentrations specified in CMR 40.1600, and that are not otherwise a hazardous waste, as specified in DEP Policy.

GROUP II (REPORTABLE SOILS; REMEDIATION WASTE)

- Group II-1: Material which meets the COMM-97-001 criteria for disposal at in-state unlined landfills to be reused as daily cover, intermediate cover, and pre-cap contouring material.

- Group II-2: Material which meets the COMM-97-001 criteria for disposal at in-state lined facilities to be reused as daily cover, intermediate cover, and pre-cap contouring material.

- Group II-3: Material which meets the WSC-94-400 criteria for regional recycling. These materials may also be acceptable for reuse as intermediate or alternate daily cover at RCRA Subtitle D facilities.

- Group II-4: Material which contains concentrations of contaminants that exceed lined and unlined landfill reuse but meet the criteria for regional thermal treatment facilities.

- Group II-5: RCRA non-hazardous waste material which contains concentrations of contaminants that exceed acceptance criteria for regional recycling or thermal treatment facilities. This material may be transported to a regional RCRA Subtitle D facility that accepts non-hazardous waste and de-characterized hazardous waste for disposal. This material also includes listed Hazardous Waste that meets the requirements for a "Contained-In" determination made by an LSP and submitted to DEP for review as outlined in DEP Technical Update "Considerations for Managing Contaminated Soil; RCRA Land Disposal Restrictions and Contained-In Determinations" dated August 2010.

GROUP III (HAZARDOUS WASTE)

- Group III-1: Soils determined to contain "listed" or "characteristic" hazardous waste constituents that cannot be readily treated on-site. This material must be transported to an out-of-state approved RCRA Subtitle C hazardous waste disposal or treatment facility that has been approved by the Owner.

- Group III-2: Soils determined to exhibit a "characteristic" of hazardous waste such as ignitability, corrosivity, reactivity or toxicity (leachability) or soils that contain hazardous constituents from a listed hazardous waste that can be successfully treated on-site and no longer exhibits a characteristic of hazardous waste or has been determined (by the applicability of the Contained-in Determination) that the material is no longer a hazardous waste.

APPENDIX D

Laboratory Analytical Data Reports

ANALYTICAL REPORT

Lab Number:	L2161350
Client:	Haley & Aldrich, Inc. 465 Medford Street, Suite 2200 Charlestown, MA 02129
ATTN:	Nathan Sherwood
Phone:	(617) 886-7400
Project Name:	12 FARNSWORTH STREET
Project Number:	201742-000
Report Date:	11/16/21

The original project report/data package is held by Alpha Analytical. This report/data package is paginated and should be reproduced only in its entirety. Alpha Analytical holds no responsibility for results and/or data that are not consistent with the original.

Certifications & Approvals: MA (M-MA086), NH NELAP (2064), CT (PH-0574), IL (200077), ME (MA00086), MD (348), NJ (MA935), NY (11148), NC (25700/666), PA (68-03671), RI (LAO00065), TX (T104704476), VT (VT-0935), VA (460195), USDA (Permit #P330-17-00196).

Eight Walkup Drive, Westborough, MA 01581-1019
508-898-9220 (Fax) 508-898-9193 800-624-9220 - www.alphalab.com

Project Name: 12 FARNSWORTH STREET
Project Number: 201742-000

Lab Number: L2161350
Report Date: 11/16/21

Alpha Sample ID	Client ID	Matrix	Sample Location	Collection Date/Time	Receive Date
L2161350-01	HA21-1-0-6	SOIL	BOSTON, MA	11/04/21 08:30	11/04/21

Project Name:	12 FARNSWORTH STREET	**Lab Number:**	L2161350
Project Number:	201742-000	**Report Date:**	11/16/21

Case Narrative

The samples were received in accordance with the Chain of Custody and no significant deviations were encountered during the preparation or analysis unless otherwise noted. Sample Receipt, Container Information, and the Chain of Custody are located at the back of the report.

Results contained within this report relate only to the samples submitted under this Alpha Lab Number and meet NELAP requirements for all NELAP accredited parameters unless otherwise noted in the following narrative. The data presented in this report is organized by parameter (i.e. VOC, SVOC, etc.). Sample specific Quality Control data (i.e. Surrogate Spike Recovery) is reported at the end of the target analyte list for each individual sample, followed by the Laboratory Batch Quality Control at the end of each parameter. Tentatively Identified Compounds (TICs), if requested, are reported for compounds identified to be present and are not part of the method/program Target Compound List, even if only a subset of the TCL are being reported. If a sample was re-analyzed or re-extracted due to a required quality control corrective action and if both sets of data are reported, the Laboratory ID of the re-analysis or re-extraction is designated with an "R" or "RE", respectively.

When multiple Batch Quality Control elements are reported (e.g. more than one LCS), the associated samples for each element are noted in the grey shaded header line of each data table. Any Laboratory Batch, Sample Specific % recovery or RPD value that is outside the listed Acceptance Criteria is bolded in the report. In reference to questions H (CAM) or 4 (RCP) when "NO" is checked, the performance criteria for CAM and RCP methods allow for some quality control failures to occur and still be within method compliance. In these instances, the specific failure is not narrated but noted in the associated QC Outlier Summary Report, located directly after the Case Narrative. QC information is also incorporated in the Data Usability Assessment table (Format 11) of our Data Merger tool, where it can be reviewed in conjunction with the sample result, associated regulatory criteria and any associated data usability implications.

Soil/sediments, solids and tissues are reported on a dry weight basis unless otherwise noted. Definitions of all data qualifiers and acronyms used in this report are provided in the Glossary located at the back of the report.

HOLD POLICY - For samples submitted on hold, Alpha's policy is to hold samples (with the exception of Air canisters) free of charge for 21 calendar days from the date the project is completed. After 21 calendar days, we will dispose of all samples submitted including those put on hold unless you have contacted your Alpha Project Manager and made arrangements for Alpha to continue to hold the samples. Air canisters will be disposed after 3 business days from the date the project is completed.

Please contact Project Management at 800-624-9220 with any questions.

I, the undersigned, attest under the pains and penalties of perjury that, to the best of my knowledge and belief and based upon my personal inquiry of those responsible for providing the information contained in this analytical report, such information is accurate and complete. This certificate of analysis is not complete unless this page accompanies any and all pages of this report.

Authorized Signature: Caitlin Walukevich

Caitlin Walukevich

Title: Technical Director/Representative

Date: 11/16/21

METALS

Project Name: 12 FARNSWORTH STREET
Project Number: 201742-000
Lab Number: L2161350
Report Date: 11/16/21

SAMPLE RESULTS

Lab ID: L2161350-01
Client ID: HA21-1-0-6
Sample Location: BOSTON, MA

Date Collected: 11/04/21 08:30
Date Received: 11/04/21
Field Prep: Not Specified

Sample Depth:
Matrix: Soil

TCLP/SPLP Ext. Date: 11/11/21 22:07

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Prep Method	Analytical Method	Analyst
TCLP Metals by EPA 1311 - Mansfield Lab											
Lead, TCLP	ND		mg/l	0.500	--	1	11/15/21 10:34	11/15/21 16:49	EPA 3015	1,6010D	SV
Mercury, TCLP	ND		mg/l	0.0010	--	1	11/15/21 11:01	11/15/21 14:05	EPA 7470A	1,7470A	AC

Project Name: 12 FARNSWORTH STREET **Lab Number:** L2161350

Project Number: 201742-000 **Report Date:** 11/16/21

Method Blank Analysis
Batch Quality Control

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
TCLP Metals by EPA 1311 - Mansfield Lab for sample(s): 01 Batch: WG1571384-1										
Lead, TCLP	ND		mg/l	0.500	--	1	11/15/21 10:34	11/15/21 15:47	1,6010D	SV

Prep Information

Digestion Method: EPA 3015

TCLP/SPLP Extraction Date: 11/10/21 22:03

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
TCLP Metals by EPA 1311 - Mansfield Lab for sample(s): 01 Batch: WG1571386-1										
Mercury, TCLP	ND		mg/l	0.0010	--	1	11/15/21 11:01	11/15/21 13:39	1,7470A	AC

Prep Information

Digestion Method: EPA 7470A

TCLP/SPLP Extraction Date: 11/10/21 22:03

Lab Control Sample Analysis
Batch Quality Control

Project Name: 12 FARNSWORTH STREET
Project Number: 201742-000

Lab Number: L2161350
Report Date: 11/16/21

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
TCLP Metals by EPA 1311 - Mansfield Lab Associated sample(s): 01 Batch: WG1571384-2								
Lead, TCLP	96		-		75-125	-		20
TCLP Metals by EPA 1311 - Mansfield Lab Associated sample(s): 01 Batch: WG1571386-2								
Mercury, TCLP	110		-		80-120	-		

Matrix Spike Analysis
Batch Quality Control

Project Name: 12 FARNSWORTH STREET
Project Number: 201742-000
Lab Number: L2161350
Report Date: 11/16/21

Parameter	Native Sample	MS Added	MS Found	MS %Recovery	Qual	MSD Found	MSD %Recovery	Qual	Recovery Limits	RPD	Qual	RPD Limits
TCLP Metals by EPA 1311 - Mansfield Lab Associated sample(s): 01 QC Batch ID: WG1571384-3 QC Sample: L2161979-01 Client ID: MS Sample												
Lead, TCLP	ND	5.3	5.58	105		-	-		75-125	-		20
TCLP Metals by EPA 1311 - Mansfield Lab Associated sample(s): 01 QC Batch ID: WG1571386-3 QC Sample: L2161313-02 Client ID: MS Sample												
Mercury, TCLP	ND	0.025	0.0239	96		-	-		80-120	-		20

Lab Duplicate Analysis

Batch Quality Control

Project Name: 12 FARNSWORTH STREET

Project Number: 201742-000

Lab Number: L2161350

Report Date: 11/16/21

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
TCLP Metals by EPA 1311 - Mansfield Lab Associated sample(s): 01 QC Batch ID: WG1571384-4 QC Sample: L2161979-01 Client ID: DUP Sample						
Lead, TCLP	ND	ND	mg/l	NC		20
TCLP Metals by EPA 1311 - Mansfield Lab Associated sample(s): 01 QC Batch ID: WG1571386-4 QC Sample: L2161313-02 Client ID: DUP Sample						
Mercury, TCLP	ND	ND	mg/l	NC		20

Project Name: 12 FARNSWORTH STREET
Project Number: 201742-000

Lab Number: L2161350
Report Date: 11/16/21

Sample Receipt and Container Information

Were project specific reporting limits specified? YES

Cooler Information

Cooler	Custody Seal
A	Absent

Container Information

Container ID	Container Type	Cooler	Initial pH	Final pH	Temp deg C	Pres	Seal	Frozen Date/Time	Analysis(*)
L2161350-01H	Glass 500ml/16oz unpreserved	A	NA		3.4	Y	Absent		-
L2161350-01X	Plastic 120ml HNO3 preserved Extracts	A	NA		3.4	Y	Absent		HG-C(28),PB-CI(180)
L2161350-01X9	Tumble Vessel	A	NA		3.4	Y	Absent		-

*Values in parentheses indicate holding time in days

Project Name: 12 FARNSWORTH STREET **Lab Number:** L2161350

Project Number: 201742-000 **Report Date:** 11/16/21

GLOSSARY

Acronyms

DL	- Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the limit of quantitation (LOQ). The DL includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.)
EDL	- Estimated Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The EDL includes any adjustments from dilutions, concentrations or moisture content, where applicable. The use of EDLs is specific to the analysis of PAHs using Solid-Phase Microextraction (SPME).
EMPC	- Estimated Maximum Possible Concentration: The concentration that results from the signal present at the retention time of an analyte when the ions meet all of the identification criteria except the ion abundance ratio criteria. An EMPC is a worst-case estimate of the concentration.
EPA	- Environmental Protection Agency.
LCS	- Laboratory Control Sample: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.
LCSD	- Laboratory Control Sample Duplicate: Refer to LCS.
LFB	- Laboratory Fortified Blank: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.
LOD	- Limit of Detection: This value represents the level to which a target analyte can reliably be detected for a specific analyte in a specific matrix by a specific method. The LOD includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.)
LOQ	- Limit of Quantitation: The value at which an instrument can accurately measure an analyte at a specific concentration. The LOQ includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.) Limit of Quantitation: The value at which an instrument can accurately measure an analyte at a specific concentration. The LOQ includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.)
MDL	- Method Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The MDL includes any adjustments from dilutions, concentrations or moisture content, where applicable.
MS	- Matrix Spike Sample: A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. For Method 332.0, the spike recovery is calculated using the native concentration, including estimated values.
MSD	- Matrix Spike Sample Duplicate: Refer to MS.
NA	- Not Applicable.
NC	- Not Calculated: Term is utilized when one or more of the results utilized in the calculation are non-detect at the parameter's reporting unit.
NDPA/DPA	- N-Nitrosodiphenylamine/Diphenylamine.
NI	- Not Ignitable.
NP	- Non-Plastic: Term is utilized for the analysis of Atterberg Limits in soil.
NR	- No Results: Term is utilized when 'No Target Compounds Requested' is reported for the analysis of Volatile or Semivolatile Organic TIC only requests.
RL	- Reporting Limit: The value at which an instrument can accurately measure an analyte at a specific concentration. The RL includes any adjustments from dilutions, concentrations or moisture content, where applicable.
RPD	- Relative Percent Difference: The results from matrix and/or matrix spike duplicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD). Values which are less than five times the reporting limit for any individual parameter are evaluated by utilizing the absolute difference between the values; although the RPD value will be provided in the report.
SRM	- Standard Reference Material: A reference sample of a known or certified value that is of the same or similar matrix as the associated field samples.
STLP	- Semi-dynamic Tank Leaching Procedure per EPA Method 1315.
TEF	- Toxic Equivalency Factors: The values assigned to each dioxin and furan to evaluate their toxicity relative to 2,3,7,8-TCDD.
TEQ	- Toxic Equivalent: The measure of a sample's toxicity derived by multiplying each dioxin and furan by its corresponding TEF and then summing the resulting values.
TIC	- Tentatively Identified Compound: A compound that has been identified to be present and is not part of the target compound list (TCL) for the method and/or program. All TICs are qualitatively identified and reported as estimated concentrations.

Report Format: Data Usability Report

Project Name:	12 FARNSWORTH STREET	**Lab Number:**	L2161350
Project Number:	201742-000	**Report Date:**	11/16/21

Footnotes

1 - The reference for this analyte should be considered modified since this analyte is absent from the target analyte list of the original method.

Terms

Analytical Method: Both the document from which the method originates and the analytical reference method. (Example: EPA 8260B is shown as 1,8260B.) The codes for the reference method documents are provided in the References section of the Addendum.

Difference: With respect to Total Oxidizable Precursor (TOP) Assay analysis, the difference is defined as the Post-Treatment value minus the Pre-Treatment value.

Final pH: As it pertains to Sample Receipt & Container Information section of the report, Final pH reflects pH of container determined after adjustment at the laboratory, if applicable. If no adjustment required, value reflects Initial pH.

Frozen Date/Time: With respect to Volatile Organics in soil, Frozen Date/Time reflects the date/time at which associated Reagent Water-preserved vials were initially frozen. Note: If frozen date/time is beyond 48 hours from sample collection, value will be reflected in 'bold'.

Initial pH: As it pertains to Sample Receipt & Container Information section of the report, Initial pH reflects pH of container determined upon receipt, if applicable.

PAH Total: With respect to Alkylated PAH analyses, the 'PAHs, Total' result is defined as the summation of results for all or a subset of the following compounds: Naphthalene, C1-C4 Naphthalenes, 2-Methylnaphthalene, 1-Methylnaphthalene, Biphenyl, Acenaphthylene, Acenaphthene, Fluorene, C1-C3 Fluorenes, Phenanthrene, C1-C4 Phenanthrenes/Anthracenes, Anthracene, Fluoranthene, Pyrene, C1-C4 Fluoranthenes/Pyrenes, Benz(a)anthracene, Chrysene, C1-C4 Chrysenes, Benzo(b)fluoranthene, Benzo(j)+(k)fluoranthene, Benzo(e)pyrene, Benzo(a)pyrene, Perylene, Indeno(1,2,3-cd)pyrene, Dibenz(ah)+(ac)anthracene, Benzo(g,h,i)perylene. If a 'Total' result is requested, the results of its individual components will also be reported.

PFAS Total: With respect to PFAS analyses, the 'PFAS, Total (5)' result is defined as the summation of results for: PFHpA, PFHxS, PFOA, PFNA and PFOS. In addition, the 'PFAS, Total (6)' result is defined as the summation of results for: PFHpA, PFHxS, PFOA, PFNA, PFDA and PFOS. For MassDEP DW compliance analysis only, the 'PFAS, Total (6)' result is defined as the summation of results at or above the RL. Note: If a 'Total' result is requested, the results of its individual components will also be reported.

The target compound Chlordane (CAS No. 57-74-9) is reported for GC ECD analyses. Per EPA,this compound "refers to a mixture of chlordane isomers, other chlorinated hydrocarbons and numerous other components." (Reference: USEPA Toxicological Review of Chlordane, In Support of Summary Information on the Integrated Risk Information System (IRIS), December 1997.)

Total: With respect to Organic analyses, a 'Total' result is defined as the summation of results for individual isomers or Aroclors. If a 'Total' result is requested, the results of its individual components will also be reported. This is applicable to 'Total' results for methods 8260, 8081 and 8082.

Data Qualifiers

A - Spectra identified as "Aldol Condensates" are byproducts of the extraction/concentration procedures when acetone is introduced in the process.

B - The analyte was detected above the reporting limit in the associated method blank. Flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For MCP-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For DOD-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank AND the analyte was detected above one-half the reporting limit (or above the reporting limit for common lab contaminants) in the associated method blank. For NJ-Air-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte above the reporting limit. For NJ-related projects (excluding Air), flag only applies to associated field samples that have detectable concentrations of the analyte, which was detected above the reporting limit in the associated method blank or above five times the reporting limit for common lab contaminants (Phthalates, Acetone, Methylene Chloride, 2-Butanone).

C - Co-elution: The target analyte co-elutes with a known lab standard (i.e. surrogate, internal standards, etc.) for co-extracted analyses.

D - Concentration of analyte was quantified from diluted analysis. Flag only applies to field samples that have detectable concentrations of the analyte.

E - Concentration of analyte exceeds the range of the calibration curve and/or linear range of the instrument.

F - The ratio of quantifier ion response to qualifier ion response falls outside of the laboratory criteria. Results are considered to be an estimated maximum concentration.

G - The concentration may be biased high due to matrix interferences (i.e, co-elution) with non-target compound(s). The result should be considered estimated.

H - The analysis of pH was performed beyond the regulatory-required holding time of 15 minutes from the time of sample collection.

I - The lower value for the two columns has been reported due to obvious interference.

J - Estimated value. This represents an estimated concentration for Tentatively Identified Compounds (TICs).

M - Reporting Limit (RL) exceeds the MCP CAM Reporting Limit for this analyte.

ND - Not detected at the reporting limit (RL) for the sample.

NJ - Presumptive evidence of compound. This represents an estimated concentration for Tentatively Identified Compounds (TICs), where

Project Name:	12 FARNSWORTH STREET	**Lab Number:**	L2161350
Project Number:	201742-000	**Report Date:**	11/16/21

Data Qualifiers

the identification is based on a mass spectral library search.

P - The RPD between the results for the two columns exceeds the method-specified criteria.

Q - The quality control sample exceeds the associated acceptance criteria. For DOD-related projects, LCS and/or Continuing Calibration Standard exceedences are also qualified on all associated sample results. Note: This flag is not applicable for matrix spike recoveries when the sample concentration is greater than 4x the spike added or for batch duplicate RPD when the sample concentrations are less than 5x the RL. (Metals only.)

R - Analytical results are from sample re-analysis.

RE - Analytical results are from sample re-extraction.

S - Analytical results are from modified screening analysis.

V - The surrogate associated with this target analyte has a recovery outside the QC acceptance limits. (Applicable to MassDEP DW Compliance samples only.)

Z - The batch matrix spike and/or duplicate associated with this target analyte has a recovery/RPD outside the QC acceptance limits. (Applicable to MassDEP DW Compliance samples only.)

Project Name: 12 FARNSWORTH STREET **Lab Number:** L2161350
Project Number: 201742-000 **Report Date:** 11/16/21

REFERENCES

1 Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. EPA SW-846. Third Edition. Updates I - VI, 2018.

LIMITATION OF LIABILITIES

Alpha Analytical performs services with reasonable care and diligence normal to the analytical testing laboratory industry. In the event of an error, the sole and exclusive responsibility of Alpha Analytical shall be to re-perform the work at it's own expense. In no event shall Alpha Analytical be held liable for any incidental, consequential or special damages, including but not limited to, damages in any way connected with the use of, interpretation of, information or analysis provided by Alpha Analytical.

We strongly urge our clients to comply with EPA protocol regarding sample volume, preservation, cooling, containers, sampling procedures, holding time and splitting of samples in the field.

Certification Information

The following analytes are not included in our Primary NELAP Scope of Accreditation:

Westborough Facility
EPA 624/624.1: m/p-xylene, o-xylene, Naphthalene
EPA 625/625.1: alpha-Terpineol
EPA 8260C/8260D: NPW: 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene, Azobenzene; SCM: Iodomethane (methyl iodide), 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene.
EPA 8270D/8270E: NPW: Dimethylnaphthalene,1,4-Diphenylhydrazine, alpha-Terpineol; SCM: Dimethylnaphthalene,1,4-Diphenylhydrazine.
SM4500: NPW: Amenable Cyanide; SCM: Total Phosphorus, TKN, NO2, NO3.

Mansfield Facility
SM 2540D: TSS
EPA 8082A: NPW: PCB: 1, 5, 31, 87,101, 110, 141, 151, 153, 180, 183, 187.
EPA TO-15: Halothane, 2,4,4-Trimethyl-2-pentene, 2,4,4-Trimethyl-1-pentene, Thiophene, 2-Methylthiophene, 3-Methylthiophene, 2-Ethylthiophene, 1,2,3-Trimethylbenzene, Indan, Indene, 1,2,4,5-Tetramethylbenzene, Benzothiophene, 1-Methylnaphthalene.
Biological Tissue Matrix: EPA 3050B

The following analytes are included in our Massachusetts DEP Scope of Accreditation

Westborough Facility:

Drinking Water
EPA 300.0: Chloride, Nitrate-N, Fluoride, Sulfate; **EPA 353.2**: Nitrate-N, Nitrite-N; **SM4500NO3-F**: Nitrate-N, Nitrite-N; **SM4500F-C, SM4500CN-CE, EPA 180.1, SM2130B, SM4500Cl-D, SM2320B, SM2540C, SM4500H-B, SM4500NO2-B**
EPA 332: Perchlorate; **EPA 524.2:** THMs and VOCs; **EPA 504.1:** EDB, DBCP.
Microbiology: **SM9215B; SM9223-P/A, SM9223B-Colilert-QT,SM9222D**.

Non-Potable Water
SM4500H,B, EPA 120.1, SM2510B, SM2540C, SM2320B, SM4500CL-E, SM4500F-BC, SM4500NH3-BH: Ammonia-N and Kjeldahl-N, **EPA 350.1**: Ammonia-N, **LACHAT 10-107-06-1-B**: Ammonia-N, **EPA 351.1, SM4500NO3-F, EPA 353.2**: Nitrate-N, **SM4500P-E, SM4500P-B, E, SM4500SO4-E, SM5220D, EPA 410.4, SM5210B, SM5310C, SM4500CL-D, EPA 1664, EPA 420.1, SM4500-CN-CE, SM2540D, EPA 300: Chloride, Sulfate, Nitrate.**
EPA 624.1: Volatile Halocarbons & Aromatics,
EPA 608.3: Chlordane, Toxaphene, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, Dieldrin, DDD, DDE, DDT, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin Aldehyde, Heptachlor, Heptachlor Epoxide, PCBs
EPA 625.1: SVOC (Acid/Base/Neutral Extractables), **EPA 600/4-81-045**: PCB-Oil.
Microbiology: **SM9223B-Colilert-QT; Enterolert-QT, SM9221E, EPA 1600, EPA 1603, SM9222D.**

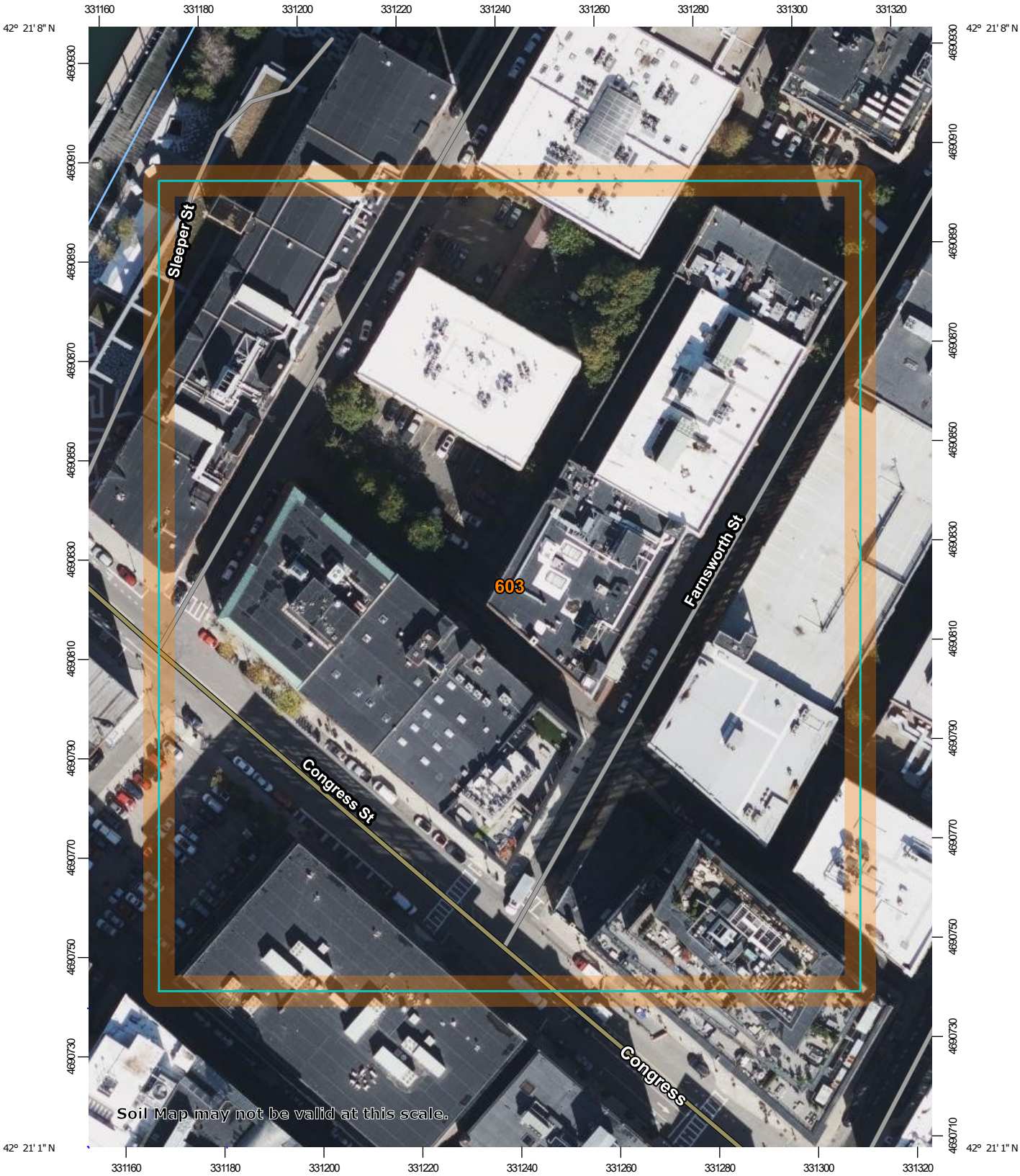
Mansfield Facility:

Drinking Water
EPA 200.7: Al, Ba, Cd, Cr, Cu, Fe, Mn, Ni, Na, Ag, Ca, Zn. **EPA 200.8:** Al, Sb, As, Ba, Be, Cd, Cr, Cu, Pb, Mn, Ni, Se, Ag, TL, Zn. **EPA 245.1** Hg.
EPA 522, EPA 537.1.

Non-Potable Water
EPA 200.7: Al, Sb, As, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Sr, TL, Ti, V, Zn.
EPA 200.8: Al, Sb, As, Be, Cd, Cr, Cu, Fe, Pb, Mn, Ni, K, Se, Ag, Na, TL, Zn.
EPA 245.1 Hg.
SM2340B

For a complete listing of analytes and methods, please contact your Alpha Project Manager.

Soil Map—Norfolk and Suffolk Counties, Massachusetts
((12 Farnsworth Street, Boston, MA))



Map Scale: 1:1,100 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 15 30 60 90

Feet: 0 50 100 200 300

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

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

Special Point Features

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

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

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

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

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

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

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

Soil Survey Area: Norfolk and Suffolk Counties, Massachusetts
Survey Area Data: Version 17, Sep 3, 2021

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

Date(s) aerial images were photographed: Aug 13, 2020—Oct 18, 2020

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
603	Urban land, wet substratum, 0 to 3 percent slopes	5.7	100.0%
Totals for Area of Interest		**5.7**	**100.0%**

U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with the
Commonwealth of Massachusetts
Massachusetts Geological Survey
and Executive Office for Administration and Finance

Scientific Investigations Map 3402
Quadrangle 126—Boston South
Discussion of surficial materials and description of map units available at https://doi.org/10.3133/sim3402

Base from U.S. Geological Survey, 1970

Map was scanned, processed, georeferenced, rectified, and cropped by the Massachusetts Geological Survey

Lambert Conformal Conic projection. North American Datum of 1983

Massachusetts state plane coordinate system, mainland zone

Hydrographic information is not intended for navigational purposes

15°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2018

SCALE 1:24 000

1 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

MASSACHUSETTS
MAP LOCATION

Map units were modified from LaForge (1932), and from Stone, B.D., 1982, unpublished field map; bedrock outcrops and areas of shallow bedrock were reproduced from Kaye (1980). Some units were mapped or revised from recent field studies and from analysis of topographic (lidar) data and 2005 orthophoto images.

Surficial Materials Map of the Boston South Quadrangle, Massachusetts

Compiled by
Byron D. Stone and Mary L. DiGiacomo-Cohen

2018

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government

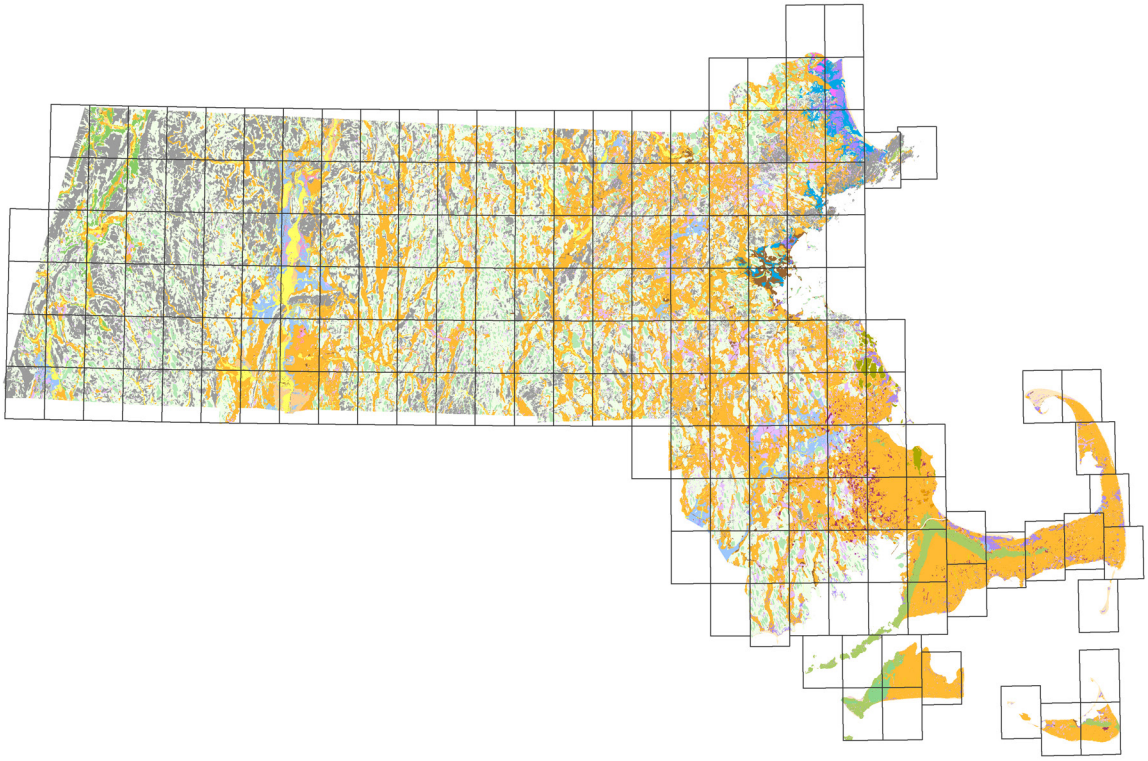
For sale by U.S. Geological Survey, Box 25286, Denver Federal Center, Denver, CO 80225; https://store.usgs.gov; 1–888–ASK–USGS (1–888–275–8747)

Suggested citation: Stone, B.D., and DiGiacomo-Cohen, M.L., comps., 2018, Surficial materials map of the Boston South quadrangle, Massachusetts, quadrangle 126 *in* Stone, J.R., Stone, B.D., DiGiacomo-Cohen, M.L., and Mabee, S.B., comps., Surficial materials of Massachusetts—A 1:24,000-scale geologic map database: U.S. Geological Survey Scientific Investigations Map 3402, 1 sheet, scale 1:24,000, https://doi.org/10.3133/sim3402.

ISSN 2329-132X (online)
https://doi.org/10.3133/sim3402

Prepared in cooperation with the Commonwealth of Massachusetts,
Massachusetts Geological Survey and Executive Office for Administration and Finance

Surficial Materials of Massachusetts—A 1:24,000-Scale Geologic Map Database



Pamphlet to accompany

Scientific Investigations Map 3402

Supersedes USGS Open-File Reports 2006–1260–A, –B, –C, –D, –E, –F, –G, and –I

U.S. Department of the Interior
U.S. Geological Survey

Cover. Map showing distribution of surficial materials in Massachusetts and the 7.5-minute quadrangle grid.

Surficial Materials of Massachusetts—A 1:24,000-Scale Geologic Map Database

Compiled by Janet Radway Stone, Byron D. Stone, Mary L. DiGiacomo-Cohen, and Stephen B. Mabee

Prepared in cooperation with the Commonwealth of Massachusetts, Massachusetts Geological Survey and Executive Office for Administration and Finance

Scientific Investigations Map 3402
Supersedes USGS Open-File Reports 2006–1260–A, –B, –C, –D, –E, –F, –G, and –I

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
RYAN K. ZINKE, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2018

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Suggested citation:
Stone, J.R., Stone, B.D., DiGiacomo-Cohen, M.L., and Mabee, S.B., comps., 2018, Surficial materials of Massachusetts—A 1:24,000-scale geologic map database: U.S. Geological Survey Scientific Investigations Map 3402, 189 sheets, scale 1:24,000; index map, scale 1:250,000; 58-p. pamphlet; and geodatabase files, https://doi.org/10.3133/sim3402.

ISSN 2329-132X (online)

Contents

Introduction....1
Surficial Materials in Massachusetts....1
Glacial Till and Moraine Deposits....4
Glacial Stratified Deposits....5
Postglacial Deposits....7
Map Compilation for Surficial Materials Quadrangle Maps....10
List of Surficial Materials Maps of Quadrangles 1–189....18
Description of Map Units....22
Postglacial Deposits....22
Early Postglacial Deposits....22
Glacial Stratified Deposits....23
Glacial Till and Moraine Deposits....24
Bedrock Areas....25
References Cited....26
Appendix 1. Sources of Data and Information on Map Units and Mapping, by 7.5-Minute Quadrangle....37

Map files

[Available for downloading at https://doi.org/10.3133/sim3402.]

Index map of 7.5-minute quadrangles in Massachusetts showing distribution of surficial materials, at 1:250,000 scale

Surficial materials maps of quadrangles 1–189, at 1:24,000 scale

Figures

1. Shaded-relief maps of Massachusetts showing major cities, selected physiographic regions, major rivers, and other cited features....2
2–7. Photographs showing:
2. Exposure of red till derived from Mesozoic sedimentary rocks of the Connecticut Valley lowland, in the West Springfield quadrangle....4
3. Exposure of gray till derived from metamorphic rocks in the Haverhill quadrangle....4
4. Ablation till matrix surrounding numerous large boulders in the Dogtown moraine, Gloucester quadrangle....5
5. Gravel deposit containing some sand beds in fluvial meltwater terrace sediments in the Woronoco quadrangle....5
6. Sand deposit of delta bottomset beds containing crossbedded sands interbedded with layers of very fine sand and silt, in the Southwick quadrangle....5
7. Varved silt and clay deposits in outcrop and in core deposited in glacial Lake Hitchcock in the Connecticut Valley lowland....6

8. South-to-north cross section showing typical distribution of surficial materials in most valleys in Massachusetts, resulting from sequential morphosequence deposition by a northward-retreating ice sheet....8
9. Block diagrams illustrating the typical areal and vertical distribution of glacial and postglacial deposits overlying bedrock in the Connecticut River valley and in the Cape Cod and islands region....9
10. Index map of 7.5-minute, 1:24,000-scale quadrangles in Massachusetts....10
11. Maps showing database layers in a portion of the Mount Toby quadrangle....14
12. Diagram showing grain-size classification used in this report....23

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)

Surficial Materials of Massachusetts—A 1:24,000-Scale Geologic Map Database

Compiled by Janet Radway Stone,[1] Byron D. Stone,[1] Mary L. DiGiacomo-Cohen,[1] and Stephen B. Mabee[2]

Introduction

The surficial geologic map database defines the distribution of nonlithified earth materials at the land surface in the 189 7.5-minute, 1:24,000-scale quadrangles that cover the Commonwealth of Massachusetts (index map), an area of approximately 10,554 square miles (mi^2). Across Massachusetts, these materials range in thickness from a few feet to more than 500 feet (ft). In some places, surficial materials are absent where bedrock is at the land surface. The geologic map database differentiates surficial materials of Quaternary age on the basis of their lithologic characteristics (such as grain size and sedimentary structures), constructional geomorphic features, stratigraphic relationships, and age. Surficial materials also are known in engineering classifications as unconsolidated soils, which include coarse-grained soils, fine-grained soils, and organic fine-grained soils. Surficial materials underlie and are the parent materials of modern pedogenic soils, which have developed in the surficial materials at the land surface. Surficial earth materials significantly affect human use of the land, and an accurate description of their distribution is particularly important for assessing water resources, construction-aggregate resources, and earth-surface hazards, and for making land-use decisions.

The mapped distribution of surficial materials that lie between the land surface and the bedrock surface is based on detailed geologic mapping of 7.5-minute topographic quadrangles, produced as part of an earlier (1938–1982) cooperative statewide mapping program between the U.S. Geological Survey (USGS) and the Massachusetts Department of Public Works (now Massachusetts Department of Transportation) (Page, 1967; Stone, 1982). Each of the 105 published geologic quadrangle maps presents a detailed description of local geologic map units, discusses the genesis of the deposits, and gives age correlations among units. Previously unpublished field compilation maps exist on paper or mylar sheets for 84 quadrangles, and these have been digitally rendered for the present map compilation. Regional summaries based on the Massachusetts surficial geologic mapping studies discuss the ages of multiple glaciations, the nature of glaciofluvial, glaciolacustrine, and glaciomarine deposits, and the processes of ice advance and retreat across Massachusetts (Koteff and Pessl, 1981; papers in Larson and Stone, 1982; Oldale and Barlow, 1986; Stone and Borns, 1986; Warren and Stone, 1986).

This compilation of surficial geologic materials defines the areas of exposed bedrock and the boundaries between glacial till, glacial stratified deposits, and overlying postglacial deposits at a 1:24,000-scale level of accuracy. The surficial geologic map database covering 189 quadrangles revises previous digital surficial geologic maps (Stone and others, 1993; MassGIS, 1999) that were compiled on base maps at regional scales of 1:125,000 and 1:250,000. The purpose of this study is to provide fundamental geologic data for the evaluation of natural resources, hazards, and land information within the Commonwealth of Massachusetts.

Surficial Materials in Massachusetts

Most of the surficial materials in Massachusetts (index map) are deposits of the last two continental ice sheets that covered all of New England in the latter part of the Pleistocene ice age (Schafer and Hartshorn, 1965; Oldale and others, 1982; Stone and Borns, 1986). The glacial deposits are divided into two broad categories, ***glacial till and moraine deposits*** and ***glacial stratified deposits***. Till, the most widespread glacial deposit, was laid down directly by glacier ice. Glacial stratified deposits are concentrated in valleys and lowland areas and were laid down by glacial meltwater in streams, lakes, and the sea in front of the retreating ice margin during the last deglaciation. ***Postglacial deposits***, primarily flood-plain alluvium and swamp deposits, make up a lesser proportion of the unconsolidated materials.

The bedrock surface in Massachusetts generally consists of relatively fresh, unweathered bedrock, but in some places such as in the Housatonic Valley (fig. 1) in the western part of the Commonwealth, there is a locally thick saprolitic cover.

[1]U.S. Geological Survey.

[2]Massachusetts Geological Survey.

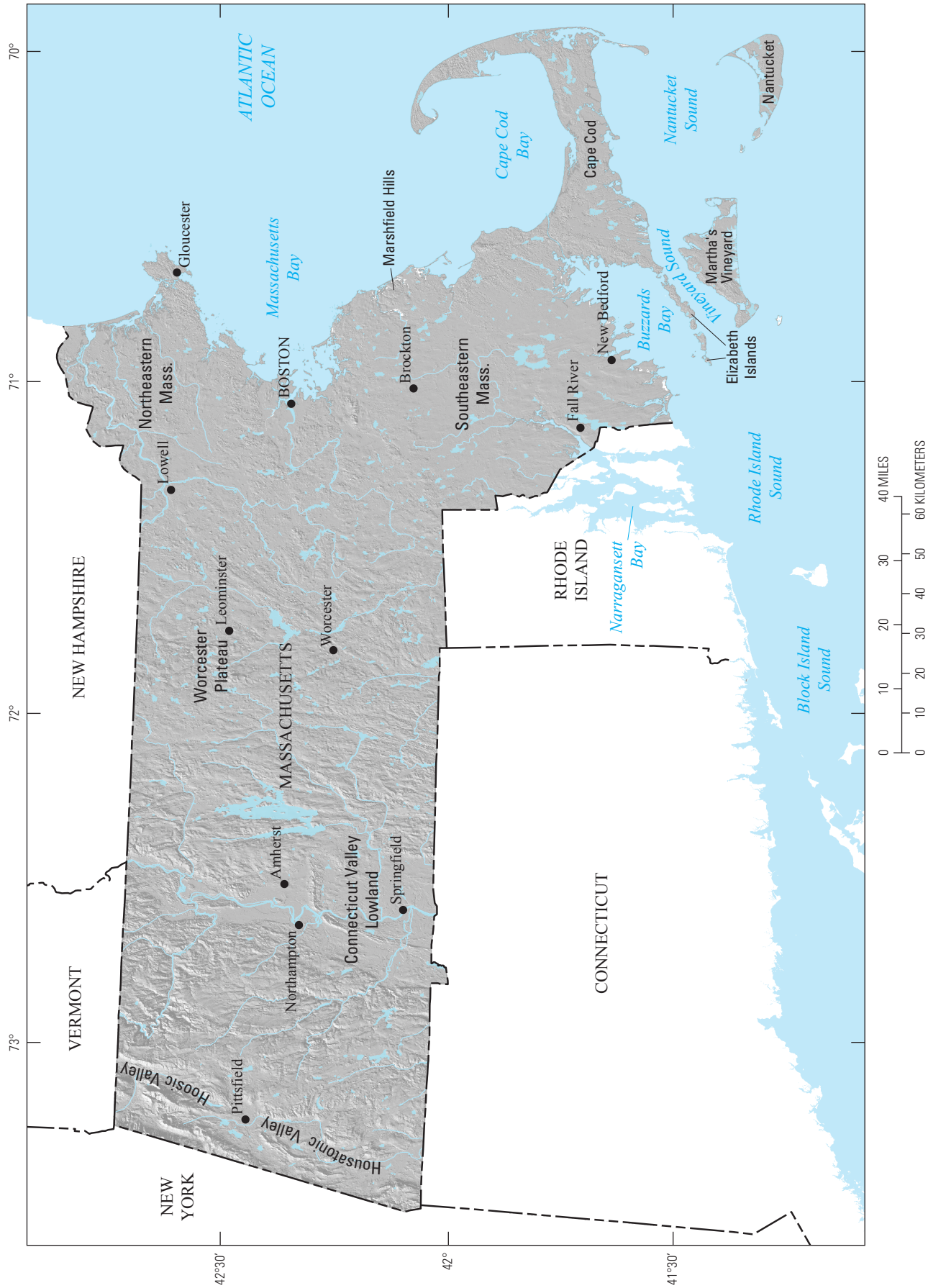

Figure 1A. Shaded-relief map of Massachusetts showing major cities, selected physiographic regions, and other cited features. Shaded relief is from Massachusetts Bureau of Geographic Information (MassGIS).

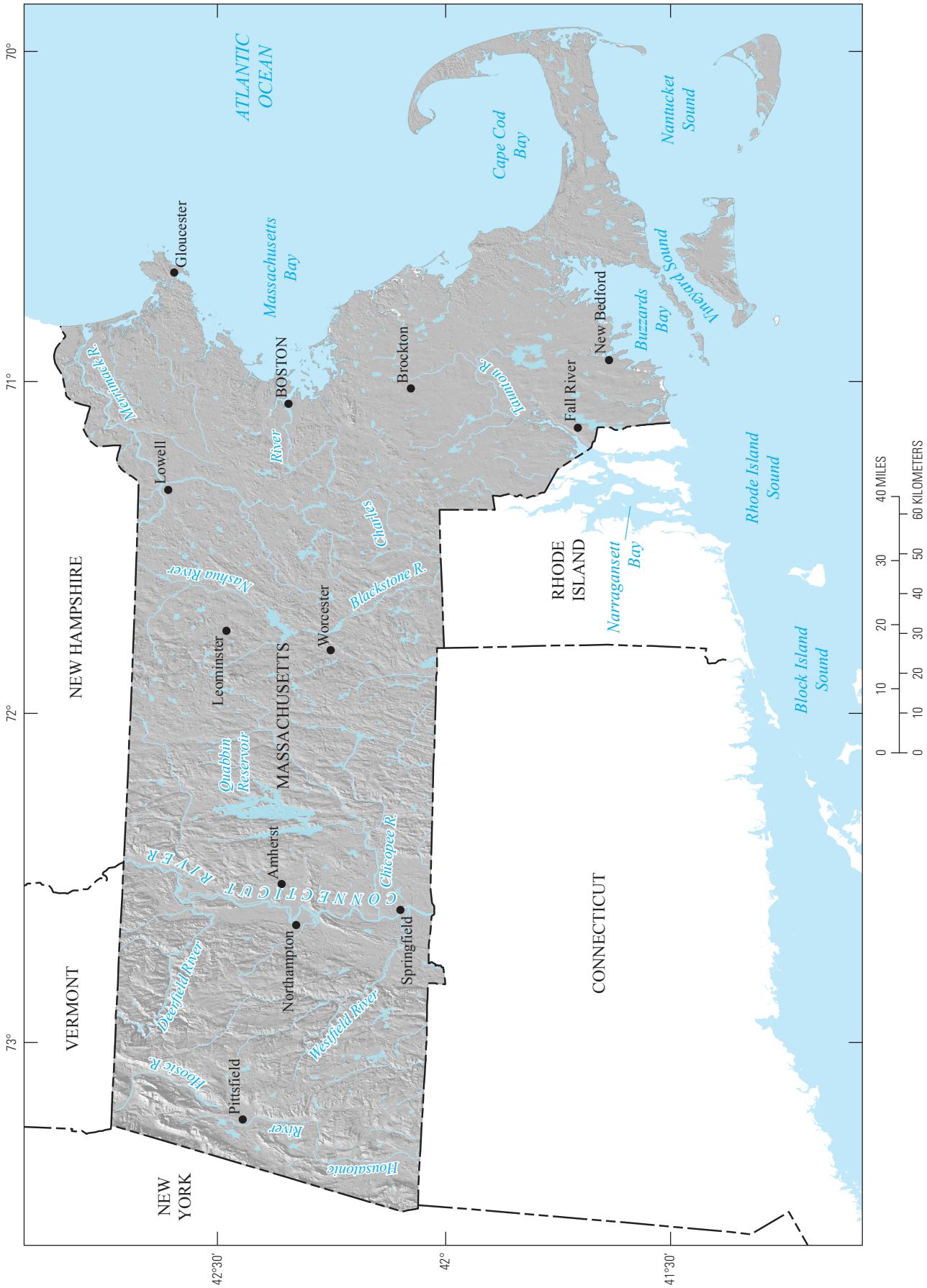

Figure 1*B*. Shaded-relief map of Massachusetts showing major rivers and major cities. Shaded relief is from Massachusetts Bureau of Geographic Information (MassGIS).

Glacial Till and Moraine Deposits

Glacial till deposits consist of nonsorted, generally nonstratified mixtures of mineral and rock particles ranging in grain size from clay to large boulders. The matrix of most tills is composed dominantly of fine sand and silt. Boulders, within and on the surface of tills, range from sparse to abundant. Some tills contain lenses of sorted sand and gravel, and less commonly, masses of laminated fine-grained sediments. The color and lithologic characteristics of till deposits vary across Massachusetts but generally reflect the composition of the local underlying and northerly adjacent bedrock, from which the till was derived (figs. 2, 3). Till blankets the bedrock surface in variable thickness, ranging from a few inches to more than 200 ft, and commonly underlies stratified meltwater deposits. Tills deposited during the last two glaciations occur in superposition within Massachusetts (Koteff, 1966; Newton, 1978; Weddle and others, 1989). The upper, younger till was deposited during the last (late Wisconsinan) glaciation; it is the most extensive till and commonly is observed in surface exposures, especially in areas where till thickness is less than 10 to 15 ft (thin-till unit). The lower, older till ("old" till) was deposited during an earlier glaciation (probably Illinoian). The lower till has a more limited distribution; it is principally a subsurface deposit that constitutes the bulk of material in drumlins and other hills, where till thickness is greater than 15 ft. On eastern Nantucket Island, sandy and bouldery upper till at the surface overlies glacial stratified deposits and marine beds of Sangamon age that overlie till of probable Illinoian age (Oldale and others, 1982), which is correlated with the lower till on the mainland. The distribution of lower till is shown primarily by the thick-till unit. The lower till generally is overlain by a thin mantle of upper till in these areas. In all exposures showing the superposed two tills, the base of the upper till truncates the weathered surface of the lower till. The lower part of the upper till commonly displays a zone of shearing, dislocation, and brecciation in which clasts of lower till were mixed and incorporated into the upper till during the last glaciation.

Figure 3. Exposure of gray till derived from metamorphic rocks in the Haverhill quadrangle. Note iron- and manganese-stained joints typical of lower, older till commonly found in the cores of drumlins. Shovel handle is 18 inches long.

Thin-till deposits of late Wisconsinan age are shown on the basal, subsurface layer of this database where drill-hole data indicate the nearly ubiquitous presence of compact, sandy till that lies directly on bedrock or, in southeastern Massachusetts, on Tertiary coastal-plain strata or early Pleistocene deposits.

