APPENDIX A TO BIDDING DOCUMENTS

BRIGHAM STREET CULVERT FEASIBILITY STUDY

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Town of Hudson, MA

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1. INTRODUCTION

The Town of Hudson (Town) contracted with Woodard & Curran, Inc. (Woodard & Curran) to evaluate the existing Brigham Street culvert(s) in Hudson, MA, Middlesex County, which are two adjacent structures that provide conveyance for an unnamed stream. The unnamed stream is an approximately 1-mile-long stream which flows in a northwesterly direction between Maxwell Circle, Harriman Road, Brigham Street and Park Street prior to its confluence with a wetland system approximately 380 feet from Park Street. The original Brigham Street culvert is a reinforced concrete slab with an approximate span of 36-inches supported by vertical concrete sides and stone abutments approximately 22-inches tall with portions of the culvert reported to be constructed of stone masonry. The culvert failed, and two corrugated HDPE pipes (12 inch and 15 inch) were installed in November 2022 to provide temporary conveyance through the crossing. Brigham Street culvert daylights to a stream bisecting to properties at 106 and 108 Park Street. The Town does not have a drainage easement for this stream. The stream is conveyed beneath Park Street through a 36-inch diameter (CMP) culvert to a wetland system, which ultimately discharges to the Assabet River approximately 1,000 feet downstream from Park Street.

The purpose of this Report is to provide a description of the data collection and engineering evaluation to support the replacement of the existing culvert below Brigham Street as part of the Brigham Street Culvert Replacement Project (Project). Replacing the existing culvert with a new structure that does not lack structural deficiencies, is designed to provide increased flow capacity, and consistent with the Massachusetts Stream Crossing Standards to maximum extent practicable will provide a benefit to the wildlife in the area, provide a safety benefit to residents, and improve climate resilience. A map showing the location of the Project and the stream with cross sections used in the hydraulic model are provided in **Appendix A**.

As part of the data collection phase of the Project, Woodard & Curran coordinated the following tasks:

- **Soil borings and geotechnical evaluation:** Completed by GZA GeoEnvironmental, Inc. (GZA) on February 17, 2023.
- **Resource area delineation:** Completed by EcoTec, Inc. (EcoTec) on February 27, 2023.
- **Survey of Project area:** Completed by WSP USA, Inc. (WSP) during March 2023.
- **CCTV investigation:** Conducted by BMC Corp. (BMC) on March 2023.

In addition to coordinating the tasks listed above, Woodard & Curran evaluated the presence of critical infrastructure and critical areas, as defined by the Massachusetts Stormwater Handbook, within the Project area. The data collected and reviewed for this phase of the Project is further described in Section 2 of this report.

As part of the engineering evaluation, Woodard & Curran developed a hydrologic & hydraulic model of the existing conditions within the project area including the Park Street culvert crossing to understand downstream impacts. This model was analyzed under several different flow conditions to complete an alternatives analysis of three potential replacements for the existing culverts. In addition to the hydrologic and hydraulic analysis, an evaluation of the Stream Crossing Standards and the development of an opinion of probable cost for each alternative was conducted. These evaluations are further described in Section 3 of this report.

2. EXISTING CONDITIONS

2.1 Physical Conditions

The existing upstream side of the Brigham Street culvert has a reinforced concrete slab headwall with an approximate span of 36-inches supported by vertical concrete sides and stone abutments with portions of the culvert reported to be constructed of stone masonry. Two corrugated HDPE pipes, one 70 foot long, 12-inch and one 75 foot long 15-inch were installed along the stream bed that convey flow from the unnamed stream in a northwesterly direction beneath Brigham Street (Photo 1). Within the extents of the evaluation, this culvert is considered the upstream culvert. This culvert is only temporary due to a previous structure failure. The culvert is undersized and is subject to neighboring residential property flooding.

Photo 1: Downstream of Brigham Culvert Crossing

The Park Street culvert is located approximately 135 feet northwest downstream of the Brigham Street culvert. The culvert is a 36-inch Corrugated metal pipe, approximately 350 feet long and daylights to a wetland system which ultimately discharges to the Assabet River. The culvert and headwalls are in fair condition (Photo 2).

Photo 2: Upstream of Park Street Culvert Crossing

Existing conditions survey drawings for both the Brigham and Park Street areas are provided in **Appendix B**.

The unnamed stream that runs underneath Brigham Street Culvert is bounded by an area with single family homes and associated driveways and lawns. It has been reported the stream upstream of the Brigham Street culvert experiences flooding during heavy storm events. Brigham Street begins to overtop during the 25-year storm event according to the modeling effort further described in Section 3 of this report. The undersized system will continue to flood neighboring residential private properties, impact wildlife, plant species, and threaten the stability of the road and surrounding embankments if left in its current condition.

During the phase of field reconnaissance and CCTV investigation, BMC was able to capture CCTV footage of approximately 133 feet of the Park Street culvert. Sediment build up in the Park Street culvert blocked passage for the CCTV crawler to capture the entire CMP culvert. The portion that was captured with CCTV revealed that there are unknown pipes that tie directly into Park Street CMP culvert that may or may not impact the hydraulics of Park Street. These penetrations are located directly at the drain crossing that runs perpendicular to the culvert pipe shown in the survey provided in **Appendix B.**

2.1.1 Background

The unnamed stream conveys flow from upstream wetland areas and channels in a northwestern direction before flowing through the Brigham Street culvert and Park Street Culvert that continues to convey along a larger wetland area that ultimately discharge at the Assabet River approximately 1000 feet downstream of Park Street. EcoTec conducted an inspection and reported evidence of Wetland hydrology, including hydric soils, saturated soils, pore lining, and evidence of flooding all observed within the delineated wetland.

The Brigham Street Culvert daylights to a stream bisecting the properties at 106 and 108 Park Street. The stream bank is bounded by grass pasture, and brush nearby crossing approximately 130 feet between Brigham Street and Park Street.

The contributing drainage are flowing to Brigham Street culvert and Park Street culvert is estimated to be 147 acres based on a delineation conducted by Stream Stats, a tool developed by the United States Geological Survey (USGS). A bankfull width, typically defined as the channel width during the 2-year storm event or the flow that fills the channel without overflowing onto the flood plain, was determined to be 10.1 feet upstream of the Brigham Street culvert and 7 feet upstream of Park Street based on top of bank flag locations. The Wetland Resource Area Analysis dated February 27, 2023, prepared by EcoTec is provided as **Appendix C.**

2.1.2 Stream Topography

The average gradient of the unnamed stream upstream of Brigham Street culvert has been calculated to be approximately 3.1% upstream of the culvert and 5.8% between Brigham Street and Park Street. Average gradient of the unnamed stream is based on the topographic survey of the Project area, which extended approximately 210 feet upstream of Brigham Street culvert crossing and approximately 320 feet downstream of the Park Street culvert crossing . The Existing Brigham Street culverts invert were not able to be surveyed due to sediment deposition. It was assumed that the bottom of the headwall elevation represents the invert elevations for the Brigham Street culvert pipe. The Brigham Street culvert has a calculated slope of approximately 1.8% and the Park Street culvert has a calculated slope of approximately 1.3%. Survey drawings of the culverts and unnamed stream are provided in **Appendix B**.

2.1.3 Utility Infrastructure

The Town supplies drinking water and sewer service to residents in the neighborhood within the Project area. Following a review of a survey completed within the Project area, natural gas, water, sanitary sewer, and storm drain run perpendicular to the Brigham Street culvert crossing. Overhead electrical utilities are also present above the existing culverts.

The location of utilities within the Project area informed the types and size of culverts selected for analysis as adequate space between the utilities and the culvert will need to be accounted for during the design of the new culvert. Utilities located within the Project will need to be supported, bypassed, or reconstructed during construction of the culvert replacement. **Table 2-1** below shows the approximate elevation of the top of the culvert and the approximate elevation of the utilities within the road at their approximate crossing location. Natural gas is assumed to be located 3 feet below the ground surface, and water utilities are assumed to be 5 feet below the ground surface. Sanitary Sewer services are located in the project area and crossing elevations will be determined during detailed design. Storm drain information is calculated based on intersecting pipes and Structure inverts along both Park Street and Brigham Street.

Table 2-1: Approximate Utility Location and Size

Utility	Existing Culvert Crown Elevation at Utility[1]	Utility Invert Elevation[2]	Separation Between Utility and Culvert (ft)
Brigham Street Utility Crossings			
Gas	221.1	228.6	7.5
Drain	221.1	227.9	6.8
Water 1	220.9	226.2	5.3
Force Main Sewer	220.9	TBD[4]	TBD
Park Street Utility Crossings			
Gas	215.6	218.3	2.7
Water 1	215.5	215.9	0.4
Water 2	215.4	216.0	0.6
Drain	215.2	215.4	.1
Force Main Sewer	215.2	TBD	TBD

Notes: 1. Crown elevation is assumed from the outside of the culvert. 2. Utility invert elevation is assumed from the inside of the pipe. 3. Elevations refer to the North American Vertical Datum of 1988 (NAVD88). 4. Elevations for crossings to be determined (TBD) during detailed design.

As depicted in Table 2-1 above, the drainpipe at Park Street is the closest existing utility to the culvert and therefore determines the maximum height of the proposed structure. The proposed 3-foot-high culvert will provide similar separation between utilities as we will have to reconstruct the drainpipe that currently sits on top of the existing CMP pipe at Park Street. Overhead electric utilities are present at both Brigham Street and Park Street Culvert Crossings.

2.2 Geotechnical

GZA completed a subsurface exploration program consisting of 3 soil borings, 2 on Brigham Street and 1 on Park Street. Boring GZ-1 and GZ-2 were drilled in the roadway to the northeast and southwest of the existing Brigham Street Culvert. Boring GZ-3 was drilled approximately 34 feet away from the existing headwall at Park Street due to conflicts with overhead and underground utilities. Boring locations are shown in the Geotechnical Report in **Appendix D.**

Surficial layers of boring GZ-1 at Brigham Street, located within the roadway north of the culvert, consisted of 3 inches of asphalt and 11.7 feet of sand, gravel, and a little silt for fill. Surficial Layers were followed by sand, gravel and little silt layers to an approximate depth of 27 feet below ground surface. The end of exploration was 27 feet below ground surface. Surficial layers of boring GZ-2 at Brigham Street, located within the roadway south of the culvert, consisted of 3 inches of asphalt and 9.5 feet of dry sand, some silt and little gravel for fill. Surficial layers were followed by buried topsoil that consisted of sand, some silt, trace of gravel and organics at an approximate depth of 12.5 feet below ground surface. Below the buried topsoil followed wet gravel, sand, and some silt at to an approximate depth of 27 feet below ground where exploration also ended.

