total proposed impervious area for the project is 2.93 acres, this includes the reduced parking lot areas, new pathways/plazas, and visitor center. The proposed stormwater design aims to reduce pollutant levels to the Merrimack River and reduce impervious ground surface.

The site has been divided into five groundcover classes. All hardscaped and asphalt surfaces have been classified as "impermeable". All building roofs have been classified as "roof". All planted areas have been classified as either "planting, >6% slope" or "planting, <2% slope". The upstream catchment area (shown as CM-1 on Figure 6 in Appendix B) conveyed through DMH-P1 includes "urban runoff area" from the top of the hill on State Street to Market Square. This information was provided by the City and was determined to have a C value of 0.85. Further information, including a figure of the existing upstream contributing area, is provided in the Drainage Analysis Memo in Appendix E of this report.

Groundcover	C Value
Impermeable	0.90
Roof	0.95
Urban Runoff Area	0.85
Planting, >6% slope	0.5
Planting, <2% slope	0.25

See Appendix B, Figure 5 for a map showing the existing and proposed groundcovers. See Appendix B, Figure 6 for a proposed catchment area map.

Through a combination of water quality practices, the majority of runoff generated onsite is treated. The existing 24-30" culvert from Water Street to the river will be replaced with a larger culvert pipe to increase capacity and reduce flooding of Market Square. The existing 30" outfall through the bulkhead will be left in place for this project. This outfall will be replaced from the manhole installed at the end of this project as part of the future bulkhead renovation project. An analysis of the existing 24" to 30" culvert was performed as a part of this project. The analysis and design recommendations to upgrade the existing drainage culvert from Ferry Wharf Way through Market Landing Park is provided in Appendix E of this report. The design methodology and assumptions are stated in the Drainage Analysis Memo provided in Appendix E.

The project will also include installation of new drainage inlets, conveyance pipes, and water quality structures to collect and treat runoff from the park prior to connecting to the existing outfalls. The design has been prepared in accordance with recommendations in the Massachusetts Department of Environmental Protection Stormwater Handbook.

A brief description of the proposed Best Management Practices (BMP's) incorporated into the stormwater management system are as follows:

Deep-Sump Hooded Catch Basins

Catch basins provided throughout the site collect stormwater runoff from the proposed parking areas and are connected to the project's stormwater collection system. The deep-sump provides runoff an opportunity to separate from solids and floatable pollutants prior to discharge and are used as a pretreatment device throughout the project.

Water Quality Units

Structural stormwater treatment devices, proposed as Stormceptor STC450i, CDS1515-3-C Water Quality Inlet and CDS2015-4-C Water Quality Unit are designed to mechanically separate pollutants from stormwater flows through centrifugal force and vortex separation. Units are proposed prior to connecting to the existing stormwater management system. Each unit has been sized in accordance with guidance provided by MassDEP to insure proper sediment removal efficiencies.

The site discharges to the Merrimack River which is a tidal water body and land subject to coastal storm flowage. According to the MassDEP Stormwater Handbook, the requirement to provide calculations for post-development peak discharge rates "may be waived for discharges subject to land subject to coastal storm flowage" as defined in 310 CMR. The emphasis of the design is to provide a drainage system to treat and convey the parking lot runoff to the existing outfalls (i.e. Design Point 1 and Design Point 2 as shown on Figure 6 in Appendix B) as well as reduce the overland flow to the extent practicable. By

reducing the impervious coverage on the site, surface runoff will be decreased and infiltrative capacity of the site is improved. Due to these factors, no subsurface or surface retention or detention of stormwater is necessary.

5.0 Hydraulic Analysis

The proposed storm drain collection system was analyzed to ensure that the pipe capacities proposed can accommodate the 25-year storm event, as well as meeting minimum and maximum flow velocities to the extent practicable. Results of that analysis are provided in Appendix D. Rainfall data for the 25-year design storm event are also provided in Appendix D.

The pipes were designed to provide adequate capacity for the design storm event during open channel flow conditions and to have a minimum full flow velocity of 2 feet per second and a maximum full flow velocity of 16 feet per second.

The drainage system was also analyzed with a tailwater elevation of 6.9′ to represent the estimated 2050 MHHW. The system was analyzed with the proposed 60″ pipe from DMH-P1 to the outfall at the bulkhead and also with the existing 30″ outfall pipe from DMH-P4 to the bulkhead to check the function of the drainage system during this interim condition.

The hydraulic grade line will not exceed the rim elevation at any of the drainage structures with the future 60″ outfall with the exception of CB-102 and CB-P2. CB-102 is below the 2050 sea level MHHW due to the need to meet grades at the adjacent parking area beyond the scope of this project. CB-P2 exceeds rim elevations by approximately .5". Although the rim is exceeded in the 2050 MHHW scenario, the hydraulic grade line is much better than today's existing conditions. During interim conditions with the 30″ outfall, the hydraulic grade line will exceed the rim elevation of some of the structures.

6.0 Regulatory Compliance

As demonstrated below, the Project complies with the ten MassDEP Stormwater Standards for a redevelopment project under the Massachusetts Wetlands Protection Act and the City of Newburyport Stormwater Rules and Regulations. The Massachusetts Stormwater Checklist is provided in Appendix A.

6.1 STANDARD 1: NO NEW UNTREATED DISCHARGES

The Project has been designed to comply with Standard 1. There are no new untreated discharges proposed to the Merrimack River. The proposed stormwater system will treat runoff from the site prior to connecting to the existing stormwater outfalls.

6.2 STANDARD 2: PEAK RATE ATTENUATION

The site discharges to the Merrimack River which is a tidal water body and land subject to coastal storm flowage. According to the MassDEP Stormwater Handbook, the requirement "may be waived for discharges subject to land subject to coastal storm flowage." Therefore, a waiver of this requirement is warranted.

The Project is reducing the amount of impervious area and therefore is not significantly altering the hydrologic conditions of the existing land cover. As a result, the Project is expected to have decreased runoff rates from existing conditions. A plan comparison has been demonstrated in Figure 6, Proposed Catchment Areas. This is included in the report Appendix.

6.3 STANDARD 3: STORMWATER RECHARGE

The Project will result in a reduction in paved and impervious surface area. Therefore, the sites ability to recharge stormwater runoff will be improved through greater surface permeability. Constructing an underground recharge system at this site is not practical due to the proximity to the Merrimack River. As a result, the Project complies with Standard 3. A plan comparison has been demonstrated in Appendix B, Figure 5, Impervious Areas - Existing vs. Proposed.

Existing Impervious Area	Proposed Impervious Area
146,658 sf	127,896 sf

The emphasis of the design was focused on treating stormwater, which has a great environmental benefit at the project riverfront.

6.4 STANDARD 4: WATER QUALITY

Standard 4 of the Massachusetts Stormwater Standards addresses stormwater quality requirements. This standard requires that new stormwater management systems be designed to achieve an 80% Total Suspended Solids (TSS) removal rate prior to discharge. MassDEP has published presumed removal rates for each of the BMP's featured in their design guidelines. The manufacturer (Contech) for the selected water quality units has provided predicted net annual load removal efficiency rates. These rates were used to calculate the TSS removal rates for each treatment train described below. Manufacturer's data and a summary of the estimated TSS removal rates are provided in Appendix D of this report.

Additionally, this standard addresses components of a long-term source control and pollution prevention plan. A long-term pollution prevention plan can be found in Appendix G of this report.

The following treatment trains have been incorporated into the design of the stormwater management system and have been designed to remove 80% of the Total Suspended Solids:

Treatment Train (1): This treatment train consists of deep-sump, hooded catch basins and a proprietary water quality treatment device. The overall TSS removal for this train is 85%.

Treatment Train (2): This treatment train consists of deep-sump, hooded catch basins and a proprietary water quality treatment device. The overall TSS removal for this train is 85%.

Treatment Train (3): This treatment train consists of deep-sump, hooded catch basins and a proprietary water quality treatment device. The overall TSS removal for this train is 85%.

Treatment Train (4): This treatment train consists of deep-sump, hooded catch basins and a proprietary water quality treatment device. The overall TSS removal for this train is 85%.

The project has been designed such that all proposed impervious surfaces, excluding the building rooftops and minimal hardscaped plazas/walkways, pass through one of the previously described treatment trains, which results in the required TSS removal for the project.

6.5 STANDARD 5: LAND USES WITH HIGHER POTENTIAL POLLUTANT LOADS (LUHPPLS)

The development consists of a public park and will not generate more than 1,000 vehicle trips per day. Therefore, it is not considered a land use with higher potential pollutant loads.

6.6 STANDARD 6: CRITICAL AREAS

The proposed development discharges via municipal storm drain to the Merrimack River. The Merrimack River is defined as a shellfish growing area. This is not an Outstanding Water Resource. It is not within the Zone II or Interim Wellhead Protection Area of a public water supply. The treatment train includes BMPs to treat the stormwater prior to discharging to the Merrimack River.

6.7 STANDARD 7: REDEVELOPMENT PROJECTS

The Project is the reconstruction of an existing park and redevelopment of existing parking lots to green space and does not propose additional impervious area and therefore is a redevelopment. The project proposes to utilize existing stormwater management infrastructure within the southern portion of the project, minimal improvements to those systems are proposed. In general, the project has been designed to comply with Standards 2 through 6 to the maximum extent practicable as discussed throughout this Section. Standards 1, 8, 9, and 10 have been fully met.

6.8 STANDARD 8: CONSTRUCTION PERIOD POLLUTION PREVENTION AND EROSION AND SEDIMENTATION CONTROLS

The Project will disturb more than 1 acre of land and therefore an Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Construction General Permit will be obtained before the start of construction.

A draft Stormwater Pollution Prevention Plan (SWPPP) has been prepared to meet the requirements of the MassDEP Stormwater Handbook Standard 8 and EPA NPDES General Construction Permit, and will be finalized by the Contractor prior to construction. See Appendix F for the draft SWPPP.

6.9 STANDARD 9: LONG-TERM OPERATION AND MAINTENANCE PLAN

A Stormwater Operations and Maintenance Plan has been prepared to ensure that the stormwater management system functions as designed. A copy of the O&M Plan is included in Appendix G of this report. The O&M plan indicates the responsible parties for the project, routine and non-routine maintenance tasks and inspection criteria.

6.10 STANDARD 10: PROHIBITION OF ILLICIT DISCHARGES

There are no known existing or proposed illicit discharges to the stormwater management system. The submitted draft SWPPP and Maintenance Plan have been created to prevent any illicit discharges from occurring. See Appendix F for the draft SWPPP and Appendix G for the Operation and Maintenance Plan.

APPENDIX A – MASSDEP STORMWATER CHECKLIST

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.

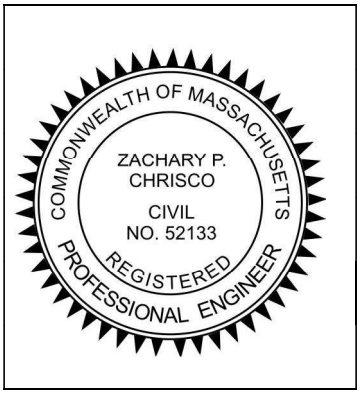
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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



July 15, 2022

Signature and Date

Checklist

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

☐ New development

☒ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

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

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

Standard 1: No New Untreated Discharges

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

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☐ Required Recharge Volume calculation provided.

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

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

☐ Static ☐ Simple Dynamic ☐ Dynamic 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.

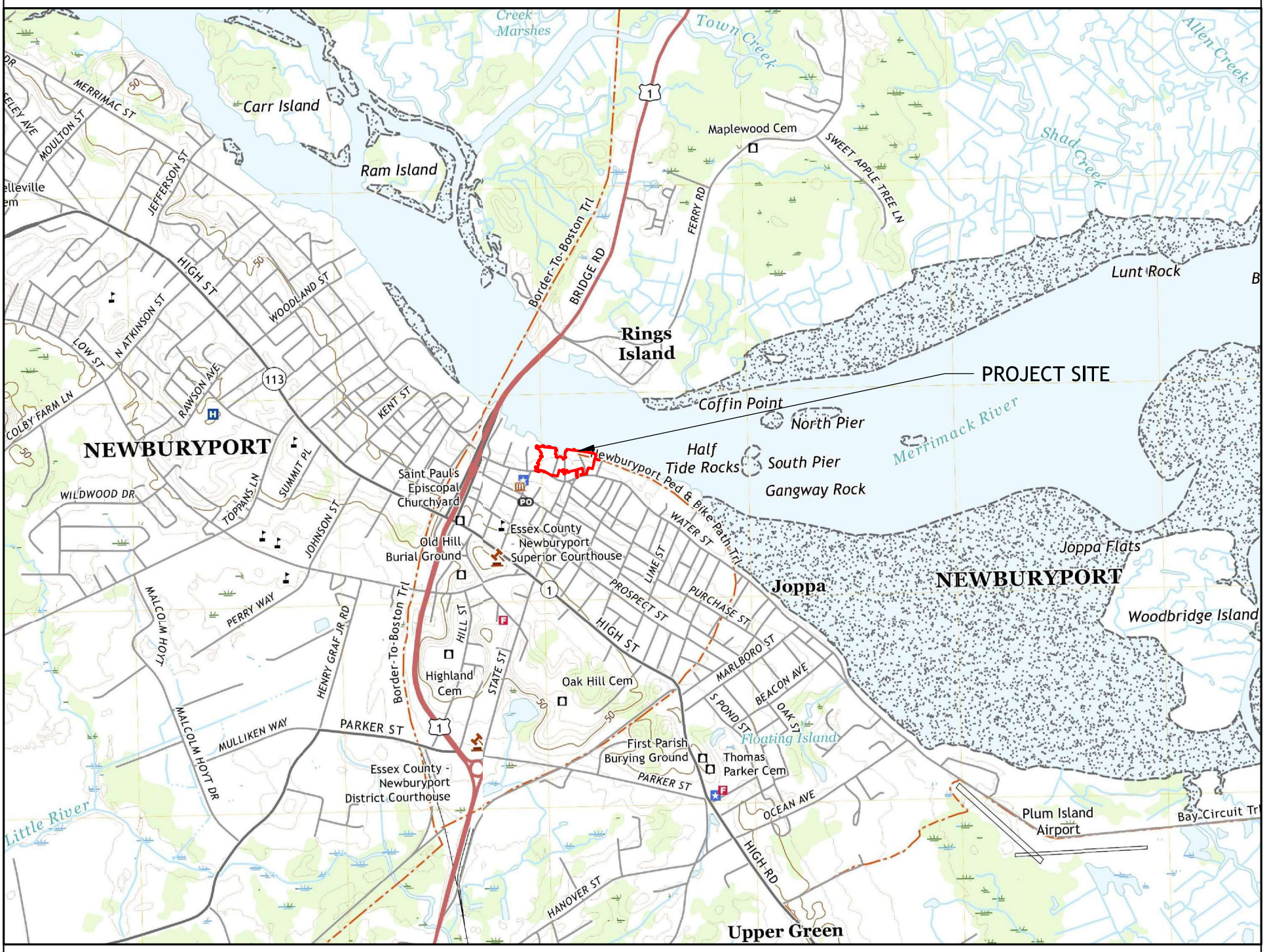
Standard 10: Prohibition of Illicit Discharges

☒ 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 – FIGURES



0 2000 4000 Feet

LEGEND

LIMIT OF WORK

Project Title & Number:

MARKET LANDING PARK EXPANSION
#08314.00

Drawing Title:

USGS SITE MAP

SHEET REF

ISSUE REF

Architects

SASAKI

SCALE 1" = 2000'

DRAWN BY AF

DATE JUNE 15, 2022

REVISION NUMBER

SKETCH NUMBER

FIG 001

LEGEND

LIMIT OF WORK

MassDEP
Massachusetts Department of Environmental Protection

Map Legend

- Community Groundwater Well
- Community Surface Water Intake
- Emergency Surface Water Intake
- Non-Community Groundwater Well
- NHESP Certified Vernal Pool
- NHESP Potential Vernal Pool
- School
- Hospital
- Long Term Care Residence
- Prison
- Pipeline
- Powerline
- Town and State Boundary
- DEP Region Boundary
- 10 Meter Contour Interval
- 3 Meter Contour Interval
- Perennial Stream or Shoreline
- Intermittent Stream
- Intermittent Shoreline
- Manmade Shoreline
- Ditch or Canal
- Aqueduct
- Dam
- Channel in Water
- Surface Water Supply Watershed Boundary
- Public Water Supply Protection Area (Zone A)
- Interim Wellhead Protection Area (IWPA)
- Approved Wellhead Protection Area (Zone II)
- Solid Waste Landfill
- Areas of Critical Environmental Concern
- EPA Designated Sole Source Aquifer
- Protected Open Space
- Non-Potential Drinking Water Source Area: High Yield
- Non-Potential Drinking Water Source Area: Medium Yield
- Potentially Productive High Yield Aquifer
- Potentially Productive Medium Yield Aquifer
- MBTA Blue Line
- MBTA Green Line
- MBTA Orange Line
- MBTA Red Line
- Active Rail Lines
- Major Highway - Limited Access
- Major Road - Not Limited Access
- Local Street or Road
- Open Water
- Public Water Supply Reservoir
- Tidal Flat
- Inundated Area
- Fresh Water Wetland
- Cranberry Bog
- Salt Water Wetland
- NHESP Estimated Habitat of Rare Wildlife

Project Title & Number:

MARKET LANDING PARK EXPANSION
#08314.00

Drawing Title:

PRIORITY RESOURCE MAP

SHEET REF

ISSUE REF

Architects

SASAKI

SCALE: 1" = 500'

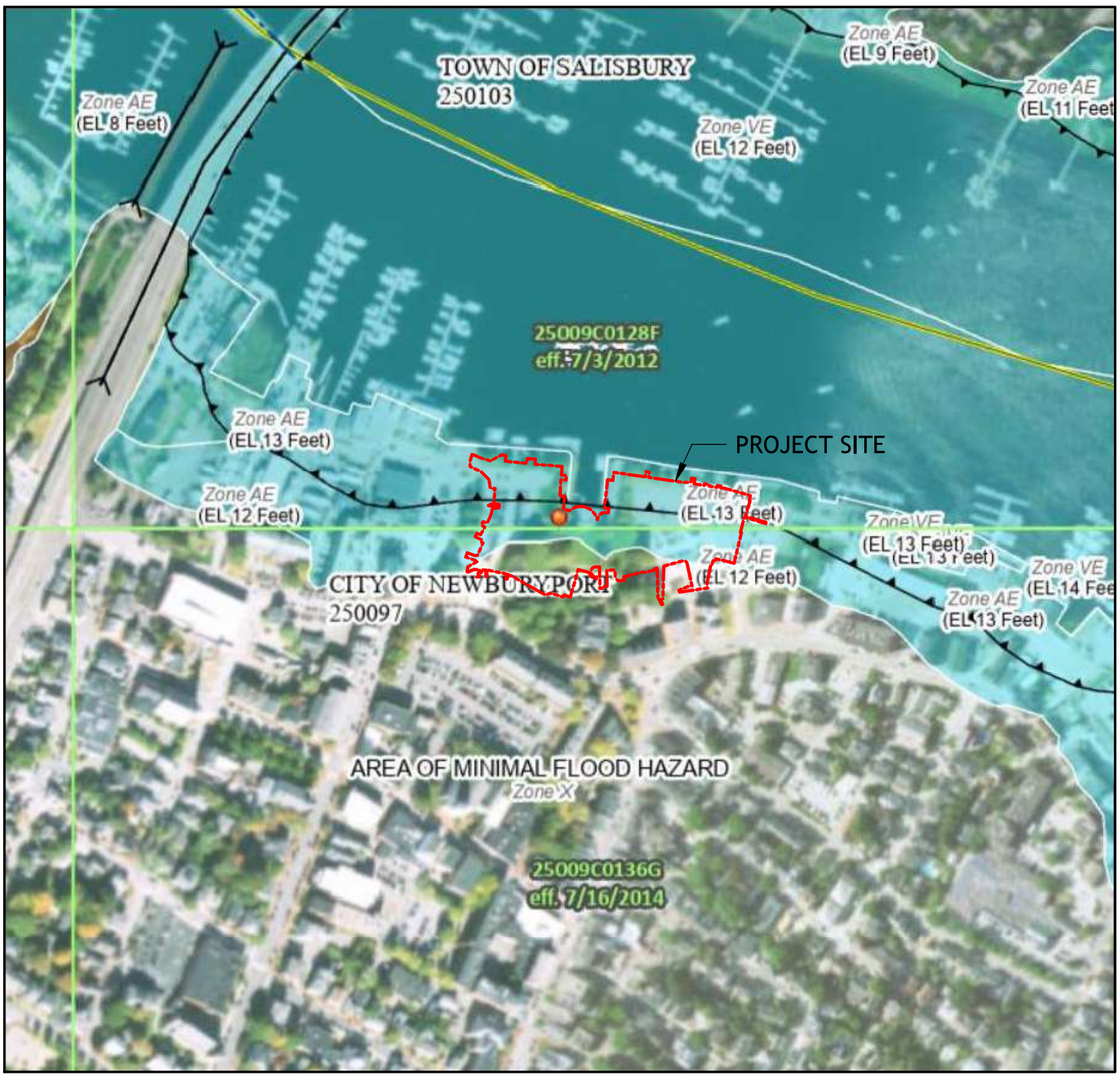
DRAWN BY: AF

DATE: JUNE 15, 2022

REVISION NUMBER

SKETCH NUMBER

FIG 003



0 500 1000 Feet

LEGEND

LIMIT OF WORK

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) Zone A, V, A99
- With BFE or Depth Zone AE, AO, AH, VE, AR
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
- Future Conditions 1% Annual Chance Flood Hazard Zone X
- Area with Reduced Flood Risk due to Levee. See Notes. Zone X
- Area with Flood Risk due to Levee Zone D

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard Zone X
- Effective LOMRs
- Area of Undetermined Flood Hazard Zone D

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

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

Project Title & Number:

MARKET LANDING PARK EXPANSION
#08314.00

Drawing Title:

FEMA FLOOD MAP

SHEET REF

ISSUE REF

SCALE: 1" = 500'

DRAWN BY: AF

DATE: JUNE 15, 2022

REVISION NUMBER

SKETCH NUMBER: FIG 004

Architects

SASAKI

EXISTING CONDITIONS

LEGEND

LIMIT OF WORK

SYMBOLS	DESCRIPTION
	EXISTING PERVIOUS SURFACE (144,308 SF)
	EXISTING IMPERVIOUS SURFACE (146,658 SF)
	PROPOSED PERVIOUS SURFACE (160,070 SF)
	PROPOSED IMPERVIOUS SURFACE (127,896 SF)

PROPOSED CONDITIONS

SASAKI

64 PLEASANT STREET WATERTOWN MA 02472 USA
P 617 926 3900 F 617 924 2748 W SASAKI.COM

Permitting, Survey
VHB
https://www.vhb.com/boston/

Irrigation
Irrigation Consultants
http://www.irrigationconsulting.com

Specifications
Vince Rico Associates
vricola@aol.com

Electrical
RFS
https://www.rfsengineering.com/

Strctural
RSE
https://www.rseassociates.com/

0' 30' 60' 120'

SCALE: 1" = 60'

Project Title:
Market Landing Park Expansion
City of Newburyport
Newburyport, Massachusetts

Drawing Title:
EXISTING VS. PROPOSED IMPERVIOUS AREA

Project No: 08314.00 Scale: 1"= 60'
Drawn By: JV
Checked By: SE
Approved By: ZC
Date: 07/13/2022

Drawing No:
FIG 005

LEGEND

LIMIT OF WORK

SYMBOLS	DESCRIPTION
	CATCHMENT AREA BOUNDARY
CM-21	CATCHMENT AREA LABEL

MERRIMACK RIVER

DESIGN POINT 1

DESIGN POINT 2

CM-24 CM-23 CM-19 CM-22 CM-20 CM-30 CM-26 CM-25 CM-21

CM-15 CM-16 CM-17 CM-18 CM-14 CM-3 CM-10 CM-9 CM-13 CM-12 CM-8 CM-2 CM-5 CM-6 CM-7 CM-4 CM-27 CM-28 CM-1

ROOF LEADER

CENTRAL WHARF WAY

MARKET SQUARE

WATER STREET

NOTES:

1. AREAS DEFINED OUTSIDE THE PROPOSED CATCHMENT AREAS ARE ASSUMED TO BE OVERLAND FLOW OR AREAS NOT CONTRIBUTING TO THE PROPOSED INLETS AND ARE CONVEYED TO EXISTING STORMWATER SYSTEMS. AREAS CONTRIBUTING TO EXISTING STORMWATER SYSTEMS ARE OUTSIDE THE LIMITS OF WORK AND SHALL REMAIN UNAFFECTED BY THE PROJECT.

2. THE UPSTREAM CATCHMENT AREA (CM-1) CONVEYED THROUGH DMH-P1 INCLUDES THE AREA FROM THE TOP OF THE HILL ON STATE STREET TO MARKET SQUARE. THIS INFORMATION WAS PROVIDED BY THE CITY. FURTHER INFORMATION, INCLUDING A FIGURE OF THE EXISTING UPSTREAM CONTRIBUTING AREA, IS PROVIDED IN THE DRAINAGE ANALYSIS MEMO IN APPENDIX E OF THE STORMWATER MANAGEMENT REPORT.

SASAKI

64 PLEASANT STREET WATERTOWN MA 02472 USA
P 617 926 3300 F 617 924 2748 W SASAKI.COM

Permitting, Survey
VHB
https://www.vhb.com/boston/

Irrigation
Irrigation Consultants
http://www.irrigationconsulting.com

Specifications
Vince Rico Associates
vricola@aol.com

Electrical
RFS
https://www.rfsengineering.com/

Strctural
RSE
https://www.rseassociates.com/

0' 20' 40' 80'

SCALE: 1" = 40'

Project Title:

Market Landing Park Expansion
City of Newburyport
Newburyport, Massachusetts

Drawing Title:

PROPOSED CATCHMENT AREAS

Project No: 08314.00 Scale: 1"= 40'
Drawn By: JV
Checked By: SE
Approved By: ZC
Date: 07/13/2022

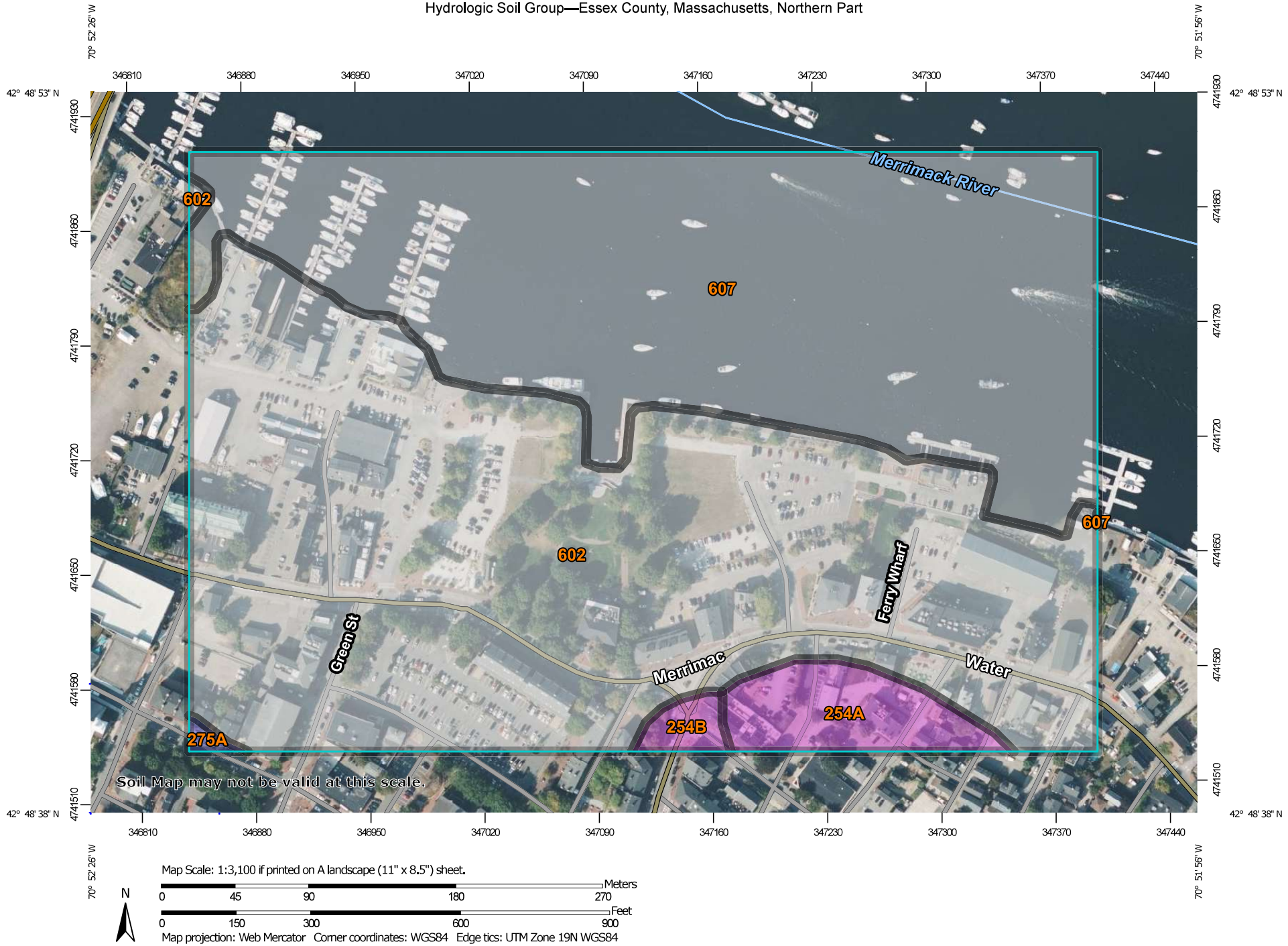
Drawing No: FIG 006

APPENDIX C – GEOTECHNICAL INVESTIGATIONS

NRCS Soils Map

Draft Geotechnical Report by Nobis Group

Hydrologic Soil Group—Essex County, Massachusetts, Northern Part



Map Scale: 1:3,100 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 45 90 180 270

Feet: 0 150 300 600 900

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

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A
A/D
B
B/D
C
C/D
D
Not rated or not available

Soil Rating Lines

A
A/D
B
B/D
C
C/D
D
Not rated or not available

Soil Rating Points

A
A/D
B
B/D
C
C/D
D
Not rated or not available

Water Features

Streams and Canals

Transportation

Rails
Interstate Highways
US Routes
Major Roads
Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

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

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

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

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

Date(s) aerial images were photographed: May 22, 2020—Sep 25, 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.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
254A	Merrimac fine sandy loam, 0 to 3 percent slopes	A	1.8	3.6%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	A	0.4	0.8%
275A	Agawam fine sandy loam, 0 to 3 percent slopes	B	0.1	0.2%
602	Urban land		27.4	54.3%
607	Water, saline		20.8	41.2%
Totals for Area of Interest			**50.6**	**100.0%**

Description

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

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

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

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

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

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

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

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

GEOTECHNICAL ENGINEERING REPORT

MARKET LANDING PARK
NEWBURYPORT, MASSACHUSETTS

Prepared for:

CITY OF NEWBURYPORT, MASSACHUSETTS

JUNE 23, 2022

Prepared by:

nobis

585 Middlesex Street
Lowell, Massachusetts 01851

June 23, 2022
File No. 100396.000

Mr. Andrew R. Port, AICP
Director of Planning & Development
Office of Planning & Development
City of Newburyport
60 Pleasant Street
Newburyport, MA 01950

c/o: Mr. Steve Engler PE, LEED AP
Sasaki

Subject: **Geotechnical Engineering Report - DRAFT**
Market Landing Park - Proposed Visitor Center and Swing Trellis
Newburyport, Massachusetts

Dear Mr. Port,

Nobis Group is pleased to provide this report to the City of Newburyport in support of the Market Landing Park expansion. The purpose of our work, and this report, is to document the data obtained and provide geotechnical recommendations for the design and construction of the proposed visitor center and swing trellis at the park.

We appreciate the opportunity to assist you with this project. If you have any questions, or if we may be of further service to you, please let us know.

Sincerely,
NOBIS GROUP

Alfred Jones, PE
Director, Geotechnical Services

Brien T. Waterman, P.E.
Project Reviewer

Nobis Group®
585 Middlesex Street
Lowell, MA 01851
T (978) 683-0891

TABLE OF CONTENTS
MARKET LANDING PARK
NEWBURYPORT, MASSACHUSETTS

FIGURES

APPENDICES

1. INTRODUCTION

1.1 Scope of Report

Nobis Engineering, Inc., d/b/a Nobis Group® (Nobis) has prepared this report for the Town of Newburyport presenting geotechnical engineering recommendations for the Market Landing Park Expansion located on Merrimac Street in Newburyport, Massachusetts (the Site). Work was performed in general accordance with the RFP originally dated November 9, 2021. All existing features relating to the above-referenced project discussed herein are based on an existing conditions survey plan prepared by VHB on May 26, 2021. Elevations presented in this report are in feet and are relative to the North American Vertical Datum of 1988 (NAVD88).

Photo 1 - View of NEBC preparing to drill NB-3

This report is subject to the limitations contained in **Appendix A**.

1.2 Project and Site Conditions

The Site is located along Merrimac and Water Streets in Newburyport, Massachusetts. The location of the Site is depicted in the Site Locus Plan attached as **Figure 1**. The site, which consists of a park, is generally level with landscaped areas (including a few trees) and gravel parking areas in the eastern and western portions of the site. The site is bounded on the north by the Merrimack River and on the south by Merrimac and Water Streets.

The park is planned for a complete renovation. As part of the renovation, a visitor center will be constructed in the southwest area of the park and a swing trellis is planned for the north center area of the site overlooking the Merrimack River. The proposed visitor center will be approximately 40-foot by 40-foot and will mainly consist of restrooms with a small lobby area. The proposed finish floor elevation of the visitor is expected at 15.33 feet, which is 40 inches above the existing ground surface elevation of 12 feet. The proposed swing trellis will consist of a single row of swings (approximately 160 feet in length) positioned to enjoy the view of the Merrimack River. The swing area will consist of brick pavers accessed via a few stairs. The proposed raise in grade in swing trellis area is up to approximately 2.5 feet.

Based on preliminary loads provided to Sasaki by the RSE (project structural), preliminary service loading for the visitor center building will be approximately 1 kip per lineal foot for the bearing

walls. Depending on how the large canopy is framed, there could be concentrated load at the buildings' corner columns ranging from approximately 17 to 19 kips.

The column loads for the swing trellis are anticipated to be approximately 5 kips with a column base bending moment of approximately 20 kip-feet.

Site utilities include, but are not limited to, underground and over-head electrical and telephone, underground cable, drainage, sewer, water, and gas lines. Existing site conditions and the proposed visitor center and swing trellis locations are depicted in the attached **Figure 2**.