End moraine deposits occur predominantly in southeastern Massachusetts and are composed mostly of bouldery ablation till (fig. 4), but locally may include sorted sediments especially at depth beneath the till. These deposits were laid down by glacial-melting and thrusting processes along active ice margins during retreat of the last (late Wisconsinan) ice sheet. End moraine deposits are composed of a surface layer, 6 to 30 ft thick, of sandy and bouldery ablation till, local compact sandy till, or a layered, sandy and bouldery sediment of probable debris-flow origin; these materials commonly overlie coarse stratified deposits. Sedimentary units in all the moraines have limited lateral extent and irregular thickness; stratification is deformed by collapse structures around kettle depressions and by glaciotectonic folds and thrust faults in some deposits. The Buzzard's Bay moraine in western Cape Cod and the Elizabeth Islands and the moraine along the north coast of Martha's Vineyard are largely ice-collapse ridges that overlie thick subsurface deposits of sorted and layered meltwater sediments, mainly sand and fine gravel and minor silt and clay, as reported in drill-hole descriptions. The Sandwich moraine in northern Cape Cod, and moraines in western Martha's Vineyard and Nantucket, are thrust moraine

Figure 2. Exposure of red till derived from Mesozoic sedimentary rocks of the Connecticut Valley lowland, in the West Springfield quadrangle. Field of view is approximately 3 feet wide.

Figure 4. Ablation till matrix surrounding numerous large boulders in the Dogtown moraine, Gloucester quadrangle. Boulder in left foreground is about 4 feet across.

Figure 5. Gravel deposit containing some sand beds in fluvial meltwater terrace sediments in the Woronoco quadrangle. Gravel clasts are derived predominantly from metamorphic rocks in the western uplands.

deposits that overlie glacially deformed older meltwater and marine deposits, mostly sand and gravel (Oldale and O'Hara, 1984). The Gay Head moraine on western Martha's Vineyard includes ice-thrusted beds of Tertiary fossiliferous sand, gravel, and silty clay deposits, and Pleistocene sand and silty clay beds (Shaler, 1898; Woodworth and Wigglesworth, 1934; Kaye, 1964). The extensive end moraines on Nantucket and Martha's Vineyard (index map) are related to the terminal position of the late Wisconsinan ice sheet; the end moraines on Cape Cod were formed along recessional positions. Less extensive end moraines are present locally elsewhere in southeastern Massachusetts, in the Boston area, and in the Gloucester-Rockport area of northeastern Massachusetts (index map).

Glacial Stratified Deposits

Glacial stratified deposits consist of layers of well-sorted to poorly sorted gravel, sand, silt, and clay laid down by flowing meltwater in glacial streams, lakes, and marine embayments that occupied the valleys and lowlands of Massachusetts during retreat of the last ice sheet. Textural variations within the meltwater deposits occur both areally and vertically because meltwater-flow regimes were different in glaciofluvial (stream), glaciodeltaic (where a stream entered a lake or the sea), glaciolacustrine (lake bottom), and glaciomarine (marine bottom) depositional environments. Grain-size variations also resulted from meltwater deposition in positions either proximal to, or distal from, the retreating glacier margin, which was the principal sediment source. A common depositional setting contained a proximal, ice-marginal meltwater stream in which horizontally bedded glaciofluvial gravel and (or) sand and gravel were laid down (fig. 5); farther down valley, the stream entered a glacial lake where glaciodeltaic sediments were deposited, consisting of horizontally layered sand and gravel delta-topset beds overlying inclined layers of sand in delta-foreset beds. Farther out in the glacial lake, very fine sand, silt, and clay settled out on the lake bottom in flat-lying, thinly bedded glaciolacustrine layers (figs. 6, 7). Thick sequences having these textural variations commonly are present in the vertical section of meltwater deposits across the region (Stone, J.R., and others, 1992).

Most of the meltwater sediments in Massachusetts were deposited in or graded to large and small glacial lakes. These large and small lakes formed in north-sloping valleys and basins where they were dammed by the ice margin

Figure 6. Sand deposit of delta bottomset beds containing cross-bedded sands interbedded with layers of very fine sand and silt, in the Southwick quadrangle. Reddish color of the sand is due to its derivation from Mesozoic rocks of the Connecticut Valley lowland.

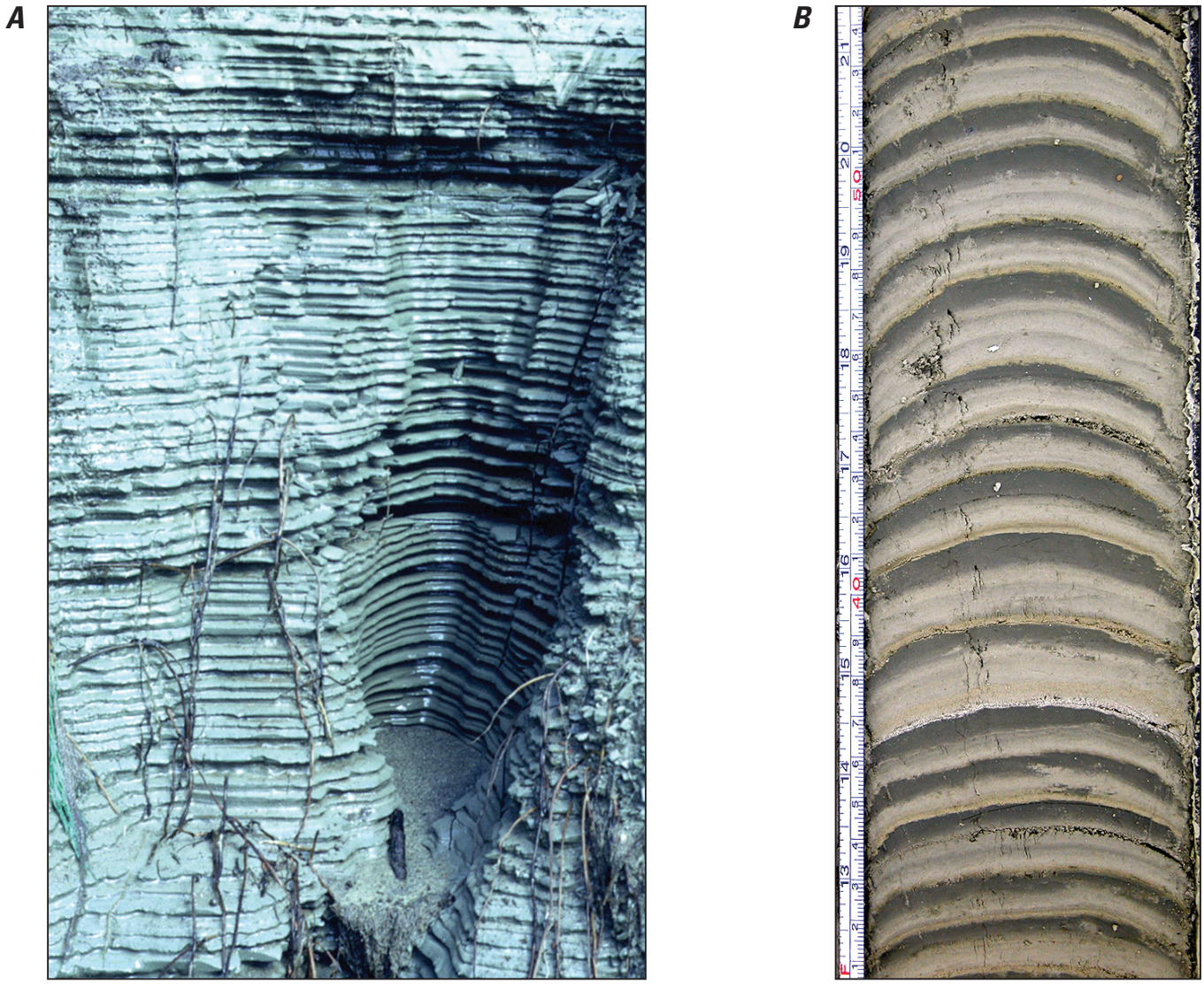

Figure 7. Varved silt and clay deposits (*A*, in outcrop; *B*, in core) deposited in glacial Lake Hitchcock in the Connecticut Valley lowland. Scale beside the core is in inches and centimeters; varves in both images are of similar thickness.

(ice-dammed lakes) and in south-sloping valleys and basins where they were dammed by slightly older deltaic sediments (sediment-dammed lakes). The largest glacial lake in Massachusetts was an extensive sediment-dammed lake (glacial Lake Hitchcock), which occupied the Connecticut Valley lowland at altitudes below 365 ft during the retreat of the last ice sheet. Glacial Lake Hitchcock was dammed behind a mass of older deltaic sediments in the Rocky Hill-Glastonbury area of central Connecticut, and the lake lengthened northward into northern Vermont and New Hampshire as the ice sheet retreated. In southeastern Massachusetts, an extensive sediment-dammed lake, glacial Lake Narragansett, expanded during ice retreat from the Narragansett Bay region of Rhode Island (Boothroyd, 2003; Boothroyd and August, 2008) into the coastal valleys of Block Island Sound and the Taunton River drainage basin in southeastern Massachusetts. Other large glacial lakes include glacial Lake Charles and glacial Lake Concord in the east-cental part of the State, and glacial Lake Bascom in the north-draining Hoosic Valley in the northwestern part of the State.

Detailed surficial geologic maps can show meltwater sedimentary units within each glacial lake or valley outwash system (Jahns, 1941, 1953; Koteff, 1966). These units, known as *morphosequences* (Koteff, 1974; Koteff and Pessl, 1981), are the smallest mappable stratigraphic units depictable on detailed geologic maps. Morphosequences are bodies of stratified meltwater sediments that are contained in a continuum of landforms, grading from ice-contact forms (eskers, kames) to non-ice-contact forms (flat valley terraces, delta plains) that were deposited simultaneously at and beyond the margin of

the ice sheet, and were graded to a specific base level. Each morphosequence consists of a proximal part (head) deposited within or near the ice margin and a distal part deposited farther away from the ice margin. Both grain size and ice-melt collapse deformation of beds decrease from the proximal to the distal part of each morphosequence. The head of each morphosequence is either ice marginal (ice contact) or near ice marginal. The surface altitude of fluvial sediments in each morphosequence was controlled by a specific base level, either a glacial-lake or marine water plane or a valley knickpoint. Few morphosequences extend distally more than 6 mi, and most are less than 1 mi in length. The most extensive morphosequences in Massachusetts are the glaciodeltaic outwash plains of Cape Cod, Nantucket, and Martha's Vineyard. For example, the Harwich outwash plain in southern Cape Cod contains coarse fluvial topset deposits and sandy foreset beds, which overlie silt and clay bottomset lacustrine beds at depth (Cotton and Koteff, 1962).

In any one basin, individual morphosequences were deposited sequentially as the ice margin retreated systematically northward. Consequently, in many places the distal, finer grained facies of a younger morphosequence stratigraphically overlies the proximal, coarse-grained facies of a preceding morphosequence.

Figure 8 shows an example of the variability of sediment types in the subsurface of glacial stratified deposits. The figure shows schematically the relationship between coarse-grained deltaic deposits (sand and gravel, and sand) and extensive fine-grained lake (or marine) deposits (fine and very fine sand, silt, and clay) in the subsurface. Such coarse- and fine-grained units are common in most of the valleys and lowlands of Massachusetts (Langer, 1979; Stone and others, 1979; Stone, J.R., and others, 1992; Stone and others, 2005). On these maps, coarse-grained and fine-grained textural variations within glacial stratified deposits are shown only where they occur at the land surface. Subsurface textural variations are not shown.

The areal distribution of till and stratified deposits is related to the physiography of Massachusetts (fig. 1). The thickness of these materials varies considerably within the physiographic regions because of such factors as the high relief of the bedrock surface, changing environments of deposition during deglaciation, and various effects of postglacial erosion and removal of glacial sediments (fig. 9). In highland areas, notably in the western and central parts of the State, till is the major surficial material and is present as a discontinuous mantle of variable thickness over the bedrock surface. Till is thickest in drumlins (reportedly as much as 230 ft thick) and on the northwest slopes of most bedrock hills. Glacial meltwater deposits that average 50 ft in thickness (Stone and others, 1993) overlie the till in small upland valleys and north-sloping basins between bedrock hills. Glacial stratified deposits are the predominant surficial materials in the Connecticut Valley lowland, in lowlands in northeastern and southeastern Massachusetts, and on Cape Cod and the islands. These deposits generally overlie till; however, well logs indicate that in some places till is not present and the stratified deposits lie directly on bedrock. On Cape Cod and the islands, in much of the lowland in southeastern Massachusetts, and in parts of the Connecticut Valley lowland, these deposits completely cover the till-draped bedrock surface.

Postglacial Deposits

Postglacial deposits locally overlie the glacial deposits throughout the State. In some areas, early postglacial deposits, such as stream-terrace deposits and inland-dune deposits in the Connecticut Valley and marine regressive deposits in the northeastern part of the State, have been mapped. Over the entire area, alluvium underlies the flood plains of most streams and rivers. Swamp deposits occur in low-lying, poorly drained areas in upland and lowland settings, but are shown only where they are estimated to be at least 3 ft thick. Salt-marsh and estuarine deposits are present mainly along the tidal portions of streams and rivers entering the offshore areas. Beach and dune deposits occur along the shoreline.

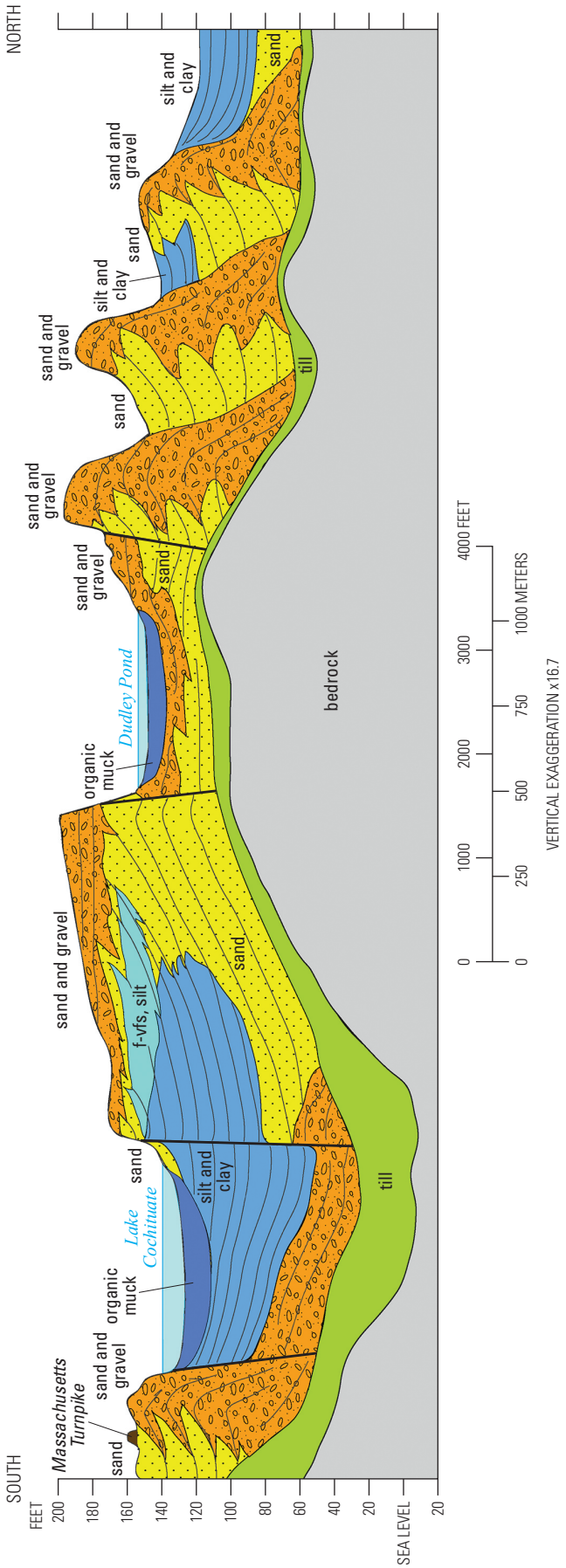

Figure 8. South-to-north cross section showing typical distribution of surficial materials in most valleys in Massachusetts, resulting from sequential morphosequence deposition by a northward-retreating ice sheet. Faults and collapse of sedimentary beds were caused by the melting of buried blocks of ice. Modified from Eggleston and others (2012, fig. 6). Abbreviation: f-vfs, fine to very fine sand.

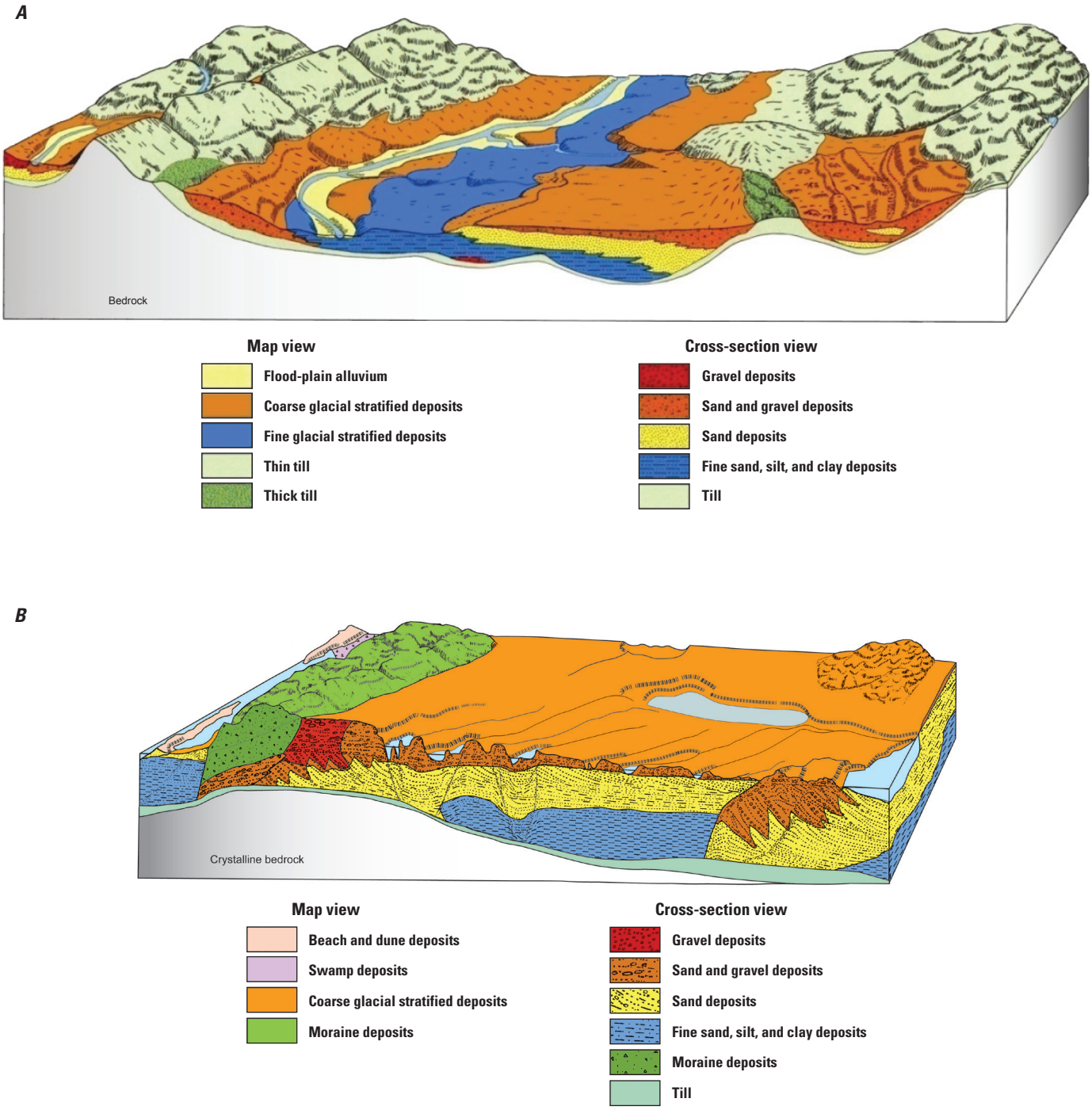

Figure 9. Block diagrams illustrating the typical areal (map view) and vertical (cross-section view) distribution of glacial and postglacial deposits overlying bedrock. *A*, in the Connecticut River valley (modified from Stone, J.R., and others, 1992). *B*, in the Cape Cod and islands region (modified from Strahler, 1966; Oldale, 1975a; and Masterson and others, 1997).

Map Compilation for Surficial Materials Quadrangle Maps

This geologic map database shows surficial materials in the 189 7.5-minute quadrangles in Massachusetts (fig. 10).

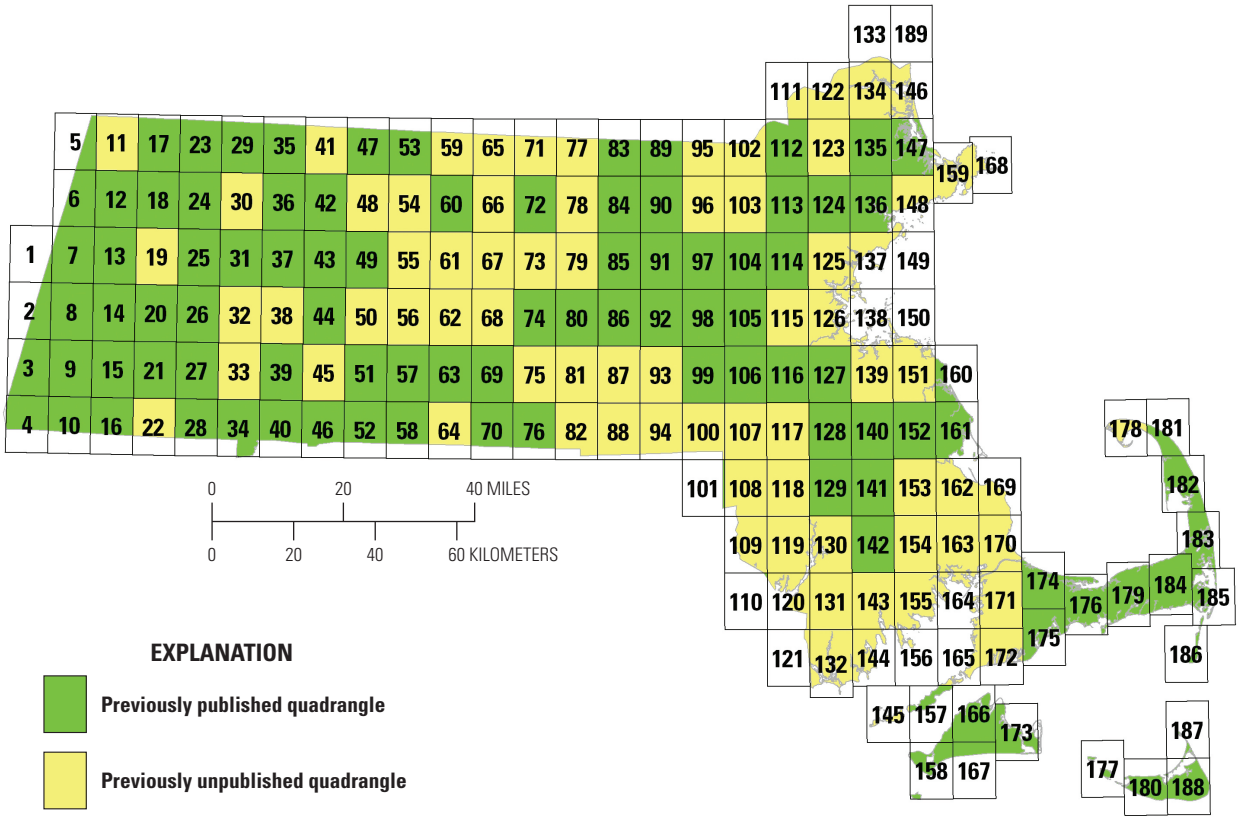

Figure 10. Index map of 7.5-minute, 1:24,000-scale quadrangles in Massachusetts. Quadrangle names and numbers are listed below:

1	Canaan	21	Otis
2	State Line	22	Tolland Center
3	Egremont	23	Rowe
4	Bashbish Falls	24	Plainfield
5	Berlin	25	Worthington
6	Hancock	26	Chester
7	Pittsfield West	27	Blandford
8	Stockbridge	28	West Granville
9	Great Barrington	29	Heath
10	Ashley Falls	30	Ashfield
11	Williamstown	31	Goshen
12	Cheshire	32	Westhampton
13	Pittsfield East	33	Woronoco
14	East Lee	34	Southwick
15	Monterey	35	Colrain
16	South Sandisfield	36	Shelburne Falls
17	North Adams	37	Williamsburg
18	Windsor	38	Easthampton
19	Peru	39	Mount Tom
20	Becket	40	West Springfield

Quadrangle names and numbers shown in figure 10—Continued

41	Bernardston
42	Greenfield
43	Mount Toby
44	Mount Holyoke
45	Springfield North
46	Springfield South
47	Northfield
48	Millers Falls
49	Shutesbury
50	Belchertown
51	Ludlow
52	Hampden
53	Mount Grace
54	Orange
55	Quabbin Reservoir
56	Winsor Dam
57	Palmer
58	Monson
59	Royalston
60	Athol
61	Petersham
62	Ware
63	Warren
64	Wales
65	Winchendon
66	Templeton
67	Barre
68	North Brookfield
69	East Brookfield
70	Southbridge
71	Ashburnham
72	Gardner
73	Wachusett Mountain
74	Paxton
75	Leicester
76	Webster
77	Ashby
78	Fitchburg
79	Sterling
80	Worcester North
81	Worcester South
82	Oxford
83	Townsend
84	Shirley
85	Clinton
86	Shrewsbury
87	Grafton
88	Uxbridge
89	Pepperell
90	Ayer
91	Hudson
92	Marlborough
93	Milford
94	Blackstone
95	Nashua South
96	Westford
97	Maynard
98	Framingham
99	Holliston
100	Franklin
101	Pawtucket
102	Lowell
103	Billerica
104	Concord
105	Natick
106	Medfield
107	Wrentham
108	Attleboro
109	East Providence
110	Bristol
111	Salem Depot
112	Lawrence
113	Wilmington
114	Lexington
115	Newton
116	Norwood
117	Mansfield
118	Norton
119	Somerset
120	Fall River
121	Tiverton
122	Haverhill
123	South Groveland
124	Reading
125	Boston North
126	Boston South
127	Blue Hills
128	Brockton
129	Taunton
130	Assonet
131	Fall River East
132	Westport
133	Exeter
134	Newburyport West
135	Georgetown
136	Salem
137	Lynn
138	Hull
139	Weymouth
140	Whitman

Quadrangle names and numbers shown in figure 10—Continued

141	Bridgewater
142	Assawompset Pond
143	New Bedford North
144	New Bedford South
145	Cuttyhunk
146	Newburyport East
147	Ipswich
148	Marblehead North
149	Marblehead South
150	Nantasket Beach
151	Cohasset
152	Hanover
153	Plympton
154	Snipatuit Pond
155	Marion
156	Sconticut Neck
157	Naushon Island
158	Squibnocket
159	Gloucester
160	Scituate
161	Duxbury
162	Plymouth
163	Wareham
164	Onset
165	Woods Hole
166	Vineyard Haven
167	Tisbury Great Pond
168	Rockport
169	Manomet
170	Sagamore
171	Pocasset
172	Falmouth
173	Edgartown
174	Sandwich
175	Cotuit
176	Hyannis
177	Tuckernuck Island
178	Provincetown
179	Dennis
180	Nantucket
181	North Truro
182	Wellfleet
183	Orleans
184	Harwich
185	Chatham
186	Monomoy Point
187	Great Point
188	Siasconset
189	Hampton

The statewide surficial geologic map was compiled in several steps:

1. Paper copies of the previously published surficial geologic maps for 105 quadrangles were scanned and georeferenced by the Massachusetts Bureau of Geographic Information (MassGIS).

2. The Office of the Massachusetts State Geologist (now the Massachusetts Geological Survey) vectorized the georeferenced images in order to digitally retain the original linework of the published maps (Mabee and others, 2004).

3. Digital geologic map units were compiled and grouped into basic units in four shapefiles, listed as follows:

   a. *Postglacial deposits* including artificial fill, cranberry bog deposits, flood-plain alluvium, swamp deposits, salt-marsh and estuarine deposits, and beach and dune deposits;

   b. *Early postglacial deposits* including alluvial-fan deposits, valley-floor fluvial deposits, stream-terrace deposits, marine regressive deposits, inland-dune deposits, and talus deposits;

   c. *Glacial stratified deposits* including coarse deposits, fine deposits, glaciomarine fine deposits, and stagnant-ice deposits;

   d. *Glacial till and bedrock* including end moraine deposits, thrust moraine deposits, thin-till deposits, thick-till deposits (drumlins), and bedrock outcrops, including areas of shallow bedrock. The distribution of glacial stratified deposits beneath adjacent overlying postglacial deposits and water bodies was inferred by the compilers.

4. The same basic units as those listed in step 3 above were compiled and digitized for 84 unpublished quadrangles from scanned field maps by USGS personnel.

5. The 189 individual quadrangle maps were joined and edge-matched in order to form a seamless digital geologic map layer. Discrepancies along quadrangle boundaries were resolved, and thick-till areas, glacially modified coastal-plain hill deposits, thick valley till and fine deposits, and shallow-bedrock areas were added by the compilers in quadrangles where these units had not been previously mapped.

6. Shapefiles, base maps, and source information were compiled into a geodatabase format.

All geologic mapping was completed at 1:24,000 scale (several quadrangles were previously published at 1:31,680 scale). The 1:24,000-scale topographic base maps (1944–1977 editions) used for this mapping effort, which nearly all have a 10-ft contour interval, are included as part of the digital data package in the BaseMaps folder. The geodatabase included with this report contains MapUnitPolys, MapUnitOverlay-Polys, and OverlayPolys, which show the distribution of geologic units that cover the entire map area and are intended for use at quadrangle scale (1:24,000). These data layers can be clipped by quadrangle or by town boundary. Unlike the units in conventional geologic maps, the digitally defined MapUnitOverlayPolys are arranged in order according to superposition. The polygons for till and bedrock are on the bottom and are overlain by the succeeding stratified deposits; these materials are shown everywhere they occur, including beneath postglacial deposits such as swamp deposits, and also beneath water bodies. The postglacial deposits are on top because these materials overlie the other, older deposits. Instructions for using the digital files are included in the README file and in the metadata in the geodatabase (see links at https://doi.org/10.3133/sim3402). Figure 11 illustrates the stacking of geologic units in a portion of the Mount Toby quadrangle (no. 43).

In addition to the seamless digital layers that cover the entire compilation area, Adobe PDF map files of the surficial geology layers shown with 1:24,000-scale topographic base-map images have been generated for each quadrangle (see maps of quadrangles 1–189, indexed in figure 10).

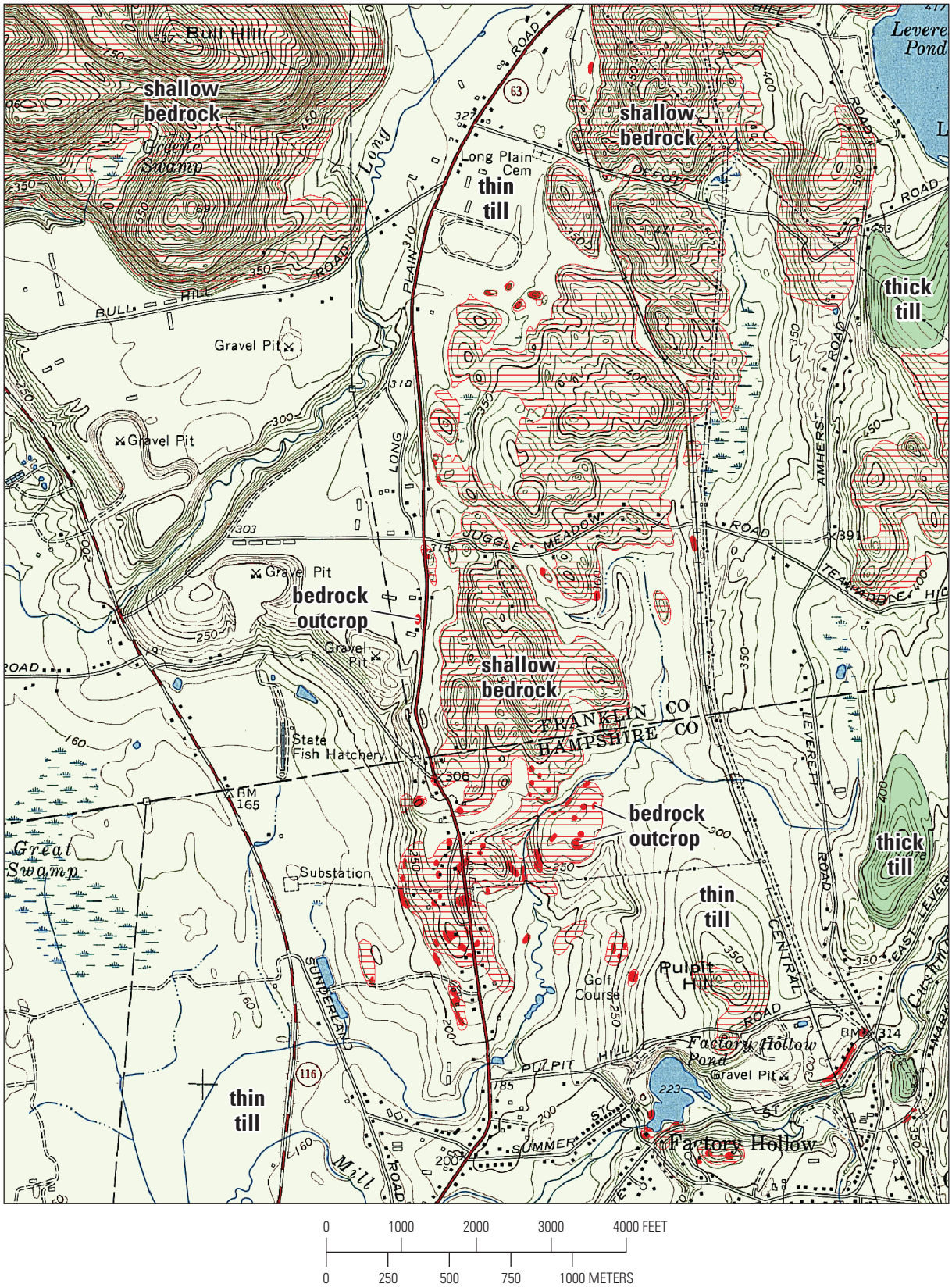

Figure 11*A*. Glacial till and bedrock polygons in a portion of the Mount Toby quadrangle (no. 43) at 1:24,000 scale. See Description of Map Units for definition of units.

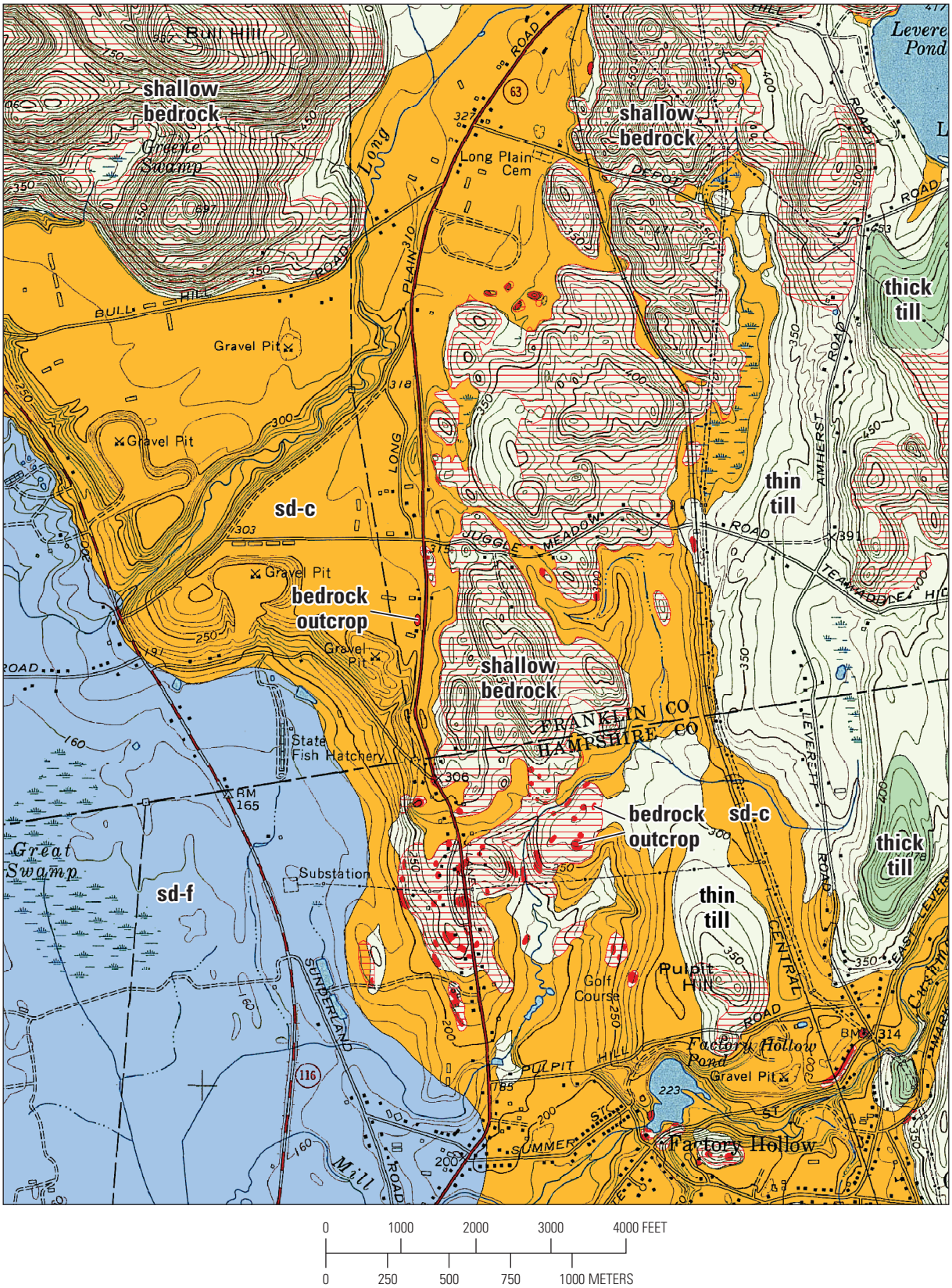

Figure 11*B*. Glacial stratified deposits polygons (sd-c and sd-f) overlying till and shallow bedrock in a portion of the Mount Toby quadrangle (no. 43) at 1:24,000 scale. See Description of Map Units for definition of units. Abbreviations: sd-c, coarse stratified deposits; sd-f, fine stratified deposits.

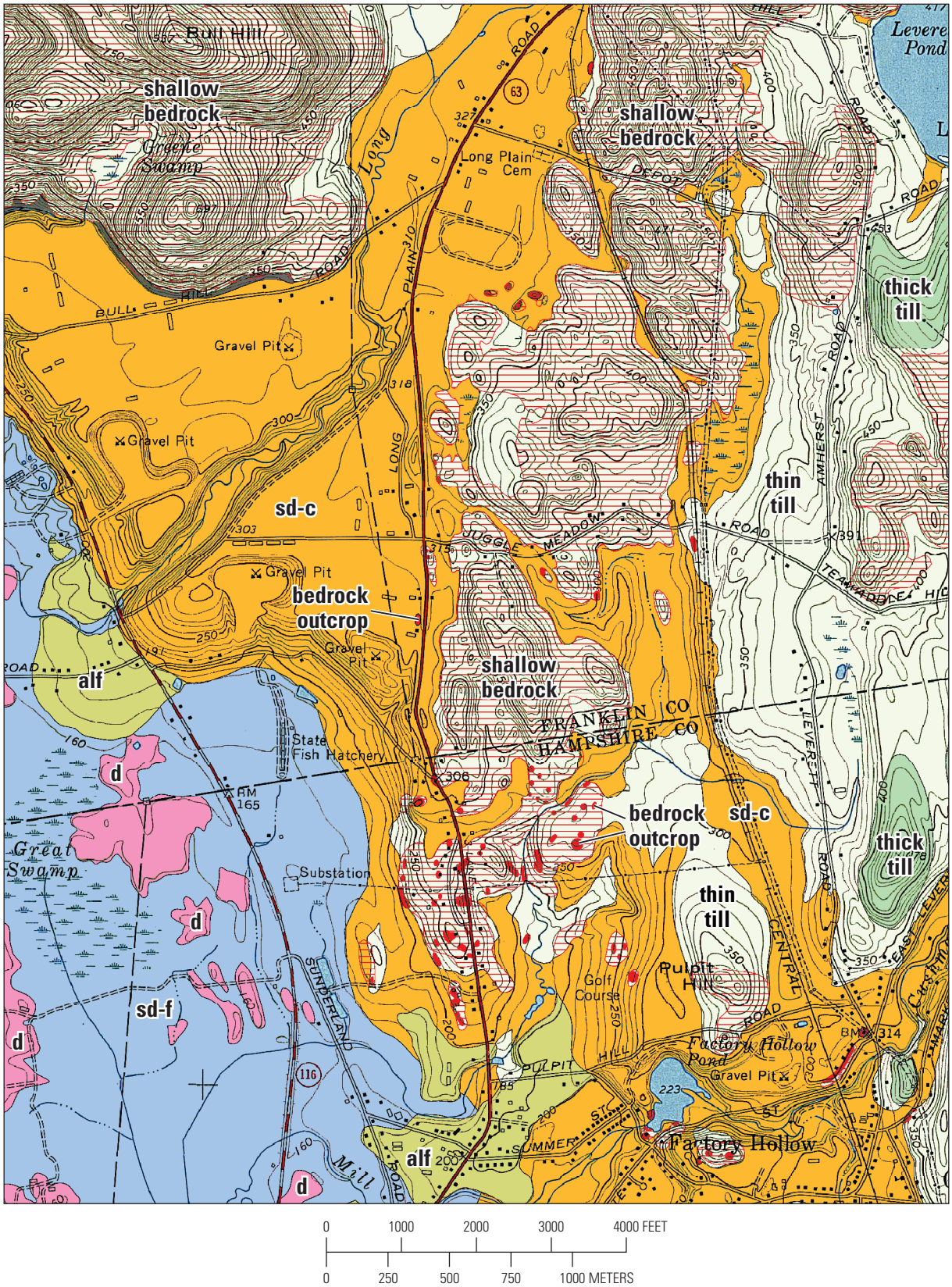

Figure 11*C*. Early postglacial deposits polygons (alf, d) overlying glacial stratified deposits (sd-c, sd-f) in a portion of the Mount Toby quadrangle (no. 43) at 1:24,000 scale. See Description of Map Units for definition of units. Abbreviations: alf, alluvial-fan deposits; d, inland-dune deposits; sd-c, coarse stratified deposits; sd-f, fine stratified deposits.

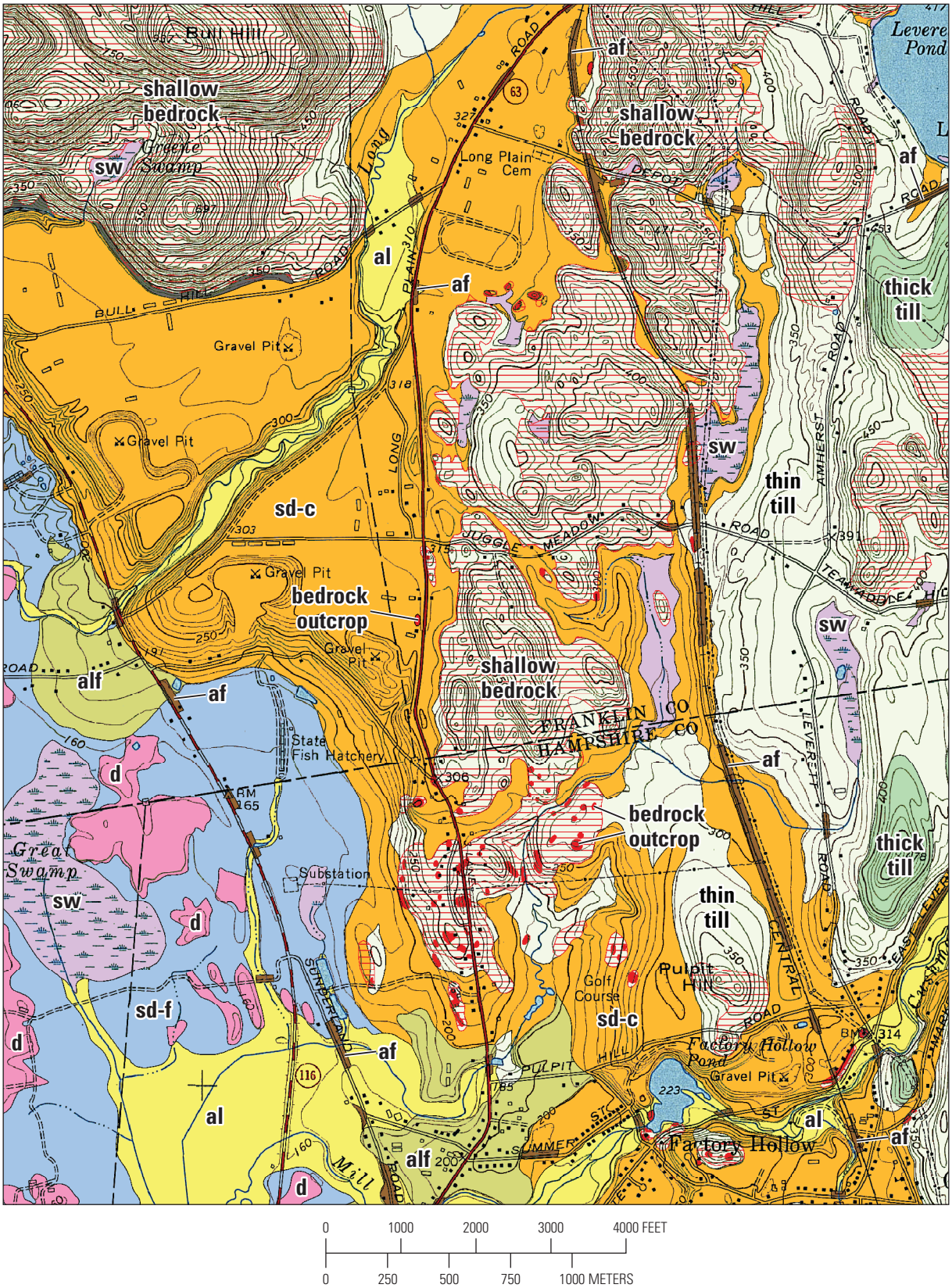

Figure 11*D*. Postglacial deposits polygons (af, al, sw) overlying all older deposits in a portion of the Mount Toby quadrangle (no. 43) at 1:24,000 scale. See Description of Map Units for definition of units. Abbreviations: af, artificial fill; al, flood-plain alluvium; alf, alluvial-fan deposits; d, inland-dune deposits; sd-c, coarse stratified deposits; sd-f, fine stratified deposits; sw, swamp deposits.