Surficial layers of boring GZ-3 at Park Street, located at approximately 34 feet away from the existing headwall consisted of 3 inches of asphalt and 4.7 feet of sand, little gravel, and a little silt for fill. Surficial layers were followed by wet sand and gravel with little silt approximately 27 feet below ground surface where exploration also ended.

The Geotechnical Engineering Memorandum includes several recommendations to be considered during the design and construction of the new culverts related to subgrade preparation, foundation design assumptions, and dewatering. The Memorandum, inclusive of backfill gradation recommendations, boring location map, soil test boring logs, and soil laboratory results, is provided as **Appendix D** of this Report.

2.3 Resource Areas

A resource area delineation was conducted by EcoTec, Inc on February 27, 2023. Applicable wetland and other resource area features were identified and flagged in accordance with Massachusetts Department of Environmental Protection (MassDEP) guidance. The extent of the flagged wetlands can be seen on the survey, included in **Appendix B**. The Wetland Resource Area Analysis is provided with a "DEP Bordering Vegetated Wetland Delineation Form" in **Appendix C**.

Based on the evaluation described above, the following natural resource areas, as defined under the Wetlands Protection Act (WPA) regulations (310 CMR 10.00) and the U.S. Clean Water Act (Section 404 and 401 wetland), have been identified within the Project area:

- Bank (310 CMR 10.54);
- Bordering Vegetated Wetland (BVW) (310 CMR 10.55);
- Land Under Water Bodies and Waterways (LUWBW) (310 CMR 10.56);
- Bordering Land Subject to Flooding (BLSF) (310 CMR 10.57); and
- Riverfront Area (310 CMR 10.58).

Woodard & Curran anticipates the following resource area impacts may result as part of this culvert replacement Project:

- Temporary disturbances: Bank BVW, LUWBW, BLSF, and Riverfront
- Permanent disturbances: Bank, LUWBW, BLSF and Riverfront

2.4 Critical Areas

The WPA defines Critical Areas as Outstanding Resource Waters as designated in 314 CMR 4.00, Special Resource Waters as designated in 310 CMR 4.00, recharge areas for public water supplies as defined in 310 CMR 22.02, bathing beaches, cold-water fisheries, and shellfish growing areas. In addition, Critical Areas include locations which support wildlife habitat such as rare species habitats and vernal pools. Woodard & Curran reviewed the Massachusetts Geographic Information System (MassGIS) data files to determine whether any sensitive resource or protected areas exist within the vicinity of the Project area. From this review, the following was determined:

- The Massachusetts Endangered Species Act (MESA) protects rare species and their habitats by prohibiting the taking of any plant or animal species listed as Endangered, Threatened, or Special Concern by the Massachusetts Division of Fisheries & Wildlife. MESA review is required by the Natural Heritage & Endangered Species Program (NHESP) for projects or activities located within a Priority Estimated Habitat or Rare Species Habitat. Review of available MassGIS data shows there are no Priority of Estimated Habitats located within the Project area.
- Per MassGIS Data and the Wetland Resource Area Analysis completed by EcoTec, there are no Certified or Potential Vernal Pools within the Project area.
- Per MassGIS Data, the Project is not located within any Areas of Critical Environmental Concern.
- Per MassGIS Data, the Project is not located within any shellfish growing areas.
- The Massachusetts Stormwater Handbook defines Outstanding Resource Waters and Recharge Areas for Public Water Supplies as critical areas. Review of MassGIS Data indicated no Interim Wellhead Protection Areas, Approved Wellhead Protection Zones (Zone II), Potentially Productive Aquifers, or Outstanding Resource Waters are located within the project area.
- Per MassDEP and the University of Massachusetts Habitat of Potential Regional or Statewide Importance maps, the proposed Project is not located within a habitat of potential regional or statewide importance.

The Environmental Resource Map and Habitat of Potential Regional or Statewide Importance Map for the Project area are included in **Appendix E**.

2.5 CCTV Investigation

BMC conducted a CCTV investigation of the Park Street culvert to help evaluate the condition of the existing structure. During the investigation, BMC was only able to capture footage through 133 feet of pipe. Sediment build-up in the Park Street culvert blocked the passage for the CCTV crawler to conduct a complete inspection of the 350-foot long CMP culvert. The CCTV footage, Pipe Graphic Report, and Tabular Report prepared by BMC indicate evidence of corrosive surface damage, unmapped pipe tapped into the culvert, a miscellaneous channel opening, settled deposits, and miscellaneous water levels. Heavy cleaning is needed to complete a full evaluation of the structure and to locate any other potential areas of concern. The CCTV investigation reports are provided in **Appendix G.**

3. ALTERNATIVES ANALYSIS

The evaluation of proposed conditions at the site included the analysis of three alternatives for replacement of the existing culverts:

- Alternative 1: 36-Inch Reinforced Concrete Pipe (RCP) at Brigham Street and a 3-foot high by 3-foot-wide Box Culvert at Park Street.
- Alternative 2: 36-Inch Reinforced Concrete Pipe (RCP) at Brigham Street.
- Alternative 3: 3-foot high by 9-foot-wide box culverts at Brigham Street and Park Street.

The following sections further describe the alternatives analyzed, the financial implications of each alternative, a constructability analysis for each alternative, the hydrologic & hydraulic analysis conducted, and each alternative's ability to meet the Stream Crossing Standards to the maximum extent practicable.

3.1 Alternative Selection

3.1.1 Alternative 1: 36-Inch Reinforced Concrete Pipe (RCP) at Brigham Street and a 3′ by 3′ Box Culvert at Park Street

Alternative 1 is considered a non-bridge option as it does not meet the 10-foot-wide threshold to be considered a bridge by MassDOT. This alternative provides additional flow capacity at both the Brigham Street and Park Street culverts that will reduce flooding at Brigham Street during storm events and it is the smallest culvert structure size that can be installed to keep the Water Surface Elevations below critical flooding elevations for the 50-year storm while also protecting the drainage utility at Park Street. At Brigham Street, an RCP culvert has been selected in place of the existing High-Density Polyethylene (HDPE) and a concrete box culvert has been selected in place of the existing Corrugated Metal Pipe (CMP) at Park Street due to the longer expected service life of RCP as compared to HDPE and CMP. This alternative has been designed to improve hydraulic capacity at both Brigham and Park Street to reduce flooding at Brigham Street and neighboring properties on the upstream side of Brigham Street during storm events. While Alternative 1 is not the most cost effective alternative and it does not meet all the Stream Crossing Standard criteria, it is the alternative that provides greatest improvement to flow capacity and flooding reduction at both Brigham Street and Park Street with minimal area of disturbance.

3.1.2 Alternative 2: 36-Inch Reinforced Concrete Pipe (RCP) at Brigham Street

Alternative 2 is considered a non-bridge option as it does not meet the 10-foot-wide threshold to be considered a bridge by MassDOT. This alternative results in the least amount of land disturbance and the lowest overall cost. Similar to Alternative 1, at Brigham Street, an RCP culvert has been selected in place of the existing High-Density Polyethylene (HDPE) pipes. This alternative has been designed to best improve the hydraulic capacity at Brigham Street and reduce flooding while maintaining the CMP pipe as a retrofit in kind with a lining of the pipe requested by the Town. The size of this proposed alternative at Brigham Street is restricted by the existing size of the downstream CMP culvert. This is the most cost-effective option with the smallest footprint, but it does not meet all the Stream Crossing Standard criteria.

3.1.3 Alternative 3: 3' by 9' Box Culverts at Brigham Street and Park Street

Alternative 3 is considered a non-bridge option as it does not meet the 10-foot-wide threshold to be considered a bridge by MassDOT. Unlike alternatives 1 and 2 this alternative has a span of 1.2 times the bankfull width upstream of the Brigham Street culvert. This alternative does have a larger flow capacity as compared to the existing conditions, but it does not meet stream crossing standards for openness as the height of this structure is driven by the size of the downstream structure. To add, installing a culvert with a height greater than 3-feet can require reconstruction to the drainpipe that crosses the Park Street culvert. This alternative has the highest cost implications, the largest area of disturbance, but it also represents the only alternative that meets most of the stream crossing standards compared to Alternatives 1 and 2.

3.2 Opinion of Probable Costs

Woodard & Curran evaluated the cost implications associated with each alternative by estimating the total area impacted by construction activities and referencing Massachusetts Department of Transportation weighted bid prices. In addition, Construction costs include excavation, demolition and installation of the culvert, traffic controls, dewatering, erosion control measures and utility protection. The cost also includes a 20% contingency for engineering and permitting and a 30% construction contingency including construction administration services. **Table 3-1** outlines the cost estimate for each alternative.

Table 3-1: Opinion of Probable Cost

Item	Alternative 1	Alternative 2	Alternative 3
Construction Cost	$1,560,000	$760,000	$2,340,000
Engineering & Permitting (20%)	$312,000	$152,000	$468,000
Construction Contingency (30%)	$468,000	$228,000	$702,000
Total	**$2,340,000**	**$1,140,000**	**$3,510,000**

As shown in **Table 3-1** above, Alternative 3 is estimated to be the costliest alternative, approximately 50% more costly than Alternative 1 and approximately 208% more costly than Alternative 2. Materials and earthwork costs are the largest contributing factors to the cost difference between the alternatives because there is no significant difference in construction duration.

3.3 Hydrologic & Hydraulic Analysis

3.3.1 Model Development

The Federal Emergency Management Agency (FEMA) Hampden County Flood Insurance Study (FIS), dated 2021, indicates that the unnamed stream has not been studied directly. A regulatory floodplain within the project area has been delineated through the development of the Assabet River study and model. The portion downstream of the unnamed stream that daylights into a wetland area and that ultimately discharges to the Assabet River, is classified as a Zone AE, or an area within the Special Flood Hazard Area (SFHA) where base flood elevations have been determined. The portion to the north near the north side of the upstream culvert is classified as a Zone X, or another area of flood hazard where there is a 0.2% chance of flood hazard and area of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile. The Flood Insurance Rate Map (FIRM) has been included in **Appendix A** of this report.