1.3 Site History

Based on our review of existing environmental reports prepared by others, the Site in this report covers two separate lots historically referred to the "East Lot" and "West Lot" located on either side of the city's waterfront park. The West lot is currently used for parking and is covered with a gravel parking surface, concrete curbs and limited landscaping. The East Lot is split into an east and west portion known as Lot 3 in the west and Lot 4 in the east. The Lot 4 of the East lot is currently used for parking and is covered with a partially asphalt, partially gravel parking surface. Lot 3 is a landscaped area and currently open park green space. The East Lot is part of a Disposal Site tracked by the Massachusetts Department of Environmental Protection (MassDEP) under Release Tracking Number (RTN) 3-15445 due to the presence of lead in the soils historically placed as fill materials. The East Lot disposal site is currently listed as having a Class B-2 Response Action Outcome (RAO) with an Activity and Use Limitation (AUL) filed by Western & Sampson in November 2011. The West Lot is not listed as a disposal site with MassDEP. Contaminants of concern at the sites consist of volatile organic compounds, petroleum hydrocarbons and metals.

The site has a long history of industrial and commercial use. A review of Sanborn maps from 1888 to 1961 indicate that the approximate north half of the East Lot nearest the river was owned and occupied by the Philadelphia and Reading Coal and Iron Company until at least 1928. The other half was used for coal, lumber and grain storage and contained several businesses including Globe Soap Company, Eagle Chemical Company, fish markets, beef and furniture warehouses, paint and hardware stores, a carpenter shop, a bowling alley, a barber shop and a grocery store. Railroad tracks were shown on the East Lot in all Sanborn maps during this period along the northern portion of the site. The 1888 to 1924 Sanborn Maps indicate that the West Lot was occupied by a lumber yard with numerous sheds and associated structures. A hotel was depicted on the southern portion of the West Lot near Merrimac Street until the 1928 Sanborn map. On maps from 1946 to 1961, a gasoline filling station was depicted on the southern portion of the west lot. The 1961 map depicts filling stations near the southwest and southeast corner of the current west parking lot and across Merrimac Street, to the south of the West Lot.

Historic Sanborn Maps are provided in **Appendix B.1**. It is not known if remnants of the existing structures, including foundations and slabs, remain buried below grade.

2. SUBSURFACE CONDITIONS

2.1 Historic Geologic Information

Based on the USGS surficial geologic map entitled "Onshore-offshore Surficial Geologic Map of the Newburyport East and Northern Half of Ipswich Quadrangles, Massachusetts" from 2013, the Site is mapped as Artificial Fill over Fluvial Terrace Deposits or Glaciomarine Deltaic and Fan Deposits. The Fluvial Terrace deposits consist of sand and gravel in inset fluvial terrace deposit. The glaciomarine deltaic deposits consist of sorted and stratified gravel, sand, silt, and minor clay deposited by flowing meltwater in glacial deltas and submarine fans during retreat of the last ice sheet. A site-focused plan view of the 2013 USGS surficial geologic map along with the corresponding descriptions of geologic units are provided on **Figure 3**.

A 1983 USGS map entitled "Bedrock Geologic Map of Massachusetts", indicates that bedrock at the Site generally consists of intrusive rocks of granodiorite of the Newburyport Complex. The bedrock is described as gray, medium grained tonalite and granodiorite. A site-focused plan view of this 1983 USGS bedrock map is provided on **Figure 4**.

2.2 Subsurface Explorations by Others

Several previous exploration programs have been performed at the site to evaluate geotechnical and environmental conditions. Two of these programs were conducted near the proposed visitor center and one previous exploration program was performed near the proposed swing trellis.

New England Boring Contractors (formerly New Hampshire Boring) performed a series of borings in both the visitor center and swing trellis locations for GZA in 2013. Borings GZ-7 through GZ-12 were performed at the proposed visitor center and borings GZ-13 through GZ-16 were performed in the general vicinity of the swing trellis.

NE Geotech performed a series of borings in 2017 in the proposed visitor center area for ESS Group. The borings consisted of SB-1 through SB-7B and were advanced to depths ranging from 4 to 15 feet below the ground surface. The borings were prepared as handwritten boring logs.

Test boring at the Site were advanced using standard drive and wash drilling techniques or hollow stem augers to depths of up to about 34.5 feet below ground surface (bgs). Standard Penetration Tests (SPTs) were generally performed at five-foot intervals.

Descriptions of subsurface conditions encountered are presented in the boring logs attached as **Appendix B.2**.

2.2 Subsurface Explorations

New England Boring Contractors (NEBC) of Derry, New Hampshire performed test borings NB-1 through NB-3 on January 26 and 27, 2022. Borings B-1 and B-2 were performed at the proposed visitor center and boring NB-3 was performed at the proposed swing trellis. A change in the proposed location of the visitor center required that additional borings be performed at the site. NEBC remobilized to the site on May 4, 2022 to perform three additional borings (NB-101 through NB-103) over two days.

Test borings were advanced using standard drive and wash drilling techniques to depths ranging from approximately 12.5 to 24.5 feet below ground surface (bgs). Standard Penetration Tests (SPTs) were performed in general accordance with ASTM D1586, with split-barrel samples recovered at generally continuous or semi-continuous intervals through fill and at five-foot intervals thereafter.

Soil from the drilling was stockpiled on a sheet of poly as the borings were advanced. At the completion of each boring, soil was placed back within the borings at the approximate depth it was removed from. Water used during drilling was placed back within the borehole prior to backfilling. Drilling was performed in general accordance with the Activity and Use Limitation (AUL) for the East and West Lots.

The borings were located using taped measurements from existing site features prior to drilling. The ground surface elevation at each boring location was estimated based on the downloaded Topographic Plan. Descriptions of subsurface conditions encountered are presented in the boring logs attached as **Appendix C**.

2.3 Laboratory Testing

Soil samples were selected by Nobis and submitted to GeoTesting Express of Acton, Massachusetts for laboratory testing. Laboratory testing included:

- One (1) test for Bulk Density and Compressive Strength Tests (ASTM D7012 Method C) and Unit Weight Determination and Dimensional and Shape Tolerances of Rock Core Specimens (ASTM D4543); and,
- One (1) suite of corrosivity testing consisting of pH measurement (ASTM D4972), soil resistivity (ASTM G57), Chloride and Sulfate Ions in Water Tests (ASTM D512-12 &

ASTM D516-16) and Oxidation-Reduction (REDOX) Potential Measurement in Clean Water (Standard Methods 23rd Edition Method 2580 B).

Testing was performed to help evaluate soil and rock properties as well as verify visual field classifications. The laboratory test results for the project are attached as **Appendix D.**

2.4 Generalized Subsurface Conditions

The generalized conditions encountered in the borings performed by Nobis consisted of topsoil or fill, underlain by silty and deposits, organic silt deposits, and/ or bedrock. Conditions were inconsistent across the site and not all strata layers were encountered in every boring. Therefore, the lithology indicated in the boring logs is approximate and is based on our review of the soil samples and knowledge of the surficial geology maps. Variations and different interpretations are likely.

Refer to the boring logs observed by Nobis in **Appendix C** for more detailed subsurface conditions. The following paragraphs provide a general description of the various strata that were encountered.

Topsoil

Topsoil was encountered at the ground surface in boring NB-3 and NB-103. The topsoil consisted of dark brown fine to coarse sand, some fine to coarse gravel some silt. Topsoil thickness varied between approximately 4 and 11 inches.

Fill

Fill was encountered from the ground surface in each boring except for NB-3 and NB-103 where it was encountered below the topsoil. The fill consisted of red, brown, gray and/or black fine to coarse sand with varying amounts of gravel and silt and numerous brick fragments. The fill ranged from loose to very dense. Fill was encountered to depths ranging from approximately 4 to 9 feet below ground surface.

Photo 1: Split-spoon sample of silty sand and gravel from NB-1

Organic Silt Deposits

Organic silt and sand was encountered below the fill in boring NB-3 and NB-103 located at the proposed swing trellis area. These soils generally consisted of black-gray organic silt and fine to medium sand with trace fine to coarse gravel. NB-103 generally had a higher sand content than in NB-3 and also based on rig chatter there may have been some cobbles/boulders within this layer in NB-103. The density of this stratum was loose to medium dense. The organic silt was encountered below the fill at a depths ranging from 4 to 9 feet and had a thickness ranging from 5 to 9 feet.

Granular Soils

Glacial till or sand/gravel was encountered below the organic deposits in NB-3 and NB-103 and below the fill in the remaining borings with the exception boring NB-2 where it was not encountered. These soils generally consisted of fine to coarse sand and gravel with varying amounts of silt and cobble and boulders. The density of this stratum was dense to very dense and the thickness ranged from 1.4 to 6.5 feet.

Bedrock

Bedrock was encountered and cored in each the borings. Bedrock was encountered in NB-1, NB-101 and NB-102 below a thin layer (under 2 feet) of silty sand or glacial till; in NB-2 directly beneath the fill; and in NB-3 and NB-103 below a thicker layer of sand/gravel or glacial till. A thin

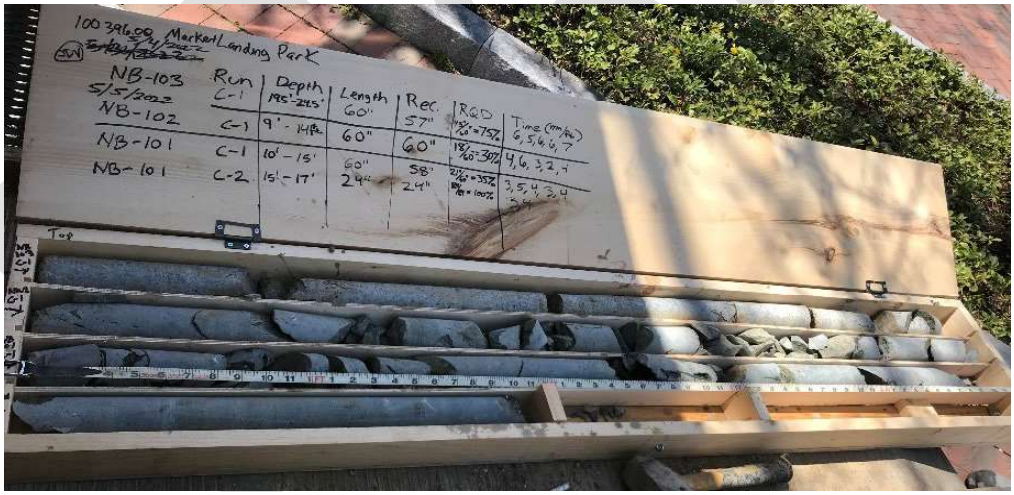


Photo 2: Bedrock cores from NB-101, NB-102 and NB-103.

layer (0.5 to 1 foot) of weathered rock was encountered at the surface of the rock within borings NB-2 and NB-103. The top of competent bedrock was encountered at depths ranging for 6 to 9.8 feet below the ground surface in the area of the visitor center (elevations ranging from +3.2 to +8.5 feet) and at a depth of approximately 19.5 feet at the swing trellis (elevation -9.5 feet). Rock coring lengths ranged from 5 to 7 feet into competent with the exception of boring NB-3 which was only

extended 1 foot into bedrock. The recoveries ranged from 67% to 100%, and the Rock Quality Designation (RQD) ranged from 0 to 100%.

The bedrock consisted of green-gray, hard, moderately weathered, and moderately to extremely fractured, fine to coarse-grained Diorite. The rock jointing ranged from vertical to horizontal. Several horizontal mechanical breaks occurred during the coring process.

Groundwater

Groundwater measurements were attempted at each boring location where encountered. The groundwater ranged from 4.1 to 12.5 feet below the ground surface, corresponding to elevations ranging from approximately El. 10.4 to El. -2.5 feet. The measured water levels likely do not represent stabilized levels and they are likely to fluctuate as a result of insufficient stabilization time, the use of water during the rotary-wash drilling processes, and the low permeability of the soil.

Note that fluctuations in the observed groundwater levels will occur due to variations in precipitation, temperature, and other factors different from those existing at the time the measurements were made.

2.5 Geotechnical Seismic Design Recommendations

We recommend using the following design parameters be used to evaluate the total lateral seismic forces on the proposed structures, as defined by the Massachusetts State Building Code 9th Edition (MSBC), and the 2015 International Building Code (IBC):

- Site Class: C (Section 1613 of the IBC)
- MCE spectral response accelerations: S_S = 0.265g and S_1 = 0.078g (MSBC Table 1604.11)
- Site Coefficients: F_a = 1.2 and F_v = 1.7
- Seismic design parameters: S_{MS} = 0.318 and S_{M1} = 0.132; S_{DS} = 0.212 and S_{D1} = 0.088
- Seismic Design Category: B (Tables 1613.5.6(1) & 1613.5.6(2) of the IBC)

3. GEOTECHNICAL CONSIDERATIONS

The primary geotechnical issues associated with design and construction of the visitor center structure and swing trellis are:

- the presence of unsuitable fill material;
- the contamination of the overburden soils at the site and associated AUL's; and,
- the presence of organic soils in the swing trellis area.

These are issues are discussed below:

- Existing Unsuitable Fill – The site is underlain by existing fill located beneath the surficial topsoil and pavement or from the surface and had a thickness of up to approximately 9 feet at the proposed visitor center and up to approximately 16 feet in the proposed swing trellis area. The fill typically has an inconsistent density, contains organics and other deleterious materials and is generally not suitable for support of the proposed structures without improvement.

- Contaminated Soil and AULs – The overburden soils at the site (and the existing fill in particular) are known to contain levels of contamination. Several historic environmental studies have been performed at the site which have indicated the overburden soils at the site have been impacted by several contaminants. As a result, two AULs have been placed over the site which restricts use of subsurface soil and groundwater. The presence of contaminated soil and associated AULs limit potential reuse options.

- Organic Deposits – The proposed swing trellis area is underlain in some areas by compressible organic material. The organic soils were encountered at depths ranging from approximately 4 to 12.5 feet and had thicknesses ranging from approximately 5 to 9 feet. The organic deposits, where encountered, generally consisted of medium stiff or more compact and included granular material with trace amounts of organic matter to material that was predominately organic silt.

3.1 Foundation Alternatives

The existing fill and organic soils, in their existing condition, are not suitable for support of the proposed visitor center and swing trellis foundations due to their compressibility and potential for settlement. As a result, foundation/slab construction is not feasible without 1) removal and replacement of existing fill and organic soils and replacement with Structural Fill; 2) improvement or partial improvement of the existing fill and/or organic soils to allow foundation construction; or, 3) transferring the foundation and slab structural loads to beneath the fill and organic soils. Therefore, Nobis has evaluated the following construction alternatives:

- *Footings after over-excavation and replacement of unsuitable soils* – Removal of the fill and organic soils would require excavations of up to 9 feet at the proposed visitor center and up to 20 feet at the swing trellis area. Some of the excavations would be below the groundwater level. Based on the environmental aspects of the overburden soils at the site, removal and disposal of excavated soils from the site would likely require a significant cost premium and reuse of excavated soils in other areas of the site may also be restricted by the AUL.

Therefore, although technically feasible for the visitor center, removal and replacement of existing fill soils at the site is not recommended.

- *Deep foundations* - The use of deep foundations for support of the proposed visitor center and swing trellis is another alternative. Due to the shallow bedrock at the proposed visitor center (less than 10 feet), a drilled foundation system such as drilled micropiles is the most feasible deep foundation alternative. Micropiles would likely be embedded within the bedrock and would likely be less than 15 feet in length. A micropile-supported structural slab would be required for this alternative, if utilized.

  Due to the fill placement that is proposed in the area of the swing trellis, deep foundations are not recommended for the swing because we anticipate the soils surrounding the swing could settle by as much as 2 inches; whereas the settlement of the swing would be negligible. Therefore, there would likely be noticeable differential settlement between the swing and surrounding pavers.

- *Ground improvement* - Nobis has evaluated the use of ground improvement in lieu of deep foundations or the removal/replacement option. Ground improvement throughout the visitor center building and slab areas and throughout the swing trellis area (including raise in grade areas) would permit shallow foundation and slab-on-grade construction. A local ground improvement contractor has indicated ground improvement consisting of Aggregate Piers or Rapid Impact Compaction (RIC) would both be feasible at the site; however, RIC would be more cost effective at the proposed visitor center. RIC would not be feasible at the swing trellis due to the improvement depth that would be required.

  Rapid Impact Compaction (RIC) densifies shallow, granular soils, using a hydraulic hammer, which repeatedly strikes an impact plate on the ground surface. It is commonly used to increase bearing capacity and decrease settlement. Ground improvement techniques are generally proprietary foundation types and are generally designed by the installer.

  Aggregate piers would be a technically feasible ground improvement method in the area of the swing trellis due to the depth of improvement required (up to about 20 feet). However, due to the relatively light loading conditions, a better option may consist of a partial removal of fill below the proposed foundation elevation throughout the trellis raise -in-grades areas, heavy proofrolling and then replacement with a Structural Fill/geogrid "sandwich". However, even with the partial over-excavation and replacement there is

still a risk of unanticipated settlement that the Owner must be willing to accept if utilizing this option.

A fill preload would further help to minimize the potential for settlements by allowing sufficient time for the organic soils to consolidate prior to foundation installation and paver placement. We anticipate that total settlements from the proposed raise-in-grade at the swing trellis location may to be up to approximately 1 to 2 inches. The majority of this settlement is expected to occur within a month or two of fill placement.

3.2 Design and Cost Considerations

Several foundation design options have been presented by Nobis herein. It should be noted that some foundation alternatives pose a higher risk of post-construction settlement than others. In addition, there are also cost premiums for each foundation option.

In Nobis's opinion and in conjunction with our understanding of the project, the most suitable foundation construction alternative for the visitor center is to improve the existing fill with Rapid Impact Compaction (RIC). This option is the anticipated to be the least expensive ground improvement method and provides relatively low risk for post-construction settlement. The recommended foundation alternative for the swing trellis is a partial removal and replacement of the existing fill beneath the foundations. This option has a greater risk of post-construction settlement but would cost substantially less than a ground improvement or a deep foundation alternative. As previously indicated, a preload of the fill would further help reduce the settlement risk at the swing trellis.

4. GEOTECHNICAL DESIGN RECOMMENDATIONS

This section presents the geotechnical recommendations for the proposed visitor center and swing trellis at the Market Landing Park Expansion in Newburyport, Massachusetts. The recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses and our current understanding of the proposed development. This report and its recommendations are subject to the limitations presented in **Appendix A**.

4.1 Visitor Center

4.1.1 Foundations

Based on the subsurface conditions, we recommend shallow foundations consisting of spread and/or continuous footings bearing on a minimum of 6 inches of Crushed Stone (wrapped in filter fabric) placed over existing fill improved with the use of RIC. The Crushed Stone layer is recommended beneath the proposed foundations to help protect the subgrade from disturbance. Subgrade preparation recommendations are provided in the construction recommendations

section of the report. Existing fill may remain below the proposed foundations and slabs provided RIC is performed as designed by the proprietary foundation contractor.

Provided that subgrade is prepared in accordance with those recommendations, footings can be sized using a preliminary allowable bearing pressure of 4,000 pounds per square foot. For foundations less than 3 feet in width, the maximum bearing capacity should be reduced to the maximum bearing capacity ÷ 3 × least lateral footing dimension. Continuous wall footings should be at least 18 inches wide and isolated footings should be at least 24 inches wide.

The existing structures (including foundations and slabs), existing pavement, and utilities, should be removed from the bearing zone of the building area prior to RIC installation and foundation construction and/or fill placement in these areas. The bearing zone is defined by a one horizontal to one vertical (1H:1V) line extending down and outward from 1 foot horizontally outside the bottom edge of exterior foundations to the bearing stratum.

For frost protection, place exterior footings and interior footings in unheated areas at least 4 feet below grade. For interior footings in heated areas, the bottom of the footing should be at least 18 inches below the surface of the floor slab bearing directly on the soil immediately adjacent to the footing. Protect all foundations and subgrades from frost during construction.

4.1.2 Floor Slab

We recommend slab-on-grade construction after improvement of the existing fill with RIC. A minimum 8-inch-thick base course of compacted Structural Fill (with less than 8 percent passing sieve No. 200) or Crushed Stone (wrapped in filter fabric) should be provided below the slab.

Subgrade preparation recommendations for subgrade soil and bedrock are provided later in the report.

4.1.3 Settlement

We recommend that the RIC Contractor prepare a stamped ground improvement design indicating that the total settlement of the building foundation and slab will be less than 1-inch and that differential settlements will be less than ½-inch in 40 horizontal feet.

4.2 Swing Trellis

4.2.1 Foundations

Due to the relatively modest loads of the proposed swing trellis structure (less than 5 kips vertical load at each column) and its anticipated ability to handle some anticipated differential settlements, we recommend the proposed swing trellis be supported on shallow foundations

bearing on a minimum of 2 feet of reinforced Structural Fill once the subgrade has been prepared as described below. Existing fill may remain below the reinforced structural fill provided it is dense and stable after proofrolling.

The reinforced Structural Fill should consist of a "sandwich" of geogrid and fill layers to reduce the potential for localized differential settlement from soft or loose zones that could be located beneath the reinforced zone. The placement of biaxial or triaxial geogrid such as Tensar Biaxial BX 1500 or Tensar TriAx TX160, or their equivalents, is recommended after excavating 2 feet below the foundation elevation throughout the entire elevated trellis area. After placement of the geogrid, 12 inches of Structural Fill should be placed and compacted. This process should be repeated to the bottom of foundation elevation. It should be noted that this option does carry some inherent settlement risk because the unsuitable fill and organics will not be fully removed.

Existing topsoil, pavement, structures, and utilities (if present) should be removed from the bearing zone of the elevated swing trellis area prior fill and geogrid placement in these areas. The bearing zone is defined by a one horizontal to one vertical (1H:1V) line extending down and outward from 1 foot horizontally outside the elevated swing trellis area. paver area bottom edge of the footing to the bearing stratum.

Footings can be sized using a maximum allowable bearing pressure of 4,000 pounds per square foot. Swing foundations should be placed at least 4 feet below grade to provide frost protection. Protect all foundations and subgrades from frost during construction.

As an additional cost saving alternative, re-use of the excavated existing fill within the geogrid is a potential substitute for using Structural Fill. However, a drop in performance of the pavers and swing trellis should be expected for this option.

4.2.2 Settlement

We recommend that the swing trellis over-excavation and reinforced structural fill placement be performed and brought up to the required finished grade as soon as possible after the start of construction. We anticipate that the majority of consolidation settlement of the organics induced from the preload will occur within the first 1 to 2 months of fill placement. Settlement platforms should be used to monitor the settlement of the preload areas. The actual duration of the preload will be determined during construction based on settlement platform survey results.

4.3 Lateral Earth Pressures

Below-grade retaining walls and below-grade spaces should be designed to resist lateral earth pressures. We recommend an equivalent fluid pressure of 65 pcf, for design of foundation walls (rigid walls, at-rest pressures) and an equivalent fluid pressure of 40 pcf for design of site retaining walls (walls free to rotate, active pressures). Where the calculated earth pressure behind walls is less than 250 pounds per square foot (psf), it should be increased to 250 psf to account for stresses created by compaction within five (5) feet of the wall. In addition, the walls should be designed for permanent surcharge load, temporary surcharge pressures (such as construction equipment or traffic) and seismic loads in accordance with the 2015 International Building Code.

These values assume horizontal backfill and that the walls are backfilled with free draining Structural Fill (provided that it has less than 8 percent passing sieve No. 200) so that no water pressure develops behind the wall. A 4-inch diameter slotted PVC drain should be provided at the base of the wall. The PVC pipe should be surrounded with an annulus of 6 inches of ¾-inch crushed stone and wrapped in filter fabric.

Use a coefficient of friction of 0.4 to resist lateral sliding between mass concrete and compacted Structural Fill or Crushed Stone. In addition to sliding resistance, foundation walls may be designed to resist lateral loads with the passive resistance of soil provided that the soil will not be removed from the front of the wall. We recommend using an equivalent fluid pressure of 180 pcf to calculate the passive resistance of soils. The top one foot of soil should be neglected when calculating passive pressures. The minimum factors of safety for sliding and overturning under static loads should be 1.5 and 2, respectively.

4.4 Pavements

The following typical minimum pavement cross-sections presented in **Table 1** are recommended for the proposed parking areas and access roads.

Table 1: Typical Minimum Pavement Cross-Sections

	Minimum Thickness	
	Car Parking	**Truck Loading/Access Roads**
Surface Course (MassDOT – M3.11.03, Table A – Surface Course – Standard Top)	2 inches	2 inches
Binder Course (MassDOT – M3.11.03, Table A – Surface Course – Dense Binder)	2.5 inches	3 inches
Structural Fill Base Course (MassDOT – M2.01.7)	12 inches	16 inches

Periodic maintenance should be anticipated. Preventative maintenance should be planned and provided through an ongoing pavement management program. Preventative maintenance activities are intended to slow the rate of pavement deteriorations, preserving pavement performance and prolonging service life.

5. CONSTRUCTION CONSIDERATIONS

5.1 Protection of Existing Structures

The roadways, utilities, and other structures to remain should be protected from adverse impacts during construction. Vibration and deformation monitoring along with pre-construction surveys are recommended for the proposed visitor center construction.

5.2 Obstructions

Obstructions and/or cobbles/boulders were not generally encountered in the borings performed at the proposed visitor center or swing trellis. However, there is the potential for encountering obstructions, cobbles or boulders during excavation and performance of RIC at the site. Specifically, the potential to encounter remnant foundations could be present in certain areas even though they were not detected with the borings. The presence of obstructions could impact performance of RIC at the site and would require removal.

5.3 Soil Subgrade Preparation

Prior to fill placement the existing school (including foundations and slabs), pavement, topsoil, existing utilities, existing fill, and organic soils should be removed within the influence zone of the proposed building areas. The influence zone is defined by one horizonal to one vertical (1H:1V) lines sloping down from the bottom exterior edge of footings. Existing fill may be left in place should RIC be utilized, provided it is substantially free of organics and other deleterious material. Where encountered, bedrock should be removed from the within the influence zone of foundations and slabs to at least 12 inches from the bottom of concrete.

Fine-grained soil subgrades should be excavated using a smooth edge bucket to reduce the potential for disturbance. Subgrade soils should be proof-compacted prior to fill placement with at least six passes in perpendicular directions using a minimum 10-ton vibratory roller in open areas, or a 1-ton vibratory roller or large plate compactor in pits and trenches. Depending on the moisture content of the soils proof compacting might need to be accomplished statically to reduce the potential for disturbing soil subgrade. Any weak or soft spots identified during proof-compaction should be over-excavated and replaced with compacted Structural Fill. Where subgrades are wet the use of Crushed Stone should be considered in lieu of Structural Fill.

Crushed stone should be wrapped in a non-woven geotextile equivalent with properties equivalent to Mirafi 140N to separate the crushed stone from soil subgrades and backfill.

The geotechnical engineer of record or their representative should observe subgrades and the proof-compaction process. Subgrade stability will be affected by temperature, precipitation, construction traffic and other factors. To reduce disturbance construction traffic (including foot traffic) should be limited to the extent practical, run-off should be diverted, and subgrades should not be left exposed overnight unless the forecast calls for above freezing, clear conditions.

5.4 Construction Dewatering and Temporary Excavation Support

Based on the groundwater levels encountered in the borings, significant dewatering is not anticipated using the ground improvement methods recommended herein. However, dewatering may be required to control surface water resulting from precipitation events. Sumps and pumps should be sufficient to control mitigate the low levels of water that are anticipated. The Contractor should be responsible for selecting the dewatering methods based on his proposed construction methods. Dewatering efforts must satisfy requirements of local, state, and federal environmental and conservation authorities.

Temporary earth support and dewatering systems should be selected by the Contractor and designed by a Professional Engineer registered in the Commonwealth of Massachusetts retained by the Contractor. Where excavation sides are cut back and sloped, they should be in accordance with Occupational Safety and Health Administration (OSHA) Construction Industry Standards.

5.5 Earthwork and Compaction

Structural Fill: Recommended below footings, within foundation bearing zones and beneath the slab base course. Imported structural fill should meet the following gradation:

Sieve Size	Percent Passing by Weight
3-inch	100
½-inch	50-85
No. 4	40-75
No. 50	8-28
No. 200	0-10*

*Limit fines to 8 percent passing the No. 200 sieve for slab base course.

Processed Gravel Base Course: To be used for the gravel base course below pavements, and shall consist of hard, inert, durable gravel and sand. It shall be free from ice and snow, roots, surface coatings, sod, loam, clay, rubbish, and other deleterious or organic matter, and shall conform to the following gradation requirements if imported from offsite:

Sieve Size	% Finer By Weight
3-inch	100
1½-inch	70-100
¼-inch	50-85
No. 4	30-60
No. 200	0-10

Crushed Stone: Recommended for the required 6-inch bearing zone beneath the visitor center foundations or as drainage material. Crushed stone shall meet the requirements defined by the Massachusetts Department of Transportation (MassDOT) Standard Specifications for Highways and Bridges, Table M2.01.0-1, Material M2.01.4 (3/4-inch stone). Crushed stone, where used, should be separated from soil subgrades, excavation sidewalls, and soil backfill with a geotextile separation fabric such as Mirafi 140N, or equivalent.

Fill below footings should be placed in loose layers not more than 12 inches thick and compacted to at least 95 percent of the maximum dry density as determined by the Modified Proctor Test (ASTM D1557). In confined areas, place only 6-inch layers and compact with manually operated, powered vibratory compactor acceptable to the geotechnical engineer. Crushed Stone, where used, for any required depth of more than 12 inches, should be placed in 6-inch layers and compacted to an unyielding surface. Crushed stone should be wrapped in filter fabric, such as Mirafi 140N, or equivalent. A plate compactor should be used within 5 feet of the existing and proposed structures to minimize additional lateral earth pressures.

5.6 Reuse of Excavated Materials

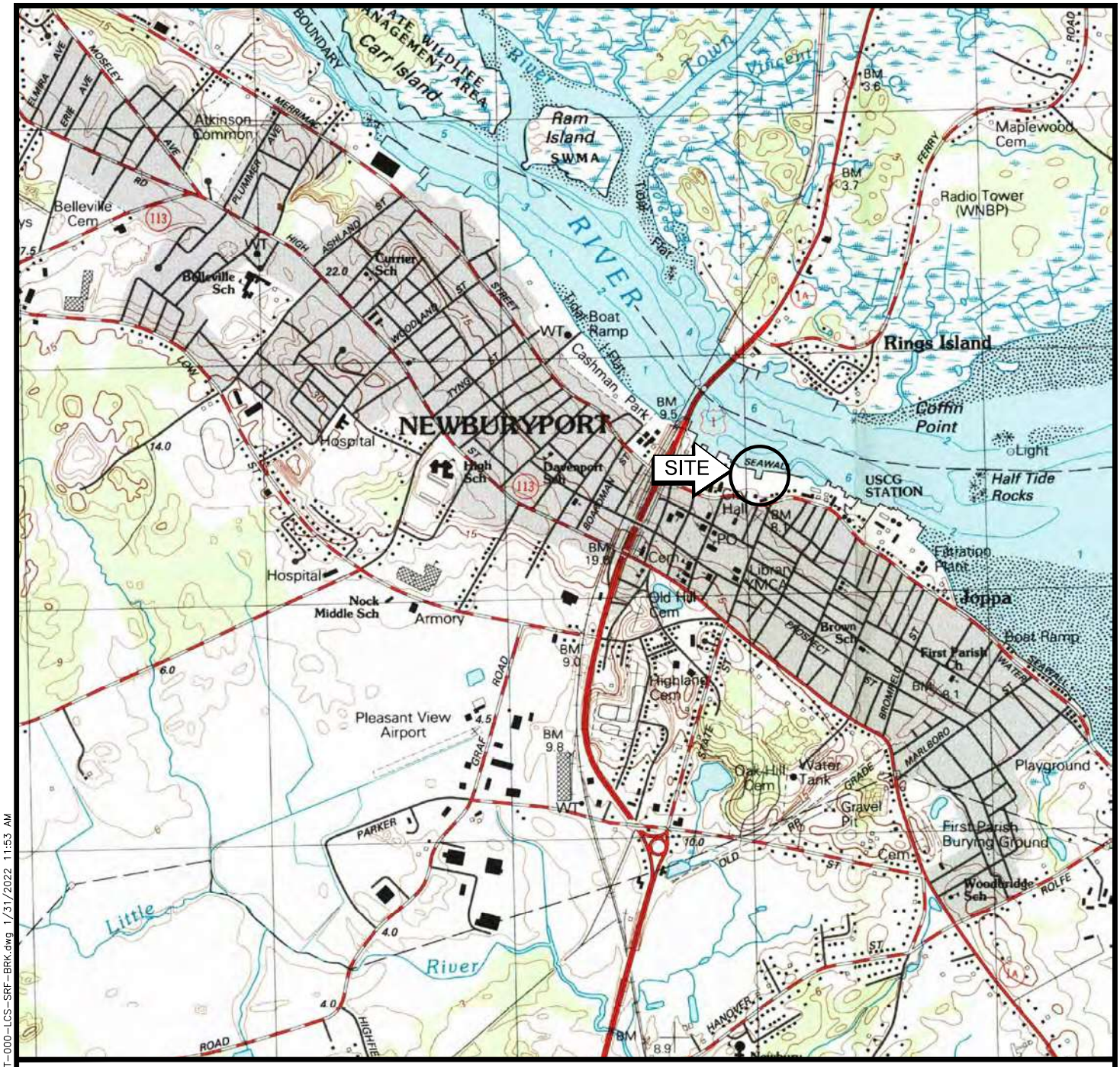
Based on the soil descriptions on the boring logs, it is not anticipated that the existing on-site soils to be excavated for foundation construction may meet the gradation requirements for structural fill. Soils not meeting the structural fill specification may be reused in areas not requiring a free-draining material, provided that the moisture content can be controlled, and the material can be compacted to the required density. Re-use of on-site soils should be at the acceptance of the geotechnical engineer prior to placement. Excavated soil that cannot be reused on-site or on other portions of the project should be removed from the site in accordance with applicable local, state, and federal regulations.

It should be noted that existing on-site soil may be used as a cost-saving alternative to the use of Structural Fill in the swing trellis area. However, reduced performance such as differential settlement and/or frost heave should be expected with the use of this material.

5.7 Contract Documents and Construction Monitoring

We recommend that Nobis be engaged to assist with preparing the specifications and to review near final plans for conformance with our geotechnical recommendations, and to provide reviews of Contractor's submittals as well as for construction observation during the earthwork and foundation phases of the project. Additionally, settlement monitoring of the preload (if performed) in the swing trellis area is recommended visa the use of three settlement platforms. Construction phase services may include RIC installations, observation of proof-rolling operations, evaluation of preload performance and placement of fill. This construction oversight is considered an important part of obtaining quality site improvements.