List of Surficial Materials Maps of Quadrangles 1–189

[A zipped folder containing the PDF map files can be found at https://doi.org/10.3133/sim3402. Map files can also be accessed individually. Numbering corresponds to numbering used in figure 10 above and on the 1:250,000-scale index map]

1. Surficial Materials Map of the Canaan quadrangle, Massachusetts
2. Surficial Materials Map of the State Line quadrangle, Massachusetts
3. Surficial Materials Map of the Egremont quadrangle, Massachusetts
4. Surficial Materials Map of the Bashbish Falls quadrangle, Massachusetts
5. Surficial Materials Map of the Berlin quadrangle, Massachusetts

6. Surficial Materials Map of the Hancock quadrangle, Massachusetts
7. Surficial Materials Map of the Pittsfield West quadrangle, Massachusetts
8. Surficial Materials Map of the Stockbridge quadrangle, Massachusetts
9. Surficial Materials Map of the Great Barrington quadrangle, Massachusetts
10. Surficial Materials Map of the Ashley Falls quadrangle, Massachusetts

11. Surficial Materials Map of the Williamstown quadrangle, Massachusetts
12. Surficial Materials Map of the Cheshire quadrangle, Massachusetts
13. Surficial Materials Map of the Pittsfield East quadrangle, Massachusetts
14. Surficial Materials Map of the East Lee quadrangle, Massachusetts
15. Surficial Materials Map of the Monterey quadrangle, Massachusetts

16. Surficial Materials Map of the South Sandisfield quadrangle, Massachusetts
17. Surficial Materials Map of the North Adams quadrangle, Massachusetts
18. Surficial Materials Map of the Windsor quadrangle, Massachusetts
19. Surficial Materials Map of the Peru quadrangle, Massachusetts
20. Surficial Materials Map of the Becket quadrangle, Massachusetts

21. Surficial Materials Map of the Otis quadrangle, Massachusetts
22. Surficial Materials Map of the Tolland Center quadrangle, Massachusetts
23. Surficial Materials Map of the Rowe quadrangle, Massachusetts
24. Surficial Materials Map of the Plainfield quadrangle, Massachusetts
25. Surficial Materials Map of the Worthington quadrangle, Massachusetts

26. Surficial Materials Map of the Chester quadrangle, Massachusetts
27. Surficial Materials Map of the Blandford quadrangle, Massachusetts
28. Surficial Materials Map of the West Granville quadrangle, Massachusetts
29. Surficial Materials Map of the Heath quadrangle, Massachusetts
30. Surficial Materials Map of the Ashfield quadrangle, Massachusetts

31. Surficial Materials Map of the Goshen quadrangle, Massachusetts
32. Surficial Materials Map of the Westhampton quadrangle, Massachusetts
33. Surficial Materials Map of the Woronoco quadrangle, Massachusetts
34. Surficial Materials Map of the Southwick quadrangle, Massachusetts
35. Surficial Materials Map of the Colrain quadrangle, Massachusetts

36. Surficial Materials Map of the Shelburne Falls quadrangle, Massachusetts
37. Surficial Materials Map of the Williamsburg quadrangle, Massachusetts
38. Surficial Materials Map of the Easthampton quadrangle, Massachusetts
39. Surficial Materials Map of the Mount Tom quadrangle, Massachusetts
40. Surficial Materials Map of the West Springfield quadrangle, Massachusetts

41. Surficial Materials Map of the Bernardston quadrangle, Massachusetts
42. Surficial Materials Map of the Greenfield quadrangle, Massachusetts
43. Surficial Materials Map of the Mount Toby quadrangle, Massachusetts
44. Surficial Materials Map of the Mount Holyoke quadrangle, Massachusetts
45. Surficial Materials Map of the Springfield North quadrangle, Massachusetts

46. Surficial Materials Map of the Springfield South quadrangle, Massachusetts
47. Surficial Materials Map of the Northfield quadrangle, Massachusetts
48. Surficial Materials Map of the Millers Falls quadrangle, Massachusetts
49. Surficial Materials Map of the Shutesbury quadrangle, Massachusetts
50. Surficial Materials Map of the Belchertown quadrangle, Massachusetts

51. Surficial Materials Map of the Ludlow quadrangle, Massachusetts
52. Surficial Materials Map of the Hampden quadrangle, Massachusetts
53. Surficial Materials Map of the Mount Grace quadrangle, Massachusetts
54. Surficial Materials Map of the Orange quadrangle, Massachusetts
55. Surficial Materials Map of the Quabbin Reservoir quadrangle, Massachusetts

56. Surficial Materials Map of the Winsor Dam quadrangle, Massachusetts
57. Surficial Materials Map of the Palmer quadrangle, Massachusetts
58. Surficial Materials Map of the Monson quadrangle, Massachusetts
59. Surficial Materials Map of the Royalston quadrangle, Massachusetts
60. Surficial Materials Map of the Athol quadrangle, Massachusetts

61. Surficial Materials Map of the Petersham quadrangle, Massachusetts
62. Surficial Materials Map of the Ware quadrangle, Massachusetts
63. Surficial Materials Map of the Warren quadrangle, Massachusetts
64. Surficial Materials Map of the Wales quadrangle, Massachusetts
65. Surficial Materials Map of the Winchendon quadrangle, Massachusetts

66. Surficial Materials Map of the Templeton quadrangle, Massachusetts
67. Surficial Materials Map of the Barre quadrangle, Massachusetts
68. Surficial Materials Map of the North Brookfield quadrangle, Massachusetts
69. Surficial Materials Map of the East Brookfield quadrangle, Massachusetts
70. Surficial Materials Map of the Southbridge quadrangle, Massachusetts

71. Surficial Materials Map of the Ashburnham quadrangle, Massachusetts
72. Surficial Materials Map of the Gardner quadrangle, Massachusetts
73. Surficial Materials Map of the Wachusett Mountain quadrangle, Massachusetts
74. Surficial Materials Map of the Paxton quadrangle, Massachusetts
75. Surficial Materials Map of the Leicester quadrangle, Massachusetts

76. Surficial Materials Map of the Webster quadrangle, Massachusetts
77. Surficial Materials Map of the Ashby quadrangle, Massachusetts
78. Surficial Materials Map of the Fitchburg quadrangle, Massachusetts
79. Surficial Materials Map of the Sterling quadrangle, Massachusetts
80. Surficial Materials Map of the Worcester North quadrangle, Massachusetts

81. Surficial Materials Map of the Worcester South quadrangle, Massachusetts
82. Surficial Materials Map of the Oxford quadrangle, Massachusetts
83. Surficial Materials Map of the Townsend quadrangle, Massachusetts
84. Surficial Materials Map of the Shirley quadrangle, Massachusetts
85. Surficial Materials Map of the Clinton quadrangle, Massachusetts

86. Surficial Materials Map of the Shrewsbury quadrangle, Massachusetts
87. Surficial Materials Map of the Grafton quadrangle, Massachusetts
88. Surficial Materials Map of the Uxbridge quadrangle, Massachusetts
89. Surficial Materials Map of the Pepperell quadrangle, Massachusetts
90. Surficial Materials Map of the Ayer quadrangle, Massachusetts

91. Surficial Materials Map of the Hudson quadrangle, Massachusetts
92. Surficial Materials Map of the Marlborough quadrangle, Massachusetts
93. Surficial Materials Map of the Milford quadrangle, Massachusetts
94. Surficial Materials Map of the Blackstone quadrangle, Massachusetts
95. Surficial Materials Map of the Nashua South quadrangle, Massachusetts

96. Surficial Materials Map of the Westford quadrangle, Massachusetts
97. Surficial Materials Map of the Maynard quadrangle, Massachusetts
98. Surficial Materials Map of the Framingham quadrangle, Massachusetts
99. Surficial Materials Map of the Holliston quadrangle, Massachusetts
100. Surficial Materials Map of the Franklin quadrangle, Massachusetts

101. Surficial Materials Map of the Pawtucket quadrangle, Massachusetts
102. Surficial Materials Map of the Lowell quadrangle, Massachusetts
103. Surficial Materials Map of the Billerica quadrangle, Massachusetts
104. Surficial Materials Map of the Concord quadrangle, Massachusetts
105. Surficial Materials Map of the Natick quadrangle, Massachusetts

106. Surficial Materials Map of the Medfield quadrangle, Massachusetts
107. Surficial Materials Map of the Wrentham quadrangle, Massachusetts
108. Surficial Materials Map of the Attleboro quadrangle, Massachusetts
109. Surficial Materials Map of the East Providence quadrangle, Massachusetts
110. Surficial Materials Map of the Bristol quadrangle, Massachusetts

111. Surficial Materials Map of the Salem Depot quadrangle, Massachusetts
112. Surficial Materials Map of the Lawrence quadrangle, Massachusetts
113. Surficial Materials Map of the Wilmington quadrangle, Massachusetts
114. Surficial Materials Map of the Lexington quadrangle, Massachusetts
115. Surficial Materials Map of the Newton quadrangle, Massachusetts

116. Surficial Materials Map of the Norwood quadrangle, Massachusetts
117. Surficial Materials Map of the Mansfield quadrangle, Massachusetts
118. Surficial Materials Map of the Norton quadrangle, Massachusetts
119. Surficial Materials Map of the Somerset quadrangle, Massachusetts
120. Surficial Materials Map of the Fall River quadrangle, Massachusetts

121. Surficial Materials Map of the Tiverton quadrangle, Massachusetts
122. Surficial Materials Map of the Haverhill quadrangle, Massachusetts
123. Surficial Materials Map of the South Groveland quadrangle, Massachusetts
124. Surficial Materials Map of the Reading quadrangle, Massachusetts
125. Surficial Materials Map of the Boston North quadrangle, Massachusetts

126. Surficial Materials Map of the Boston South quadrangle, Massachusetts
127. Surficial Materials Map of the Blue Hills quadrangle, Massachusetts
128. Surficial Materials Map of the Brockton quadrangle, Massachusetts
129. Surficial Materials Map of the Taunton quadrangle, Massachusetts
130. Surficial Materials Map of the Assonet quadrangle, Massachusetts

131. Surficial Materials Map of the Fall River East quadrangle, Massachusetts
132. Surficial Materials Map of the Westport quadrangle, Massachusetts
133. Surficial Materials Map of the Exeter quadrangle, Massachusetts
134. Surficial Materials Map of the Newburyport West quadrangle, Massachusetts
135. Surficial Materials Map of the Georgetown quadrangle, Massachusetts

136. Surficial Materials Map of the Salem quadrangle, Massachusetts
137. Surficial Materials Map of the Lynn quadrangle, Massachusetts
138. Surficial Materials Map of the Hull quadrangle, Massachusetts
139. Surficial Materials Map of the Weymouth quadrangle, Massachusetts
140. Surficial Materials Map of the Whitman quadrangle, Massachusetts

141. Surficial Materials Map of the Bridgewater quadrangle, Massachusetts
142. Surficial Materials Map of the Assawompset Pond quadrangle, Massachusetts
143. Surficial Materials Map of the New Bedford North quadrangle, Massachusetts
144. Surficial Materials Map of the New Bedford South quadrangle, Massachusetts
145. Surficial Materials Map of the Cuttyhunk quadrangle, Massachusetts

146. Surficial Materials Map of the Newburyport East quadrangle, Massachusetts
147. Surficial Materials Map of the Ipswich quadrangle, Massachusetts
148. Surficial Materials Map of the Marblehead North quadrangle, Massachusetts
149. Surficial Materials Map of the Marblehead South quadrangle, Massachusetts
150. Surficial Materials Map of the Nantasket Beach quadrangle, Massachusetts

151. Surficial Materials Map of the Cohasset quadrangle, Massachusetts
152. Surficial Materials Map of the Hanover quadrangle, Massachusetts
153. Surficial Materials Map of the Plympton quadrangle, Massachusetts
154. Surficial Materials Map of the Snipatuit Pond quadrangle, Massachusetts
155. Surficial Materials Map of the Marion quadrangle, Massachusetts

156. Surficial Materials Map of the Sconticut Neck quadrangle, Massachusetts
157. Surficial Materials Map of the Naushon Island quadrangle, Massachusetts
158. Surficial Materials Map of the Squibnocket quadrangle, Massachusetts
159. Surficial Materials Map of the Gloucester quadrangle, Massachusetts
160. Surficial Materials Map of the Scituate quadrangle, Massachusetts

161. Surficial Materials Map of the Duxbury quadrangle, Massachusetts
162. Surficial Materials Map of the Plymouth quadrangle, Massachusetts
163. Surficial Materials Map of the Wareham quadrangle, Massachusetts
164. Surficial Materials Map of the Onset quadrangle, Massachusetts
165. Surficial Materials Map of the Woods Hole quadrangle, Massachusetts

166. Surficial Materials Map of the Vineyard Haven quadrangle, Massachusetts
167. Surficial Materials Map of the Tisbury Great Pond quadrangle, Massachusetts
168. Surficial Materials Map of the Rockport quadrangle, Massachusetts
169. Surficial Materials Map of the Manomet quadrangle, Massachusetts
170. Surficial Materials Map of the Sagamore quadrangle, Massachusetts

171. Surficial Materials Map of the Pocasset quadrangle, Massachusetts
172. Surficial Materials Map of the Falmouth quadrangle, Massachusetts
173. Surficial Materials Map of the Edgartown quadrangle, Massachusetts
174. Surficial Materials Map of the Sandwich quadrangle, Massachusetts
175. Surficial Materials Map of the Cotuit quadrangle, Massachusetts

176. Surficial Materials Map of the Hyannis quadrangle, Massachusetts
177. Surficial Materials Map of the Tuckernuck Island quadrangle, Massachusetts
178. Surficial Materials Map of the Provincetown quadrangle, Massachusetts
179. Surficial Materials Map of the Dennis quadrangle, Massachusetts
180. Surficial Materials Map of the Nantucket quadrangle, Massachusetts

181. Surficial Materials Map of the North Truro quadrangle, Massachusetts
182. Surficial Materials Map of the Wellfleet quadrangle, Massachusetts
183. Surficial Materials Map of the Orleans quadrangle, Massachusetts
184. Surficial Materials Map of the Harwich quadrangle, Massachusetts
185. Surficial Materials Map of the Chatham quadrangle, Massachusetts

186. Surficial Materials Map of the Monomoy Point quadrangle, Massachusetts
187. Surficial Materials Map of the Great Point quadrangle, Massachusetts
188. Surficial Materials Map of the Siasconset quadrangle, Massachusetts
189. Surficial Materials Map of the Hampton quadrangle, Massachusetts

Description of Map Units

Postglacial Deposits

Artificial fill—Earth materials and manmade materials that have been artificially emplaced, primarily in highway and railroad embankments and in dams; unit may also include landfills, urban-development areas, and filled coastal wetlands

Cranberry bog deposits—Natural freshwater swamps or peat bogs overlain locally by artificially emplaced sand or other fill; these deposits occur primarily in southeastern Massachusetts and on Cape Cod. Commonly, cranberry bogs also are created by excavation into sand and gravel deposits that form the bed; peat and other organic material are then artificially emplaced over the bed, and water drainage pathways are diverted into the area to control seasonal flooding of the bog

Flood-plain alluvium—Sand, gravel, silt, and some organic material, stratified and well sorted to poorly sorted, beneath the flood plains of modern streams. The texture of alluvium commonly varies over short distances both laterally and vertically, and generally is similar to the texture of adjacent glacial deposits. Along smaller streams, alluvium is commonly less than 5 feet (ft) thick. The most extensive deposits of alluvium in Massachusetts are along the Housatonic, Deerfield, Westfield, Connecticut, Nashua, Merrimack, and Blackstone Rivers. Alluvium typically overlies thicker glacial stratified deposits

Swamp deposits—Organic muck and peat that contain minor amounts of sand, silt, and clay, are stratified and poorly sorted, and occur in swamps and freshwater marshes, in kettle depressions, or in poorly drained areas. Unit is shown only where deposits are estimated to be at least 3 ft thick; most deposits are less than 10 ft thick. Swamp deposits overlie glacial deposits or bedrock. They locally overlie glacial till even where they occur within thin glacial meltwater deposits

Salt-marsh and estuarine deposits—Peat and organic muck interbedded with sand and silt, deposited in saltwater or brackish-water environments of low wave energy along the coast and in river estuaries. Salt-marsh deposits are dominantly peat and muck, generally a few feet to 25 ft thick. In the major estuaries, these deposits locally overlie estuarine deposits (not mapped), which are sand and silt with minor organic material and are as much as 30 to 80 ft thick. Salt-marsh and estuarine deposits generally are underlain by adjacent glacial material, consisting of till, coarse stratified deposits, or glaciomarine fine deposits

Beach and dune deposits—Sand and fine gravel deposited along the shoreline by waves and currents, and by wind action. The texture of beach deposits varies over short distances and is generally controlled by the texture of nearby glacial materials exposed to wave action. Sand beach deposits are composed of moderately sorted, very coarse to fine sand, and are commonly laminated. Coarser layers may contain some fine gravel particles; finer layers may contain some very fine sand and silt. Gravel beach deposits are composed of granule- to cobble-size clasts in moderately sorted thin beds; deposits contain minor amounts of sand within gravel beds, and thin beds of sand as alternating layers. Beach deposits are rarely more than a few feet thick. Dune deposits are composed of moderately sorted to well-sorted, fine to medium sand, and are variably massive, laminated, and crossbedded. Dune deposits are as much as 100 ft thick. Unit includes artificial sand deposits in locally replenished beaches

Early Postglacial Deposits

Alluvial-fan deposits—Generally coarse gravel and sand deposits on steep slopes where high-gradient streams entered lower gradient valleys. Alluvial fans in some places were graded to lowering levels of glacial lakes. Fans continue to form today at some locations in Massachusetts

Valley-floor fluvial deposits—Sand, gravel, and minor silt, stratified and moderately to poorly sorted, beneath flat floors of valleys, called furrows (Mather and others, 1942), that are eroded into glacial outwash plains. The texture of the fluvial deposits commonly varies over short distances both laterally and vertically, and generally is similar to the texture of adjacent glacial deposits. The fluvial deposits overlie thick glacial stratified deposits in the upper, dry reaches of the furrow valleys and probably are less than 20 ft thick. Swamp deposits and deformation of bedding related to melting of buried ice in kettles interrupt the fluvial deposits. The deposits probably extend beneath salt-marsh and estuarine deposits in coastal valley reaches. The most extensive valley-floor fluvial deposits are on upper Cape Cod along Quaker Run and the Coonamessett, Childs, and Quashnet Rivers, and on Martha's Vineyard in Quampache Bottom

Stream-terrace deposits—Sand, gravel, and silt deposited by meteoric water (locally distal meltwater) on terraces cut into glacial meltwater sediments along rivers and streams. These deposits are shown where they overlie glaciolacustrine deposits (fine deposits map unit) and glaciomarine fine deposits; elsewhere, stream-terrace deposits are included in the coarse deposits map unit. Most stream-terrace deposits are less than 10 ft thick and overlie thicker glacial deposits; textures are commonly similar to those of underlying glacial meltwater deposits. Many stream terraces in the Connecticut River valley are composed of fine to medium sand and overlie lake-bottom silt and clay

Marine regressive deposits—Sand and minor gravel deposited along former, higher shorelines in northeastern Massachusetts by waves and currents, and by wind action on beaches and spits. These deposits are shown where they overlie glaciomarine fine deposits. Regressive beach and nearshore deposits are composed of moderately sorted, very coarse to fine sand, commonly laminated. Coarser layers may contain some fine gravel particles; finer layers may contain some very fine sand and silt. Regressive beach and nearshore deposits are rarely more than a few feet thick. Regressive spit deposits are 10 to 30 ft thick

Inland-dune deposits—Fine to medium, well-sorted sand in transverse, parabolic, and hummocky dunes as much as 60 ft thick. Deposits occur mostly in the glacial Lake Hitchcock basin (in the Connecticut Valley lowland), where sand derived from extensive glacial-lake deltas that were not yet vegetated was deposited in dune forms by early postglacial winds. Dune sand is now fixed by vegetation except where disturbed by human activities

Talus deposits—Angular, loose blocks of basalt and diabase accumulated by rockfall and creep at the base of bedrock cliffs along linear traprock ridges in the Mesozoic lowland (Connecticut Valley lowland). Talus deposits form steep, unstable slopes. Generally less than 20 ft thick

Glacial Stratified Deposits

Sorted and stratified sediments composed of gravel, sand, silt, and clay (as defined in the particle-size diagram, figure 12, below), deposited in layers by glacial meltwater. These sediments occur as four basic textural units: gravel deposits, sand and gravel deposits, sand deposits, and fine deposits. On this surficial geologic map, gravel deposits, sand and gravel deposits, and sand deposits are not differentiated and are shown as *Coarse Deposits* where they occur at the land surface. *Fine Deposits* also are shown where they occur at the land surface. Textural changes occur both areally and vertically (fig. 9); however, subsurface textural variations are not shown on this map.

PARTICLE DIAMETER										
10 256	2.5 64	.16 4	.08 2	.04 1	.02 .5	.01 .25	.005 .125	.0025 .063	.00015 .004	inches mm
Boulders	Cobbles	Pebbles	Granules	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
GRAVEL PARTICLES				SAND PARTICLES				FINE PARTICLES		

Figure 12. Grain-size classification used in this report, modified from Wentworth (1922). Abbreviation: mm, millimeter.

Coarse deposits consist of *gravel deposits*, *sand and gravel deposits*, and *sand deposits*, not differentiated in this report. *Gravel deposits* are composed of at least 50 percent gravel-size clasts; cobbles and boulders predominate; minor amounts of sand occur within gravel beds, and sand comprises a few separate layers. Gravel layers generally are poorly sorted, and bedding commonly is distorted and faulted due to postdepositional collapse related to melting of ice. *Sand and gravel deposits* occur as mixtures of gravel and sand within individual layers and as layers of sand alternating with layers of gravel. Sand and gravel layers generally range between 25 and 50 percent gravel particles and between 50 and 75 percent sand particles. Layers are well sorted to poorly sorted; bedding may be distorted and faulted due to postdepositional collapse. *Sand deposits* are composed mainly of very coarse to fine sand, commonly in well-sorted layers. Coarser layers may contain up to 25 percent gravel particles, generally granules and pebbles; finer layers may contain some very fine sand, silt, and clay

Fine deposits include very fine sand, silt, and clay that occur as well-sorted, thin layers of alternating silt and clay (varves), or as thicker layers of very fine sand and silt. Very fine to fine sand commonly occurs at the surface of these lake-bottom deposits and grades downward into rhythmically bedded silt and clay varves. In some places on the lake-bottom surface of glacial Lake Hitchcock (in the Connecticut Valley lowland) and glacial Lake Narragansett (in southeastern Massachusetts), fine deposits are overlain by as much as 30 ft of fine to medium sand, deposited as the lake level lowered or the lake shallowed; this sand has not been mapped separately. Locally, this map unit may include areas underlain by fine sand

Glaciomarine fine deposits include clay, silty clay, fine sand, and some fine gravel deposited in a higher-level sea in environments of low wave energy along the coast and in river estuaries. Fine to very fine sand, massive and laminated, commonly is present at the surface and grades downward into interbedded very fine sand, silt, silty clay, and clay. The lower silty clay and clay is massive and thinly laminated. Total thickness is generally a few feet to 75 ft

Stagnant-ice deposits—Surface coarse sediments include scattered large surface boulders, gravel deposits, and sand and gravel deposits, totaling 5 to 30 ft thick, that overlie predominantly sand deposits. Sand deposits contain deltaic foreset bedding and interlayered beds of fine sand, silt, and a little clay. Sand and silty sand deposits extend downward to basal till and bedrock. Flowtill sediments are interlayered under ice-contact slopes. Stratification in surface and underlying sediments is generally distorted and faulted due to postdepositional collapse related to melting of buried ice. Stagnant-ice deposits are confined to irregular hummocky hills, bounded by ice-contact slopes, present on tops of till hills or extending more than 30 ft above the altitudes of adjacent meltwater morphosequences in lowlands. Deposits are aligned in belts parallel to the retreating ice margin

Glacial Till and Moraine Deposits

End moraine deposits—Composed predominantly of boulders and ablation-facies sandy upper till; lenses of stratified sand and gravel occur locally within the till. In the larger deposits on Cape Cod and Martha's Vineyard, the surface ablation till is as much as 30 ft thick and overlies sand, gravel, and silty sand meltwater deposits. Some end moraine deposits include thrusted sheets of glacial meltwater deposits resulting from readvance of the ice margin (Oldale and O'Hara, 1984). Stratification in underlying sediments may also be deformed, the result of postdepositional collapse caused by melting of buried ice. Surface boulders on end moraine deposits are generally more numerous than on adjacent till surfaces; dense concentrations of boulders are present in some places. Deposits occur as freestanding hummocky landforms, commonly in ridges that trend east-northeast to west-southwest, and range in height from 10 to 100 ft

Thrust moraine deposits—In western Martha's Vineyard, thrusted moraine deposits stand as high as 300 ft in altitude and are composed of allochthonous, ice-thrusted Cretaceous, Tertiary, and older Quaternary sediments, locally overlain by thin surface till and boulders. These coastal-plain beds are fossiliferous, semi-consolidated sand, gravel, and silty clay in tilted strata that were thrust up by glacial ice into positions well above the autochthonous coastal-plain surface, which lies below sea level. Numerous northeast-southwest-trending ridges within the thrust moraine unit mark the edges of these tilted and thrusted strata

Thin till—Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered pebble, cobble, and boulder clasts; large surface boulders are common; unit was mapped where till is generally less than 10 to 15 ft thick including areas of shallow bedrock. Predominantly consists of upper till of the last glaciation; loose to moderately compact, generally sandy, commonly stony. Two facies are present in some places: a looser, coarser grained ablation facies, melted out from supraglacial position; and an underlying more compact, finer grained lodgement facies deposited subglacially. In general, both ablation and lodgement facies of upper till derived from fine-grained bedrock are finer grained, more compact, less stony and have fewer surface boulders than upper till derived from coarse-grained crystalline rocks. Across Massachusetts, fine-grained bedrock sources include the red Mesozoic sedimentary rocks of the Connecticut Valley lowland, marble in the western river valleys, and fine-grained schists in upland areas

Thick till—Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered pebbles, cobbles, and boulders in the shallow subsurface; at greater depths consists of compact, nonsorted matrix of silt, very fine sand, and some clay containing scattered small gravel clasts. Mapped in areas where till is greater than 10 to 15 ft thick, mostly in drumlin landforms in which till thickness commonly exceeds 100 ft (maximum recorded thickness is 230 ft). Although upper till of late Wisconsinan age is the surface deposit, lower till of probable Illinoian age constitutes the bulk of the material in thick-till areas. Lower till is moderately to very compact and is commonly finer grained and less stony than upper till. An oxidized zone, the lower part of a soil profile formed during a period of interglacial weathering, is generally present in the upper part of the lower till. This zone commonly shows closely spaced joints that are stained with iron and manganese oxides

Glacially modified coastal-plain hill deposits—In the Marshfield Hills area (Scituate, Cohasset, Hanover, and Duxbury quadrangles) and in the Pine Hills area (Manomet quadrangle), very compact till and older glacial stratified deposits overlie thrusted blocks of Tertiary coastal-plain strata that are semi-consolidated dark clay layers. Miocene-age green sand deposits have also been reported at depth. These hills in many places were sculpted by the last ice sheet, but they are generally larger (3–4 miles [mi] long and 1–2 mi wide) than typical drumlins

Thick valley till and fine deposits—Composed of sandy surface till with boulders, 3 to 20 ft thick, overlying finer grained till, or fine sand, silt, or clay, local boulders, and local weathered limestone and dolostone bedrock; total thickness of all sediments is 6 to 135 ft, averaging 50 ft. Materials reported in drillers' records include four descriptions usually synonymous with till: hardpan with no boulders; boulders and clay; gravelly hardpan; and clay with few boulders. Unit includes materials probably defining glaciolacustrine fine sediments or various weathered carbonate bedrock materials, listed as follows: gray clay, gray and yellow clay, black soft rock, and weathered bedrock. The subsurface fine sediments are exposed only in fresh, temporary landslide slopes or shallow excavations, where silty-clayey fine sand typically appears to be sheared, deformed, or disaggregated. Original laminations are difficult to discern. Surface morphology of the thick valley till and fine deposits includes (1) a glacially smoothed surface without bedrock outcrops or any relief related to bedrock structure; (2) locally a streamlined shape similar to small drumlins composed of thick till in other parts of Massachusetts; (3) landslide scarps and stream-cut banks commonly having 5 to 10 ft of relief, locally as much as 50 ft; and (4) dry, meltwater-carved channels 3 to 10 ft deep. These deposits extend almost continuously along lower valley slopes in the Housatonic and Hoosic River valleys, and their tributary valleys, that are underlain by marble, dolostone, or limestone and shale bedrock (Zen and others, 1983). The deposits appear to extend beneath the edges of glacial meltwater deposits in the valley bottoms, but their extent beneath thick glacial deposits in the centers of the valleys is not known. Some of these deposits are present in north-draining upland valleys in areas that also contain thick till deposits in drumlins

Bedrock Areas

Bedrock outcrops and areas of abundant outcrop or shallow bedrock—Solid color shows extent of individual bedrock outcrops; horizontal-line pattern indicates areas of shallow bedrock or areas where small outcrops are too numerous to map individually; in areas of shallow bedrock, surficial materials are less than 5 to 10 ft thick. These units were not mapped consistently among all quadrangles; see note at beginning of appendix 1 for information on bedrock outcrop mapping by quadrangle

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Appendix 1. Sources of Data and Information on Map Units and Mapping, by 7.5-Minute Quadrangle

[Number beside quadrangle name corresponds to number shown in figure 10 and on the 1:250,000-scale index map. For all quadrangles, some units were mapped or revised on the basis of recent field studies, analysis of topography, and analysis of MassGIS 2005 orthophoto images. For quadrangles where light detection and ranging (lidar) data were available, areas of thick till and (or) areas of shallow bedrock were mapped or revised on the basis of analysis of the lidar data, mapped outcrops, and soils data (Natural Resources Conservation Service [n.d.]). Additional bedrock outcrops and shallow-bedrock areas may be present, particularly within thin-till areas that have steep slopes and irregular topography]

1 Canaan Quadrangle

Map units were modified from Holmes (1965a) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include coarse glaciofluvial sediments graded to small glacial lakes in the Furnace Brook valley. Thick-till areas were delineated on the basis of topographic analysis. Bedrock outcrops are from structure symbols shown by Ratcliffe (1978). The shallow-bedrock unit represents areas of abundant outcrops, as indicated by rock structure symbols from Ratcliffe (1978).

2 State Line Quadrangle

Map units were modified from Holmes (1964b) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include coarse glaciofluvial and glaciodeltaic sediments graded to small glacial lakes in the Flat Brook, Baldwin Brook, Alford Brook, and upper Williams River valleys, and graded to glacial Lake Great Falls in the lower Williams River valley. Bedrock outcrops are from Ratcliffe (1974b).

3 Egremont Quadrangle

Map units were modified from Holmes (1964a) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Great Falls in the Green River, Seekonk Brook, Hubbard Brook, and Williams River valleys, and similar sediments graded to small glacial lakes in the Karner Brook and Alford Brook valleys. Thick-till areas and thick-valley-till areas were delineated on the basis of topographic analysis. Bedrock outcrops are from Zen and Ratcliffe (1971).

4 Bashbish Falls Quadrangle

Map units were modified from Zen and Hartshorn (1966). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Great Falls in the Race Brook, Dry Brook, lower Schenob Brook, and Willard Brook valleys, and similar sediments graded to small glacial lakes in the upper Schenob Brook valley (ice-contact unit Qcd and outwash unit Qo of Zen and Hartshorn, 1966).

5 Berlin Quadrangle

Map units were modified from Holmes (1965b); from Warren, C.R., and Stone, B.D., 1982, unpublished field map; and from Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps of the town of Williamstown. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Bascom in the West Branch Green River and Sweet Brook valleys (ice-contact deposits Qic, deltaic deposits Qfd, fine lacustrine deposits Ql, and alluvial-fan deposits Qaf of Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps). Shallow-bedrock areas include areas of “bedrock” and most areas of “thin till and bedrock” of Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps.

6 Hancock Quadrangle

Map units were modified from Holmes (1967c) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Bascom in the West Branch Green River valley, and similar sediments graded to small glacial lakes in the Kinderhook Creek and Sachem Brook valleys and occurring at the eastern end of Brodie Mountain Road.

7 Pittsfield West Quadrangle

Map units were modified from Holmes (1965d) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Housatonic in the West Branch Housatonic River valley, and similar sediments graded to small glacial lakes in the valleys of Daniels Brook, Hawthorne Brook, Smith Brook, May Brook, Lilly Brook, and Shaker Brook. Bedrock outcrops are from Ratcliffe (1978).

8 Stockbridge Quadrangle

Map units were modified from Holmes (1964c) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Great Falls in the lower Housatonic River valley and glacial Lake Housatonic in the upper Housatonic River valley, and similar sediments graded to small glacial lakes in the Konkapot Brook and Williams River valleys. Bedrock outcrops are from Ratcliffe (1974c).

9 Great Barrington Quadrangle

Map units were modified from Holmes (1964d) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Great Falls in the Housatonic River valley and the lower Williams River valley, and similar sediments graded to small glacial lakes in the Muddy Brook and Konkapot River valleys. Bedrock outcrops are from Ratcliffe (1974a).

10 Ashley Falls Quadrangle

Map units were modified from Holmes and Newman (1971). Glacial stratified deposits include predominantly coarse glaciodeltaic sediments and fine lake-bottom sediments of glacial Lake Great Falls in the Housatonic River valley (outwash unit Qo and stream-terrace unit Qst3 of glacial Lake Falls Village from Holmes and Newman, 1971), and deposits of small glacial lakes in the Konkapot River valley (ice-contact unit Qcd3 and units Qo, Qst2, and Qcd2 of Holmes and Newman, 1971). Bedrock outcrops and shallow-bedrock areas, defined as “areas of closely spaced outcrops,” were modified from Holmes and Newman (1971).

11 Williamstown Quadrangle

Map units were modified from Dohrenwend, J.C., 1979, unpublished map; from Warren, C.R., and Stone, B.D., 1982, unpublished field map; and from Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps of the town of Williamstown. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Bascom in the Hoosic River and Green River valleys (ice-contact deposits Qic, deltaic deposits Qd and Qfd, and fine lacustrine deposits Ql of Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps). Some bedrock outcrops are from Ratcliffe and others (1993). Shallow-bedrock areas include areas of “bedrock” and most areas of “thin till and bedrock” of Dethier, D.P., and DeSimone, D.J., 1988, unpublished maps.

12 Cheshire Quadrangle

Map units were modified from Holmes (1968a) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Bascom in the Hoosic River valley, and similar sediments graded to small glacial lakes in the Muddy Brook, Town Brook, and Green River valleys. Thick-till areas and thick-valley-till areas were delineated on the basis of topographic (lidar) analysis. Some bedrock outcrops are from Ratcliffe and others (1993) and Herz (1958).

13 Pittsfield East Quadrangle

Map units were modified from Holmes (1968c) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Housatonic in the lower East Branch Housatonic River valley, and similar sediments graded to small glacial lakes in the upper East Branch Housatonic River valley, the Wahconah Falls Brook valley, and the Unkamet Brook valley. Thick-till areas and thick-valley-till areas were delineated on the basis of topographic analysis (lidar). Bedrock outcrops are from Ratcliffe (1984b).

14 East Lee Quadrangle

Map units were modified from Holmes (1967b) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Housatonic in the Housatonic River valley, and similar sediments graded to small glacial lakes in the Greenwater Brook valley. Bedrock outcrops are from Ratcliffe (1985).

15 Monterey Quadrangle

Map units were modified from Holmes (1964e) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Hop Brook, Konkapot River, and Clam River valleys. Thick-till areas and thick-valley-till areas were delineated on the basis of topographic analysis. Bedrock outcrops are from Ratcliffe (1984a).

16 South Sandisfield Quadrangle

Map units were modified from Holmes (1964f) and Harwood (1979), and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Umpachene River, Riiska Brook, and Thousand Acre Swamp valleys. Deposits include scattered postglacial alluvial and swamp deposits. Bedrock outcrops are from Harwood (1979).

17 North Adams Quadrangle

Map units were modified from Holmes (1968b) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Bascom in the Hoosic River valley, and similar sediments graded to small glacial lakes in the Tunnel Brook, Canyon Brook, and Hudson Brook valleys. Bedrock outcrops are from Ratcliffe and others (1993) and Herz (1961).

18 Windsor Quadrangle

Map units were modified from Holmes (1965e) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Bascom in the Hoosic River valley; similar sediments graded to small glacial lakes in the Dry Brook valley; and glaciofluvial sediments in the upper Westfield River valley. Bedrock outcrops are from Norton (1967).

19 Peru Quadrangle

Map units were modified from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Cady Brook and East Branch Housatonic River valleys and in the Tracy Brook, Windsor Brook, and Weston Brook valleys. Bedrock outcrops are from Norton (1974).

20 Becket Quadrangle

Map units were modified from Holmes (1967a) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Spark Brook, Cushman Brook, and Walker Brook valleys; and small glaciofluvial deposits in other valleys. Bedrock outcrops are from Norton (1958).

21 Otis Quadrangle

Map units were modified from Holmes (1965c) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the West Branch Farmington River and Spark Brook valleys.

22 Tolland Center Quadrangle

Map units were modified from Holmes, G.W., 1967, unpublished field map, and Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the West Branch Farmington River, Taylor Brook, and Richardson Brook valleys.

23 Rowe Quadrangle

Map units were modified from Chidester and others (1967) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Deerfield River valley (ice-channel unit Qic, ice-contact unit Qcd, and stream-terrace unit Qst of Chidester and others, 1967). Bedrock outcrops are from Chidester and others (1967).

24 Plainfield Quadrangle

Map units were modified from Osberg and others (1971) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Chickley River and Deerfield River valleys; and glaciofluvial sediments in the Westfield River valley. Bedrock outcrops are from Osberg and others (1971).

25 Worthington Quadrangle

Map units were modified from Hatch (1969) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Alder Meadow Brook, Tower Brook, and Westfield River valleys; and glaciofluvial sediments in other valleys. Bedrock outcrops are from Hatch (1969).

26 Chester Quadrangle

Map units were modified from Hatch and others (1970) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments in the West Branch Westfield River and Middle Branch Westfield River valleys. Bedrock outcrops are from Hatch and others (1970).

27 Blandford Quadrangle

Map units were modified from Hatch and Stanley (1976) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the West Branch Westfield River valley; and scattered small deposits in other valleys. Bedrock outcrops are from Hatch and Stanley (1976).

28 West Granville Quadrangle

Map units were modified from Schnabel (1973) and from Warren, C.R., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the valleys of Exit Brook and Valley Brook. Bedrock outcrops are from Schnabel (1973). The shallow-bedrock unit represents “areas of closely spaced outcrops” of Schnabel (1973).

29 Heath Quadrangle

Map units were reproduced from Hatch and Hartshorn (1968). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Deerfield River, West Branch North River, and Mill Brook valleys, in the West Branch Brook valley, and in the Hartwell, Avery, Wilder, and Taylor Brook valleys.

30 Ashfield Quadrangle

Map units were reproduced from Hartshorn, J.H., 1975, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Deerfield River, Clesson Brook, Clark Brook, and South River valleys. Distribution of bedrock outcrops and some shallow-bedrock areas is from Hatch (1981).

31 Goshen Quadrangle

Map units were modified from Hatch and Warren (1982). Glacial stratified deposits include ice-marginal glacial-lake deposits in the Chapel Brook and West Branch Mill River valleys, which drained eastward toward the retreating ice lobe in the Connecticut River valley, and remnants of sediment-dammed glacial-lake deposits in the Westfield River valley. Bedrock outcrops include only those examined in the field during bedrock mapping (Hatch and Warren, 1982).

32 Westhampton Quadrangle

Map units were reproduced from Warren, C.R., 1976, unpublished field map. Glacial stratified deposits include coarse, ice-dammed glacial-lake deposits in the Sodom Brook and North Branch Manhan River valleys, which drained eastward toward the retreating ice margin. Remnants of coarse, sediment-dammed glacial-lake deposits are present in the south-draining Westfield River valley. Distribution of bedrock outcrops is from Clark (1987).

33 Woronoco Quadrangle

Map units were reproduced from Warren, C.R., 1976, unpublished field map. Glacial stratified deposits include coarse, ice-dammed glacial-lake deposits in upland areas, and coarse and fine deposits of glacial Lake Westfield in the lowlands. Distribution of bedrock outcrops is from Stanley and others (1982).

34 Southwick Quadrangle

Map units were reproduced from Schnabel (1971). Glacial stratified deposits include ice-dammed glacial-lake deposits in the Dickinson Brook and Munn Brook valleys, sediment-dammed glacial-lake deposits in the vicinity of Congamond Lakes, and coarse deposits of glacial Lake Westfield in the northeastern part of the quadrangle. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Schnabel (1971). The shallow-bedrock unit is defined as areas of abundant outcrops and patches of thin surficial material.

35 Colrain Quadrangle

Map units were modified from Segerstrom (1955a). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Green River, Hinsdale Brook, and North River valleys and several tributary valleys. Coarse and fine deposits of glacial Lake Hitchcock are in the southeast corner of the quadrangle. The thick-till unit is slightly modified from the Qgd (drumlins) unit of Segerstrom (1955a) and includes some areas within his Qgt unit. Bedrock outcrops were mapped mainly in areas of glacial stratified deposits. The shallow-bedrock unit is modified from the Qgm (thin ground moraine) unit of Segerstrom (1955a), which is defined as “thin deposits of ground moraine (till) with many exposures of bedrock.”

36 Shelburne Falls Quadrangle

Map units were modified from Segerstrom (1959). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small ice-dammed glacial lakes in the South River, Bear River, and Deerfield River valleys. Coarse and fine deposits of glacial Lake Hitchcock are in the eastern part of the quadrangle. The thick-till unit is modified from the Qgd (drumlins) unit of Segerstrom (1959) and includes some areas within his Qgt unit. Bedrock outcrops were mapped mainly in areas of glacial stratified deposits. The shallow-bedrock unit is modified from the Qgm (thin ground moraine) unit of Segerstrom (1959), which is defined as “thin deposits of ground moraine (till) with many exposures of bedrock.”

37 Williamsburg Quadrangle

Map units were reproduced from Segerstrom (1955b). Glacial stratified deposits include ice-marginal glacial-lake deposits in the Roaring Brook and West Brook valleys, which drained eastward toward the retreating ice lobe in the Connecticut Rvier valley, and sediment-dammed glacial-lake deposits in the Mill River valley, in the southwestern part of the quadrangle. Coarse and fine deposits of glacial Lake Hitchcock are in the eastern part of the quadrangle. The thick-till unit is slightly modified from the Qgd (drumlins) unit of Segerstrom (1955b). Bedrock outcrops were mapped mainly in areas of glacial stratified deposits. The shallow-bedrock unit is modified from the Qgm (thin ground moraine) unit of Segerstrom (1955b), which is defined as “thin deposits of ground moraine (till) with many exposures of bedrock.”

38 Easthampton Quadrangle

Map units were reproduced from Larsen, F.D., 1976, unpublished field map. Glacial stratified deposits include coarse, ice-dammed glacial-lake deposits in the Roberts Meadow Brook, Turkey Brook, Mill River, and North Branch Manhan River valleys, which drained eastward toward the retreating ice margin. Coarse and fine deposits of glacial Lake Manhan and glacial Lake Hitchcock are present in the lowland areas.

39 Mount Tom Quadrangle

Map units were reproduced from Larsen (1972). Glacial stratified deposits include coarse and fine deposits of glacial Lake Westfield in the western part of the quadrangle, glacial Lake Manhan in the northern part, and glacial Lake Hitchcock in the eastern part. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Larsen (1972). The shallow-bedrock unit is defined as areas of abundant outcrops.

40 West Springfield Quadrangle

Map units were reproduced from Colton and Hartshorn (1970). Glacial stratified deposits in the eastern half of the quadrangle include coarse and fine deposits of glacial Lake Hitchcock; the western half of the quadrangle includes predominantly coarse deposits of glacial Lake Westfield. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Colton and Hartshorn (1970). The shallow-bedrock unit is defined as large areas of nearly continuous bedrock outcrop.

41 Bernardston Quadrangle

Map units were reproduced from Stone, J.R., 1975, unpublished field map, and Larsen, F.D., 1977, unpublished field map. Mapping in the southern half of the quadrangle is based on an unpublished M.S. thesis by Retelle (1979). Glacial stratified deposits include coarse and fine deposits of glacial Lake Hitchcock in the Green River, Fall River, and Connecticut River (Dry Brook) valleys, and deposits of local higher-level lakes. Distribution of bedrock outcrops and shallow-bedrock areas is from Balk (1956a). The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

42 Greenfield Quadrangle

Map units were reproduced from Jahns (1966). Glacial stratified deposits are predominantly coarse and fine deposits of glacial Lake Hitchcock in the Green River, Deerfield River, and Connecticut River valleys; other glaciofluvial and glacio-lacustrine deposits graded to higher level ice-dammed lakes are in tributary valleys. The thick-till unit is modified from the Qgd (drumlins) unit of Jahns (1966). The shallow-bedrock unit is modified from the Qgm (thin ground moraine) unit of Jahns (1966), which is defined as “generally thin deposits of ground moraine (till) with many exposures of bedrock.”

43 Mount Toby Quadrangle

Map units were reproduced from Jahns (1951). Glacial stratified deposits include predominantly coarse and fine deposits of glacial Lake Hitchcock. Bedrock outcrops were mapped mainly in areas of glacial stratified deposits. The shallow-bedrock unit is modified from the Qgm (thin ground moraine) unit of Jahns (1951), which is defined as “thin deposits of ground moraine (till) with many exposures of bedrock;” this unit is more extensive than in other quadrangles and is probably overmapped. The thick-till unit is slightly modified from the Qgd (drumlins) unit of Jahns (1951).

44 Mount Holyoke Quadrangle

Map units were modified from Balk (1957) using unpublished field maps from Larsen, F.D., 1976, and Stone, J.R., 1976. Glacial stratified deposits are predominantly coarse and fine deposits of glacial Lake Hitchcock. The shallow-bedrock unit is modified from the areas shown as bedrock units on the map of Balk (1957); these areas are likely to contain abundant bedrock outcrops.

45 Springfield North Quadrangle

Map units were reproduced from Larsen, F.D., 1976, unpublished field map. Glacial stratified deposits include coarse and fine deposits of glacial Lake Hitchcock.

46 Springfield South Quadrangle

Map units were reproduced from Hartshorn and Koteff (1967). Glacial stratified deposits are predominantly coarse and fine deposits of glacial Lake Hitchcock. Thick-till areas were mapped based on topographic analysis, on well and test-hole data, and on the position of drumlin axes shown on the map of Hartshorn and Koteff (1967). The shallow-bedrock unit is defined as areas of scattered outcrops and areas of thinly veneered bedrock.

47 Northfield Quadrangle

Map units were reproduced from Campbell and Hartshorn (1980). Glacial stratified deposits are predominantly coarse and fine deposits of glacial Lake Hitchcock in the Connecticut River valley. Thick-till areas were mapped based on topographic analysis and the position of drumlin axes shown on the map of Campbell and Hartshorn (1980). The shallow-bedrock unit represents areas of thin surficial deposits and numerous bedrock outcrops.

48 Millers Falls Quadrangle

Map units were reproduced from Stone, J.R., 1975, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Sawmill River and Millers River valleys and their tributary valleys. In the Connecticut River valley, coarse and fine sediments of glacial Lake Hitchcock are present. Distribution of bedrock outcrops and shallow-bedrock areas is modified from Balk (1956b).

49 Shutesbury Quadrangle

Map units were reproduced from Stone, J.R. (1978). Glacial stratified deposits include deposits of ice-dammed glacial lakes in the west-draining valleys of Amethyst Brook and its tributaries, Dean Brook, Roaring Brook, and the Sawmill River, and deposits of sediment-dammed lakes in the south-draining valleys of the West Branch Swift River and Doolittle Brook. Coarse and fine deposits of glacial Lake Hitchcock are present in the southwestern part of the quadrangle. The shallow-bedrock unit is defined as areas where bedrock is inferred to be less than 10 ft beneath the surface and where numerous bedrock outcrops are likely to be found.

50 Belchertown Quadrangle

Map units were reproduced from Caggiano (1978). Glacial stratified deposits include coarse deposits of sediment-dammed glacial lakes in the Jabish Brook and Broad Brook valleys and an ice-dammed glacial lake in the Knights Pond valley, and coarse and fine deposits of glacial Lake Hitchcock in the western part of the quadrangle. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Caggiano (1978). The shallow-bedrock unit is defined as areas where surficial material is less than 10 ft thick.

51 Ludlow Quadrangle

Map units were modified from Leo (1974), using unpublished field maps by Larsen, F.D., 1976. Glacial stratified deposits include coarse, ice-dammed glacial-lake deposits in upland tributary valleys of the Chicopee River, and coarse deltaic deposits of glacial Lake Hitchcock in the western part of the quadrangle. The shallow-bedrock unit is defined as areas of abundant outcrops.

52 Hampden Quadrangle

Map units were reproduced from Hildreth and Colton (1982). Glacial stratified deposits include coarse deposits of a lowering series of ice-dammed glacial lakes in the upper Scantic River valley and its tributaries, and coarse deposits of sediment-dammed glacial lakes in the lower Scantic River valley and the North Branch and South Branch Mill River valleys. Coarse deltaic deposits of glacial Lake Hitchcock are present in the northwestern part of the quadrangle. Thick-till areas were mapped based on topographic analysis, on well and test-hole data, and on the position of drumlin axes shown on the map of Hildreth and Colton (1982). The shallow-bedrock unit is defined as areas of closely spaced outcrops and areas where surficial materials are less than 10 ft thick.

53 Mount Grace Quadrangle

Map units were reproduced from Hadley (1949). Glacial stratified deposits include units Qk and Qe of Hadley (1949), which are predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the valleys of the West Branch Tully River, Mirey Brook-Mountain Brook, Darling Brook, and Hodge Brook. Thick-till areas were delineated based on topographic analysis. The shallow-bedrock unit represents areas of abundant outcrop.

54 Orange Quadrangle

Map units were reproduced from Stone, J.R., 1976, unpublished field map, and Larsen, F.D., 1980, unpublished field map. Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial lakes in the valleys of the Millers River and tributaries, Middle Branch Swift River, and Whetstone Brook. Distribution of bedrock outcrops and shallow-bedrock areas is from Robinson (2008).

55 Quabbin Reservoir Quadrangle

Map units were reproduced from Stone, J.R., 1975, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to a series of glacial lakes in the East, Middle, and West Branch Swift River valleys; today these deposits lie mostly underwater beneath the Quabbin Reservoir. Bedrock outcrops were not mapped in the field; those shown on the map are visible on 2005 orthophoto images.

56 Winsor Dam Quadrangle

Map units were reproduced from Stone, J.R., 1976, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to glacial lakes in the Swift River, Beaver Brook, Flat Brook, and Muddy Brook valleys; today these deposits lie mostly underwater beneath the Quabbin Reservoir. Bedrock outcrops were not mapped in the field; those shown on the map are visible on 2005 orthophoto images.

57 Palmer Quadrangle

Map units were reproduced from Peper (1978). Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the valleys of the Swift River, Ware River, and Quaboag River and their tributaries. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Peper (1978). The shallow-bedrock unit is defined as “areas of abundant outcrop and thin surficial cover.”

58 Monson Quadrangle

Map units were reproduced from Peper (1977). Glacial stratified deposits include predominantly coarse glaciodeltaic sediments laid down in an ice-dammed glacial lake in the valleys of the north-draining Chicopee Brook, Twelvemile Brook, Vinica Brook, Conant Brook, and Foskett Mill Stream. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Peper (1977). The shallow-bedrock unit is defined as "areas of abundant outcrop and thin drift."

59 Royalston Quadrangle

Map units were reproduced from Stone, J.R., 1975, unpublished field map, and Larsen, F.D., 1980, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the valleys of the East Branch Tully River, Lawrence Brook, Beaver Brook, and Millers River. Few bedrock outcrops were mapped in the field; some outcrops in the northwestern part of the map area were mapped from the position of structure symbols shown by Springston (1990, pl. 2). Some outcrops were mapped where visible on 2005 orthophoto images.

60 Athol Quadrangle

Map units were modified from Eschman (1966). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the Millers River valley and tributary valleys, and in the valleys of the East Branch Swift River, Riceville Brook, and Beaver Brook. Thick-till areas were mapped based on topographic analysis and on well and test-hole data. The shallow-bedrock unit is defined as "areas of numerous small scattered exposures or where bedrock is very near the surface and controls the topography" (Eschman, 1966).

61 Petersham Quadrangle

Map units were reproduced from Stone, J.R., 1976, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to glacial lakes in the East Branch Swift River valley. Bedrock outcrops were not mapped in the field; those shown on the map are visible on 2005 orthophoto images.

62 Ware Quadrangle

Map units were modified from Mulholland (1975). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the valleys of the Ware River, Muddy Brook, Mill Brook and tributaries, and Winimusset Brook. Fine deposits occur in the subsurface in the Winimusset Brook valley (Stone, B.D., and others, 1992). Thick-till areas were mapped based on topographic analysis and on well and test-hole data. Some bedrock outcrop areas are from Field (1976). The shallow-bedrock unit represents areas of closely spaced outcrops.

63 Warren Quadrangle

Map units were reproduced from Pomeroy (1977). Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial lakes in the Quaboag River valley and its tributary valleys. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Pomeroy (1977). The shallow-bedrock unit is defined as "closely spaced outcrops where surficial deposits are thin."

64 Wales Quadrangle

Map units were reproduced from Stone, J.R., 1975, unpublished field map. Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Quinebaug River valley and its tributary valleys. Bedrock outcrops and shallow-bedrock areas were reproduced from Seiders (1976), where the shallow-bedrock unit is defined as "areas of thin till and abundant outcrop."

65 Winchendon Quadrangle

Map units were reproduced from Stone, J.R., 1979, unpublished field map. Glacial stratified deposits include coarse glaciodeltaic sediments graded to, and fine lake-bottom sediments deposited in, glacial lakes in the Otter River and Millers River valleys and their tributary valleys. The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

66 Templeton Quadrangle

Map units were reproduced from Stone, J.R., 1979, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, ice-dammed glacial lakes in the valleys of the Otter River and tributaries, and coarse sediments graded to sediment-dammed glacial lakes in the Burnshirt River-Trout Brook valley. The shallow-bedrock unit represents areas of small scattered bedrock outcrops and where bedrock is interpreted to be within 10 ft of the land surface.

67 Barre Quadrangle

Map units were reproduced from Larsen, F.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to glacial lakes in the Ware River valley and its tributary valleys. Bedrock outcrop areas are from Tucker (1977). The shallow-bedrock unit represents areas of closely spaced outcrops.

68 North Brookfield Quadrangle

Map units were reproduced from Larsen, F.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to sediment-dammed glacial lakes in the Ware River, Sevenmile River, and Fivemile River valleys and graded to ice-dammed glacial lakes in the north-draining Bell Brook and Burrow Brook valleys. Most bedrock outcrops were not mapped in the field. Those shown on the map are visible on 2005 orthophoto images.

69 East Brookfield Quadrangle

Map units were reproduced from Pomeroy (1975). Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the Quaboag River valley and its tributary valleys. Thick-till areas were mapped based on topographic analysis and on the position of drumlin axes shown on the map of Pomeroy (1975). The shallow-bedrock unit is defined as “closely spaced outcrops where surficial deposits are thin.”

70 Southbridge Quadrangle

Map units were modified from Moore (1978). Glacial stratified deposits include coarse glaciofluvial and glaciodeltaic sediments graded to small glacial lakes in the Quinebaug River valley and its tributary valleys. Bedrock outcrops were reproduced from Moore (1978), and many areas of abundant small outcrops were included in the shallow-bedrock unit.

71 Ashburnham Quadrangle

Map units were reproduced from Stone, B.D., 1978, unpublished field map. Glacial stratified deposits are predominantly coarse glaciofluvial and glaciodeltaic sediments in the Phillips Brook valley and in headwater valleys of the Millers River. Bedrock outcrops and shallow-bedrock areas in the eastern part of the quadrangle were reproduced from Peterson (1984, pl. 3). Some outcrops were mapped where visible on 2005 orthophoto images.

72 Gardner Quadrangle

Map units were reproduced from Stone, B.D. (1978). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the valleys of the Whitman River and Mahoney Brook and their tributaries. The shallow-bedrock unit is defined as “areas where surficial deposits are generally less than 3 meters (m) (10 ft) thick, and may contain numerous small bedrock outcrops.”

73 Wachusett Mountain Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to glacial lakes in the valleys of the East Branch Ware River and tributaries, West Branch Ware River, and Wachusett Brook. Bedrock outcrop areas are from Tucker (1977). The shallow-bedrock unit represents areas of closely spaced outcrops.

74 Paxton Quadrangle

Map units in the western part of the quadrangle were reproduced from Stone, B.D., 1982, unpublished field map. Map units in the eastern part of the quadrangle were reproduced from Stone (1980). Glacial stratified deposits include coarse sediments graded to glacial lakes in the Sevenmile River, Turkey Hill Brook, and Asnebumskit Brook valleys. The shallow-bedrock unit in the eastern part of the quadrangle is defined as “areas where surficial deposits are generally less than 3 m (10 ft) thick, locally containing numerous bedrock outcrops.” Some bedrock outcrops were taken from Walsh (2002).

75 Leicester Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse sediments graded to glacial lakes in the French River and Cranberry River valleys and their tributary valleys. Bedrock outcrops were not mapped in the field. Those shown on the map are visible on 2005 orthophoto images. A few outcrops were located from structure symbols shown on the map of Barosh and Johnson (1976).