The hydrologic & hydraulic model was developed using the United States Army Corps of Engineers Hydraulic Engineering Center River Analysis Stream (HEC-RAS, version 6.3.1) software. The model reflects the existing physical conditions of the unnamed stream from approximately 190 feet upstream of the Brigham Street culvert to the outfall of the Park Street culvert.

A topographic survey of the Brigham Street and Park Street culverts, extending approximately 710 feet upstream of the existing Brigham Street culvert to downstream of the Park Street culvert, was performed by WSP. The collected data included culvert invert elevations, location, size, material, and shape of the Brigham and Park Street culvert crossings. The survey includes channel geometry within the limit of the survey. These surveys, in conjunction with the stream profile information of the Assabet River within the project area published in the FIS, were used to create an existing conditions model of the reach of the stream described above. Cross sections of the Project area were developed to evaluate the reach both upstream and downstream of Brigham Street and Park Street culvert crossings. A figure depicting the location of the reach and cross sections analyzed is provided in **Appendix A**.

The peak flow rates calculated by USGS's Streamstats were utilized as baseline flow values within the HEC-RAS model for the unnamed stream. Peak flow rates for unnamed streamare estimated by StreamStats using a 2016 USGS regression equation. This equation uses a drainage area, mean basis elevation, and percentage of waterbodies and wetlands within the drainage area to compute flow statistics. The full StreamStats Report generated for this site is provided as **Appendix F** of this Report.

The MassDOT Office of Transportation Planning Board Dataset designates both Brigham Street and Park Street as urban minor arterial roads. The MassDOT Project Development & Design Guide recommends a culvert crossing under an urban minor arterial road should be designated to convey the 50-year storm event. Woodard & Curran conservatively utilized peak flow rates through the downstream culvert at Park Street as these flow rates were larger. **Table 3-2** below represents the low flow, bankfull discharge (2-year), 5-year, 10-year, 25-year, 50-year, 100-year, and 500-year peak flow rates through the Project area.

Table 3-2: Unnamed Stream (Brigham Street and Park Street Crossings) Peak Flow Rates at Willow Street

Flood Event	Peak Flow Rate (cfs)
Low Flow[1]	0.184
Bankfull Discharge	13.5
5-Year	23.1
10-Year	30.9
25-Year	42.4
50-Year	52
100-Year	62.5
500-Year	90.6

Note: 1. Low flow value represents a 7-day 2-year low flow value.

The downstream reach boundary condition for the model was defined using known water surface elevations for the Assabet River published in the FIS. The FIS only included water surface elevations for the 10-year, 50-year, 100-year, and 500-year storm events, therefore water surface elevations were interpolated for the 2-year and 25-year. **Table 3-3** below depicts the Rating Curve utilized as downstream boundary conditions within the model.

Table 3-4: Assabet River Water Surface Elevations at Project Area

Flood Event	Water Surface Elevation (ft)
Bankfull Discharge[1]	13.5
10-Year	30.9
25-Year[1]	42.4
50-Year	52.1
100-Year	62.5
500-Year	90.6

Note: 1. Approximate Water Surface Elevation based on Known FIS Data.

3.3.2 HEC-RAS Analysis

The HEC-RAS model was used to evaluate each alternative against each other and the existing culvert. This steady state model calculates several variables, including, but not limited to, water surface elevation and channel velocity, from one cross section to the next using an iterative computation procedure which calculates from downstream to upstream. Woodard & Curran evaluated the effects each alternative has on water surface elevation and channel velocity as compared to existing conditions as part of this analysis.

Water surface elevation was evaluated to determine if a new culvert would result in over topping of banks, impact Brigham Street, Park Street, or the surrounding areas. **Table 3-5** below outlines the calculated eater surface elevation at each cross section for the existing conditions and each alternative during the 100-year storm event.

Table 3-5: Brigham and Park Street Culvert Crossings Unnamed Stream Water Surface Elevation (100-Year Storm Event)

Cross Section	Existing Conditions	Alternative 1	Alternative 2	Alternative 3
924	233.60	233.60	233.59	233.59
851	232.15	232.15	232.15	232.15
740	231.69	225.19	224.77	224.71
634	231.69	225.26	224.94	223.03
577	231.69	225.26	224.94	222.03
573	231.69	225.26	224.94	222.02
Brigham Street Culvert Crossing (Road Elevation:232)				
494	220.85	219.33	220.85	219.40
489	220.85	218.72	220.86	218.72
457	220.85	217.23	220.86	216.84
412	220.85	217.26	220.86	216.24
372	220.85	217.16	220.86	215.39
369	220.85	217.17	220.86	214.47
Park Street Culvert Crossing (Road Elevation:222)				
38	212.60	212.60	212.60	212.60
32	212.60	212.60	212.60	212.60

Notes: 1. Cross section 32 is located on the downstream end while cross section 924 is located on the upstream end.

As shown in **Table 3-5** above, the water surface elevations upstream of the Brigham and Park Street culverts are reduced for alternatives 1 and 3. Water surface elevations upstream of the Brigham Street culvert was reduced and there was no significant water surface elevation change upstream and downstream of the Park street culvert. The water surface elevation between Brigham Street and Park Street is largely controlled by the flow capacity of the Park Street culvert. The water surface elevation meets the road elevation at Park Street during the 100-year storm event for Alternative 2. Alternative 1 and 3 result in reduced water surface elevations at Brigham and Park Street and provide at least 1 foot of freeboard during the 100-year storm event. Alternative 2 results in reduced water surface elevations at only Brigham Street and provide at least 1 foot of freeboard during the 100-year storm event. The largest change in water surface elevation is observed for Alternative 3 which is expected as this alternative provides the largest flow capacity of the three alternatives.

The velocity of the stream entering and exiting the culvert is evaluated to determine if a new culvert has the potential to cause scour or erosion of the streambed and banks or stream channel adjustment. Additionally, culverts designed to meet the Stream Crossing Standards should provide a design velocity and depth matching those found in the natural stream over a range of flows. **Table 3-6** below outlines the calculated average channel velocity up and downstream of Brigham Street and Park Street during existing conditions and as evaluated for each alternative. The upstream and downstream locations were selected within 2 feet of each culvert, rather than directly next to the culvert, to better evaluate velocities that represent the natural stream, not the portion of the stream directly influenced by the culvert.

Table 3-6: Unnamed Stream Average Velocity (Bankfull, 25-Year, 100-Year Storm Events)

Storm Event	Location	Existing (ft/sec)	Alternative 1 (ft/sec)	Alternative 2 (ft/sec)	Alternative 3 (ft/sec)
Bankfull Discharge	Upstream of Brigham Street	1.93	2.63	2.63	3.23
	Between Brigham and Park	2.64	3.02	2.64	3.04
	Downstream of Park Street	2.89	2.90	2.89	2.68
25-Year	Upstream of Brigham Street	1.83	3.29	3.29	4.37
	Between Brigham and Willow	2.16	3.25	2.16	3.90
	Downstream of Park Street	1.96	1.96	1.96	1.94
100-Year	Upstream of Brigham Street	2.11	2.89	3.17	4.83
	Between Brigham and Willow	0.41	2.82	0.41	4.29
	Downstream of Park Street	0.09	0.09	0.09	0.07

As shown in **Table 3-6** above, the calculated average channel velocity for each flow event is generally maintained as compared to existing conditions for each alternative downstream of Park Street and between Park Street and Brigham Street. Upstream of Brigham Street, the average channel velocity increases during these two existing for all Alternative. The increase in velocity for the Alternatives is a result of increased flow capacity, indicating that existing culvert size at Brigham Street and Park Street acts as a restriction, which is causing localize ponding and flooding upstream. This observed increase is less than 2 feet per second for smaller storm events and is increased slightly in larger storm events.

3.4 Massachusetts River and Stream Crossing Standards

The alternatives analysis conducted for replacing the existing culverts at Brigham Street and Park Street included an evaluation of each structure's ability to meet the Stream Crossing Standards to the maximum extent practicable. These standards, developed by the River and Stream Continuity Partnership, aim to provide design guidance for effective fish and wildlife crossings. The Stream Crossing Standards are based on seven important variables: type of crossing, embedment, crossing span, openness, substrate, water depth and velocity, and banks. The general and optimal standards are summarized in **Table 3-7** below.

Table 3-7: Stream Crossing Standards Summary

	General Standards	Optimal Standards
Structure Type	Open-bottom span preferred	Bridge
Embedment	If a culvert, then it should be embedded: • A minimum of 2 feet for all culverts, • A minimum of 2 feet and at least 25 percent for round pipe culverts • When embedment material includes elements > 15 inches in diameter, embedment depths should be at least twice the D_{84} of the embedment material	NA
Crossing Span	Minimum: 1.2 x bankfull width[2]	Minimum: 1.2 x bankfull width
Substrate	Matches stream substrate	Matches stream substrate
Water Depth & Velocity	Matches water depth & velocity in natural stream over a range of flows	Matches water depth & velocity in natural stream over a range of flows
Openness[3] (& height)	Openness: 0.82 ft. (0.25 m)	Conditions that inhibit wildlife passage over road Openness: 2.46 ft (0.75 m) Height: 8 ft (2.4 m) Otherwise Openness: 1.64 ft (0.5 m) Height: 6 ft (1.8 m)
Banks	• On both sides of the stream • Match the horizontal profile of the existing stream and banks • Constructed so as not to hinder use by riverine wildlife	• On both sides of the stream • Match the horizontal profile of the existing stream and banks • Constructed so as not to hinder use by riverine wildlife • Sufficient headroom for wildlife

Note: 1. Table from Massachusetts River & Stream Crossing Standards, dated March 1, 2011; 2. Bankfull width considered to be 13 feet; 3. Openness is calculated by dividing the cross-sectional area of the structure opening by its crossing length.

3.4.1 Alternative 1:

Woodard & Curran analyzed Alternative 1 for conformance to the Stream Crossing Standards. Both the Brigham Street culvert structure and the Park Street structure will not meet stream crossing standards criteria for structure type, will not meet the crossing span criteria of 1.2 times the bankfull width nor the openness criteria as Brigham Street results in an approximate openness ratio of 0.38 and 0.09 for Park Street. This alternative does meet optimal standard for substrate. During common storm events, this alternative improves flow capacity at both crossings to help reduce flooding in the nearby area. The structural integrity of both culverts will be improved, resulting in a public safety benefit. Bank resource areas may be altered as a result of Alternative 1, however, new banks will be constructed to meet and match existing non-disturbed banks following of the new crossing that will not hinder use by riverine wildlife at Brigham Street, thereby meeting the general standard for banks.