FIGURES



NORTH

1987 USGS TOPOGRAPHIC MAP OF THE
NEWBURYPORT, MASSACHUSETTS QUADRANGLE

CONTOUR INTERVAL 10 FEET
NGVD 1929

APPROXIMATE SCALE
1 INCH = 2000 FEET

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FIGURE 1

SITE LOCUS MAP
MARKET LANDING PARK EXPANSION
MERRIMAC AND WATER STREETS
NEWBURYPORT, MASSACHUSETTS

DRAWN BY:	JDV	CHECKED BY:	--
PROJECT NO.	100396.00	DATE:	JANUARY 2022

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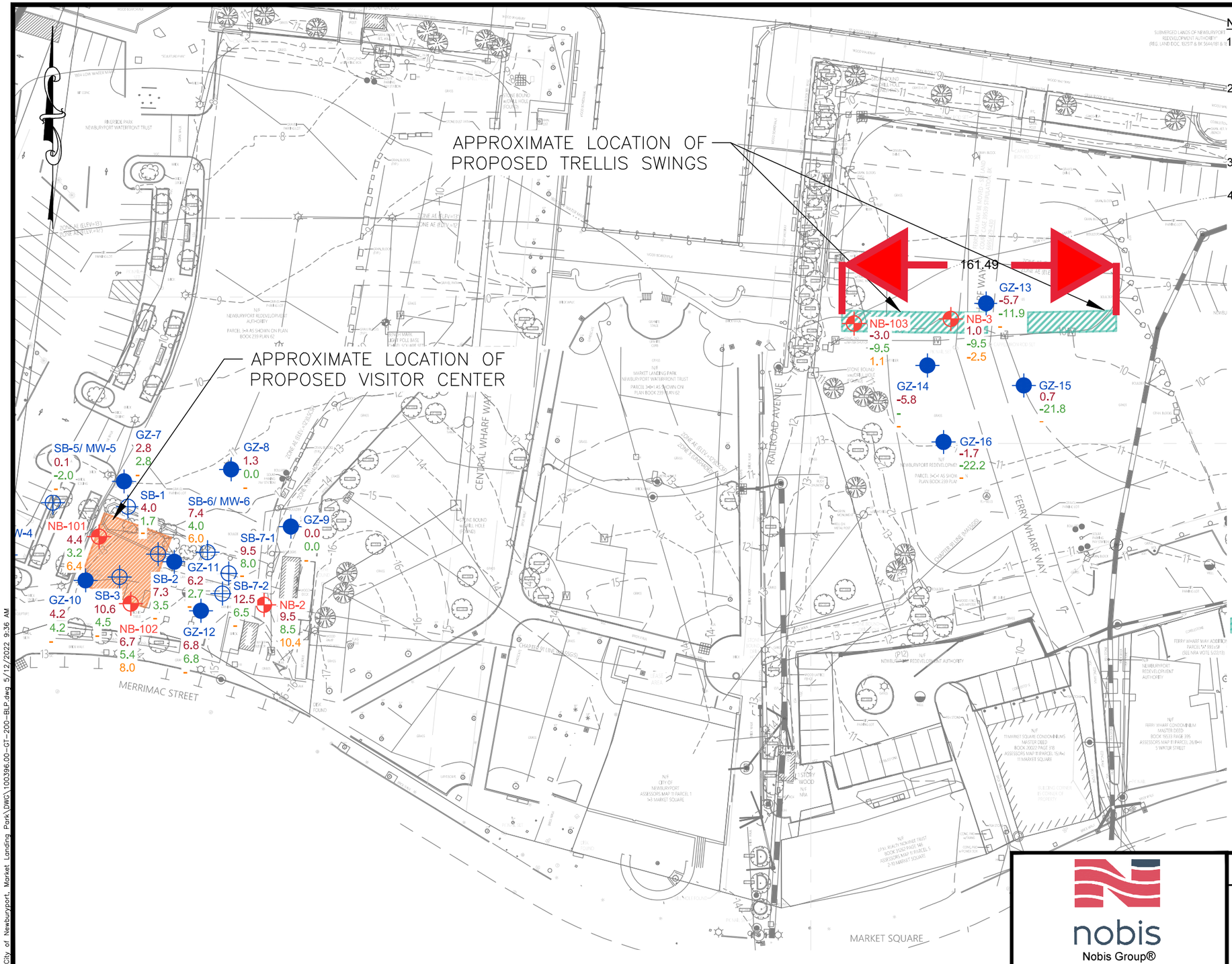

NOTES:

1. EXISTING CONDITIONS DEPICTED WERE DEVELOPED USING AN AUTOCAD DRAWING ENTITLED "15252.00-EXIST" PREPARED BY VHB AND DATED APRIL 22, 2021.
2. PRIOR SUBSURFACE EXPLORATIONS WERE PROVIDED BY SASAKI AND TAKEN FROM A 2013 GEOTECHNICAL AND ENVIRONMENTAL SITE EVALUATION PREPARED BY GZA GEOENVIRONMENTAL, INC. AND A 2017 SUBSURFACE INVESTIGATIONS PREPARED BY ESS GROUP.
3. ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
4. LOCATIONS AND SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES.

LEGEND

- APPROXIMATE LOCATION OF SOIL BORINGS COMPLETED IN JANUARY AND MAY 2022 BY NEW ENGLAND BORING CONTRACTORS OF DERRY, NH AND OBSERVED BY NOBIS
- APPROXIMATE LOCATION OF SOIL BORINGS COMPLETED IN 2013 BY NEW ENGLAND BORING CONTRACTORS OF DERRY, NH AND OBSERVED BY GZA, INC.
- APPROXIMATE LOCATION OF SOIL BORINGS COMPLETED IN 2017 BY NORTHEAST GEOTECHNICAL, INC. OF GEORGETOWN, MA AND OBSERVED BY ESS GROUP
- 6.5 — APPROXIMATE ELEVATION OF BOTTOM OF FILL LAYER " - " INDICATES FILL NOT ENCOUNTERED
- 5.5 — APPROXIMATE ELEVATION OF TOP OF BEDROCK BASED ON REFUSAL OR BEDROCK CORE SAMPLING "-" INDICATES BEDROCK NOT ENCOUNTERED
- -2.5 — APPROXIMATE ELEVATION OF GROUNDWATER TABLE "-" INDICATES NOT ENCOUNTERED OR NOT RECORDED
- PROPOSED VISITOR CENTER
- PROPOSED TRELLIS SWINGS

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FIGURE 2

BORING LOCATION PLAN
MARKET LANDING PARK EXPANSION
MERRIMAC AND WATER STREET
NEWBURYPORT, MASSACHUSETTS

DRAWN BY:	JDV	CHECKED BY:	AJ
PROJECT NO.	100396.00	DATE:	MAY 2022

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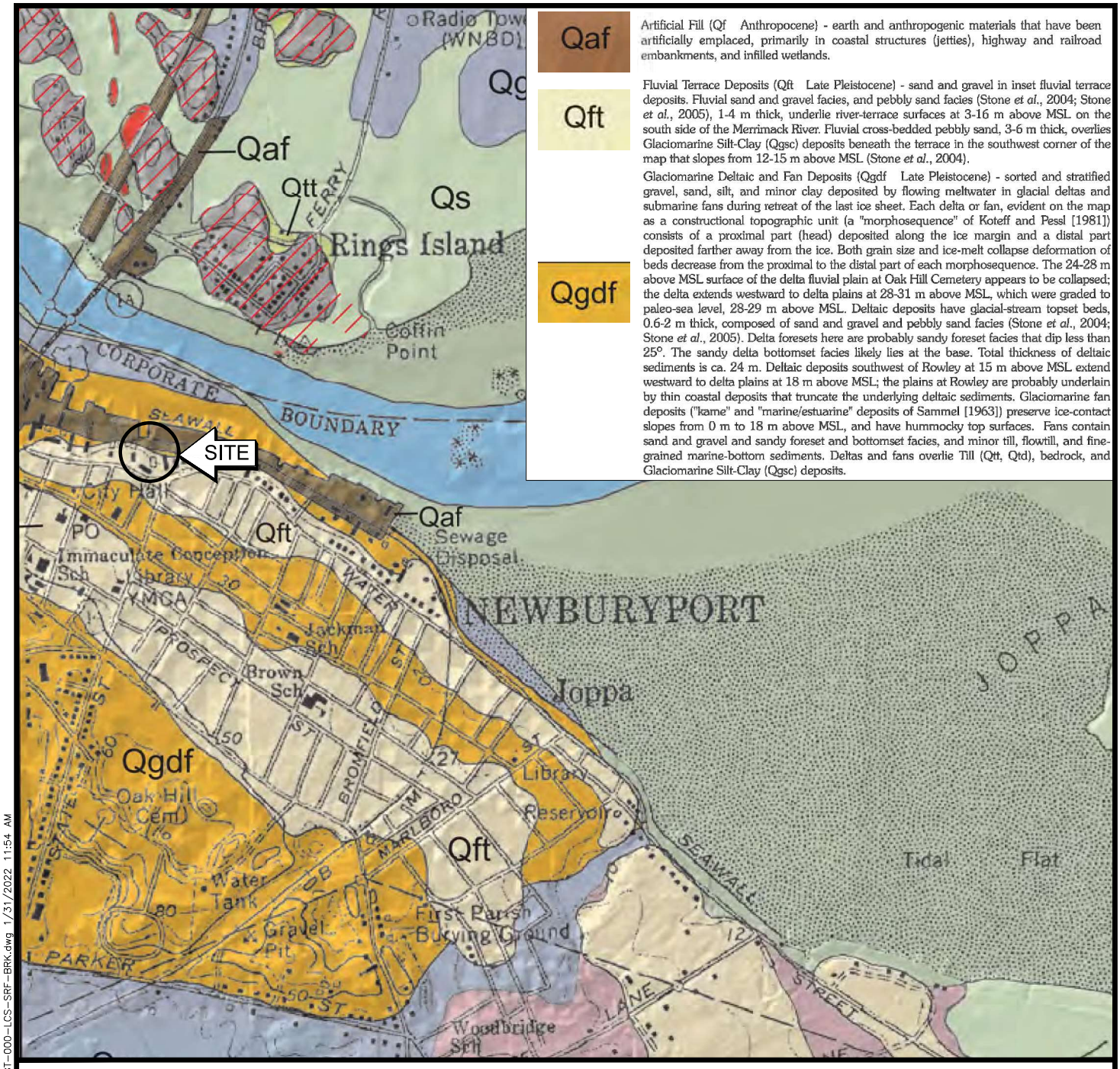

Artificial Fill (Qf Anthropocene) - earth and anthropogenic materials that have been artificially emplaced, primarily in coastal structures (jetties), highway and railroad embankments, and infilled wetlands.

Fluvial Terrace Deposits (Qft Late Pleistocene) - sand and gravel in inset fluvial terrace deposits. Fluvial sand and gravel facies, and pebbly sand facies (Stone *et al.*, 2004; Stone *et al.*, 2005), 1-4 m thick, underlie river-terrace surfaces at 3-16 m above MSL on the south side of the Merrimack River. Fluvial cross-bedded pebbly sand, 3-6 m thick, overlies Glaciomarine Silt-Clay (Qgsc) deposits beneath the terrace in the southwest corner of the map that slopes from 12-15 m above MSL (Stone *et al.*, 2004).

Glaciomarine Deltaic and Fan Deposits (Qgdf Late Pleistocene) - sorted and stratified gravel, sand, silt, and minor clay deposited by flowing meltwater in glacial deltas and submarine fans during retreat of the last ice sheet. Each delta or fan, evident on the map as a constructional topographic unit (a "morphosequence" of Koteff and Pessl [1981]) consists of a proximal part (head) deposited along the ice margin and a distal part deposited farther away from the ice. Both grain size and ice-melt collapse deformation of beds decrease from the proximal to the distal part of each morphosequence. The 24-28 m above MSL surface of the delta fluvial plain at Oak Hill Cemetery appears to be collapsed; the delta extends westward to delta plains at 28-31 m above MSL, which were graded to paleo-sea level, 28-29 m above MSL. Deltaic deposits have glacial-stream topset beds, 0.6-2 m thick, composed of sand and gravel and pebbly sand facies (Stone *et al.*, 2004; Stone *et al.*, 2005). Delta foresets here are probably sandy foreset facies that dip less than 25°. The sandy delta bottomset facies likely lies at the base. Total thickness of deltaic sediments is ca. 24 m. Deltaic deposits southwest of Rowley at 15 m above MSL extend westward to delta plains at 18 m above MSL; the plains at Rowley are probably underlain by thin coastal deposits that truncate the underlying deltaic sediments. Glaciomarine fan deposits ("kame" and "marine/estuarine" deposits of Sammel [1963]) preserve ice-contact slopes from 0 m to 18 m above MSL, and have hummocky top surfaces. Fans contain sand and gravel and sandy foreset and bottomset facies, and minor till, flowtill, and fine-grained marine-bottom sediments. Deltas and fans overlie Till (Qtt, Qtd), bedrock, and Glaciomarine Silt-Clay (Qgsc) deposits.

2013 USGS SURFICIAL GEOLOGIC MAP

"ONSHORE-OFFSHORE SURFICIAL GEOLOGIC MAP OF THE NEWBURYPORT EAST AND NORTHERN HALF OF THE IPSWICH QUADRANGLES, MASSACHUSETTS"
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

NORTH

APPROXIMATE SCALE
1 INCH = 2000 FEET

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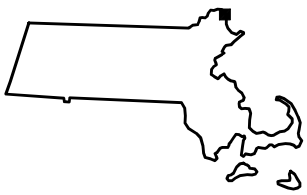

QUADRANGLE LOCATION

FIGURE 3

SURFICIAL GEOLOGIC PLAN
MARKET LANDING PARK EXPANSION
MERRIMAC AND WATER STREETS
NEWBURYPORT, MASSACHUSETTS

DRAWN BY: JDV	CHECKED BY: --
PROJECT NO. 100396.00	DATE: JANUARY 2022

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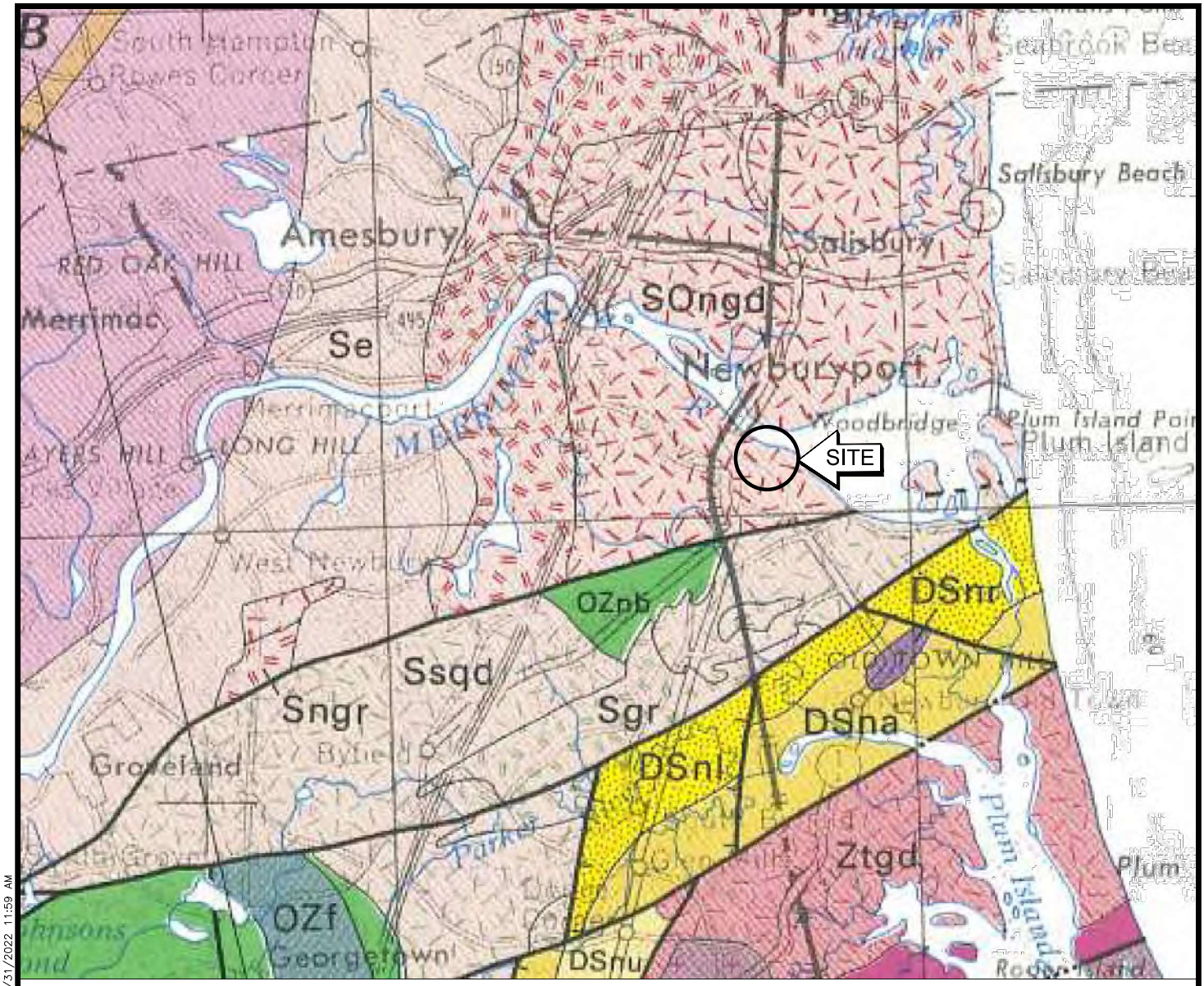

Sngr — Newburyport Complex (Silurian and Ordovician)
Gray, medium-grained porphyritic granite (Silurian) with microcline phenocrysts; intrudes SOk

SOngd — Gray, medium-grained tonalite and granodiorite (Silurian or Ordovician)

NORTH

1983 BEDROCK GEOLOGIC MAP OF MASSACHUSETTS

"BEDROCK GEOLOGIC MAP OF MASSACHUSETTS, CONTOUR INTERVAL = 100 FEET WITH SUPPLEMENTARY CONTOURS AT 50-FOOT INTERVALS, NGVD29"

APPROXIMATE SCALE
1 INCH = 10,000 FEET

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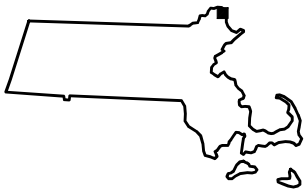

QUADRANGLE LOCATION

FIGURE 4

BEDROCK GEOLOGY PLAN
MARKET LANDING PARK EXPANSION
MERRIMAC AND WATER STREETS
NEWBURYPORT, MASSACHUSETTS

DRAWN BY: JDV	CHECKED BY: --
PROJECT NO. 100396.00	DATE: JANUARY 2022

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APPENDIX A – Limitations

GEOTECHNICAL LIMITATIONS

Explorations and Subsurface Conditions

1. The analyses and design recommendations submitted in this report are based in part upon the data obtained from subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

   In preparing this report, Nobis relied on certain information provided by the Client and other parties referenced therein which were made available to Nobis at the time of our evaluation. Nobis did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretations of widely spaced explorations and samples; actual soil transitions are probably more erratic. For specific information, refer to the exploration logs.

3. Water level readings have been made in the explorations at times and under conditions stated on the logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, and other factors occurring since the time measurements were made. The water table encountered in the course of the work may differ from that indicated in the Report.

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

4. Nobis' geotechnical services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities, or the use of structures on the property.

Additional Services

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

Use of Report

6. Nobis prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in our proposal and/or report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Reliance by any party not expressly identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to Nobis.

   This report is for design purposes only and is not sufficient to prepare an accurate construction bid. Contractors wishing a copy of the report may secure it with the understanding that its scope is limited to design considerations only.

7. Nobis' findings and conclusions are based on the work conducted as part of the scope of work set forth in our proposal and/or report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions considering the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the project design has been altered in any way, Nobis shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions.

8. Nobis' services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

Compliance with Codes and Regulations

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

Opinion of Cost

10. This report may contain or be based on comparative cost opinions for the purpose of evaluating alternative foundation schemes. These opinions may also involve approximate quantity evaluations. It should be noted that quantity estimates may not be accurate enough for construction bids. In addition, since we are not professional estimators of labor and materials cost, the evaluation of construction costs should be considered as approximate guidelines and could vary significantly from actual costs. Nobis does not guarantee the accuracy of our cost opinions as compared to contractor's bids for construction costs.

END OF LIMITATIONS

APPENDIX B – Historical Data

APPENDIX B.1 – Historic Sanborn Maps

NRA Waterfront Parking Lots
22 Merrimac Street
Newburyport, MA 01950

Inquiry Number: 3705288.1
August 26, 2013

Certified Sanborn® Map Report

EDR® Environmental Data Resources Inc

440 Wheelers Farms Road
Milford, CT 06461
800.352.0050
www.edrnet.com

Certified Sanborn® Map Report

8/26/13

Site Name:
NRA Waterfront Parking Lots
22 Merrimac Street
Newburyport, MA 01950

EDR Inquiry # 3705288.1

Client Name:
GZA GeoEnvironmental, Inc.
249 Vanderbilt Avenue
Norwood, MA 02062

Contact: Matt Steele

EDR® Environmental Data Resources Inc

The complete Sanborn Library collection has been searched by EDR, and fire insurance maps covering the target property location provided by GZA GeoEnvironmental, Inc. were identified for the years listed below. The certified Sanborn Library search results in this report can be authenticated by visiting www.edrnet.com/sanborn and entering the certification number. Only Environmental Data Resources Inc. (EDR) is authorized to grant rights for commercial reproduction of maps by Sanborn Library LLC, the copyright holder for the collection.

Certified Sanborn Results:

Site Name: NRA Waterfront Parking Lots
Address: 22 Merrimac Street
City, State, Zip: Newburyport, MA 01950
Cross Street:
P.O. # 18.0171593.00
Project: NRA Waterfront Parking Lots
Certification # B2E3-4B84-8714

Maps Provided:

1961	1894
1946	1888
1924	
1914	
1906	
1900	

Sanborn® Library search results
Certification # B2E3-4B84-8714

The Sanborn Library includes more than 1.2 million Sanborn fire insurance maps, which track historical property usage in approximately 12,000 American cities and towns. Collections searched:

- ✓ Library of Congress
- ✓ University Publications of America
- ✓ EDR Private Collection

The Sanborn Library LLC Since 1866™

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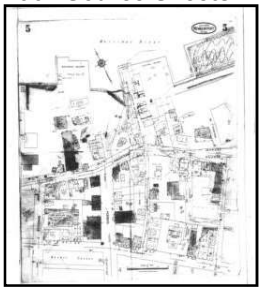
GZA GeoEnvironmental, Inc. (the client) is permitted to make up to THREE photocopies of this Sanborn Map transmittal and each fire insurance map accompanying this report solely for the limited use of its customer. No one other than the client is authorized to make copies. Upon request made directly to an EDR Account Executive, the client may be permitted to make a limited number of additional photocopies. This permission is conditioned upon compliance by the client, its customer and their agents with EDR's copyright policy; a copy of which is available upon request.

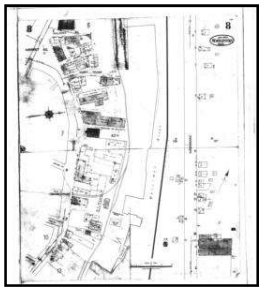
Sanborn Sheet Thumbnails

This Certified Sanborn Map Report is based upon the following Sanborn Fire Insurance map sheets.

1961 Source Sheets

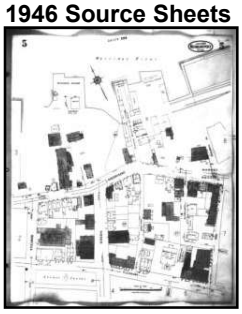


Volume 1, Sheet 5

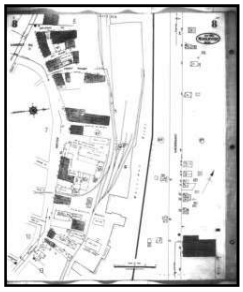


Volume 1, Sheet 8

1946 Source Sheets

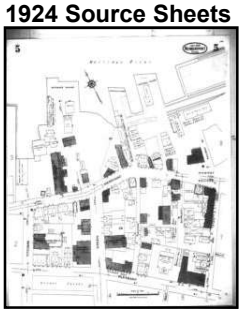


Volume 1, Sheet 5

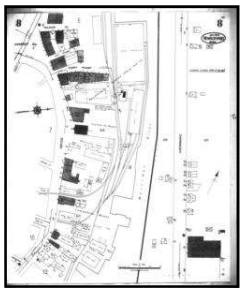


Volume 1, Sheet 8

1924 Source Sheets



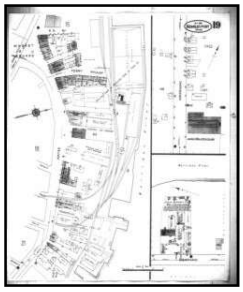
Volume 1, Sheet 5



Volume 1, Sheet 8

1914 Source Sheets

Volume 1, Sheet 15

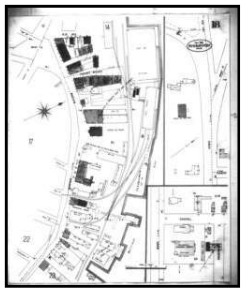


Volume 1, Sheet 19

1906 Source Sheets

Volume 1, Sheet 14

Volume 1, Sheet 17



Volume 1, Sheet 18

1900 Source Sheets

Volume 1, Sheet 11

Volume 1, Sheet 15

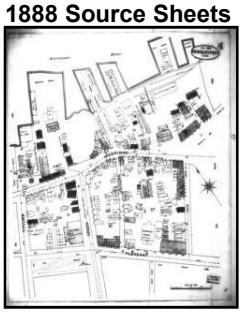
Volume 1, Sheet 16

1894 Source Sheets

Volume 1, Sheet 9

Volume 1, Sheet 14

1888 Source Sheets



Volume 1, Sheet 4

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1961 Certified Sanborn Map

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Certification # B2E3-4B84-8714

Site Name: NRA Waterfront Parking Lots
Address: 22 Merrimac Street
City, ST, ZIP: Newburyport MA 01950
Client: GZA GeoEnvironmental, Inc.
EDR Inquiry: 3705288.1
Order Date: 8/26/2013 3:59:04 PM
Certification # B2E3-4B84-8714
Copyright: 1961

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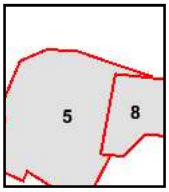
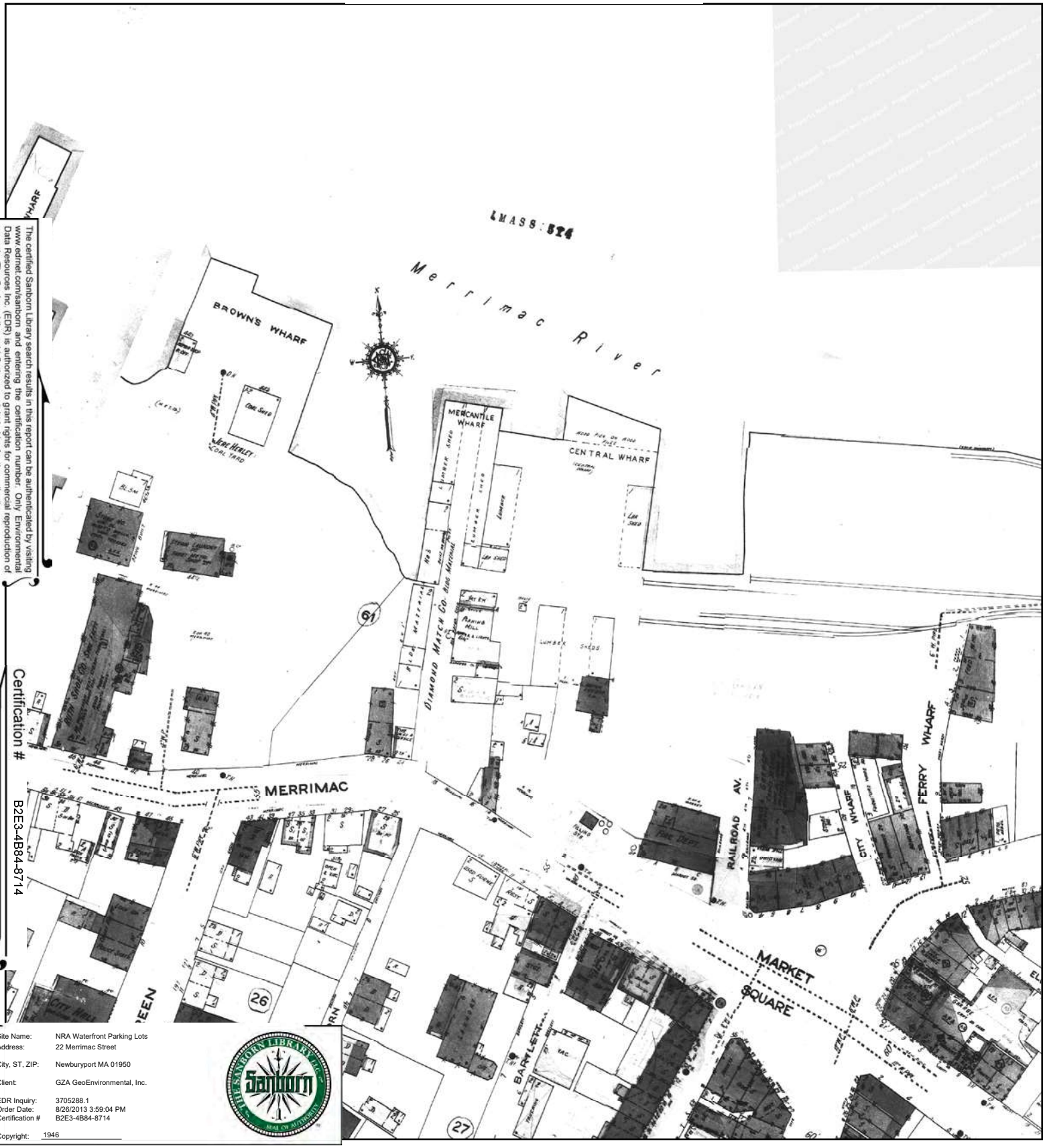


Volume 1, Sheet 5
Volume 1, Sheet 8

N

1946 Certified Sanborn Map



Certification # B2E3-4B84-8714

Site Name: NRA Waterfront Parking Lots
Address: 22 Merrimac Street
City, ST, ZIP: Newburyport MA 01950
Client: GZA GeoEnvironmental, Inc.
EDR Inquiry: 3705288.1
Order Date: 8/26/2013 3:59:04 PM
Certification # B2E3-4B84-8714
Copyright: 1946

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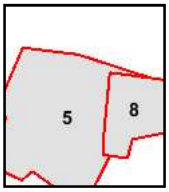

Volume 1, Sheet 5
Volume 1, Sheet 8

N

1924 Certified Sanborn Map

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Certification # B2E3-4B84-8714

Site Name:	NRA Waterfront Parking Lots
Address:	22 Merrimac Street
City, ST, ZIP:	Newburyport MA 01950
Client:	GZA GeoEnvironmental, Inc.
EDR Inquiry:	3705288.1
Order Date:	8/26/2013 3:59:04 PM
Certification #	B2E3-4B84-8714
Copyright:	1924

This Certified Sanborn Map combines the following sheets.
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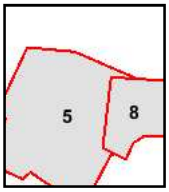

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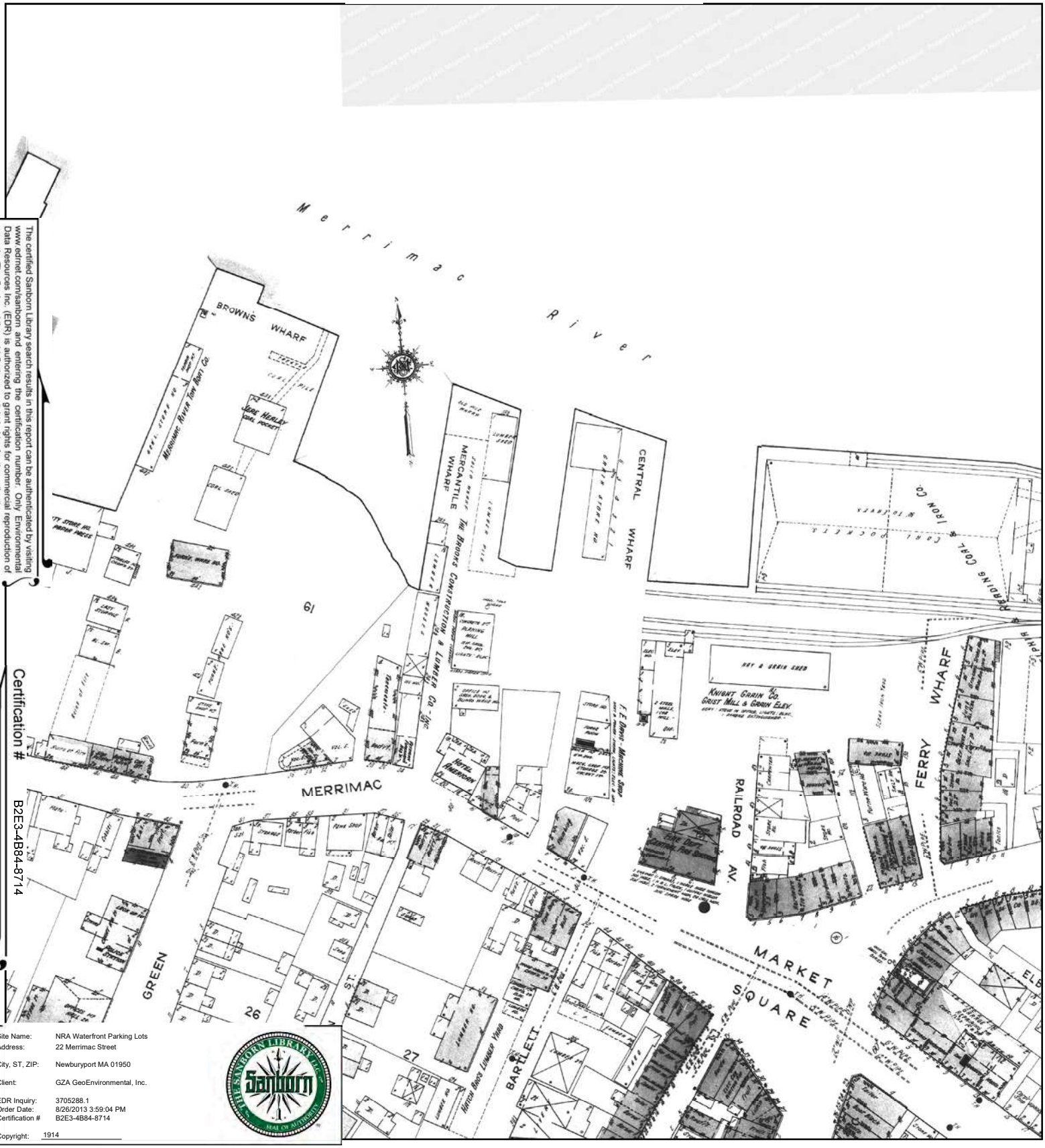
N

1914 Certified Sanborn Map



Certification # B2E3-4B84-8714

Site Name: NRA Waterfront Parking Lots
Address: 22 Merrimac Street
City, ST, ZIP: Newburyport MA 01950
Client: GZA GeoEnvironmental, Inc.
EDR Inquiry: 3705288.1
Order Date: 8/26/2013 3:59:04 PM
Certification # B2E3-4B84-8714
Copyright: 1914

This Certified Sanborn Map combines the following sheets.
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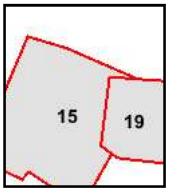

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0 Feet 150 300 600

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1906 Certified Sanborn Map

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Certification # B2E3-4B84-8714

Site Name:	NRA Waterfront Parking Lots
Address:	22 Merrimac Street
City, ST, ZIP:	Newburyport MA 01950
Client:	GZA GeoEnvironmental, Inc.
EDR Inquiry:	3705288.1
Order Date:	8/26/2013 3:59:04 PM
Certification #	B2E3-4B84-8714
Copyright:	1906

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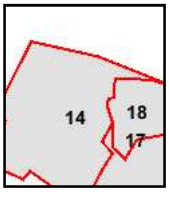

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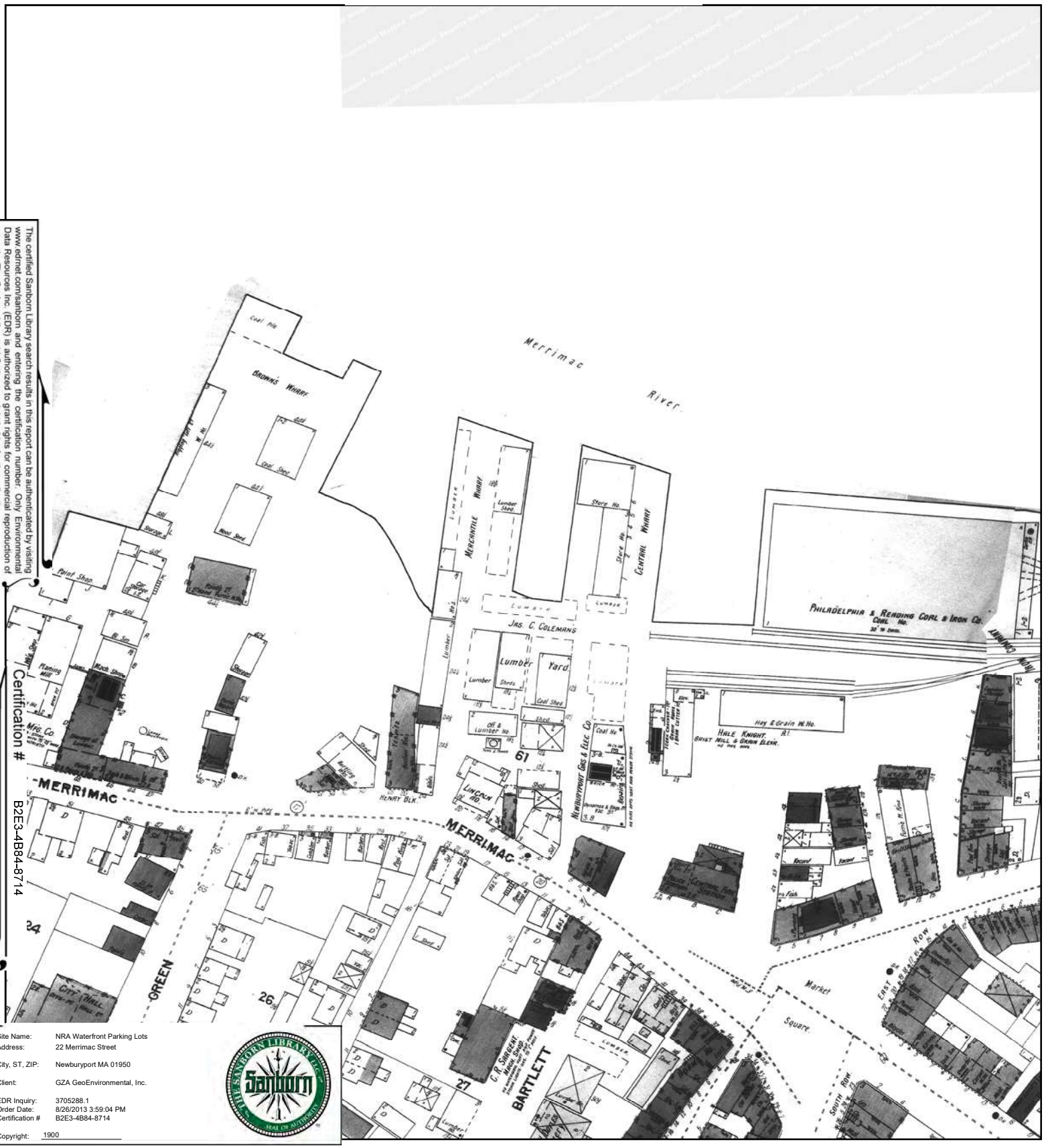
Volume 1, Sheet 17
Volume 1, Sheet 18

N

1900 Certified Sanborn Map

Certification # B2E3-4B84-8714



Site Name:	NRA Waterfront Parking Lots
Address:	22 Merrimac Street
City, ST, ZIP:	Newburyport MA 01950
Client:	GZA GeoEnvironmental, Inc.
EDR Inquiry:	3705288.1
Order Date:	8/26/2013 3:59:04 PM
Certification #	B2E3-4B84-8714
Copyright:	1900

This Certified Sanborn Map combines the following sheets.
Outlined areas indicate map sheets within the collection.