76 Webster Quadrangle

Map units were modified from Barosh (1973). Glacial stratified deposits include coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the Quinebaug River and French River valleys and their tributary valleys. Thick-till areas were modified from the Qt3 unit and from the position of drumlin axes, both shown on the map of Barosh (1973). Bedrock outcrops and areas of shallow bedrock are from Barosh (2009), where the shallow-bedrock unit is defined as “areas of abundant outcrops and areas where bedrock lies within 3 m (10 ft) of the surface.”

77 Ashby Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the South Brook, Willard Brook, and Pearl Hill Brook valleys, in the Walker and Mason Brook valleys, and in the Trapfall Brook valley.

78 Fitchburg Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Nashua in the Nashua River valley; and glaciofluvial and glaciodeltaic sediments in other tributary valleys.

79 Sterling Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the Quinapoxet River and Stillwater River valleys and other tributary valleys.

80 Worcester North Quadrangle

Map units were reproduced from Stone (1980). Glacial stratified deposits include deposits of glacial Lake Nashua, and other glaciofluvial and glaciolacustrine deposits. Some thick-till areas were reproduced from the drumlin till unit (Qtd) and the mixed-till unit (Qtm) of Stone (1980). The shallow-bedrock unit is defined as “areas where surficial deposits are generally less than 3 m (10 ft) thick, locally containing numerous bedrock outcrops.”

81 Worcester South Quadrangle

Map units were reproduced from Haselton, G.M., and Stone, B.D., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Blackstone River valley and tributary valleys and in the Wellington Brook and Dark Brook valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Haselton and Stone on their 1982 unpublished field maps. Bedrock outcrops are from Walsh and Merschat (2015) and from Dixon, H.R., 1977, unpublished field maps.

82 Oxford Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the French River valley and the Whitin Reservoir valley. Distribution of bedrock outcrops is from Barosh, P.J., 2005, unpublished field map, and Barosh (1976).

83 Townsend Quadrangle

Map units were reproduced from Koteff and Stone (1990). Glacial stratified deposits include deposits of glacial Lakes Nashua and Nissitissit, and other smaller valley deposits. Thick-till areas were inferred from aerial photographs, from topographic analysis, from well data, and from drumlin symbols shown by Koteff and Stone (1990). Not all bedrock outcrops were mapped in thin-till areas, and the shallow-bedrock unit is defined as “areas of abundant exposures and areas where surficial deposits are less than 10 ft thick, mapped in part from aerial photographs.”

84 Shirley Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map, with minor contributions from Allmendinger and Schneider (1976). Glacial stratified deposits include deposits of glacial Lake Nashua and other smaller valley deposits.

85 Clinton Quadrangle

Map units were reproduced from Koteff (1966). Glacial stratified deposits include deposits of glacial Lakes Nashua, Assabet, and Leominster, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include glacial Lake Nashua lake-bottom deposits (unit Qnbb of Koteff, 1966). Areas of thick till were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Koteff (1966). Shallow-bedrock areas are defined as "areas of abundant exposures where surficial deposits are thin; mapped largely from aerial photographs."

86 Shrewsbury Quadrangle

Map units were reproduced from Shaw (1969). Some additional outcrops are from Hepburn (1978) and Barosh (1978). Glacial stratified deposits include deposits of glacial Lakes Assabet and Nashua, and other smaller valley deposits. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Shaw (1969). Shallow-bedrock areas are defined as "areas of abundant outcrops, compiled in part from aerial photographs."

87 Grafton Quadrangle

Map units were reproduced from Haselton, G.M., and Fontaine, E., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Blackstone, Quinsigamond, and West River valleys and their tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Haselton and Fontaine on their 1982 unpublished field maps. Distribution of most bedrock outcrops is from Walsh and others (2011). Shallow-bedrock areas are areas of abundant bedrock exposures.

88 Uxbridge Quadrangle

Map units were reproduced from Haselton, G.M., and Fontaine, E., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Mumford and Blackstone River valleys and their tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Haselton and Fontaine on their 1982 unpublished field maps. Bedrock outcrops are from Walsh (2014) and from Dixon, H.R., 1977, unpublished field maps.

89 Pepperell Quadrangle

Map units were reproduced from Koteff and Volckmann (1973). Glacial stratified deposits include deposits of glacial Lakes Nashua and Nissitissit, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lakes Nashua and Nissitissit (units Qnb and Qnib of Koteff and Volckmann, 1973). Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Koteff and Volckmann (1973). Not all bedrock outcrops were mapped by Koteff and Volckmann (1973) in thin-till areas, and their shallow bedrock is defined as "areas of abundant exposures and thin surficial deposits;" their mapping of the extent of bedrock exposures in till was in part from aerial photographs.

90 Ayer Quadrangle

Map units were reproduced from Jahns (1953). Glacial stratified deposits include deposits of glacial Lake Nashua and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Nashua (unit Qnl of Jahns, 1953). Some thick-till areas were reproduced from Jahns (1953). The shallow-bedrock unit is defined as "areas where exposures are small and scattered."

91 Hudson Quadrangle

Map units were reproduced from Hansen (1956). Glacial stratified deposits include various glacial lake and stream deposits. Most thick till shown was reproduced from the drumlin till unit on the published map. Shallow-bedrock areas are large areas where Hansen (1956) mapped numerous outcrops.

92 Marlborough Quadrangle

Map units were reproduced from Hildreth and Stone (2004); bedrock outcrops and shallow-bedrock areas in part are from Kopera and others (2006). Glacial stratified deposits include deposits of glacial Lake Assabet and other glacial lakes in the Cedar Swamp and Sudbury Reservoir valleys. Shallow-bedrock areas are defined as "areas of abundant exposures and areas where surficial deposits are generally less than 10 ft thick."

93 Milford Quadrangle

Map units were reproduced from Haselton, G.M., and Fontaine, E., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the West River and Charles River valleys and their tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Haselton and Fontaine on their 1982 unpublished field maps. Most bedrock outcrops in the southern part of the quadrangle are from Shaw, C.E., Jr., 1966, unpublished field map. Shallow-bedrock areas are areas of abundant bedrock exposures.

94 Blackstone Quadrangle

Map units were reproduced from Haselton, G.M., and Fontaine, E., 1982, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Mill River and Blackstone River valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Haselton and Fontaine on their 1982 unpublished field maps. Most bedrock outcrops in the northern part of the quadrangle are from Shaw, C.E., Jr., 1966, unpublished field map. In the southern part of the quadrangle, most bedrock outcrops are from McKniff (1964) and from Goldsmith, R., 1978, unpublished field map.

95 Nashua South Quadrangle

Map units were reproduced from Holland, W.R., compiler, 1982, unpublished field map, and from Jahns and others (1946). Some bedrock outcrops are from Walsh and others (2013). Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the Merrimack River valley and its tributary valleys.

96 Westford Quadrangle

Map units were reproduced from Hartshorn, J.H., compiler, 1980, unpublished field map, and from Jahns and others (1946). Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the Nashoba Brook and Stony Brook valleys and their tributary valleys.

97 Maynard Quadrangle

Map units were reproduced from Hansen (1956). Glacial stratified deposits include various glacial lake and stream deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Sudbury (parts of unit Qsg of Hansen, 1956). Most thick till was reproduced from the drumlin till unit on the published map. Shallow-bedrock areas are large areas where Hansen (1956) mapped numerous outcrops.

98 Framingham Quadrangle

Map units were reproduced from Nelson (1974b). Glacial stratified deposits include deposits of glacial Lakes Charles and Sudbury, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lakes Charles and Sudbury (units Qlsb and Qlcb of Nelson, 1974b). Some contacts between till and glacial stratified deposits have been modified from Nelson (1974b). Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Nelson (1974b). Shallow-bedrock areas are defined as “closely spaced outcrops where surficial deposits are 10 ft thick or less.”

99 Holliston Quadrangle

Map units were reproduced from Volckmann (1975a). Glacial stratified deposits include deposits of glacial Lake Medfield, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Medfield (unit Qm2 of Volckmann, 1975a). Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Volckmann (1975a). Shallow-bedrock areas are defined as “large areas of abundant outcrop and generally thin drift.”

100 Franklin Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field maps. Bedrock outcrops are from Lyons (1977) and from Goldsmith, R., 1978, unpublished field maps. Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Peters River, Charles River, Miscoe Brook, and Mine Brook valleys and their tributary valleys.

101 Pawtucket Quadrangle

Map units were reproduced from Chute (1949). Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Abbott Run valley.

102 Lowell Quadrangle

Map units were reproduced from Hartshorn, J.H., compiler, 1982, unpublished field map. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the Merrimack River valley and its tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, from well data, and from drumlin symbols shown on the unpublished field map.

103 Billerica Quadrangle

Map units were reproduced from Holland (1980) and Castle (1950). Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments in the Concord River valley and its tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, from well data, and from drumlin symbols shown in Holland (1980).

104 Concord Quadrangle

Map units were reproduced from Koteff (1964b). Glacial stratified deposits include deposits of glacial Lakes Sudbury and Concord, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lakes Sudbury and Concord (units Qlsb and Qlcb of Koteff, 1964b). Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Koteff (1964b). Shallow-bedrock areas are defined as “areas of abundant exposures where surficial deposits are thin.” Some bedrock outcrops are from Bell (1976).

105 Natick Quadrangle

Map units were reproduced from Nelson (1974a). Glacial stratified deposits include deposits of glacial Lakes Charles and Sudbury, and other smaller valley deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Sudbury (unit Qlsb of Nelson, 1974a). Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Nelson (1974a). Shallow-bedrock areas are defined as “closely spaced outcrops where surficial deposits are thin.”

106 Medfield Quadrangle

Map units were reproduced from Volckmann (1975b). Glacial stratified deposits include deposits of glacial Lake Medfield, and other smaller valley deposits. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Volckmann (1975b). Shallow-bedrock areas are areas of abundant outcrop.

107 Wrentham Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field maps. Bedrock outcrops are from Stone’s unpublished field maps and from Lyons (1977) and Williams and Willey (1973). Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Ten Mile, Mill, and Neponset River valleys and their tributary valleys.

108 Attleboro Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field maps. Bedrock outcrops are from Stone’s unpublished field maps and from Lyons (1977) and Willey and others (1978). Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments in the Abbott Run valley, the Ten Mile, Sevenmile, and Bungay River valleys, the Bliss Brook valley, and the Wading River valley.

109 East Providence Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic and fine lake-bottom sediments deposited in, glacial Lake Narragansett in the Runnins River, Ten Mile River, and Palmer River lowlands. Thick-till areas were delineated based on topographic analysis. Distribution of bedrock outcrops is from Willey and others (1978) and Lyons (1977), and from Stone’s 1982 unpublished field map. The shallow-bedrock unit represents areas of numerous outcrops.

110 Bristol Quadrangle

Map units were reproduced from Smith (1955). Glacial stratified deposits include fine glaciofluvial sediments of outwash-plain deposits (unit Qop of Smith, 1955), which grade to glacial Lake Narragansett deposits in the eastern Narragansett Bay lowland.

111 Salem Depot Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map.

112 Lawrence Quadrangle

Map units were reproduced from Castle (1958). Glacial stratified deposits include deposits of glacial Lake Methuen, and other glaciofluvial and glaciolacustrine deposits. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Methuen (unit Qml of Castle, 1958). Deposits mapped as morainal ice-contact deposits (unit Qmi of Castle, 1958) have been included here as coarse stratified deposits. Some thick-till areas were reproduced from the drumlin till unit (Qgd of Castle, 1958).

113 Wilmington Quadrangle

Map units were reproduced from Castle (1959). Glacial stratified deposits include glaciofluvial and glaciolacustrine sediments. Some thick-till areas were reproduced from the drumlin till unit (Qgd of Castle, 1959).

114 Lexington Quadrangle

Map units were modified from LaForge (1932) and Chute (eastern part of map, 1959), and from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial-stream outwash deposits, eskers, and kames of LaForge [1932]; outwash units of Chute [1959]) are coarse glaciofluvial and glaciodeltaic sediments graded to small glacial lakes, and glaciofluvial and glaciodeltaic sediments graded to the glaciomarine sea level in the Boston basin. Other coarse stratified sediments are in local ice-contact deposits in the uplands. Fine deposits (Qcl of Chute, 1959) at the surface and in the subsurface of the Little River-Fresh Pond lowland are mainly glaciolacustrine deposits of a local glacial lake. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932) or was delineated based on topographic analysis. Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Moraine deposits are part of the Fresh Pond moraine (Chute, 1959). Bedrock outcrops were reproduced from Chute (1959). Some additional outcrops are from Bell (1976). Shallow bedrock, in the eastern part of the quadrangle, is from Chute (1959) and represents areas where outcrops are “too abundant to map separately.”

115 Newton Quadrangle

Map units were modified from LaForge (1932) and Chute (northeastern part of map, 1959), and from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial stream deposits, eskers, and kames of LaForge [1932]; glacial-lake and glacial stream deposits of Chute [1959]) are coarse glaciofluvial and glaciodeltaic sediments graded to glacial Lake Charles (Clapp, 1904; Nelson, 1974a) and graded to small glacial lakes in the East Dedham, Roslindale, and Faneuil areas, and in the valleys of Cheese Cake Brook and the Charles River. Other coarse stratified sediments are in local ice-contact deposits in the uplands and in large, high-standing deposits in the Mount Auburn Cemetery area. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932). Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Bedrock outcrops and areas of shallow bedrock were reproduced from Kaye (1980); some additional outcrops are from Thompson (2015).

116 Norwood Quadrangle

Map units were reproduced from Chute (1966). Glacial stratified deposits include predominantly coarse deposits graded to a series of glacial lakes in the Neponset River valley. Bedrock outcrops and “groups of closely spaced outcrops” were reproduced from Chute (1966).

117 Mansfield Quadrangle

Map units were reproduced from Stone, B.D., and Peper, J.D., 1982, unpublished field map. Glacial stratified deposits are coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Neponset River valley.

118 Norton Quadrangle

Map units were reproduced from Stone, B.D., and Peper, J.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Threemile River and Wading River valleys and the Palmer River, Segreganset River, and Rumford River valleys; and sediments graded to glacial Lake Taunton in the middle Threemile River, Canoe River, and Mulberry Meadow Brook valleys. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Willey (1973). Distribution of bedrock outcrops is from Williams and Willey (1973), Lyons (1977), and Willey and others (1978), and from Stone and Peper on their 1982 unpublished field map. The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

119 Somerset Quadrangle

Map units were reproduced from Peper, J.D., and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments graded to glacial Lake Narragansett in the Palmer River, Cole River, and Taunton River valleys, and graded to small glacial lakes in the upper Rocky Run, upper Cole River, and Segreganset River basins. Thick-till areas were delineated based on topographic analysis. Distribution of bedrock outcrops is from Willey and others (1978), Williams and Willey (1973), and Lyons (1977), and from Peper and Stone on their 1982 unpublished field map. The shallow-bedrock unit represents areas of numerous outcrops.

120 Fall River Quadrangle

Map units were reproduced from Peper, J.D., assisted by Powars, D.A., and Baginski, M., 1982, unpublished field map. Distribution of bedrock outcrops is from Lyons (1977) and Willey and others (1978), and from Peper on his 1982 unpublished field map. Glacial stratified deposits include glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Narragansett in the Cole River, Lee River, and Taunton River valleys. Thick-till areas were delineated based on topographic analysis.

121 Tiverton Quadrangle

Map units were modified from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, a local glacial lake in the Stony Brook (Sawdy Pond) valley. Distribution of bedrock outcrops is from Willey and others (1978) and from Stone on his 1982 unpublished field map. The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

122 Haverhill Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map.

123 South Groveland Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field maps. Some bedrock outcrops are from Bell (1976).

124 Reading Quadrangle

Map units were reproduced from Oldale (1962); some additional bedrock outcrops are from Bell (1976). Glacial stratified deposits include glaciofluvial and glaciolacustrine deposits in the Saugus River, Suntaug Lake, and Ipswich River valleys. Fine glacial stratified deposits at the land surface include glacial-lake deposits (unit Ql of Oldale, 1962). Some thick-till areas were reproduced from the drumlin till (unit Qgd of Oldale, 1962). The shallow-bedrock unit is defined as areas “where individual outcrops are not plotted.”

125 Boston North Quadrangle

Map units were modified from LaForge (1932) and Chute (western part of map, 1959), and from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial-stream outwash deposits, eskers, and kames of LaForge [1932]; one outwash unit of Chute [1959]) are coarse glaciofluvial and glaciodeltaic sediments graded to small glacial lakes in the Aberjona River, Malden River, Crystal Lake, Mill River, Bennetts Pond Brook, and Saugus River valleys, and glaciofluvial and glaciodeltaic sediments graded to a probable upland ice-dammed basin in northern Revere. Other glaciofluvial and glaciodeltaic sediments underlying Medford and parts of Malden and Revere are graded to the glaciomarine sea level in the Boston basin. Fine deposits in the subsurface beneath marsh deposits are glaciomarine sediments. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932). Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Moraine deposits are part of the Fresh Pond moraine (Chute, 1959). Bedrock outcrops and areas of shallow bedrock (from “area of numerous bedrock outcrops”) were reproduced from Kaye (1980). Some additional outcrops are from Bell (1976).

126 Boston South Quadrangle

Map units were modified from LaForge (1932) and from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial stream deposits of LaForge [1932]) are coarse glaciofluvial and glaciodeltaic sediments graded to the glaciomarine sea level in the Boston basin, and glaciofluvial and glaciodeltaic sediments graded to small glacial lakes in the Muddy River and Neponset River valleys. Fine deposits (some unlabeled units of Kaye [1978]) at the surface and in the subsurface beneath marsh and coarse stratified deposits are glaciomarine sediments. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932). Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Bedrock outcrops and areas of shallow bedrock were reproduced from Kaye (1980).

127 Blue Hills Quadrangle

Map units were modified from Chute (1965a). Glacial stratified deposits include predominantly coarse deposits graded to a series of glacial lakes in the Neponset River valley and tributaries, and in the Monatiquot River valley. Bedrock outcrops were reproduced from Chute (1965a). The shallow-bedrock unit is defined as "areas of numerous outcrops not separately mapped."

128 Brockton Quadrangle

Map units were reproduced from Chute (1950). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the Trout Brook and Salisbury Plain River valleys; and coarse glaciofluvial and glaciodeltaic sediments and finer glaciolacustrine deposits in the Hockomock River valley and tributary valleys.

129 Taunton Quadrangle

Map units were modified from Hartshorn (1967). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as a group of glaciofluvial landforms (units Qic, Qk, Qkt, Qkp, Qow, and Qgf of Hartshorn [1967] included in his glaciofluvial deposits, and kame delta [unit Qkd of Hartshorn, 1967] included in his glaciolacustrine deposits). These deposits were graded to glacial Lake Taunton in the Taunton River lowland. Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders, mapped as kame deposits (unit Qk of Hartshorn, 1967). The thick-till unit is from the Qd (drumlin) unit of Hartshorn (1967). Distribution of bedrock outcrops is from Hartshorn (1967) and Williams and Willey (1973). The shallow-bedrock unit represents areas of numerous exposures.

130 Assonet Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Narragansett in the Taunton River and Assonet River valleys. Distribution of bedrock outcrops is from Williams and Willey (1973) and Lyons (1977), and from Stone, 1982, unpublished field map. Thick-till areas were delineated based on topographic analysis. The shallow-bedrock unit represents areas of abundant outcrop.

131 Fall River East Quadrangle

Map units were reproduced from Peper, J.D., assisted by Powars, D.A., and Baginski, M., 1982, unpublished field map. Distribution of bedrock outcrops is from Williams and Willey (1973), Lyons (1977), Willey and others (1978), and Peper (1982 unpublished field map). Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the East Branch Westport River, Shingle Island River, and Copicut River valleys. Similar coarse sediments lie along and beneath North Watuppa Pond, and in the upland basin of Queen Gutter Brook. Thick-till areas were delineated based on topographic analysis. The shallow-bedrock unit represents areas of abundant outcrop.

132 Westport Quadrangle

Map units were reproduced from Peper, J.D., and Stone, B.D., assisted by Powars, D.A., and Baginski, M., 1982, unpublished field map. Glacial stratified deposits in the lower East and West Branch valleys include predominantly coarse glaciofluvial and glaciodeltaic sediments graded to the glacial lake in Rhode Island Sound. Coarse glaciofluvial and glaciodeltaic sediments in the upper East Branch and Destruction Brook valleys were graded to small glacial lakes. Thick-till areas were delineated based on topographic analysis. Distribution of bedrock outcrops is from Willey and others (1978). The shallow-bedrock unit represents areas of abundant outcrop.

133 Exeter Quadrangle

Map units were modified from Goldsmith (2001). Glacial stratified deposits include coarse deposits and glaciomarine fine deposits in the Back River valley and tributary valleys. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Goldsmith (2001).

134 Newburyport West Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Bedrock outcrops and areas of shallow bedrock are from Shride (1976); the shallow-bedrock unit represents "areas where surficial deposits are mostly less than 2 m (6 ft) thick; individual outcrops, commonly numerous, are not everywhere shown."

135 Georgetown Quadrangle

Map units were reproduced from Cuppels (1969). Glacial stratified deposits include glaciofluvial, glaciolacustrine, and glaciomarine deposits. Fine glacial stratified deposits at the land surface include parts of marine and estuarine deposits (unit Qm of Cuppels, 1969); the fine unit has been extended beneath adjacent water bodies and postglacial deposits on this map. Thick-till areas were inferred from aerial photographs, from topographic analysis, and from drumlin symbols shown by Cuppels (1969).

136 Salem Quadrangle

Map units were reproduced from Oldale (1964); some outcrops are from Bell (1976). Glacial stratified deposits include glaciofluvial, glaciolacustrine, and glaciomarine deposits. Fine glacial stratified deposits at the land surface include marine clay deposits (unit Qmd of Oldale, 1964); the fine unit has been extended beneath adjacent water bodies and postglacial deposits on this map. The shallow-bedrock unit is defined as “where individual outcrops are not plotted.”

137 Lynn Quadrangle

Map units were modified from LaForge (1932) and from Kaye, C.A., 1976, unpublished field map, and Stone, B.D., 1982, unpublished field map. Bedrock outcrops and areas of shallow bedrock (patterned areas are where outcrops are “too abundant to map separately”) were modified from Bell (1977). Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Glacial stratified deposits (glacial stream deposits, eskers, and kames of LaForge [1932]; some unlabeled units of Kaye [1976 unpublished field map]) are coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Sluice Pond and Spring Pond valleys, and glaciofluvial and glaciodeltaic sediments underlying the cities of Lynn and Marblehead and graded to the glaciomarine sea level in Massachusetts Bay. Fine deposits (some unlabeled units of Kaye (1976 unpublished field map) at the surface and in the subsurface beneath marsh and coarse stratified deposits are glaciomarine deposits. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932).

138 Hull Quadrangle

Map units were modified from LaForge (1932) and from Kaye, C.A., 1969, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial stream deposits of LaForge [1932]; outwash sand and gravel deposit of Kaye [1969 unpublished field map]) are coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the Town River Bay, Rock Island Cove, and Weymouth River valleys. The distribution of thick-till deposits was modified from the drumlins units of LaForge (1932) and Kaye (1969 unpublished field map). Thin-till deposits include areas of ground moraine and recessional moraine deposits of LaForge (1932). Bedrock outcrops were reproduced from Kaye (1969 unpublished field map). Shallow-bedrock areas contain numerous bedrock outcrops.

139 Weymouth Quadrangle

Map units were modified from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits are coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the valleys of the Monatiquot River, Weymouth River and tributaries, Weir River and tributaries, and Cushing Brook. A few bedrock outcrop areas are from Lyons (1977).

140 Whitman Quadrangle

Map units were reproduced from Petersen and Shaw (1967). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the French Stream, Beaver Brook, Shumatuscacant River, and Poor Meadow Brook valleys; and finer glaciolacustrine deposits in the Town River, Matfield River, and Satucket River valleys. The shallow-bedrock unit in the northwestern part of the quadrangle is defined as “areas where exposures are numerous.”

141 Bridgewater Quadrangle

Map units were modified from Hartshorn (1960). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as a group of glaciofluvial landforms (units Qic, Qk, Qkt, Qkp, Qow, and Qou of Hartshorn [1960] included in his glaciofluvial deposits, and kame delta [unit Qkd of Hartshorn, 1960] included in his glaciolacustrine deposits). These deposits were graded to glacial Lake Taunton in the Taunton River lowland and to local glacial lakes in the Nemasket River lowland in the southeastern part of the map area. Fine glacial stratified deposits at the land surface include lake-bottom deposits of glacial Lake Taunton (unit Ql of Hartshorn, 1960). Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders, mapped as kame deposits (unit Qk of Hartshorn, 1960). Distribution of bedrock outcrops is from Hartshorn (1960). The shallow-bedrock unit represents areas of numerous exposures.

142 Assawompset Pond Quadrangle

Map units were reproduced from Koteff (1964a). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments grouped in meltwater sequence deposits (units Qc_1, Qc_2, Qc_5–Qc_7, Qce_3, Qce_4, Qcw_3, and Qcw_4 of Koteff [1964a]) and noncorrelated deposits (units Qc and Qsg of Koteff [1964a]). These deposits were graded to local glacial lakes in the Fall Brook and Squam Brook valleys and the Nemasket River lowland. Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders, mapped as kame deposits (unit Qc) by Koteff (1964a). Small moraine deposits composed of coarse gravel and sand are unit Qem_2 of Koteff (1964a). Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Willey (1973). Distribution of bedrock outcrops is from Koteff (1964a). The shallow-bedrock unit was modified from the ruled pattern area of bedrock exposures of Koteff (1964a), which is defined as “areas of abundant exposures and thin surficial deposits.”

143 New Bedford North Quadrangle

Map units were reproduced from Peper, J.D., assisted by Powars, D.A., and Haley, J.C., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, a large glacial lake in the lower Acushnet River valley and small glacial lakes in the valleys of the Paskamanset River and upland Acushnet Cedar Swamp. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1978). Distribution of bedrock outcrops is from Williams and Tasker (1978) and from Peper (1982 unpublished field map). The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

144 New Bedford South Quadrangle

Map units were reproduced from Peper, J.D., and Stone, B.D., assisted by Powars, D.A., and Haley, J.C., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Narragansett in the Slocums River and Little River valleys and small glacial lakes in the Paskamanset River valley. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1978). Distribution of bedrock outcrops is from Williams and Tasker (1978) and from Peper and Stone (1982 unpublished field map). The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

145 Cuttyhunk Quadrangle

Map units were reproduced from Mather, K.F., Goldthwait, R.P., and Thiesmeyer, L.R., 1942, unpublished field map, and from Stone, B.D., 1982, unpublished field map. Moraine deposits are deposits of the Buzzards Bay moraine.

146 Newburyport East Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map. Bedrock outcrops and areas of shallow bedrock are from Shride (1976); the shallow-bedrock unit represents “areas where surficial deposits are mostly less than 2 m (6 ft) thick; individual outcrops, commonly numerous, are not everywhere shown.”

147 Ipswich Quadrangle

Map units were reproduced from Sammel (1963). Glacial stratified deposits include glaciofluvial, glaciolacustrine, and glaciomarine deposits. Fine glacial stratified deposits at the land surface include marine and estuarine clay deposits (unit Qmc of Sammel, 1963). Some thick-till areas were reproduced from the drumlin till unit (Qd) of Sammel (1963).

148 Marblehead North Quadrangle

Map units were modified from Carnevale (1979).

149 Marblehead South Quadrangle

Map units were modified from LaForge (1932) and from Kaye, C.A., 1976, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits (glacial stream deposits of LaForge, 1932) are coarse glaciofluvial and glaciodeltaic sediments graded to the glaciomarine sea level in Massachusetts Bay. Fine deposits in the subsurface beneath marsh deposits are glaciomarine deposits. Thin-till deposits are areas of ground moraine deposits of LaForge (1932). Bedrock outcrops and areas of shallow bedrock were modified from Bell (1977). Shallow-bedrock areas were modified from patterned areas of Bell (1977) where outcrops are “too abundant to map separately.”

150 Nantasket Beach Quadrangle

Map units were modified from LaForge (1932) and from Kaye, C.A., 1969, unpublished field map, and Stone, B.D., 1982, unpublished field map. The distribution of thick-till deposits was modified from the drumlins unit of LaForge (1932) and Kaye (1969 unpublished field map). Thin-till deposits are areas of ground moraine and deposits of LaForge (1932). Bedrock outcrops were reproduced from Kaye (1969 unpublished field map). Shallow-bedrock areas contain numerous bedrock outcrops.

151 Cohasset Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map, and from Crosby (1900). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the valleys of Herring Brook and the North River and their tributaries. A few bedrock outcrop areas are from Lyons (1977).

152 Hanover Quadrangle

Map units were reproduced from Shaw and Petersen (1967). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as sequential outwash plains.

153 Plympton Quadrangle

Map units were reproduced from Goldthwait, R.P., and Thiesmeyer, L.R., 1940, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as part of the Carver outwash plain (Mather and others, 1942; Larson, 1982) in the southeastern part of the quadrangle, as kames and kame deltas in the northeastern part of the quadrangle, and as kames and kame deltas that were graded to glacial Lake Taunton in the Taunton River lowland in the northwestern part of the quadrangle (Lake Taunton of Larson, 1982; Stone and Peper, 1982). Other parts of these deposits were graded to local glacial lakes in the Shorts Brook and upper Winnetuxet River lowlands in the southwestern and central parts of the quadrangle. Distribution of bedrock outcrops is from Williams and Willey (1973) and Lyons (1977).

154 Snipatuit Pond Quadrangle

Map units were reproduced from Thiesmeyer, L.R., and Goldthwait, R.P., 1940, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, small glacial lakes in the Weweantic River and Sippican River valleys. Distribution of bedrock outcrops is from Williams and Willey (1973) and Lyons (1977).

155 Marion Quadrangle

Map units were reproduced from Thiesmeyer, L.R., and Goldthwait, R.P., 1940, unpublished field map, and Peper, J.D., and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial lakes in the Nasketucket River, Sippecan River, and Mattapoisett River valleys, and coastal valleys. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1978). Distribution of bedrock outcrops is from Williams and Tasker (1978) and from Peper and Stone (1982 unpublished field map).

156 Sconticut Neck Quadrangle

Map units were reproduced from Peper, J.D., assisted by Buchanan, J., 1982, unpublished field map. Distribution of bedrock outcrops is from Williams and Tasker (1978) and from Peper (1982 unpublished field map).

157 Naushon Island Quadrangle

Map units were modified from Kaye (1972); from Mather, K.F., Goldthwait, R.P., and Thiesmeyer, L.R., 1942, unpublished field map; and from Stone, B.D., 1982, unpublished field map. Moraine deposits are part of the Buzzards Bay moraine.

158 Squibnocket Quadrangle

Map units were modified from Kaye (1972) and from Stone, B.D., 1982, unpublished field map. Moraine deposits are part of the Martha's Vineyard moraine. Glacial stratified deposits are glaciofluvial sediments.

159 Gloucester Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map.

160 Scituate Quadrangle

Map units were modified from Chute (1965c). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments in the valleys of the North River and its tributaries. Coastal-plain sediments described by Chute (but only mapped as exposed at Third Cliff) have been expanded upon in this report in description (glacially modified coastal-plain hill deposits) and extent to include the Marshfield Hills and other hills previously mapped as drumlins or Qgm by Chute (1965c).

161 Duxbury Quadrangle

Map units were reproduced from Chute (1965b). Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as outwash plains, and finer glaciolacustrine deposits in the Jones River valley. Coastal-plain sediments described by Chute (but only mapped by him as exposed at Third Cliff in the Scituate quadrangle) have been expanded upon in this report in description (glacially modified coastal-plain hill deposits) and extent to include the Marshfield Hills and other hills previously mapped as Qgm by Chute (1965b).

162 Plymouth Quadrangle

Map units were reproduced from Thiesmeyer, L.R., 1940, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped (1) as part of the Wareham, King's Pond, and Carver outwash plains and as collapsed sand and gravel sediments of the Ellisville and Hog Rock moraines (Mather and others, 1942; Larson, 1982) in the southwestern part of the quadrangle; (2) as deposits of the Plymouth kame field in the northeastern part of the quadrangle; and (3) as kames and kame deltas graded to a glacial lake in the Jones River lowland (Larson, 1982; Stone and Peper, 1982). Small moraine deposits composed of till overlying gravel and sand are modified from deposits of the Monk's Hill moraine of Thiesmeyer (1940 unpublished field map). Distribution of bedrock outcrops is from Thiesmeyer's unpublished field map and from Stone (1982 unpublished field map). The shallow-bedrock unit represents areas of small scattered bedrock outcrops.

163 Wareham Quadrangle

Map units were reproduced from Goldthwait, R.P., and Thiesmeyer, L.R., 1940, unpublished field maps, and Stone, B.D., 1982, unpublished field maps. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as part of the Wareham and King's Pond outwash plains and as collapsed sand and gravel sediments of the Hog Rock moraine (Mather and others, 1942; Larson, 1982). Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders (Mather and others, 1942; Larson, 1982). Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1974).

164 Onset Quadrangle

Map units were reproduced from Thiesmeyer, L.R., and Goldthwait, R.P., 1940, unpublished field map, and Peper, J.D., and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial sediments graded to, and glaciodeltaic sediments deposited in, glacial Lake Narragansett in the coastal valley; these deposits were mapped as part of the Wareham outwash plain and as collapsed sand and gravel sediments of the Hog Rock moraine (Mather and others, 1942; Larson, 1982). Other parts of these deposits were graded to local glacial lakes in the southeastern and northeastern parts of the quadrangle. Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1974).

165 Woods Hole Quadrangle

Map units were reproduced from Mather, K.F., Goldthwait, R.P., and Thiesmeyer, L.R., 1942, unpublished field maps; from Stone, B.D., 1982, unpublished field maps; and from Masterson and others (1997). Moraine deposits are part of the Buzzards Bay moraine.

166 Vineyard Haven Quadrangle

Map units were modified from Kaye (1972) and from Stone, B.D., 1982, unpublished field map. Moraine deposits are part of the Martha's Vineyard moraine. Glacial stratified deposits are glaciofluvial sediments.

167 Tisbury Great Pond Quadrangle

Map units were modified from Kaye (1972) and from Stone, B.D., 1982, unpublished field map. Moraine deposits are part of the Martha's Vineyard moraine. Glacial stratified deposits are glaciofluvial sediments.

168 Rockport Quadrangle

Map units were reproduced from Stone, B.D., 1982, unpublished field map.

169 Manomet Quadrangle

Map units were modified from Goldthwait, R.P., and Thiesmeyer, L.R, 1940, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments, mapped as part of the Wareham outwash plain. These deposits also include the collapsed sand and gravel sediments of the Ellisville moraine (Mather and others, 1942; Larson, 1982) in the southwestern part of the quadrangle, deposits of the Plymouth kame field in the northwestern part of the quadrangle, and kames and kame deltas graded to glacial Lake Cape Cod Bay (Larson, 1982; Stone and Peper, 1982) in the eastern part of the quadrangle. The glacially modified coastal-plain hill deposits beneath the Pine Hills, Indian Hill, and Telegraph Hill are known from geophysical studies and drill-hole samples (Hansen and Lapham, 1992) and from exposures in the sides of the hills.

170 Sagamore Quadrangle

Map units were modified from Thiesmeyer, L.R., 1940, unpublished field map, and Stone, B.D., 1982, unpublished field map. Glacial stratified deposits include predominantly coarse glaciofluvial and glaciodeltaic sediments mapped as part of the Wareham outwash plain and as collapsed sand and gravel sediments of the Hog Rock moraine (Mather and others, 1942; Larson, 1982). Other parts of these deposits were graded to local glacial lakes in the southeastern and northeastern parts of the quadrangle. Stagnant-ice deposits include coarse glaciofluvial and glaciodeltaic sediments, flowtill deposits, and boulders. Moraine deposits are part of the Sandwich moraine (Thiesmeyer, L.R., 1940, unpublished field map) in the southern part of the quadrangle. Thick-till areas were delineated based on topographic analysis and on subsurface data of Williams and Tasker (1974).

171 Pocasset Quadrangle

Map units were reproduced from Mather, K.F., Goldthwait, R.P., and Thiesmeyer, L.R., 1942, unpublished field maps; from Stone, B.D., 1982, unpublished field maps; and from Masterson and others (1997). Moraine deposits are part of the Sandwich and Buzzards Bay moraines. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments.

172 Falmouth Quadrangle

Map units were reproduced from Mather, K.F., Goldthwait, R.P., and Thiesmeyer, L.R., 1942, unpublished field maps; from Stone, B.D., 1982, unpublished field maps; and from Masterson and others (1997). Moraine deposits are part of the Buzzards Bay moraine. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments.

173 Edgartown Quadrangle

Map units were modified from Kaye (1972) and from Stone, B.D., 1982, unpublished field map. Glacial stratified deposits are glaciofluvial sediments.

174 Sandwich Quadrangle

Map units were reproduced from Oldale (1975b). Moraine deposits are part of the Sandwich moraine. Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic sediments. Glaciolacustrine fine deposits at the land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Ql2 of Oldale, 1975b).

175 Cotuit Quadrangle

Map units were reproduced from Oldale (1975a). Glacial stratified deposits include glaciofluvial, glaciodeltaic, and kame deposits.

176 Hyannis Quadrangle

Map units were reproduced from Oldale (1974b). Moraine deposits are part of the Sandwich moraine. Glacial stratified deposits include glaciofluvial, glaciodeltaic, and kame deposits. Glaciolacustrine fine deposits at the land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Ql2 of Oldale, 1974b).

177 Tuckernuck Island Quadrangle

Map units were reproduced from Oldale (1985). Glacial stratified deposits are glaciofluvial sediments.

178 Provincetown Quadrangle

Map units were reproduced from Hartshorn, J.H., 1967, unpublished field map.

179 Dennis Quadrangle

Map units were reproduced from Oldale (1974a). Moraine deposits are part of the Sandwich moraine. Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial, glaciolacustrine, and kame deposits.

180 Nantucket Quadrangle

Map units were reproduced from Oldale (1985). Moraine deposits are part of the Nantucket moraine. Glacial stratified deposits are glaciofluvial sediments.

181 North Truro Quadrangle

Map units were reproduced from Koteff and others (1967). Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic sediments.

182 Wellfleet Quadrangle

Map units were reproduced from Oldale (1968). Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay.

183 Orleans Quadrangle

Map units were reproduced from Oldale and others (1971). Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic sediments. Glaciolacustrine fine deposits at the land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Qlb of Oldale and others, 1971).

184 Harwich Quadrangle

Map units were reproduced from Oldale (1969). Glacial stratified deposits include deposits of glacial Lake Cape Cod Bay, and other glaciofluvial and glaciodeltaic sediments. Glaciolacustrine fine deposits at the land surface include lake-bottom deposits of glacial Lake Cape Cod Bay (unit Qlb of Oldale, 1969).

185 Chatham Quadrangle

Map units were reproduced from Oldale and Koteff (1970). Glacial stratified deposits include glaciofluvial, glaciodeltaic, and kame deposits.

186 Monomoy Point Quadrangle

Map units were reproduced from Koteff and others (1968).

187 Great Point Quadrangle

Map units were reproduced from Oldale (1985).

188 Siasconset Quadrangle

Map units were reproduced from Oldale (1985). Moraine deposits are part of the Nantucket moraine. Glacial stratified deposits include glaciofluvial and glaciodeltaic sediments.

189 Hampton Quadrangle

Map unit was reproduced from Koteff and others (1989).

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Appendix C

Northeast Regional Climate Center (NRCC)
Extreme Precipitation Table

Extreme Precipitation Tables

Northeast Regional Climate Center

Data represents point estimates calculated from partial duration series. All precipitation amounts are displayed in inches.

Smoothing	Yes
State	
Location	
Longitude	71.049 degrees West
Latitude	42.351 degrees North
Elevation	0 feet
Date/Time	Mon, 31 Jan 2022 13:40:20 -0500

Extreme Precipitation Estimates

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.28	0.43	0.53	0.70	0.87	1.10	**1yr**	0.75	1.04	1.28	1.64	2.10	2.72	3.00	**1yr**	2.40	2.89	3.31	4.00	4.69	**1yr**
2yr	0.35	0.54	0.68	0.89	1.12	1.41	**2yr**	0.97	1.29	1.64	2.06	2.59	3.26	3.62	**2yr**	2.89	3.48	3.99	4.74	5.38	**2yr**
5yr	0.42	0.65	0.82	1.10	1.40	1.79	**5yr**	1.21	1.62	2.08	2.61	3.28	4.11	4.59	**5yr**	3.64	4.42	5.04	5.99	6.71	**5yr**
10yr	0.47	0.75	0.94	1.28	1.67	2.14	**10yr**	1.44	1.93	2.49	3.14	3.93	4.90	5.50	**10yr**	4.34	5.29	6.01	7.16	7.94	**10yr**
25yr	0.57	0.90	1.14	1.57	2.09	2.70	**25yr**	1.80	2.43	3.16	3.99	4.99	6.19	6.98	**25yr**	5.47	6.71	7.61	9.07	9.93	**25yr**
50yr	0.64	1.03	1.32	1.84	2.48	3.24	**50yr**	2.14	2.90	3.80	4.80	5.98	7.38	8.37	**50yr**	6.53	8.05	9.09	10.85	11.77	**50yr**
100yr	0.73	1.18	1.52	2.16	2.95	3.89	**100yr**	2.55	3.46	4.57	5.76	7.16	8.81	10.04	**100yr**	7.80	9.66	10.87	12.99	13.95	**100yr**
200yr	0.84	1.38	1.78	2.55	3.52	4.65	**200yr**	3.04	4.12	5.47	6.90	8.57	10.52	12.06	**200yr**	9.31	11.59	13.00	15.55	16.54	**200yr**
500yr	1.02	1.68	2.19	3.17	4.44	5.90	**500yr**	3.83	5.19	6.95	8.78	10.89	13.32	15.36	**500yr**	11.79	14.77	16.49	19.74	20.74	**500yr**

Lower Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.25	0.39	0.47	0.64	0.78	0.87	**1yr**	0.68	0.85	1.16	1.44	1.79	2.46	2.56	**1yr**	2.18	2.46	2.77	3.51	4.34	**1yr**
2yr	0.33	0.52	0.64	0.86	1.06	1.27	**2yr**	0.92	1.24	1.46	1.94	2.52	3.17	3.50	**2yr**	2.80	3.37	3.87	4.61	5.25	**2yr**
5yr	0.39	0.61	0.75	1.04	1.32	1.53	**5yr**	1.14	1.49	1.74	2.26	2.92	3.81	4.25	**5yr**	3.38	4.08	4.68	5.63	6.33	**5yr**
10yr	0.44	0.68	0.84	1.18	1.52	1.76	**10yr**	1.31	1.72	1.99	2.55	3.27	4.40	4.91	**10yr**	3.89	4.72	5.41	6.50	7.27	**10yr**
25yr	0.51	0.78	0.97	1.38	1.82	2.09	**25yr**	1.57	2.05	2.37	2.97	3.81	5.30	5.95	**25yr**	4.69	5.72	6.58	7.75	8.77	**25yr**
50yr	0.57	0.87	1.08	1.55	2.09	2.41	**50yr**	1.80	2.36	2.69	3.35	4.27	6.11	6.89	**50yr**	5.41	6.62	7.63	8.95	10.10	**50yr**
100yr	0.64	0.97	1.22	1.76	2.41	2.75	**100yr**	2.08	2.69	3.07	3.75	4.79	7.06	7.99	**100yr**	6.25	7.68	8.86	10.32	11.66	**100yr**
200yr	0.72	1.09	1.38	2.00	2.79	3.16	**200yr**	2.41	3.09	3.50	4.21	5.38	8.16	9.27	**200yr**	7.22	8.91	10.32	11.88	13.50	**200yr**
500yr	0.85	1.27	1.64	2.38	3.38	3.78	**500yr**	2.92	3.69	4.15	4.91	6.28	9.89	11.28	**500yr**	8.76	10.85	12.64	14.33	16.38	**500yr**

Upper Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.31	0.47	0.58	0.78	0.96	1.12	**1yr**	0.83	1.10	1.32	1.77	2.28	2.92	3.25	**1yr**	2.58	3.13	3.60	4.29	4.98	**1yr**
2yr	0.36	0.56	0.69	0.94	1.16	1.36	**2yr**	1.00	1.33	1.58	2.09	2.71	3.38	3.75	**2yr**	2.99	3.60	4.12	4.92	5.54	**2yr**
5yr	0.46	0.70	0.87	1.20	1.52	1.80	**5yr**	1.32	1.76	2.08	2.70	3.45	4.40	4.95	**5yr**	3.90	4.76	5.40	6.34	7.13	**5yr**
10yr	0.56	0.86	1.06	1.49	1.92	2.22	**10yr**	1.66	2.17	2.58	3.28	4.15	5.39	6.11	**10yr**	4.77	5.87	6.63	7.72	8.63	**10yr**
25yr	0.73	1.11	1.38	1.97	2.60	2.92	**25yr**	2.24	2.86	3.43	4.25	5.30	7.06	8.06	**25yr**	6.25	7.75	8.71	10.55	11.16	**25yr**
50yr	0.89	1.35	1.68	2.42	3.26	3.62	**50yr**	2.81	3.54	4.25	5.17	6.39	8.67	9.96	**50yr**	7.67	9.57	10.71	13.05	13.54	**50yr**
100yr	1.09	1.65	2.07	2.99	4.10	4.47	**100yr**	3.53	4.37	5.29	6.36	7.69	10.64	12.32	**100yr**	9.42	11.84	13.14	16.15	16.44	**100yr**
200yr	1.34	2.01	2.55	3.69	5.14	5.53	**200yr**	4.44	5.40	6.58	7.75	9.24	13.04	15.23	**200yr**	11.54	14.65	16.13	19.99	19.95	**200yr**
500yr	1.75	2.61	3.36	4.88	6.94	7.30	**500yr**	5.99	7.14	8.79	10.07	11.82	17.10	20.17	**500yr**	15.14	19.39	21.17	26.55	25.78	**500yr**

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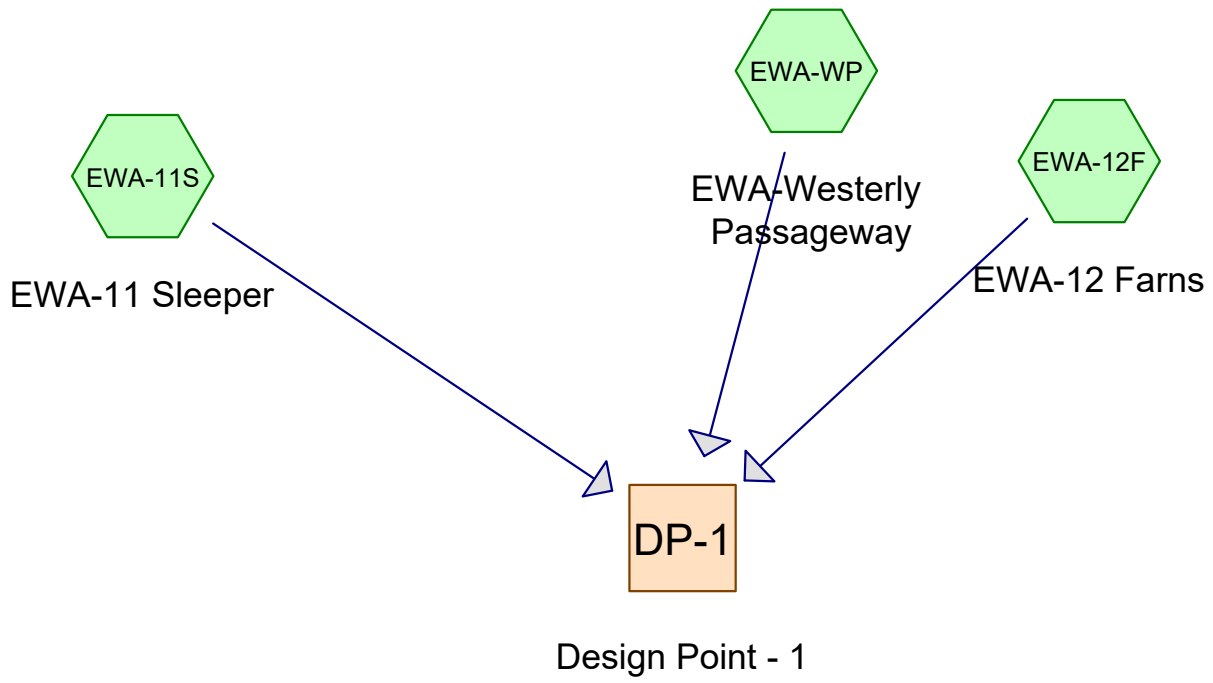
Appendix D
HydroCAD Input/Output Data

Existing



Subcat Reach Pond Link

Routing Diagram for 12 Farnsworth & 11 Sleeper _ Pre Development
Prepared by Simpson Gumpertz & Heger, Printed 2/14/2022
HydroCAD® 10.00 s/n 01673 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
260	79	<50% Grass cover, Poor, HSG B (EWA-11S)
202	96	Gravel surface, HSG B (EWA-WP)
65	98	Misc. Mechanical Equipment (EWA-WP)
1,400	98	Patio (EWA-12F)
26	98	Paved parking, HSG B (EWA-11S)
10,700	98	Roofs, HSG B (EWA-12F)
40	98	Transformer Pad (EWA-11S)
12,693	**98**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
11,188	HSG B	EWA-11S, EWA-12F, EWA-WP
0	HSG C	
0	HSG D	
1,505	Other	EWA-11S, EWA-12F, EWA-WP
12,693		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover
0	260	0	0	0	260	<50% Grass cover, Poor
0	0	0	0	65	65	Misc. Mechanical Equipment
0	0	0	0	1,400	1,400	Patio
0	0	0	0	40	40	Transformer Pad
0	26	0	0	0	26	Paved parking
0	10,700	0	0	0	10,700	Roofs
0	202	0	0	0	202	Gravel surface
0	**11,188**	**0**	**0**	**1,505**	**12,693**	**TOTAL AREA**

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EWA-11S: EWA-11 Sleeper Runoff Area=326 sf 20.25% Impervious Runoff Depth=1.66"
Tc=5.0 min CN=83 Runoff=0.02 cfs 45 cf

Subcatchment EWA-12F: EWA-12 Farns Runoff Area=12,100 sf 100.00% Impervious Runoff Depth=3.03"
Tc=5.0 min CN=98 Runoff=0.91 cfs 3,052 cf

Subcatchment EWA-WP: EWA-Westerly Runoff Area=267 sf 24.34% Impervious Runoff Depth=2.81"
Tc=5.0 min CN=96 Runoff=0.02 cfs 62 cf

Reach DP-1: Design Point - 1 Inflow=0.95 cfs 3,160 cf
Outflow=0.95 cfs 3,160 cf

Total Runoff Area = 12,693 sf Runoff Volume = 3,160 cf Average Runoff Depth = 2.99"
3.64% Pervious = 462 sf 96.36% Impervious = 12,231 sf

Summary for Subcatchment EWA-11S: EWA-11 Sleeper

Runoff = 0.02 cfs @ 12.08 hrs, Volume= 45 cf, Depth= 1.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.26"

	Area (sf)	CN	Description
	260	79	<50% Grass cover, Poor, HSG B
*	40	98	Transformer Pad
	26	98	Paved parking, HSG B
	326	83	Weighted Average
	260		79.75% Pervious Area
	66		20.25% Impervious Area