3.4.2 Alternative 2:

In addition, Woodard & Curran analyzed Alternative 2 for conformance to the Stream Crossing Standards. The Brigham Street culvert structure will not meet stream crossing standards criteria for structure type, will not meet the crossing span criteria of 1.2 times the bankfull width nor the openness criteria as Brigham Street results in an approximate openness ratio of 0.38. This alternative does meet optimal standard for substrate and general standards for water depth and velocity and banks. During common storm events, this alternative improves flow capacity and helps reduce flooding at the Brigham Street culvert only and no hydraulic improvements will be made for the Park Street culvert. The structural integrity of both culverts will be improved, resulting in a public safety benefit. Similar to Alternative 1, Bank resource areas may be altered as a result of this alternative, however, new banks will be constructed to meet and match existing non-disturbed banks following of the new crossing that will not hinder use by riverine wildlife at Brigham Street, thereby meeting the general standard for banks.

3.4.3 Alternative 3:

Lastly, Woodard & Curran analyzed Alternative 3 for conformance to Stream Crossing Standards. Unlike Alternative 1 and 2, this alternative does meet the stream crossing standard criteria of 1.2 times the bankfull width but does not meet the stream crossing standards for structure type or Openness. The structures result in an approximate flow area of 27 square feet, which results in an openness ratio of approximately 0.36 at Brigham Street and 0.08 at Park Street. To meet Stream Crossing Standards for openness the culvert structures would need to be at a minimum of 7 feet in height and this requirement is not feasible for this site. This alternative results in an increase in velocity compared to the existing condition and Alternative 1 and 2. Similarly to Alternative 1, bank resources may be altered as a result of this alternative. New banks will be constructed to meet and match existing non-disturbed banks following the installation of the new crossings that will not hinder use by riverine wildlife at both crossings thereby meeting the general standard for banks.

3.4.4 Comparison to the Massachusetts Stream Crossing Standards

Table 3-8 below outlines the alternatives assessed and their ability to meet the Massachusetts Stream Crossing Standards. As mentioned in the Massachusetts Stream Crossings Handbook of the Division of Ecological Restoration, Crossing Guidelines Section, General and Optimum standards are a set of standards in which crossings should be designed to help balance cost, logistics of designs, and stream protection. General standards provide fish passage, stream continuity, some wildlife passage and should be meet for all new permanent and where feasible. In the other hand, Optimum standards provide fish passage, stream continuity, wildlife passage and should be used in areas of critical habitat for rare and endangered species and areas of statewide significance. Alternatives that are noted with (None) do not meet General or Optimum standards.

Table 3-8: Alternatives Analysis – Stream Crossing Standards

Brigham Street Culvert Crossing			
Standard	**Alternative 1**	**Alternative 2**	**Alternative 3**
Structure Type	None	None	None
Embedment	N/A	N/A	N/A
Crossing Span	None	None	Optimal
Substrate	Optimal	Optimal	Optimal
Water Depth & Velocity	General	General	General
Openness (& height)	None (0.38 feet)	None (0.38 feet)	None (0.36 feet)
Banks	General	General	General

Park Street Culvert Crossing			
Standard	**Alternative 1**	**Alternative 2**	**Alternative 3**
Structure Type	None	N/A	None
Embedment	N/A	N/A	N/A
Crossing Span	None	N/A	Optimal
Substrate	Optimal	N/A	Optimal
Water Depth & Velocity	General	N/A	General
Openness (& height)	None (0.38 feet)	N/A	None (0.36 feet)
Banks	General	N/A	General

As shown in Table 3-8 above, Alternative 3 best meets the Stream Crossing Standards. Alternative 1 and 2 meet similar standards criteria except for crossing span at both crossings (except for Park Street on Alternative 2). All alternatives provide an improvement to the existing hydraulic performance of both crossings (except for Park Street on Alternative 2).

4. SUMMARY

4.1 Recommendations

This report summarizes the data collection and engineering evaluation conducted for the Brigham Street Culvert Replacement Project. Three alternatives are presented for the Town's consideration for replacement of the existing Brigham Street and Park Street culverts. The alternatives meet some of the Stream Crossing Standards and provide an improvement over the existing condition. Information provided in this report can be used by the Town to select a preferred alternative and as a basis for the permitting and design of a replacement culvert.

4.2 Next Steps

Following the receipt of this Report, the Town can move into the design phase of this Project with a selected alternative. This phase will include the full design of the culvert including modeling and the development of design drawings and construction documents. To assist in the final design, the following should be completed:

- Prevent erosion and scour by designing a culvert to match the existing velocities elsewhere in the channel seen on site as practical.
- If Alternative 1 or 3 are selected, conduct a drainage analysis and evaluate if minor drainage improvements can be made in parallel with the culvert replacement.
- Limit temporary construction disturbance to critical areas.
- Conduct heavy cleaning of the Park Street culvert and conduct CCTV of the entirety of pipe segment.

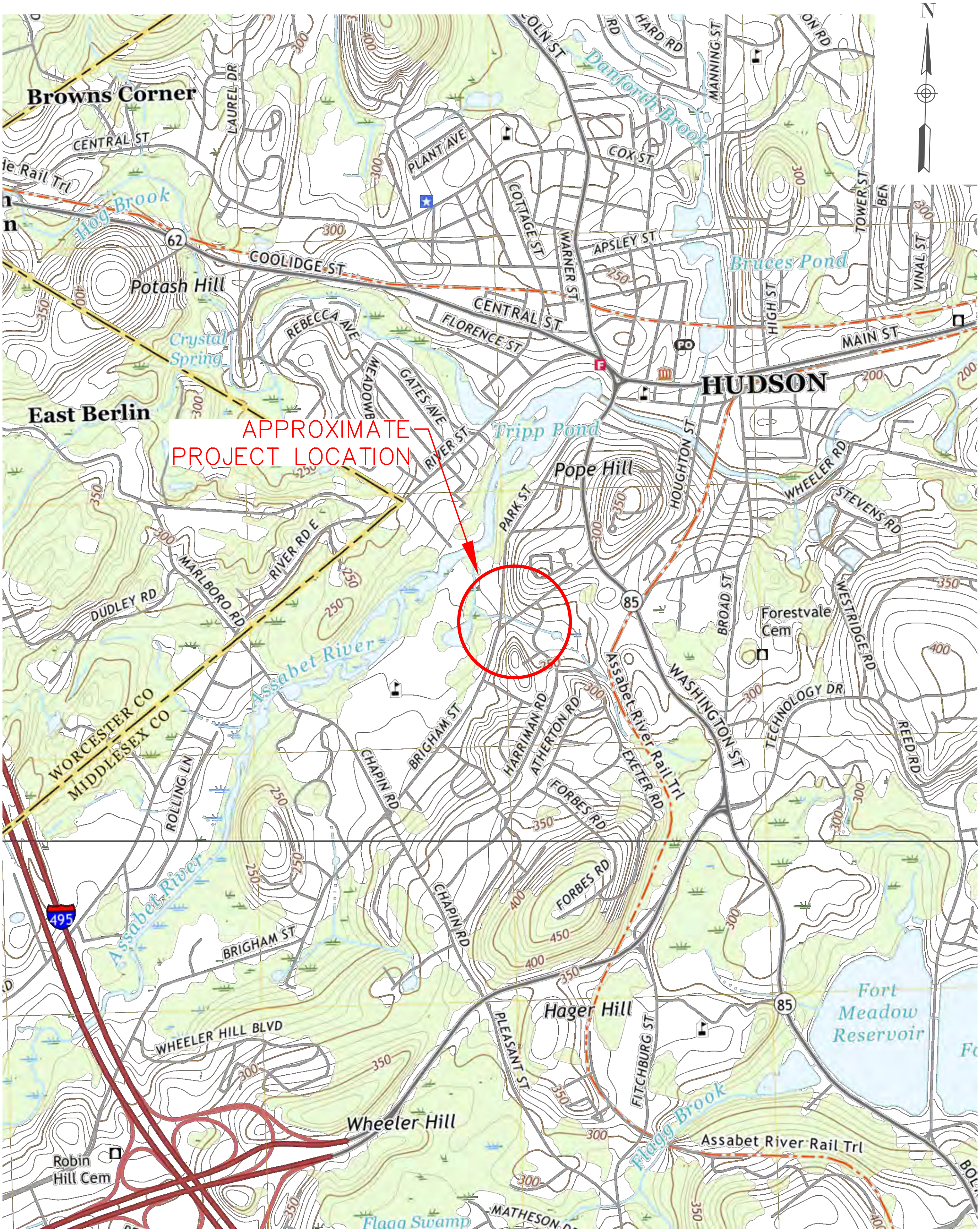
4.3 Future Permitting Considerations

The Town will need to obtain several permits prior to the construction of a new replacement culvert. The following permits are anticipated for the Project:

- United States Army Corps of Engineers Section 404 Permit;
- United States Army Corps Pre-Construction Notification;
- Notice of Intent under the Massachusetts Wetlands Protection Act;
- Massachusetts Department of Environmental Protection Water Quality Certification (Section 401);
- Environmental Notification Form under the Massachusetts Environmental Policy Act;

APPENDIX A: PROJECT MAPS

PLOT SCALE: 1:1



NOTE: TOPOGRAPHIC MAP, DATED 2021, ACCESSED FROM UNITED STATES GEOLOGICAL FIELD SURVEY (USGS) ON MARCH 11, 2023.