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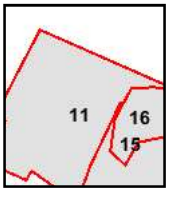

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Volume 1, Sheet 16

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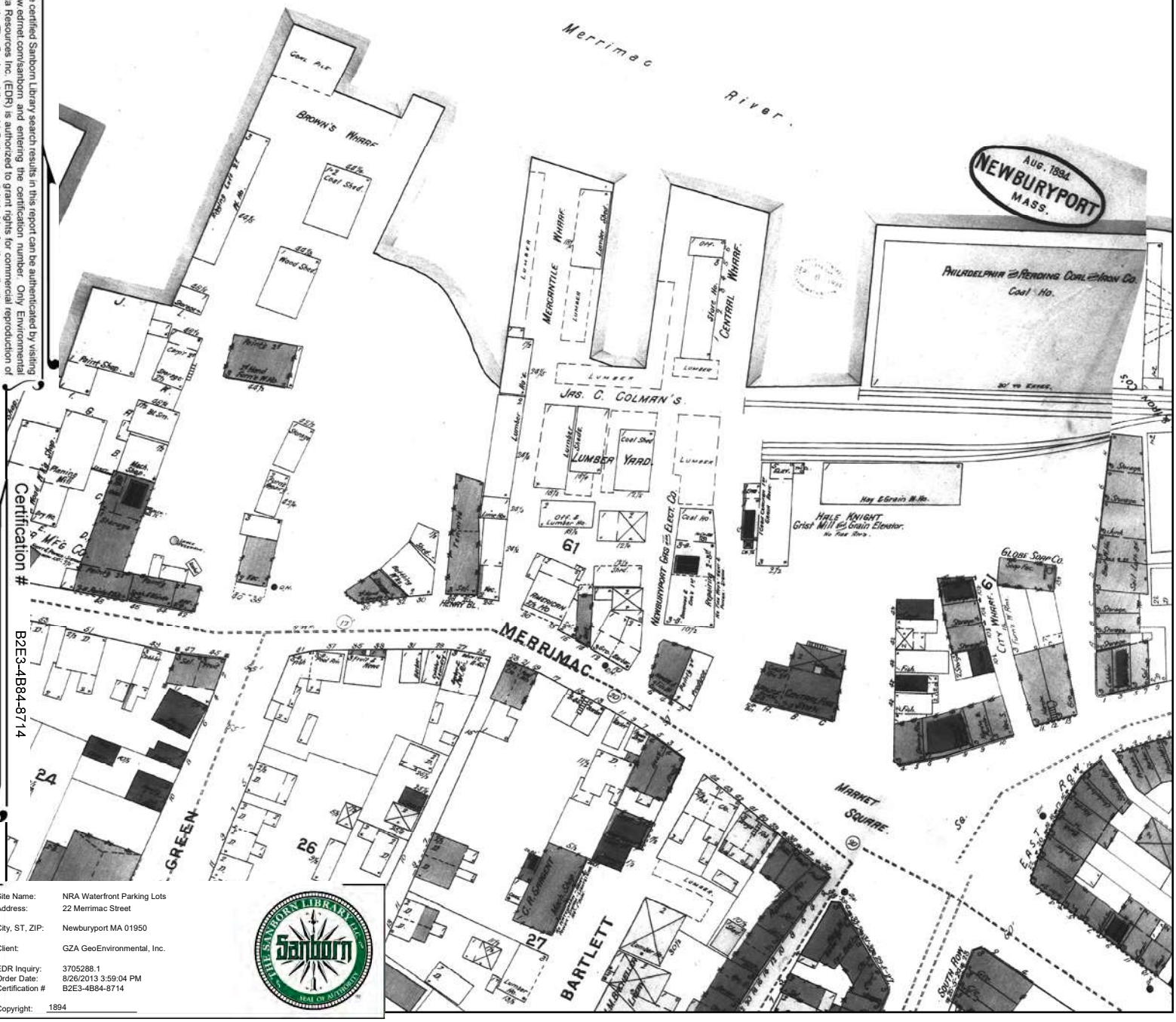
1894 Certified Sanborn Map

Certification # B2E3-4B84-8714



Site Name: NRA Waterfront Parking Lots
Address: 22 Merrimac Street
City, ST, ZIP: Newburyport MA 01950
Client: GZA GeoEnvironmental, Inc.
EDR Inquiry: 3705288.1
Order Date: 8/26/2013 3:59:04 PM
Certification # B2E3-4B84-8714
Copyright: 1894

This Certified Sanborn Map combines the following sheets.
Outlined areas indicate map sheets within the collection.

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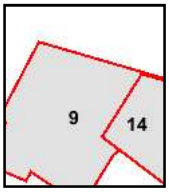

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Volume 1, Sheet 14

N

1888 Certified Sanborn Map

Certification # B2E3-4B84-8714

Site Name:	NRA Waterfront Parking Lots
Address:	22 Merrimac Street
City, ST, ZIP:	Newburyport MA 01950
Client:	GZA GeoEnvironmental, Inc.
EDR Inquiry:	3705288.1
Order Date:	8/26/2013 3:59:04 PM
Certification #	B2E3-4B84-8714
Copyright:	1888

This Certified Sanborn Map combines the following sheets.
Outlined areas indicate map sheets within the collection.

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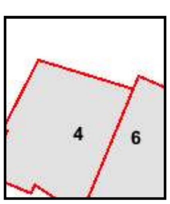

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Volume 1, Sheet 6

N

APPENDIX B.2 – Exploration Logs Completed by Others

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

NRA - Geotechnical & Environmental
Waterfront Parking Lots
Newburyport, Massachusetts

BORING NO.: GZ-7
SHEET: 1 of 1
PROJECT NO: 18.0171593.00
REVIEWED BY:

Drilling Co.: New Hampshire Boring	**Type of Rig:** Dietrich	**Boring Location:** See Plan	**H. Datum:**
Foreman: Walter Hoeckele	**Rig Model:** D-50	**Ground Surface Elev. (ft.):** 11.1	
Logged By: Matt Steele	**Drilling Method:** Auger	**Final Boring Depth (ft.):** 8.3	**V. Datum:** NAVD 88
		Date Start - Finish: 8/7/2013 - 8/7/2013	

Auger/Casing Type: HSA	**Sampler Type:** Split Spoon	
I.D/O.D.(in): 2.25"	**I.D./O.D. (in.):** 1-3/8"/2"	
Hammer Weight (lb.):	**Sampler Hmr Wt (lb):** 140 lbs	
Hammer Fall (in.):	**Sampler Hmr Fall (in):** 30"	
Other:	**Other:**	

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time
Not	Measured			

Depth (ft)	Casing Blows/ Core Rate	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	Blows (per 6 in.)	SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
		S-1	0-2	24	14	21 31 27 34	58	S-1A: Top 4": Dry, very dense, gray, fine to coarse SAND, some Gravel, trace Silt. (Parking Surface) S-1B: Bottom 10": Dry, very dense, brown, fine to coarse SAND, some Gravel, trace Silt . (FILL)	1	S1 ND	0.5'	GRAVEL PARKING SURFACE	10.6'
5		S-2	4-6	24	8	3 3 4 2	7	S-2: Moist, loose, brown, fine to coarse SAND, some Gravel, trace Silt, trace Brick. (FILL)		S2 ND		FILL	
		S-3	8.3-8.3	0	0	100/0"	R	S-3: No Recovery. Bottom of boring at 8.3 feet.	2 3		8.3'		2.8'
10													
15													
20													
25													
30													

REMARKS

1. Field testing results represent total organic vapor levels, referenced to a benzene standard, measured in the headspace of sealed soil sample jars using a MiniRae 3000 organic vapor meter equipped with a photoionization detector (PID) and 10.6eV lamp. Results in parts per million by volume (ppmv). ND indicates nothing detected (<0.1 ppmv).
2. Obstruction encountered with auger at about 8.3 feet.
3. Spoon refusal at about 8.3 feet.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: GZ-7

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

NRA - Geotechnical & Environmental
Waterfront Parking Lots
Newburyport, Massachusetts

BORING NO.: GZ-8
SHEET: 1 of 1
PROJECT NO: 18.0171593.00
REVIEWED BY:

Drilling Co.: New Hampshire Boring	**Type of Rig:** Dietrich	**Boring Location:** See Plan	**H. Datum:**
Foreman: Walter Hoeckele	**Rig Model:** D-50	**Ground Surface Elev. (ft.):** 11.5	
Logged By: Matt Steele	**Drilling Method:** Drive & Wash	**Final Boring Depth (ft.):** 9.6	**V. Datum:** NAVD 88
		Date Start - Finish: 8/6/2013 - 8/6/2013	

Auger/Casing Type: HSA	**Sampler Type:** Split Spoon	
I.D/O.D.(in): 4"	**I.D./O.D. (in.):** 1-3/8"/2"	
Hammer Weight (lb.): 300 lbs	**Sampler Hmr Wt (lb):** 140 lbs	
Hammer Fall (in.): 30"	**Sampler Hmr Fall (in):** 30"	
Other:	**Other:**	

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time
Not	Measured			

Depth (ft)	Casing Blows/ Core Rate	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	Blows (per 6 in.)	SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
		S-1	0-2	24	16	30 30 23 20	53	S-1A: Top 6": Dry, very dense, gray, fine to coarse SAND, some Gravel, little Silt. (Parking Surface) S-1B: Bottom 10": Dry, very dense, brown, fine to coarse SAND, little Silt, trace Gravel, trace Coal.	1	S1A 5.5 S1B 5.7	0.5'	GRAVEL PARKING SURFACE	11.0'
5		S-2	4-6	24	10	9 5 3 3	8	S-2: Loose, black, fine to coarse SAND, little Silt, trace Gravel, some Brick, little Shells.	2	S2 ND	8.3'	FILL	3.2'
10								Bottom of boring at 9.6 feet.					
15													
20													
25													
30													

REMARKS

1. Field testing results represent total organic vapor levels, referenced to a benzene standard, measured in the headspace of sealed soil sample jars using a MiniRae 3000 organic vapor meter equipped with a photoionization detector (PID) and 10.6eV lamp. Results in parts per million by volume (ppmv). ND indicates nothing detected (<0.1 ppmv).
2. Obstruction encountered at about 8 feet bgs, drill cuttings indicate rock, tricone rollerbit to about 9.6 feet.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: GZ-8

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

NRA - Geotechnical & Environmental
Waterfront Parking Lots
Newburyport, Massachusetts

BORING NO.: GZ-9
SHEET: 1 of 1
PROJECT NO: 18.0171593.00
REVIEWED BY:

Drilling Co.: New Hampshire Boring	**Type of Rig:** Dietrich	**Boring Location:** See Plan	**H. Datum:**
Foreman: Walter Hoeckele	**Rig Model:** D-50	**Ground Surface Elev. (ft.):** 13.7	
Logged By: Matt Steele	**Drilling Method:** Auger	**Final Boring Depth (ft.):** 14.2	**V. Datum:** NAVD 88
		Date Start - Finish: 8/7/2013 - 8/7/2013	

Auger/Casing Type: HSA	**Sampler Type:** Split Spoon	
I.D/O.D.(in): 2.25"	**I.D./O.D. (in.):** 1-3/8"/2"	
Hammer Weight (lb.):	**Sampler Hmr Wt (lb):** 140 lbs	
Hammer Fall (in.):	**Sampler Hmr Fall (in):** 30"	
Other:	**Other:**	

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time

Depth (ft)	Casing Blows/ Core Rate	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	Blows (per 6 in.)	SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
		S-1	0-2	24	16	4 10 13 18	23	S-1A: Top 6": Dry, medium dense, dark brown, fine to coarse SAND, little Gravel, trace Silt, trace Roots. (TOPSOIL) S-1B: Bottom 10": Dry, medium dense, brown, fine to coarse SAND, little Gravel, trace Silt, trace Roots.	1	S1A ND S1B ND	0.5'	TOPSOIL	13.2'
5		S-2	4-6	24	18	5 6 5 3	11	S-2: Moist, medium dense, brown, fine to coarse SAND, some Silt, little Gravel, trace Shells, trace Brick, trace Glass, trace Coal.		S2 ND		FILL	
10		S-3	9-11	24	3	1 2 2 3	4	S-3: Wet, loose, black, fine to coarse SAND, little Silt, trace Gravel, trace Glass, trace Wood fibers.	2	S3 ND			
15		S-4	14-14.2	2	2	100/2"	R	S-4: Wet, fine to coarse SAND, some Silt, little Gravel.	3		14.2'		-0.5'
								Bottom of boring at 14.2 feet.					
20													
25													
30													

REMARKS

1. Field testing results represent total organic vapor levels, referenced to a benzene standard, measured in the headspace of sealed soil sample jars using a MiniRae 3000 organic vapor meter equipped with a photoionization detector (PID) and 10.6eV lamp. Results in parts per million by volume (ppmv). ND indicates nothing detected (<0.1 ppmv).
2. Auger grinding/resistance at about 12 feet bgs.
3. Obstruction encountered spoon refusal with rock fragments in tip.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: GZ-9

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

NRA - Geotechnical & Environmental
Waterfront Parking Lots
Newburyport, Massachusetts

BORING NO.: GZ-10
SHEET: 1 of 1
PROJECT NO: 18.0171593.00
REVIEWED BY:

Drilling Co.: New Hampshire Boring	**Type of Rig:** Dietrich	**Boring Location:** See Plan	**H. Datum:**
Foreman: Walter Hoeckele	**Rig Model:** D-50	**Ground Surface Elev. (ft.):** 12.5	
Logged By: Matt Steele	**Drilling Method:** Auger	**Final Boring Depth (ft.):** 8	**V. Datum:** NAVD 88
		Date Start - Finish: 8/7/2013 - 8/7/2013	

Auger/Casing Type: HSA	**Sampler Type:** Split Spoon	
I.D/O.D.(in): 2.25"	**I.D./O.D. (in.):** 1-3/8"/2"	
Hammer Weight (lb.):	**Sampler Hmr Wt (lb):** 140 lbs	
Hammer Fall (in.):	**Sampler Hmr Fall (in):** 30"	
Other:	**Other:** Safe-T-Hoist Used	

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time
Not	Measured			

Depth (ft)	Casing Blows/ Core Rate	Sample No.	Sample Depth (ft.)	Sample Pen. (in)	Sample Rec. (in)	Sample Blows (per 6 in.)	Sample SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
		S-1	0-2	24	14	20 25 19 27	44	S-1A: Top 6": Dry, dense, gray, fine to coarse SAND, some Gravel, trace Silt (Parking Surface).	1	S1A	0.5'	GRAVEL PARKING SURFACE	12.0'
									2	0.1			
		S-2	2-4	24	14	24 30 39 46	69	S-1B: Bottom 8": Dry, brown, fine to coarse SAND, little Gravel, trace Silt, trace Bricks.	3	S1B			
								S-2A: Top 7": Dry, very dense, brown, fine to coarse SAND, trace Silt, trace Gravel.	4	1.4			
5		S-3	4-6	24	16	32 35 38 42	73	S-2B: Bottom 7": Dry, brown, fine to coarse SAND, some Silt, trace Wood, trace Brick.		S2A 100.6		FILL	
		S-4	6-6.3	3	3	100/3"	R	S-3: Moist, very dense, brown, fine to coarse SAND, some Gravel, trace Silt, trace Brick.		S2B 288			
								S-4: Moist, very dense, brown, fine to coarse SAND, some Gravel, little Silt, trace Brick.		S5 106.7	8.3'		4.2'
		S-5	8-8	0	0	100/0"	R	S-5: No Recovery.					
10								Bottom of boring at 8 feet.					
15													
20													
25													
30													

REMARKS

1. Field testing results represent total organic vapor levels, referenced to a benzene standard, measured in the headspace of sealed soil sample jars using a MiniRae 3000 organic vapor meter equipped with a photoionization detector (PID) and 10.6eV lamp. Results in parts per million by volume (ppmv). ND indicates nothing detected (<0.1 ppmv).
2. Samples S-1 and S-2 driven continuously.
3. Strong petroleum odor noted in sample from 4.5 to 6.3 feet.
4. Augered to refusal at about 8 feet.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: GZ-10

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

NRA - Geotechnical & Environmental
Waterfront Parking Lots
Newburyport, Massachusetts

BORING NO.: GZ-11
SHEET: 1 of 1
PROJECT NO: 18.0171593.00
REVIEWED BY:

Drilling Co.: New Hampshire Boring	**Type of Rig:** Dietrich	**Boring Location:** See Plan	**H. Datum:**
Foreman: Walter Hoeckele	**Rig Model:** D-50	**Ground Surface Elev. (ft.):** 13.2	
Logged By: Matt Steele	**Drilling Method:** Drive & Wash	**Final Boring Depth (ft.):** 14.3	**V. Datum:** NAVD 88
		Date Start - Finish: 8/7/2013 - 8/7/2013	

Auger/Casing Type: HW	**Sampler Type:** Split Spoon	
I.D/O.D.(in): 4"	**I.D./O.D. (in.):** 1-3/8"/2"	
Hammer Weight (lb.): 300 lbs	**Sampler Hmr Wt (lb):** 140 lbs	
Hammer Fall (in.): 30"	**Sampler Hmr Fall (in):** 30"	
Other:	**Other:**	

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time
Not	Measured			

Depth (ft)	Casing Blows/ Core Rate	Sample No.	Sample Depth (ft.)	Sample Pen. (in)	Sample Rec. (in)	Sample Blows (per 6 in.)	Sample SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
		S-1	0-2	24	14	21 31 17 14	48	S-1A: Top 1" Dry, dense, gray, fine to coarse SAND, some Gravel, trace Silt. S-1B: Bottom 10": Dry, dense, brown, fine to coarse SAND, little Gravel, little Silt. (FILL)	1 2	S1 ND	0.4'	GRAVEL PARKING SURFACE	12.8'
5		S-2	4-6	24		7 7 4 3	11	S-2: Wet, fine to coarse SAND, trace Gravel, trace Silt, trace Brick.		S2 ND		FILL	
											7'		6.2'
10		S-3	9-10.5	18	10	13 25 100/5"	R	S-3A: Top 4": Moist, dense, brown, fine to medium SAND, trace Silt, trace Gravel. S-3B: Bottom 4": Moist, dense, brown, SILT, some Sand, trace Gravel.	3			FINE SAND AND SILT	
	min/ft 4:20 7:31 4:20	C-1 C-2	11.3-12.8 12.8-14.3	18 18	14 14			C-1: Hard, moderately severely weathered, fine-grained, green, GRANODIORITE, with very thin, very close fractures. Extremely fractured. C-2: Hard, moderately severely weathered, fine-grained, green, GRANODIORITE, with very thin, very close fractures. Extremely fractured.	4 5 6 7 8 9	RQD 0% RQD 42%	10.5'	ROCK	2.7'
15								Bottom of boring at 14.3 feet.			14.3'		-1.1'
20													
25													
30													

REMARKS

1. Field testing results represent total organic vapor levels, referenced to a benzene standard, measured in the headspace of sealed soil sample jars using a MiniRae 3000 organic vapor meter equipped with a photoionization detector (PID) and 10.6eV lamp. Results in parts per million by volume (ppmv). ND indicates nothing detected (<0.1 ppmv).
2. Silt and rock fragments in tip.
3. Casing driven to about 10.4 feet, seated in bedrock.
4. Tricone rollerbit to about 11.3 feet.
5. Data in column named "Casing Blows/Core Rate" column represents core barrel penetration rate in minutes per foot. RQD = "Rock Quality Designation".
6. Drill rate reduced at about 12 feet bgs.
7. Cored C-1 advance from 11.3 to 12.9, core highly fractured.
8. Lost drill water at about 13.8 feet.
9. Recovered C-2, highly fractured.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: GZ-11

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

NRA - Geotechnical & Environmental
Waterfront Parking Lots
Newburyport, Massachusetts

BORING NO.: GZ-12
SHEET: 1 of 1
PROJECT NO: 18.0171593.00
REVIEWED BY:

Drilling Co.: New Hampshire Boring	**Type of Rig:** Dietrich	**Boring Location:** See Plan	**H. Datum:**
Foreman: Walter Hoeckele	**Rig Model:** D-50	**Ground Surface Elev. (ft.):** 14.5	
Logged By: Matt Steele	**Drilling Method:** HSA	**Final Boring Depth (ft.):** 7.7	**V. Datum:** NAVD 88
		Date Start - Finish: 8/7/2013 - 8/7/2013	

Auger/Casing Type: HSA	**Sampler Type:** Split Spoon	
I.D/O.D.(in): 2.25"	**I.D./O.D. (in.):** 1-3/8"/2"	
Hammer Weight (lb.):	**Sampler Hmr Wt (lb):** 140 lbs	
Hammer Fall (in.):	**Sampler Hmr Fall (in):** 30"	
Other:	**Other:**	

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time
Not	Measured			

Depth (ft)	Casing Blows/ Core Rate	Sample No.	Sample Depth (ft.)	Sample Pen. (in)	Sample Rec. (in)	Sample Blows (per 6 in.)	Sample SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
		S-1	0-2	15	10	23 32 100/3"	R	S-1A: Top 2" Dry, very dense, gray, fine to coarse SAND, some Gravel, trace Silt. S-1B: Bottom 8": Dry, brown, fine to coarse SAND, little Gravel, little Silt, trace Brick.	1 2 3	S1 2.8	0.5'	GRAVEL PARKING SURFACE	14.0'
5		S-2	4-6	24	14	2 2 3 6	5	S-2: Dry, loose, brown, fine to coarse SAND, some Silt, trace Gravel.		S2 ND		FILL	
		S-3	7.7-7.7	1	1	100/1"	R	S-3: Wet, gray, SILT and CLAY, some Sand.	4 5	S3 23.7	7.7'		6.8'
10								Bottom of boring at 7.7 feet.					
15													
20													
25													
30													

REMARKS

1. Field testing results represent total organic vapor levels, referenced to a benzene standard, measured in the headspace of sealed soil sample jars using a MiniRae 3000 organic vapor meter equipped with a photoionization detector (PID) and 10.6eV lamp. Results in parts per million by volume (ppmv). ND indicates nothing detected (<0.1 ppmv).
2. Obstruction encountered at about 1.3 feet, moved boring 2 feet north.
3. Easy auger conditions from about 2 to 4 feet.
4. Obstruction encountered at about 7.7 feet.
5. Possible petroleum-like odor noted in sample S-3, spoon refusal at about 7.7 feet.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: GZ-12

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

NRA - Geotechnical & Environmental
Waterfront Parking Lots
Newburyport, Massachusetts

BORING NO.: GZ-13
SHEET: 1 of 1
PROJECT NO: 18.0171593.00
REVIEWED BY:

Drilling Co.: New Hampshire Boring	**Type of Rig:** Dietrich	**Boring Location:** See Plan	**H. Datum:**
Foreman: Walter Hoeckele	**Rig Model:** D-50	**Ground Surface Elev. (ft.):** 9.3	
Logged By: Matt Steele	**Drilling Method:** Drive & Wash	**Final Boring Depth (ft.):** 21.8	**V. Datum:** NAVD 88
		Date Start - Finish: 8/8/2013 - 8/18/2013	

Auger/Casing Type: HW	**Sampler Type:** Split Spoon	
I.D/O.D.(in): 4"	**I.D./O.D. (in.):** 1-3/8"/2"	
Hammer Weight (lb.): 300 lbs	**Sampler Hmr Wt (lb):** 140 lbs	
Hammer Fall (in.): 30"	**Sampler Hmr Fall (in):** 30"	
Other:	**Other:**	

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time
Not	Measured			

Depth (ft)	Casing Blows/ Core Rate	Sample No.	Sample Depth (ft.)	Sample Pen. (in)	Sample Rec. (in)	Sample Blows (per 6 in.)	Sample SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
		S-1	0-2	24	14	23 80 70 37	R	S-1A: Top 4" Dry, very dense, gray, fine to coarse SAND, some Gravel, trace Silt (Parking Surface). S-1B: Bottom 10": Dry, very dense, brown, fine to coarse SAND, little Gravel, trace Silt, trace Brick, trace Ceramics. (FILL)	1 2	S1A ND S1B ND	0.3'	PARKING SURFACE	9.0'
5		S-2	4-6	24	10	16 15 10 7	25	S-2A: Top 8": Medium dense, brown, fine to coarse SAND, little Gravel, trace Brick. S-2B: Bottom 2": Medium dense, SILT, some fine Sand, trace Gravel.	4 3			FILL	
10		S-3	9-11	24	2	1 1 2 6	3	S-3: WOOD fibers (cuttings).					
		S-4	11-13	24	24	5 2 2 5	4	S-4: Loose, SILT and fine SAND, some Wood, trace Brick. (FILL)					
15		S-5	14.5-16.5	24	8	26 21 9 15	30	S-5A: Top 4": Dense, fine to coarse GRAVEL, some Sand, trace Wood fibers. S-5B: Bottom 4": Medium dense, brown, SILT, some Sand.	5		15'		-5.7'
												SILT AND SAND	
20		S-6	19-21	24	14	14 8 11 15	19	S-6: Medium dense, light brown SILT, trace Sand.	6				
									7		21.2'		-11.9'
											21.8'	ROCK	-12.5'
								Bottom of boring at 21.8 feet.					
25													
30													

REMARKS

1. Field testing results represent total organic vapor levels, referenced to a benzene standard, measured in the headspace of sealed soil sample jars using a MiniRae 3000 organic vapor meter equipped with a photoionization detector (PID) and 10.6eV lamp. Results in parts per million by volume (ppmv). ND indicates nothing detected (<0.1 ppmv).
2. Brick fragments in tip of sample S-1.
4. Drove 3-inch split spoon, no recovery.
3. Casing bouncing at about 8 feet, wood fibers in cuttings for 8 inches.
5. Wood fibers in cuttings at about 14.5 feet.
6. Increased resistance at the tip of sample S-6.
7. Obstruction encountered at about 21.2 feet used tricone rollerbit to 21.8 feet.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: GZ-13

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

NRA - Geotechnical & Environmental
Waterfront Parking Lots
Newburyport, Massachusetts

BORING NO.: GZ-14
SHEET: 1 of 1
PROJECT NO: 18.0171593.00
REVIEWED BY:

Drilling Co.: New Hampshire Boring	**Type of Rig:** Dietrich	**Boring Location:** See Plan	**H. Datum:**
Foreman: Walter Hoeckele	**Rig Model:** D-50	**Ground Surface Elev. (ft.):** 10.2	
Logged By: Matt Steele	**Drilling Method:** Auger	**Final Boring Depth (ft.):** 16	**V. Datum:** NAVD 88
		Date Start - Finish: 8/8/2013 - 8/8/2013	

Auger/Casing Type: HSA	**Sampler Type:** Split Spoon	
I.D/O.D.(in): 2.25"	**I.D./O.D. (in.):** 1-3/8"/2"	
Hammer Weight (lb.):	**Sampler Hmr Wt (lb):** 140 lbs	
Hammer Fall (in.):	**Sampler Hmr Fall (in):** 30"	
Other:	**Other:**	

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time

Depth (ft)	Casing Blows/ Core Rate	Sample No.	Sample Depth (ft.)	Sample Pen. (in)	Sample Rec. (in)	Sample Blows (per 6 in.)	Sample SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
									1		0.3'	GRAVEL PARKING SURFACE	9.9'
		S-1	1-3	24	16	2 6 6 12	12	S-1: Dry, medium dense, brown, fine to coarse SAND, some Silt, little Gravel.					
5		S-2	4-6	24	14	20 15 30 32	45	S-2: Wet, dense, brown, fine SAND and SILT, little Gravel, trace Brick.	2	S2 ND			
		S-3	6-8	24	20	5 7 11 10	18	S-3: Wet, black, SILT, some Sand, trace Wood fibers, trace Cinders.	3	S3 ND		FILL	
10		S-4	9-11	24	8	9 9 5 6	14	S-4: Wet, medium dense, dark brown, Silt, trace Sand, trace Wood fibers.	4	S4 ND			
15		S-5	14-16	24	14	3 13 10 8	23	S-5A: Top 8": Wet, medium dense, dark brown, SILT, trace Brick, trace Organic fibers. S-5B: Bottom 6": Wet, medium dense, fine to coarse SAND, little Gravel, little Silt, trace Brick.		S5A ND S5B ND	16'		-5.8'
								Bottom of boring at 16 feet.					
20													
25													
30													

REMARKS

1. Field testing results represent total organic vapor levels, referenced to a benzene standard, measured in the headspace of sealed soil sample jars using a MiniRae 3000 organic vapor meter equipped with a photoionization detector (PID) and 10.6eV lamp. Results in parts per million by volume (ppmv). ND indicates nothing detected (<0.1 ppmv).
2. Sample for analysis from S-2.
3. Sample for analysis from S-3.
4. Organic odor noted in sample S-4.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: GZ-14

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

NRA - Geotechnical & Environmental
Waterfront Parking Lots
Newburyport, Massachusetts

BORING NO.: GZ-15
SHEET: 1 of 1
PROJECT NO: 18.0171593.00
REVIEWED BY:

Drilling Co.: New Hampshire Boring	**Type of Rig:** Dietrich	**Boring Location:** See Plan	**H. Datum:**
Foreman: Walter Hoeckele	**Rig Model:** D-50	**Ground Surface Elev. (ft.):** 10.2	
Logged By: Matt Steele	**Drilling Method:** Drive & Wash	**Final Boring Depth (ft.):** 34.5	**V. Datum:** NAVD 88
		Date Start - Finish: 8/8/2013 - 8/8/2013	

Auger/Casing Type: HW	**Sampler Type:** Split Spoon	
I.D/O.D.(in): 4"	**I.D./O.D. (in.):** 1-3/8"/2"	
Hammer Weight (lb.): 300 lbs	**Sampler Hmr Wt (lb):** 140 lbs	
Hammer Fall (in.): 30"	**Sampler Hmr Fall (in):** 30"	
Other:	**Other:**	