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

Hydrograph for Subcatchment EWA-11S: EWA-11 Sleeper

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.03	0.00	0.00
2.00	0.07	0.00	0.00
3.00	0.10	0.00	0.00
4.00	0.14	0.00	0.00
5.00	0.19	0.00	0.00
6.00	0.23	0.00	0.00
7.00	0.30	0.00	0.00
8.00	0.37	0.00	0.00
9.00	0.48	0.00	0.00
10.00	0.62	0.02	0.00
11.00	0.82	0.07	0.00
12.00	1.63	0.46	**0.01**
13.00	2.44	1.01	**0.00**
14.00	2.64	1.17	0.00
15.00	2.78	1.28	0.00
16.00	2.89	1.36	0.00
17.00	2.96	1.42	0.00
18.00	3.03	1.47	0.00
19.00	3.07	1.51	0.00
20.00	3.12	1.54	0.00
21.00	3.16	1.58	0.00
22.00	3.20	1.61	0.00
23.00	3.23	1.63	0.00
24.00	**3.26**	**1.66**	0.00
25.00	3.26	1.66	0.00
26.00	3.26	1.66	0.00
27.00	3.26	1.66	0.00
28.00	3.26	1.66	0.00
29.00	3.26	1.66	0.00
30.00	3.26	1.66	0.00
31.00	3.26	1.66	0.00
32.00	3.26	1.66	0.00
33.00	3.26	1.66	0.00
34.00	3.26	1.66	0.00
35.00	3.26	1.66	0.00
36.00	3.26	1.66	0.00
37.00	3.26	1.66	0.00
38.00	3.26	1.66	0.00
39.00	3.26	1.66	0.00
40.00	3.26	1.66	0.00
41.00	3.26	1.66	0.00
42.00	3.26	1.66	0.00
43.00	3.26	1.66	0.00
44.00	3.26	1.66	0.00
45.00	3.26	1.66	0.00
46.00	3.26	1.66	0.00
47.00	3.26	1.66	0.00
48.00	3.26	1.66	0.00
49.00	3.26	1.66	0.00
50.00	3.26	1.66	0.00
51.00	3.26	1.66	0.00
52.00	3.26	1.66	0.00
53.00	3.26	1.66	0.00
54.00	3.26	1.66	0.00
55.00	3.26	1.66	0.00
56.00	3.26	1.66	0.00
57.00	3.26	1.66	0.00
58.00	3.26	1.66	0.00
59.00	3.26	1.66	0.00
60.00	3.26	1.66	0.00
61.00	3.26	1.66	0.00
62.00	3.26	1.66	0.00
63.00	3.26	1.66	0.00
64.00	3.26	1.66	0.00
65.00	3.26	1.66	0.00
66.00	3.26	1.66	0.00
67.00	3.26	1.66	0.00
68.00	3.26	1.66	0.00
69.00	3.26	1.66	0.00
70.00	3.26	1.66	0.00
71.00	3.26	1.66	0.00
72.00	3.26	1.66	0.00

Summary for Subcatchment EWA-12F: EWA-12 Farns

Runoff = 0.91 cfs @ 12.07 hrs, Volume= 3,052 cf, Depth= 3.03"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.26"

	Area (sf)	CN	Description
	10,700	98	Roofs, HSG B
*	1,400	98	Patio
	12,100	98	Weighted Average
	12,100		100.00% Impervious Area

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

Hydrograph for Subcatchment EWA-12F: EWA-12 Farns

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.03	0.00	0.00
2.00	0.07	0.00	0.00
3.00	0.10	0.01	0.00
4.00	0.14	0.03	0.01
5.00	0.19	0.06	0.01
6.00	0.23	0.09	0.01
7.00	0.30	0.14	0.02
8.00	0.37	0.20	0.02
9.00	0.48	0.30	0.03
10.00	0.62	0.42	0.04
11.00	0.82	0.61	0.06
12.00	1.63	1.41	**0.61**
13.00	2.44	2.22	**0.07**
14.00	2.64	2.41	0.05
15.00	2.78	2.55	0.03
16.00	2.89	2.66	0.02
17.00	2.96	2.73	0.02
18.00	3.03	2.79	0.01
19.00	3.07	2.84	0.01
20.00	3.12	2.89	0.01
21.00	3.16	2.93	0.01
22.00	3.20	2.96	0.01
23.00	3.23	3.00	0.01
24.00	**3.26**	**3.03**	0.01
25.00	3.26	3.03	0.00
26.00	3.26	3.03	0.00
27.00	3.26	3.03	0.00
28.00	3.26	3.03	0.00
29.00	3.26	3.03	0.00
30.00	3.26	3.03	0.00
31.00	3.26	3.03	0.00
32.00	3.26	3.03	0.00
33.00	3.26	3.03	0.00
34.00	3.26	3.03	0.00
35.00	3.26	3.03	0.00
36.00	3.26	3.03	0.00
37.00	3.26	3.03	0.00
38.00	3.26	3.03	0.00
39.00	3.26	3.03	0.00
40.00	3.26	3.03	0.00
41.00	3.26	3.03	0.00
42.00	3.26	3.03	0.00
43.00	3.26	3.03	0.00
44.00	3.26	3.03	0.00
45.00	3.26	3.03	0.00
46.00	3.26	3.03	0.00
47.00	3.26	3.03	0.00
48.00	3.26	3.03	0.00
49.00	3.26	3.03	0.00
50.00	3.26	3.03	0.00
51.00	3.26	3.03	0.00
52.00	3.26	3.03	0.00
53.00	3.26	3.03	0.00
54.00	3.26	3.03	0.00
55.00	3.26	3.03	0.00
56.00	3.26	3.03	0.00
57.00	3.26	3.03	0.00
58.00	3.26	3.03	0.00
59.00	3.26	3.03	0.00
60.00	3.26	3.03	0.00
61.00	3.26	3.03	0.00
62.00	3.26	3.03	0.00
63.00	3.26	3.03	0.00
64.00	3.26	3.03	0.00
65.00	3.26	3.03	0.00
66.00	3.26	3.03	0.00
67.00	3.26	3.03	0.00
68.00	3.26	3.03	0.00
69.00	3.26	3.03	0.00
70.00	3.26	3.03	0.00
71.00	3.26	3.03	0.00
72.00	3.26	3.03	0.00

Summary for Subcatchment EWA-WP: EWA-Westerly Passageway

Runoff = 0.02 cfs @ 12.07 hrs, Volume= 62 cf, Depth= 2.81"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.26"

	Area (sf)	CN	Description
	202	96	Gravel surface, HSG B
*	65	98	Misc. Mechanical Equipment
	267	96	Weighted Average
	202		75.66% Pervious Area
	65		24.34% Impervious Area

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

Hydrograph for Subcatchment EWA-WP: EWA-Westerly Passageway

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.03	0.00	0.00
2.00	0.07	0.00	0.00
3.00	0.10	0.00	0.00
4.00	0.14	0.01	0.00
5.00	0.19	0.02	0.00
6.00	0.23	0.04	0.00
7.00	0.30	0.07	0.00
8.00	0.37	0.12	0.00
9.00	0.48	0.19	0.00
10.00	0.62	0.30	0.00
11.00	0.82	0.47	0.00
12.00	1.63	1.22	**0.01**
13.00	2.44	2.01	**0.00**
14.00	2.64	2.20	0.00
15.00	2.78	2.34	0.00
16.00	2.89	2.44	0.00
17.00	2.96	2.52	0.00
18.00	3.03	2.58	0.00
19.00	3.07	2.63	0.00
20.00	3.12	2.67	0.00
21.00	3.16	2.71	0.00
22.00	3.20	2.75	0.00
23.00	3.23	2.78	0.00
24.00	**3.26**	**2.81**	0.00
25.00	3.26	2.81	0.00
26.00	3.26	2.81	0.00
27.00	3.26	2.81	0.00
28.00	3.26	2.81	0.00
29.00	3.26	2.81	0.00
30.00	3.26	2.81	0.00
31.00	3.26	2.81	0.00
32.00	3.26	2.81	0.00
33.00	3.26	2.81	0.00
34.00	3.26	2.81	0.00
35.00	3.26	2.81	0.00
36.00	3.26	2.81	0.00
37.00	3.26	2.81	0.00
38.00	3.26	2.81	0.00
39.00	3.26	2.81	0.00
40.00	3.26	2.81	0.00
41.00	3.26	2.81	0.00
42.00	3.26	2.81	0.00
43.00	3.26	2.81	0.00
44.00	3.26	2.81	0.00
45.00	3.26	2.81	0.00
46.00	3.26	2.81	0.00
47.00	3.26	2.81	0.00
48.00	3.26	2.81	0.00
49.00	3.26	2.81	0.00
50.00	3.26	2.81	0.00
51.00	3.26	2.81	0.00
52.00	3.26	2.81	0.00
53.00	3.26	2.81	0.00
54.00	3.26	2.81	0.00
55.00	3.26	2.81	0.00
56.00	3.26	2.81	0.00
57.00	3.26	2.81	0.00
58.00	3.26	2.81	0.00
59.00	3.26	2.81	0.00
60.00	3.26	2.81	0.00
61.00	3.26	2.81	0.00
62.00	3.26	2.81	0.00
63.00	3.26	2.81	0.00
64.00	3.26	2.81	0.00
65.00	3.26	2.81	0.00
66.00	3.26	2.81	0.00
67.00	3.26	2.81	0.00
68.00	3.26	2.81	0.00
69.00	3.26	2.81	0.00
70.00	3.26	2.81	0.00
71.00	3.26	2.81	0.00
72.00	3.26	2.81	0.00

Summary for Reach DP-1: Design Point - 1

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	12,693 sf, 96.36% Impervious,	Inflow Depth =	2.99"	for 2-yr event	
Inflow =	0.95 cfs @ 12.07 hrs,	Volume=	3,160 cf		
Outflow =	0.95 cfs @ 12.07 hrs,	Volume=	3,160 cf,	Atten= 0%,	Lag= 0.0 min

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

Hydrograph for Reach DP-1: Design Point - 1

Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)	Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)
0.00	0.00		0.00	52.00	0.00		0.00
1.00	0.00		0.00	53.00	0.00		0.00
2.00	0.00		0.00	54.00	0.00		0.00
3.00	0.00		0.00	55.00	0.00		0.00
4.00	0.01		0.01	56.00	0.00		0.00
5.00	0.01		0.01	57.00	0.00		0.00
6.00	0.01		0.01	58.00	0.00		0.00
7.00	0.02		0.02	59.00	0.00		0.00
8.00	0.02		0.02	60.00	0.00		0.00
9.00	0.03		0.03	61.00	0.00		0.00
10.00	0.04		0.04	62.00	0.00		0.00
11.00	0.06		0.06	63.00	0.00		0.00
12.00	**0.64**		**0.64**	64.00	0.00		0.00
13.00	**0.08**		**0.08**	65.00	0.00		0.00
14.00	0.05		0.05	66.00	0.00		0.00
15.00	0.04		0.04	67.00	0.00		0.00
16.00	0.03		0.03	68.00	0.00		0.00
17.00	0.02		0.02	69.00	0.00		0.00
18.00	0.02		0.02	70.00	0.00		0.00
19.00	0.01		0.01	71.00	0.00		0.00
20.00	0.01		0.01	72.00	0.00		0.00
21.00	0.01		0.01				
22.00	0.01		0.01				
23.00	0.01		0.01				
24.00	0.01		0.01				
25.00	0.00		0.00				
26.00	0.00		0.00				
27.00	0.00		0.00				
28.00	0.00		0.00				
29.00	0.00		0.00				
30.00	0.00		0.00				
31.00	0.00		0.00				
32.00	0.00		0.00				
33.00	0.00		0.00				
34.00	0.00		0.00				
35.00	0.00		0.00				
36.00	0.00		0.00				
37.00	0.00		0.00				
38.00	0.00		0.00				
39.00	0.00		0.00				
40.00	0.00		0.00				
41.00	0.00		0.00				
42.00	0.00		0.00				
43.00	0.00		0.00				
44.00	0.00		0.00				
45.00	0.00		0.00				
46.00	0.00		0.00				
47.00	0.00		0.00				
48.00	0.00		0.00				
49.00	0.00		0.00				
50.00	0.00		0.00				
51.00	0.00		0.00				

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EWA-11S: EWA-11 Sleeper Runoff Area=326 sf 20.25% Impervious Runoff Depth=3.08"
Tc=5.0 min CN=83 Runoff=0.03 cfs 84 cf

Subcatchment EWA-12F: EWA-12 Farns Runoff Area=12,100 sf 100.00% Impervious Runoff Depth=4.66"
Tc=5.0 min CN=98 Runoff=1.38 cfs 4,702 cf

Subcatchment EWA-WP: EWA-Westerly Runoff Area=267 sf 24.34% Impervious Runoff Depth=4.43"
Tc=5.0 min CN=96 Runoff=0.03 cfs 99 cf

Reach DP-1: Design Point - 1 Inflow=1.44 cfs 4,885 cf
Outflow=1.44 cfs 4,885 cf

Total Runoff Area = 12,693 sf Runoff Volume = 4,885 cf Average Runoff Depth = 4.62"
3.64% Pervious = 462 sf 96.36% Impervious = 12,231 sf

Summary for Subcatchment EWA-11S: EWA-11 Sleeper

Runoff = 0.03 cfs @ 12.07 hrs, Volume= 84 cf, Depth= 3.08"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.90"

	Area (sf)	CN	Description
	260	79	<50% Grass cover, Poor, HSG B
*	40	98	Transformer Pad
	26	98	Paved parking, HSG B
	326	83	Weighted Average
	260		79.75% Pervious Area
	66		20.25% Impervious Area

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

Hydrograph for Subcatchment EWA-11S: EWA-11 Sleeper

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.05	0.00	0.00
2.00	0.10	0.00	0.00
3.00	0.15	0.00	0.00
4.00	0.21	0.00	0.00
5.00	0.28	0.00	0.00
6.00	0.35	0.00	0.00
7.00	0.44	0.00	0.00
8.00	0.56	0.01	0.00
9.00	0.71	0.04	0.00
10.00	0.93	0.10	0.00
11.00	1.22	0.23	0.00
12.00	2.45	1.02	**0.02**
13.00	3.67	2.01	**0.00**
14.00	3.97	2.26	0.00
15.00	4.19	2.45	0.00
16.00	4.34	2.59	0.00
17.00	4.46	2.69	0.00
18.00	4.55	2.77	0.00
19.00	4.62	2.83	0.00
20.00	4.69	2.89	0.00
21.00	4.75	2.95	0.00
22.00	4.81	3.00	0.00
23.00	4.86	3.04	0.00
24.00	**4.90**	**3.08**	0.00
25.00	4.90	3.08	0.00
26.00	4.90	3.08	0.00
27.00	4.90	3.08	0.00
28.00	4.90	3.08	0.00
29.00	4.90	3.08	0.00
30.00	4.90	3.08	0.00
31.00	4.90	3.08	0.00
32.00	4.90	3.08	0.00
33.00	4.90	3.08	0.00
34.00	4.90	3.08	0.00
35.00	4.90	3.08	0.00
36.00	4.90	3.08	0.00
37.00	4.90	3.08	0.00
38.00	4.90	3.08	0.00
39.00	4.90	3.08	0.00
40.00	4.90	3.08	0.00
41.00	4.90	3.08	0.00
42.00	4.90	3.08	0.00
43.00	4.90	3.08	0.00
44.00	4.90	3.08	0.00
45.00	4.90	3.08	0.00
46.00	4.90	3.08	0.00
47.00	4.90	3.08	0.00
48.00	4.90	3.08	0.00
49.00	4.90	3.08	0.00
50.00	4.90	3.08	0.00
51.00	4.90	3.08	0.00
52.00	4.90	3.08	0.00
53.00	4.90	3.08	0.00
54.00	4.90	3.08	0.00
55.00	4.90	3.08	0.00
56.00	4.90	3.08	0.00
57.00	4.90	3.08	0.00
58.00	4.90	3.08	0.00
59.00	4.90	3.08	0.00
60.00	4.90	3.08	0.00
61.00	4.90	3.08	0.00
62.00	4.90	3.08	0.00
63.00	4.90	3.08	0.00
64.00	4.90	3.08	0.00
65.00	4.90	3.08	0.00
66.00	4.90	3.08	0.00
67.00	4.90	3.08	0.00
68.00	4.90	3.08	0.00
69.00	4.90	3.08	0.00
70.00	4.90	3.08	0.00
71.00	4.90	3.08	0.00
72.00	4.90	3.08	0.00

Summary for Subcatchment EWA-12F: EWA-12 Farns

Runoff = 1.38 cfs @ 12.07 hrs, Volume= 4,702 cf, Depth= 4.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.90"

	Area (sf)	CN	Description
	10,700	98	Roofs, HSG B
*	1,400	98	Patio
	12,100	98	Weighted Average
	12,100		100.00% Impervious Area

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

Hydrograph for Subcatchment EWA-12F: EWA-12 Farns

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.05	0.00	0.00
2.00	0.10	0.01	0.01
3.00	0.15	0.04	0.01
4.00	0.21	0.08	0.01
5.00	0.28	0.13	0.02
6.00	0.35	0.19	0.02
7.00	0.44	0.27	0.03
8.00	0.56	0.37	0.03
9.00	0.71	0.52	0.05
10.00	0.93	0.72	0.06
11.00	1.22	1.01	0.10
12.00	2.45	2.22	**0.93**
13.00	3.67	3.44	**0.11**
14.00	3.97	3.74	0.07
15.00	4.19	3.95	0.05
16.00	4.34	4.11	0.04
17.00	4.46	4.22	0.03
18.00	4.55	4.31	0.02
19.00	4.62	4.39	0.02
20.00	4.69	4.45	0.02
21.00	4.75	4.51	0.02
22.00	4.81	4.57	0.01
23.00	4.86	4.62	0.01
24.00	**4.90**	**4.66**	0.01
25.00	4.90	4.66	0.00
26.00	4.90	4.66	0.00
27.00	4.90	4.66	0.00
28.00	4.90	4.66	0.00
29.00	4.90	4.66	0.00
30.00	4.90	4.66	0.00
31.00	4.90	4.66	0.00
32.00	4.90	4.66	0.00
33.00	4.90	4.66	0.00
34.00	4.90	4.66	0.00
35.00	4.90	4.66	0.00
36.00	4.90	4.66	0.00
37.00	4.90	4.66	0.00
38.00	4.90	4.66	0.00
39.00	4.90	4.66	0.00
40.00	4.90	4.66	0.00
41.00	4.90	4.66	0.00
42.00	4.90	4.66	0.00
43.00	4.90	4.66	0.00
44.00	4.90	4.66	0.00
45.00	4.90	4.66	0.00
46.00	4.90	4.66	0.00
47.00	4.90	4.66	0.00
48.00	4.90	4.66	0.00
49.00	4.90	4.66	0.00
50.00	4.90	4.66	0.00
51.00	4.90	4.66	0.00
52.00	4.90	4.66	0.00
53.00	4.90	4.66	0.00
54.00	4.90	4.66	0.00
55.00	4.90	4.66	0.00
56.00	4.90	4.66	0.00
57.00	4.90	4.66	0.00
58.00	4.90	4.66	0.00
59.00	4.90	4.66	0.00
60.00	4.90	4.66	0.00
61.00	4.90	4.66	0.00
62.00	4.90	4.66	0.00
63.00	4.90	4.66	0.00
64.00	4.90	4.66	0.00
65.00	4.90	4.66	0.00
66.00	4.90	4.66	0.00
67.00	4.90	4.66	0.00
68.00	4.90	4.66	0.00
69.00	4.90	4.66	0.00
70.00	4.90	4.66	0.00
71.00	4.90	4.66	0.00
72.00	4.90	4.66	0.00

Summary for Subcatchment EWA-WP: EWA-Westerly Passageway

Runoff = 0.03 cfs @ 12.07 hrs, Volume= 99 cf, Depth= 4.43"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.90"

	Area (sf)	CN	Description
	202	96	Gravel surface, HSG B
*	65	98	Misc. Mechanical Equipment
	267	96	Weighted Average
	202		75.66% Pervious Area
	65		24.34% Impervious Area

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

Hydrograph for Subcatchment EWA-WP: EWA-Westerly Passageway

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.05	0.00	0.00
2.00	0.10	0.00	0.00
3.00	0.15	0.01	0.00
4.00	0.21	0.03	0.00
5.00	0.28	0.06	0.00
6.00	0.35	0.11	0.00
7.00	0.44	0.17	0.00
8.00	0.56	0.25	0.00
9.00	0.71	0.38	0.00
10.00	0.93	0.56	0.00
11.00	1.22	0.84	0.00
12.00	2.45	2.01	**0.02**
13.00	3.67	3.22	**0.00**
14.00	3.97	3.51	0.00
15.00	4.19	3.72	0.00
16.00	4.34	3.88	0.00
17.00	4.46	3.99	0.00
18.00	4.55	4.08	0.00
19.00	4.62	4.16	0.00
20.00	4.69	4.22	0.00
21.00	4.75	4.28	0.00
22.00	4.81	4.34	0.00
23.00	4.86	4.39	0.00
24.00	**4.90**	**4.43**	0.00
25.00	4.90	4.43	0.00
26.00	4.90	4.43	0.00
27.00	4.90	4.43	0.00
28.00	4.90	4.43	0.00
29.00	4.90	4.43	0.00
30.00	4.90	4.43	0.00
31.00	4.90	4.43	0.00
32.00	4.90	4.43	0.00
33.00	4.90	4.43	0.00
34.00	4.90	4.43	0.00
35.00	4.90	4.43	0.00
36.00	4.90	4.43	0.00
37.00	4.90	4.43	0.00
38.00	4.90	4.43	0.00
39.00	4.90	4.43	0.00
40.00	4.90	4.43	0.00
41.00	4.90	4.43	0.00
42.00	4.90	4.43	0.00
43.00	4.90	4.43	0.00
44.00	4.90	4.43	0.00
45.00	4.90	4.43	0.00
46.00	4.90	4.43	0.00
47.00	4.90	4.43	0.00
48.00	4.90	4.43	0.00
49.00	4.90	4.43	0.00
50.00	4.90	4.43	0.00
51.00	4.90	4.43	0.00
52.00	4.90	4.43	0.00
53.00	4.90	4.43	0.00
54.00	4.90	4.43	0.00
55.00	4.90	4.43	0.00
56.00	4.90	4.43	0.00
57.00	4.90	4.43	0.00
58.00	4.90	4.43	0.00
59.00	4.90	4.43	0.00
60.00	4.90	4.43	0.00
61.00	4.90	4.43	0.00
62.00	4.90	4.43	0.00
63.00	4.90	4.43	0.00
64.00	4.90	4.43	0.00
65.00	4.90	4.43	0.00
66.00	4.90	4.43	0.00
67.00	4.90	4.43	0.00
68.00	4.90	4.43	0.00
69.00	4.90	4.43	0.00
70.00	4.90	4.43	0.00
71.00	4.90	4.43	0.00
72.00	4.90	4.43	0.00

Summary for Reach DP-1: Design Point - 1

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 12,693 sf, 96.36% Impervious, Inflow Depth = 4.62" for 10-yr event
Inflow = 1.44 cfs @ 12.07 hrs, Volume= 4,885 cf
Outflow = 1.44 cfs @ 12.07 hrs, Volume= 4,885 cf, Atten= 0%, Lag= 0.0 min

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

Hydrograph for Reach DP-1: Design Point - 1

Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)	Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)
0.00	0.00		0.00	52.00	0.00		0.00
1.00	0.00		0.00	53.00	0.00		0.00
2.00	0.01		0.01	54.00	0.00		0.00
3.00	0.01		0.01	55.00	0.00		0.00
4.00	0.01		0.01	56.00	0.00		0.00
5.00	0.02		0.02	57.00	0.00		0.00
6.00	0.02		0.02	58.00	0.00		0.00
7.00	0.03		0.03	59.00	0.00		0.00
8.00	0.03		0.03	60.00	0.00		0.00
9.00	0.05		0.05	61.00	0.00		0.00
10.00	0.07		0.07	62.00	0.00		0.00
11.00	0.10		0.10	63.00	0.00		0.00
12.00	**0.97**		**0.97**	64.00	0.00		0.00
13.00	**0.11**		**0.11**	65.00	0.00		0.00
14.00	0.07		0.07	66.00	0.00		0.00
15.00	0.05		0.05	67.00	0.00		0.00
16.00	0.04		0.04	68.00	0.00		0.00
17.00	0.03		0.03	69.00	0.00		0.00
18.00	0.02		0.02	70.00	0.00		0.00
19.00	0.02		0.02	71.00	0.00		0.00
20.00	0.02		0.02	72.00	0.00		0.00
21.00	0.02		0.02				
22.00	0.02		0.02				
23.00	0.01		0.01				
24.00	0.01		0.01				
25.00	0.00		0.00				
26.00	0.00		0.00				
27.00	0.00		0.00				
28.00	0.00		0.00				
29.00	0.00		0.00				
30.00	0.00		0.00				
31.00	0.00		0.00				
32.00	0.00		0.00				
33.00	0.00		0.00				
34.00	0.00		0.00				
35.00	0.00		0.00				
36.00	0.00		0.00				
37.00	0.00		0.00				
38.00	0.00		0.00				
39.00	0.00		0.00				
40.00	0.00		0.00				
41.00	0.00		0.00				
42.00	0.00		0.00				
43.00	0.00		0.00				
44.00	0.00		0.00				
45.00	0.00		0.00				
46.00	0.00		0.00				
47.00	0.00		0.00				
48.00	0.00		0.00				
49.00	0.00		0.00				
50.00	0.00		0.00				
51.00	0.00		0.00				

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EWA-11S: EWA-11 Sleeper Runoff Area=326 sf 20.25% Impervious Runoff Depth=4.27"
Tc=5.0 min CN=83 Runoff=0.04 cfs 116 cf

Subcatchment EWA-12F: EWA-12 Farns Runoff Area=12,100 sf 100.00% Impervious Runoff Depth=5.95"
Tc=5.0 min CN=98 Runoff=1.75 cfs 6,001 cf

Subcatchment EWA-WP: EWA-Westerly Runoff Area=267 sf 24.34% Impervious Runoff Depth=5.72"
Tc=5.0 min CN=96 Runoff=0.04 cfs 127 cf

Reach DP-1: Design Point - 1 Inflow=1.82 cfs 6,244 cf
Outflow=1.82 cfs 6,244 cf

Total Runoff Area = 12,693 sf Runoff Volume = 6,244 cf Average Runoff Depth = 5.90"
3.64% Pervious = 462 sf 96.36% Impervious = 12,231 sf

Summary for Subcatchment EWA-11S: EWA-11 Sleeper

Runoff = 0.04 cfs @ 12.07 hrs, Volume= 116 cf, Depth= 4.27"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.19"

	Area (sf)	CN	Description
	260	79	<50% Grass cover, Poor, HSG B
*	40	98	Transformer Pad
	26	98	Paved parking, HSG B
	326	83	Weighted Average
	260		79.75% Pervious Area
	66		20.25% Impervious Area

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

Hydrograph for Subcatchment EWA-11S: EWA-11 Sleeper

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.06	0.00	0.00
2.00	0.12	0.00	0.00
3.00	0.19	0.00	0.00
4.00	0.27	0.00	0.00
5.00	0.35	0.00	0.00
6.00	0.45	0.00	0.00
7.00	0.56	0.01	0.00
8.00	0.71	0.04	0.00
9.00	0.90	0.10	0.00
10.00	1.17	0.21	0.00
11.00	1.55	0.41	0.00
12.00	3.09	1.52	**0.02**
13.00	4.64	2.85	**0.00**
14.00	5.02	3.19	0.00
15.00	5.29	3.44	0.00
16.00	5.48	3.62	0.00
17.00	5.63	3.75	0.00
18.00	5.74	3.85	0.00
19.00	5.84	3.94	0.00
20.00	5.92	4.02	0.00
21.00	6.00	4.09	0.00
22.00	6.07	4.16	0.00
23.00	6.13	4.22	0.00
24.00	**6.19**	**4.27**	0.00
25.00	6.19	4.27	0.00
26.00	6.19	4.27	0.00
27.00	6.19	4.27	0.00
28.00	6.19	4.27	0.00
29.00	6.19	4.27	0.00
30.00	6.19	4.27	0.00
31.00	6.19	4.27	0.00
32.00	6.19	4.27	0.00
33.00	6.19	4.27	0.00
34.00	6.19	4.27	0.00
35.00	6.19	4.27	0.00
36.00	6.19	4.27	0.00
37.00	6.19	4.27	0.00
38.00	6.19	4.27	0.00
39.00	6.19	4.27	0.00
40.00	6.19	4.27	0.00
41.00	6.19	4.27	0.00
42.00	6.19	4.27	0.00
43.00	6.19	4.27	0.00
44.00	6.19	4.27	0.00
45.00	6.19	4.27	0.00
46.00	6.19	4.27	0.00
47.00	6.19	4.27	0.00
48.00	6.19	4.27	0.00
49.00	6.19	4.27	0.00
50.00	6.19	4.27	0.00
51.00	6.19	4.27	0.00
52.00	6.19	4.27	0.00
53.00	6.19	4.27	0.00
54.00	6.19	4.27	0.00
55.00	6.19	4.27	0.00
56.00	6.19	4.27	0.00
57.00	6.19	4.27	0.00
58.00	6.19	4.27	0.00
59.00	6.19	4.27	0.00
60.00	6.19	4.27	0.00
61.00	6.19	4.27	0.00
62.00	6.19	4.27	0.00
63.00	6.19	4.27	0.00
64.00	6.19	4.27	0.00
65.00	6.19	4.27	0.00
66.00	6.19	4.27	0.00
67.00	6.19	4.27	0.00
68.00	6.19	4.27	0.00
69.00	6.19	4.27	0.00
70.00	6.19	4.27	0.00
71.00	6.19	4.27	0.00
72.00	6.19	4.27	0.00

Summary for Subcatchment EWA-12F: EWA-12 Farns

Runoff = 1.75 cfs @ 12.07 hrs, Volume= 6,001 cf, Depth= 5.95"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.19"

	Area (sf)	CN	Description
	10,700	98	Roofs, HSG B
*	1,400	98	Patio
	12,100	98	Weighted Average
	12,100		100.00% Impervious Area

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

Hydrograph for Subcatchment EWA-12F: EWA-12 Farns

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.06	0.00	0.00
2.00	0.12	0.02	0.01
3.00	0.19	0.06	0.01
4.00	0.27	0.12	0.02
5.00	0.35	0.19	0.02
6.00	0.45	0.27	0.02
7.00	0.56	0.37	0.03
8.00	0.71	0.51	0.04
9.00	0.90	0.70	0.06
10.00	1.17	0.96	0.08
11.00	1.55	1.33	0.12
12.00	3.09	2.86	**1.18**
13.00	4.64	4.41	**0.14**
14.00	5.02	4.78	0.09
15.00	5.29	5.05	0.07
16.00	5.48	5.25	0.05
17.00	5.63	5.39	0.04
18.00	5.74	5.51	0.03
19.00	5.84	5.60	0.03
20.00	5.92	5.69	0.02
21.00	6.00	5.76	0.02
22.00	6.07	5.83	0.02
23.00	6.13	5.90	0.02
24.00	**6.19**	**5.95**	0.01
25.00	6.19	5.95	0.00
26.00	6.19	5.95	0.00
27.00	6.19	5.95	0.00
28.00	6.19	5.95	0.00
29.00	6.19	5.95	0.00
30.00	6.19	5.95	0.00
31.00	6.19	5.95	0.00
32.00	6.19	5.95	0.00
33.00	6.19	5.95	0.00
34.00	6.19	5.95	0.00
35.00	6.19	5.95	0.00
36.00	6.19	5.95	0.00
37.00	6.19	5.95	0.00
38.00	6.19	5.95	0.00
39.00	6.19	5.95	0.00
40.00	6.19	5.95	0.00
41.00	6.19	5.95	0.00
42.00	6.19	5.95	0.00
43.00	6.19	5.95	0.00
44.00	6.19	5.95	0.00
45.00	6.19	5.95	0.00
46.00	6.19	5.95	0.00
47.00	6.19	5.95	0.00
48.00	6.19	5.95	0.00
49.00	6.19	5.95	0.00
50.00	6.19	5.95	0.00
51.00	6.19	5.95	0.00
52.00	6.19	5.95	0.00
53.00	6.19	5.95	0.00
54.00	6.19	5.95	0.00
55.00	6.19	5.95	0.00
56.00	6.19	5.95	0.00
57.00	6.19	5.95	0.00
58.00	6.19	5.95	0.00
59.00	6.19	5.95	0.00
60.00	6.19	5.95	0.00
61.00	6.19	5.95	0.00
62.00	6.19	5.95	0.00
63.00	6.19	5.95	0.00
64.00	6.19	5.95	0.00
65.00	6.19	5.95	0.00
66.00	6.19	5.95	0.00
67.00	6.19	5.95	0.00
68.00	6.19	5.95	0.00
69.00	6.19	5.95	0.00
70.00	6.19	5.95	0.00
71.00	6.19	5.95	0.00
72.00	6.19	5.95	0.00

Summary for Subcatchment EWA-WP: EWA-Westerly Passageway

Runoff = 0.04 cfs @ 12.07 hrs, Volume= 127 cf, Depth= 5.72"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.19"

	Area (sf)	CN	Description
	202	96	Gravel surface, HSG B
*	65	98	Misc. Mechanical Equipment
	267	96	Weighted Average
	202		75.66% Pervious Area
	65		24.34% Impervious Area

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

Hydrograph for Subcatchment EWA-WP: EWA-Westerly Passageway

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.06	0.00	0.00
2.00	0.12	0.00	0.00
3.00	0.19	0.02	0.00
4.00	0.27	0.06	0.00
5.00	0.35	0.10	0.00
6.00	0.45	0.17	0.00
7.00	0.56	0.25	0.00
8.00	0.71	0.37	0.00
9.00	0.90	0.54	0.00
10.00	1.17	0.79	0.00
11.00	1.55	1.14	0.00
12.00	3.09	2.65	**0.03**
13.00	4.64	4.18	**0.00**
14.00	5.02	4.55	0.00
15.00	5.29	4.82	0.00
16.00	5.48	5.01	0.00
17.00	5.63	5.16	0.00
18.00	5.74	5.27	0.00
19.00	5.84	5.37	0.00
20.00	5.92	5.45	0.00
21.00	6.00	5.53	0.00
22.00	6.07	5.60	0.00
23.00	6.13	5.66	0.00
24.00	**6.19**	**5.72**	0.00
25.00	6.19	5.72	0.00
26.00	6.19	5.72	0.00
27.00	6.19	5.72	0.00
28.00	6.19	5.72	0.00
29.00	6.19	5.72	0.00
30.00	6.19	5.72	0.00
31.00	6.19	5.72	0.00
32.00	6.19	5.72	0.00
33.00	6.19	5.72	0.00
34.00	6.19	5.72	0.00
35.00	6.19	5.72	0.00
36.00	6.19	5.72	0.00
37.00	6.19	5.72	0.00
38.00	6.19	5.72	0.00
39.00	6.19	5.72	0.00
40.00	6.19	5.72	0.00
41.00	6.19	5.72	0.00
42.00	6.19	5.72	0.00
43.00	6.19	5.72	0.00
44.00	6.19	5.72	0.00
45.00	6.19	5.72	0.00
46.00	6.19	5.72	0.00
47.00	6.19	5.72	0.00
48.00	6.19	5.72	0.00
49.00	6.19	5.72	0.00
50.00	6.19	5.72	0.00
51.00	6.19	5.72	0.00
52.00	6.19	5.72	0.00
53.00	6.19	5.72	0.00
54.00	6.19	5.72	0.00
55.00	6.19	5.72	0.00
56.00	6.19	5.72	0.00
57.00	6.19	5.72	0.00
58.00	6.19	5.72	0.00
59.00	6.19	5.72	0.00
60.00	6.19	5.72	0.00
61.00	6.19	5.72	0.00
62.00	6.19	5.72	0.00
63.00	6.19	5.72	0.00
64.00	6.19	5.72	0.00
65.00	6.19	5.72	0.00
66.00	6.19	5.72	0.00
67.00	6.19	5.72	0.00
68.00	6.19	5.72	0.00
69.00	6.19	5.72	0.00
70.00	6.19	5.72	0.00
71.00	6.19	5.72	0.00
72.00	6.19	5.72	0.00

Summary for Reach DP-1: Design Point - 1

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	12,693 sf, 96.36% Impervious,	Inflow Depth =	5.90"	for 25-yr event	
Inflow =	1.82 cfs @ 12.07 hrs,	Volume=	6,244 cf		
Outflow =	1.82 cfs @ 12.07 hrs,	Volume=	6,244 cf,	Atten= 0%,	Lag= 0.0 min

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

Hydrograph for Reach DP-1: Design Point - 1

Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)	Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)
0.00	0.00		0.00	52.00	0.00		0.00
1.00	0.00		0.00	53.00	0.00		0.00
2.00	0.01		0.01	54.00	0.00		0.00
3.00	0.01		0.01	55.00	0.00		0.00
4.00	0.02		0.02	56.00	0.00		0.00
5.00	0.02		0.02	57.00	0.00		0.00
6.00	0.02		0.02	58.00	0.00		0.00
7.00	0.03		0.03	59.00	0.00		0.00
8.00	0.04		0.04	60.00	0.00		0.00
9.00	0.06		0.06	61.00	0.00		0.00
10.00	0.08		0.08	62.00	0.00		0.00
11.00	0.13		0.13	63.00	0.00		0.00
12.00	**1.23**		**1.23**	64.00	0.00		0.00
13.00	**0.15**		**0.15**	65.00	0.00		0.00
14.00	0.09		0.09	66.00	0.00		0.00
15.00	0.07		0.07	67.00	0.00		0.00
16.00	0.05		0.05	68.00	0.00		0.00
17.00	0.04		0.04	69.00	0.00		0.00
18.00	0.03		0.03	70.00	0.00		0.00
19.00	0.03		0.03	71.00	0.00		0.00
20.00	0.02		0.02	72.00	0.00		0.00
21.00	0.02		0.02				
22.00	0.02		0.02				
23.00	0.02		0.02				
24.00	0.02		0.02				
25.00	0.00		0.00				
26.00	0.00		0.00				
27.00	0.00		0.00				
28.00	0.00		0.00				
29.00	0.00		0.00				
30.00	0.00		0.00				
31.00	0.00		0.00				
32.00	0.00		0.00				
33.00	0.00		0.00				
34.00	0.00		0.00				
35.00	0.00		0.00				
36.00	0.00		0.00				
37.00	0.00		0.00				
38.00	0.00		0.00				
39.00	0.00		0.00				
40.00	0.00		0.00				
41.00	0.00		0.00				
42.00	0.00		0.00				
43.00	0.00		0.00				
44.00	0.00		0.00				
45.00	0.00		0.00				
46.00	0.00		0.00				
47.00	0.00		0.00				
48.00	0.00		0.00				
49.00	0.00		0.00				
50.00	0.00		0.00				
51.00	0.00		0.00				

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EWA-11S: EWA-11 Sleeper Runoff Area=326 sf 20.25% Impervious Runoff Depth=6.75"
Tc=5.0 min CN=83 Runoff=0.06 cfs 183 cf

Subcatchment EWA-12F: EWA-12 Farns Runoff Area=12,100 sf 100.00% Impervious Runoff Depth=8.57"
Tc=5.0 min CN=98 Runoff=2.49 cfs 8,641 cf

Subcatchment EWA-WP: EWA-Westerly Runoff Area=267 sf 24.34% Impervious Runoff Depth=8.33"
Tc=5.0 min CN=96 Runoff=0.05 cfs 185 cf

Reach DP-1: Design Point - 1 Inflow=2.60 cfs 9,010 cf
Outflow=2.60 cfs 9,010 cf

Total Runoff Area = 12,693 sf Runoff Volume = 9,010 cf Average Runoff Depth = 8.52"
3.64% Pervious = 462 sf 96.36% Impervious = 12,231 sf

Summary for Subcatchment EWA-11S: EWA-11 Sleeper

Runoff = 0.06 cfs @ 12.07 hrs, Volume= 183 cf, Depth= 6.75"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.81"

	Area (sf)	CN	Description
	260	79	<50% Grass cover, Poor, HSG B
*	40	98	Transformer Pad
	26	98	Paved parking, HSG B
	326	83	Weighted Average
	260		79.75% Pervious Area
	66		20.25% Impervious Area

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

Hydrograph for Subcatchment EWA-11S: EWA-11 Sleeper

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.09	0.00	0.00
2.00	0.18	0.00	0.00
3.00	0.27	0.00	0.00
4.00	0.38	0.00	0.00
5.00	0.50	0.00	0.00
6.00	0.63	0.02	0.00
7.00	0.80	0.06	0.00
8.00	1.00	0.13	0.00
9.00	1.28	0.26	0.00
10.00	1.67	0.48	0.00
11.00	2.20	0.84	0.00
12.00	4.40	2.64	**0.04**
13.00	6.61	4.66	**0.00**
14.00	7.14	5.16	0.00
15.00	7.53	5.53	0.00
16.00	7.81	5.79	0.00
17.00	8.01	5.99	0.00
18.00	8.18	6.15	0.00
19.00	8.31	6.27	0.00
20.00	8.43	6.39	0.00
21.00	8.54	6.50	0.00
22.00	8.64	6.59	0.00
23.00	8.73	6.68	0.00
24.00	**8.81**	**6.75**	0.00
25.00	8.81	6.75	0.00
26.00	8.81	6.75	0.00
27.00	8.81	6.75	0.00
28.00	8.81	6.75	0.00
29.00	8.81	6.75	0.00
30.00	8.81	6.75	0.00
31.00	8.81	6.75	0.00
32.00	8.81	6.75	0.00
33.00	8.81	6.75	0.00
34.00	8.81	6.75	0.00
35.00	8.81	6.75	0.00
36.00	8.81	6.75	0.00
37.00	8.81	6.75	0.00
38.00	8.81	6.75	0.00
39.00	8.81	6.75	0.00
40.00	8.81	6.75	0.00
41.00	8.81	6.75	0.00
42.00	8.81	6.75	0.00
43.00	8.81	6.75	0.00
44.00	8.81	6.75	0.00
45.00	8.81	6.75	0.00
46.00	8.81	6.75	0.00
47.00	8.81	6.75	0.00
48.00	8.81	6.75	0.00
49.00	8.81	6.75	0.00
50.00	8.81	6.75	0.00
51.00	8.81	6.75	0.00
52.00	8.81	6.75	0.00
53.00	8.81	6.75	0.00
54.00	8.81	6.75	0.00
55.00	8.81	6.75	0.00
56.00	8.81	6.75	0.00
57.00	8.81	6.75	0.00
58.00	8.81	6.75	0.00
59.00	8.81	6.75	0.00
60.00	8.81	6.75	0.00
61.00	8.81	6.75	0.00
62.00	8.81	6.75	0.00
63.00	8.81	6.75	0.00
64.00	8.81	6.75	0.00
65.00	8.81	6.75	0.00
66.00	8.81	6.75	0.00
67.00	8.81	6.75	0.00
68.00	8.81	6.75	0.00
69.00	8.81	6.75	0.00
70.00	8.81	6.75	0.00
71.00	8.81	6.75	0.00
72.00	8.81	6.75	0.00

Summary for Subcatchment EWA-12F: EWA-12 Farns

Runoff = 2.49 cfs @ 12.07 hrs, Volume= 8,641 cf, Depth= 8.57"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.81"

	Area (sf)	CN	Description
	10,700	98	Roofs, HSG B
*	1,400	98	Patio
	12,100	98	Weighted Average
	12,100		100.00% Impervious Area

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

Hydrograph for Subcatchment EWA-12F: EWA-12 Farns

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.09	0.01	0.01
2.00	0.18	0.05	0.02
3.00	0.27	0.12	0.02
4.00	0.38	0.21	0.03
5.00	0.50	0.32	0.03
6.00	0.63	0.44	0.04
7.00	0.80	0.60	0.05
8.00	1.00	0.80	0.06
9.00	1.28	1.07	0.09
10.00	1.67	1.44	0.12
11.00	2.20	1.98	0.17
12.00	4.40	4.17	**1.68**
13.00	6.61	6.37	**0.20**
14.00	7.14	6.91	0.13
15.00	7.53	7.29	0.09
16.00	7.81	7.57	0.07
17.00	8.01	7.77	0.05
18.00	8.18	7.94	0.04
19.00	8.31	8.07	0.04
20.00	8.43	8.19	0.03
21.00	8.54	8.30	0.03
22.00	8.64	8.40	0.03
23.00	8.73	8.49	0.02
24.00	**8.81**	**8.57**	0.02
25.00	8.81	8.57	0.00
26.00	8.81	8.57	0.00
27.00	8.81	8.57	0.00
28.00	8.81	8.57	0.00
29.00	8.81	8.57	0.00
30.00	8.81	8.57	0.00
31.00	8.81	8.57	0.00
32.00	8.81	8.57	0.00
33.00	8.81	8.57	0.00
34.00	8.81	8.57	0.00
35.00	8.81	8.57	0.00
36.00	8.81	8.57	0.00
37.00	8.81	8.57	0.00
38.00	8.81	8.57	0.00
39.00	8.81	8.57	0.00
40.00	8.81	8.57	0.00
41.00	8.81	8.57	0.00
42.00	8.81	8.57	0.00
43.00	8.81	8.57	0.00
44.00	8.81	8.57	0.00
45.00	8.81	8.57	0.00
46.00	8.81	8.57	0.00
47.00	8.81	8.57	0.00
48.00	8.81	8.57	0.00
49.00	8.81	8.57	0.00
50.00	8.81	8.57	0.00
51.00	8.81	8.57	0.00
52.00	8.81	8.57	0.00
53.00	8.81	8.57	0.00
54.00	8.81	8.57	0.00
55.00	8.81	8.57	0.00
56.00	8.81	8.57	0.00
57.00	8.81	8.57	0.00
58.00	8.81	8.57	0.00
59.00	8.81	8.57	0.00
60.00	8.81	8.57	0.00
61.00	8.81	8.57	0.00
62.00	8.81	8.57	0.00
63.00	8.81	8.57	0.00
64.00	8.81	8.57	0.00
65.00	8.81	8.57	0.00
66.00	8.81	8.57	0.00
67.00	8.81	8.57	0.00
68.00	8.81	8.57	0.00
69.00	8.81	8.57	0.00
70.00	8.81	8.57	0.00
71.00	8.81	8.57	0.00
72.00	8.81	8.57	0.00

Summary for Subcatchment EWA-WP: EWA-Westerly Passageway

Runoff = 0.05 cfs @ 12.07 hrs, Volume= 185 cf, Depth= 8.33"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.81"

	Area (sf)	CN	Description
	202	96	Gravel surface, HSG B
*	65	98	Misc. Mechanical Equipment
	267	96	Weighted Average
	202		75.66% Pervious Area
	65		24.34% Impervious Area

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

Hydrograph for Subcatchment EWA-WP: EWA-Westerly Passageway

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.09	0.00	0.00
2.00	0.18	0.02	0.00
3.00	0.27	0.06	0.00
4.00	0.38	0.12	0.00
5.00	0.50	0.21	0.00
6.00	0.63	0.31	0.00
7.00	0.80	0.45	0.00
8.00	1.00	0.63	0.00
9.00	1.28	0.89	0.00
10.00	1.67	1.25	0.00
11.00	2.20	1.77	0.00
12.00	4.40	3.94	**0.04**
13.00	6.61	6.13	**0.00**
14.00	7.14	6.67	0.00
15.00	7.53	7.05	0.00
16.00	7.81	7.33	0.00
17.00	8.01	7.53	0.00
18.00	8.18	7.70	0.00
19.00	8.31	7.83	0.00
20.00	8.43	7.95	0.00
21.00	8.54	8.06	0.00
22.00	8.64	8.16	0.00
23.00	8.73	8.25	0.00
24.00	**8.81**	**8.33**	0.00
25.00	8.81	8.33	0.00
26.00	8.81	8.33	0.00
27.00	8.81	8.33	0.00
28.00	8.81	8.33	0.00
29.00	8.81	8.33	0.00
30.00	8.81	8.33	0.00
31.00	8.81	8.33	0.00
32.00	8.81	8.33	0.00
33.00	8.81	8.33	0.00
34.00	8.81	8.33	0.00
35.00	8.81	8.33	0.00
36.00	8.81	8.33	0.00
37.00	8.81	8.33	0.00
38.00	8.81	8.33	0.00
39.00	8.81	8.33	0.00
40.00	8.81	8.33	0.00
41.00	8.81	8.33	0.00
42.00	8.81	8.33	0.00
43.00	8.81	8.33	0.00
44.00	8.81	8.33	0.00
45.00	8.81	8.33	0.00
46.00	8.81	8.33	0.00
47.00	8.81	8.33	0.00
48.00	8.81	8.33	0.00
49.00	8.81	8.33	0.00
50.00	8.81	8.33	0.00
51.00	8.81	8.33	0.00
52.00	8.81	8.33	0.00
53.00	8.81	8.33	0.00
54.00	8.81	8.33	0.00
55.00	8.81	8.33	0.00
56.00	8.81	8.33	0.00
57.00	8.81	8.33	0.00
58.00	8.81	8.33	0.00
59.00	8.81	8.33	0.00
60.00	8.81	8.33	0.00
61.00	8.81	8.33	0.00
62.00	8.81	8.33	0.00
63.00	8.81	8.33	0.00
64.00	8.81	8.33	0.00
65.00	8.81	8.33	0.00
66.00	8.81	8.33	0.00
67.00	8.81	8.33	0.00
68.00	8.81	8.33	0.00
69.00	8.81	8.33	0.00
70.00	8.81	8.33	0.00
71.00	8.81	8.33	0.00
72.00	8.81	8.33	0.00

Summary for Reach DP-1: Design Point - 1

[40] Hint: Not Described (Outflow=Inflow)

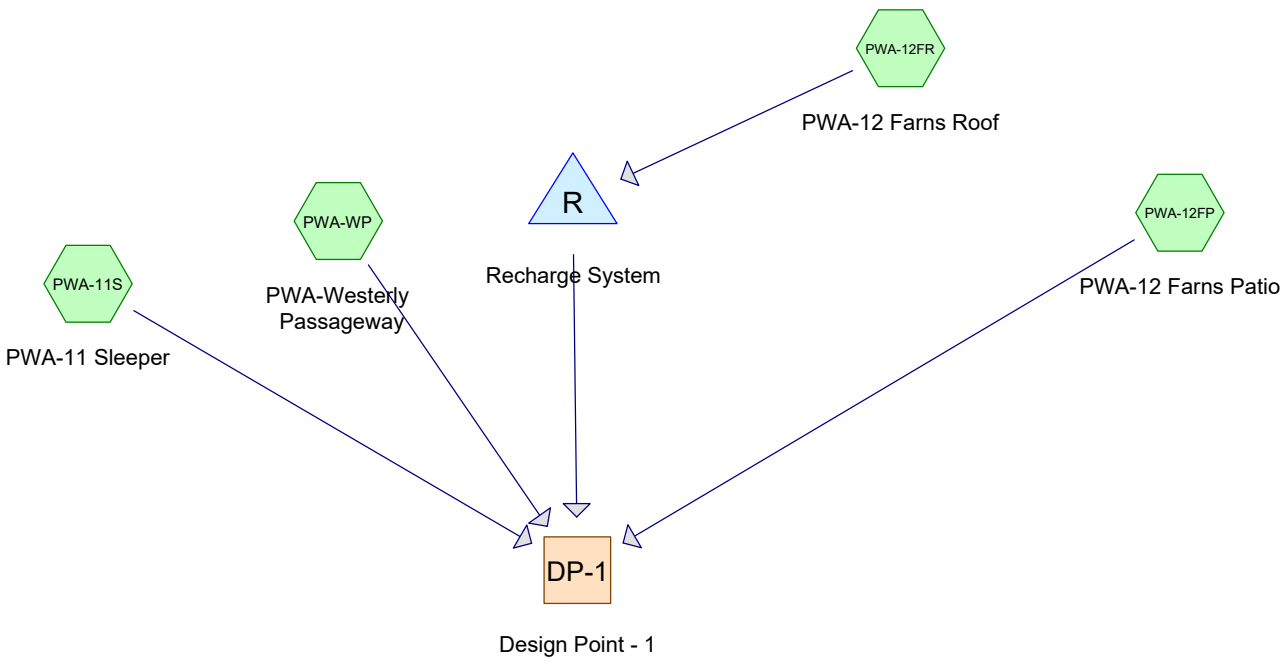
Inflow Area =	12,693 sf, 96.36% Impervious,	Inflow Depth =	8.52"	for	100-yr event
Inflow =	2.60 cfs @ 12.07 hrs,	Volume=	9,010 cf		
Outflow =	2.60 cfs @ 12.07 hrs,	Volume=	9,010 cf,	Atten= 0%,	Lag= 0.0 min

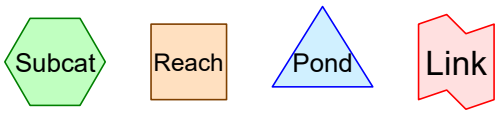
Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Hydrograph for Reach DP-1: Design Point - 1

Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)	Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)
0.00	0.00		0.00	52.00	0.00		0.00
1.00	0.01		0.01	53.00	0.00		0.00
2.00	0.02		0.02	54.00	0.00		0.00
3.00	0.02		0.02	55.00	0.00		0.00
4.00	0.03		0.03	56.00	0.00		0.00
5.00	0.03		0.03	57.00	0.00		0.00
6.00	0.04		0.04	58.00	0.00		0.00
7.00	0.05		0.05	59.00	0.00		0.00
8.00	0.06		0.06	60.00	0.00		0.00
9.00	0.09		0.09	61.00	0.00		0.00
10.00	0.12		0.12	62.00	0.00		0.00
11.00	0.18		0.18	63.00	0.00		0.00
12.00	**1.76**		**1.76**	64.00	0.00		0.00
13.00	**0.21**		**0.21**	65.00	0.00		0.00
14.00	0.13		0.13	66.00	0.00		0.00
15.00	0.10		0.10	67.00	0.00		0.00
16.00	0.07		0.07	68.00	0.00		0.00
17.00	0.06		0.06	69.00	0.00		0.00
18.00	0.04		0.04	70.00	0.00		0.00
19.00	0.04		0.04	71.00	0.00		0.00
20.00	0.03		0.03	72.00	0.00		0.00
21.00	0.03		0.03				
22.00	0.03		0.03				
23.00	0.03		0.03				
24.00	0.02		0.02				
25.00	0.00		0.00				
26.00	0.00		0.00				
27.00	0.00		0.00				
28.00	0.00		0.00				
29.00	0.00		0.00				
30.00	0.00		0.00				
31.00	0.00		0.00				
32.00	0.00		0.00				
33.00	0.00		0.00				
34.00	0.00		0.00				
35.00	0.00		0.00				
36.00	0.00		0.00				
37.00	0.00		0.00				
38.00	0.00		0.00				
39.00	0.00		0.00				
40.00	0.00		0.00				
41.00	0.00		0.00				
42.00	0.00		0.00				
43.00	0.00		0.00				
44.00	0.00		0.00				
45.00	0.00		0.00				
46.00	0.00		0.00				
47.00	0.00		0.00				
48.00	0.00		0.00				
49.00	0.00		0.00				
50.00	0.00		0.00				
51.00	0.00		0.00				

Proposed





Routing Diagram for 12 Farnsworth & 11 Sleeper _ Post Development
Prepared by Simpson Gumpertz & Heger, Printed 2/14/2022
HydroCAD® 10.00 s/n 01673 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
358	68	Permeable Pavers (PWA-11S, PWA-WP)
57	79	<50% Grass cover, Poor, HSG B (PWA-11S)
73	96	Gravel surface, HSG B (PWA-WP)
41	98	Misc. Mechanical Equipment. (PWA-WP)
1,400	98	Patio (PWA-12FP)
10,700	98	Roofs, HSG B (PWA-12FR)
64	98	Transformer Pad (PWA-11S)
12,693	**97**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
10,830	HSG B	PWA-11S, PWA-12FR, PWA-WP
0	HSG C	
0	HSG D	
1,863	Other	PWA-11S, PWA-12FP, PWA-WP
12,693		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover
0	0	0	0	41	41	Misc. Mechanical Equipment.
0	0	0	0	1,400	1,400	Patio
0	0	0	0	358	358	Permeable Pavers
0	57	0	0	0	57	<50% Grass cover, Poor
0	0	0	0	64	64	Transformer Pad
0	10,700	0	0	0	10,700	Roofs
0	73	0	0	0	73	Gravel surface
0	**10,830**	**0**	**0**	**1,863**	**12,693**	**TOTAL AREA**

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PWA-11S: PWA-11 Sleeper Runoff Area=323 sf 19.81% Impervious Runoff Depth=1.19"
Tc=5.0 min CN=76 Runoff=0.01 cfs 32 cf

Subcatchment PWA-12FP: PWA-12 Farns Runoff Area=1,400 sf 100.00% Impervious Runoff Depth=3.03"
Tc=5.0 min CN=98 Runoff=0.11 cfs 353 cf

Subcatchment PWA-12FR: PWA-12 Farns Runoff Area=10,700 sf 100.00% Impervious Runoff Depth=3.03"
Tc=5.0 min CN=98 Runoff=0.81 cfs 2,699 cf

Subcatchment PWA-WP: PWA-Westerly Runoff Area=270 sf 15.19% Impervious Runoff Depth=1.45"
Tc=5.0 min CN=80 Runoff=0.01 cfs 33 cf

Reach DP-1: Design Point - 1 Inflow=0.91 cfs 1,856 cf
Outflow=0.91 cfs 1,856 cf

Pond R: Recharge System Peak Elev=13.43' Storage=970 cf Inflow=0.81 cfs 2,699 cf
Discarded=0.00 cfs 1,135 cf Primary=0.79 cfs 1,438 cf Outflow=0.79 cfs 2,573 cf

Total Runoff Area = 12,693 sf Runoff Volume = 3,117 cf Average Runoff Depth = 2.95"
3.84% Pervious = 488 sf 96.16% Impervious = 12,205 sf

Summary for Subcatchment PWA-11S: PWA-11 Sleeper

Runoff = 0.01 cfs @ 12.08 hrs, Volume= 32 cf, Depth= 1.19"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.26"

	Area (sf)	CN	Description
*	202	68	Permeable Pavers
	57	79	<50% Grass cover, Poor, HSG B
*	64	98	Transformer Pad
	323	76	Weighted Average
	259		80.19% Pervious Area
	64		19.81% Impervious Area

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

Hydrograph for Subcatchment PWA-11S: PWA-11 Sleeper

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.03	0.00	0.00
2.00	0.07	0.00	0.00
3.00	0.10	0.00	0.00
4.00	0.14	0.00	0.00
5.00	0.19	0.00	0.00
6.00	0.23	0.00	0.00
7.00	0.30	0.00	0.00
8.00	0.37	0.00	0.00
9.00	0.48	0.00	0.00
10.00	0.62	0.00	0.00
11.00	0.82	0.01	0.00
12.00	1.63	0.24	**0.01**
13.00	2.44	0.66	**0.00**
14.00	2.64	0.78	0.00
15.00	2.78	0.87	0.00
16.00	2.89	0.94	0.00
17.00	2.96	0.99	0.00
18.00	3.03	1.03	0.00
19.00	3.07	1.07	0.00
20.00	3.12	1.10	0.00
21.00	3.16	1.12	0.00
22.00	3.20	1.15	0.00
23.00	3.23	1.17	0.00
24.00	**3.26**	**1.19**	0.00
25.00	3.26	1.19	0.00
26.00	3.26	1.19	0.00
27.00	3.26	1.19	0.00
28.00	3.26	1.19	0.00
29.00	3.26	1.19	0.00
30.00	3.26	1.19	0.00
31.00	3.26	1.19	0.00
32.00	3.26	1.19	0.00
33.00	3.26	1.19	0.00
34.00	3.26	1.19	0.00
35.00	3.26	1.19	0.00
36.00	3.26	1.19	0.00
37.00	3.26	1.19	0.00
38.00	3.26	1.19	0.00
39.00	3.26	1.19	0.00
40.00	3.26	1.19	0.00
41.00	3.26	1.19	0.00
42.00	3.26	1.19	0.00
43.00	3.26	1.19	0.00
44.00	3.26	1.19	0.00
45.00	3.26	1.19	0.00
46.00	3.26	1.19	0.00
47.00	3.26	1.19	0.00
48.00	3.26	1.19	0.00
49.00	3.26	1.19	0.00
50.00	3.26	1.19	0.00
51.00	3.26	1.19	0.00
52.00	3.26	1.19	0.00
53.00	3.26	1.19	0.00
54.00	3.26	1.19	0.00
55.00	3.26	1.19	0.00
56.00	3.26	1.19	0.00
57.00	3.26	1.19	0.00
58.00	3.26	1.19	0.00
59.00	3.26	1.19	0.00
60.00	3.26	1.19	0.00
61.00	3.26	1.19	0.00
62.00	3.26	1.19	0.00
63.00	3.26	1.19	0.00
64.00	3.26	1.19	0.00
65.00	3.26	1.19	0.00
66.00	3.26	1.19	0.00
67.00	3.26	1.19	0.00
68.00	3.26	1.19	0.00
69.00	3.26	1.19	0.00
70.00	3.26	1.19	0.00
71.00	3.26	1.19	0.00
72.00	3.26	1.19	0.00

Summary for Subcatchment PWA-12FP: PWA-12 Farns Patio

Runoff = 0.11 cfs @ 12.07 hrs, Volume= 353 cf, Depth= 3.03"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.26"

	Area (sf)	CN	Description
*	1,400	98	Patio
	1,400		100.00% Impervious Area

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

Hydrograph for Subcatchment PWA-12FP: PWA-12 Farns Patio

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.03	0.00	0.00
2.00	0.07	0.00	0.00
3.00	0.10	0.01	0.00
4.00	0.14	0.03	0.00
5.00	0.19	0.06	0.00
6.00	0.23	0.09	0.00
7.00	0.30	0.14	0.00
8.00	0.37	0.20	0.00
9.00	0.48	0.30	0.00
10.00	0.62	0.42	0.00
11.00	0.82	0.61	0.01
12.00	1.63	1.41	**0.07**
13.00	2.44	2.22	**0.01**
14.00	2.64	2.41	0.01
15.00	2.78	2.55	0.00
16.00	2.89	2.66	0.00
17.00	2.96	2.73	0.00
18.00	3.03	2.79	0.00
19.00	3.07	2.84	0.00
20.00	3.12	2.89	0.00
21.00	3.16	2.93	0.00
22.00	3.20	2.96	0.00
23.00	3.23	3.00	0.00
24.00	**3.26**	**3.03**	0.00
25.00	3.26	3.03	0.00
26.00	3.26	3.03	0.00
27.00	3.26	3.03	0.00
28.00	3.26	3.03	0.00
29.00	3.26	3.03	0.00
30.00	3.26	3.03	0.00
31.00	3.26	3.03	0.00
32.00	3.26	3.03	0.00
33.00	3.26	3.03	0.00
34.00	3.26	3.03	0.00
35.00	3.26	3.03	0.00
36.00	3.26	3.03	0.00
37.00	3.26	3.03	0.00
38.00	3.26	3.03	0.00
39.00	3.26	3.03	0.00
40.00	3.26	3.03	0.00
41.00	3.26	3.03	0.00
42.00	3.26	3.03	0.00
43.00	3.26	3.03	0.00
44.00	3.26	3.03	0.00
45.00	3.26	3.03	0.00
46.00	3.26	3.03	0.00
47.00	3.26	3.03	0.00
48.00	3.26	3.03	0.00
49.00	3.26	3.03	0.00
50.00	3.26	3.03	0.00
51.00	3.26	3.03	0.00
52.00	3.26	3.03	0.00
53.00	3.26	3.03	0.00
54.00	3.26	3.03	0.00
55.00	3.26	3.03	0.00
56.00	3.26	3.03	0.00
57.00	3.26	3.03	0.00
58.00	3.26	3.03	0.00
59.00	3.26	3.03	0.00
60.00	3.26	3.03	0.00
61.00	3.26	3.03	0.00
62.00	3.26	3.03	0.00
63.00	3.26	3.03	0.00
64.00	3.26	3.03	0.00
65.00	3.26	3.03	0.00
66.00	3.26	3.03	0.00
67.00	3.26	3.03	0.00
68.00	3.26	3.03	0.00
69.00	3.26	3.03	0.00
70.00	3.26	3.03	0.00
71.00	3.26	3.03	0.00
72.00	3.26	3.03	0.00

Summary for Subcatchment PWA-12FR: PWA-12 Farns Roof

Runoff = 0.81 cfs @ 12.07 hrs, Volume= 2,699 cf, Depth= 3.03"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.26"

Area (sf)	CN	Description
10,700	98	Roofs, HSG B
10,700		100.00% Impervious Area

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

Hydrograph for Subcatchment PWA-12FR: PWA-12 Farns Roof

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.03	0.00	0.00
2.00	0.07	0.00	0.00
3.00	0.10	0.01	0.00
4.00	0.14	0.03	0.01
5.00	0.19	0.06	0.01
6.00	0.23	0.09	0.01
7.00	0.30	0.14	0.01
8.00	0.37	0.20	0.02
9.00	0.48	0.30	0.03
10.00	0.62	0.42	0.04
11.00	0.82	0.61	0.05
12.00	1.63	1.41	**0.54**
13.00	2.44	2.22	**0.06**
14.00	2.64	2.41	0.04
15.00	2.78	2.55	0.03
16.00	2.89	2.66	0.02
17.00	2.96	2.73	0.02
18.00	3.03	2.79	0.01
19.00	3.07	2.84	0.01
20.00	3.12	2.89	0.01
21.00	3.16	2.93	0.01
22.00	3.20	2.96	0.01
23.00	3.23	3.00	0.01
24.00	**3.26**	**3.03**	0.01
25.00	3.26	3.03	0.00
26.00	3.26	3.03	0.00
27.00	3.26	3.03	0.00
28.00	3.26	3.03	0.00
29.00	3.26	3.03	0.00
30.00	3.26	3.03	0.00
31.00	3.26	3.03	0.00
32.00	3.26	3.03	0.00
33.00	3.26	3.03	0.00
34.00	3.26	3.03	0.00
35.00	3.26	3.03	0.00
36.00	3.26	3.03	0.00
37.00	3.26	3.03	0.00
38.00	3.26	3.03	0.00
39.00	3.26	3.03	0.00
40.00	3.26	3.03	0.00
41.00	3.26	3.03	0.00
42.00	3.26	3.03	0.00
43.00	3.26	3.03	0.00
44.00	3.26	3.03	0.00
45.00	3.26	3.03	0.00
46.00	3.26	3.03	0.00
47.00	3.26	3.03	0.00
48.00	3.26	3.03	0.00
49.00	3.26	3.03	0.00
50.00	3.26	3.03	0.00
51.00	3.26	3.03	0.00
52.00	3.26	3.03	0.00
53.00	3.26	3.03	0.00
54.00	3.26	3.03	0.00
55.00	3.26	3.03	0.00
56.00	3.26	3.03	0.00
57.00	3.26	3.03	0.00
58.00	3.26	3.03	0.00
59.00	3.26	3.03	0.00
60.00	3.26	3.03	0.00
61.00	3.26	3.03	0.00
62.00	3.26	3.03	0.00
63.00	3.26	3.03	0.00
64.00	3.26	3.03	0.00
65.00	3.26	3.03	0.00
66.00	3.26	3.03	0.00
67.00	3.26	3.03	0.00
68.00	3.26	3.03	0.00
69.00	3.26	3.03	0.00
70.00	3.26	3.03	0.00
71.00	3.26	3.03	0.00
72.00	3.26	3.03	0.00

Summary for Subcatchment PWA-WP: PWA-Westerly Passageway

Runoff = 0.01 cfs @ 12.08 hrs, Volume= 33 cf, Depth= 1.45"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-yr Rainfall=3.26"

	Area (sf)	CN	Description
*	156	68	Permeable Pavers
*	41	98	Misc. Mechanical Equipment.
	73	96	Gravel surface, HSG B
	270	80	Weighted Average
	229		84.81% Pervious Area
	41		15.19% Impervious Area

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

Hydrograph for Subcatchment PWA-WP: PWA-Westerly Passageway

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.03	0.00	0.00
2.00	0.07	0.00	0.00
3.00	0.10	0.00	0.00
4.00	0.14	0.00	0.00
5.00	0.19	0.00	0.00
6.00	0.23	0.00	0.00
7.00	0.30	0.00	0.00
8.00	0.37	0.00	0.00
9.00	0.48	0.00	0.00
10.00	0.62	0.01	0.00
11.00	0.82	0.04	0.00
12.00	1.63	0.35	**0.01**
13.00	2.44	0.85	**0.00**
14.00	2.64	0.99	0.00
15.00	2.78	1.09	0.00
16.00	2.89	1.17	0.00
17.00	2.96	1.22	0.00
18.00	3.03	1.27	0.00
19.00	3.07	1.31	0.00
20.00	3.12	1.34	0.00
21.00	3.16	1.37	0.00
22.00	3.20	1.40	0.00
23.00	3.23	1.43	0.00
24.00	**3.26**	**1.45**	0.00
25.00	3.26	1.45	0.00
26.00	3.26	1.45	0.00
27.00	3.26	1.45	0.00
28.00	3.26	1.45	0.00
29.00	3.26	1.45	0.00
30.00	3.26	1.45	0.00
31.00	3.26	1.45	0.00
32.00	3.26	1.45	0.00
33.00	3.26	1.45	0.00
34.00	3.26	1.45	0.00
35.00	3.26	1.45	0.00
36.00	3.26	1.45	0.00
37.00	3.26	1.45	0.00
38.00	3.26	1.45	0.00
39.00	3.26	1.45	0.00
40.00	3.26	1.45	0.00
41.00	3.26	1.45	0.00
42.00	3.26	1.45	0.00
43.00	3.26	1.45	0.00
44.00	3.26	1.45	0.00
45.00	3.26	1.45	0.00
46.00	3.26	1.45	0.00
47.00	3.26	1.45	0.00
48.00	3.26	1.45	0.00
49.00	3.26	1.45	0.00
50.00	3.26	1.45	0.00
51.00	3.26	1.45	0.00
52.00	3.26	1.45	0.00
53.00	3.26	1.45	0.00
54.00	3.26	1.45	0.00
55.00	3.26	1.45	0.00
56.00	3.26	1.45	0.00
57.00	3.26	1.45	0.00
58.00	3.26	1.45	0.00
59.00	3.26	1.45	0.00
60.00	3.26	1.45	0.00
61.00	3.26	1.45	0.00
62.00	3.26	1.45	0.00
63.00	3.26	1.45	0.00
64.00	3.26	1.45	0.00
65.00	3.26	1.45	0.00
66.00	3.26	1.45	0.00
67.00	3.26	1.45	0.00
68.00	3.26	1.45	0.00
69.00	3.26	1.45	0.00
70.00	3.26	1.45	0.00
71.00	3.26	1.45	0.00
72.00	3.26	1.45	0.00

Summary for Reach DP-1: Design Point - 1

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	12,693 sf, 96.16% Impervious,	Inflow Depth =	1.75"	for 2-yr event	
Inflow =	0.91 cfs @ 12.08 hrs,	Volume=	1,856 cf		
Outflow =	0.91 cfs @ 12.08 hrs,	Volume=	1,856 cf,	Atten= 0%,	Lag= 0.0 min

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

Hydrograph for Reach DP-1: Design Point - 1

Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)	Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)
0.00	0.00		0.00	52.00	0.00		0.00
1.00	0.00		0.00	53.00	0.00		0.00
2.00	0.00		0.00	54.00	0.00		0.00
3.00	0.00		0.00	55.00	0.00		0.00
4.00	0.00		0.00	56.00	0.00		0.00
5.00	0.00		0.00	57.00	0.00		0.00
6.00	0.00		0.00	58.00	0.00		0.00
7.00	0.00		0.00	59.00	0.00		0.00
8.00	0.00		0.00	60.00	0.00		0.00
9.00	0.00		0.00	61.00	0.00		0.00
10.00	0.00		0.00	62.00	0.00		0.00
11.00	0.01		0.01	63.00	0.00		0.00
12.00	**0.09**		**0.09**	64.00	0.00		0.00
13.00	**0.07**		**0.07**	65.00	0.00		0.00
14.00	0.04		0.04	66.00	0.00		0.00
15.00	0.03		0.03	67.00	0.00		0.00
16.00	0.02		0.02	68.00	0.00		0.00
17.00	0.02		0.02	69.00	0.00		0.00
18.00	0.01		0.01	70.00	0.00		0.00
19.00	0.01		0.01	71.00	0.00		0.00
20.00	0.01		0.01	72.00	0.00		0.00
21.00	0.01		0.01				
22.00	0.01		0.01				
23.00	0.00		0.00				
24.00	0.00		0.00				
25.00	0.00		0.00				
26.00	0.00		0.00				
27.00	0.00		0.00				
28.00	0.00		0.00				
29.00	0.00		0.00				
30.00	0.00		0.00				
31.00	0.00		0.00				
32.00	0.00		0.00				
33.00	0.00		0.00				
34.00	0.00		0.00				
35.00	0.00		0.00				
36.00	0.00		0.00				
37.00	0.00		0.00				
38.00	0.00		0.00				
39.00	0.00		0.00				
40.00	0.00		0.00				
41.00	0.00		0.00				
42.00	0.00		0.00				
43.00	0.00		0.00				
44.00	0.00		0.00				
45.00	0.00		0.00				
46.00	0.00		0.00				
47.00	0.00		0.00				
48.00	0.00		0.00				
49.00	0.00		0.00				
50.00	0.00		0.00				
51.00	0.00		0.00				

Summary for Pond R: Recharge System

**Elevations are based on an assumed surface elevation of 100'. Elevations shall be field adjusted to accomodate actual surface elevations.

Inflow Area =	10,700 sf,	100.00% Impervious,	Inflow Depth =	3.03"	for 2-yr event
Inflow =	0.81 cfs @	12.07 hrs,	Volume=	2,699 cf	
Outflow =	0.79 cfs @	12.08 hrs,	Volume=	2,573 cf,	Atten= 2%, Lag= 0.8 min
Discarded =	0.00 cfs @	4.36 hrs,	Volume=	1,135 cf	
Primary =	0.79 cfs @	12.08 hrs,	Volume=	1,438 cf	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 13.43' @ 12.08 hrs Surf.Area= 659 sf Storage= 970 cf
Flood Elev= 16.46' Surf.Area= 659 sf Storage= 1,381 cf

Plug-Flow detention time= 725.5 min calculated for 2,572 cf (95% of inflow)
Center-of-Mass det. time= 698.3 min (1,453.4 - 755.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	11.00'	323 cf	**11.00'W x 26.38'L x 3.75'H Field A** 1,088 cf Overall - 281 cf Embedded = 807 cf x 40.0% Voids
#2A	11.75'	281 cf	**StormTech SC-740** x 6 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap Row Length Adjustment= +0.44' x 6.45 sf x 2 rows
#3B	11.00'	404 cf	**11.00'W x 33.50'L x 3.75'H Field B** 1,382 cf Overall - 373 cf Embedded = 1,009 cf x 40.0% Voids
#4B	11.75'	373 cf	**StormTech SC-740** x 8 Inside #3 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap Row Length Adjustment= +0.44' x 6.45 sf x 2 rows
		1,381 cf	Total Available Storage

Storage Group A created with Chamber Wizard
Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	11.00'	**0.300 in/hr Exfiltration over Horizontal area**
#2	Primary	13.30'	**5.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.00 cfs @ 4.36 hrs HW=11.05' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.00 cfs)

Primary OutFlow Max=0.78 cfs @ 12.08 hrs HW=13.43' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 0.78 cfs @ 1.19 fps)

Pond R: Recharge System - Chamber Wizard Field A

Chamber Model = StormTech SC-740
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
Row Length Adjustment= +0.44' x 6.45 sf x 2 rows

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

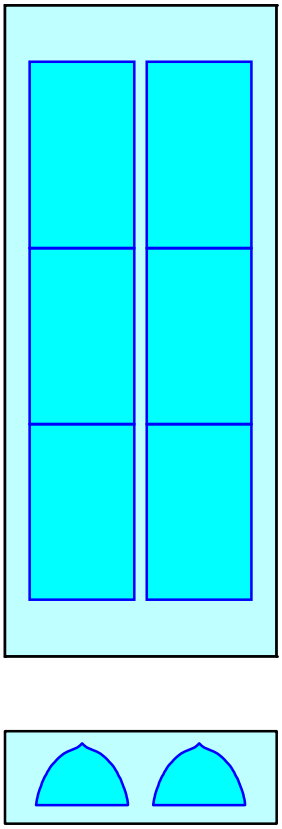
3 Chambers/Row x 7.12' Long +0.44' Row Adjustment = 21.80' Row Length +27.5" End Stone x 2 = 26.38' Base Length
2 Rows x 51.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.00' Base Width
9.0" Base + 30.0" Chamber Height + 6.0" Cover = 3.75' Field Height

6 Chambers x 45.9 cf +0.44' Row Adjustment x 6.45 sf x 2 Rows = 281.3 cf Chamber Storage

1,088.2 cf Field - 281.3 cf Chambers = 806.9 cf Stone x 40.0% Voids = 322.8 cf Stone Storage

Stone + Chamber Storage = 604.1 cf = 0.014 af
Overall Storage Efficiency = 55.5%

6 Chambers
40.3 cy Field
29.9 cy Stone



Pond R: Recharge System - Chamber Wizard Field B

Chamber Model = StormTech SC-740
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
Row Length Adjustment= +0.44' x 6.45 sf x 2 rows

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

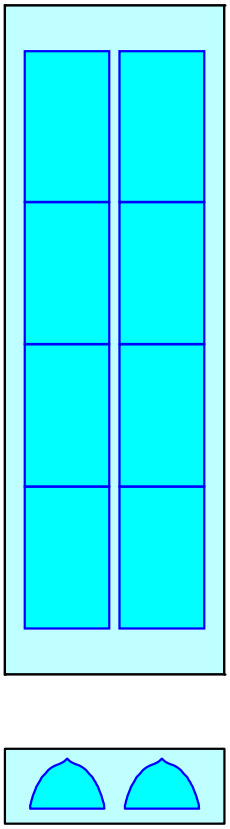
4 Chambers/Row x 7.12' Long +0.44' Row Adjustment = 28.92' Row Length +27.5" End Stone x 2 = 33.50' Base Length
2 Rows x 51.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.00' Base Width
9.0" Base + 30.0" Chamber Height + 6.0" Cover = 3.75' Field Height

8 Chambers x 45.9 cf +0.44' Row Adjustment x 6.45 sf x 2 Rows = 373.2 cf Chamber Storage

1,382.0 cf Field - 373.2 cf Chambers = 1,008.8 cf Stone x 40.0% Voids = 403.5 cf Stone Storage

Stone + Chamber Storage = 776.7 cf = 0.018 af
Overall Storage Efficiency = 56.2%

8 Chambers
51.2 cy Field
37.4 cy Stone



Hydrograph for Pond R: Recharge System

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)
0.00	0.00	0	11.00	0.00	0.00	0.00
2.00	0.00	1	11.01	0.00	0.00	0.00
4.00	0.01	12	11.05	0.00	**0.00**	0.00
6.00	0.01	34	11.13	0.00	**0.00**	0.00
8.00	0.02	97	11.37	0.00	0.00	0.00
10.00	0.04	255	11.87	0.00	0.00	0.00
12.00	**0.54**	**915**	**13.30**	**0.01**	0.00	**0.00**
14.00	**0.04**	**920**	**13.31**	**0.04**	0.00	**0.04**
16.00	0.02	917	13.31	0.02	0.00	0.02
18.00	0.01	916	13.30	0.01	0.00	0.01
20.00	0.01	916	13.30	0.01	0.00	0.01
22.00	0.01	916	13.30	0.01	0.00	0.00
24.00	0.01	915	13.30	0.01	0.00	0.00
26.00	0.00	884	13.23	0.00	0.00	0.00
28.00	0.00	851	13.15	0.00	0.00	0.00
30.00	0.00	818	13.07	0.00	0.00	0.00
32.00	0.00	785	13.00	0.00	0.00	0.00
34.00	0.00	752	12.92	0.00	0.00	0.00
36.00	0.00	719	12.85	0.00	0.00	0.00
38.00	0.00	686	12.78	0.00	0.00	0.00
40.00	0.00	653	12.70	0.00	0.00	0.00
42.00	0.00	620	12.63	0.00	0.00	0.00
44.00	0.00	587	12.56	0.00	0.00	0.00
46.00	0.00	554	12.49	0.00	0.00	0.00
48.00	0.00	521	12.42	0.00	0.00	0.00
50.00	0.00	489	12.35	0.00	0.00	0.00
52.00	0.00	456	12.28	0.00	0.00	0.00
54.00	0.00	423	12.21	0.00	0.00	0.00
56.00	0.00	390	12.14	0.00	0.00	0.00
58.00	0.00	357	12.08	0.00	0.00	0.00
60.00	0.00	324	12.01	0.00	0.00	0.00
62.00	0.00	291	11.94	0.00	0.00	0.00
64.00	0.00	258	11.87	0.00	0.00	0.00
66.00	0.00	225	11.81	0.00	0.00	0.00
68.00	0.00	192	11.73	0.00	0.00	0.00
70.00	0.00	159	11.60	0.00	0.00	0.00
72.00	0.00	126	11.48	0.00	0.00	0.00

Stage-Discharge for Pond R: Recharge System

Elevation (feet)	Discharge (cfs)	Discarded (cfs)	Primary (cfs)
11.00	0.00	**0.00**	0.00
11.10	0.00	**0.00**	0.00
11.20	0.00	0.00	0.00
11.30	0.00	0.00	0.00
11.40	0.00	0.00	0.00
11.50	0.00	0.00	0.00
11.60	0.00	0.00	0.00
11.70	0.00	0.00	0.00
11.80	0.00	0.00	0.00
11.90	0.00	0.00	0.00
12.00	0.00	0.00	0.00
12.10	0.00	0.00	0.00
12.20	0.00	0.00	0.00
12.30	0.00	0.00	0.00
12.40	0.00	0.00	0.00
12.50	0.00	0.00	0.00
12.60	0.00	0.00	0.00
12.70	0.00	0.00	0.00
12.80	0.00	0.00	0.00
12.90	0.00	0.00	0.00
13.00	0.00	0.00	0.00
13.10	0.00	0.00	0.00
13.20	0.00	0.00	0.00
13.30	0.00	0.00	0.00
13.40	0.52	0.00	0.51
13.50	1.46	0.00	1.45
13.60	2.66	0.00	2.65
13.70	4.07	0.00	4.07
13.80	5.67	0.00	5.66
13.90	7.42	0.00	7.42
14.00	9.31	0.00	9.31
14.10	11.33	0.00	11.32
14.20	13.46	0.00	13.46
14.30	15.70	0.00	15.70
14.40	18.04	0.00	18.03
14.50	20.47	0.00	20.46
14.60	22.98	0.00	22.97
14.70	25.57	0.00	25.57
14.80	28.24	0.00	28.23
14.90	30.98	0.00	30.97
15.00	33.78	0.00	33.78
15.10	36.65	0.00	36.64
15.20	39.57	0.00	39.57
15.30	42.55	0.00	42.55
15.40	45.58	0.00	45.58
15.50	48.66	0.00	48.66
15.60	51.79	0.00	51.78
15.70	54.96	0.00	54.95
15.80	58.17	0.00	58.17
15.90	61.42	0.00	61.42
16.00	64.71	0.00	64.70
16.10	68.03	0.00	68.02
16.20	71.38	0.00	71.38
16.30	74.77	0.00	74.76
16.40	**78.18**	0.00	**78.17**

Stage-Area-Storage for Pond R: Recharge System

Elevation (feet)	Horizontal (sq-ft)	Storage (cubic-feet)
11.00	**659**	0
11.10	659	26
11.20	659	53
11.30	659	79
11.40	659	105
11.50	659	132
11.60	659	158
11.70	659	184
11.80	659	222
11.90	659	271
12.00	659	320
12.10	659	368
12.20	659	416
12.30	659	464
12.40	659	511
12.50	659	558
12.60	659	605
12.70	659	651
12.80	659	697
12.90	659	742
13.00	659	786
13.10	659	830
13.20	659	873
13.30	659	915
13.40	659	956
13.50	659	997
13.60	659	1,036
13.70	659	1,074
13.80	659	1,111
13.90	659	1,146
14.00	659	1,178
14.10	659	1,208
14.20	659	1,236
14.30	659	1,262
14.40	659	1,289
14.50	659	1,315
14.60	659	1,341
14.70	659	**1,368**
14.80	659	**1,381**
14.90	659	1,381
15.00	659	1,381
15.10	659	1,381
15.20	659	1,381
15.30	659	1,381
15.40	659	1,381
15.50	659	1,381
15.60	659	1,381
15.70	659	1,381
15.80	659	1,381
15.90	659	1,381
16.00	659	1,381
16.10	659	1,381
16.20	659	1,381
16.30	659	1,381
16.40	659	1,381

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PWA-11S: PWA-11 Sleeper Runoff Area=323 sf 19.81% Impervious Runoff Depth=2.45"
Tc=5.0 min CN=76 Runoff=0.02 cfs 66 cf

Subcatchment PWA-12FP: PWA-12 Farns Runoff Area=1,400 sf 100.00% Impervious Runoff Depth=4.66"
Tc=5.0 min CN=98 Runoff=0.16 cfs 544 cf

Subcatchment PWA-12FR: PWA-12 Farns Runoff Area=10,700 sf 100.00% Impervious Runoff Depth=4.66"
Tc=5.0 min CN=98 Runoff=1.22 cfs 4,158 cf

Subcatchment PWA-WP: PWA-Westerly Runoff Area=270 sf 15.19% Impervious Runoff Depth=2.81"
Tc=5.0 min CN=80 Runoff=0.02 cfs 63 cf

Reach DP-1: Design Point - 1 Inflow=1.40 cfs 3,553 cf
Outflow=1.40 cfs 3,553 cf

Pond R: Recharge System Peak Elev=13.48' Storage=987 cf Inflow=1.22 cfs 4,158 cf
Discarded=0.00 cfs 1,152 cf Primary=1.20 cfs 2,879 cf Outflow=1.21 cfs 4,032 cf

Total Runoff Area = 12,693 sf Runoff Volume = 4,831 cf Average Runoff Depth = 4.57"
3.84% Pervious = 488 sf 96.16% Impervious = 12,205 sf

Summary for Subcatchment PWA-11S: PWA-11 Sleeper

Runoff = 0.02 cfs @ 12.08 hrs, Volume= 66 cf, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.90"

	Area (sf)	CN	Description
*	202	68	Permeable Pavers
	57	79	<50% Grass cover, Poor, HSG B
*	64	98	Transformer Pad
	323	76	Weighted Average
	259		80.19% Pervious Area
	64		19.81% Impervious Area

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

Hydrograph for Subcatchment PWA-11S: PWA-11 Sleeper

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.05	0.00	0.00
2.00	0.10	0.00	0.00
3.00	0.15	0.00	0.00
4.00	0.21	0.00	0.00
5.00	0.28	0.00	0.00
6.00	0.35	0.00	0.00
7.00	0.44	0.00	0.00
8.00	0.56	0.00	0.00
9.00	0.71	0.00	0.00
10.00	0.93	0.03	0.00
11.00	1.22	0.09	0.00
12.00	2.45	0.66	**0.01**
13.00	3.67	1.49	**0.00**
14.00	3.97	1.72	0.00
15.00	4.19	1.88	0.00
16.00	4.34	2.00	0.00
17.00	4.46	2.10	0.00
18.00	4.55	2.17	0.00
19.00	4.62	2.23	0.00
20.00	4.69	2.28	0.00
21.00	4.75	2.33	0.00
22.00	4.81	2.38	0.00
23.00	4.86	2.42	0.00
24.00	**4.90**	**2.45**	0.00
25.00	4.90	2.45	0.00
26.00	4.90	2.45	0.00
27.00	4.90	2.45	0.00
28.00	4.90	2.45	0.00
29.00	4.90	2.45	0.00
30.00	4.90	2.45	0.00
31.00	4.90	2.45	0.00
32.00	4.90	2.45	0.00
33.00	4.90	2.45	0.00
34.00	4.90	2.45	0.00
35.00	4.90	2.45	0.00
36.00	4.90	2.45	0.00
37.00	4.90	2.45	0.00
38.00	4.90	2.45	0.00
39.00	4.90	2.45	0.00
40.00	4.90	2.45	0.00
41.00	4.90	2.45	0.00
42.00	4.90	2.45	0.00
43.00	4.90	2.45	0.00
44.00	4.90	2.45	0.00
45.00	4.90	2.45	0.00
46.00	4.90	2.45	0.00
47.00	4.90	2.45	0.00
48.00	4.90	2.45	0.00
49.00	4.90	2.45	0.00
50.00	4.90	2.45	0.00
51.00	4.90	2.45	0.00
52.00	4.90	2.45	0.00
53.00	4.90	2.45	0.00
54.00	4.90	2.45	0.00
55.00	4.90	2.45	0.00
56.00	4.90	2.45	0.00
57.00	4.90	2.45	0.00
58.00	4.90	2.45	0.00
59.00	4.90	2.45	0.00
60.00	4.90	2.45	0.00
61.00	4.90	2.45	0.00
62.00	4.90	2.45	0.00
63.00	4.90	2.45	0.00
64.00	4.90	2.45	0.00
65.00	4.90	2.45	0.00
66.00	4.90	2.45	0.00
67.00	4.90	2.45	0.00
68.00	4.90	2.45	0.00
69.00	4.90	2.45	0.00
70.00	4.90	2.45	0.00
71.00	4.90	2.45	0.00
72.00	4.90	2.45	0.00

Summary for Subcatchment PWA-12FP: PWA-12 Farns Patio

Runoff = 0.16 cfs @ 12.07 hrs, Volume= 544 cf, Depth= 4.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.90"

	Area (sf)	CN	Description
*	1,400	98	Patio
	1,400		100.00% Impervious Area

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

Hydrograph for Subcatchment PWA-12FP: PWA-12 Farns Patio

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.05	0.00	0.00
2.00	0.10	0.01	0.00
3.00	0.15	0.04	0.00
4.00	0.21	0.08	0.00
5.00	0.28	0.13	0.00
6.00	0.35	0.19	0.00
7.00	0.44	0.27	0.00
8.00	0.56	0.37	0.00
9.00	0.71	0.52	0.01
10.00	0.93	0.72	0.01
11.00	1.22	1.01	0.01
12.00	2.45	2.22	**0.11**
13.00	3.67	3.44	**0.01**
14.00	3.97	3.74	0.01
15.00	4.19	3.95	0.01
16.00	4.34	4.11	0.00
17.00	4.46	4.22	0.00
18.00	4.55	4.31	0.00
19.00	4.62	4.39	0.00
20.00	4.69	4.45	0.00
21.00	4.75	4.51	0.00
22.00	4.81	4.57	0.00
23.00	4.86	4.62	0.00
24.00	**4.90**	**4.66**	0.00
25.00	4.90	4.66	0.00
26.00	4.90	4.66	0.00
27.00	4.90	4.66	0.00
28.00	4.90	4.66	0.00
29.00	4.90	4.66	0.00
30.00	4.90	4.66	0.00
31.00	4.90	4.66	0.00
32.00	4.90	4.66	0.00
33.00	4.90	4.66	0.00
34.00	4.90	4.66	0.00
35.00	4.90	4.66	0.00
36.00	4.90	4.66	0.00
37.00	4.90	4.66	0.00
38.00	4.90	4.66	0.00
39.00	4.90	4.66	0.00
40.00	4.90	4.66	0.00
41.00	4.90	4.66	0.00
42.00	4.90	4.66	0.00
43.00	4.90	4.66	0.00
44.00	4.90	4.66	0.00
45.00	4.90	4.66	0.00
46.00	4.90	4.66	0.00
47.00	4.90	4.66	0.00
48.00	4.90	4.66	0.00
49.00	4.90	4.66	0.00
50.00	4.90	4.66	0.00
51.00	4.90	4.66	0.00
52.00	4.90	4.66	0.00
53.00	4.90	4.66	0.00
54.00	4.90	4.66	0.00
55.00	4.90	4.66	0.00
56.00	4.90	4.66	0.00
57.00	4.90	4.66	0.00
58.00	4.90	4.66	0.00
59.00	4.90	4.66	0.00
60.00	4.90	4.66	0.00
61.00	4.90	4.66	0.00
62.00	4.90	4.66	0.00
63.00	4.90	4.66	0.00
64.00	4.90	4.66	0.00
65.00	4.90	4.66	0.00
66.00	4.90	4.66	0.00
67.00	4.90	4.66	0.00
68.00	4.90	4.66	0.00
69.00	4.90	4.66	0.00
70.00	4.90	4.66	0.00
71.00	4.90	4.66	0.00
72.00	4.90	4.66	0.00

Summary for Subcatchment PWA-12FR: PWA-12 Farns Roof

Runoff = 1.22 cfs @ 12.07 hrs, Volume= 4,158 cf, Depth= 4.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.90"

Area (sf)	CN	Description
10,700	98	Roofs, HSG B
10,700		100.00% Impervious Area

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

Hydrograph for Subcatchment PWA-12FR: PWA-12 Farns Roof

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.05	0.00	0.00
2.00	0.10	0.01	0.00
3.00	0.15	0.04	0.01
4.00	0.21	0.08	0.01
5.00	0.28	0.13	0.01
6.00	0.35	0.19	0.02
7.00	0.44	0.27	0.02
8.00	0.56	0.37	0.03
9.00	0.71	0.52	0.04
10.00	0.93	0.72	0.06
11.00	1.22	1.01	0.08
12.00	2.45	2.22	**0.82**
13.00	3.67	3.44	**0.10**
14.00	3.97	3.74	0.06
15.00	4.19	3.95	0.05
16.00	4.34	4.11	0.03
17.00	4.46	4.22	0.03
18.00	4.55	4.31	0.02
19.00	4.62	4.39	0.02
20.00	4.69	4.45	0.02
21.00	4.75	4.51	0.01
22.00	4.81	4.57	0.01
23.00	4.86	4.62	0.01
24.00	**4.90**	**4.66**	0.01
25.00	4.90	4.66	0.00
26.00	4.90	4.66	0.00
27.00	4.90	4.66	0.00
28.00	4.90	4.66	0.00
29.00	4.90	4.66	0.00
30.00	4.90	4.66	0.00
31.00	4.90	4.66	0.00
32.00	4.90	4.66	0.00
33.00	4.90	4.66	0.00
34.00	4.90	4.66	0.00
35.00	4.90	4.66	0.00
36.00	4.90	4.66	0.00
37.00	4.90	4.66	0.00
38.00	4.90	4.66	0.00
39.00	4.90	4.66	0.00
40.00	4.90	4.66	0.00
41.00	4.90	4.66	0.00
42.00	4.90	4.66	0.00
43.00	4.90	4.66	0.00
44.00	4.90	4.66	0.00
45.00	4.90	4.66	0.00
46.00	4.90	4.66	0.00
47.00	4.90	4.66	0.00
48.00	4.90	4.66	0.00
49.00	4.90	4.66	0.00
50.00	4.90	4.66	0.00
51.00	4.90	4.66	0.00
52.00	4.90	4.66	0.00
53.00	4.90	4.66	0.00
54.00	4.90	4.66	0.00
55.00	4.90	4.66	0.00
56.00	4.90	4.66	0.00
57.00	4.90	4.66	0.00
58.00	4.90	4.66	0.00
59.00	4.90	4.66	0.00
60.00	4.90	4.66	0.00
61.00	4.90	4.66	0.00
62.00	4.90	4.66	0.00
63.00	4.90	4.66	0.00
64.00	4.90	4.66	0.00
65.00	4.90	4.66	0.00
66.00	4.90	4.66	0.00
67.00	4.90	4.66	0.00
68.00	4.90	4.66	0.00
69.00	4.90	4.66	0.00
70.00	4.90	4.66	0.00
71.00	4.90	4.66	0.00
72.00	4.90	4.66	0.00

Summary for Subcatchment PWA-WP: PWA-Westerly Passageway

Runoff = 0.02 cfs @ 12.07 hrs, Volume= 63 cf, Depth= 2.81"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-yr Rainfall=4.90"

	Area (sf)	CN	Description
*	156	68	Permeable Pavers
*	41	98	Misc. Mechanical Equipment.
	73	96	Gravel surface, HSG B
	270	80	Weighted Average
	229		84.81% Pervious Area
	41		15.19% Impervious Area

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

Hydrograph for Subcatchment PWA-WP: PWA-Westerly Passageway

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.05	0.00	0.00
2.00	0.10	0.00	0.00
3.00	0.15	0.00	0.00
4.00	0.21	0.00	0.00
5.00	0.28	0.00	0.00
6.00	0.35	0.00	0.00
7.00	0.44	0.00	0.00
8.00	0.56	0.00	0.00
9.00	0.71	0.02	0.00
10.00	0.93	0.06	0.00
11.00	1.22	0.16	0.00
12.00	2.45	0.85	**0.01**
13.00	3.67	1.78	**0.00**
14.00	3.97	2.02	0.00
15.00	4.19	2.20	0.00
16.00	4.34	2.33	0.00
17.00	4.46	2.42	0.00
18.00	4.55	2.50	0.00
19.00	4.62	2.57	0.00
20.00	4.69	2.62	0.00
21.00	4.75	2.68	0.00
22.00	4.81	2.72	0.00
23.00	4.86	2.77	0.00
24.00	**4.90**	**2.81**	0.00
25.00	4.90	2.81	0.00
26.00	4.90	2.81	0.00
27.00	4.90	2.81	0.00
28.00	4.90	2.81	0.00
29.00	4.90	2.81	0.00
30.00	4.90	2.81	0.00
31.00	4.90	2.81	0.00
32.00	4.90	2.81	0.00
33.00	4.90	2.81	0.00
34.00	4.90	2.81	0.00
35.00	4.90	2.81	0.00
36.00	4.90	2.81	0.00
37.00	4.90	2.81	0.00
38.00	4.90	2.81	0.00
39.00	4.90	2.81	0.00
40.00	4.90	2.81	0.00
41.00	4.90	2.81	0.00
42.00	4.90	2.81	0.00
43.00	4.90	2.81	0.00
44.00	4.90	2.81	0.00
45.00	4.90	2.81	0.00
46.00	4.90	2.81	0.00
47.00	4.90	2.81	0.00
48.00	4.90	2.81	0.00
49.00	4.90	2.81	0.00
50.00	4.90	2.81	0.00
51.00	4.90	2.81	0.00
52.00	4.90	2.81	0.00
53.00	4.90	2.81	0.00
54.00	4.90	2.81	0.00
55.00	4.90	2.81	0.00
56.00	4.90	2.81	0.00
57.00	4.90	2.81	0.00
58.00	4.90	2.81	0.00
59.00	4.90	2.81	0.00
60.00	4.90	2.81	0.00
61.00	4.90	2.81	0.00
62.00	4.90	2.81	0.00
63.00	4.90	2.81	0.00
64.00	4.90	2.81	0.00
65.00	4.90	2.81	0.00
66.00	4.90	2.81	0.00
67.00	4.90	2.81	0.00
68.00	4.90	2.81	0.00
69.00	4.90	2.81	0.00
70.00	4.90	2.81	0.00
71.00	4.90	2.81	0.00
72.00	4.90	2.81	0.00

Summary for Reach DP-1: Design Point - 1

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	12,693 sf, 96.16% Impervious,	Inflow Depth =	3.36"	for	10-yr event
Inflow =	1.40 cfs @ 12.08 hrs,	Volume=	3,553 cf		
Outflow =	1.40 cfs @ 12.08 hrs,	Volume=	3,553 cf,	Atten= 0%,	Lag= 0.0 min

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

Hydrograph for Reach DP-1: Design Point - 1

Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)	Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)
0.00	0.00		0.00	52.00	0.00		0.00
1.00	0.00		0.00	53.00	0.00		0.00
2.00	0.00		0.00	54.00	0.00		0.00
3.00	0.00		0.00	55.00	0.00		0.00
4.00	0.00		0.00	56.00	0.00		0.00
5.00	0.00		0.00	57.00	0.00		0.00
6.00	0.00		0.00	58.00	0.00		0.00
7.00	0.00		0.00	59.00	0.00		0.00
8.00	0.00		0.00	60.00	0.00		0.00
9.00	0.01		0.01	61.00	0.00		0.00
10.00	0.01		0.01	62.00	0.00		0.00
11.00	0.01		0.01	63.00	0.00		0.00
12.00	**0.87**		**0.87**	64.00	0.00		0.00
13.00	**0.11**		**0.11**	65.00	0.00		0.00
14.00	0.07		0.07	66.00	0.00		0.00
15.00	0.05		0.05	67.00	0.00		0.00
16.00	0.03		0.03	68.00	0.00		0.00
17.00	0.03		0.03	69.00	0.00		0.00
18.00	0.02		0.02	70.00	0.00		0.00
19.00	0.02		0.02	71.00	0.00		0.00
20.00	0.01		0.01	72.00	0.00		0.00
21.00	0.01		0.01				
22.00	0.01		0.01				
23.00	0.01		0.01				
24.00	0.01		0.01				
25.00	0.00		0.00				
26.00	0.00		0.00				
27.00	0.00		0.00				
28.00	0.00		0.00				
29.00	0.00		0.00				
30.00	0.00		0.00				
31.00	0.00		0.00				
32.00	0.00		0.00				
33.00	0.00		0.00				
34.00	0.00		0.00				
35.00	0.00		0.00				
36.00	0.00		0.00				
37.00	0.00		0.00				
38.00	0.00		0.00				
39.00	0.00		0.00				
40.00	0.00		0.00				
41.00	0.00		0.00				
42.00	0.00		0.00				
43.00	0.00		0.00				
44.00	0.00		0.00				
45.00	0.00		0.00				
46.00	0.00		0.00				
47.00	0.00		0.00				
48.00	0.00		0.00				
49.00	0.00		0.00				
50.00	0.00		0.00				
51.00	0.00		0.00				

Summary for Pond R: Recharge System

**Elevations are based on an assumed surface elevation of 100'. Elevations shall be field adjusted to accomodate actual surface elevations.