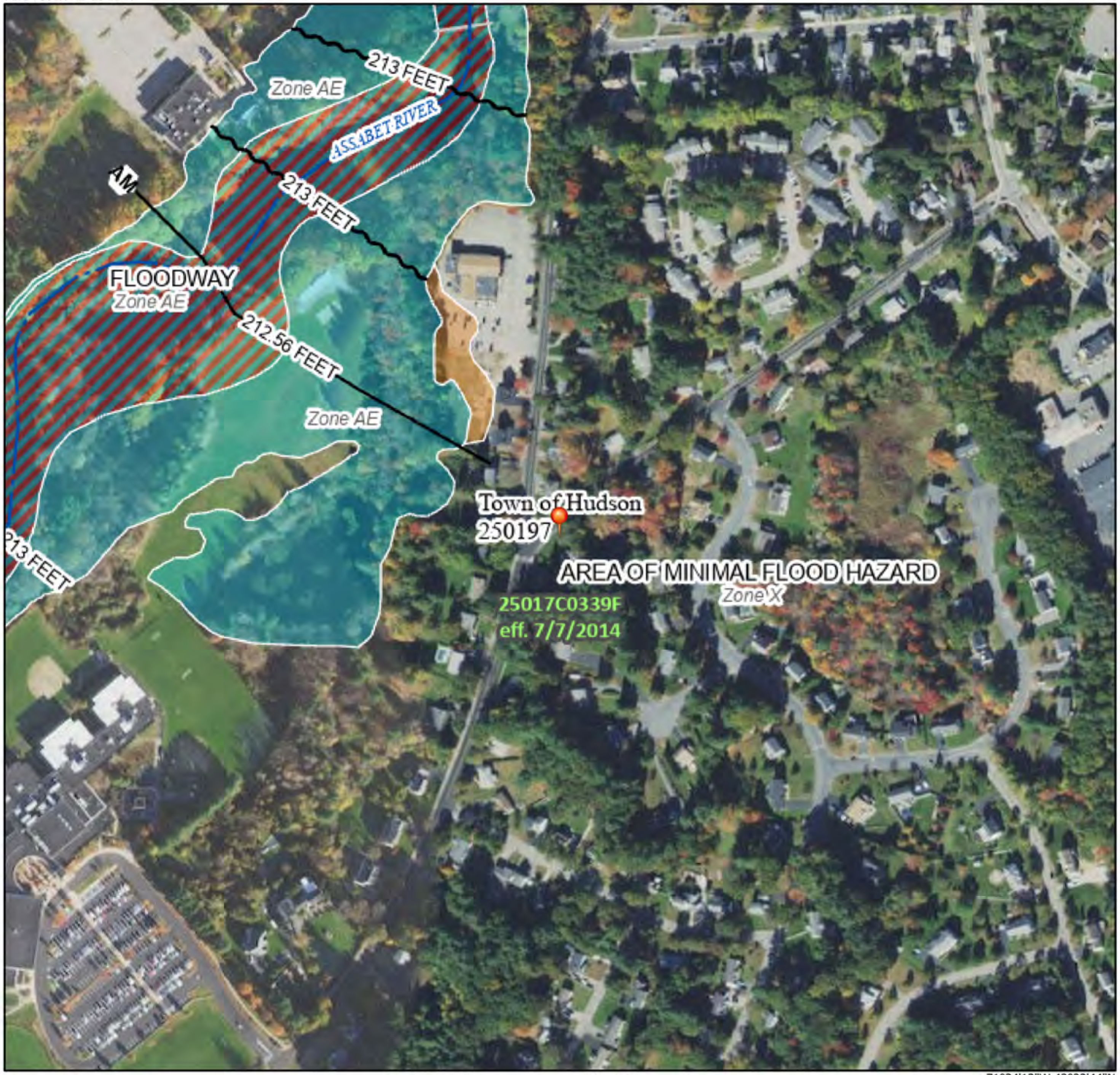
Woodard & Curran	Client Info: TOWN OF HUDSON, MASSACHUSETTS 1 MUNICIPAL DRIVE HUDSON MA, 01749	Job No: 0234865.00 Date: JUNE 2023 Scale: N.T.S Des by: HAO Drn by: HAO Chk by: KLD	Drawing Title SITE LOCUS MAP PARK STREET AND BRIGHAM STREET CULVERTS	Drawing Number FIGURE 1

\\woodardcurran.net\shared\projects\0234865.00 hudson ma culvert design park & brigham st\wip\drawings\figures\site locus map

National Flood Hazard Layer FIRMette

FEMA

71°34'50"W 42°23'11"N



71°34'12"W 42°22'44"N

Feet

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

1:6,000

Basemap Imagery Source: USGS National Map 2023

Legend

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

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) *Zone A, V, A99*
		With BFE or Depth *Zone AE, AO, AH, VE, AR*
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
		Future Conditions 1% Annual Chance Flood Hazard *Zone X*
		Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
		Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN	Area of Minimal Flood Hazard *Zone X*
		Effective LOMRs
		Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES	B 20.2 / 17.5	Cross Sections with 1% Annual Chance Water Surface Elevation
	8	Coastal Transect
	513	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

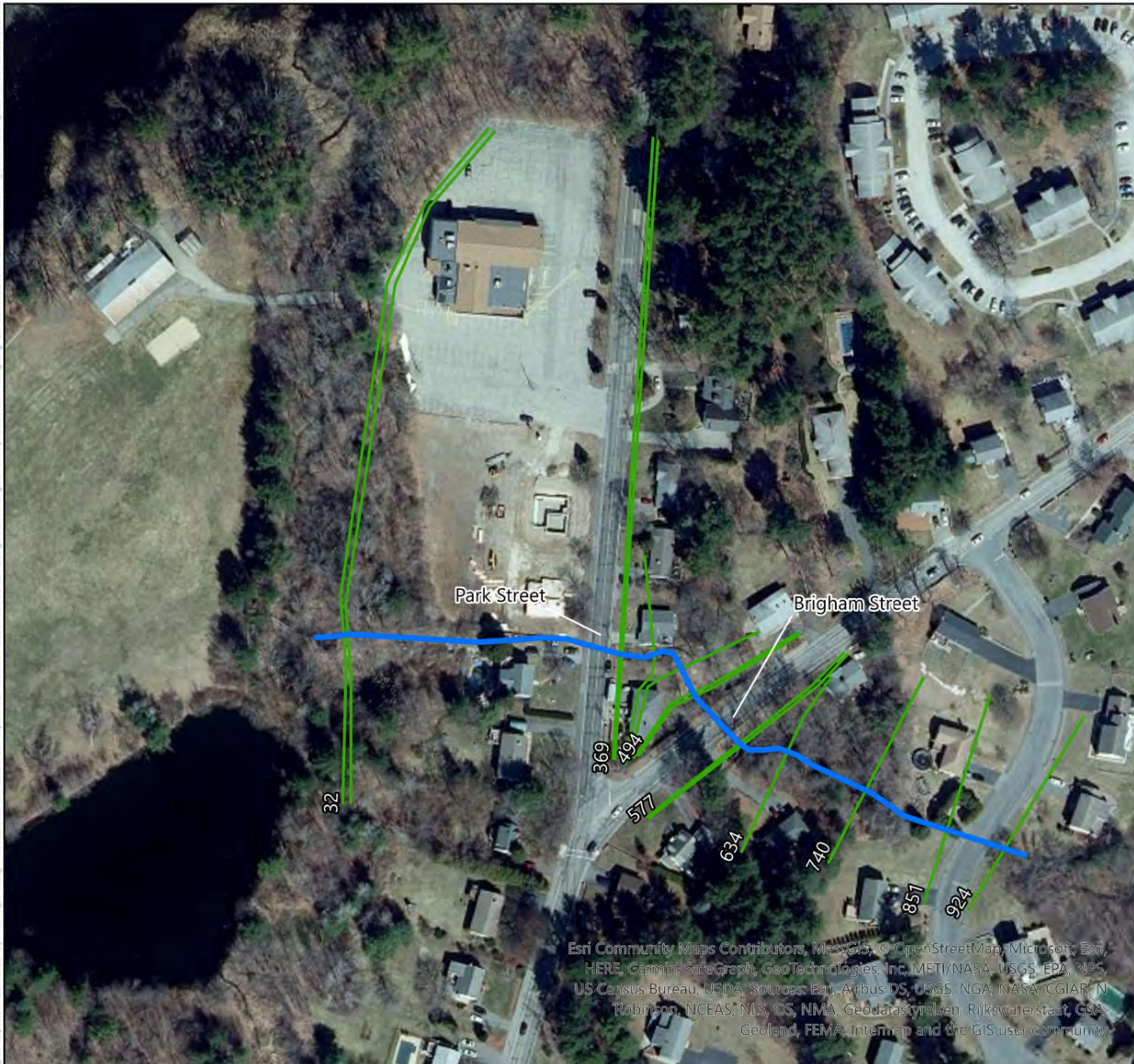
N

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

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

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 6/21/2023 at 1:56 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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