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time
Not	Recorded			

Depth (ft)	Casing Blows/ Core Rate	Sample No.	Sample Depth (ft.)	Sample Pen. (in)	Sample Rec. (in)	Sample Blows (per 6 in.)	Sample SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
		S-1	0-2	24	16	19 20 31 29	51	S-1A: Top 4" Dry, very dense, gray, fine to coarse SAND, some Gravel, trace Silt. (Parking Surface)	1 2	S1A ND	0.3'	PARKING LOT	9.9'
								S-1B: Bottom 12": Dry, very dense, brown, SILT, little Sand, little Gravel.	3	S1B ND			
5		S-2	4-6	24		9 9 11 10	20	S-2: Moist, medium dense, brown, fine to coarse SAND, trace Silt, trace Gravel.	4	S2 ND		FILL	
10		S-3	9-11	24	16	6 4 8 10	12	S-3A: Top 6": Medium dense, gray, fine to medium SAND, trace Silt.	5		9.5' 9.8'	CLAY	0.7' 0.4'
								S-3B: MIddle 3": Gray, CLAY and SILT, trace Sand.				SAND	
								S-3C: Bottom 7": Medium dense, black, fine to medium SAND, little Silt.			12.5'		-2.3'
15		S-4	14-16	24	14	8 6 7 13	13	S-4: Medium dense, black, SILT, trace Gravel, trace Sand, trace Organic fibers.				ORGANIC SILT	
									6				
20		S-5	19-21	24	12	5 12 17 31	29	S-5A: Top 6": Medium dense, brown, SILT, little Sand, trace Gravel, trace Organic fibers.	7		19.5'		-9.3'
								S-5B: Bottom 6": Medium dense, olive, SILT, some fine Sand, trace Gravel.					
25		S-6	24-26	24	18	22 27 21 34	48	S-6: Dense, brown SILT, some fine Sand, brown fine sand lenses.				SILT	
									8				
30		S-7	29-31	24	20	8 10 21 24	31	S-7A: Top 12": Dense, brown, SILT, trace Sand.	9				
								S-7B: Bottom 8": Dense, brown, SILT, little Sand.					
									10		32'		-21.8'
35												WEATHERED ROCK	
											34.5'		-24.3'
								Bottom of boring at 34.5 feet.					
40													

REMARKS

1. Field testing results represent total organic vapor levels, referenced to a benzene standard, measured in the headspace of sealed soil sample jars using a MiniRae 3000 organic vapor meter equipped with a photoionization detector (PID) and 10.6eV lamp. Results in parts per million by volume (ppmv). ND indicates nothing detected (<0.1 ppmv).
2. Easier driving casing from 2 feet to 9 feet.
3. Cuttings at about 3 feet indicate brick.
4. Possible brick in sample S-2.
5. Open-hole drilling from about 9 feet.
6. Increase drill resistance at about 18 feet, wood fibers in cuttings.
7. Organic odor noted in sample S-5A.
8. Possible Clay in tip.
9. Orange fine sand partings (~ 1/8") in sample S-7B.
10. Trinecone rollerbit grinding from about 32 to 34.5 feet.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: GZ-15

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

NRA - Geotechnical & Environmental
Waterfront Parking Lots
Newburyport, Massachusetts

BORING NO.: GZ-16
SHEET: 1 of 1
PROJECT NO: 18.0171593.00
REVIEWED BY:

Drilling Co.: New Hampshire Boring	**Type of Rig:** Dietrich	**Boring Location:** See Plan	**H. Datum:**
Foreman: Walter Hoeckele	**Rig Model:** D-50	**Ground Surface Elev. (ft.):** 10.8	
Logged By: Matt Steele	**Drilling Method:** Drive & Wash	**Final Boring Depth (ft.):** 34	**V. Datum:** NAVD 88
		Date Start - Finish: 8/8/2013 - 8/8/2013	

Auger/Casing Type: HW	**Sampler Type:** Split Spoon		
I.D/O.D.(in): 4"	**I.D./O.D. (in.):** 1-3/8"/2"		
Hammer Weight (lb.): 300 lbs	**Sampler Hmr Wt (lb):** 140 lbs		
Hammer Fall (in.): 30"	**Sampler Hmr Fall (in):** 30"		
Other:	**Other:**		

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time

Depth (ft)	Casing Blows/ Core Rate	Sample No.	Sample Depth (ft.)	Sample Pen. (in)	Sample Rec. (in)	Sample Blows (per 6 in.)	Sample SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
		S-1	0-2	24	9	19 30 38 29	68	S-1A: Top 3" Dry, very dense, gray, fine to coarse SAND and GRAVEL, trace Silt (Parking Surface). S-1B: Bottom 6": Dry, very dense, brown, fine to coarse SAND, some Gravel, trace Silt, trace Brick.	1	S1A ND S1B ND	0.5'	PARKING SURFACE	10.3'
5		S-2	4-6	24	16	25 29 20 13	49	S-2A: Top 10": Dense, dark brown, SILT and SAND, little Gravel, trace Shells. S-2B: Bottom 6": Dense, brown, fine SAND, some Silt, little Gravel.		S2A ND S2B ND		FILL	
10		S-3	9-11	24	5	16 9 6 5	15	S-3: WOOD fibers and wash Metal fragments.	2	S3 2.3	12.5' 13'	SAND	-1.7' -2.2'
15		S-4	14-16	24	14	15 16 22 28	38	S-4A: Top 4": Dense, brown, fine to coarse SAND and SILT, trace Gravel. S-4B: Bottom 10": Dense, gray SILT, little fine to medium Sand, trace Gravel.	3	S4A ND			
20		S-5	19-21	24	16	22 28 31 40	59	S-5: Very dense, olive/gray, SILT, trace fine to coarse Sand.		S5A ND		SILT AND FINE SAND	
25		S-6	24-26	24	18	25 36 49 48	85	S-6: Very dense, olive/gray, SILT, trace Sand, 1-inch seam coarse Sand.					
30		S-7	29-31	24	20	10 18 16 24	34	S-7: Dense, light brown, SILT and fine SAND.	4		33'	ROCK	-22.2'
35								Bottom of boring at 34 feet.	5 6		34'		-23.2'
40													

REMARKS

1. Field testing results represent total organic vapor levels, referenced to a benzene standard, measured in the headspace of sealed soil sample jars using a MiniRae 3000 organic vapor meter equipped with a photoionization detector (PID) and 10.6eV lamp. Results in parts per million by volume (ppmv). ND indicates nothing detected (<0.1 ppmv).
2. Wood in cuttings at about 8 feet.
3. Open hole drilling from about 14 feet to the bottom of the boring.
4. Possible Clayey Silt at top of spoon.
5. Obstruction encountered at 33 feet, cuttings indicate rock.
6. Tricone rollerbit to about 34 feet.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: GZ-16

ess group

Site: West Lot, 24 Merrimac St. | Boring/Well No: SB-1

Client Name: Newburyport Redev. Auth. | Depth to Water (ft): N/A

Date(s): 4/2/17 | Well Diameter (inches): N/A

Drilling Company: N.E. Geotech | Well Screen Slot Size: N/A

Drilling Method: GeoProbe | Measuring Point: N/A

Sampling Method: Grab | Measuring Point Elevation: N/A

ESS Observer: M. Phillips | Ground Surface Elevation: N/A

Depth bgs (ft.)	Sample or Run Designation	Sample Type	Blows per 6 inches or Core Run (time/ft.)	Recovery/Penetration (ft)	Rock Quality Designation	Screening Data PID (ppm)	Screening Data FID (ppm)	Depth (feet)	Materials Description	Graphical Log	Well Construction
0				3.0'/5		0.6		0	0-3.0'→ DRY, DK BRN, FINE SAND and SILT, little fine gravel, trace brick, trace coal ash. Intermittent DARK Bands (BIK) looks like UF.		0
5	SB-1 @ 1200			3.4'/5		0.5		-5	0-3.0'→ MOIST, DK BRN, FINE SAND and SILT, trace fine gravel, trace shells, trace brick, trace wood. 3.0'-3.4'→ Moist, Greenish BRN, little fine gravel FINE SAND and SILT.		5
10				0.3/5				-10	Refusal @ 10.3'		10
15								-15			15

LEGEND:

ND: not detected
N/A: not applicable
bgs: below ground surface
NM: not measured

SAMPLE TYPES:
D: drive
W: washed
TP: test pit
ST: Shelby Tube
A: auger
HA: hand auger
C: cored
RC: rotasonic core

ROCK

ROCK QUALITY DESIGNATION (RQD):
reported in % = [length of core in pieces 4" and longer/length of run] x 100

SOIL

[1] Density designation based on blow counts for each 12" of penetration using a 140 lb. wt x 30" drop on a 2" O.D. spilt spoon sampler. If blow counts are not taken then density may be estimated

MOISTURE:
dry
damp
moist
wet

[2] PROPORTIONS USED:
Trace: <10%
Little: 10-20%
Some: 20-35%
And: 35-50%

[1] PLASTIC SOILS DENSITY:
0-2: very soft
3-4: soft
5-8: medium stiff
9-15: stiff
16-30: very stiff
>30: hard

[1] GRANULAR SOILS DENSITY:
0-4: very loose
5-9: loose
10-29: medium dense
30-49: dense
50+: very dense

NOTES:
Refusal @ 10.3'. Tried pushing 10-15' probe, hit refusal right away.

Site: West Lot, 24 Merrimac St. | Boring/Well No: SB-2

Client Name: Newburyport Redev. Auth. | Depth to Water (ft): N/A

Date(s): 4/2/17 | Well Diameter (inches):

Drilling Company: N.E. Geotech | Well Screen Slot Size:

Drilling Method: GeoProbe | Measuring Point:

Sampling Method: Grab | Measuring Point Elevation: N/A

ESS Observer: M. Phillips | Ground Surface Elevation: N/A

Depth bgs (ft.)	Sample or Run Designation	Sample Type	Blows per 6 inches or Core Run (time/ft.)	Recovery/Penetration (ft)	Rock Quality Designation	Screening Data PID (ppm)	Screening Data FID (ppm)	Depth (feet)	Materials Description	Graphical Log	Well Construction
0								0	0-1.4' -> DRY, DK BWN to BWN, FINE SAND, little silt, trace brick, trace fine gravel,		0
				3.0'					1.4'-3.0' -> DRY, BWN, FINE SAND and SILT, trace brick, trace coal, trace concrete.		1
				/5'		0.1					2
5								-5			3
									0-1.2' -> Moist to wet, BWN and BLK FINE SAND, ~~little~~ Little Brick, trace wood, trace petroleum odor		4
	SB-2 @1040			2.4'		15.0			1.2'-3.0' -> Wet, BWN + Lt. gray, FINE SAND and Gravel, trace silt		5
				/5							6
											7
10								-10	refusal @ 10'		8
											9
											10
											11
											12
											13
											14
15								-15			15

LEGEND:

ND: not detected
N/A: not applicable
bgs: below ground surface
NM: not measured

SAMPLE TYPES:
D: drive
W: washed
TP: test pit
ST: Shelby Tube
A: auger
HA: hand auger
C: cored
RC: rotasonic core

ROCK

ROCK QUALITY DESIGNATION (RQD):
reported in % = [length of core in pieces 4" and longer/length of run] x 100

SOIL

[1] Density designation based on blow counts for each 12" of penetration using a 140 lb. wt x 30" drop on a 2" O.D. spilt spoon sampler. If blow counts are not taken then density may be estimated

MOISTURE:
dry
damp
moist
wet

[2] PROPORTIONS USED:
Trace: <10%
Little: 10-20%
Some: 20-35%
And: 35-50%

[1] PLASTIC SOILS DENSITY:
0-2: very soft
3-4: soft
5-8: medium stiff
9-15: stiff
16-30: very stiff
>30: hard

[1] GRANULAR SOILS DENSITY:
0-4: very loose
5-9: loose
10-29: medium dense
30-49: dense
50+: very dense

NOTES:
Refusal @ 10'

Site: West Lot, 24 Merrimac St. | Boring/Well No: SB-3

Client Name: Newburyport Redev. Auth. | Depth to Water (ft):

Date(s): 4/7/17 | Well Diameter (inches):

Drilling Company: N.E. Geotech | Well Screen Slot Size:

Drilling Method: GeoProbe | Measuring Point:

Sampling Method: | Measuring Point Elevation:

ESS Observer: M. Phillips | Ground Surface Elevation:

Depth bgs (ft.)	Sample or Run Designation	Sample Type	Blows per 6 inches or Core Run (time/ft.)	Recovery/Penetration (ft)	Rock Quality Designation	Screening Data: PID (ppm)	Screening Data: FID (ppm)	Depth (feet)	Materials Description	Graphical Log	Well Construction
0								0	0-2.4' → DRY, FINE SAND and SILT, Little fine gravel, trace med. sand		0
				3.1/5					2.4'-2.7' → DRY, BLK, FINE SAND, trace fine gravel, trace coal/Ash, trace coal.		1
						0.4			2.7'-3.1' → DRY, BRWN, FINE SAND and SILT, trace fine gravel.		2
5	SB-3 @1122					32.1		-5			3
				3.5/4					0-3.5' → Moist to wet, FINE SAND and SILT, BLK bands have petro odor, trace fine gravel, greenish gray @ bottom 2", more gravel		4
10								-10	refusal @ 9.0'		5
											6
											7
											8
											9
											10
											11
											12
											13
											14
15								-15			15

LEGEND:

ND: not detected
N/A: not applicable
bgs: below ground surface
NM: not measured

SAMPLE TYPES:
D: drive
W: washed
TP: test pit
ST: Shelby Tube
A: auger
HA: hand auger
C: cored
RC: rotasonic core

ROCK

ROCK QUALITY DESIGNATION (RQD):
reported in % = [length of core in pieces 4" and longer/length of run] x 100

SOIL

[1] Density designation based on blow counts for each 12" of penetration using a 140 lb. wt x 30" drop on a 2" O.D. split spoon sampler. If blow counts are not taken then density may be estimated

[1] PLASTIC SOILS DENSITY:
0-2: very soft
3-4: soft
5-8: medium stiff
9-15: stiff
16-30: very stiff
>30: hard

MOISTURE:
dry
damp
moist
wet

[2] PROPORTIONS USED:
Trace: <10%
Little: 10-20%
Some: 20-35%
And: 35-50%

[1] GRANULAR SOILS DENSITY:
0-4: very loose
5-9: loose
10-29: medium dense
30-49: dense
50+: very dense

NOTES:
Refusal @ 9.0'

ess group

Site: West Lot, 24 Merrimac St. | Boring/Well No: SB-4/MW-4

Client Name: Newburyport Redev. Auth. | Depth to Water (ft):

Date(s): 4/7/17 | Well Diameter (inches): 2

Drilling Company: N.E. Geotech | Well Screen Slot Size: 0.10

Drilling Method: GeoProbe | Measuring Point: TPVC

Sampling Method: Grab | Measuring Point Elevation:

ESS Observer: M. Phillips | Ground Surface Elevation:

Depth bgs (ft.)	Sample or Run Designation	Sample Type	Blows per 6 inches or Core Run (time/ft.)	Recovery/Penetration (ft)	Rock Quality Designation	Screening Data: PID (ppm)	Screening Data: FID (ppm)	Depth (feet)	Materials Description	Graphical Log	Well Construction
0								0	0-0.4' -> Asphalt + concrete		0 CONC. RB
				3.5' / 5		0.4			0.4'-3.5' -> DRY, DK BWN, FINE SAND and SILT, little fine gravel, trace brick, trace coal, trace coal Ash, trace glass.		1 SAND 2 3 Bent 4 Riser
5								-5	0-3.3' -> Moist, DK BWN + BLK, FINE SAND and SILT, trace brick, trace coal, trace coal Ash, petroleum odor in bottom Foot.		5 SAND 6 7 8 9
				3.3' / 5		4.8	9.5'				
10	SB-4 @ 1310					96.1		-10	0-1.7' -> Moist to wet, BLK, FINE SAND and SILT, trace brick, trace fine gravel, trace clay, petroleum sheen on outside of core sample.		10 11 12 13
				3.4' / 5					1.7'-3.4' -> Moist to wet, BWN, FINE SAND and SILT.		14 Screen
15								-15			15

LEGEND:

ND: not detected
N/A: not applicable
bgs: below ground surface
NM: not measured

SAMPLE TYPES:
D: drive
W: washed
TP: test pit
ST: Shelby Tube
A: auger
HA: hand auger
C: cored
RC: rotasonic core

ROCK

ROCK QUALITY DESIGNATION (RQD):
reported in % = [length of core in pieces 4" and longer/length of run] x 100

SOIL

[1] Density designation based on blow counts for each 12" of penetration using a 140 lb. wt x 30" drop on a 2" O.D. spilt spoon sampler. If blow counts are not taken then density may be estimated

[1] PLASTIC SOILS DENSITY:
0-2: very soft
3-4: soft
5-8: medium stiff
9-15: stiff
16-30: very stiff
>30: hard

MOISTURE:
dry
damp
moist
wet

[2] PROPORTIONS USED:
Trace: <10%
Little: 10-20%
Some: 20-35%
And: 35-50%

[1] GRANULAR SOILS DENSITY:
0-4: very loose
5-9: loose
10-29: medium dense
30-49: dense
50+: very dense

NOTES:
Petroleum sheen observed on soils from 10'-12'.

BORING AND WELL CONSTRUCTION LOG

ess group

Site: West Lot, 24 Merrimac St. | Boring/Well No: SB-5 / MW-5
Client Name: Newburyport Redev. Auth. | Depth to Water (ft):
Date(s): 4/7/17 | Well Diameter (inches): 2
Drilling Company: N.E. Geotech | Well Screen Slot Size: 0.10
Drilling Method: GeoProbe | Measuring Point: TPVC
Sampling Method: Grab | Measuring Point Elevation: N/A
ESS Observer: M. Phillips | Ground Surface Elevation: N/A

Depth bgs (ft.)	Sample or Run Designation	Sample Type	Blows per 6 inches or Core Run (time/ft.)	Recovery/Penetration (ft)	Rock Quality Designation	Screening Data PID (ppm)	Screening Data FID (ppm)	Depth (feet)	Materials Description	Graphical Log	Well Construction
0				2.5'/5'		0.1		0	0-0.8' -> Asphalt 0.8'-2.0' -> Moist, DK BWN & BLK, FINE SAND and SILT, Little fine gravel, trace glass, trace wood, trace concrete, trace ash. 2.0'-2.5' -> Moist, BWN, FINE SAND & SILT, trace concrete		0 Flush mount Bentonite 3
5								-5	0-0.6' -> same as above 0.6'-2.0' -> Moist -> wet, Gray, FINE SAND and SILT, trace fine gravel, trace brick.		4
10	SB-5 @ 0900			2.4'/5'		0.6		-10	2.0'-2.4' -> Moist -> Wet, BLK, FINE SAND & SILT, trace brick, petroleum odor		10 SAND
				2.7'/4' (MP)		0.2			0-1.9' -> wet, BLK, FINE and MED. sand, trace metal, trace brick, trace coal, trace glass, trace shells.		14
15								-15	Refusal @ 14' 1.9'-2.7' -> wet, BWN, FINE SAND.		15

LEGEND:
ND: not detected
N/A: not applicable
bgs: below ground surface
NM: not measured

SAMPLE TYPES:
D: drive
W: washed
TP: test pit
ST: Shelby Tube
A: auger
HA: hand auger
C: cored
RC: rotasonic core

ROCK
ROCK QUALITY DESIGNATION (RQD):
reported in % = [length of core in pieces 4" and longer/length of run] x 100

SOIL
[1] Density designation based on blow counts for each 12" of penetration using a 140 lb. wt x 30" drop on a 2" O.D. spilt spoon sampler. If blow counts are not taken then density may be estimated

MOISTURE:
dry
damp
moist
wet

[2] PROPORTIONS USED:
Trace: <10%
Little: 10-20%
Some: 20-35%
And: 35-50%

[1] PLASTIC SOILS DENSITY:
0-2: very soft
3-4: soft
5-8: medium stiff
9-15: stiff
16-30: very stiff
>30: hard

[1] GRANULAR SOILS DENSITY:
0-4: very loose
5-9: loose
10-29: medium dense
30-49: dense
50+: very dense

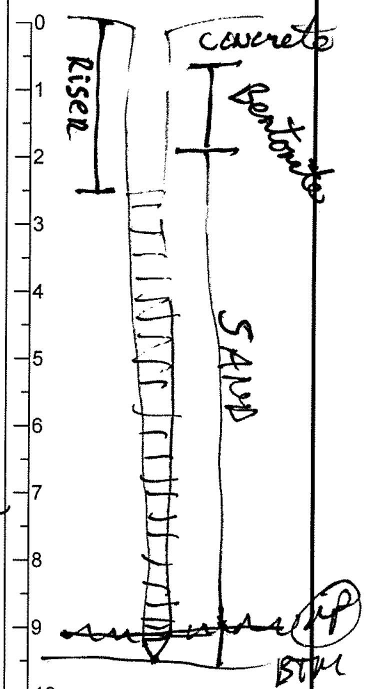
NOTES:
Refusal @ 14'
water @ ≈ 11'

BORING AND WELL CONSTRUCTION LOG

ESS group

Site: West Lot, 24 Merrimac St.	Boring/Well No: SB-6
Client Name: Newburyport Redev. Authority	Depth to Water (ft): ~ 7.0'
Date(s): 7/13/17	Well Diameter (inches): 1.0"
Drilling Company: N.E. Geotech	Well Screen Slot Size: 0.10
Drilling Method: GeoProbe	Measuring Point: NA
Sampling Method: Grab/Macro Sampler	Measuring Point Elevation: NA
ESS Observer: M. Phillips	Ground Surface Elevation:

Depth bgs (ft.)	Sample or Run Designation	Sample Type	Blows per 6 inches or Core Run (time/ft.)	Recovery/Penetration (ft)	Rock Quality Designation	Screening Data PID (ppm)	Screening Data FID (ppm)	Depth (feet)	Materials Description	Graphical Log	Well Construction
0–4				3.0' / 4.0'		0.0		0–4	0-0.4' -> crushed shells + gravel. 0.4'-2.0' -> Moist, DK BWN, FINE SAND + SILT, trace fine gravel, trace coal slag. 2.0'-2.7' -> Moist, BWN, FINE SAND and SILT, trace fine gravel, trace med. sand. 2.7'-3.0' -> Brick, concrete.		
4–8	SB-6 (5.3-5.6) @1235			2.5' / 4.0'		45.6 (5.3-5.6)		4–8	4.0'-5.3' -> Brick, wood, trace concrete. 5.3'-5.6 -> Moist, Blk, FINE SAND + SILT, petro odor. 5.6'-8.0' -> Moist, BWN, FINE SAND + SILT	~~A~~	
8–9						0.1		8–10	~~SAND~~ 8-9' -> SAME as above, Refusal @ 9.0'		



LEGEND:
ND: not detected
N/A: not applicable
bgs: below ground surface
NM: not measured

SAMPLE TYPES:
D: drive
W: washed
TP: test pit
ST: Shelby Tube
A: auger
HA: hand auger
C: cored
RC: rotasonic core

ROCK
ROCK QUALITY DESIGNATION (RQD): reported in % = [length of core in pieces 4" and longer/length of run] x 100

SOIL
[1] Density designation based on blow counts for each 12" of penetration using a 140 lb. wt x 30" drop on a 2" O.D. spilt spoon sampler. If blow counts are not taken then density may be estimated

[1] PLASTIC SOILS DENSITY:
0-2: very soft
3-4: soft
5-8: medium stiff
9-15: stiff
16-30: very stiff
>30: hard

MOISTURE:
dry
damp
moist
wet

[2] PROPORTIONS USED:
Trace: <10%
Little: 10-20%
Some: 20-35%
And: 35-50%

[1] GRANULAR SOILS DENSITY:
0-4: very loose
5-9: loose
10-29: medium dense
30-49: dense
50+: very dense

NOTES:
Refusal @ 9.0'
water ~ @ 7.0' bgs

BORING AND WELL CONSTRUCTION LOG

ess group

Site: West Lot, 24 Merrimac St.
Client Name: Newburyport Redev. Authority
Date(s): 7/13/17
Drilling Company: N.E. GeoTech
Drilling Method: GeoProbe
Sampling Method: Grab/Macro Sampler
ESS Observer: M. Phillips

Boring/Well No: SB-7/1
Depth to Water (ft): NA
Well Diameter (inches): NA
Well Screen Slot Size: NA
Measuring Point: NA
Measuring Point Elevation: NA
Ground Surface Elevation: NA

Depth bgs (ft.)	Sample or Run Designation	Sample Type	Blows per 6 inches or Core Run (time/ft.)	Recovery/Penetration (ft)	Rock Quality Designation	Screening Data PID (ppm)	Screening Data FID (ppm)	Depth (feet)	Materials Description	Graphical Log	Well Construction
0				2.7'/4.0		0.0		0	0 - 1.0' -> Moist, DK BRN, FINE SAND + SILT, trace fine gravel, trace coarse gravel & trace brick, trace asphalt. 1.0' - 1.1' -> DRY, BLK, SILT, Coal slag, trace fine gravel. 1.1' - 4.0' -> DRY, DK BRN, FINE SAND & SILT, little fine gravel, trace brick, trace concrete		0
5								-5	4.0' - 5.5' -> Moist, BRN, FINE SAND + SILT, little coarse gravel (bedrock?). Refusal @ 5.5'		5
10								-10			10
15								-15			15

LEGEND:
ND: not detected
N/A: not applicable
bgs: below ground surface
NM: not measured

SAMPLE TYPES:
D: drive
W: washed
TP: test pit
ST: Shelby Tube
A: auger
HA: hand auger
C: cored
RC: rotasonic core

ROCK
ROCK QUALITY DESIGNATION (RQD): reported in % = [length of core in pieces 4" and longer/length of run] x 100

SOIL
[1] Density designation based on blow counts for each 12" of penetration using a 140 lb. wt x 30" drop on a 2" O.D. spilt spoon sampler. If blow counts are not taken then density may be estimated

MOISTURE: dry, damp, moist, wet

[2] PROPORTIONS USED: Trace: <10%; Little: 10-20%; Some: 20-35%; And: 35-50%

[1] PLASTIC SOILS DENSITY: 0-2: very soft; 3-4: soft; 5-8: medium stiff; 9-15: stiff; 16-30: very stiff; >30: hard

[1] GRANULAR SOILS DENSITY: 0-4: very loose; 5-9: loose; 10-29: medium dense; 30-49: dense; 50+: very dense

NOTES:
- refusal @ 5.5'
- Move ≈ 10' South towards Merrimac St for 2nd Attempt

BORING AND WELL CONSTRUCTION LOG

ess group

Site: West Lot, 24 Merrimac Street
Client Name: Newburyport Redev. Authority
Date(s): 7/13/17
Drilling Company: N.E. GeoTech
Drilling Method: GeoProbe
Sampling Method: Grab/Macro Sleeve
ESS Observer: M. Phillips

Boring/Well No: SB-7-2
Depth to Water (ft): NA
Well Diameter (inches): NA
Well Screen Slot Size: NA
Measuring Point: NA
Measuring Point Elevation: NA
Ground Surface Elevation: NA

Depth bgs (ft.)	Sample or Run Designation	Sample Type	Blows per 6 inches or Core Run (time/ft.)	Recovery/Penetration (ft)	Rock Quality Designation	Screening Data PID (ppm)	Screening Data FID (ppm)	Depth (feet)	Materials Description	Graphical Log	Well Construction
0				2.8'/4.0'		0.0		0	0-0.7'-> Moist, DK Brn, FINE SAND + SILT, trace brick, trace coarse gravel, trace med. sand.		0
									0.7'-1.0'-> DRY, BLK, FINE SAND + FINE Gravel, trace coal Slag.		1
									1.0'-4.0'-> DRY, DK BRN, FINE SAND + SILT, little fine gravel, trace coarse gravel.		2
											3
5	SB-7 (6-7') @1345			2.5'/4.0'		0.0		-5			4
											5
									4.0'-6.0'-> SAME AS ABOVE		6
									6.0'-7.0'-> Moist, BRN, FINE SAND + SILT, trace coarse gravel, trace fine gravel.		7
											8
											9
10								-10	Refusal @ 7.0'		10
											11
											12
											13
											14
15								-15			15

LEGEND:
ND: not detected
N/A: not applicable
bgs: below ground surface
NM: not measured

SAMPLE TYPES:
D: drive
W: washed
TP: test pit
ST: Shelby Tube
A: auger
HA: hand auger
C: cored
RC: rotasonic core

ROCK
ROCK QUALITY DESIGNATION (RQD):
reported in % = [length of core in pieces 4" and longer/length of run] x 100

SOIL
[1] Density designation based on blow counts for each 12" of penetration using a 140 lb. wt x 30" drop on a 2" O.D. split spoon sampler. If blow counts are not taken then density may be estimated

MOISTURE:
dry
damp
moist
wet

[2] PROPORTIONS USED:
Trace: <10%
Little: 10-20%
Some: 20-35%
And: 35-50%

[1] PLASTIC SOILS DENSITY:
0-2: very soft
3-4: soft
5-8: medium stiff
9-15: stiff
16-30: very stiff
>30: hard

[1] GRANULAR SOILS DENSITY:
0-4: very loose
5-9: loose
10-29: medium dense
30-49: dense
50+: very dense

NOTES:

APPENDIX C – Nobis Exploration Logs

BORING LOG

Project: Market Landing Park Expansion

Location: Newburyport, Massachusetts

Nobis Project No.: 100396.00

Boring No.: NB-101

Boring Location:

Checked by: S. Kurtzer

Date Start: May 5, 2022

Date Finish: May 5, 2022

Contractor: New England Boring Contractors

Driller: P. Schofield

Nobis Rep.: J. Vanotti

Rig Type / Model: Truck / B-47 Mobile

Hammer Type: Automatic Hammer

Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 13

Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 05/05/22	13:45	6.6	10	17	10 minutes

Depth (ft.)	SAMPLE INFORMATION Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	LITHOLOGY Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1	S-1	17	0-2	4 11						S-1: Medium dense, dark gray, fine to coarse SAND and fine to coarse Gravel, little Silt. Moist. (FILL).	1
2				18 11							
3	S-2	17	2-4	12 12						S-2: Medium dense, dark brown-gray, fine to coarse SAND, little fine to coarse Gravel, trace Silt, very few brick fragments. Moist. (FILL).	
4				10 28							
5	S-3	7	4-6	13 13					FILL	S-3: Medium dense, gray-red, fine to coarse SAND and fine to coarse Gravel, little Silt, numerous brick fragments. Moist. (FILL).	
6				15 13							
7	S-4	8	6-8	4 4			▼			S-4: Loose, dark brown-red, fine to coarse GRAVEL, some fine to coarse Sand, some Organic Silt, few brick fragments. Wet. (FILL).	
8				3 3							
9	S-5	11	8-9.8	36 23					4.4 / 8.6	S-5A (7"): Dense, gray-white-red, fine to coarse SAND, some fine to coarse Gravel, trace Silt. Wet. (FILL).	
10				16 60/3"					SAND 3.2 / 9.8	S-5B (4"): Dense, brown, fine to coarse SAND, little Silt. Wet.	
11	C-1	58	10-15		97/35	3				C-1: Hard, slightly weathered, moderately fractured, dark gray-green, fine to medium grained, DIORITE, 45-degree angle joints.	
12						5					
13						4					
14						3			BEDROCK		
15						4					
16	C-2	24	15-17		100/100	3				C-2: Hard, fresh, sound, green-gray, fine to medium grained, DIORITE, slightly dipping joints.	
17						4			-4.0 / 17.0		
18										Boring terminated at 17 feet.	
19											
20											
21											
22											
23											
24											
25											

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

1) Borings backfilled with drilling spoils replaced in-kind and one (1) bags of filter sand.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BORING LOG

Project: Market Landing Park Expansion

Location: Newburyport, Massachusetts

Nobis Project No.: 100396.00

Boring No.: NB-102

Boring Location:

Checked by: S. Kurtzer

Date Start: May 5, 2022

Date Finish: May 5, 2022

Contractor: New England Boring Contractors

Driller: P. Schofield

Nobis Rep.: J. Vanotti

Rig Type / Model: Truck / B-47 Mobile

Hammer Type: Automatic Hammer

Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 14

Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 05/05/22	10:10	6	9	14	10 minutes

Depth (ft.)	SAMPLE INFORMATION Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	LITHOLOGY Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1	S-1	14	0-2	7 22						S-1: Dense, dark gray-brown, fine to coarse SAND, some fine to coarse Gravel, little Silt. Moist. (FILL).	1
2				12 8							
3	S-2	20	2-4	7 12						S-2: Dense, brown-gray-red, fine to coarse SAND, some fine to coarse Gravel, some Silt, several brick fragments. Moist. (FILL).	
4				28 28					FILL		
5	S-3	8	4-6	9 9						S-3: Medium dense, red-brown, fine to coarse SAND, some fine to coarse Gravel, little Silt, several brick fragments. Wet. (FILL).	
6				7 6			▼				
7	S-4	13	6-7.3	15 10						S-4: Very dense, red-brown-black, fine to coarse SAND and fine to coarse Gravel, some Silt, few brick fragments, slight petroleum odor. Wet. (FILL).	
8				60/3"					6.7 / 7.3	Advanced roller-bit under heavy drilling resistance from approximatel 7- to 8-feet below ground surface.	
9	S-5	6	8-8.6	37 60/1"					GLACIAL TILL 5.4 / 8.6	S-5: Very dense, gray, fine to coarse SAND and fine to coarse Gravel, little Silt. Wet. (GLACIAL TILL).	
10	C-1	60	9-14		100/30	4				C-1: Hard, slightly weathered, extremely fractured, dark gray-green, fine to medium grained, DIORITE, vertical to 45-degree angle joints.	
11						6					
12						3			BEDROCK		
13						2					
14						4			0.0 / 14.0		
15										Boring terminated at 14 feet.	
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

1) Borings backfilled with drilling spoils replaced in-kind and two (2) bags of filter sand.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BORING LOG

Project: Market Landing Park Expansion

Location: Newburyport, Massachusetts

Nobis Project No.: 100396.00

Boring No.: NB-103

Boring Location:

Checked by: S. Kurtzer

Date Start: May 4, 2022

Date Finish: May 4, 2022

Contractor: New England Boring Contractors

Driller: P. Schofield

Nobis Rep.: J. Vanotti

Rig Type / Model: Truck / B-47 Mobile

Hammer Type: Automatic Hammer

Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 10

Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 05/04/22	15:00	8.9	19.5	24.5	10 minutes

Depth (ft.)	SAMPLE INFORMATION Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	LITHOLOGY Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1	S-1	24	0-2	10 8					9.7 / 0.3 TOPSOIL	S-1A (4"): Medium dense, dark brown, fine to medium SAND, some Silt, few grass roots. Moist. (TOPSOIL).	1
2				11 13						S-1B (20"): Medium dense, gray-brown, fine to coarse SAND, some Silt, little fine to coarse Gravel, few brick fragments. Moist. (FILL).	
3	S-2	12	2-4	17 15					FILL	S-2: Medium dense, gray-brown, fine to coarse SAND, little fine to coarse Gravel, little Silt, very few wood pieces and roots. Moist. (FILL).	
4				12 11					6.0 / 4.0		
5	S-3	14	4-6	8 4						S-3: Loose, gray-black, fine to coarse SAND, some Organic Silt, trace fine Gravel. Wet.	
6				3 5							
7											
8											
9							▼		ORGANIC SILT AND SAND		
10	S-4	4	9-11	4 3						S-4: Loose, Piece of wood in spoon. Wet.	
11				4 8							
12											
13									-3.0 / 13.0		
14										Wash color observed to change from dark gray to brown, indicative of a possible strata transition.	
15	S-5	7	14-16	13 35						S-5: Very dense, gray-brown, fine to medium SAND and Silt, trace fine Gravel. Wet. (GLACIAL TILL).	
16				15 26					GLACIAL TILL		
17										Significant rig chatter observed from approximately 16- to 19-feet below ground surface, indicative of possible cobbles and boulders.	
18											
19									-9.0 / 19.0		
20	S-6 C-1	3 57	19-19.3 19.5-24.5	60/3"	95/75	6			WEATHERED BEDROCK -9.5 / 19.5	S-6: Very dense, gray-brown, fine to coarse SAND, some Silt, trace fine Gravel, possible weathered bedrock fragments. Wet.	
21						5				C-1: Hard, slightly weathered, moderately fractured, gray-green, fine to coarse grained, DIORITE, horizontal to 45-degree angle joints.	
22						6			BEDROCK		
23						6					
24						7					
25									-14.5 / 24.5	Boring terminated at 24.5 feet.	