Inflow Area =	10,700 sf,	100.00% Impervious,	Inflow Depth =	4.66"	for 10-yr event
Inflow =	1.22 cfs @	12.07 hrs,	Volume=	4,158 cf	
Outflow =	1.21 cfs @	12.08 hrs,	Volume=	4,032 cf,	Atten= 1%, Lag= 0.7 min
Discarded =	0.00 cfs @	2.84 hrs,	Volume=	1,152 cf	
Primary =	1.20 cfs @	12.08 hrs,	Volume=	2,879 cf	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 13.48' @ 12.08 hrs Surf.Area= 659 sf Storage= 987 cf
Flood Elev= 16.46' Surf.Area= 659 sf Storage= 1,381 cf

Plug-Flow detention time= 483.0 min calculated for 4,031 cf (97% of inflow)
Center-of-Mass det. time= 464.3 min (1,211.8 - 747.4)

Volume	Invert	Avail.Storage	Storage Description
#1A	11.00'	323 cf	**11.00'W x 26.38'L x 3.75'H Field A** 1,088 cf Overall - 281 cf Embedded = 807 cf x 40.0% Voids
#2A	11.75'	281 cf	**StormTech SC-740** x 6 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap Row Length Adjustment= +0.44' x 6.45 sf x 2 rows
#3B	11.00'	404 cf	**11.00'W x 33.50'L x 3.75'H Field B** 1,382 cf Overall - 373 cf Embedded = 1,009 cf x 40.0% Voids
#4B	11.75'	373 cf	**StormTech SC-740** x 8 Inside #3 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap Row Length Adjustment= +0.44' x 6.45 sf x 2 rows
		1,381 cf	Total Available Storage

Storage Group A created with Chamber Wizard
Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	11.00'	**0.300 in/hr Exfiltration over Horizontal area**
#2	Primary	13.30'	**5.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.00 cfs @ 2.84 hrs HW=11.05' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.00 cfs)

Primary OutFlow Max=1.19 cfs @ 12.08 hrs HW=13.48' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 1.19 cfs @ 1.37 fps)

Pond R: Recharge System - Chamber Wizard Field A

Chamber Model = StormTech SC-740
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
Row Length Adjustment= +0.44' x 6.45 sf x 2 rows

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

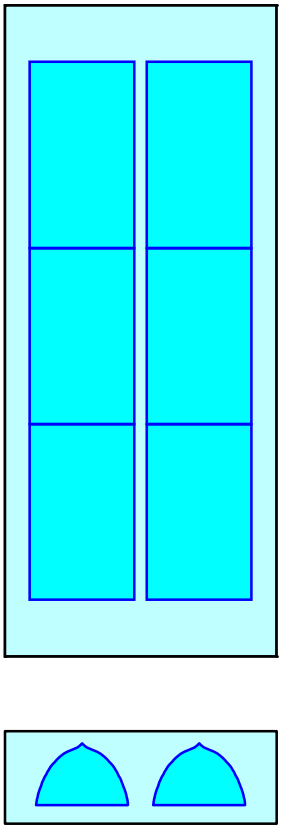
3 Chambers/Row x 7.12' Long +0.44' Row Adjustment = 21.80' Row Length +27.5" End Stone x 2 = 26.38' Base Length
2 Rows x 51.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.00' Base Width
9.0" Base + 30.0" Chamber Height + 6.0" Cover = 3.75' Field Height

6 Chambers x 45.9 cf +0.44' Row Adjustment x 6.45 sf x 2 Rows = 281.3 cf Chamber Storage

1,088.2 cf Field - 281.3 cf Chambers = 806.9 cf Stone x 40.0% Voids = 322.8 cf Stone Storage

Stone + Chamber Storage = 604.1 cf = 0.014 af
Overall Storage Efficiency = 55.5%

6 Chambers
40.3 cy Field
29.9 cy Stone



Pond R: Recharge System - Chamber Wizard Field B

Chamber Model = StormTech SC-740
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
Row Length Adjustment= +0.44' x 6.45 sf x 2 rows

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

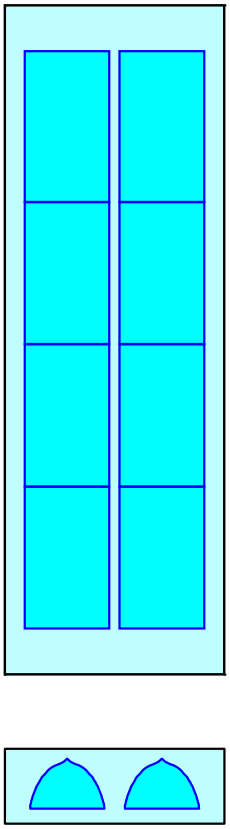
4 Chambers/Row x 7.12' Long +0.44' Row Adjustment = 28.92' Row Length +27.5" End Stone x 2 = 33.50' Base Length
2 Rows x 51.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.00' Base Width
9.0" Base + 30.0" Chamber Height + 6.0" Cover = 3.75' Field Height

8 Chambers x 45.9 cf +0.44' Row Adjustment x 6.45 sf x 2 Rows = 373.2 cf Chamber Storage

1,382.0 cf Field - 373.2 cf Chambers = 1,008.8 cf Stone x 40.0% Voids = 403.5 cf Stone Storage

Stone + Chamber Storage = 776.7 cf = 0.018 af
Overall Storage Efficiency = 56.2%

8 Chambers
51.2 cy Field
37.4 cy Stone



Hydrograph for Pond R: Recharge System

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)
0.00	0.00	0	11.00	0.00	0.00	0.00
2.00	0.00	7	11.03	0.00	**0.00**	0.00
4.00	0.01	33	11.13	0.00	**0.00**	0.00
6.00	0.02	98	11.37	0.00	0.00	0.00
8.00	0.03	225	11.81	0.00	0.00	0.00
10.00	0.06	495	12.36	0.00	0.00	0.00
12.00	**0.82**	**967**	**13.43**	**0.74**	0.00	**0.74**
14.00	**0.06**	**923**	**13.32**	**0.06**	0.00	**0.06**
16.00	0.03	919	13.31	0.03	0.00	0.03
18.00	0.02	917	13.31	0.02	0.00	0.02
20.00	0.02	917	13.30	0.02	0.00	0.01
22.00	0.01	916	13.30	0.01	0.00	0.01
24.00	0.01	916	13.30	0.01	0.00	0.01
26.00	0.00	884	13.23	0.00	0.00	0.00
28.00	0.00	851	13.15	0.00	0.00	0.00
30.00	0.00	818	13.07	0.00	0.00	0.00
32.00	0.00	785	13.00	0.00	0.00	0.00
34.00	0.00	752	12.92	0.00	0.00	0.00
36.00	0.00	719	12.85	0.00	0.00	0.00
38.00	0.00	687	12.78	0.00	0.00	0.00
40.00	0.00	654	12.71	0.00	0.00	0.00
42.00	0.00	621	12.63	0.00	0.00	0.00
44.00	0.00	588	12.56	0.00	0.00	0.00
46.00	0.00	555	12.49	0.00	0.00	0.00
48.00	0.00	522	12.42	0.00	0.00	0.00
50.00	0.00	489	12.35	0.00	0.00	0.00
52.00	0.00	456	12.28	0.00	0.00	0.00
54.00	0.00	423	12.21	0.00	0.00	0.00
56.00	0.00	390	12.15	0.00	0.00	0.00
58.00	0.00	357	12.08	0.00	0.00	0.00
60.00	0.00	324	12.01	0.00	0.00	0.00
62.00	0.00	291	11.94	0.00	0.00	0.00
64.00	0.00	258	11.87	0.00	0.00	0.00
66.00	0.00	225	11.81	0.00	0.00	0.00
68.00	0.00	192	11.73	0.00	0.00	0.00
70.00	0.00	160	11.61	0.00	0.00	0.00
72.00	0.00	127	11.48	0.00	0.00	0.00

Stage-Discharge for Pond R: Recharge System

Elevation (feet)	Discharge (cfs)	Discarded (cfs)	Primary (cfs)
11.00	0.00	**0.00**	0.00
11.10	0.00	**0.00**	0.00
11.20	0.00	0.00	0.00
11.30	0.00	0.00	0.00
11.40	0.00	0.00	0.00
11.50	0.00	0.00	0.00
11.60	0.00	0.00	0.00
11.70	0.00	0.00	0.00
11.80	0.00	0.00	0.00
11.90	0.00	0.00	0.00
12.00	0.00	0.00	0.00
12.10	0.00	0.00	0.00
12.20	0.00	0.00	0.00
12.30	0.00	0.00	0.00
12.40	0.00	0.00	0.00
12.50	0.00	0.00	0.00
12.60	0.00	0.00	0.00
12.70	0.00	0.00	0.00
12.80	0.00	0.00	0.00
12.90	0.00	0.00	0.00
13.00	0.00	0.00	0.00
13.10	0.00	0.00	0.00
13.20	0.00	0.00	0.00
13.30	0.00	0.00	0.00
13.40	0.52	0.00	0.51
13.50	1.46	0.00	1.45
13.60	2.66	0.00	2.65
13.70	4.07	0.00	4.07
13.80	5.67	0.00	5.66
13.90	7.42	0.00	7.42
14.00	9.31	0.00	9.31
14.10	11.33	0.00	11.32
14.20	13.46	0.00	13.46
14.30	15.70	0.00	15.70
14.40	18.04	0.00	18.03
14.50	20.47	0.00	20.46
14.60	22.98	0.00	22.97
14.70	25.57	0.00	25.57
14.80	28.24	0.00	28.23
14.90	30.98	0.00	30.97
15.00	33.78	0.00	33.78
15.10	36.65	0.00	36.64
15.20	39.57	0.00	39.57
15.30	42.55	0.00	42.55
15.40	45.58	0.00	45.58
15.50	48.66	0.00	48.66
15.60	51.79	0.00	51.78
15.70	54.96	0.00	54.95
15.80	58.17	0.00	58.17
15.90	61.42	0.00	61.42
16.00	64.71	0.00	64.70
16.10	68.03	0.00	68.02
16.20	71.38	0.00	71.38
16.30	74.77	0.00	74.76
16.40	**78.18**	0.00	**78.17**

Stage-Area-Storage for Pond R: Recharge System

Elevation (feet)	Horizontal (sq-ft)	Storage (cubic-feet)
11.00	**659**	0
11.10	659	26
11.20	659	53
11.30	659	79
11.40	659	105
11.50	659	132
11.60	659	158
11.70	659	184
11.80	659	222
11.90	659	271
12.00	659	320
12.10	659	368
12.20	659	416
12.30	659	464
12.40	659	511
12.50	659	558
12.60	659	605
12.70	659	651
12.80	659	697
12.90	659	742
13.00	659	786
13.10	659	830
13.20	659	873
13.30	659	915
13.40	659	956
13.50	659	997
13.60	659	1,036
13.70	659	1,074
13.80	659	1,111
13.90	659	1,146
14.00	659	1,178
14.10	659	1,208
14.20	659	1,236
14.30	659	1,262
14.40	659	1,289
14.50	659	1,315
14.60	659	1,341
14.70	659	**1,368**
14.80	659	**1,381**
14.90	659	1,381
15.00	659	1,381
15.10	659	1,381
15.20	659	1,381
15.30	659	1,381
15.40	659	1,381
15.50	659	1,381
15.60	659	1,381
15.70	659	1,381
15.80	659	1,381
15.90	659	1,381
16.00	659	1,381
16.10	659	1,381
16.20	659	1,381
16.30	659	1,381
16.40	659	1,381

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PWA-11S: PWA-11 Sleeper Runoff Area=323 sf 19.81% Impervious Runoff Depth=3.54"
Tc=5.0 min CN=76 Runoff=0.03 cfs 95 cf

Subcatchment PWA-12FP: PWA-12 Farns Runoff Area=1,400 sf 100.00% Impervious Runoff Depth=5.95"
Tc=5.0 min CN=98 Runoff=0.20 cfs 694 cf

Subcatchment PWA-12FR: PWA-12 Farns Runoff Area=10,700 sf 100.00% Impervious Runoff Depth=5.95"
Tc=5.0 min CN=98 Runoff=1.54 cfs 5,307 cf

Subcatchment PWA-WP: PWA-Westerly Runoff Area=270 sf 15.19% Impervious Runoff Depth=3.95"
Tc=5.0 min CN=80 Runoff=0.03 cfs 89 cf

Reach DP-1: Design Point - 1 Inflow=1.79 cfs 4,899 cf
Outflow=1.79 cfs 4,899 cf

Pond R: Recharge System Peak Elev=13.51' Storage=999 cf Inflow=1.54 cfs 5,307 cf
Discarded=0.00 cfs 1,160 cf Primary=1.52 cfs 4,020 cf Outflow=1.53 cfs 5,180 cf

Total Runoff Area = 12,693 sf Runoff Volume = 6,186 cf Average Runoff Depth = 5.85"
3.84% Pervious = 488 sf 96.16% Impervious = 12,205 sf

Summary for Subcatchment PWA-11S: PWA-11 Sleeper

Runoff = 0.03 cfs @ 12.07 hrs, Volume= 95 cf, Depth= 3.54"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.19"

	Area (sf)	CN	Description
*	202	68	Permeable Pavers
	57	79	<50% Grass cover, Poor, HSG B
*	64	98	Transformer Pad
	323	76	Weighted Average
	259		80.19% Pervious Area
	64		19.81% Impervious Area

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

Hydrograph for Subcatchment PWA-11S: PWA-11 Sleeper

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.06	0.00	0.00
2.00	0.12	0.00	0.00
3.00	0.19	0.00	0.00
4.00	0.27	0.00	0.00
5.00	0.35	0.00	0.00
6.00	0.45	0.00	0.00
7.00	0.56	0.00	0.00
8.00	0.71	0.00	0.00
9.00	0.90	0.02	0.00
10.00	1.17	0.08	0.00
11.00	1.55	0.21	0.00
12.00	3.09	1.08	**0.02**
13.00	4.64	2.24	**0.00**
14.00	5.02	2.55	0.00
15.00	5.29	2.77	0.00
16.00	5.48	2.94	0.00
17.00	5.63	3.06	0.00
18.00	5.74	3.16	0.00
19.00	5.84	3.24	0.00
20.00	5.92	3.31	0.00
21.00	6.00	3.38	0.00
22.00	6.07	3.44	0.00
23.00	6.13	3.50	0.00
24.00	**6.19**	**3.54**	0.00
25.00	6.19	3.54	0.00
26.00	6.19	3.54	0.00
27.00	6.19	3.54	0.00
28.00	6.19	3.54	0.00
29.00	6.19	3.54	0.00
30.00	6.19	3.54	0.00
31.00	6.19	3.54	0.00
32.00	6.19	3.54	0.00
33.00	6.19	3.54	0.00
34.00	6.19	3.54	0.00
35.00	6.19	3.54	0.00
36.00	6.19	3.54	0.00
37.00	6.19	3.54	0.00
38.00	6.19	3.54	0.00
39.00	6.19	3.54	0.00
40.00	6.19	3.54	0.00
41.00	6.19	3.54	0.00
42.00	6.19	3.54	0.00
43.00	6.19	3.54	0.00
44.00	6.19	3.54	0.00
45.00	6.19	3.54	0.00
46.00	6.19	3.54	0.00
47.00	6.19	3.54	0.00
48.00	6.19	3.54	0.00
49.00	6.19	3.54	0.00
50.00	6.19	3.54	0.00
51.00	6.19	3.54	0.00
52.00	6.19	3.54	0.00
53.00	6.19	3.54	0.00
54.00	6.19	3.54	0.00
55.00	6.19	3.54	0.00
56.00	6.19	3.54	0.00
57.00	6.19	3.54	0.00
58.00	6.19	3.54	0.00
59.00	6.19	3.54	0.00
60.00	6.19	3.54	0.00
61.00	6.19	3.54	0.00
62.00	6.19	3.54	0.00
63.00	6.19	3.54	0.00
64.00	6.19	3.54	0.00
65.00	6.19	3.54	0.00
66.00	6.19	3.54	0.00
67.00	6.19	3.54	0.00
68.00	6.19	3.54	0.00
69.00	6.19	3.54	0.00
70.00	6.19	3.54	0.00
71.00	6.19	3.54	0.00
72.00	6.19	3.54	0.00

Summary for Subcatchment PWA-12FP: PWA-12 Farns Patio

Runoff = 0.20 cfs @ 12.07 hrs, Volume= 694 cf, Depth= 5.95"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.19"

	Area (sf)	CN	Description
*	1,400	98	Patio
	1,400		100.00% Impervious Area

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

Hydrograph for Subcatchment PWA-12FP: PWA-12 Farns Patio

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.06	0.00	0.00
2.00	0.12	0.02	0.00
3.00	0.19	0.06	0.00
4.00	0.27	0.12	0.00
5.00	0.35	0.19	0.00
6.00	0.45	0.27	0.00
7.00	0.56	0.37	0.00
8.00	0.71	0.51	0.00
9.00	0.90	0.70	0.01
10.00	1.17	0.96	0.01
11.00	1.55	1.33	0.01
12.00	3.09	2.86	**0.14**
13.00	4.64	4.41	**0.02**
14.00	5.02	4.78	0.01
15.00	5.29	5.05	0.01
16.00	5.48	5.25	0.01
17.00	5.63	5.39	0.00
18.00	5.74	5.51	0.00
19.00	5.84	5.60	0.00
20.00	5.92	5.69	0.00
21.00	6.00	5.76	0.00
22.00	6.07	5.83	0.00
23.00	6.13	5.90	0.00
24.00	**6.19**	**5.95**	0.00
25.00	6.19	5.95	0.00
26.00	6.19	5.95	0.00
27.00	6.19	5.95	0.00
28.00	6.19	5.95	0.00
29.00	6.19	5.95	0.00
30.00	6.19	5.95	0.00
31.00	6.19	5.95	0.00
32.00	6.19	5.95	0.00
33.00	6.19	5.95	0.00
34.00	6.19	5.95	0.00
35.00	6.19	5.95	0.00
36.00	6.19	5.95	0.00
37.00	6.19	5.95	0.00
38.00	6.19	5.95	0.00
39.00	6.19	5.95	0.00
40.00	6.19	5.95	0.00
41.00	6.19	5.95	0.00
42.00	6.19	5.95	0.00
43.00	6.19	5.95	0.00
44.00	6.19	5.95	0.00
45.00	6.19	5.95	0.00
46.00	6.19	5.95	0.00
47.00	6.19	5.95	0.00
48.00	6.19	5.95	0.00
49.00	6.19	5.95	0.00
50.00	6.19	5.95	0.00
51.00	6.19	5.95	0.00
52.00	6.19	5.95	0.00
53.00	6.19	5.95	0.00
54.00	6.19	5.95	0.00
55.00	6.19	5.95	0.00
56.00	6.19	5.95	0.00
57.00	6.19	5.95	0.00
58.00	6.19	5.95	0.00
59.00	6.19	5.95	0.00
60.00	6.19	5.95	0.00
61.00	6.19	5.95	0.00
62.00	6.19	5.95	0.00
63.00	6.19	5.95	0.00
64.00	6.19	5.95	0.00
65.00	6.19	5.95	0.00
66.00	6.19	5.95	0.00
67.00	6.19	5.95	0.00
68.00	6.19	5.95	0.00
69.00	6.19	5.95	0.00
70.00	6.19	5.95	0.00
71.00	6.19	5.95	0.00
72.00	6.19	5.95	0.00

Summary for Subcatchment PWA-12FR: PWA-12 Farns Roof

Runoff = 1.54 cfs @ 12.07 hrs, Volume= 5,307 cf, Depth= 5.95"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.19"

Area (sf)	CN	Description
10,700	98	Roofs, HSG B
10,700		100.00% Impervious Area

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

Hydrograph for Subcatchment PWA-12FR: PWA-12 Farns Roof

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.06	0.00	0.00
2.00	0.12	0.02	0.01
3.00	0.19	0.06	0.01
4.00	0.27	0.12	0.02
5.00	0.35	0.19	0.02
6.00	0.45	0.27	0.02
7.00	0.56	0.37	0.03
8.00	0.71	0.51	0.04
9.00	0.90	0.70	0.05
10.00	1.17	0.96	0.07
11.00	1.55	1.33	0.11
12.00	3.09	2.86	**1.04**
13.00	4.64	4.41	**0.12**
14.00	5.02	4.78	0.08
15.00	5.29	5.05	0.06
16.00	5.48	5.25	0.04
17.00	5.63	5.39	0.03
18.00	5.74	5.51	0.03
19.00	5.84	5.60	0.02
20.00	5.92	5.69	0.02
21.00	6.00	5.76	0.02
22.00	6.07	5.83	0.02
23.00	6.13	5.90	0.01
24.00	**6.19**	**5.95**	0.01
25.00	6.19	5.95	0.00
26.00	6.19	5.95	0.00
27.00	6.19	5.95	0.00
28.00	6.19	5.95	0.00
29.00	6.19	5.95	0.00
30.00	6.19	5.95	0.00
31.00	6.19	5.95	0.00
32.00	6.19	5.95	0.00
33.00	6.19	5.95	0.00
34.00	6.19	5.95	0.00
35.00	6.19	5.95	0.00
36.00	6.19	5.95	0.00
37.00	6.19	5.95	0.00
38.00	6.19	5.95	0.00
39.00	6.19	5.95	0.00
40.00	6.19	5.95	0.00
41.00	6.19	5.95	0.00
42.00	6.19	5.95	0.00
43.00	6.19	5.95	0.00
44.00	6.19	5.95	0.00
45.00	6.19	5.95	0.00
46.00	6.19	5.95	0.00
47.00	6.19	5.95	0.00
48.00	6.19	5.95	0.00
49.00	6.19	5.95	0.00
50.00	6.19	5.95	0.00
51.00	6.19	5.95	0.00
52.00	6.19	5.95	0.00
53.00	6.19	5.95	0.00
54.00	6.19	5.95	0.00
55.00	6.19	5.95	0.00
56.00	6.19	5.95	0.00
57.00	6.19	5.95	0.00
58.00	6.19	5.95	0.00
59.00	6.19	5.95	0.00
60.00	6.19	5.95	0.00
61.00	6.19	5.95	0.00
62.00	6.19	5.95	0.00
63.00	6.19	5.95	0.00
64.00	6.19	5.95	0.00
65.00	6.19	5.95	0.00
66.00	6.19	5.95	0.00
67.00	6.19	5.95	0.00
68.00	6.19	5.95	0.00
69.00	6.19	5.95	0.00
70.00	6.19	5.95	0.00
71.00	6.19	5.95	0.00
72.00	6.19	5.95	0.00

Summary for Subcatchment PWA-WP: PWA-Westerly Passageway

Runoff = 0.03 cfs @ 12.07 hrs, Volume= 89 cf, Depth= 3.95"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-yr Rainfall=6.19"

	Area (sf)	CN	Description
*	156	68	Permeable Pavers
*	41	98	Misc. Mechanical Equipment.
	73	96	Gravel surface, HSG B
	270	80	Weighted Average
	229		84.81% Pervious Area
	41		15.19% Impervious Area

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

Hydrograph for Subcatchment PWA-WP: PWA-Westerly Passageway

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.06	0.00	0.00
2.00	0.12	0.00	0.00
3.00	0.19	0.00	0.00
4.00	0.27	0.00	0.00
5.00	0.35	0.00	0.00
6.00	0.45	0.00	0.00
7.00	0.56	0.00	0.00
8.00	0.71	0.02	0.00
9.00	0.90	0.06	0.00
10.00	1.17	0.14	0.00
11.00	1.55	0.31	0.00
12.00	3.09	1.32	**0.02**
13.00	4.64	2.58	**0.00**
14.00	5.02	2.91	0.00
15.00	5.29	3.15	0.00
16.00	5.48	3.32	0.00
17.00	5.63	3.45	0.00
18.00	5.74	3.55	0.00
19.00	5.84	3.64	0.00
20.00	5.92	3.71	0.00
21.00	6.00	3.78	0.00
22.00	6.07	3.85	0.00
23.00	6.13	3.90	0.00
24.00	**6.19**	**3.95**	0.00
25.00	6.19	3.95	0.00
26.00	6.19	3.95	0.00
27.00	6.19	3.95	0.00
28.00	6.19	3.95	0.00
29.00	6.19	3.95	0.00
30.00	6.19	3.95	0.00
31.00	6.19	3.95	0.00
32.00	6.19	3.95	0.00
33.00	6.19	3.95	0.00
34.00	6.19	3.95	0.00
35.00	6.19	3.95	0.00
36.00	6.19	3.95	0.00
37.00	6.19	3.95	0.00
38.00	6.19	3.95	0.00
39.00	6.19	3.95	0.00
40.00	6.19	3.95	0.00
41.00	6.19	3.95	0.00
42.00	6.19	3.95	0.00
43.00	6.19	3.95	0.00
44.00	6.19	3.95	0.00
45.00	6.19	3.95	0.00
46.00	6.19	3.95	0.00
47.00	6.19	3.95	0.00
48.00	6.19	3.95	0.00
49.00	6.19	3.95	0.00
50.00	6.19	3.95	0.00
51.00	6.19	3.95	0.00
52.00	6.19	3.95	0.00
53.00	6.19	3.95	0.00
54.00	6.19	3.95	0.00
55.00	6.19	3.95	0.00
56.00	6.19	3.95	0.00
57.00	6.19	3.95	0.00
58.00	6.19	3.95	0.00
59.00	6.19	3.95	0.00
60.00	6.19	3.95	0.00
61.00	6.19	3.95	0.00
62.00	6.19	3.95	0.00
63.00	6.19	3.95	0.00
64.00	6.19	3.95	0.00
65.00	6.19	3.95	0.00
66.00	6.19	3.95	0.00
67.00	6.19	3.95	0.00
68.00	6.19	3.95	0.00
69.00	6.19	3.95	0.00
70.00	6.19	3.95	0.00
71.00	6.19	3.95	0.00
72.00	6.19	3.95	0.00

Summary for Reach DP-1: Design Point - 1

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	12,693 sf, 96.16% Impervious,	Inflow Depth =	4.63"	for 25-yr event	
Inflow =	1.79 cfs @ 12.08 hrs,	Volume=	4,899 cf		
Outflow =	1.79 cfs @ 12.08 hrs,	Volume=	4,899 cf,	Atten= 0%,	Lag= 0.0 min

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

Hydrograph for Reach DP-1: Design Point - 1

Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)	Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)
0.00	0.00		0.00	52.00	0.00		0.00
1.00	0.00		0.00	53.00	0.00		0.00
2.00	0.00		0.00	54.00	0.00		0.00
3.00	0.00		0.00	55.00	0.00		0.00
4.00	0.00		0.00	56.00	0.00		0.00
5.00	0.00		0.00	57.00	0.00		0.00
6.00	0.00		0.00	58.00	0.00		0.00
7.00	0.00		0.00	59.00	0.00		0.00
8.00	0.01		0.01	60.00	0.00		0.00
9.00	0.01		0.01	61.00	0.00		0.00
10.00	0.01		0.01	62.00	0.00		0.00
11.00	0.12		0.12	63.00	0.00		0.00
12.00	**1.12**		**1.12**	64.00	0.00		0.00
13.00	**0.14**		**0.14**	65.00	0.00		0.00
14.00	0.09		0.09	66.00	0.00		0.00
15.00	0.07		0.07	67.00	0.00		0.00
16.00	0.04		0.04	68.00	0.00		0.00
17.00	0.03		0.03	69.00	0.00		0.00
18.00	0.03		0.03	70.00	0.00		0.00
19.00	0.02		0.02	71.00	0.00		0.00
20.00	0.02		0.02	72.00	0.00		0.00
21.00	0.02		0.02				
22.00	0.02		0.02				
23.00	0.01		0.01				
24.00	0.01		0.01				
25.00	0.00		0.00				
26.00	0.00		0.00				
27.00	0.00		0.00				
28.00	0.00		0.00				
29.00	0.00		0.00				
30.00	0.00		0.00				
31.00	0.00		0.00				
32.00	0.00		0.00				
33.00	0.00		0.00				
34.00	0.00		0.00				
35.00	0.00		0.00				
36.00	0.00		0.00				
37.00	0.00		0.00				
38.00	0.00		0.00				
39.00	0.00		0.00				
40.00	0.00		0.00				
41.00	0.00		0.00				
42.00	0.00		0.00				
43.00	0.00		0.00				
44.00	0.00		0.00				
45.00	0.00		0.00				
46.00	0.00		0.00				
47.00	0.00		0.00				
48.00	0.00		0.00				
49.00	0.00		0.00				
50.00	0.00		0.00				
51.00	0.00		0.00				

Summary for Pond R: Recharge System

**Elevations are based on an assumed surface elevation of 100'. Elevations shall be field adjusted to accomodate actual surface elevations.

Inflow Area =	10,700 sf,	100.00% Impervious,	Inflow Depth =	5.95"	for 25-yr event
Inflow =	1.54 cfs @	12.07 hrs,	Volume=	5,307 cf	
Outflow =	1.53 cfs @	12.08 hrs,	Volume=	5,180 cf,	Atten= 1%, Lag= 0.6 min
Discarded =	0.00 cfs @	2.18 hrs,	Volume=	1,160 cf	
Primary =	1.52 cfs @	12.08 hrs,	Volume=	4,020 cf	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 13.51' @ 12.08 hrs Surf.Area= 659 sf Storage= 999 cf
Flood Elev= 16.46' Surf.Area= 659 sf Storage= 1,381 cf

Plug-Flow detention time= 386.7 min calculated for 5,179 cf (98% of inflow)
Center-of-Mass det. time= 371.7 min (1,115.5 - 743.8)

Volume	Invert	Avail.Storage	Storage Description
#1A	11.00'	323 cf	**11.00'W x 26.38'L x 3.75'H Field A** 1,088 cf Overall - 281 cf Embedded = 807 cf x 40.0% Voids
#2A	11.75'	281 cf	**StormTech SC-740** x 6 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap Row Length Adjustment= +0.44' x 6.45 sf x 2 rows
#3B	11.00'	404 cf	**11.00'W x 33.50'L x 3.75'H Field B** 1,382 cf Overall - 373 cf Embedded = 1,009 cf x 40.0% Voids
#4B	11.75'	373 cf	**StormTech SC-740** x 8 Inside #3 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap Row Length Adjustment= +0.44' x 6.45 sf x 2 rows
		1,381 cf	Total Available Storage

Storage Group A created with Chamber Wizard
Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	11.00'	**0.300 in/hr Exfiltration over Horizontal area**
#2	Primary	13.30'	**5.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.00 cfs @ 2.18 hrs HW=11.05' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.00 cfs)

Primary OutFlow Max=1.52 cfs @ 12.08 hrs HW=13.51' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 1.52 cfs @ 1.49 fps)

Pond R: Recharge System - Chamber Wizard Field A

Chamber Model = StormTech SC-740
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
Row Length Adjustment= +0.44' x 6.45 sf x 2 rows

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

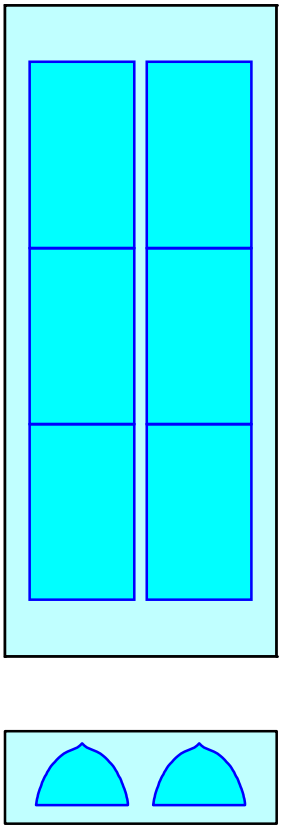
3 Chambers/Row x 7.12' Long +0.44' Row Adjustment = 21.80' Row Length +27.5" End Stone x 2 = 26.38' Base Length
2 Rows x 51.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.00' Base Width
9.0" Base + 30.0" Chamber Height + 6.0" Cover = 3.75' Field Height

6 Chambers x 45.9 cf +0.44' Row Adjustment x 6.45 sf x 2 Rows = 281.3 cf Chamber Storage

1,088.2 cf Field - 281.3 cf Chambers = 806.9 cf Stone x 40.0% Voids = 322.8 cf Stone Storage

Stone + Chamber Storage = 604.1 cf = 0.014 af
Overall Storage Efficiency = 55.5%

6 Chambers
40.3 cy Field
29.9 cy Stone



Pond R: Recharge System - Chamber Wizard Field B

Chamber Model = StormTech SC-740
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
Row Length Adjustment= +0.44' x 6.45 sf x 2 rows

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

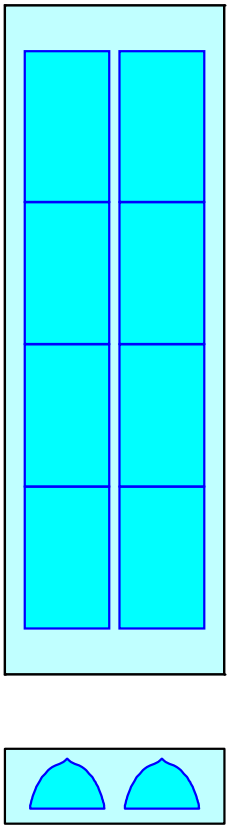
4 Chambers/Row x 7.12' Long +0.44' Row Adjustment = 28.92' Row Length +27.5" End Stone x 2 = 33.50' Base Length
2 Rows x 51.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.00' Base Width
9.0" Base + 30.0" Chamber Height + 6.0" Cover = 3.75' Field Height

8 Chambers x 45.9 cf +0.44' Row Adjustment x 6.45 sf x 2 Rows = 373.2 cf Chamber Storage

1,382.0 cf Field - 373.2 cf Chambers = 1,008.8 cf Stone x 40.0% Voids = 403.5 cf Stone Storage

Stone + Chamber Storage = 776.7 cf = 0.018 af
Overall Storage Efficiency = 56.2%

8 Chambers
51.2 cy Field
37.4 cy Stone



Hydrograph for Pond R: Recharge System

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)
0.00	0.00	0	11.00	0.00	0.00	0.00
2.00	0.01	12	11.05	0.00	**0.00**	0.00
4.00	0.02	61	11.23	0.00	**0.00**	0.00
6.00	0.02	161	11.61	0.00	0.00	0.00
8.00	0.04	337	12.04	0.00	0.00	0.00
10.00	0.07	694	12.79	0.00	0.00	0.00
12.00	**1.04**	**976**	**13.45**	**0.94**	0.00	**0.94**
14.00	**0.08**	**926**	**13.33**	**0.08**	0.00	**0.07**
16.00	0.04	920	13.31	0.04	0.00	0.04
18.00	0.03	918	13.31	0.03	0.00	0.02
20.00	0.02	917	13.31	0.02	0.00	0.02
22.00	0.02	917	13.30	0.02	0.00	0.01
24.00	0.01	916	13.30	0.01	0.00	0.01
26.00	0.00	884	13.23	0.00	0.00	0.00
28.00	0.00	851	13.15	0.00	0.00	0.00
30.00	0.00	818	13.07	0.00	0.00	0.00
32.00	0.00	786	13.00	0.00	0.00	0.00
34.00	0.00	753	12.92	0.00	0.00	0.00
36.00	0.00	720	12.85	0.00	0.00	0.00
38.00	0.00	687	12.78	0.00	0.00	0.00
40.00	0.00	654	12.71	0.00	0.00	0.00
42.00	0.00	621	12.63	0.00	0.00	0.00
44.00	0.00	588	12.56	0.00	0.00	0.00
46.00	0.00	555	12.49	0.00	0.00	0.00
48.00	0.00	522	12.42	0.00	0.00	0.00
50.00	0.00	489	12.35	0.00	0.00	0.00
52.00	0.00	456	12.28	0.00	0.00	0.00
54.00	0.00	423	12.21	0.00	0.00	0.00
56.00	0.00	390	12.15	0.00	0.00	0.00
58.00	0.00	357	12.08	0.00	0.00	0.00
60.00	0.00	324	12.01	0.00	0.00	0.00
62.00	0.00	291	11.94	0.00	0.00	0.00
64.00	0.00	259	11.87	0.00	0.00	0.00
66.00	0.00	226	11.81	0.00	0.00	0.00
68.00	0.00	193	11.73	0.00	0.00	0.00
70.00	0.00	160	11.61	0.00	0.00	0.00
72.00	0.00	127	11.48	0.00	0.00	0.00

Stage-Discharge for Pond R: Recharge System

Elevation (feet)	Discharge (cfs)	Discarded (cfs)	Primary (cfs)
11.00	0.00	**0.00**	0.00
11.10	0.00	**0.00**	0.00
11.20	0.00	0.00	0.00
11.30	0.00	0.00	0.00
11.40	0.00	0.00	0.00
11.50	0.00	0.00	0.00
11.60	0.00	0.00	0.00
11.70	0.00	0.00	0.00
11.80	0.00	0.00	0.00
11.90	0.00	0.00	0.00
12.00	0.00	0.00	0.00
12.10	0.00	0.00	0.00
12.20	0.00	0.00	0.00
12.30	0.00	0.00	0.00
12.40	0.00	0.00	0.00
12.50	0.00	0.00	0.00
12.60	0.00	0.00	0.00
12.70	0.00	0.00	0.00
12.80	0.00	0.00	0.00
12.90	0.00	0.00	0.00
13.00	0.00	0.00	0.00
13.10	0.00	0.00	0.00
13.20	0.00	0.00	0.00
13.30	0.00	0.00	0.00
13.40	0.52	0.00	0.51
13.50	1.46	0.00	1.45
13.60	2.66	0.00	2.65
13.70	4.07	0.00	4.07
13.80	5.67	0.00	5.66
13.90	7.42	0.00	7.42
14.00	9.31	0.00	9.31
14.10	11.33	0.00	11.32
14.20	13.46	0.00	13.46
14.30	15.70	0.00	15.70
14.40	18.04	0.00	18.03
14.50	20.47	0.00	20.46
14.60	22.98	0.00	22.97
14.70	25.57	0.00	25.57
14.80	28.24	0.00	28.23
14.90	30.98	0.00	30.97
15.00	33.78	0.00	33.78
15.10	36.65	0.00	36.64
15.20	39.57	0.00	39.57
15.30	42.55	0.00	42.55
15.40	45.58	0.00	45.58
15.50	48.66	0.00	48.66
15.60	51.79	0.00	51.78
15.70	54.96	0.00	54.95
15.80	58.17	0.00	58.17
15.90	61.42	0.00	61.42
16.00	64.71	0.00	64.70
16.10	68.03	0.00	68.02
16.20	71.38	0.00	71.38
16.30	74.77	0.00	74.76
16.40	**78.18**	0.00	**78.17**

Stage-Area-Storage for Pond R: Recharge System

Elevation (feet)	Horizontal (sq-ft)	Storage (cubic-feet)
11.00	**659**	0
11.10	659	26
11.20	659	53
11.30	659	79
11.40	659	105
11.50	659	132
11.60	659	158
11.70	659	184
11.80	659	222
11.90	659	271
12.00	659	320
12.10	659	368
12.20	659	416
12.30	659	464
12.40	659	511
12.50	659	558
12.60	659	605
12.70	659	651
12.80	659	697
12.90	659	742
13.00	659	786
13.10	659	830
13.20	659	873
13.30	659	915
13.40	659	956
13.50	659	997
13.60	659	1,036
13.70	659	1,074
13.80	659	1,111
13.90	659	1,146
14.00	659	1,178
14.10	659	1,208
14.20	659	1,236
14.30	659	1,262
14.40	659	1,289
14.50	659	1,315
14.60	659	1,341
14.70	659	**1,368**
14.80	659	**1,381**
14.90	659	1,381
15.00	659	1,381
15.10	659	1,381
15.20	659	1,381
15.30	659	1,381
15.40	659	1,381
15.50	659	1,381
15.60	659	1,381
15.70	659	1,381
15.80	659	1,381
15.90	659	1,381
16.00	659	1,381
16.10	659	1,381
16.20	659	1,381
16.30	659	1,381
16.40	659	1,381

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment PWA-11S: PWA-11 Sleeper Runoff Area=323 sf 19.81% Impervious Runoff Depth=5.90"
Tc=5.0 min CN=76 Runoff=0.05 cfs 159 cf

Subcatchment PWA-12FP: PWA-12 Farns Runoff Area=1,400 sf 100.00% Impervious Runoff Depth=8.57"
Tc=5.0 min CN=98 Runoff=0.29 cfs 1,000 cf

Subcatchment PWA-12FR: PWA-12 Farns Runoff Area=10,700 sf 100.00% Impervious Runoff Depth=8.57"
Tc=5.0 min CN=98 Runoff=2.20 cfs 7,641 cf

Subcatchment PWA-WP: PWA-Westerly Runoff Area=270 sf 15.19% Impervious Runoff Depth=6.39"
Tc=5.0 min CN=80 Runoff=0.05 cfs 144 cf

Reach DP-1: Design Point - 1 Inflow=2.56 cfs 7,649 cf
Outflow=2.56 cfs 7,649 cf

Pond R: Recharge System Peak Elev=13.56' Storage=1,021 cf Inflow=2.20 cfs 7,641 cf
Discarded=0.00 cfs 1,168 cf Primary=2.18 cfs 6,347 cf Outflow=2.18 cfs 7,514 cf

Total Runoff Area = 12,693 sf Runoff Volume = 8,944 cf Average Runoff Depth = 8.46"
3.84% Pervious = 488 sf 96.16% Impervious = 12,205 sf

Summary for Subcatchment PWA-11S: PWA-11 Sleeper

Runoff = 0.05 cfs @ 12.07 hrs, Volume= 159 cf, Depth= 5.90"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.81"

	Area (sf)	CN	Description
*	202	68	Permeable Pavers
	57	79	<50% Grass cover, Poor, HSG B
*	64	98	Transformer Pad
	323	76	Weighted Average
	259		80.19% Pervious Area
	64		19.81% Impervious Area

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

Hydrograph for Subcatchment PWA-11S: PWA-11 Sleeper

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.09	0.00	0.00
2.00	0.18	0.00	0.00
3.00	0.27	0.00	0.00
4.00	0.38	0.00	0.00
5.00	0.50	0.00	0.00
6.00	0.63	0.00	0.00
7.00	0.80	0.01	0.00
8.00	1.00	0.04	0.00
9.00	1.28	0.11	0.00
10.00	1.67	0.25	0.00
11.00	2.20	0.52	0.00
12.00	4.40	2.05	**0.03**
13.00	6.61	3.91	**0.00**
14.00	7.14	4.39	0.00
15.00	7.53	4.73	0.00
16.00	7.81	4.98	0.00
17.00	8.01	5.17	0.00
18.00	8.18	5.32	0.00
19.00	8.31	5.44	0.00
20.00	8.43	5.55	0.00
21.00	8.54	5.65	0.00
22.00	8.64	5.74	0.00
23.00	8.73	5.83	0.00
24.00	**8.81**	**5.90**	0.00
25.00	8.81	5.90	0.00
26.00	8.81	5.90	0.00
27.00	8.81	5.90	0.00
28.00	8.81	5.90	0.00
29.00	8.81	5.90	0.00
30.00	8.81	5.90	0.00
31.00	8.81	5.90	0.00
32.00	8.81	5.90	0.00
33.00	8.81	5.90	0.00
34.00	8.81	5.90	0.00
35.00	8.81	5.90	0.00
36.00	8.81	5.90	0.00
37.00	8.81	5.90	0.00
38.00	8.81	5.90	0.00
39.00	8.81	5.90	0.00
40.00	8.81	5.90	0.00
41.00	8.81	5.90	0.00
42.00	8.81	5.90	0.00
43.00	8.81	5.90	0.00
44.00	8.81	5.90	0.00
45.00	8.81	5.90	0.00
46.00	8.81	5.90	0.00
47.00	8.81	5.90	0.00
48.00	8.81	5.90	0.00
49.00	8.81	5.90	0.00
50.00	8.81	5.90	0.00
51.00	8.81	5.90	0.00
52.00	8.81	5.90	0.00
53.00	8.81	5.90	0.00
54.00	8.81	5.90	0.00
55.00	8.81	5.90	0.00
56.00	8.81	5.90	0.00
57.00	8.81	5.90	0.00
58.00	8.81	5.90	0.00
59.00	8.81	5.90	0.00
60.00	8.81	5.90	0.00
61.00	8.81	5.90	0.00
62.00	8.81	5.90	0.00
63.00	8.81	5.90	0.00
64.00	8.81	5.90	0.00
65.00	8.81	5.90	0.00
66.00	8.81	5.90	0.00
67.00	8.81	5.90	0.00
68.00	8.81	5.90	0.00
69.00	8.81	5.90	0.00
70.00	8.81	5.90	0.00
71.00	8.81	5.90	0.00
72.00	8.81	5.90	0.00

Summary for Subcatchment PWA-12FP: PWA-12 Farns Patio

Runoff = 0.29 cfs @ 12.07 hrs, Volume= 1,000 cf, Depth= 8.57"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.81"

	Area (sf)	CN	Description
*	1,400	98	Patio
	1,400		100.00% Impervious Area

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

Hydrograph for Subcatchment PWA-12FP: PWA-12 Farns Patio

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.09	0.01	0.00
2.00	0.18	0.05	0.00
3.00	0.27	0.12	0.00
4.00	0.38	0.21	0.00
5.00	0.50	0.32	0.00
6.00	0.63	0.44	0.00
7.00	0.80	0.60	0.01
8.00	1.00	0.80	0.01
9.00	1.28	1.07	0.01
10.00	1.67	1.44	0.01
11.00	2.20	1.98	0.02
12.00	4.40	4.17	**0.19**
13.00	6.61	6.37	**0.02**
14.00	7.14	6.91	0.01
15.00	7.53	7.29	0.01
16.00	7.81	7.57	0.01
17.00	8.01	7.77	0.01
18.00	8.18	7.94	0.00
19.00	8.31	8.07	0.00
20.00	8.43	8.19	0.00
21.00	8.54	8.30	0.00
22.00	8.64	8.40	0.00
23.00	8.73	8.49	0.00
24.00	**8.81**	**8.57**	0.00
25.00	8.81	8.57	0.00
26.00	8.81	8.57	0.00
27.00	8.81	8.57	0.00
28.00	8.81	8.57	0.00
29.00	8.81	8.57	0.00
30.00	8.81	8.57	0.00
31.00	8.81	8.57	0.00
32.00	8.81	8.57	0.00
33.00	8.81	8.57	0.00
34.00	8.81	8.57	0.00
35.00	8.81	8.57	0.00
36.00	8.81	8.57	0.00
37.00	8.81	8.57	0.00
38.00	8.81	8.57	0.00
39.00	8.81	8.57	0.00
40.00	8.81	8.57	0.00
41.00	8.81	8.57	0.00
42.00	8.81	8.57	0.00
43.00	8.81	8.57	0.00
44.00	8.81	8.57	0.00
45.00	8.81	8.57	0.00
46.00	8.81	8.57	0.00
47.00	8.81	8.57	0.00
48.00	8.81	8.57	0.00
49.00	8.81	8.57	0.00
50.00	8.81	8.57	0.00
51.00	8.81	8.57	0.00
52.00	8.81	8.57	0.00
53.00	8.81	8.57	0.00
54.00	8.81	8.57	0.00
55.00	8.81	8.57	0.00
56.00	8.81	8.57	0.00
57.00	8.81	8.57	0.00
58.00	8.81	8.57	0.00
59.00	8.81	8.57	0.00
60.00	8.81	8.57	0.00
61.00	8.81	8.57	0.00
62.00	8.81	8.57	0.00
63.00	8.81	8.57	0.00
64.00	8.81	8.57	0.00
65.00	8.81	8.57	0.00
66.00	8.81	8.57	0.00
67.00	8.81	8.57	0.00
68.00	8.81	8.57	0.00
69.00	8.81	8.57	0.00
70.00	8.81	8.57	0.00
71.00	8.81	8.57	0.00
72.00	8.81	8.57	0.00

Summary for Subcatchment PWA-12FR: PWA-12 Farns Roof

Runoff = 2.20 cfs @ 12.07 hrs, Volume= 7,641 cf, Depth= 8.57"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.81"

Area (sf)	CN	Description
10,700	98	Roofs, HSG B
10,700		100.00% Impervious Area

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

Hydrograph for Subcatchment PWA-12FR: PWA-12 Farns Roof

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.09	0.01	0.01
2.00	0.18	0.05	0.01
3.00	0.27	0.12	0.02
4.00	0.38	0.21	0.02
5.00	0.50	0.32	0.03
6.00	0.63	0.44	0.03
7.00	0.80	0.60	0.04
8.00	1.00	0.80	0.05
9.00	1.28	1.07	0.08
10.00	1.67	1.44	0.10
11.00	2.20	1.98	0.15
12.00	4.40	4.17	**1.49**
13.00	6.61	6.37	**0.17**
14.00	7.14	6.91	0.11
15.00	7.53	7.29	0.08
16.00	7.81	7.57	0.06
17.00	8.01	7.77	0.05
18.00	8.18	7.94	0.04
19.00	8.31	8.07	0.03
20.00	8.43	8.19	0.03
21.00	8.54	8.30	0.03
22.00	8.64	8.40	0.02
23.00	8.73	8.49	0.02
24.00	**8.81**	**8.57**	0.02
25.00	8.81	8.57	0.00
26.00	8.81	8.57	0.00
27.00	8.81	8.57	0.00
28.00	8.81	8.57	0.00
29.00	8.81	8.57	0.00
30.00	8.81	8.57	0.00
31.00	8.81	8.57	0.00
32.00	8.81	8.57	0.00
33.00	8.81	8.57	0.00
34.00	8.81	8.57	0.00
35.00	8.81	8.57	0.00
36.00	8.81	8.57	0.00
37.00	8.81	8.57	0.00
38.00	8.81	8.57	0.00
39.00	8.81	8.57	0.00
40.00	8.81	8.57	0.00
41.00	8.81	8.57	0.00
42.00	8.81	8.57	0.00
43.00	8.81	8.57	0.00
44.00	8.81	8.57	0.00
45.00	8.81	8.57	0.00
46.00	8.81	8.57	0.00
47.00	8.81	8.57	0.00
48.00	8.81	8.57	0.00
49.00	8.81	8.57	0.00
50.00	8.81	8.57	0.00
51.00	8.81	8.57	0.00
52.00	8.81	8.57	0.00
53.00	8.81	8.57	0.00
54.00	8.81	8.57	0.00
55.00	8.81	8.57	0.00
56.00	8.81	8.57	0.00
57.00	8.81	8.57	0.00
58.00	8.81	8.57	0.00
59.00	8.81	8.57	0.00
60.00	8.81	8.57	0.00
61.00	8.81	8.57	0.00
62.00	8.81	8.57	0.00
63.00	8.81	8.57	0.00
64.00	8.81	8.57	0.00
65.00	8.81	8.57	0.00
66.00	8.81	8.57	0.00
67.00	8.81	8.57	0.00
68.00	8.81	8.57	0.00
69.00	8.81	8.57	0.00
70.00	8.81	8.57	0.00
71.00	8.81	8.57	0.00
72.00	8.81	8.57	0.00

Summary for Subcatchment PWA-WP: PWA-Westerly Passageway

Runoff = 0.05 cfs @ 12.07 hrs, Volume= 144 cf, Depth= 6.39"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-yr Rainfall=8.81"

	Area (sf)	CN	Description
*	156	68	Permeable Pavers
*	41	98	Misc. Mechanical Equipment.
	73	96	Gravel surface, HSG B
	270	80	Weighted Average
	229		84.81% Pervious Area
	41		15.19% Impervious Area

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

Hydrograph for Subcatchment PWA-WP: PWA-Westerly Passageway

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
1.00	0.09	0.00	0.00
2.00	0.18	0.00	0.00
3.00	0.27	0.00	0.00
4.00	0.38	0.00	0.00
5.00	0.50	0.00	0.00
6.00	0.63	0.01	0.00
7.00	0.80	0.03	0.00
8.00	1.00	0.08	0.00
9.00	1.28	0.19	0.00
10.00	1.67	0.37	0.00
11.00	2.20	0.69	0.00
12.00	4.40	2.38	**0.03**
13.00	6.61	4.33	**0.00**
14.00	7.14	4.83	0.00
15.00	7.53	5.18	0.00
16.00	7.81	5.44	0.00
17.00	8.01	5.64	0.00
18.00	8.18	5.79	0.00
19.00	8.31	5.92	0.00
20.00	8.43	6.03	0.00
21.00	8.54	6.13	0.00
22.00	8.64	6.23	0.00
23.00	8.73	6.31	0.00
24.00	**8.81**	**6.39**	0.00
25.00	8.81	6.39	0.00
26.00	8.81	6.39	0.00
27.00	8.81	6.39	0.00
28.00	8.81	6.39	0.00
29.00	8.81	6.39	0.00
30.00	8.81	6.39	0.00
31.00	8.81	6.39	0.00
32.00	8.81	6.39	0.00
33.00	8.81	6.39	0.00
34.00	8.81	6.39	0.00
35.00	8.81	6.39	0.00
36.00	8.81	6.39	0.00
37.00	8.81	6.39	0.00
38.00	8.81	6.39	0.00
39.00	8.81	6.39	0.00
40.00	8.81	6.39	0.00
41.00	8.81	6.39	0.00
42.00	8.81	6.39	0.00
43.00	8.81	6.39	0.00
44.00	8.81	6.39	0.00
45.00	8.81	6.39	0.00
46.00	8.81	6.39	0.00
47.00	8.81	6.39	0.00
48.00	8.81	6.39	0.00
49.00	8.81	6.39	0.00
50.00	8.81	6.39	0.00
51.00	8.81	6.39	0.00
52.00	8.81	6.39	0.00
53.00	8.81	6.39	0.00
54.00	8.81	6.39	0.00
55.00	8.81	6.39	0.00
56.00	8.81	6.39	0.00
57.00	8.81	6.39	0.00
58.00	8.81	6.39	0.00
59.00	8.81	6.39	0.00
60.00	8.81	6.39	0.00
61.00	8.81	6.39	0.00
62.00	8.81	6.39	0.00
63.00	8.81	6.39	0.00
64.00	8.81	6.39	0.00
65.00	8.81	6.39	0.00
66.00	8.81	6.39	0.00
67.00	8.81	6.39	0.00
68.00	8.81	6.39	0.00
69.00	8.81	6.39	0.00
70.00	8.81	6.39	0.00
71.00	8.81	6.39	0.00
72.00	8.81	6.39	0.00

Summary for Reach DP-1: Design Point - 1

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	12,693 sf, 96.16% Impervious,	Inflow Depth =	7.23"	for	100-yr event
Inflow =	2.56 cfs @ 12.08 hrs,	Volume=	7,649 cf		
Outflow =	2.56 cfs @ 12.08 hrs,	Volume=	7,649 cf,	Atten= 0%,	Lag= 0.0 min

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

Hydrograph for Reach DP-1: Design Point - 1

Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)	Time (hours)	Inflow (cfs)	Elevation (feet)	Outflow (cfs)
0.00	0.00		0.00	52.00	0.00		0.00
1.00	0.00		0.00	53.00	0.00		0.00
2.00	0.00		0.00	54.00	0.00		0.00
3.00	0.00		0.00	55.00	0.00		0.00
4.00	0.00		0.00	56.00	0.00		0.00
5.00	0.00		0.00	57.00	0.00		0.00
6.00	0.00		0.00	58.00	0.00		0.00
7.00	0.01		0.01	59.00	0.00		0.00
8.00	0.01		0.01	60.00	0.00		0.00
9.00	0.01		0.01	61.00	0.00		0.00
10.00	0.11		0.11	62.00	0.00		0.00
11.00	0.17		0.17	63.00	0.00		0.00
12.00	**1.62**		**1.62**	64.00	0.00		0.00
13.00	**0.21**		**0.21**	65.00	0.00		0.00
14.00	0.13		0.13	66.00	0.00		0.00
15.00	0.10		0.10	67.00	0.00		0.00
16.00	0.07		0.07	68.00	0.00		0.00
17.00	0.05		0.05	69.00	0.00		0.00
18.00	0.04		0.04	70.00	0.00		0.00
19.00	0.03		0.03	71.00	0.00		0.00
20.00	0.03		0.03	72.00	0.00		0.00
21.00	0.03		0.03				
22.00	0.02		0.02				
23.00	0.02		0.02				
24.00	0.02		0.02				
25.00	0.00		0.00				
26.00	0.00		0.00				
27.00	0.00		0.00				
28.00	0.00		0.00				
29.00	0.00		0.00				
30.00	0.00		0.00				
31.00	0.00		0.00				
32.00	0.00		0.00				
33.00	0.00		0.00				
34.00	0.00		0.00				
35.00	0.00		0.00				
36.00	0.00		0.00				
37.00	0.00		0.00				
38.00	0.00		0.00				
39.00	0.00		0.00				
40.00	0.00		0.00				
41.00	0.00		0.00				
42.00	0.00		0.00				
43.00	0.00		0.00				
44.00	0.00		0.00				
45.00	0.00		0.00				
46.00	0.00		0.00				
47.00	0.00		0.00				
48.00	0.00		0.00				
49.00	0.00		0.00				
50.00	0.00		0.00				
51.00	0.00		0.00				

Summary for Pond R: Recharge System

**Elevations are based on an assumed surface elevation of 100'. Elevations shall be field adjusted to accomodate actual surface elevations.