Brigham Street Crossing

Culvert Replacement Feasibility Study
Cross Section Location Map

N

Legend

- Unnamed Stream
- Cross-Sections

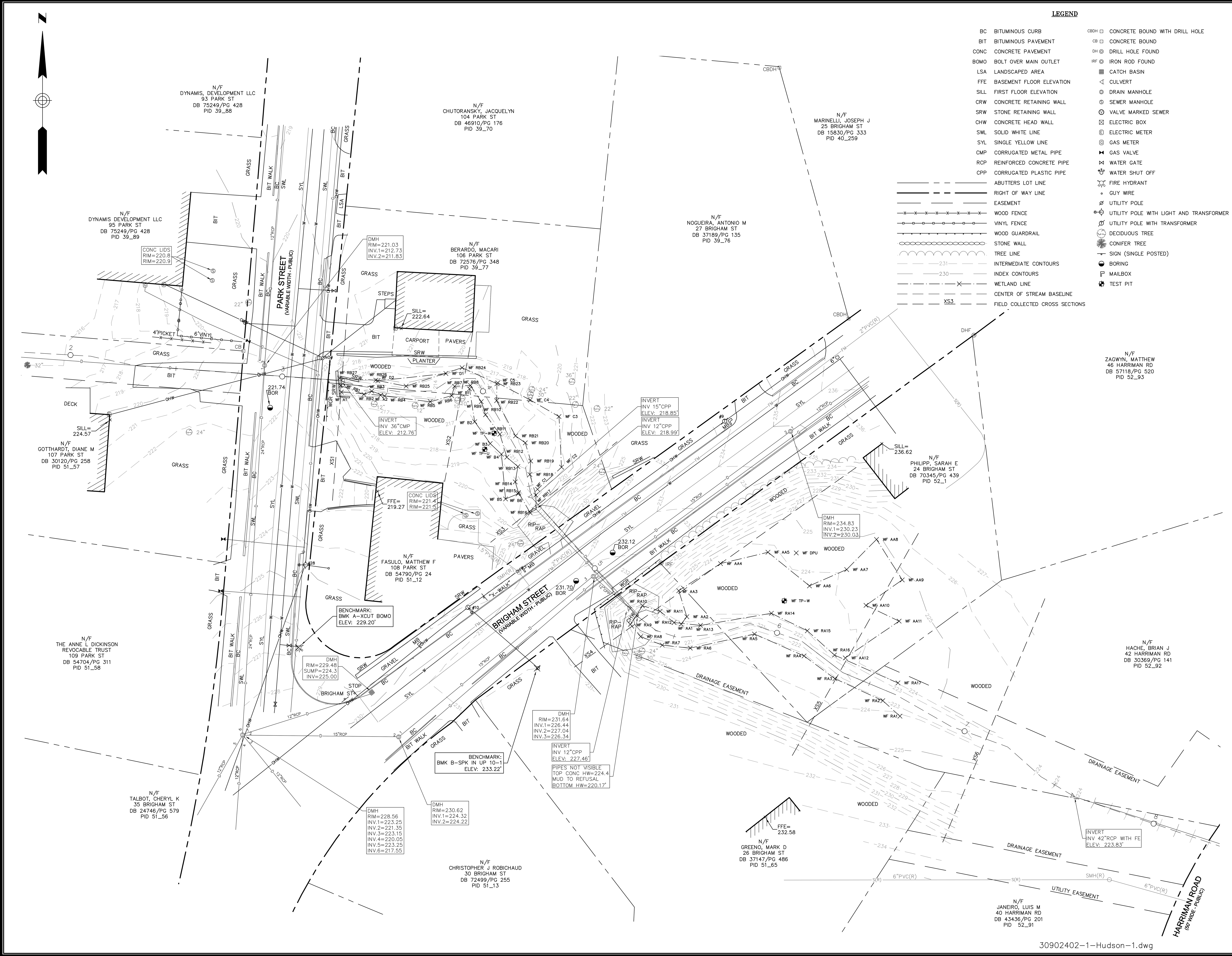
0 40 80 160 US Feet

Woodard & Curran

Project #: 0234865.00
Map Created: June 2023

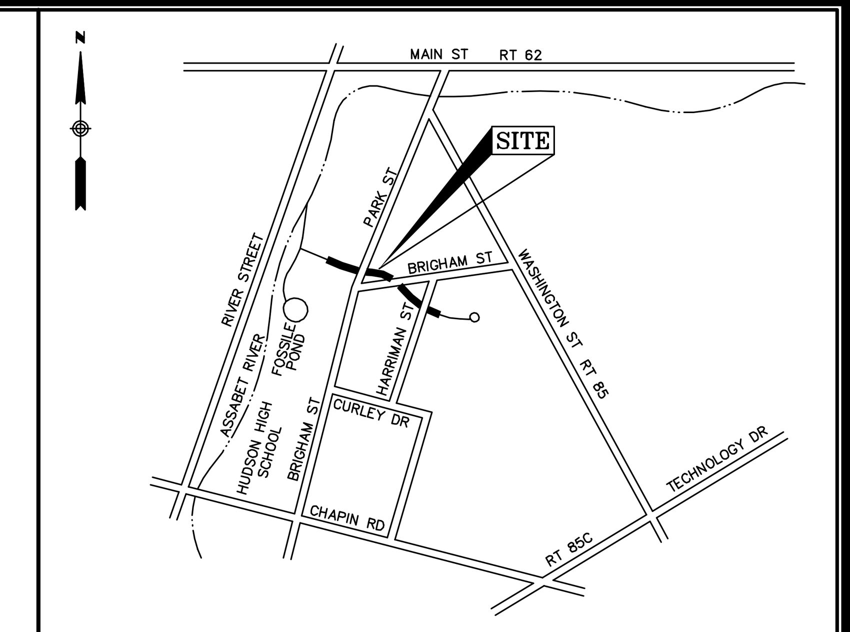
Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources: MassGIS USGS Orthos Imagery 2021.**

APPENDIX B: SURVEY DRAWINGS



LEGEND

BC	BITUMINOUS CURB
BIT	BITUMINOUS PAVEMENT
CONC	CONCRETE PAVEMENT
BOMO	BOLT OVER MAIN OUTLET
LSA	LANDSCAPED AREA
FFE	BASEMENT FLOOR ELEVATION
SILL	FIRST FLOOR ELEVATION
CRW	CONCRETE RETAINING WALL
SRW	STONE RETAINING WALL
CHW	CONCRETE HEAD WALL
SWL	SOLID WHITE LINE
SYL	SINGLE YELLOW LINE
CMP	CORRUGATED METAL PIPE
RCP	REINFORCED CONCRETE PIPE
CPP	CORRUGATED PLASTIC PIPE
	ABUTTERS LOT LINE
	RIGHT OF WAY LINE
	EASEMENT
	WOOD FENCE
	VINYL FENCE
	WOOD GUARDRAIL
	STONE WALL
	TREE LINE
231	INTERMEDIATE CONTOURS
230	INDEX CONTOURS
	WETLAND LINE
	CENTER OF STREAM BASELINE
XS3	FIELD COLLECTED CROSS SECTIONS
CBDH	CONCRETE BOUND WITH DRILL HOLE
CB	CONCRETE BOUND
DH	DRILL HOLE FOUND
IRF	IRON ROD FOUND
	CATCH BASIN
	CULVERT
	DRAIN MANHOLE
	SEWER MANHOLE
	VALVE MARKED SEWER
	ELECTRIC BOX
	ELECTRIC METER
	GAS METER
	GAS VALVE
	WATER GATE
	WATER SHUT OFF
	FIRE HYDRANT
	GUY WIRE
	UTILITY POLE
	UTILITY POLE WITH LIGHT AND TRANSFORMER
	UTILITY POLE WITH TRANSFORMER
	DECIDUOUS TREE
	CONIFER TREE
	SIGN (SINGLE POSTED)
	BORING
	MAILBOX
	TEST PIT



LOCUS MAP
(N.T.S.)

PLAN REFERENCES

PLAN 230 OF 1953
PLAN 2040 OF 1954
PLAN 1441 OF 1967
PLAN 528 OF 1969
PLAN 1066 OF 1974
PLAN 1420 OF 1975
PLAN 1383 OF 1977
PLAN 180 OF 1985
PLAN 1707 OF 1985
PLAN 102 OF 1989
PLAN 183 OF 1991
PLAN 456 OF 2020

UTILITY STATEMENTS

THE LOCATION OF THE UTILITIES AS SHOWN HEREON HAVE BEEN COMPILED FROM VISIBLE STRUCTURES AND INFORMATION OBTAINED FROM VARIOUS SOURCES. THE ACTUAL LOCATION OF ALL UTILITIES AND UNDERGROUND STRUCTURES SHALL BE CONSIDERED APPROXIMATE AND SHALL BE VERIFIED BY THE OWNER PRIOR TO ANY CONSTRUCTION. THE SURVEYOR MAKES NO GUARANTEES THAT THE UNDERGROUND UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICES OR ABANDONED. THE SURVEYOR FURTHER DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED.

NOTES

1. THIS PLAN WAS PREPARED FROM AN ACTUAL ON THE GROUND FIELD SURVEY CONDUCTED BY WSP IN MARCH OF 2023.

2. THE HORIZONTAL DATUM SHOWN HEREON IS REFERENCED TO THE NORTH AMERICAN DATUM OF 1983, MASSACHUSETTS STATE PLANE MAINLAND COORDINATE SYSTEM AND WAS ESTABLISHED UTILIZING RTK GPS SURVEY TECHNIQUES.

3. THE VERTICAL DATUM SHOWN HEREON IS REFERENCED TO NAVD88 AND WAS ESTABLISHED ON SITE UTILIZING RTK GPS SURVEY TECHNIQUES.

4. THE SURVEYED PROPERTY IS SUBJECT BUT NOT LIMITED TO THE INFORMATION SHOWN HEREON. ALL INFORMATION THAT MAY AFFECT THE QUALITY OF THE TITLE TO BOTH THE SUBJECT AND ADJOINING PARCELS SHOULD BE VERIFIED BY AN ACCURATE AND CURRENT TITLE REPORT. THIS SURVEY WAS PREPARED WITHOUT THE BENEFIT OF A CURRENT TITLE REPORT.

5. WETLANDS WERE DELIMITED BY OTHERS AND LOCATED BY WSP IN MARCH OF 2023.

GRAPHIC SCALE

20 0 10 20 40 80

(IN FEET)
1 inch = 20 ft.

REVISION	
DATE	DESCRIPTION
--/--/--	---

EXISTING CONDITIONS PLAN

PARK STREET & BRIGHAM STREET
HUDSON, MASSACHUSETTS
PREPARED FOR
WOODARD & CURRAN

WSP USA Inc.
100 North Parkway-First Floor
Worcester, MA 01605
508.248.1970

Drawn By	RBP	Date	Job No.
Surveyed By	TC/EC	APRIL 10, 2023	3002402.001
Checked By	DPP	Scale	Sheet No.
Book No.	CHA-92	1" = 20'	1 OF 1

APPENDIX C: WETLANDS REPORT

EcoTec, Inc.

ENVIRONMENTAL CONSULTING SERVICES
102 Grove Street
Worcester, MA 01605-2629
508-752-9666 – Fax: 508-752-9494

March 13, 2023

Carly Quinn, PE
Woodard & Curran
33 Bond Street
Providence, RI 02903

RE: Wetland Resource Evaluation, Brigham Street Culvert, Hudson, Massachusetts

Dear Ms. Quinn:

On February 27, 2023, EcoTec, Inc. inspected the above-referenced property for the presence of wetland resources as defined by: (1) the Massachusetts Wetlands Protection Act (M.G.L. Ch. 131, § 40; the "Act") and its implementing regulations (310 CMR 10.00 *et seq.*; the "Regulations"); and (2) the U.S. Clean Water Act (i.e., Section 404 and 401 wetlands). Scott Jordan conducted the inspection.

The subject site consists of a the area within the vicinity of a proposed culvert replacement project along Brigham Street and Park Street in Hudson, Massachusetts. The upland portions of the site consist of existing single family homes with associated driveways and lawns. The wetland resources observed on the site are described below.