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

1) Borings backfilled with drilling spoils replaced in-kind and three (3) bags of filter sand.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BORING LOG

Project: Market Landing Park Expansion

Location: Newburyport, Massachusetts

Nobis Project No.: 100396.00

Boring No.: NB-1

Boring Location:

Checked by: S. Kurtzer

Date Start: January 27, 2022

Date Finish: January 27, 2022

Contractor: New England Boring Contractors

Driller: G. Peacock

Nobis Rep.: J. Vanotti

Rig Type / Model: ATV Track Rig / Mobile B-57

Hammer Type: Automatic Hammer

Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 14.5

Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 01/27/22	10:00	6.5	8	12.5	10 min

Depth (ft.)	SAMPLE INFORMATION Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	LITHOLOGY Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1										Boring was vacuum excavated to approximately 6-feet to clear utilites in the area.	1
2											
3									FILL	Vacuum excavated material was fill that consisted of Brown-gray, fine to coarse SAND, some fine to coarse Gravel, little Silt, with numerous brick fragments.	
4											
5											
6									8.5 / 6.0		
7	S-1	20	6-7.7	9 16			▼		SAND	S-1: Very dense, gray-brown, fine to medium SAND, some fine to coarse Gravel, some Silt. Moist. [Laboratory Testing Performed: pH in distilled water = 6.2, pH in Calcium Chloride = 6.1, Electrical Resistivity = 2,479 ohm-cm, Chlorides = 39ppm, Sulfates = <10ppm, Reduction Oxidation Potential = 122.8 @ 19.7 Celsius; Composite with NB-3, S-2].	2
8				38 50/2"					6.7 / 7.8	Advanced roller-bit to 8-feet under heavy pressure.	
9	C-1	54	8-12.5		100/67	5			BEDROCK	C-1: Hard, moderately weathered, moderately fractured, gray, fine-grained, DIORITE, horizontal to 45-degree angle joints. [Laboratory Testing Performed - Bulk Density and Compressive Strength: Density = 171pcf, Compressive Strength = 13,072psi, Failure Type = 3].	
10						6					
11						7					
12						6					
13						4			2.0 / 12.5	Boring terminated at 12.5 feet.	
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

1) Boring backfilled with drilling spoils replaced in-kind and two (2) bags of filter sand.
2) Water introduced to bore hole during drive and wash techniques.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BORING LOG

Project: Market Landing Park Expansion

Location: Newburyport, Massachusetts

Nobis Project No.: 100396.00

Boring No.: NB-2

Boring Location:

Checked by: S. Kurtzer

Date Start: January 27, 2022

Date Finish: January 27, 2022

Contractor: New England Boring Contractors

Driller: G. Peacock

Nobis Rep.: J. Vanotti

Rig Type / Model: ATV Track Rig / Mobile B-57

Hammer Type: Automatic Hammer

Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 14.5

Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 01/27/22	14:30	4.1	6	13	10 min

Depth (ft.)	SAMPLE INFORMATION Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	LITHOLOGY Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1										Boring was vacuum excavated to approximately 5-feet to clear utilites in the area.	1
2											
3									FILL	Vacuum excavated material was fill that consisted of Brown-gray, fine to coarse SAND, some fine to coarse Gravel, little Silt, with numerous brick fragments.	
4							▼				
5									9.5 / 5.0		
6									WEATHERED BEDROCK 8.5 / 6.0	Advanced roller-bit under heavy pressure to approximately 6-feet.	
7	C-1	48	6-10		100/0	7				C-1: Hard, moderately weathered, extremely fractured, gray, fine-grained, DIORITE, severely dipping joints.	2
8						8					
9						10					
10						15			BEDROCK		
11	C-2	36	10-13		100/0	7				C-2: Hard, moderately weathered, extremely fractured, gray, fine-grained, DIORITE, vertical and horizontal joints.	
12						8					
13						10			1.5 / 13.0		
14										Boring terminated at 13 feet.	
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

1) Boring backfilled with drilling spoils replaced in-kind and two (2) bags of filter sand.
2) Water introduced to bore hole during drive and wash techniques.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

BORING LOG

Project: Market Landing Park Expansion

Location: Newburyport, Massachusetts

Nobis Project No.: 100396.00

Boring No.: NB-3

Boring Location:

Checked by: S. Kurtzer

Date Start: January 26, 2022

Date Finish: January 26, 2022

Contractor: New England Boring Contractors

Driller: G. Peacock

Nobis Rep.: J. Vanotti

Rig Type / Model: ATV Track Rig / Mobile B-57

Hammer Type: Automatic Hammer

Hammer Hoist: Automatic

Ground Surface Elev.: (+/-) 10

Datum: NAVD 88

	Drilling Method	Sampler
Type	Casing	Split-Spoon
Size ID (in.)	4	1-3/8
Advancement	Drive and Wash	140-lb Hammer

Groundwater Observations

Date	Time	Depth Below Ground (ft.)	Depth of Casing (ft.)	Depth to Bottom of Hole (ft.)	Stabilization Time
▼ 01/26/22	14:45	12.5	19.5	20.5	10 min

Depth (ft.)	Type & No.	Rec (in.)	Depth (ft.)	Blows/ 6 in.	REC % / RQD %	Drilling Rate (min/ft)	Ground Water	Graphic	Stratum Elev. / Depth (ft.)	SAMPLE DESCRIPTION AND REMARKS (Classification System: Modified Burmister)	NOTES
1	S-1	23	0-2	16 52					TOPSOIL 9.1 / 0.9	S-1A (11"): Very dense, dark brown, fine to coarse SAND, some fine to coarse Gravel, some Silt. Dry. (TOPSOIL).	1
2				27 22						S-1B (12"): Very dense, gray-brown, fine to coarse SAND and Gravel, little Silt. Dry. (FILL).	
3	S-2	20	2-4	14 18						S-2: Dense, brown-gray-black, fine to coarse SAND and Gravel, some Silt. Dry. (FILL). [Laboratory Testing Performed: pH in distilled water = 6.2, pH in Calcium Chloride = 6.1, Electrical Resistivity = 2,479 ohm-cm, Chlorides = 39ppm, Sulfates = <10ppm, Reduction Oxidation Potential = 122.8 @ 19.7 Celsius; Composite with NB-1, S-1].	
4				26 16							
5	S-3	7	4-6	7 11					FILL	S-3: Medium dense, gray-black, fine to coarse SAND, some fine to coarse Gravel, some Silt. Dry. (FILL).	
6				9 10							
7										Significant Rig chatter observed from approximately 6- to 9-feet, possible cobbles and boulders in the fill.	
8											
9									1.0 / 9.0		
10	S-4	6	9-11	3 6					ORGANIC SILT	S-4: Medium dense, black-gray, Organic SILT and fine to medium Sand, trace fine to coarse Gravel. Wet. (ORGANIC DEPOSITS).	2
11				19 5							3
12										Significant Rig chatter observed from approximately 9- to 14-feet, possible cobbles and boulders.	
13							▼				
14									-4.0 / 14.0		
15	S-5	8	14-16	7 15					SAND AND GRAVEL	S-5: Dense, gray-black, fine to coarse SAND and Gravel, some Silt. Wet.	
16				33 15							
17										Significant Rig chatter observed from approximately 16- to 19-feet, possible cobbles and boulders.	
18											
19										S-6: Very dense, gray, fine to coarse GRAVEL, some fine to coarse Sand, trace Silt. Wet. possible cobbles in sample tip.	
20	S-6	4	19-19.3	50/4"					-9.5 / 19.5		
	C-1	8	19.5-20.5		67/50	6			BEDROCK -10.5 / 20.5	C-1: Hard, slightly weathered, moderately fractured, gray-white, coarse-grained, DIORITE, 45-degree angle joints.	
21										Boring terminated at 20.5 feet.	
22											
23											
24											
25											

Soil	Percentage	Non-Soil
trace	5 - 10	very few
little	10 - 20	few
some	20 - 35	several
and	35 - 50	numerous

NOTES:

1) All borings backfilled with drilling spoils replaced in-kind and eight (4) bags of filter sand total.
2) Due to difficult drilling, boring was abandoned, offset 5-feet north and reattempted.
3) Casing broke while advancing to 10-feet during second attempt, abandonded 2nd, offset 5-feet north and began and completed a 3rd attempt.

Soil descriptions, and lithology, are based on visual classifications and should be considered approximate. Stratification lines are approximate boundaries between stratums; transitions may be gradual.

APPENDIX D – Laboratory Test Results

Client:	Nobis Engineering, Inc.				
Project:	Market Landing Park				
Location:	Newburyport, MA			Project No:	GTX-315068
Boring ID:	NB-1	Sample Type:	cylinder	Tested By:	tlm
Sample ID:	L-1	Test Date:	03/03/22	Checked By:	smd
Depth :	10.1'-11'	Test Id:	659502		
Test Comment:	---				
Visual Description:	See photograph(s)				
Sample Comment:	---				

Bulk Density and Compressive Strength of Rock Core Specimens by ASTM D7012 Method C

Boring ID	Sample Number	Depth	Bulk Density, pcf	Compressive strength, psi	Failure Type	Meets ASTM D4543	Note(s)
NB-1	L-1	10.29-10.65 ft	171	13072	3	Yes	---

Notes: Density determined on core samples by measuring dimensions and weight and then calculating.

All specimens tested at the approximate as-received moisture content and at standard laboratory temperature.

The axial load was applied continuously at a stress rate that produced failure in a test time between 2 and 15 minutes.

Failure Type: 1 = Intact Material Failure; 2 = Discontinuity Failure; 3 = Intact Material and Discontinuity Failure (See attached photographs)

Client:	Nobis Engineering, Inc.	Test Date:	2/22/2022
Project Name:	Market Landing Park	Tested By:	kdp/bp
Project Location:	Newburyport, MA	Checked By:	smd
GTX #:	315068		
Boring ID:	NB-1		
Sample ID:	L-1		
Depth:	10.29-10.65 ft		
Visual Description:	See photographs		

UNIT WEIGHT DETERMINATION AND DIMENSIONAL AND SHAPE TOLERANCES OF ROCK CORE SPECIMENS BY ASTM D4543

BULK DENSITY

	1	2	Average
Specimen Length, in:	4.29	4.29	4.29
Specimen Diameter, in:	1.99	1.99	1.99
Specimen Mass, g:	598.8		
Bulk Density, lb/ft^3	171	**Minimum Diameter Tolerence Met?**	YES
Length to Diameter Ratio:	2.2	**Length to Diameter Ratio Tolerance Met?**	YES

DEVIATION FROM STRAIGHTNESS (Procedure S1)

Maximum gap between side of core and reference surface plate:
Is the maximum gap ≤ 0.02 in.? YES

Maximum difference must be < 0.020 in.
Straightness Tolerance Met? YES

END FLATNESS AND PARALLELISM (Procedure FP1)

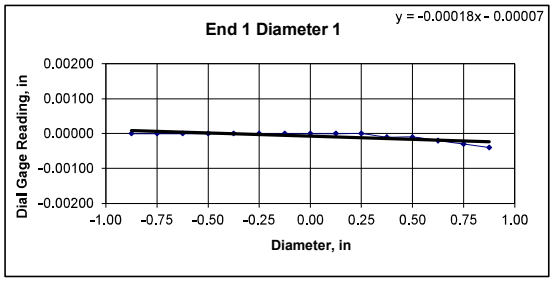
END 1	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00010	-0.00010	-0.00020	-0.00030	-0.00040
Diameter 2, in (rotated 90°)	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00000	0.00000	-0.00010	-0.00020	-0.00030	-0.00040	-0.00050	-0.00050	-0.00060

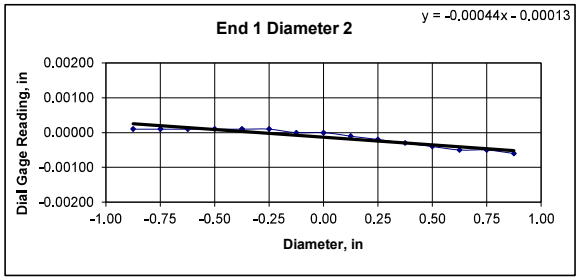
Difference between max and min readings, in:
0° = 0.00040 90° = 0.00070

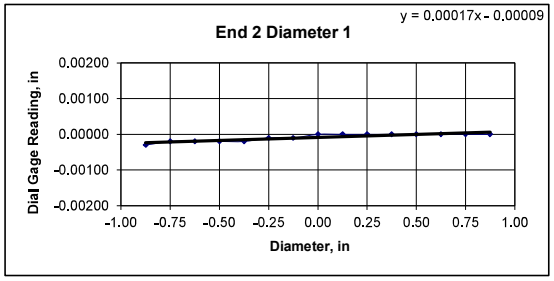
END 2	-0.875	-0.750	-0.625	-0.500	-0.375	-0.250	-0.125	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875
Diameter 1, in	-0.00030	-0.00020	-0.00020	-0.00020	-0.00020	-0.00010	-0.00010	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Diameter 2, in (rotated 90°)	-0.00060	-0.00050	-0.00050	-0.00040	-0.00030	-0.00020	-0.00010	0.00000	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010

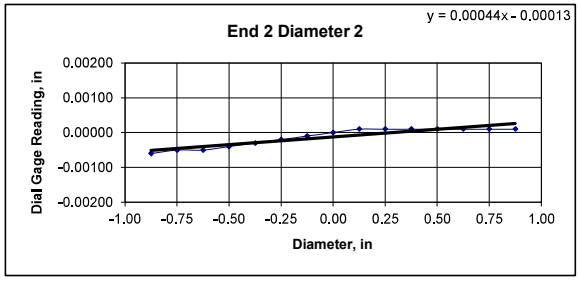
Difference between max and min readings, in:
0° = 0.0003 90° = 0.0007

Maximum difference must be < 0.0020 in. Difference = ± 0.00035
Flatness Tolerance Met? YES









DIAMETER 1

End 1:
Slope of Best Fit Line 0.00018
Angle of Best Fit Line: 0.01031

End 2:
Slope of Best Fit Line 0.00017
Angle of Best Fit Line: 0.00982

Maximum Angular Difference: 0.00049

Parallelism Tolerance Met? YES
Spherically Seated

DIAMETER 2

End 1:
Slope of Best Fit Line 0.00044
Angle of Best Fit Line: 0.02521

End 2:
Slope of Best Fit Line 0.00044
Angle of Best Fit Line: 0.02537

Maximum Angular Difference: 0.00016

Parallelism Tolerance Met? YES
Spherically Seated

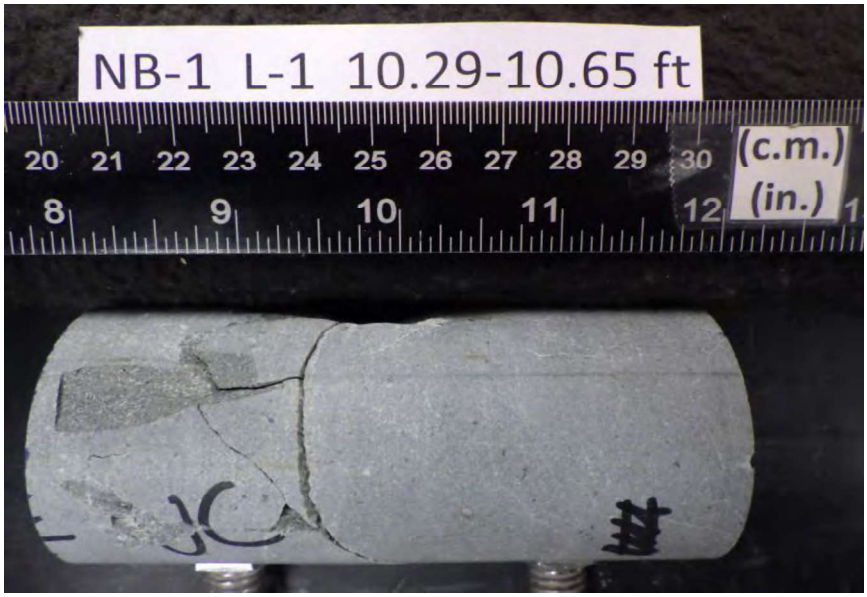
PERPENDICULARITY (Procedure P1) (Calculated from End Flatness and Parallelism measurements above)

END 1	Difference, Maximum and Minimum (in.)	Diameter (in.)	Slope	Angle°	Perpendicularity Tolerance Met?
Diameter 1, in	0.00040	1.990	0.00020	0.012	YES
Diameter 2, in (rotated 90°)	0.00070	1.990	0.00035	0.020	YES
END 2					
Diameter 1, in	0.00030	1.990	0.00015	0.009	YES
Diameter 2, in (rotated 90°)	0.00070	1.990	0.00035	0.020	YES

Maximum angle of departure must be ≤ 0.25°
Perpendicularity Tolerance Met? YES

Client:	Nobis Engineering, Inc.
Project Name:	Market Landing Park
Project Location:	Newburyport, MA
GTX #:	315068
Test Date:	3/3/2022
Tested By:	kdp/bp
Checked By:	smd
Boring ID:	NB-1
Sample ID:	L-1
Depth, ft:	10.29-10.65

After cutting and grinding



After break

Client:	Nobis Engineering, Inc.				
Project:	Market Landing Park				
Location:	Newburyport, MA			Project No:	GTX-315068
Boring ID:	NB-1, NB-3	Sample Type:	jar	Tested By:	amp
Sample ID:	S-1, S-2	Test Date:	02/24/22	Checked By:	bfs
Depth :	6'-7.8', 2'-4'	Test Id:	659493		
Test Comment:	---				
Visual Description:	Moist, brown silt with gravel				
Sample Comment:	---				

pH of Soil by ASTM D4972

Boring ID	Sample ID	Depth	Visual Description	pH of Soil in Distilled Water	pH of Soil in Calcium Chloride
NB-1, NB-3	S-1, S-2	6'-7.8', 2'-4'	Moist, brown silt with gravel	6.2	6.1

Notes: Sample Preparation: screened through #10 sieve

Method A, pH meter used

Client:	Nobis Engineering, Inc.
Project:	Market Landing Park
Location:	Newburyport, MA
GTX#:	315068
Test Date:	02/24/22
Tested By:	AMP
Checked By:	bfs

Laboratory Measurement of Soil Resistivity Using the Wenner Four-Electrode Method by ASTM G57 (Laboratory Measurement)

Boring ID	Sample ID	Depth, ft.	Sample Description	Electrical Resistivity, ohm-cm	Electrical Conductivity, $(ohm\text{-}cm)^{-1}$
NB-1, NB-3	S-1, S-2	6-7.8/2-4	Moist, brown silt with gravel	2,479	4.03E-04

Notes: Test Equipment: Nilsson Model 400 Soil Resistance Meter, MC Miller Soil Box
Water added to sample to create a thick slurry prior to testing (saturated condition).
Electrical Conductivity is calculated as inverse of Electrical Resistivity (per ASTM G57)
Test conducted in standard laboratory atmosphere: 68-73 F

PO Box 572455 / Salt Lake City UT 84157-2455 / USA
TEL +1 801 262 2448 · FAX +1 801 262 9870 · www.TEi-TS.com

GEOTESTING EPXRESS INCORPORATED
125 NAGOG PARK
ACTON MA 01720-3451
USA

Analysis No.	TS-A2210157
Report Date	24 February 2022
Date Sampled	18 February 2022
Date Received	22 February 2022
Where Sampled	Acton, MA USA
Sampled By	Client

This is to attest that we have examined: Soil: Project: Market Landing Park; Site Location: Newburyport, MA; Job Number: GTX-315068

When examined to the applicable requirements of:

ASTM D 512-12*	"Standard Test Methods for Chloride Ion in Water" Method B
ASTM D 516-16	"Standard Test Method for Sulfate Ion in Water"
ASTM G 200-20	"Standard Test Method for Measurement of Oxidation-Reduction Potential (ORP) of Soil"

Results:

ASTM D512 - Chloride Method B

Sample		Results		Detection Limit
		ppm (mg/kg)	%[1]	
NB-1, NB-3		39.	0.0039	10.
S-1, S-2	6-7.8 – 2-4'			

NOTE: [1]Percent by weight after drying and prepared as per the Standard. *Withdrawn 2021 without Replacement

ASTM D 516 – Sulfates (Soluble)

Sample		Results		Detection Limit
		ppm (mg/kg)	%[1]	
NB-1, NB-3		< 10.	< 0.0010	10.
S-1, S-2	6-7.8 – 2-4'			

NOTE: [1]Percent by weight after drying and prepared as per the Standard.

Testing Services analytical Laboratory
3455 South 500 West
Salt Lake City, UT 84115-4234 USA
TEL: +1 801 262 2448
FAX: +1 801 262 9870

ASTM G 200 – Reduction Oxidation Potential (REDOX)

Sample		Results	Detection Limit
NB-1, NB-3		122.8 @ 19.7 ºC	0.1mV
S-1, S-2	6-7.8 – 2-4'		

NOTE: Prepared as per the Standard.

END OF ANALYSIS

USEPA Laboratory ID UT00930

Merrill Gee P.E. – Engineer in Charge

APPENDIX D – STORMWATER CALCULATIONS

NRCC Rainfall Data

IDF Input Table

SewerGEM Flextables

Contech Design Summary

Water Quality Calculations

TSS Removal Calculations

NRCC RAINFALL DATA

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	Massachusetts
Location	
Longitude	70.877 degrees West
Latitude	42.813 degrees North
Elevation	0 feet
Date/Time	Mon, 11 Jul 2022 09:49:08 -0400

Extreme Precipitation Estimates

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.27	0.41	0.51	0.67	0.83	1.06	**1yr**	0.72	0.99	1.24	1.59	2.06	2.70	2.99	**1yr**	2.39	2.87	3.30	4.01	4.69	**1yr**
2yr	0.33	0.51	0.63	0.83	1.04	1.33	**2yr**	0.90	1.21	1.54	1.97	2.52	3.23	3.60	**2yr**	2.86	3.46	3.98	4.72	5.39	**2yr**
5yr	0.39	0.60	0.76	1.01	1.29	1.66	**5yr**	1.12	1.52	1.95	2.50	3.20	4.12	4.63	**5yr**	3.65	4.45	5.12	6.04	6.80	**5yr**
10yr	0.43	0.68	0.86	1.17	1.52	1.98	**10yr**	1.31	1.80	2.33	3.00	3.85	4.96	5.60	**10yr**	4.39	5.38	6.20	7.27	8.10	**10yr**
25yr	0.51	0.81	1.03	1.42	1.89	2.47	**25yr**	1.63	2.26	2.93	3.80	4.92	6.34	7.20	**25yr**	5.61	6.92	7.98	9.31	10.23	**25yr**
50yr	0.57	0.91	1.17	1.64	2.23	2.96	**50yr**	1.92	2.68	3.52	4.58	5.93	7.63	8.72	**50yr**	6.75	8.38	9.68	11.23	12.21	**50yr**
100yr	0.65	1.05	1.36	1.92	2.62	3.51	**100yr**	2.26	3.19	4.19	5.48	7.12	9.20	10.55	**100yr**	8.14	10.15	11.73	13.55	14.58	**100yr**
200yr	0.74	1.21	1.57	2.25	3.09	4.17	**200yr**	2.67	3.79	5.00	6.57	8.56	11.09	12.78	**200yr**	9.81	12.29	14.22	16.35	17.42	**200yr**
500yr	0.89	1.46	1.90	2.75	3.85	5.25	**500yr**	3.33	4.76	6.32	8.36	10.94	14.21	16.46	**500yr**	12.57	15.83	18.35	20.97	22.04	**500yr**

Lower Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.24	0.37	0.45	0.60	0.74	0.87	**1yr**	0.64	0.86	0.99	1.31	1.64	2.51	2.62	**1yr**	2.22	2.52	2.97	3.57	4.26	**1yr**
2yr	0.32	0.49	0.61	0.82	1.01	1.21	**2yr**	0.88	1.19	1.39	1.83	2.34	3.18	3.54	**2yr**	2.81	3.40	3.89	4.62	5.31	**2yr**
5yr	0.37	0.56	0.70	0.96	1.22	1.45	**5yr**	1.05	1.42	1.64	2.13	2.73	3.86	4.33	**5yr**	3.42	4.16	4.79	5.66	6.39	**5yr**
10yr	0.41	0.63	0.77	1.08	1.40	1.67	**10yr**	1.21	1.63	1.85	2.39	3.06	4.47	5.03	**10yr**	3.96	4.84	5.59	6.54	7.32	**10yr**
25yr	0.47	0.71	0.89	1.27	1.67	2.00	**25yr**	1.44	1.95	2.16	2.77	3.55	5.41	6.14	**25yr**	4.79	5.91	6.83	7.87	8.76	**25yr**
50yr	0.52	0.79	0.99	1.42	1.91	2.30	**50yr**	1.65	2.25	2.43	3.09	3.97	6.24	7.13	**50yr**	5.52	6.85	7.94	9.06	10.01	**50yr**
100yr	0.59	0.89	1.11	1.61	2.20	2.64	**100yr**	1.90	2.58	2.73	3.44	4.42	7.18	8.26	**100yr**	6.35	7.94	9.24	10.41	11.39	**100yr**
200yr	0.66	0.99	1.26	1.82	2.53	3.03	**200yr**	2.19	2.96	3.06	3.82	4.91	8.25	9.59	**200yr**	7.30	9.22	10.73	11.92	12.97	**200yr**
500yr	0.77	1.15	1.48	2.16	3.07	3.66	**500yr**	2.65	3.58	3.57	4.39	5.67	9.85	11.64	**500yr**	8.72	11.20	13.07	14.16	15.38	**500yr**

Upper Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.29	0.45	0.55	0.74	0.91	1.08	**1yr**	0.78	1.06	1.31	1.71	2.17	2.88	3.18	**1yr**	2.55	3.06	3.55	4.35	4.99	**1yr**
2yr	0.34	0.53	0.65	0.88	1.08	1.30	**2yr**	0.94	1.27	1.50	1.97	2.51	3.31	3.69	**2yr**	2.93	3.55	4.09	4.90	5.56	**2yr**
5yr	0.42	0.64	0.80	1.09	1.39	1.68	**5yr**	1.20	1.64	1.93	2.54	3.24	4.40	4.94	**5yr**	3.90	4.75	5.48	6.45	7.24	**5yr**
10yr	0.50	0.76	0.94	1.32	1.70	2.06	**10yr**	1.47	2.02	2.35	3.11	3.93	5.49	6.17	**10yr**	4.86	5.94	6.89	8.05	8.91	**10yr**
25yr	0.62	0.95	1.18	1.68	2.21	2.70	**25yr**	1.91	2.64	3.05	4.06	5.09	7.37	8.32	**25yr**	6.53	8.00	9.31	10.81	11.74	**25yr**
50yr	0.74	1.12	1.40	2.01	2.70	3.31	**50yr**	2.33	3.24	3.73	4.97	6.22	9.24	10.43	**50yr**	8.18	10.03	11.74	13.53	14.46	**50yr**
100yr	0.88	1.33	1.67	2.41	3.30	4.06	**100yr**	2.85	3.97	4.56	6.11	7.60	11.61	13.09	**100yr**	10.28	12.59	14.77	17.01	17.83	**100yr**
200yr	1.04	1.57	1.99	2.88	4.02	4.98	**200yr**	3.47	4.87	5.59	7.50	9.28	14.62	16.45	**200yr**	12.93	15.82	18.65	21.35	21.99	**200yr**
500yr	1.32	1.97	2.53	3.67	5.22	6.52	**500yr**	4.51	6.37	7.31	9.88	12.12	19.86	22.25	**500yr**	17.57	21.40	25.30	28.85	29.12	**500yr**

Powered by ACIS Northeast Regional Climate Center

IDF INPUT TABLE

Storm Data Detailed Report: IDF Table_July 2022

Element Details

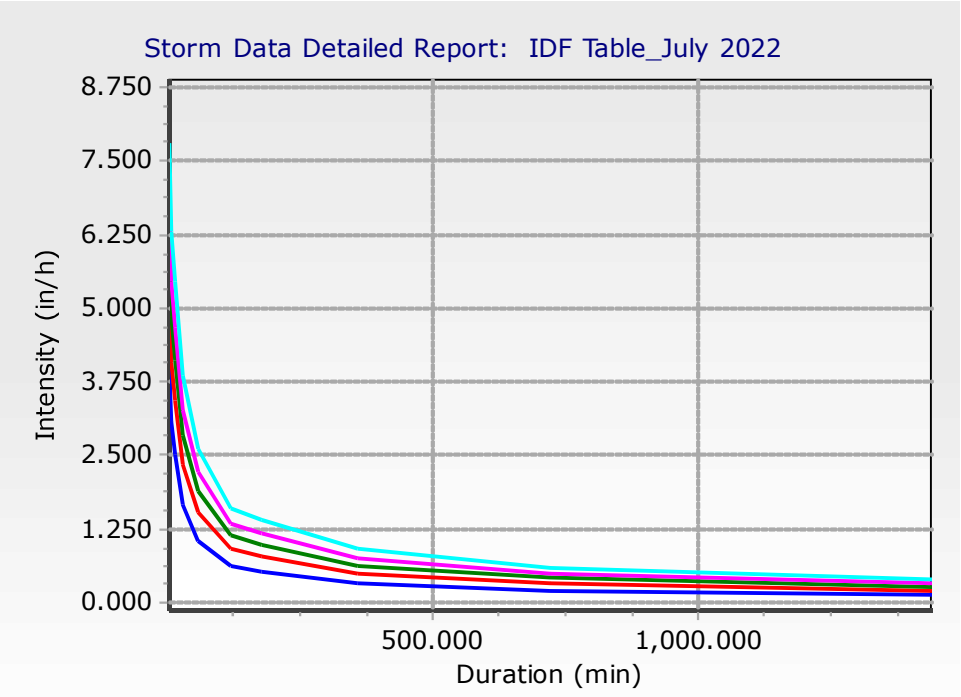
ID	251	Notes	
Label	IDF Table_July 2022		

Duration (min)	2 Year (in/h)	10 Year (in/h)	25 Year (in/h)	50 Year (in/h)	100 Year (in/h)
5.000	3.960	5.160	6.120	6.840	7.800
10.000	3.060	4.080	4.860	5.460	6.300
15.000	2.520	3.440	4.120	4.680	5.440
30.000	1.660	2.340	2.840	3.280	3.840
60.000	1.040	1.520	1.890	2.230	2.620
120.000	0.610	0.900	1.130	1.340	1.600
180.000	0.510	0.780	0.980	1.170	1.400
360.000	0.330	0.500	0.630	0.760	0.910
720.000	0.210	0.320	0.410	0.490	0.590
1,440.000	0.130	0.210	0.260	0.320	0.380

Library Status Summary

	Synchronization Details
ID	251
Label	IDF Table_July 2022
Modified Date	7/11/2022 9:58:52 PM
Library Source	Orphan (local)
Library Modified Date	Orphan (local)
Synchronization Status	Orphan (local)
Engineering Reference Guid	Orphan (local)

Storm Data Detailed Report: IDF Table_July 2022



SEWERGEM FLEXTABLES

CATCHMENT TABLE						
Label	**Outflow Element**	**Area (User Defined)**	**Runoff Coefficient (Rational)**	**Time of Concentration (minutes)**	**Catchment Intensity (in/h)**	**Flow (Total Out) (cfs)**
CM-1	DMH P1	34.16	0.85	5	6.12	179.12
CM-2	CB-P2	0.175	0.9	5	6.12	0.97
CM-3	AD 206	0.18	0.2	5	6.12	0.22
CM-4	EX CB 400B	0.089	0.9	5	6.12	0.49
CM-5	EX CB 400A	0.1	0.9	5	6.12	0.56
CM-6	CB 401	0.067	0.9	5	6.12	0.37
CM-7	EX CB 400C	0.294	0.9	5	6.12	1.63
CM-8	AD 401	0.244	0.25	5	6.12	0.38
CM-9	CB 201 (WQI)	0.186	0.9	5	6.12	1.03
CM-10	EX CB 203	0.1	0.9	5	6.12	0.56
CM-12	CB 202	0.175	0.9	5	6.12	0.97
CM-13	CB 204 (WQI)	0.11	0.9	5	6.12	0.61
CM-14	AD 201	0.092	0.5	5	6.12	0.28
CM-15	AD 202	0.094	0.5	5	6.12	0.29
CM-16	AD 203	0.115	0.5	5	6.12	0.35
CM-17	AD 204	0.129	0.5	5	6.12	0.4
CM-18	AD 205	0.199	0.5	5	6.12	0.61
CM-19	AD 101	0.11	0.5	5	6.12	0.34
CM-20	AD 102	0.05	0.5	5	6.12	0.15
CM-21	AD 103	0.2	0.2	5	6.12	0.25
CM-22	AD 104	0.048	0.5	5	6.12	0.15
CM-23	AD 105	0.037	0.5	5	6.12	0.11
CM-24	AD 106	0.04	0.5	5	6.12	0.12
CM-25	CB 101	0.25	0.9	5	6.12	1.39
CM-26	CB 102	0.349	0.9	5	6.12	1.94
CM-27	CB-P2	0.075	0.9	5	6.12	0.42
CM-28	CB-P2	0.079	0.9	5	6.12	0.44
CM-30	AD 102A	0.05	0.9	5	6.12	0.28
ROOF LEADER	ROOF LEADER 1	0.032	0.95	5	6.12	0.19