Inflow Area =	10,700 sf,	100.00% Impervious,	Inflow Depth =	8.57"	for 100-yr event
Inflow =	2.20 cfs @	12.07 hrs,	Volume=	7,641 cf	
Outflow =	2.18 cfs @	12.08 hrs,	Volume=	7,514 cf,	Atten= 1%, Lag= 0.6 min
Discarded =	0.00 cfs @	1.46 hrs,	Volume=	1,168 cf	
Primary =	2.18 cfs @	12.08 hrs,	Volume=	6,347 cf	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 13.56' @ 12.08 hrs Surf.Area= 659 sf Storage= 1,021 cf
Flood Elev= 16.46' Surf.Area= 659 sf Storage= 1,381 cf

Plug-Flow detention time= 278.1 min calculated for 7,513 cf (98% of inflow)
Center-of-Mass det. time= 267.5 min (1,006.6 - 739.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	11.00'	323 cf	**11.00'W x 26.38'L x 3.75'H Field A** 1,088 cf Overall - 281 cf Embedded = 807 cf x 40.0% Voids
#2A	11.75'	281 cf	**StormTech SC-740** x 6 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap Row Length Adjustment= +0.44' x 6.45 sf x 2 rows
#3B	11.00'	404 cf	**11.00'W x 33.50'L x 3.75'H Field B** 1,382 cf Overall - 373 cf Embedded = 1,009 cf x 40.0% Voids
#4B	11.75'	373 cf	**StormTech SC-740** x 8 Inside #3 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap Row Length Adjustment= +0.44' x 6.45 sf x 2 rows
		1,381 cf	Total Available Storage

Storage Group A created with Chamber Wizard
Storage Group B created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	11.00'	**0.300 in/hr Exfiltration over Horizontal area**
#2	Primary	13.30'	**5.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.00 cfs @ 1.46 hrs HW=11.06' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.00 cfs)

Primary OutFlow Max=2.17 cfs @ 12.08 hrs HW=13.56' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 2.17 cfs @ 1.68 fps)

Pond R: Recharge System - Chamber Wizard Field A

Chamber Model = StormTech SC-740
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
Row Length Adjustment= +0.44' x 6.45 sf x 2 rows

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

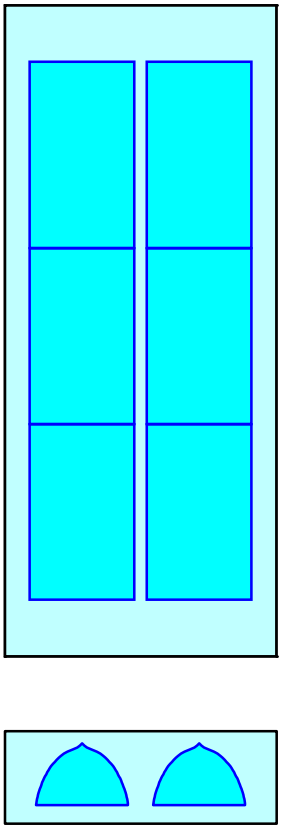
3 Chambers/Row x 7.12' Long +0.44' Row Adjustment = 21.80' Row Length +27.5" End Stone x 2 = 26.38' Base Length
2 Rows x 51.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.00' Base Width
9.0" Base + 30.0" Chamber Height + 6.0" Cover = 3.75' Field Height

6 Chambers x 45.9 cf +0.44' Row Adjustment x 6.45 sf x 2 Rows = 281.3 cf Chamber Storage

1,088.2 cf Field - 281.3 cf Chambers = 806.9 cf Stone x 40.0% Voids = 322.8 cf Stone Storage

Stone + Chamber Storage = 604.1 cf = 0.014 af
Overall Storage Efficiency = 55.5%

6 Chambers
40.3 cy Field
29.9 cy Stone



Pond R: Recharge System - Chamber Wizard Field B

Chamber Model = StormTech SC-740
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
Row Length Adjustment= +0.44' x 6.45 sf x 2 rows

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

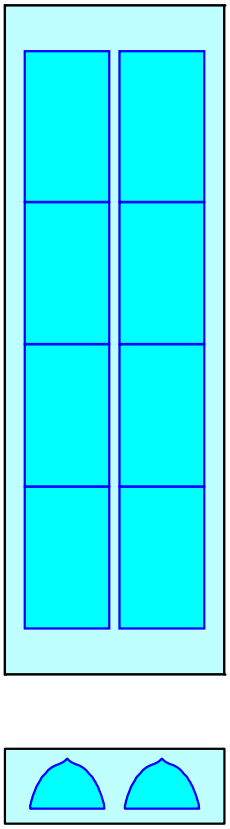
4 Chambers/Row x 7.12' Long +0.44' Row Adjustment = 28.92' Row Length +27.5" End Stone x 2 = 33.50' Base Length
2 Rows x 51.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.00' Base Width
9.0" Base + 30.0" Chamber Height + 6.0" Cover = 3.75' Field Height

8 Chambers x 45.9 cf +0.44' Row Adjustment x 6.45 sf x 2 Rows = 373.2 cf Chamber Storage

1,382.0 cf Field - 373.2 cf Chambers = 1,008.8 cf Stone x 40.0% Voids = 403.5 cf Stone Storage

Stone + Chamber Storage = 776.7 cf = 0.018 af
Overall Storage Efficiency = 56.2%

8 Chambers
51.2 cy Field
37.4 cy Stone



Hydrograph for Pond R: Recharge System

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)
0.00	0.00	0	11.00	0.00	**0.00**	0.00
2.00	0.01	29	11.11	0.00	**0.00**	0.00
4.00	0.02	133	11.51	0.00	0.00	0.00
6.00	0.03	304	11.97	0.00	0.00	0.00
8.00	0.05	580	12.55	0.00	0.00	0.00
10.00	0.10	929	13.33	0.10	0.00	0.10
12.00	**1.49**	**993**	**13.49**	**1.36**	0.00	**1.36**
14.00	**0.11**	**930**	**13.33**	**0.11**	0.00	**0.11**
16.00	0.06	923	13.32	0.06	0.00	0.06
18.00	0.04	919	13.31	0.04	0.00	0.03
20.00	0.03	918	13.31	0.03	0.00	0.02
22.00	0.02	918	13.31	0.02	0.00	0.02
24.00	0.02	917	13.30	0.02	0.00	0.01
26.00	0.00	885	13.23	0.00	0.00	0.00
28.00	0.00	852	13.15	0.00	0.00	0.00
30.00	0.00	819	13.07	0.00	0.00	0.00
32.00	0.00	786	13.00	0.00	0.00	0.00
34.00	0.00	753	12.93	0.00	0.00	0.00
36.00	0.00	720	12.85	0.00	0.00	0.00
38.00	0.00	687	12.78	0.00	0.00	0.00
40.00	0.00	654	12.71	0.00	0.00	0.00
42.00	0.00	621	12.63	0.00	0.00	0.00
44.00	0.00	588	12.56	0.00	0.00	0.00
46.00	0.00	555	12.49	0.00	0.00	0.00
48.00	0.00	522	12.42	0.00	0.00	0.00
50.00	0.00	489	12.35	0.00	0.00	0.00
52.00	0.00	456	12.28	0.00	0.00	0.00
54.00	0.00	423	12.22	0.00	0.00	0.00
56.00	0.00	391	12.15	0.00	0.00	0.00
58.00	0.00	358	12.08	0.00	0.00	0.00
60.00	0.00	325	12.01	0.00	0.00	0.00
62.00	0.00	292	11.94	0.00	0.00	0.00
64.00	0.00	259	11.87	0.00	0.00	0.00
66.00	0.00	226	11.81	0.00	0.00	0.00
68.00	0.00	193	11.73	0.00	0.00	0.00
70.00	0.00	160	11.61	0.00	0.00	0.00
72.00	0.00	127	11.48	0.00	0.00	0.00

Stage-Discharge for Pond R: Recharge System

Elevation (feet)	Discharge (cfs)	Discarded (cfs)	Primary (cfs)
11.00	0.00	**0.00**	0.00
11.10	0.00	**0.00**	0.00
11.20	0.00	0.00	0.00
11.30	0.00	0.00	0.00
11.40	0.00	0.00	0.00
11.50	0.00	0.00	0.00
11.60	0.00	0.00	0.00
11.70	0.00	0.00	0.00
11.80	0.00	0.00	0.00
11.90	0.00	0.00	0.00
12.00	0.00	0.00	0.00
12.10	0.00	0.00	0.00
12.20	0.00	0.00	0.00
12.30	0.00	0.00	0.00
12.40	0.00	0.00	0.00
12.50	0.00	0.00	0.00
12.60	0.00	0.00	0.00
12.70	0.00	0.00	0.00
12.80	0.00	0.00	0.00
12.90	0.00	0.00	0.00
13.00	0.00	0.00	0.00
13.10	0.00	0.00	0.00
13.20	0.00	0.00	0.00
13.30	0.00	0.00	0.00
13.40	0.52	0.00	0.51
13.50	1.46	0.00	1.45
13.60	2.66	0.00	2.65
13.70	4.07	0.00	4.07
13.80	5.67	0.00	5.66
13.90	7.42	0.00	7.42
14.00	9.31	0.00	9.31
14.10	11.33	0.00	11.32
14.20	13.46	0.00	13.46
14.30	15.70	0.00	15.70
14.40	18.04	0.00	18.03
14.50	20.47	0.00	20.46
14.60	22.98	0.00	22.97
14.70	25.57	0.00	25.57
14.80	28.24	0.00	28.23
14.90	30.98	0.00	30.97
15.00	33.78	0.00	33.78
15.10	36.65	0.00	36.64
15.20	39.57	0.00	39.57
15.30	42.55	0.00	42.55
15.40	45.58	0.00	45.58
15.50	48.66	0.00	48.66
15.60	51.79	0.00	51.78
15.70	54.96	0.00	54.95
15.80	58.17	0.00	58.17
15.90	61.42	0.00	61.42
16.00	64.71	0.00	64.70
16.10	68.03	0.00	68.02
16.20	71.38	0.00	71.38
16.30	74.77	0.00	74.76
16.40	**78.18**	0.00	**78.17**

Stage-Area-Storage for Pond R: Recharge System

Elevation (feet)	Horizontal (sq-ft)	Storage (cubic-feet)
11.00	**659**	0
11.10	659	26
11.20	659	53
11.30	659	79
11.40	659	105
11.50	659	132
11.60	659	158
11.70	659	184
11.80	659	222
11.90	659	271
12.00	659	320
12.10	659	368
12.20	659	416
12.30	659	464
12.40	659	511
12.50	659	558
12.60	659	605
12.70	659	651
12.80	659	697
12.90	659	742
13.00	659	786
13.10	659	830
13.20	659	873
13.30	659	915
13.40	659	956
13.50	659	997
13.60	659	1,036
13.70	659	1,074
13.80	659	1,111
13.90	659	1,146
14.00	659	1,178
14.10	659	1,208
14.20	659	1,236
14.30	659	1,262
14.40	659	1,289
14.50	659	1,315
14.60	659	1,341
14.70	659	**1,368**
14.80	659	**1,381**
14.90	659	1,381
15.00	659	1,381
15.10	659	1,381
15.20	659	1,381
15.30	659	1,381
15.40	659	1,381
15.50	659	1,381
15.60	659	1,381
15.70	659	1,381
15.80	659	1,381
15.90	659	1,381
16.00	659	1,381
16.10	659	1,381
16.20	659	1,381
16.30	659	1,381
16.40	659	1,381

Appendix E
Recharge Calculations

SHEET NO. 1 of 1

PROJECT NO. 210659

DATE 22 November 2021

BY EBT

CHECKED BY CAC

CLIENT Perkins & Will

SUBJECT Recharge System – 12 Farnsworth Street, Boston, MA

Required Recharge Volume[1] (R_v)		
Target Depth Factor[2]	1.0	in.
Impervious Area[3]	10,700	SF
$R_{vRequired}$	***892***	CF
Check Chamber Design Drawdown		
$R_{vProvided}$[4]	915	CF
$R_{vRequired}$	892	CF
k[5]	0.3	in./hr.
Bottom Area Provided	660	SF
Maximum Drawdown Allowed	72	hr.
$Time_{drawdown}$[6]	***55***	hr.

[1] Calculation performed in accordance with Volume 3 Chapter 1 of the Massachusetts Stormwater Handbook and Standards for the "Static" method. (*Rv = Target Depth Factor x Impervious Area*)

[2] Total Depth Factor is equal to 1.0 inch of rainfall over the roof area per BWSC requirements for buildings under 100,000 SF.

[3] Roof area is based upon the existing conditions survey provided by Feldman Geospatial dated 17 October 2021.

[4] See HydroCad Stage-Area-Storage Table attached to this calculation.

[5] In-situ permeability (k) provided by Haley and Aldrich based upon a falling head permeability test on 5 November 2021. The infiltration rate for the soil classification based upon Rawls is 0.52 in./hr; the calculations consider the more restrictive rate.

[6] Total drawdown time calculated per Volume 3 Chapter 1 of the Massachusetts Stormwater Handbook and Standards, Step 5 for "Static" method for calculating recharge requirements (Standard 3). ($Time_{drawdown} = Rv / (k \times Bottom\ Area)$)

Stage-Area-Storage for Pond R: Recharge System

Elevation (feet)	Horizontal (sq-ft)	Storage (cubic-feet)
11.00	**659**	0
11.10	659	26
11.20	659	53
11.30	659	79
11.40	659	105
11.50	659	132
11.60	659	158
11.70	659	184
11.80	659	222
11.90	659	271
12.00	659	320
12.10	659	368
12.20	659	416
12.30	659	464
12.40	659	511
12.50	659	558
12.60	659	605
12.70	659	651
12.80	659	697
12.90	659	742
13.00	659	786
13.10	659	830
13.20	659	873
13.30	659	915
13.40	659	956
13.50	659	997
13.60	659	1,036
13.70	659	1,074
13.80	659	1,111
13.90	659	1,146
14.00	659	1,178
14.10	659	1,208
14.20	659	1,236
14.30	659	1,262
14.40	659	1,289
14.50	659	1,315
14.60	659	1,341
14.70	659	**1,368**
14.80	659	**1,381**
14.90	659	1,381
15.00	659	1,381
15.10	659	1,381
15.20	659	1,381
15.30	659	1,381
15.40	659	1,381
15.50	659	1,381
15.60	659	1,381
15.70	659	1,381
15.80	659	1,381
15.90	659	1,381
16.00	659	1,381
16.10	659	1,381
16.20	659	1,381
16.30	659	1,381
16.40	659	1,381

SHEET NO. 1 of 1

PROJECT NO. 210659

DATE 03 February 2022

CLIENT Perkins & Will

BY EBT

SUBJECT Permeable Pavers – 12 Farnsworth Street, Boston, MA

CHECKED BY RJA

Required Recharge Volume[1] (R_v)		
Target Depth Factor[2]	1.0	in.
Impervious Area[3]	422	SF
$R_{vRequired}$	***35***	CF
Check Chamber Design Drawdown		
$R_{vProvided}$[4]	143	CF
$R_{vRequired}$	35	CF
k[5]	0.3	in./hr.
Bottom Area Provided[7]	358	SF
Maximum Drawdown Allowed	72	hr.
$Time_{drawdown}$[6]	***16***	hr.

[1] Calculation performed in accordance with Volume 3 Chapter 1 of the Massachusetts Stormwater Handbook and Standards for the "Static" method. (*Rv = Target Depth Factor x Impervious Area*)

[2] Total Depth Factor is equal to 1.0 inch of rainfall over the roof area per BWSC requirements for buildings under 100,000 SF.

[3] Roof area is based upon the existing conditions survey provided by Feldman Geospatial dated 17 October 2021.

[4] Provided volume is calculated by multiplying the bottom area provided by a 12" thick stone subbase storage layer (assuming 40% stone voids).

[5] In-situ permeability (k) provided by Haley and Aldrich based upon a falling head permeability test on 5 November 2021. The infiltration rate for the soil classification based upon Rawls is 0.52 in./hr; the calculations consider the more restrictive rate.

[6] Total drawdown time calculated per Volume 3 Chapter 1 of the Massachusetts Stormwater Handbook and Standards, Step 5 for "Static" method for calculating recharge requirements (Standard 3). ($Time_{drawdown} = Rv / (k \times Bottom\ Area)$)

[7] Bottom area provided does not include the area beneath the proposed 8'x8' transformer pad.

Appendix F

Operation and Maintenance Plan & Long-Term Pollution Prevention Plan

Operations and Maintenance Plan
& Long-Term Pollution Prevention Plan
Phase 3 Real Estate Partners
12 Farnsworth Street
Boston, MA

16 February 2022

Table of Contents

	Table of Contents	i
1.	INTRODUCTION	1
	1.1 Responsibility	1
	1.2 Documentation	2
2.	MAINTENANCE PROGRAM	3
	2.1 Inspection and Maintenance Frequency and Corrective Measures	3
	2.1.1 ADS Sub-Slab Recharge System	3
	2.1.2 Permeable Pavers	3
	2.1.3 Storm Drain Piping	4
3.	STORM MANAGEMENT SYSTEM ACCESS	4
4.	LONG-TERM POLLUTION PREVENTION PLAN	5
	4.1 Good Housekeeping Practices	5
	4.1.1 Spill Prevention and Response Plans	5
	4.1.2 Solid Waste Management	5
	4.1.3 Snow Storage, Disposal, and Plowing:	6
5.	OPERATION AND MAINTENANCE BUDGET	7
6.	SIGNATURE PAGE	8

List of Appendices

Appendix A Sample Operation and Maintenance Log

Appendix B Sample Inspection Forms

Appendix C ADS Recharge System Maintenance

Appendix D Permeable Paver Maintenance

1. INTRODUCTION

The Stormwater Management Systems Operations and Maintenance (O&M) Plan shall be implemented at the project site located at 12 Farnsworth Street, Boston Massachusetts to maintain the performance of that the stormwater management system. Phase 3 Real Estate Partners (P3RE) possesses the primary responsibility for overseeing and executing the O&M plan and assigning personnel who will be responsible for the proper operation and maintenance of the stormwater management system.

1.1 Responsibility

The purpose of the stormwater management O&M Plan is to require inspection of the system, removal of accumulated sediments, oils, and debris, and implementation of corrective action and record keeping activities. The below O&M activities will be performed by a professional engineer or other technical professional engaged by P3RE, with expertise and experience with stormwater management facilities operation and maintenance.

The ongoing responsibility is the Owner, its successors, and assigns. Adequate maintenance is defined in this document as good working condition. The Authority is responsible to develop and maintain an operation and maintenance budget suitable to implement the O&M plan described herein.

Contact information is provided below:

Owner:	BP3_BOS7 12 Farnsworth LLC
Contact:	W. Neil Fox, III
Address:	c/o Phase 3 Real Estate Partners III, Inc. P.O. Box 927729
City, State:	San Diego, CA 92192
Telephone:	858-545-0888

1.2 Documentation

An Operation and Maintenance Log and Schedule will be kept on the premises and maintained by the Owner or Property Manager summarizing inspections, maintenance, repairs, and any corrective actions taken. The log will include the date on which each inspection or maintenance task was performed, a description of the inspection findings or maintenance completed, and the name of the inspector or maintenance personnel performing the task. If a maintenance task requires the clean-out of any sediments or debris, the location where the sediment and debris was disposed after removal will be indicated.

2. MAINTENANCE PROGRAM

P3RE will be responsible for the implementation of the O&M Plan set forth in this document. The responsible party will ensure that inspections and record keeping are timely and accurate and that cleaning and maintenance are performed in accordance with the recommended frequency for each stormwater component. P3RE will also be responsible for the maintenance of all drainage components to continue their function as designed. The Operation and Maintenance Log shall include the date and the amount of the last significant storm event in excess of one 1 in. of rain in a 24 hr. period, physical conditions of the structures, depth of sediment in structures, evidence of overtopping or debris blockage, and maintenance required of each structure. A blank sample Operation and Maintenance Log and Inspection Forms for tracking and maintenance of key components of the stormwater management system are attached for reference.

2.1 Inspection and Maintenance Frequency and Corrective Measures

The following areas, facilities, and measures will be inspected by P3RE and maintained as specified below. Identified deficiencies will be corrected. Accumulated sediments and debris will be properly handled and disposed of offsite, in accordance with local, state, and federal guidelines and regulations.

2.1.1 ADS Sub-Slab Recharge System

The ADS Recharge System will be inspected annually and cleaned as necessary after major rain events. The ADS Recharge System will be inspected and maintained in accordance with the manufacturer's recommendations. Refer to Appendix C for Technical Notes on the ADS Recharge System maintenances. Sediments will be properly handled and disposed of offsite, in accordance with local, state, and federal guidelines and regulations.

2.1.2 Permeable Pavers

The permeable pavers will be inspected and maintained on an as-needed basis in accordance with the recommendations in the Massachusetts Stormwater Handbook. Refer to Appendix D

for Technical Notes on maintenance of permeable paver systems. Sediments will be properly handled and disposed of offsite, in accordance with local, state, and federal guidelines and regulations.

2.1.3 Storm Drain Piping

The storm drain piping will be inspected annually and cleaned as necessary during inspection of the sub-slab recharge system. Sediments and hydrocarbons will be properly handled and disposed of offsite, in accordance with local, state, and federal guidelines and regulations

3. STORM MANAGEMENT SYSTEM ACCESS

The proposed on-site stormwater management system consists permeable pavers, a sub-slab recharge system and associated diversion structure, and storm drain piping. P3RE, their successors, and assigns authorizes the City of Boston Conservation Commission to enter the premises to inspect the stormwater management system at their discretion.

Regarding access to each drainage features on site, P3RE will accept a condition of approval that allows appropriate City of Boston staff (i.e., City Engineer, or Conservation Commission agent) to enter the site with prior P3RE notification to review any or all parts of the stormwater management system.

4. LONG-TERM POLLUTION PREVENTION PLAN

4.1 Good Housekeeping Practices

Prevent or reduce pollutant runoff from the project development through the use of street sweeping, and erosion and catch basin cleaning.

Provisions for storing materials and waste products inside or under cover: All materials stored on site shall be stored in a neat and orderly fashion in their appropriate containers and under a roof or other secure enclosure. Waste products should be placed in secure receptacles until they are emptied by a licensed solid waste management company in Massachusetts.

4.1.1 Spill Prevention and Response Plans

Prevention: All materials stored on site shall be stored in a neat and orderly fashion in their appropriate containers and under a roof or other secure enclosure. Products will be kept in their original containers with the original manufacturer's label. Products should not be mixed with one another unless recommended by the manufacturer. If possible, all of the product should be used up before disposing of the container. The manufacturer's recommendations for proper use and disposal should be followed.

Response: Manufacturer's recommended methods for cleanup shall be followed. Spills should be cleaned up immediately after discovery. The spill area shall be kept well ventilated and personnel shall wear appropriate protective clothing to prevent injury from contact with a hazardous substance. Spills of toxic or hazardous material shall be reported to the appropriate State and/or local authority in accordance with local and/or State regulations.

4.1.2 Solid Waste Management

Waste products shall be placed in secure receptacles until they are emptied by a licensed solid waste management company in Massachusetts.

4.1.3 Snow Storage, Disposal, and Plowing:

Snow disposal will be in accordance with the Department of Environmental Protection, Bureau of Resource Protection, Snow Disposal Guidelines, effective December 21, 2015. In general, snow will be plowed in accordance with standard operating procedures. During construction, snow will be plowed and stored in designated areas adjacent to the parking lots and roadways.

5. OPERATION AND MAINTENANCE BUDGET

Based on the inspections, maintenance frequencies, and procedures described in Section 2 of this Stormwater Operations and Maintenance Plan and on current industry prices for jet-vac trucks, street sweepers, and trained personnel we estimate that the operation and maintenance costs will be approximately $10,000/year. This estimate may vary due to major storm frequencies, actual site conditions, industry price escalation, and other factors.

6. SIGNATURE PAGE

The Stormwater Management Systems Operations and Maintenance (O&M) Plan shall be implemented at the project site located at 12 Farnsworth Street, Boston, Massachusetts shall be the responsibility of:

Owner:	BP3_BOS7 12 Farnsworth LLC
Contact:	W. Neil Fox, III
Address:	c/o Phase 3 Real Estate Partners III, Inc. P.O. Box 927729
City, State:	San Diego, CA 92192
Telephone:	858-545-0888

Signature: _____ Date: _____

APPENDIX A: SAMPLE OPERATION AND MAINTENANCE LOG

Property Manager / Contract Operator: _____Date: _____

- Routine
- Response to Rainfall Event (__inches)
- Other ____

BMP	Frequency	Structures Inspected	Date Performed	Comments
Recharge System	Annual Inspections			
	Annual Cleaning			
Permeable Pavers	Annual Inspections			
	Annual Cleaning			

APPENDIX B: SAMPLE INSPECTION FORMS

Attached are sample individual stormwater management system inspection forms to be filled out by the Owner, Property Manager, or Contract Operator.

RECHARGE SYSTEM

12 FARNSWORTH STREET, BOSTON, MA 02210

OWNER: _____

PROPERTY MANAGER: _____

INSPECTED BY: _____

DATE OF INSPECTION: _____

RECHARGE SYSTEM INSPECTED: _____

	Acceptable	Needs Work	Notes

DATE OF CLEANING: _____ BY WHOM: _____

DATE OF REPAIR: _____ BY WHOM: _____

NOTE ANY DISCREPANCIES AND SUGGESTED CORRECTIVE ACTIONS:

_____

_____

_____

_____

_____

_____

PERMEABLE PAVERS

12 FARNSWORTH STREET, BOSTON, MA 02210

OWNER: _____

PROPERTY MANAGER: _____

INSPECTED BY: _____

DATE OF INSPECTION: _____

PAVERS INSPECTED: _____

	Acceptable	Needs Work	Notes

DATE OF CLEANING: _____ BY WHOM: _____

DATE OF REPAIR: _____ BY WHOM: _____

NOTE ANY DISCREPANCIES AND SUGGESTED CORRECTIVE ACTIONS:

_____

_____

_____

_____

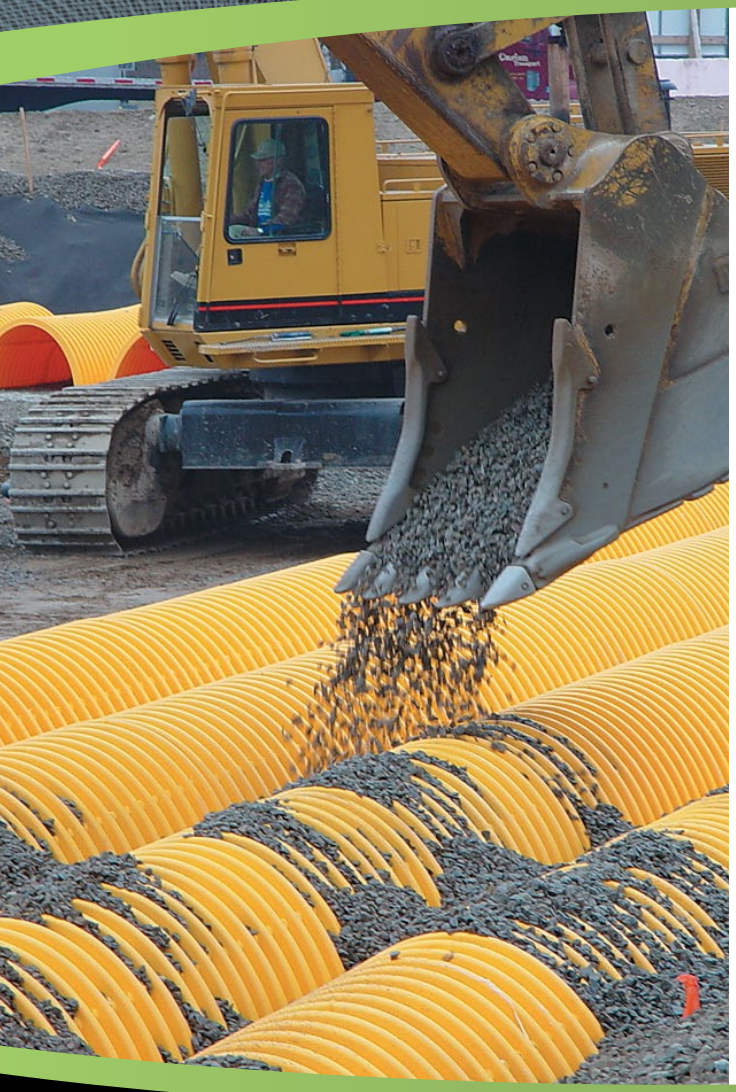
_____

_____

StormTech®

SC-160LP, SC-310, SC-740 & DC-780 Design Manual

StormTech® Chamber Systems for Stormwater Management



*THE MOST **ADVANCED** NAME IN WATER MANAGEMENT SOLUTIONS®*

ADS®

12.0 Inspection and Maintenance

12.1 ISOLATOR ROW INSPECTION

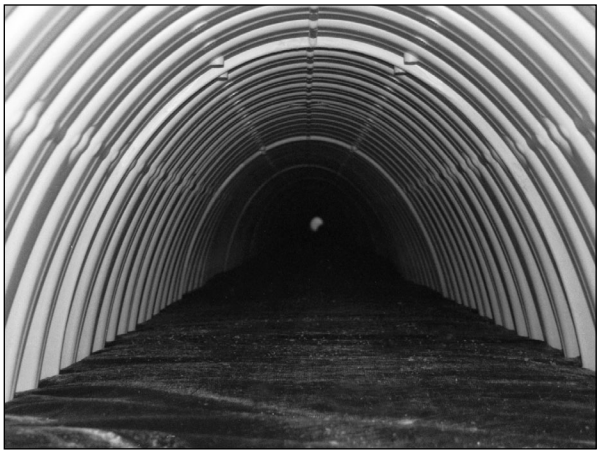
Regular inspection and maintenance are essential to assure a properly functioning stormwater system. Inspection is easily accomplished through the manhole or optional inspection ports of an Isolator Row. Please follow local and OSHA rules for a confined space entry.

Inspection ports can allow inspection to be accomplished completely from the surface without the need for a confined space entry. Inspection ports provide visual access to the system with the use of a flashlight. A stadia rod may be inserted to determine the depth of sediment. If upon visual inspection it is found that sediment has accumulated to an average depth exceeding 3" (76 mm), cleanout is required.

A StormTech Isolator Row should initially be inspected immediately after completion of the site's construction. While every effort should be made to prevent sediment from entering the system during construction, it is during this time that excess amounts of sediments are most likely to enter any stormwater system. Inspection and maintenance, if necessary, should be performed prior to passing responsibility over to the site's owner. Once in normal service, a StormTech Isolator Row should be inspected bi-annually until an understanding of the sites characteristics is developed. The site's maintenance manager can then revise the inspection schedule based on experience or local requirements.

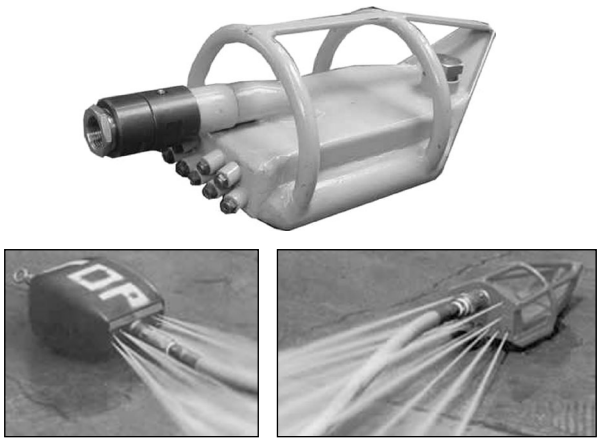
12.2 ISOLATOR ROW MAINTENANCE

JetVac maintenance is recommended if sediment has been collected to an average depth of 3" (76 mm) inside the Isolator Row. More frequent maintenance may be required to maintain minimum flow rates through the Isolator Row. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row while scouring and suspending sediments. As the nozzle is retrieved, a wave of suspended sediments is flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/ JetVac combination vehicles. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45" (1143 mm) are best. The JetVac process shall only be performed on StormTech Rows that have AASHTO class 1 woven geotextile over the foundation stone (ADS 315ST or equal).



Looking down the Isolator Row

A typical JetVac truck (This is not a StormTech product.)



Examples of culvert cleaning nozzles appropriate for Isolator Row maintenance. (These are not StormTech products).

12.0 Inspection & Maintenance

STORMTECH ISOLATOR™ ROW - STEP-BY-STEP MAINTENANCE PROCEDURES

Step 1) Inspect Isolator Row for sediment

A) Inspection ports (if present)

i. Remove lid from floor box frame

ii. Remove cap from inspection riser

iii. Using a flashlight and stadia rod, measure depth of sediment

iv. If sediment is at, or above, 3" (76 mm) depth proceed to Step 2. If not proceed to Step 3.

B) All Isolator Rows

i. Remove cover from manhole at upstream end of Isolator Row

ii. Using a flashlight, inspect down Isolator Row through outlet pipe

1. Follow OSHA regulations for confined space entry if entering manhole
2. Mirrors on poles or cameras may be used to avoid a confined space entry

iii. If sediment is at or above the lower row of sidewall holes [approximately 3" (76 mm)] proceed to Step 2. If not proceed to Step 3.

Step 2) Clean out Isolator Row using the JetVac process

A) A fixed floor cleaning nozzle with rear facing nozzle spread of 45" (1143 mm) or more is preferable

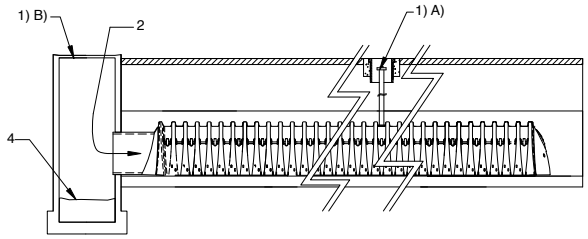
B) Apply multiple passes of JetVac until backflush water is clean

C) Vacuum manhole sump as required during jetting

Step 3) Replace all caps, lids and covers

Step 4) Inspect and clean catch basins and manholes upstream of the StormTech system following local guidelines.

Figure 20 – StormTech Isolator Row (not to scale)



12.3 ECCENTRIC PIPE HEADER INSPECTION

Theses guidelines do not supercede a pipe manufacturer's recommended I&M procedures. Consult with the manufacturer of the pipe header system for specific I&M procedures. Inspection of the header system should be carried out quarterly. On sites which generate higher levels of sediment more frequent inspections may be necessary. Headers may be accessed through risers, access ports or manholes. Measurement of sediment may be taken with a stadia rod or similar device. Cleanout of sediment should occur when the sediment volume has reduced the storage area by 25% or the depth of sediment has reached approximately 25% of the diameter of the structure.

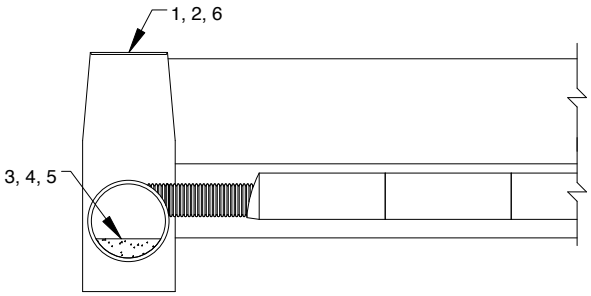
12.4 ECCENTRIC PIPE MANIFOLD MAINTENANCE

Cleanout of accumulated material should be accomplished by vacuum pumping the material from the header. Cleanout should be accomplished during dry weather. Care should be taken to avoid flushing sediments out through the outlet pipes and into the chamber rows.

Eccentric Header Step-by-Step Maintenance Procedures

1. Locate manholes connected to the manifold system
2. Remove grates or covers
3. Using a stadia rod, measure the depth of sediment
4. If sediment is at a depth of about 25% pipe volume or 25% pipe diameter proceed to step 5. If not proceed to step 6.
5. Vacuum pump the sediment. Do not flush sediment out inlet pipes.
6. Replace grates and covers
7. Record depth and date and schedule next inspection

Figure 21 – Eccentric Manifold Maintenance



Please contact StormTech's Technical Services Department at 888-892-2894 for a spreadsheet to estimate cleaning intervals.

Porous Pavement

Description: Porous pavement is a paved surface with a higher than normal percentage of air voids to allow water to pass through it and infiltrate into the subsoil. This porous surface replaces traditional pavement, allowing parking lot, driveway, and roadway runoff to infiltrate directly into the soil and receive water quality treatment. All permeable paving systems consist of a durable, load-bearing, pervious surface overlying a stone bed that stores rainwater before it infiltrates into the underlying soil. Permeable paving techniques include porous asphalt, pervious concrete, paving stones, and manufactured "grass pavers" made of concrete or plastic. Permeable paving may be used for walkways, patios, plazas, driveways, parking stalls, and overflow parking areas.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides peak flow attenuation for small storms.
3 - Recharge	Provides groundwater recharge.
4 - TSS Removal	80% TSS Removal credit if storage bed is sized to hold ½-inch or 1-inch Water Quality Volume, and designed to drain within 72 hours.
5 - Higher Pollutant Loading	Not suitable.
6 - Discharges near or to Critical Areas	Not suitable especially within Zone IIs or Zone A's of public water supplies.
7 - Redevelopment	Suitable.

Advantages/Benefits:

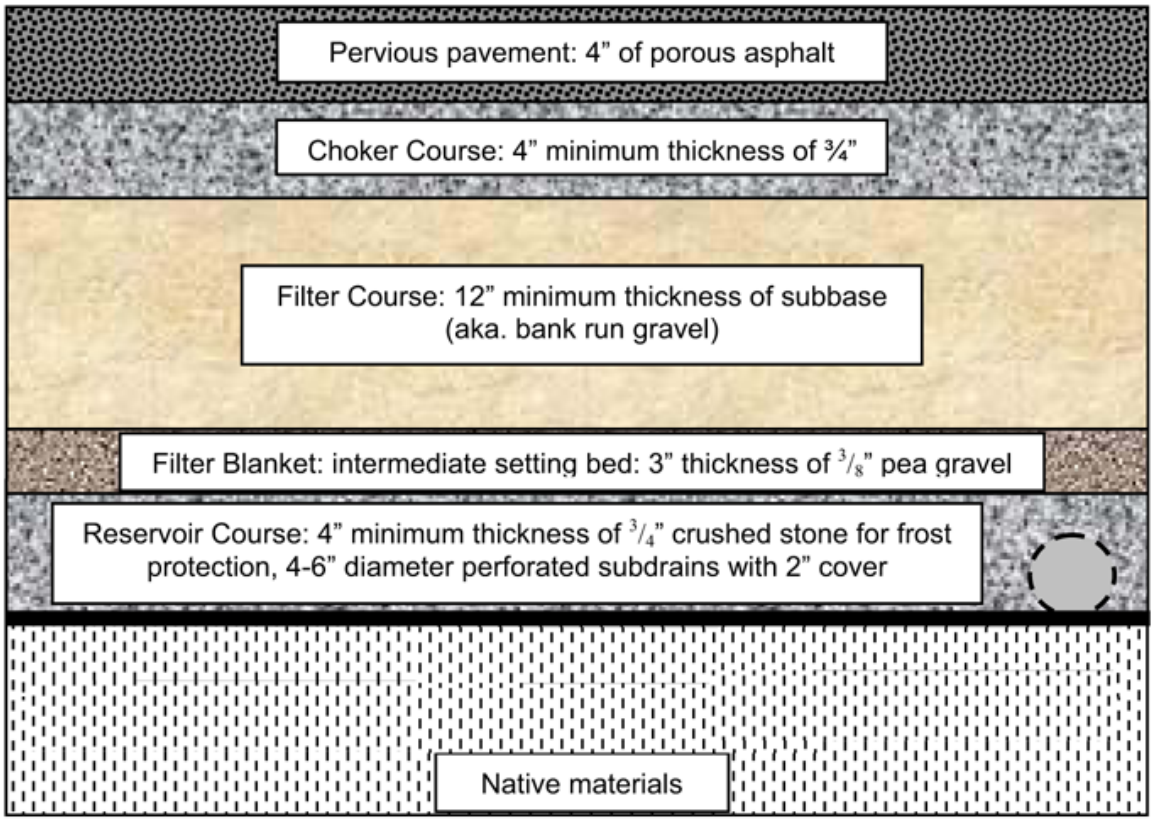
- Reduce stormwater runoff volume from paved surfaces
- Reduce peak discharge rates.
- Increase recharge through infiltration.
- Reduce pollutant transport through direct infiltration.
- Can last for decades in cold climates if properly designed, installed, and maintained
- Improved site landscaping benefits (grass pavers only).
- Can be used as a retrofit when parking lots are replaced.

Disadvantages/Limitations:

- Prone to clogging so aggressive maintenance with jet washing and vacuum street sweepers is required.
- No winter sanding is allowed.
- Winter road salt and deicer runoff concern near drinking water supplies for both porous pavements and impervious pavements.
- Soils need to have a permeability of at least 0.17 inches per hour.
- Special care is needed to avoid compacting underlying parent soils.

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) 80%
- Nutrients (Nitrogen, phosphorus) Insufficient data
- Metals (copper, lead, zinc, cadmium) Insufficient data
- Pathogens (coliform, e coli) Insufficient data



adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Monitor to ensure that the paving surface drains properly after storms	As needed
For porous asphalts and concretes, clean the surface using power washer to dislodge trapped particles and then vacuum sweep the area. For paving stones, add joint material (sand) to replace material that has been transported.	As needed
Inspect the surface annually for deterioration	Annually
Assess exfiltration capability at least once a year. When exfiltration capacity is found to decline, implement measures from the Operation and Maintenance Plan to restore original exfiltration capacity.	As needed, but at least once a year
Reseed grass pavers to fill in bare spots.	As needed

Special Features

Most appropriate for pedestrian-only areas and for low-volume, low-speed areas such as overflow parking areas, residential driveways, alleys, and parking stalls.

Porous Pavement

Applicability

Porous pavement, also known as permeable paving, is appropriate for pedestrian-only areas and for low-volume, low-speed areas such as overflow parking areas, residential driveways, alleys, parking stalls, bikepaths, walkways, and patios. It can be constructed where the underlying soils have a permeability of at least 0.17 inches per hour. Porous paving is an excellent technique for dense urban areas, because it does not require any additional land. Porous pavement can be successfully installed in cold climates as long as the design includes features to reduce frost heaving.

Porous paving is not appropriate for high traffic/ high speed areas, because it has lower load-bearing capacity than conventional pavement. Do not use porous pavement in areas of higher potential pollutant loads, because stormwater cannot be pretreated prior to infiltration. Heavy winter sanding will clog joints and void spaces. On some highways, MassHighway Department uses an Open Graded Friction Course (OGF) that has a permeable top coat but an impermeable base course. MassDEP provides no Water Quality or Recharge Credit for OGC, because it does not provide treatment or recharge. The primary benefit of OGF pavements is reductions in noise and hydroplaning.

Effectiveness

Porous pavement provides groundwater recharge and reduces stormwater runoff volume. Depending on design, paving material, soil type, and rainfall, porous paving can infiltrate as much as 70% to 80% of annual rainfall. To qualify for the Water Quality and Recharge Credits, size the storage layer to hold the Required Water Quality or Required Recharge Volume, whichever is larger, using the Static Method, and design the system to dewater within 72 hours. Porous pavement may reduce peak discharge rates significantly by diverting stormwater into the ground and away from pipe-and-basin stormwater management systems, up to the volume housed in the storage layer. Grass pavers can improve site appearance by providing vegetation where there would otherwise be pavement. Porous paving can increase the effective developable area of a site, because the infiltration provided by permeable paving can significantly reduce the need for large stormwater management structures.

Planning considerations

Porous paving must not receive stormwater from other drainage areas, especially any areas that are not fully stabilized.
Use porous paving only on gentle slopes (less than 5%). Do not use it in high-traffic areas or where it will be subject to heavy axle loads.
Consider the setback requirements when considering porous pavement:

Considerations	Setback Requirements
Slope	Less than 5%
Septic system	
soil absorption system	50 feet
Private well	100 feet
Public well	Outside the Zone 1
Public reservoir	Outside the Zone A
Surface Waters	100 feet
Cellar Foundations	20 feet
Slab Foundations	10 feet
Property Lines	10 feet
Minimum depth	2 feet vertical separation above seasonal high groundwater from bottom of storage layer
Frost Line	Below frost line
Bedrock	As with any stormwater exfiltration system, determine if it is feasible in locations with high bedrock. Presence of bedrock near land surface reduces the ability of soils to exfiltrate to groundwater.

Porous paving reduces the need for other stormwater conveyances and treatment structures, resulting in cost savings.

Permeable paving also reduces the amount of land needed for stormwater management.

Design

There are three major types of permeable paving:

- Porous asphalt and pervious concrete. Although it appears to be the same as traditional asphalt or concrete pavement, it is mixed with a very low content of fine sand, so that it has from 10%-25% void space.

- Paving stones (also known as unit pavers) are impermeable blocks made of brick, stone, or concrete, set on a prepared sand base. The joints between the blocks are filled with sand or stone dust to allow water to percolate to the subsurface. Some concrete paving stones have an open cell design to increase permeability.

- Grass pavers (also known as turf blocks) are a type of open-cell unit paver in which the cells are filled with soil and planted with turf. The pavers, made of concrete or synthetic material, distribute the weight of traffic and prevent compression of the underlying soil.

Each of these products is constructed over a storage bed.

Storage Bed Design
The University of New Hampshire has developed specifications for storage beds used in connection with porous asphalt or pervious concrete. According to UNH, the storage bed should be constructed as indicated in Figure PP 1 with the following components from top to bottom:

- a 4-inch choker course comprised of uniformly graded crushed stone,
- a filter course, at least 12 inches thick, of poorly graded sand or bankrun gravel to provide enhanced filtration and delayed infiltration
- a filter blanket, at least 3 inches thick, of pea stone gravel to prevent material from entering the reservoir course, and
- a reservoir course of uniformly graded crushed stone with a high void content to maximize the storage of infiltrated water and to create a capillary barrier to winter freeze thaw. The bottom of the stone reservoir must be completely flat so that runoff can infiltrate through the entire surface.

The size of the storage bed may have to be increased to accommodate the larger of the Required Water Quality and the Required Recharge Volume.

If paving stones or grass pavers are used, a top course of sand that is one inch thick should be placed above the choker coarse.

Overflow Edge
Some designs incorporate an "overflow edge," which is a trench surrounding the edge of the pavement. The trench connects to the stone reservoir below the surface of the pavement and acts as a backup in case the surface clogs.

Preparation of Porous Asphalt
Care must be taken in batching and placing porous asphalt. Unless batched and installed properly, porous pavement may have a reduced exfiltration ability. At Walden Pond State Reservation, several of the areas paved with porous asphalt did not meet the target exfiltration rate. Cores were taken and it was found that the batches had more sand and/or asphalt than was specified, and those sections had to be removed and repaved.

It is critical to minimize the amount of asphalt binder. Using greater amounts of asphalt binder could lead to a greater likelihood of "binder" or asphalt drawdown and clogging of voids. Sun light heating can liquefy the asphalt. The liquefied asphalt then drains into the voids, clogging them. Such clogging is not remedied by power washing and vacuuming. The topcoat in such instances needs to be scarified and resurfaced. The University of New Hampshire has prepared detailed specifications for preparing and installing pourous asphalt that are intended to prevent asphalt problems.

Additional Design Considerations

- Provide an open-graded subbase with minimum 40% void space.
- Use surface and stone beds to accommodate design traffic loads
- Generally, do not use porous pavement for slopes greater than 5 %.
- Do not place bottom on compacted fill.
- Provide perforated pipe network along bed bottoms for distribution
- Provide a three-foot buffer between the bed bottom and the seasonal high groundwater elevation, and a two-foot buffer for bedrock.

Cold Weather Design Considerations

Porous pavement performs well in cold climates. Porous pavement can reduce meltwater runoff and avoid excessive water on the road during the snowmelt period.

In cold climates, the major concern is the potential for frost heaving. The storage bed specifications prepared by the University of New Hampshire address this concern.

Maintenance

In most porous pavement designs, the pavement itself acts as pretreatment to the stone reservoir below. Consequently, frequent cleaning and maintenance of the pavement surface is critical to prevent clogging. To keep the surface clean, frequent vacuum sweeping along with jet washing of asphalt and concrete pavement is required. No winter sanding shall be conducted on the porous surface.

As discussed, designs that include an "overflow edge" provide a backup in case the surface clogs. If the surface clogs, stormwater will flow over the surface and into the trench, where some infiltration and treatment will occur. For proper maintenance:

- Post signs identifying porous pavement areas.
- Minimize salt use during winter months. If drinking water sources are located nearby (see setbacks), porous pavements may not be allowed.
- No winter sanding is allowed.
- Keep landscaped areas well maintained to prevent soil from being transported onto the pavement.
- Clean the surface using vacuum sweeping machines monthly. For paving stones, periodically add joint material (sand) to replace material that has been transported.
- Regularly monitor the paving surface to make sure it drains properly after storms.
- Never reseal or repave with impermeable materials.
- Inspect the surface annually for deterioration or spalling.
- Periodically reseed grass pavers to fill in bare spots.
- Attach rollers to the bottoms of snowplows to prevent them from catching on the edges of grass pavers and some paving stones.

Adapted from:
MassDEP, Massachusetts Nonpoint Source Pollution Management Manual, 2006.

References

Ferguson, Bruce, K., Porous Pavements, 2005, CRC Press. Taylor and Francis Group, Boca Raton

UNH, 2007, UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds, Revised October 2007, http://www.unh.edu/erg/cstev/pubs_specs_info/unhsc_pa_apec_07_07_final.pdf

Asphalt Pavement for Stormwater Management, http://www.unh.edu/erg/cstev/pubs_specs_info/porous_ashpalt_fact_sheet.pdf

University of New Hampshire Center for Stormwater Technology Evaluation and Verification; this research group tests and evaluates stormwater BMPs on the UNH campus.

- An article about the use of permeable pavers at the Westfarms Mall in Connecticut.
- Case Studies from Uni-Group USA, a block paver manufacturer.
- The Nonpoint Education For Municipal Officials program at the University of Connecticut has been involved in numerous permeable paving pilot projects.
- Permeable paver specifications courtesy of the Low Impact Development Center.
- Porous pavement design and operational criteria from the US Environmental Protection Agency, which also publishes a Low Impact Development Page. Also see this report on a Field Evaluation of Permeable Pavements for Stormwater Management (PDF.)
- New Jersey Stormwater Best Management Practices Manual February 2004.