Methodology

The site was inspected, and areas suspected to qualify as wetland resources were identified. The boundary of Bordering Vegetated Wetlands or, in the absence of Bordering Vegetated Wetlands, Bank was delineated in the field in accordance with the definitions set forth in the regulations at 310 CMR 10.55(2)(c) and 310 CMR 10.54(2). Section 10.55(2)(c) states that "The boundary of Bordering Vegetated Wetlands is the line within which 50% or more of the vegetational community consists of wetland indicator plants and saturated or inundated conditions exist." Section 10.54(2)(c) states that "The upper boundary of Bank is the first observable break in the slope or the mean annual flood level, whichever is lower." The methodology used to delineate Bordering Vegetated Wetlands is further described in: (1) the BVW Policy "*BVW: Bordering Vegetated Wetlands Delineation Criteria and Methodology*," issued March 1, 1995; and (2) "*Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act: A Handbook*," produced by the Massachusetts Department of Environmental Protection, dated March 1995. The plant taxonomy used in this report is based on the *National List of Plant Species that Occur in Wetlands: Massachusetts* (Fish and Wildlife Service, U.S. Department of the Interior, 1988). Federal wetlands were presumed to have boundaries conterminous with the delineated Bordering Vegetated Wetlands and Bank. One set of DEP Bordering Vegetated Wetland Delineation Field Data Forms completed for observation plots located in the wetlands and uplands near flag B-3 is attached. The table below provides the Flag Numbers, Flag Type, and Wetland Types and Locations for the delineated wetland resources.

Flag Numbers	Flag Type	Wetland Types and Locations
Start RA1 to RA17 Stop	Pink Flags	Mean Annual High-water Line (MAHWL) and Bank of perennial stream located in the eastern portion of the site.
Start A1 to A2 Stop	Blue Flags	Boundary of Bordering Vegetated Wetlands located in the central portion of the site that is associated with a perennial stream.
Start B1 to B6 Stop	Blue Flags	Boundary of Bordering Vegetated Wetlands located in the central portion of the site that is associated with a perennial stream.
Start C1 to C5 Stop	Blue Flags	Boundary of Bordering Vegetated Wetlands located in the central portion of the site that is associated with a perennial stream.
Start D1 to D2 Stop	Blue Flags	Boundary of Bordering Vegetated Wetlands located in the central portion of the site that is associated with a perennial stream.
Start RB1 to RB27 Stop	Pink Flags	Mean Annual High-water Line (MAHWL) and Bank of perennial stream located in the central portion of the site.
Start E1 to E5 Stop	Blue Flags	Boundary of Bordering Vegetated Wetlands located in the western portion of the site that is associated with a perennial stream.
Start F1 to F3 Stop	Blue Flags	Boundary of Bordering Vegetated Wetlands located in the western portion of the site that is associated with a perennial stream.
Start RC1 to RC4 Stop	Pink Flags	Mean Annual High-water Line (MAHWL) and Bank of perennial stream located in the western portion of the site.
Start AA1 to AA12 Stop	Blue Flags	Boundary of Bordering Vegetated Wetlands located in the eastern portion of the site, at 24 Brigham Street, that is associated with a perennial stream.

Findings

Wetlands AA, A, B, C, D, E & F (i.e., flags AA1 to AA12, A1 to A2, B1 to B6, C1 to C5, D1 to D2, E1 to E5, and F1 to F3) consists of wooded/shrub swamps located on the site that are associated with a perennial stream. Plant species observed include red maple (*Acer rubrum*) and American elm (*Ulmus americana*) trees and/or saplings; silky dogwood (*Cornus amomum*), glossy buckthorn (*Rhamnus frangula*), and American elderberry (*Sambucus canadensis*) shrubs; and sensitive fern (*Onoclea sensibilis*), spotted touch-me-not (*Impatiens capensis*), purple loosestrife (*Lythrum salicaria*), soft rush (*Juncus effusus*), spotted touch-me-not (*Impatiens capensis*), and golden-rods (*Solidago sp*.), ground cover. Evidence of wetland hydrology, including hydric soils, saturated soils, pore linings, and evidence of flooding, was observed within the delineated wetland. This vegetated wetland borders a perennial stream; accordingly, the vegetated wetlands would be regulated as Bordering Vegetated Wetlands and the perennial stream would be regulated as Bank and Land Under Water Bodies and Waterways under the Act. A 100-foot Buffer Zone extends horizontally outward from the edge of Bordering Vegetated Wetlands and Bank under the Act.

Bordering Land Subject to Flooding is an area that floods due to a rise in floodwaters from a bordering waterway or water body. Where flood studies have been completed, the boundary of Bordering Land Subject to Flooding is based upon flood profile data prepared by the National Flood Insurance Program. Section 10.57(2)(a)3. states that "The boundary of Bordering Land Subject to Flooding is the estimated maximum lateral extent of flood water which will theoretically result from the statistical 100-year frequency storm." The project engineer should evaluate the most recent National Flood Insurance Program flood profile data to determine if Bordering Land Subject to Flooding occurs on the site. Bordering Land Subject to Flooding would occur in areas where the 100-year flood elevation is located outside of or upgradient of the delineated Bordering Vegetated Wetlands or Bank boundary. Bordering Land Subject to Flooding does not have a Buffer Zone under the Act.

The Massachusetts Rivers Protection Act amended the Act to establish an additional wetland resource area: Riverfront Area. Based upon a review of the current USGS Map (i.e., Hudson Quadrangle, dated 1997, attached), a stream that is shown as perennial is located on the site. Streams that are shown as perennial on the current USGS map are designated perennial under the Massachusetts Wetlands Protection Act regulations. Unless this perennial designation is overcome, Riverfront Area is presumed to extend 200 feet horizontally upgradient from the mean annual high-water line of the stream. Section 10.58(2)(a)2. states that the "Mean annual high-water line of a river is the line that is apparent from visible markings or changes in the character of soils or vegetation due to prolonged presence of water and that distinguishes between predominantly aquatic and predominantly terrestrial land. Field indicators of bankfull conditions shall be used to determine the mean annual high-water line. Bankfull field indicators include but are not limited to: changes in slope, changes in vegetation, stain lines, top of pointbars, changes in bank materials, or bank undercuts." Section 10.58(2)(a)2.a. states that "In most rivers, the first observable break in slope is coincident with bankfull conditions and the mean annual high-water line." The mean annual high-water line of the stream was delineated in the field with flags RA1 to RA17, RB1 to RB27 and RC1 to RC4 based upon the above-referenced regulation. Furthermore, based upon a review of the current USGS Map and observations made during the site inspection, there are no other mapped or unmapped streams located within 200 feet of the site. Accordingly, except as noted above, Riverfront Area would not occur on the site. Riverfront Area does not have a Buffer Zone under the Act, but may overlap other wetland resources and their Buffer Zones.

The Regulations require that no project may be permitted that will have any adverse effect on specified habitat sites of rare vertebrate or invertebrate species, as identified by procedures set forth at 310 CMR 10.59. Based upon a review of the *Massachusetts Natural Heritage Atlas*, 15th edition, Priority Habitats and Estimated Habitats from the NHESP Interactive Viewer, valid from August 1, 2021, and Certified Vernal Pools from MassGIS, there are no Estimated Habitats [for use with the Act and Regulations (310 CMR 10.00 *et seq*.)], Priority Habitats [for use with Massachusetts Endangered Species Act (M.G.L. Ch. 131A; "MESA") and MESA Regulations (321 CMR 10.00 *et seq*.)], or Certified Vernal Pools on or in the immediate vicinity of the site. A copy of this map is attached.

The reader should be aware that the regulatory authority for determining wetland jurisdiction rests with local, state, and federal authorities. A brief description of my experience and qualifications is attached. If you have any questions, please feel free to contact me at any time.

Cordially,
ECOTEC, INC

Scott Jordan
Senior Environmental Scientist

Attachments (12 pages)

11/W/HudsonBrighamStCulvertReport

BORDERING VEGETATED WETLAND DETERMINATION FORM

Project/Site: Brigham Street Culvert City/Town: Hudson Sampling Date: 2/27/23

Applicant/Owner: ______ Sampling Point or Zone: TPWet @ B3

Investigator(s): Scott Jordan, EcoTec, Inc. Latitude/Longitude: 42.38299 / -71.57517

Soil Map Unit Name: 254 B Merrimac Fine Sandy Loam NWI or DEP Classification: Wet meadow

Are climatic/hydrologic conditions on the site typical for this time of year? Yes x No ____ (If no, explain in Remarks)

Are Vegetation ____ , Soil ____ , or Hydrology ____ significantly disturbed? (If yes, explain in Remarks)

Are Vegetation ____ , Soil ____ , or Hydrology ____ naturally problematic? (If yes, explain in Remarks)

SUMMARY OF FINDINGS – Attach site map and photograph log showing sampling locations, transects, etc.

Wetland vegetation criterion met? Yes x No ____ Hydric Soils criterion met? Yes x No ____ Wetlands hydrology present? Yes x No ____	**Is the Sampled Area within a Wetland?**	Yes x No ____
Remarks, Photo Details, Flagging, etc.:		

HYDROLOGY

Field Observations:			
Surface Water Present?	Yes ____	No x	Depth (inches) ____
Water Table Present?	Yes x	No ____	Depth (inches) 6"
Saturation Present (including capillary fringe)?	Yes x	No ____	Depth (inches) surface

Wetland Hydrology Indicators

Reliable Indicators of Wetlands Hydrology	Indicators that can be Reliable with Proper Interpretation	Indicators of the Influence of Water
____ Water-stained leaves	____ Hydrological records	____ Direct observation of inundation
____ Evidence of aquatic fauna	x Free water in a soil test hole	____ Drainage patterns
____ Iron deposits	x Saturated soil	____ Drift lines
____ Algal mats or crusts	____ Water marks	____ Scoured areas
____ Oxidized rhizospheres/pore linings	____ Moss trim lines	____ Sediment deposits
____ Thin muck surfaces	____ Presence of reduced iron	____ Surface soil cracks
____ Plants with air-filled tissue (aerenchyma)	____ Woody plants with adventitious roots	____ Sparsely vegetated concave surface
____ Plants with polymorphic leaves	____ Trees with shallow root systems	____ Microtopographic relief
____ Plants with floating leaves	____ Woody plants with enlarged lenticels	____ Geographic position (depression, toe of slope, fringing lowland)
____ Hydrogen sulfide odor		
Remarks (describe recorded data from stream gauge, monitoring well, aerial photos, previous inspections, if available):		

This form is only for BVW delineations. Other wetland resource areas may be present and should be delineated according to the applicable regulatory provisions.

Sampling Point TPwet @B3

VEGETATION – Use both common and scientific names of plants.