SEWERGEM FLEXTABLES

CONDITION 1: EXISTING 30" OF TO REMAIN AT DP-2

CATCH BASIN TABLE											
Label	Elevation (Rim) (ft)	Elevation (invert) (ft)	Capture Efficiency (Calculated) (%)	Flow (Captured) (cfs)	Inlet	Inlet Location	Headloss Method	Depth (Gutter) (in)	Flow (Additional Subsurface) (cfs)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
AD 101	9.78	5.9	100	0.34	18" AD	In Sag	AASHTO	1.3	0	7.39	7.38
AD 102	9.35	5	100	0.15	18" AD	In Sag	AASHTO	0.9	0	7.38	7.37
AD 102A	9.35	5.5	100	0.28	18" AD	In Sag	AASHTO	1.2	0	7.38	7.38
AD 103	9.75	4.81	100	0.25	18" AD	In Sag	AASHTO	1.1	0	7.34	7.34
AD 104	9.9	4.02	100	0.15	18" AD	In Sag	AASHTO	0.9	0	7.34	7.33
AD 105	9.75	3.79	100	0.11	18" AD	In Sag	AASHTO	0.8	0	7.31	7.29
AD 106	9	3.09	100	0.12	18" AD	In Sag	AASHTO	0.8	0	7.24	7.19
AD 201	9.8	6.79	100	0.28	18" AD	In Sag	AASHTO	1.2	0	8.93	8.92
AD 202	10	5.85	100	0.29	18" AD	In Sag	AASHTO	1.2	0	8.92	8.91
AD 203	8.9	4.86	100	0.35	18" AD	In Sag	AASHTO	1.4	0	8.91	8.9
AD 204	8.9	4.7	100	0.4	18" AD	In Sag	AASHTO	1.5	0	8.91	8.9
AD 205	9.8	3.3	100	0.61	18" AD	In Sag	AASHTO	1.9	0	9.18	9.15
AD 206	9	2.08	100	0.22	18" AD	In Sag	AASHTO	1.1	0	9	9
AD 401	11.2	6.77	100	0.38	18" AD	In Sag	AASHTO	1.4	0	10.13	10.13
CB 101	8.5	5.5	100	1.39	24" CB	In Sag	AASHTO	2.6	0	7.24	7.22
CB 102	6.55	2.57	100	1.94	24" CB	In Sag	AASHTO	3.1	0	6.58	6.55
CB 201 (WQI)	10.8	4.18	100	1.03	24" CB	In Sag	AASHTO	2.2	0	10.12	10.1
CB 202	9.5	5.5	100	0.97	24" CB	In Sag	AASHTO	2.1	0	9.51	9.5
CB 204 (WQI)	10.5	4.3	100	0.61	24" CB	In Sag	AASHTO	1.6	0	10.39	10.34
CB 401	11.3	5.98	100	0.37	24" CB	In Sag	AASHTO	1.2	0	10.36	10.36
CB-P2	10.19	1.64	100	1.83	24" x 48" Grate Type 4 DCB	In Sag	AASHTO	2.5	0	11.33	10.19
EX CB 203	9.4	5.4	100	0.56	24" CB	In Sag	AASHTO	1.6	0	9.4	9.4
EX CB 400A	10.8	5.5	100	0.56	24" CB	In Sag	AASHTO	1.5	0	10.4	10.4
EX CB 400B	10.53	5.5	100	0.49	24" CB	In Sag	AASHTO	1.5	0	10.4	10.4
EX CB 400C	9.72	5	100	1.63	24" CB	In Sag	AASHTO	2.9	0	9.74	9.72
ROOF LEADER 1	15	14.15	100	0.19	4" ROOF CONNECTION	In Sag	AASHTO	0.9	0	14.43	14.39

CONDUIT TABLE																		
Label	Start Node	Elevation Ground (Start) (ft)	Invert (Start) (ft)	Cover (Start) (ft)	Stop Node	Invert (Stop) (ft)	Cover (Stop) (ft)	Length (Scaled) (ft)	Slope (Calculated) (ft/ft)	Diameter (in)	Material	Manning's n	Capacity (Full Flow) (cfs)	Area (Full Flow) (ft^2)	Flow (cfs)	Velocity (ft/s)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Velocity (Full Flow) (ft/s)
P1	DMH P1	11.03	2.6	3.43	CB-P2	1.64	3.55	106.9	0.009	60	Corrugate	0.012	267.37	19.6	179.12	9.12	10.62	10.19	267.37
P4	DMH P4	9.1	-1.9	8.5	OF 33	-2.1	7.99	41.2	0.005	30	Concrete	0.013	28.57	4.9	129.09	26.3	10.98	6.9	28.57
P3	DMH P3	11.26	-0.23	6.49	DMH P4	-1.9	6	130.5	0.013	60	Corrugate	0.012	319.14	19.6	145.88	7.43	9.45	9.1	319.14
CO-21	DMH 402 (WQU)	11.35	5	5.35	CB-P2	4.1	5.09	100.4	0.009	12	Concrete	0.013	3.37	0.8	1.24	1.58	10.31	10.19	3.37
CO-25	CB 401	11.3	5.98	4.32	DMH 402 (WQU)	5.1	5.25	87.6	0.01	12	Corrugate	0.012	3.87	0.8	0.37	0.47	10.36	10.35	3.87
CO-20	EX DMH 401	10.73	5.3	4.43	DMH 402 (WQU)	5	5.35	48	0.006	12	Corrugate	0.012	3.05	0.8	1.03	1.31	10.38	10.35	3.05
CO-24	EX CB 400A	10.8	5.5	4.3	EX DMH 401	5.3	4.43	18	0.011	12	Concrete	0.013	3.75	0.8	0.56	0.71	10.4	10.4	3.75
CO-26	EX CB 400B	10.53	5.5	4.03	EX DMH 401	5.3	4.43	12.6	0.016	12	Concrete	0.013	4.49	0.8	0.49	0.63	10.4	10.4	4.49
CO-27	EX CB 400C	9.72	5	3.72	CB-P2	4.7	4.49	40.8	0.007	12	Concrete	0.013	3.05	0.8	1.63	2.08	10.28	10.19	3.05
CO-28	AD 401	11.2	6.77	3.43	CB 201 (WQI)	4.28	5.52	147.1	0.017	12	Corrugate	0.012	5.02	0.8	0.38	0.48	10.13	10.12	5.02
CO-29	CB 201 (WQI)	10.8	4.18	5.62	DMH P3	2.77	7.49	47.2	0.03	12	Corrugate	0.012	6.67	0.8	1.11	1.42	10.1	10.06	6.67
CO-44	EX CB 203	9.4	6.4	2	DMH 201	5.98	2.94	41.9	0.01	12	Corrugate	0.012	3.87	0.8	0.56	0.71	9.93	9.92	3.87
CO-32	CB 202	9.5	5.5	3	CB 204 (WQI)	4.65	4.85	56.6	0.015	12	Corrugate	0.012	4.73	0.8	0.97	1.24	10.42	10.39	4.73
CO-31	CB 204 (WQI)	10.5	4.55	4.95	DMH P3	2.77	7.49	117.2	0.015	12	Corrugate	0.012	4.76	0.8	1.87	2.39	10.34	10.06	4.76
P2	CB-P2	10.19	1.64	3.55	DMH P3	-0.23	6.49	172.6	0.011	60	Corrugate	0.012	293.65	19.6	152.61	7.77	10.57	10.06	293.65
CO-33	AD 201	9.8	6.79	2.01	AD 202	5.85	3.15	93.7	0.01	12	Corrugate	0.012	3.87	0.8	0.28	0.36	8.92	8.92	3.87
CO-34	AD 202	10	5.85	3.15	AD 203	4.86	3.04	99.4	0.01	12	Corrugate	0.012	3.85	0.8	0.47	0.6	8.91	8.9	3.85
CO-35	AD 203	8.9	4.86	3.04	AD 204	4.7	3.2	15.6	0.01	12	Corrugate	0.012	3.9	0.8	0.69	0.88	8.9	8.9	3.90
CO-36	AD 204	8.9	4.7	3.2	AD 205	3.3	5.5	140.5	0.01	12	Corrugate	0.012	3.85	0.8	0.98	1.24	9.27	9.18	3.85
CO-37	AD 205	9.8	3.3	5.5	DMH P4	1.1	7	44.6	0.049	12	Corrugate	0.012	8.57	0.8	1.34	1.71	9.15	9.1	8.57
CO-38	AD 206	9	2.08	5.92	DMH P4	1.1	7	12.3	0.08	12	Corrugate	0.012	10.89	0.8	0.22	0.28	9.1	9.1	10.89
CO-48	CB 101	8.5	5.5	2	DMH 101	2.73	5.67	45.8	0.06	12	Corrugate	0.012	9.49	0.8	1.39	1.77	7.22	7.16	9.49
CO-47	AD 103	9.75	4.81	3.94	AD 104	4.02	4.88	30.1	0.026	12	Corrugate	0.012	6.25	0.8	0.25	0.31	7.34	7.34	6.25
CO-50	AD 101	9.78	5.9	2.88	AD 102	5	3.35	85.7	0.011	12	Corrugate	0.012	3.96	0.8	0.34	0.43	7.38	7.38	3.96
CO-44	AD 102	9.35	5	3.35	AD 104	4.02	4.88	98.5	0.01	12	Corrugate	0.012	3.85	0.8	0.67	0.85	7.37	7.34	3.85
CO-45	AD 104	9.9	4.02	4.88	AD 105	3.79	4.96	22.8	0.01	12	Corrugate	0.012	3.88	0.8	0.92	1.17	7.33	7.31	3.88
CO-46	AD 105	9.75	3.79	4.96	AD 106	3.09	4.91	69.5	0.01	12	Corrugate	0.012	3.87	0.8	1	1.27	7.29	7.24	3.87
CO-49	CB 102	6.55	2.57	2.98	DMH 102 (WQU)	2.23	5.91	17.2	0.02	12	Corrugate	0.012	5.44	0.8	1.94	2.47	6.89	6.85	5.44
CO-54	AD 106	9	3.09	4.91	DMH 101	2.66	5.74	42.3	0.01	12	Corrugate	0.012	3.89	0.8	1.06	1.36	7.19	7.16	3.89
CO-43	DMH 102 (WQU)	9.14	1.63	6.52	EX DMH 103	1.03	4.14	59.7	0.01	12	Corrugate	0.012	3.86	0.8	3.47	4.41	6.65	6.17	3.86
CO-52	ROOF LEADER 1	15	14.15	0.52	CO-1	11.76	1.2	77.2	0.031	4	Corrugate	0.012	0.36	0.1	0.19	4.19	14.39	12.09	0.36
CO-53	CO-1	13.29	11.76	1.2	OUTLET INTO EXIS	11.29	1.67	11.7	0.04	4	Corrugate	0.012	0.41	0.1	0.19	4.61	12	11.45	0.41
CO-56	DMH 101	9.4	2.66	5.74	DMH 102 (WQU)	1.73	6.41	83.5	0.011	12	Corrugate	0.012	4.07	0.8	2.08	2.65	7.09	6.85	4.07
CO-30	DMH 201	9.92	5.88	3.04	CB 204 (WQI)	5.06	4.44	81.3	0.01	12	Corrugate	0.012	3.88	0.8	0.53	0.68	10.4	10.39	3.88

MANHOLE TABLE					
Label	Elevation (Ground) (ft)	Elevation (Invert) (ft)	Headloss Method	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
CO-1	13.29	11.76	AASHTO	12.09	12
DMH 101	9.4	2.66	AASHTO	7.16	7.09
DMH 102 (WQU)	9.14	1.6	AASHTO	6.85	6.65
DMH 201	9.92	4.93	AASHTO	9.93	9.92
DMH 402 (WQU)	11.35	5	AASHTO	10.35	10.31
DMH P1	11.03	2.6	AASHTO	11.04	10.62
DMH P3	11.26	-0.23	AASHTO	10.06	9.45
DMH P4	9.1	-1.9	AASHTO	12.26	9.1
EX DMH 103	6.17	-1.8	AASHTO	6.47	6.17
EX DMH 401	10.73	5.3	AASHTO	10.4	10.38

SEWERGEM FLEXTABLES

CONDITION 2: OF AT DP-2 UPGRADED FROM 30" OF TO 60" OF

CATCH BASIN TABLE											
Label	Elevation (Rim) (ft)	Elevation (invert) (ft)	Capture Efficiency (Calculated) (%)	Flow (Captured) (cfs)	Inlet	Inlet Location	Headloss Method	Depth (Gutter) (in)	Flow (Additional Subsurface) (cfs)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
AD 101	9.78	5.9	100	0.34	18" AD	In Sag	AASHTO	1.3	0	7.39	7.38
AD 102	9.35	5	100	0.15	18" AD	In Sag	AASHTO	0.9	0	7.38	7.37
AD 102A	9.35	5.5	100	0.28	18" AD	In Sag	AASHTO	1.2	0	7.38	7.38
AD 103	9.75	4.81	100	0.25	18" AD	In Sag	AASHTO	1.1	0	7.34	7.34
AD 104	9.9	4.02	100	0.15	18" AD	In Sag	AASHTO	0.9	0	7.34	7.33
AD 105	9.75	3.79	100	0.11	18" AD	In Sag	AASHTO	0.8	0	7.31	7.29
AD 106	9	3.09	100	0.12	18" AD	In Sag	AASHTO	0.8	0	7.24	7.19
AD 201	9.8	6.79	100	0.28	18" AD	In Sag	AASHTO	1.2	0	7.84	7.84
AD 202	10	5.85	100	0.29	18" AD	In Sag	AASHTO	1.2	0	7.84	7.83
AD 203	8.9	4.86	100	0.35	18" AD	In Sag	AASHTO	1.4	0	7.82	7.81
AD 204	8.9	4.7	100	0.4	18" AD	In Sag	AASHTO	1.5	0	7.81	7.79
AD 205	9.8	3.3	100	0.61	18" AD	In Sag	AASHTO	1.9	0	7.7	7.68
AD 206	9	2.08	100	0.22	18" AD	In Sag	AASHTO	1.1	0	7.63	7.62
AD 401	11.2	6.77	100	0.38	18" AD	In Sag	AASHTO	1.4	0	8.66	8.65
CB 101	8.5	5.5	100	1.39	24" CB	In Sag	AASHTO	2.6	0	7.24	7.22
CB 102	6.55	2.57	100	1.94	24" CB	In Sag	AASHTO	3.1	0	6.58	6.55
CB 201 (WQI)	10.8	4.18	100	1.03	24" CB	In Sag	AASHTO	2.2	0	8.64	8.63
CB 202	9.5	5.5	100	0.97	24" CB	In Sag	AASHTO	2.1	0	8.95	8.95
CB 204 (WQI)	10.5	4.3	100	0.61	24" CB	In Sag	AASHTO	1.6	0	8.91	8.86
CB 401	11.3	5.98	100	0.37	24" CB	In Sag	AASHTO	1.2	0	10.36	10.36
CB-P2	10.19	1.64	100	1.83	24" x 48" Grate Type 4 DCB	In Sag	AASHTO	2.5	0	10.23	9.09
EX CB 203	9.4	5.4	100	0.56	24" CB	In Sag	AASHTO	1.6	0	8.95	8.94
EX CB 400A	10.8	5.5	100	0.56	24" CB	In Sag	AASHTO	1.5	0	10.4	10.4
EX CB 400B	10.53	5.5	100	0.49	24" CB	In Sag	AASHTO	1.5	0	10.4	10.4
EX CB 400C	9.72	5	100	1.63	24" CB	In Sag	AASHTO	2.9	0	9.74	9.72
ROOF LEADER 1	15	14.15	100	0.19	4" ROOF CONNECTION	In Sag	AASHTO	0.9	0	14.43	14.39

CONDUIT TABLE																			
Label	Start Node	Elevation Ground (Start) (ft)	Invert (Start) (ft)	Cover (Start) (ft)	Stop Node	Invert (Stop) (ft)	Cover (Stop) (ft)	Length (Scaled) (ft)	Slope (Calculated) (ft/ft)	Diameter (in)	Material	Manning's n	Capacity (Full Flow) (cfs)	Area (Full Flow) (ft^2)	Flow (cfs)	Velocity (ft/s)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Velocity (Full Flow) (ft/s)
P1	DMH P1	11.03	2.6	3.43	CB-P2	1.64	3.55	106.9	0.009	60	HDPE	0.012	267.37	19.6	179.12	9.12	10.62	10.19	267.37
P4	DMH P4	9.1	-1.9	6	OF 33	-2.3	5.69	41.2	0.01	60	HDPE	0.012	277.88	19.6	129.09	6.57	6.99	6.9	277.88
P3	DMH P3	11.26	-0.23	6.49	DMH P4	-1.9	6	130.5	0.013	60	HDPE	0.012	319.14	19.6	145.88	7.43	7.97	7.62	319.14
CO-21	DMH 402 (WQU)	11.35	5	5.35	CB-P2	4.1	5.09	100.4	0.009	12	Concrete	0.013	3.37	0.8	1.24	1.58	10.31	10.19	3.37
CO-25	CB 401	11.3	5.98	4.32	DMH 402 (WQU)	5.1	5.25	87.6	0.01	12	HDPE	0.012	3.87	0.8	0.37	0.47	10.36	10.35	3.87
CO-20	EX DMH 401	10.73	5.3	4.43	DMH 402 (WQU)	5	5.35	48	0.006	12	HDPE	0.012	3.05	0.8	1.03	1.31	10.38	10.35	3.05
CO-24	EX CB 400A	10.8	5.5	4.3	EX DMH 401	5.3	4.43	18	0.011	12	Concrete	0.013	3.75	0.8	0.56	0.71	10.4	10.4	3.75
CO-26	EX CB 400B	10.53	5.5	4.03	EX DMH 401	5.3	4.43	12.6	0.016	12	Concrete	0.013	4.49	0.8	0.49	0.63	10.4	10.4	4.49
CO-27	EX CB 400C	9.72	5	3.72	CB-P2	4.7	4.49	40.8	0.007	12	Concrete	0.013	3.05	0.8	1.63	2.08	10.28	10.19	3.05
CO-28	AD 401	11.2	6.77	3.43	CB 201 (WQI)	4.28	5.52	147.1	0.017	12	HDPE	0.012	5.02	0.8	0.38	0.48	8.65	8.64	5.02
CO-29	CB 201 (WQI)	10.8	4.18	5.62	DMH P3	2.77	7.49	47.2	0.03	12	HDPE	0.012	6.67	0.8	1.11	1.42	8.63	8.59	6.67
CO-44	EX CB 203	9.4	6.4	2	DMH 201	5.98	2.94	41.9	0.01	12	HDPE	0.012	3.87	0.8	0.56	0.71	8.94	8.93	3.87
CO-32	CB 202	9.5	5.5	3	CB 204 (WQI)	4.65	4.85	56.6	0.015	12	HDPE	0.012	4.73	0.8	0.97	1.24	8.95	8.91	4.73
CO-31	CB 204 (WQI)	10.5	4.55	4.95	DMH P3	2.77	7.49	117.2	0.015	12	HDPE	0.012	4.76	0.8	1.87	2.39	8.86	8.59	4.76
P2	CB-P2	10.19	1.64	3.55	DMH P3	-0.23	6.49	172.6	0.011	60	HDPE	0.012	293.65	19.6	152.61	7.77	9.09	8.59	293.65
CO-33	AD 201	9.8	6.79	2.01	AD 202	5.85	3.15	93.7	0.01	12	HDPE	0.012	3.87	0.8	0.28	0.36	7.84	7.84	3.87
CO-34	AD 202	10	5.85	3.15	AD 203	4.86	3.04	99.4	0.01	12	HDPE	0.012	3.85	0.8	0.47	0.6	7.83	7.82	3.85
CO-35	AD 203	8.9	4.86	3.04	AD 204	4.7	3.2	15.6	0.01	12	HDPE	0.012	3.9	0.8	0.69	0.88	7.81	7.81	3.90
CO-36	AD 204	8.9	4.7	3.2	AD 205	3.3	5.5	140.5	0.01	12	HDPE	0.012	3.85	0.8	0.98	1.24	7.79	7.7	3.85
CO-37	AD 205	9.8	3.3	5.5	DMH P4	1.1	7	44.6	0.049	12	HDPE	0.012	8.57	0.8	1.34	1.71	7.68	7.62	8.57
CO-38	AD 206	9	2.08	5.92	DMH P4	1.1	7	12.3	0.08	12	HDPE	0.012	10.89	0.8	0.22	0.28	7.62	7.62	10.89
CO-48	CB 101	8.5	5.5	2	DMH 101	2.73	5.67	45.8	0.06	12	HDPE	0.012	9.49	0.8	1.39	1.77	7.22	7.16	9.49
CO-47	AD 103	9.75	4.81	3.94	AD 104	4.02	4.88	30.1	0.026	12	HDPE	0.012	6.25	0.8	0.25	0.31	7.34	7.34	6.25
CO-50	AD 101	9.78	5.9	2.88	AD 102	5	3.35	85.7	0.011	12	HDPE	0.012	3.96	0.8	0.34	0.43	7.38	7.38	3.96
CO-44	AD 102	9.35	5	3.35	AD 104	4.02	4.88	98.5	0.01	12	HDPE	0.012	3.85	0.8	0.67	0.85	7.37	7.34	3.85
CO-45	AD 104	9.9	4.02	4.88	AD 105	3.79	4.96	22.8	0.01	12	HDPE	0.012	3.88	0.8	0.92	1.17	7.33	7.31	3.88
CO-46	AD 105	9.75	3.79	4.96	AD 106	3.09	4.91	69.5	0.01	12	HDPE	0.012	3.87	0.8	1	1.27	7.29	7.24	3.87
CO-49	CB 102	6.55	2.57	2.98	DMH 102 (WQU)	2.23	5.91	17.2	0.02	12	HDPE	0.012	5.44	0.8	1.94	2.47	6.89	6.85	5.44
CO-54	AD 106	9	3.09	4.91	DMH 101	2.66	5.74	42.3	0.01	12	HDPE	0.012	3.89	0.8	1.06	1.36	7.19	7.16	3.89
CO-43	DMH 102 (WQU)	9.14	1.63	6.52	EX DMH 103	1.03	4.14	59.7	0.01	12	HDPE	0.012	3.86	0.8	3.47	4.41	6.65	6.17	3.86
CO-52	ROOF LEADER 1	15	14.15	0.52	CO-1	11.76	1.2	77.2	0.031	4	HDPE	0.012	0.36	0.1	0.19	4.19	14.39	12.09	0.36
CO-53	CO-1	13.29	11.76	1.2	OUTLET INTO EXIS	11.29	1.67	11.7	0.04	4	HDPE	0.012	0.41	0.1	0.19	4.61	12	11.45	0.41
CO-56	DMH 101	9.4	2.66	5.74	DMH 102 (WQU)	1.73	6.41	83.5	0.011	12	HDPE	0.012	4.07	0.8	2.08	2.65	7.09	6.85	4.07
CO-30	DMH 201	9.92	5.88	3.04	CB 204 (WQI)	5.06	4.44	81.3	0.01	12	HDPE	0.012	3.88	0.8	0.53	0.68	8.93	8.91	3.88

MANHOLE TABLE					
Label	Elevation (Ground) (ft)	Elevation (Invert) (ft)	Headloss Method	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
CO-1	13.29	11.76	AASHTO	12.09	12
DMH 101	9.4	2.66	AASHTO	7.16	7.09
DMH 102 (WQU)	9.14	1.6	AASHTO	6.85	6.65
DMH 201	9.92	4.93	AASHTO	8.93	8.93
DMH 402 (WQU)	11.35	5	AASHTO	10.35	10.31
DMH P1	11.03	2.6	AASHTO	11.04	10.62
DMH P3	11.26	-0.23	AASHTO	8.59	7.97
DMH P4	9.1	-1.9	AASHTO	7.62	6.99
EX DMH 103	6.17	-1.8	AASHTO	6.47	6.17
EX DMH 401	10.73	5.3	AASHTO	10.4	10.38

CONTECH DESIGN SUMMARY

CONTECH ENGINEERED SOLUTIONS

CDS TECHNOLOGIES

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

MARKET LANDING PARK EXPANSION
NEWBURYPORT, MA

Area	0.20 ac	Unit Site Designation	DMH 402
Weighted C	0.9	Rainfall Station #	69
t_c	5 min		
CDS Model	1515-3	CDS Treatment Capacity	**1.0 cfs**

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Incremental Removal (%)
0.02	10.2%	10.2%	0.00	0.00	10.2
0.04	9.6%	19.8%	0.01	0.01	9.6
0.06	9.4%	29.3%	0.01	0.01	9.4
0.08	7.7%	37.0%	0.01	0.01	7.7
0.10	8.6%	45.6%	0.02	0.02	8.6
0.12	6.3%	51.9%	0.02	0.02	6.3
0.14	4.7%	56.5%	0.03	0.03	4.7
0.16	4.6%	61.2%	0.03	0.03	4.6
0.18	3.5%	64.7%	0.03	0.03	3.5
0.20	4.3%	69.1%	0.04	0.04	4.3
0.25	8.0%	77.1%	0.05	0.05	7.9
0.30	5.6%	82.7%	0.05	0.05	5.5
0.35	4.4%	87.0%	0.06	0.06	4.3
0.40	2.5%	89.5%	0.07	0.07	2.5
0.45	2.5%	92.1%	0.08	0.08	2.5
0.50	1.4%	93.5%	0.09	0.09	1.3
0.75	5.0%	98.5%	0.14	0.14	4.8
1.00	1.0%	99.5%	0.18	0.18	0.9
1.50	0.0%	99.5%	0.27	0.27	0.0
2.00	0.0%	99.5%	0.36	0.36	0.0
3.00	0.5%	100.0%	0.54	0.54	0.4
					99.2
				Removal Efficiency Adjustment[2] =	6.5%
				Predicted % Annual Rainfall Treated =	93.5%
				Predicted Net Annual Load Removal Efficiency =	**92.7%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

Brief Stormceptor Sizing Report - DMH 402

Project Information & Location			
Project Name	Market Landing Park Expansion	**Project Number**	710623
City	Newburyport	**State/ Province**	Massachusetts
Country	United States of America	**Date**	5/12/2022
Designer Information		**EOR Information (optional)**	
Name	Jim Lyons	**Name**	Jamie Veillette
Company	Contech Engineered Solutions	**Company**	Sasaki
Phone #	413-246-5151	**Phone #**	617-923-7155
Email	jimlyons413@gmail.com	**Email**	jveillette@sasaki.com

Stormwater Treatment Recommendation
The recommended Stormceptor Model(s) which achieve or exceed the user defined water quality objective for each site within the project are listed in the below Sizing Summary table.

Site Name	DMH 402
Target TSS Removal (%)	80
TSS Removal (%) Provided	93
Recommended Stormceptor Model	STC 450i

The recommended Stormceptor Model achieves the water quality objectives based on the selected inputs, historical rainfall records and selected particle size distribution.

Stormceptor Sizing Summary	
Stormceptor Model	**% TSS Removal Provided**
STC 450i	93
STC 900	96
STC 1200	96
STC 1800	97
STC 2400	98
STC 3600	98
STC 4800	99
STC 6000	99
STC 7200	99
STC 11000	99
STC 13000	99
STC 16000	100

Sizing Details

Drainage Area

Total Area (acres)	0.2
Imperviousness %	100.0

Rainfall

Station Name	ROCKPORT 1 ESE
State/Province	Massachusetts
Station ID #	6977
Years of Records	36
Latitude	42°39'0"N
Longitude	70°36'0"W

Water Quality Objective

TSS Removal (%)	80.0
Runoff Volume Capture (%)	
Oil Spill Capture Volume (Gal)	
Peak Conveyed Flow Rate (CFS)	
Water Quality Flow Rate (CFS)	0.25

Up Stream Storage

Storage (ac-ft)	Discharge (cfs)
0.000	0.000

Up Stream Flow Diversion

Max. Flow to Stormceptor (cfs)	

Particle Size Distribution (PSD)
The selected PSD defines TSS removal

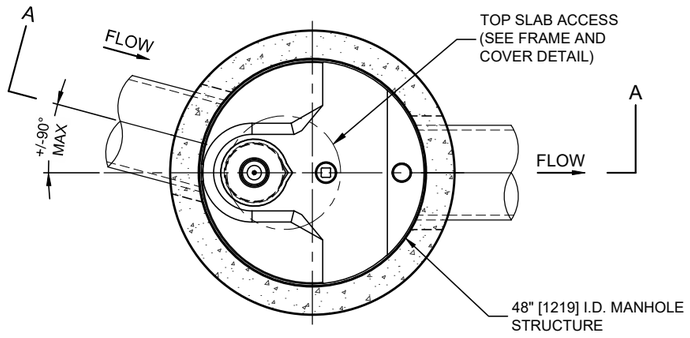
OK-110

Particle Diameter (microns)	Distribution %	Specific Gravity
1.0	0.0	2.65
53.0	3.0	2.65
75.0	15.0	2.65
88.0	25.0	2.65
106.0	41.0	2.65
125.0	15.0	2.65
150.0	1.0	2.65
212.0	0.0	2.65

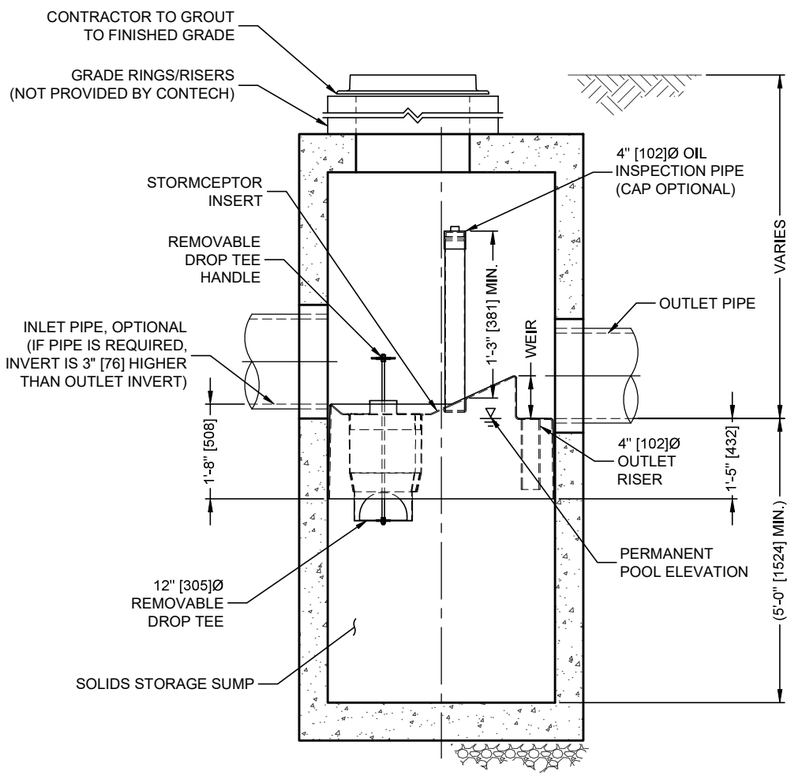
Notes

• Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor, which uses the EPA Rainfall and Runoff modules.
• Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal defined by the selected PSD, and based on stable site conditions only, after construction is completed.
• For submerged applications or sites specific to spill control, please contact your local Stormceptor representative for further design assistance.

For Stormceptor Specifications and Drawings Please Visit:
https://www.conteches.com/technical-guides/search?filter=1WBC0O5EYX



PLAN VIEW
TOP SLAB NOT SHOWN



SECTION A-A

Stormceptor®
FOR PATENT INFORMATION, GO TO www.ContechES.com/IP

STORMCEPTOR DESIGN NOTES

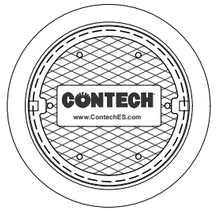
THE STANDARD STC450I CONFIGURATION WITH ROUND, SOLID FRAME AND COVER, AND INLET PIPE IS SHOWN. ALTERNATE CONFIGURATIONS ARE AVAILABLE AND ARE LISTED BELOW. SOME CONFIGURATIONS MAY BE COMBINED TO SUIT SITE REQUIREMENTS.

CONFIGURATION DESCRIPTION
GRATED INLET ONLY (NO INLET PIPE)
GRATED INLET WITH INLET PIPE OR PIPES
CURB INLET ONLY (NO INLET PIPE)
CURB INLET WITH INLET PIPE OR PIPES

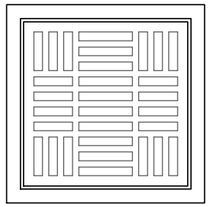
SITE SPECIFIC DATA REQUIREMENTS

STRUCTURE ID			
WATER QUALITY FLOW RATE (cfs [L/s])			
PEAK FLOW RATE (cfs [L/s])			
RETURN PERIOD OF PEAK FLOW (yrs)			
RIM ELEVATION			
PIPE DATA:	INVERT	MATERIAL	DIAMETER
INLET PIPE 1			
INLET PIPE 2			
OUTLET PIPE			

NOTES / SPECIAL REQUIREMENTS:



FRAME AND COVER
(MAY VARY)
NOT TO SCALE



FRAME AND GRATE
(MAY VARY)
NOT TO SCALE

GENERAL NOTES
1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. FOR SITE SPECIFIC DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHT, PLEASE CONTACT YOUR CONTECH ENGINEERED SOLUTIONS LLC REPRESENTATIVE. www.ContechES.com
3. STORMCEPTOR WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING. CONTRACTOR TO CONFIRM STRUCTURE MEETS REQUIREMENTS OF PROJECT.
4. STORMCEPTOR STRUCTURE SHALL MEET AASHTO HS20 LOAD RATING, ASSUMING EARTH COVER OF 0' - 2' [610], AND GROUNDWATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION. CASTINGS SHALL MEET AASHTO M306 AND BE CAST WITH THE CONTECH LOGO.
5. STORMCEPTOR STRUCTURE SHALL BE PRECAST CONCRETE CONFORMING TO ASTM C478 AND AASHTO LOAD FACTOR DESIGN METHOD.
6. ALTERNATE UNITS ARE SHOWN IN MILLIMETERS [mm].

INSTALLATION NOTES
A. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
B. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE STORMCEPTOR MANHOLE STRUCTURE.
C. CONTRACTOR TO INSTALL JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS AND ASSEMBLE STRUCTURE.
D. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT INLET AND OUTLET PIPE(S). MATCH PIPE INVERTS WITH ELEVATIONS SHOWN. ALL PIPE CENTERLINES TO MATCH PIPE OPENING CENTERLINES.
E. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

CONTECH ENGINEERED SOLUTIONS LLC
www.contechES.com
9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069
800-338-1122 513-645-7000 513-645-7993 FAX

STC450i
STORMCEPTOR
STANDARD DETAIL

I:\COMMON\CAD\TREATMENT\23 STORMCEPTOR\40 STANDARD DRAWINGS\IN PROCESS\STC450I-DTL.DWG 2/1/2019 3:12 PM

CONTECH ENGINEERED SOLUTIONS

CDS TECHNOLOGIES

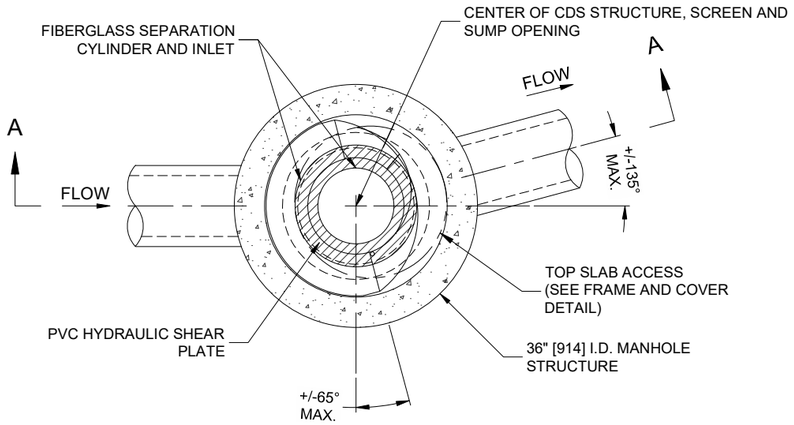
CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

MARKET LANDING PARK EXPANSION
NEWBURYPORT, MA

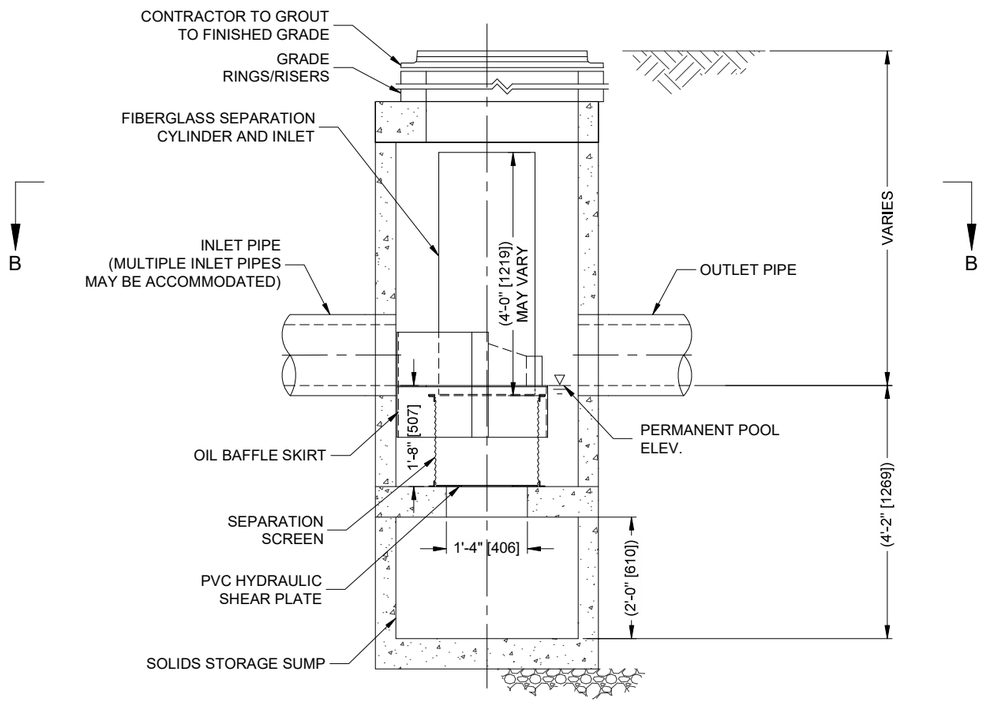
Area	0.65 ac	Unit Site Designation	DMH 102
Weighted C	0.9	Rainfall Station #	69
t_c	5 min		
CDS Model	1515-3	CDS Treatment Capacity	**1.0 cfs**

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	10.2
0.04	9.6%	19.8%	0.02	0.02	9.6
0.06	9.4%	29.3%	0.04	0.04	9.4
0.08	7.7%	37.0%	0.05	0.05	7.7
0.10	8.6%	45.6%	0.06	0.06	8.5
0.12	6.3%	51.9%	0.07	0.07	6.2
0.14	4.7%	56.5%	0.08	0.08	4.5
0.16	4.6%	61.2%	0.09	0.09	4.5
0.18	3.5%	64.7%	0.11	0.11	3.4
0.20	4.3%	69.1%	0.12	0.12	4.2
0.25	8.0%	77.1%	0.15	0.15	7.6
0.30	5.6%	82.7%	0.18	0.18	5.2
0.35	4.4%	87.0%	0.20	0.20	4.0
0.40	2.5%	89.5%	0.23	0.23	2.3
0.45	2.5%	92.1%	0.26	0.26	2.2
0.50	1.4%	93.5%	0.29	0.29	1.2
0.75	5.0%	98.5%	0.44	0.44	4.1
1.00	1.0%	99.5%	0.58	0.58	0.7
1.50	0.0%	99.5%	0.88	0.88	0.0
2.00	0.0%	99.5%	1.17	1.00	0.0
3.00	0.5%	100.0%	1.75	1.00	0.1
					95.6
				Removal Efficiency Adjustment[2] =	6.5%
				Predicted % Annual Rainfall Treated =	93.3%
				Predicted Net Annual Load Removal Efficiency =	**89.2%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.



PLAN VIEW B-B
N.T.S.

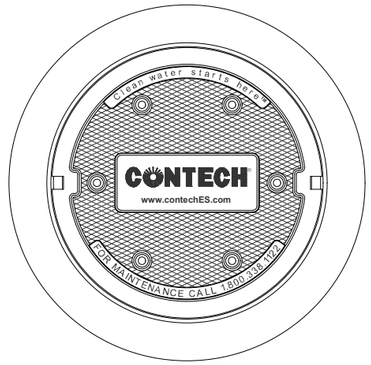


ELEVATION A-A
N.T.S.

CDS1515-3-C DESIGN NOTES

CDS1515-3-C RATED TREATMENT CAPACITY IS 1.0 CFS, OR PER LOCAL REGULATIONS.

THE STANDARD CDS1515-3-C CONFIGURATION IS SHOWN.



FRAME AND COVER
(DIAMETER VARIES)
N.T.S.

SITE SPECIFIC DATA REQUIREMENTS

STRUCTURE ID	
WATER QUALITY FLOW RATE (CFS OR L/s)	*
PEAK FLOW RATE (CFS OR L/s)	*
RETURN PERIOD OF PEAK FLOW (YRS)	*
SCREEN APERTURE (2400 OR 4700)	*

PIPE DATA:	I.E.	MATERIAL	DIAMETER
INLET PIPE 1	*	*	*
INLET PIPE 2	*	*	*
OUTLET PIPE	*	*	*

RIM ELEVATION	*

ANTI-FLOTATION BALLAST	WIDTH	HEIGHT
	*	*

NOTES/SPECIAL REQUIREMENTS:

* PER ENGINEER OF RECORD

GENERAL NOTES
1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. FOR SITE SPECIFIC DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHT, PLEASE CONTACT YOUR CONTECH ENGINEERED SOLUTIONS LLC REPRESENTATIVE. www.ContechES.com
3. CDS WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING. CONTRACTOR TO CONFIRM STRUCTURE MEETS REQUIREMENTS OF PROJECT.
4. STRUCTURE SHALL MEET AASHTO HS20 LOAD RATING, ASSUMING EARTH COVER OF 0' - 2', AND GROUNDWATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION. CASTINGS SHALL MEET AASHTO M306 AND BE CAST WITH THE CONTECH LOGO..
5. IF REQUIRED, PVC HYDRAULIC SHEAR PLATE IS PLACED ON SHELF AT BOTTOM OF SCREEN CYLINDER. REMOVE AND REPLACE AS NECESSARY DURING MAINTENANCE CLEANING.
6. CDS STRUCTURE SHALL BE PRECAST CONCRETE CONFORMING TO ASTM C-478 AND AASHTO LOAD FACTOR DESIGN METHOD.

INSTALLATION NOTES
A. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
B. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE CDS MANHOLE STRUCTURE.
C. CONTRACTOR TO INSTALL JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS AND ASSEMBLE STRUCTURE.
D. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT INLET AND OUTLET PIPE(S). MATCH PIPE INVERTS WITH ELEVATIONS SHOWN. ALL PIPE CENTERLINES TO MATCH PIPE OPENING CENTERLINES.
E. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

CONTECH ENGINEERED SOLUTIONS LLC
www.contechES.com
9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069
800-338-1122 513-645-7000 513-645-7993 FAX

CDS1515-3-C ONLINE CDS STANDARD DETAIL

CONTECH ENGINEERED SOLUTIONS

CDS TECHNOLOGIES

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

MARKET LANDING PARK EXPANSION
NEWBURYPORT, MA

Area	0.42 ac	Unit Site Designation	CB 201
Weighted C	0.9	Rainfall Station #	69
t_c	5 min		
CDS Model	1515-3	CDS Treatment Capacity	**1.0 cfs**

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	10.2
0.04	9.6%	19.8%	0.02	0.02	9.6
0.06	9.4%	29.3%	0.02	0.02	9.4
0.08	7.7%	37.0%	0.03	0.03	7.7
0.10	8.6%	45.6%	0.04	0.04	8.5
0.12	6.3%	51.9%	0.05	0.05	6.2
0.14	4.7%	56.5%	0.05	0.05	4.6
0.16	4.6%	61.2%	0.06	0.06	4.6
0.18	3.5%	64.7%	0.07	0.07	3.5
0.20	4.3%	69.1%	0.08	0.08	4.2
0.25	8.0%	77.1%	0.09	0.09	7.7
0.30	5.6%	82.7%	0.11	0.11	5.4
0.35	4.4%	87.0%	0.13	0.13	4.2
0.40	2.5%	89.5%	0.15	0.15	2.4
0.45	2.5%	92.1%	0.17	0.17	2.4
0.50	1.4%	93.5%	0.19	0.19	1.3
0.75	5.0%	98.5%	0.28	0.28	4.4
1.00	1.0%	99.5%	0.38	0.38	0.8
1.50	0.0%	99.5%	0.57	0.57	0.0
2.00	0.0%	99.5%	0.76	0.76	0.0
3.00	0.5%	100.0%	1.13	1.00	0.2
					97.5
				Removal Efficiency Adjustment[2] =	6.5%
				Predicted % Annual Rainfall Treated =	93.5%
				Predicted Net Annual Load Removal Efficiency =	**91.0%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CONTECH ENGINEERED SOLUTIONS

CDS TECHNOLOGIES

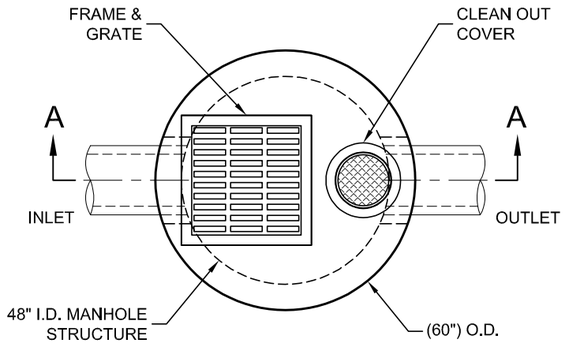
CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

MARKET LANDING PARK EXPANSION
NEWBURYPORT, MA

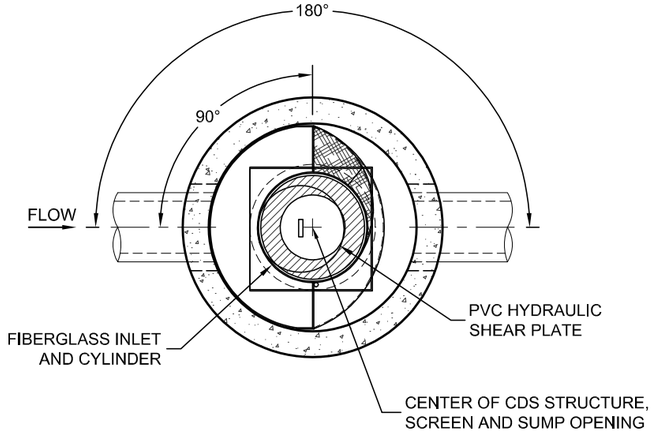
Area	0.39 ac	Unit Site Designation	CB 204
Weighted C	0.9	Rainfall Station #	69
t_c	5 min		
CDS Model	1515-3	CDS Treatment Capacity	**1.0 cfs**

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	10.2
0.04	9.6%	19.8%	0.01	0.01	9.6
0.06	9.4%	29.3%	0.02	0.02	9.4
0.08	7.7%	37.0%	0.03	0.03	7.7
0.10	8.6%	45.6%	0.03	0.03	8.6
0.12	6.3%	51.9%	0.04	0.04	6.3
0.14	4.7%	56.5%	0.05	0.05	4.6
0.16	4.6%	61.2%	0.06	0.06	4.6
0.18	3.5%	64.7%	0.06	0.06	3.5
0.20	4.3%	69.1%	0.07	0.07	4.3
0.25	8.0%	77.1%	0.09	0.09	7.8
0.30	5.6%	82.7%	0.10	0.10	5.4
0.35	4.4%	87.0%	0.12	0.12	4.2
0.40	2.5%	89.5%	0.14	0.14	2.4
0.45	2.5%	92.1%	0.16	0.16	2.4
0.50	1.4%	93.5%	0.17	0.17	1.3
0.75	5.0%	98.5%	0.26	0.26	4.5
1.00	1.0%	99.5%	0.35	0.35	0.9
1.50	0.0%	99.5%	0.52	0.52	0.0
2.00	0.0%	99.5%	0.69	0.69	0.0
3.00	0.5%	100.0%	1.04	1.00	0.3
					97.8
				Removal Efficiency Adjustment[2] =	6.5%
				Predicted % Annual Rainfall Treated =	93.5%
				Predicted Net Annual Load Removal Efficiency =	**91.3%**

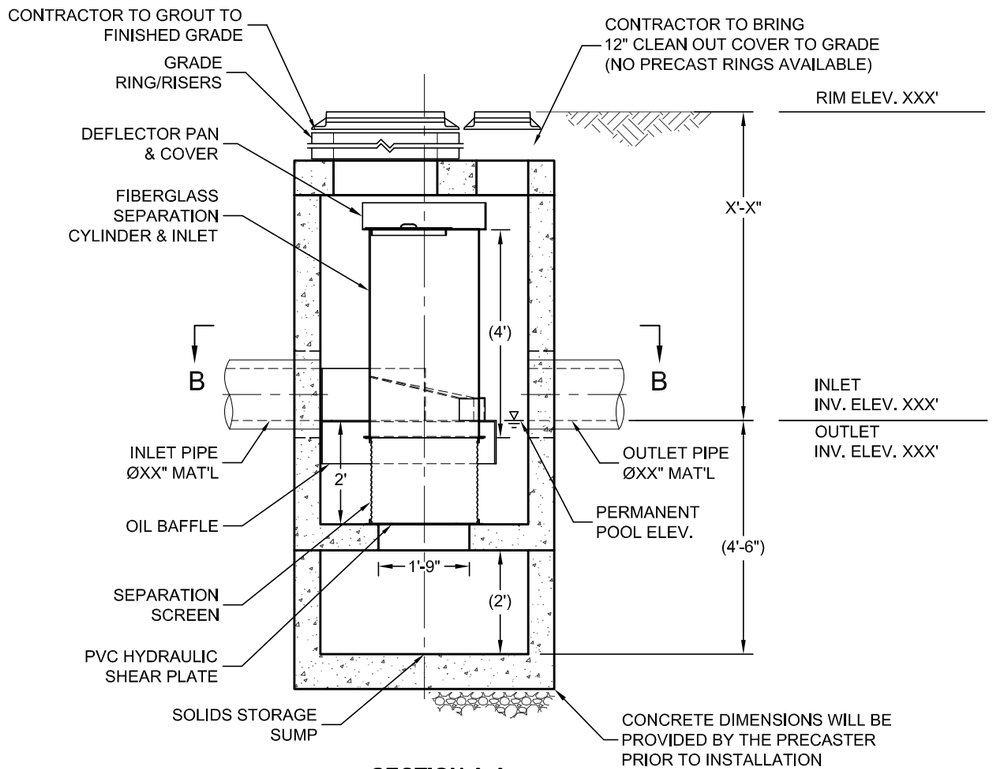
1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.



PLAN VIEW



SECTION B-B



SECTION A-A

MATERIALS LIST - PROVIDED BY CONTECH

COUNT	DESCRIPTION	INSTALLED BY
1	FIBERGLASS INLET & CYLINDER	CONTECH
1	PVC HYDRAULIC SHEER PLATE	CONTECH
1	4700 MICRON SEP. SCREEN	CONTECH
1	28"x28" DEFLECTOR PAN & COVER	CONTECH
1	SEALANT FOR JOINTS	CONTRACTOR
-	GRADE RINGS/ RISERS	CONTRACTOR
1	24"x24" FRAME AND GRATE	CONTRACTOR
1	Ø12"x4" CLEAN OUT COVER	CONTRACTOR

SITE DESIGN DATA

WATER QUALITY FLOW RATE	XX CFS
PEAK FLOW RATE	XX CFS
RETURN PERIOD OF PEAK FLOW	XX YRS

GENERAL NOTES
1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. DIMENSIONS MARKED WITH ( ) ARE REFERENCE DIMENSIONS. ACTUAL DIMENSIONS MAY VARY.
3. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR CONTECH STORMWATER SOLUTIONS REPRESENTATIVE. www.contechstormwater.com
4. CDS WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
5. STRUCTURE AND CASTINGS SHALL MEET AASHTO HS20 LOAD RATING.
6. PVC HYDRAULIC SHEAR PLATE IS PLACED ON SHELF AT BOTTOM OF SCREEN CYLINDER. REMOVE AND REPLACE AS NECESSARY DURING MAINTENANCE CLEANING.

INSTALLATION NOTES
1. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
2. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE CDS MANHOLE STRUCTURE (LIFTING CLUTCHES PROVIDED).
3. CONTRACTOR TO ADD JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS, AND ASSEMBLE STRUCTURE.
4. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES. MATCH PIPE INVERTS WITH ELEVATIONS SHOWN.
5. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

STRUCTURE WEIGHT
APPROXIMATE HEAVIEST PICK = T.B.D. LBS.

PRELIMINARY

CDS2015-4 - XXXXX-01
XXX
XXX, XX
SITE DESIGNATION: XXX

CONTECH STORMWATER SOLUTIONS
contechstormwater.com

BASE FILE NAME: CDS2015-4-SUB.DWG
SCALE: NONE
DESIGNED: | DRAWN: N/A
DATE: XX/XX/XX
REV:

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WATER QUALITY CALCULATIONS

Project: Market Landing Park Expansion
Location: Newburyport, MA
Prepared For: Sasaki / Jamie Veillette

CONTECH ENGINEERED SOLUTIONS

Purpose: To calculate the water quality flow rate (WQF) over a given site area. In this situation the WQF is derived from the first 1" of runoff from the contributing impervious surface.

Reference: Massachusetts Dept. of Environmental Protection Wetlands Program / United States Department of Agriculture Natural Resources Conservation Service TR-55 Manual

Procedure: Determine unit peak discharge using Figure 1 or 2. Figure 2 is in tabular form so is preferred. Using the tc, read the unit peak discharge (qu) from Figure 1 or Table in Figure 2. qu is expressed in the following units: cfs/mi^2/watershed inches (csm/in).

Compute Q Rate using the following equation:

$$Q = (qu)\ (A)\ (WQV)$$

where:

Q = flow rate associated with first 1" of runoff
qu = the unit peak discharge, in csm/in.
A = impervious surface drainage area (in square miles)
WQV = water quality volume in watershed inches (1" in this case)

Structure Name	Impv. (acres)	A (miles^2)	t_c (min)	t_c (hr)	WQV (in)	qu (csm/in.)	Q (cfs)
DMH 402	0.26	0.0003984	5.0	0.083	1.00	795.00	0.32
DMH 102	0.65	0.0010141	5.0	0.083	1.00	795.00	0.81
CB 201	0.42	0.0006563	5.0	0.083	1.00	795.00	0.52
CB 204	0.39	0.0006016	5.0	0.083	1.00	795.00	0.48

TSS REMOVAL WORKSHEETS

TSS Removal Treatment Train Summary

Date:	July 13, 2022
Project:	Market Landing Park Expansion
Project No:	08314.00
Location:	Newburyport, MA
Prepared by:	JV
Checked by:	SE

Objective: Stormwater management systems will be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). This will be achieved by the used of the following treatment trains.

Treatment Train (1):	Deep-Sump, Hooded Catch Basin	→	Contech WQU (DMH 402)
Treatment Train (2):	Deep-Sump, Hooded Catch Basin	→	Contech WQU (DMH 103)
Treatment Train (3):	Deep-Sump, Hooded Catch Basin	→	Contech WQI (CB 201)
Treatment Train (4):	Deep-Sump, Hooded Catch Basin	→	Contech WQI (CB 204)

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

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

Location: Treatment Train 1 - DMH 402 (WQU)

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep-Sump, Hooded Catch Basin	0.25	**1.00**	0.25	0.75
Proprietary Treatment Practice	0.80	0.75	0.60	0.15

Total TSS Removal = 85%

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

Project: ML Park Expansion

Prepared By: JV

Date: 07/13/2022

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

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed

1. From MassDEP Stormwater Handbook Vol. 1

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

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

Location: Treatment Train 2 - DMH-102 (WQU)

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep-Sump, Hooded Catch Basin	0.25	**1.00**	0.25	0.75
Proprietary Treatment Practice	0.80	0.75	0.60	0.15

Total TSS Removal = 85%

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

Project: ML Park Expansion

Prepared By: JV

Date: 07/13/2022

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

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed

1. From MassDEP Stormwater Handbook Vol. 1

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

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

Location: Treatment Train 3 - CB-201 (WQI)

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep-Sump, Hooded Catch Basin	0.25	**1.00**	0.25	0.75
Proprietary Treatment Practice	0.80	0.75	0.60	0.15

Total TSS Removal = 85%

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

Project: ML Park Expansion

Prepared By: JV

Date: 07/13/2022

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

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed

1. From MassDEP Stormwater Handbook Vol. 1

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

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

Location: Treatment Train 4 - CB-204 (WQI)

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep-Sump, Hooded Catch Basin	0.25	**1.00**	0.25	0.75
Proprietary Treatment Practice	0.80	0.75	0.60	0.15

Total TSS Removal = 85%

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

Project: ML Park Expansion

Prepared By: JV

Date: 07/13/2022

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

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed

1. From MassDEP Stormwater Handbook Vol. 1

APPENDIX E – OFFSITE DRAINAGE ANALYSIS MEMO

SASAKI

Memorandum

Date	July 15, 2022
To	Jon-Eric White, City Engineer
From	Steve Engler, Jamie Veillette (Sasaki)
Project Name	Newburyport Market Landing Park
Project No.	08314.00
Subject	Drainage Analysis Study of Market Landing

OBJECTIVE

The purpose of this report is to evaluate the existing drainage system from Ferry Wharf Way through Market Landing Park in downtown Newburyport, Massachusetts. The narrative below summarizes the capacity of the existing drainage system and provides recommendations to reduce flooding in the upstream drainage system.

SUMMARY

The study area being evaluated includes State Street from Greenleaf Street to Water Street and extends from Water Street to the Merrimack River via Ferry Wharf Way. See Figure 1 for a map of the study area. The intersection of State Street and Water Street is known as Market Square. From conversations with the City, we understand that this area of Market Square has experienced frequent flooding in the past. The catchment area being conveyed through the existing drainage system at this low point on Water Street includes the area from the top of the hill on State Street to Market Square. The analysis of the existing drainage system begins at existing catch basins at the low point of Water Street through Ferry Wharf Way to the bulkhead at the Merrimack River.

In 2008, a study was completed by Malcom Pirnie to assess the impact of disconnecting existing upstream catch basins from the City' sanitary sewer system and reconnecting the catch basins to this drainage system. This study recommended that several pipes be upsized and a diversion pipe be installed between the existing drainage systems on the east and west side of State Street. These changes were not completed. However, the wheelchair ramp and walkway at Ferry Wharf Way was regraded to allow surface water to flow along Ferry Wharf Way between existing buildings from Water Street through Market Landing Park to the Merrimack River.

METHODOLOGY

A hydraulic analysis model was created in the modeling software SewerGEMS to analyze the performance of the existing pipe network for the 10- and 25-year storm events using the Rational Method. The analysis took into consideration the following:

ASSUMPTIONS:

- Manning's n value of 0.013 for Reinforced Concrete Pipes (RCP) and 0.012 for High Density Poly Ethylene (HDPE) Pipes
- A runoff coefficient of 0.85 for the urban runoff area and 0.90 for the paved parking areas were used for catchment area calculations.
- The topography, catchment area, drainage map from the City, and the previous drainage study by Malcolm Pirnie were utilized to model the existing upstream drainage.
- The upstream drainage system, including analysis of inlet capacities and bypass flows were *not* analyzed as part of this study.
- The upstream drainage contributing to the system was utilized for pre and post development flows for the Project Site
- AASTHO method was utilized to calculate structure head loss
- The Hazen-Williams method was utilized to calculate pipe losses (based on the velocity head of the exit conduit)

INPUTS:

- Intensity-Duration-Frequency (IDF) Curves were created from the Northeast Regional Climate Center (NRCC) rainfall data for the given storm events. NRCC rainfall data is provided in Appendix A of this report and IDF curve data is provided in Appendix B of this report.
- Existing rim and invert elevations were estimated using the graphical profiles from the 2008 Malcolm Pirnie study or provided by field survey dated February 2022 provided by VHB. The survey data is incomplete and field measurements were provided by the City where rim and invert elevations were not provided. Both the study and survey show varying information for the existing drainage system. In these cases, the most recent field survey data and City information were utilized.
- Existing tailwater conditions were evaluated for MLW at -4.0', MHW at 4.2', MHHW at 4.5', and 2070 MHHW at 8.7'. The tailwater conditions analyzed are provided from a Climate Resilience Assessment performed by VHB in May 2021. The NOAA SLR projections referenced in this assessment have since been updated in a technical report released by NOAA in February 2022. Under higher emissions scenarios, SLR projections have slightly decreased. This may result in slightly fewer inundation events in the coming decades, but does not warrant lowering SLR projections from what is currently shown.
- All elevations are based on the North American Vertical Datum of 1988 (NAVD).

RESULTS:

- All proposed storm drainage alternatives have been designed for the 25-year storm hydraulic grade line (HGL) to pass below rim structures to the extent practicable

- All proposed pipe slopes will achieve a minimum velocity of 2 fps and maximum velocity of 16 fps in the full-flow condition
- All proposed pipes will achieve a minimum cover between crown of pipe and finished grade of 24-inches

EXISTING DRAINAGE INFRASTRUCTURE RESULTS

As noted in the Malcom Pirnie study, the majority of runoff along State Street appears to bypass available collection points and flows to the bottom of the hill where ponding occurs along Water Street. For modeling purposes, it has been assumed that the runoff from the catchment study area enters the system at MH -1 at the intersection of Water Street and Ferry Wharf Way. Additional inflow areas were calculated at CB-1 and MH-5by means of the Rational Method to account for flows within the East Lot not provided in the Malcolm Pirnie study. See Figure 1 for the catchment areas contributing to the existing drainage system and Figure 2 for the existing system drainage layout.

SewerGEMS profiles of the existing drainage system for the storm events modeled are provided in Appendix C of this report. Tidal conditions for the Merrimack River were taken into consideration in the model for mean low water (MLW) at -4.0 feet, mean high water (MHW) at 4.2 feet, mean high high water (MHHW) at 4.5 feet, and 2070 MHHW of 8.7 feet. The overall results of the hydraulic analysis model are summarized below.

The existing drainage system evaluated includes 346 linear feet of 2-foot square concrete box culverts and 143 linear feet of 30-inch circular concrete pipe. The existing systems starts at invert elevation 5.0 ft and ends at -2.1 ft. The existing hydraulic grade line (HGL) is above ground elevations for all pipe segments in the 10-year storm event under mean high-water conditions. The existing hydraulic analysis model indicates the system is surcharging for the events evaluated. The 10-yr and 25-yr storm events were modeled for the existing drainage system under the four tailwater scenarios previously listed. Graphical profiles of these existing scenarios are provided in Appendix C, pages 7-15.

EVALUATION OF PROPOSED ALTERNATIVES

The goal of this modeling exercise was to analyze the existing drainage system along Ferry Wharf Way and provide recommendations that would reduce surcharge in the upstream system. SewerGEMS profiles of proposed alternatives for the storm scenarios evaluated are provided in Appendix C of this report. Four alternatives were considered to upgrade the existing system. All alternatives propose to realign the existing system from MH-P2 (Inlet) to MH-P4 before the bulkhead to provide a more direct connection. See figure 3 for a layout of the proposed drainage system.

ALTERNATIVE 1: 48" HDPE TO OUTFALL

Alternative 1 proposes upgrading the existing system with a 48-inch HDPE pipe from the drainage manhole at the intersection of Ferry Wharf Way and Water Street to the bulkhead. The 25-year hydraulic grade line surpasses the rim elevations at all structure elevations under current mean high-water conditions. See Appendix C pages 17-25 for model and results.

ALTERNATIVE 2: 60" HDPE TO OUTFALL

Alternative 2 proposes upgrading the existing system with a 60-inch HDPE pipe from the drainage manhole at the intersection of Ferry Wharf Way and Water Street to the bulkhead. The 25-year hydraulic grade line passes below the rim elevations at all structure elevations under mean high water. Under 2070 MHHW tailwater conditions the 25-year HGL passes below rim elevations except for the last segment of pipe between MH-P4 and OF-33 where the 2070 MHHW sea level rise is above ground elevations. See Appendix C pages 26-34 for model and results.

ALTERNATIVE 2A: 60" HDPE TO EXISTING 30" RCP

Alternative 2A proposes upgrading the existing system with a 60-inch HDPE pipe from the drainage manhole at the intersection of Ferry Wharf Way and Water Street to the drainage manhole prior to the existing 30-in outfall at the Merrimack River. The 10-year hydraulic grade line passes below the rim elevations from MH-P1 to MH-P3 under mean high-water conditions. The HGL surpasses the rim elevation at MH-P4 due to the existing 30-in reinforced concrete pipe (RCP) remaining in place. As modeled in the existing conditions, the 30-in" RCP outfall is undersized. See Appendix C pages 35-43 for model and results.

ALTERNATIVE 3: 66" HDPE TO OUTFALL

Alternative 3 proposes upgrading the existing system with a 66-inch HDPE pipe from the drainage manhole at the intersection of Ferry Wharf Way and Water Street to the bulkhead. The 25-year hydraulic grade line (HGL) passes below the rim elevations at all structure elevations under current mean high water. Under 2070 MHHW tailwater conditions the 25-year HGL passes below rim elevations except for the last segment of pipe where the 2070 MHHW sea level rise is above ground elevations. See Appendix C pages 44-52 for model and results.

Table 1 presents the sea level rise scenarios versus the HGL results for each proposed alternative. A check mark indicates that HGL will not exceed the rim elevations for the design storm event and tailwater scenario.

TABLE 1

ALTERNATIVES	STORM EVENT	TAILWATER SCENARIO			
		Current MLW (-4.0')	Current MHW (4.2')	Current MHHW (4.5')	2070 MHHW (8.7')
Baseline	10-YR	×	×	×	×
	25-YR	×	×	×	×
Alt 1: 48" Pipe	10-YR	✓	×	×	×
	25-YR	×	×	×	×
Alt. 2: 60" Pipe	10-YR	✓	✓	✓	×
	25-YR	✓	✓	✓	×
Alt. 2A: 60" to 30" Pipe	10-YR	×	×	×	×
	25-YR	×	×	×	×
Alt. 3: 66" Pipe	10-YR	✓	✓	✓	×
	25-YR	✓	✓	✓	×

RECOMMENDATION

Alternative 2 is the preferred recommendation for upgrades to the existing system. Alternative 2 proposes upgrading the existing system to 60-in HDPE pipes with four 96-inch manholes to the bulkhead. Consideration may be given to Alternative 2A, which proposes upgrading the existing system to 60-in HDPE pipes with four 96-inch manholes prior to the 30-in existing RCP outfall pipe. This alternative offers a phased approach so that the existing 30-in RCP pipe can be replaced with a 60-in HDPE pipe in the future. Replacing the entire span of pipe with the 60-in HDPE pipe achieves the desired results to maintain the 25-year HGL below rim elevations for all sea level rise scenarios up to 2050 MHHW (+2.4' SLR) conditions. Projected MHHW was calculated by adding the projected SLR to the current MHHW elevation.

COST ESTIMATE

A preliminary cost estimate is provided below for the preferred recommendation. Sasaki has no control over the cost or availability of labor, equipment or materials, market conditions or the Contractor's method of pricing. The estimates of probable construction costs are made on the basis of Sasaki's professional judgment and experience. Sasaki makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the work will not vary from this estimate of the probable construction cost. The values in this report were calculate using the MassDOT 2022 weighted bid prices and RS Means 2022 construction cost data. The cost estimate includes the following assumptions:

- Removal of two existing drainage manholes and one catch basin
- All remaining existing drainage structures are to be abandoned in-place. Inlets and outlets of structures to be abandoned shall be plugged with masonry. Upper portions of the masonry shall be removed to a depth of 3 ft below the finished grade at the location designated by the

Engineer, and the structures shall be completely filled with selected excavated material placed in 6-in. layers and thoroughly compacted.

- All remaining existing drainage pipes shall be abandoned in-place and filled with controlled density flowable fill
- Patch paving has been assumed for the construction of this project
- Below depths of 3ft, out of state landfill soil disposal for 25% of trench excavation has been incorporated into the construction estimate and the remaining 75% is in state soil disposal. Please note these assumptions are based on preliminary recommendations provided by a Licensed Soil Professional and are only to be used as an approximate breakdown. Based on previous environmental reports available to VHB, it was assumed the first 0 to 3ft were surficial soils that should be able to go to an in-state landfill. Soils from 3 ft to at least depths of 14 ft were designated as urban fill and found to have the presence of lead. During construction, the excess soils will need to be stockpiled, tested, and profiled for off-site disposal/facility acceptance.
- Class B trench excavation shall include the removal and disposal for existing pipe demolition between MH-P1 and MH-P2
- No conflicts with existing utilities based on information provided in the survey performed by VHB and dated March 2022
- The bulkhead design team will assist with the feasibility and cost estimates for upgrading the existing 30-in outlet
- No permitting or engineering design services costs are included
- No traffic detail or legal costs are included
- Proposed system excludes stormwater quality units
- Excavation support beyond standard trenching means and methods is not included
- No rock excavation costs are included
- Escalation is not included – all values are based on current costs from RS Means 2022 and April 2022 MassDOT Weighted Bid Prices for District 4

TABLE 2: ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST FOR ALTERNATIVE 2A

Item	Quantity	Unit	Unit Cost	Subtotal	Total
A. Site Preparation & Demolition					
Sawcutting Asphalt Pavement	707	LF	$ 10.00	$ 7,070.00	
Drainage Structure Removed	3	EA	$ 750.00	$ 2,250.00	
Drainage Structure Abandoned	3	EA	$ 800.00	$ 2,400.00	
Controlled Density Fill for Pipe Abandonment	47	CY	$ 185.00	$ 8,695.00	
					$ 20,415
B. Earthwork					
Gravel Borrow for Backfillling Structures and Pipes	403	CY	$ 55.00	$ 22,165.00	
Ordinary Borrow	435	CY	$ 30.00	$ 13,050.00	
					$ 35,215
C. Utilities & Infrastructure					
60" HDPE Pipe	420	LF	$ 320.00	$ 134,400.00	
Drainage Structure (less than 8ft deep)	2	EA	$ 5,800.00	$ 11,600.00	
Drainage Structure (9 to 14ft deep)	2	EA	$ 8,000.00	$ 16,000.00	
Frame and Cover	3	EA	$ 800.00	$ 2,400.00	
Frame and Grate (MassDOT Cascade Type)	1	EA	$ 950.00	$ 950.00	
					$ 165,350
D. Hardscape and Surface Finishings					
Surface Restoration	2000	SF	$ 20.00	$ 40,000.00	
Restoration of ADA Ramp	6	SY	$ 100.00	$ 600.00	
Temporary Asphalt Patching	46.55	TON	$ 210.00	$ 9,775.50	
Concrete Sidewalk Repair	81	SY	$ 75.00	$ 6,075.00	
					$ 56,451
				Subtotal	$ 277,431
				Allowance for Regulated Soil Disposal	$ 112,705
				Allowance for Dewatering Treatment	$ 100,000
				Allowance for Utilities	$ 20,000
				Base Bid Total	$ 510,136
				General Conditions/Gen Req's (8%)	$ 40,811
				Insurance + Bond (2%)	$ 10,203
				Design + Pricing Contingency (5%)	$ 25,507
				Construction Contingency (7.5%)	$ 38,260
				Escalation Contingency (4%)	$ 20,405
				Construction Administration (2%)	$ 10,203
				Markup Total	$ 145,389
				TOTAL Mark-Up Costs + BASE BID	$ 655,525

LIST OF FIGURES

APPENDICES

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FIGURES