Tree Stratum Plot size 30'

Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1. Red maple	Acer rubrum	FAC	15	yes	yes
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
			15 = Total Cover		

Shrub/Sapling Stratum Plot size 15'

Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1. American elder	Sambucus canadensis	FACW-	10	yes	yes
2. Silky dogwood	Cornus amomum	FACW	5	yes	yes
3.					
4.					
5.					
6.					
7.					
8.					
9.					
			15 = Total Cover		

Herb Stratum Plot size 5'

Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1. Purple loosestrife	Lythrum salicaria	FACW+	50	yes	yes
2. Goldenrod	Solidago spp.	WET	30	yes	yes
3. Jewelweed	Impatiens capensis	FACW	20	yes	yes
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
			100 = Total Cover		

Sampling Point TPwet@B3

VEGETATION – continued.

Woody Vine Stratum Plot size 30'

Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1. None					
2.					
3.					
4.					
			______ = Total Cover		

Rapid Test:	Do all dominant species have an indicator status of OBL or FACW?			Yes ______ No x
Dominance Test:	Number of dominant species	Number of dominant species that are wetland indicator plants		Do wetland indicator plants make up ≥ 50% of dominant plant species?
	6	6		Yes x No ______
Prevalence Index:		Total % Cover (all strata)	Multiply by:	Result
	OBL species		X 1	=
	FACW species		X 2	=
	FAC species		X 3	=
	FACU species		X 4	=
	UPL species		X 5	=
	Column Totals	(A)		(B)
	Prevalence Index	B/A =		Is the Prevalence Index ≤ 3.0? Yes ______ No ______
Wetland vegetation criterion met?	**Yes** x **No** ______			

Definitions of Vegetation Strata

Tree - Woody plants 3 in. (7.62 cm) or more in diameter at breast height (DBH), regardless of height

Shrub/Sapling - Woody plants less than 3 in. (7.62 cm) DBH and greater than or equal to 3.3 ft. (1 m) tall

Herb - All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.3 ft. (1 m) tall

Woody vines - All woody vines greater than 3.3 ft. (1 m) in height

Cover Ranges	
Range	Midpoint
1-5 %	3.0 %
6-15 %	10.5 %
15-25 %	20.5 %
26-50 %	38.0 %
51-75 %	63.0 %
76-95 %	85.5 %
96-100 %	98.0 %

Sampling Point TPwet@B3

SOIL

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators)

Depth (inches)	Matrix		Redox Features				Texture	Remarks
	Color (moist)	%	Color (moist)	%	Type[1]	Location[2]		
0-8	10YR 2/1						Mucky loam	Oa
8+							Rock	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators (Check all that apply)		**Indicators for Problematic Hydric Soils**
___ Histosol (A1)	___ Sandy Redox (S5)	___ 2 cm Muck (A10)
x Histic Epipedon (A2)	___ Stripped Matrix (S6)	___ 5 cm Mucky Peat or Peat (S3)
___ Black Histic (A3)	___ Polyvalue Below Surface (S8)	___ Dark Surface (S7)
___ Hydrogen Sulfide (A4)	___ Thin Dark Surface (S9)	___ Polyvalue Below Surface (S8)
___ Stratified Layers (A5)	x Loamy Mucky Mineral (F1)	___ Thin Dark Surface (S9)
___ Depleted Below Dark Surface (A11)	___ Loamy Gleyed Matrix (F2)	___ Iron-Manganese Masses (F12)
___ Thick Dark Surface (A12)	___ Depleted Matrix (F3)	___ Mesic Spodic (A17)
___ Sandy Mucky Mineral (S1)	___ Redox Dark Surface (F7)	___ Red Parent Material (F21)
___ Sandy Gleyed Matrix (S4)	___ Depleted Dark Surface (F8)	___ Very Shallow Dark Surface (TF12)
___ Dark Surface (S7)		___ Other (Include Explanation in Remarks)

Restrictive Layer (if observed) Type: ______________ Depth (inches): ________

Remarks:

Hydric Soils criterion met? Yes x No ________

BORDERING VEGETATED WETLAND DETERMINATION FORM

Project/Site: Brigham Street Culvert City/Town: Hudson Sampling Date: 2/27/23
Applicant/Owner: ______ Sampling Point or Zone: TPU @ B3
Investigator(s): Scott Jordan, EcoTec, Inc. Latitude/Longitude: 42.38299 / -71.57517
Soil Map Unit Name: 254B Merrimac fine sandy loam NWI or DEP Classification: lawn
Are climatic/hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks)
Are Vegetation X , Soil ____ , or Hydrology ____ significantly disturbed? (If yes, explain in Remarks)
Are Vegetation ____ , Soil ____ , or Hydrology ____ naturally problematic? (If yes, explain in Remarks)

SUMMARY OF FINDINGS – Attach site map and photograph log showing sampling locations, transects, etc.

Wetland vegetation criterion met? Yes ____ No X Hydric Soils criterion met? Yes ____ No X Wetlands hydrology present? Yes ____ No X	**Is the Sampled Area within a Wetland?** Yes ____ No X
Remarks, Photo Details, Flagging, etc.: Plot in lawn	

HYDROLOGY

Field Observations:			
Surface Water Present?	Yes ____	No X	Depth (inches) ____
Water Table Present?	Yes ____	No X	Depth (inches) ____
Saturation Present (including capillary fringe)?	Yes ____	No X	Depth (inches) ____

Wetland Hydrology Indicators

Reliable Indicators of Wetlands Hydrology	Indicators that can be Reliable with Proper Interpretation	Indicators of the Influence of Water
____ Water-stained leaves	____ Hydrological records	____ Direct observation of inundation
____ Evidence of aquatic fauna	____ Free water in a soil test hole	____ Drainage patterns
____ Iron deposits	____ Saturated soil	____ Drift lines
____ Algal mats or crusts	____ Water marks	____ Scoured areas
____ Oxidized rhizospheres/pore linings	____ Moss trim lines	____ Sediment deposits
____ Thin muck surfaces	____ Presence of reduced iron	____ Surface soil cracks
____ Plants with air-filled tissue (aerenchyma)	____ Woody plants with adventitious roots	____ Sparsely vegetated concave surface
____ Plants with polymorphic leaves	____ Trees with shallow root systems	____ Microtopographic relief
____ Plants with floating leaves	____ Woody plants with enlarged lenticels	____ Geographic position (depression, toe of slope, fringing lowland)
____ Hydrogen sulfide odor		

Remarks (describe recorded data from stream gauge, monitoring well, aerial photos, previous inspections, if available):

This form is only for BVW delineations. Other wetland resource areas may be present and should be delineated according to the applicable regulatory provisions.

Sampling Point TPU @B3

VEGETATION – Use both common and scientific names of plants.

Tree Stratum Plot size 30'

Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1. None					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

0 = Total Cover

Shrub/Sapling Stratum Plot size 15'

Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1. silky dogwood	Cornus amomum	FACW	5	yes	yes
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

5 = Total Cover

Herb Stratum Plot size 5'

Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1. lawn/turf	Graminene spp.	UPL	100	yes	No
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					

100 = Total Cover

Sampling Point ___________

VEGETATION – continued.

Woody Vine Stratum Plot size 30'					
Common name	Scientific name	Indicator Status	Absolute % Cover	Dominant? (yes/no)	Wetland Indictor? (yes/no)
1. None					
2.					
3.					
4.					
			0 = Total Cover		

Rapid Test:	Do all dominant species have an indicator status of OBL or FACW?			Yes _______ No X
Dominance Test:	Number of dominant species	Number of dominant species that are wetland indicator plants		Do wetland indicator plants make up ≥ 50% of dominant plant species? Yes X No ________
	2	1		
Prevalence Index:		Total % Cover (all strata)	Multiply by:	Result
	OBL species		X 1	=
	FACW species		X 2	=
	FAC species		X 3	=
	FACU species		X 4	=
	UPL species		X 5	=
	Column Totals	(A)		(B)
	Prevalence Index	B/A =		Is the Prevalence Index ≤ 3.0? Yes _______ No ________
Wetland vegetation criterion met?		**Yes** X **No** __________		

Definitions of Vegetation Strata

Tree - Woody plants 3 in. (7.62 cm) or more in diameter at breast height (DBH), regardless of height

Shrub/Sapling - Woody plants less than 3 in. (7.62 cm) DBH and greater than or equal to 3.3 ft. (1 m) tall

Herb - All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.3 ft. (1 m) tall

Woody vines - All woody vines greater than 3.3 ft. (1 m) in height

Cover Ranges	
Range	Midpoint
1-5 %	3.0 %
6-15 %	10.5 %
15-25 %	20.5 %
26-50 %	38.0 %
51-75 %	63.0 %
76-95 %	85.5 %
96-100 %	98.0 %

Sampling Point TPUeB3

SOIL

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators)

Depth (inches)	Matrix		Redox Features				Texture	Remarks
	Color (moist)	%	Color (moist)	%	Type[1]	Location[2]		
0-12	10YR2/1						FSL	
12-14	2.5Y5/4						FSL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators (Check all that apply)		**Indicators for Problematic Hydric Soils**
____ Histosol (A1)	____ Sandy Redox (S5)	____ 2 cm Muck (A10)
____ Histic Epipedon (A2)	____ Stripped Matrix (S6)	____ 5 cm Mucky Peat or Peat (S3)
____ Black Histic (A3)	____ Polyvalue Below Surface (S8)	____ Dark Surface (S7)
____ Hydrogen Sulfide (A4)	____ Thin Dark Surface (S9)	____ Polyvalue Below Surface (S8)
____ Stratified Layers (A5)	____ Loamy Mucky Mineral (F1)	____ Thin Dark Surface (S9)
____ Depleted Below Dark Surface (A11)	____ Loamy Gleyed Matrix (F2)	____ Iron-Manganese Masses (F12)
____ Thick Dark Surface (A12)	____ Depleted Matrix (F3)	____ Mesic Spodic (A17)
____ Sandy Mucky Mineral (S1)	____ Redox Dark Surface (F7)	____ Red Parent Material (F21)
____ Sandy Gleyed Matrix (S4)	____ Depleted Dark Surface (F8)	____ Very Shallow Dark Surface (TF12)
____ Dark Surface (S7)		____ Other (Include Explanation in Remarks)

Restrictive Layer (if observed) Type: ____________________ Depth (inches): ________

Remarks:

Hydric Soils criterion met? Yes ________ No __X______

National Flood Hazard Layer FIRMette

FEMA

71°34'50"W 42°23'11"N

71°34'13"W 42°22'44"N

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

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

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

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

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

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

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

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- Coastal Transect
- 513 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

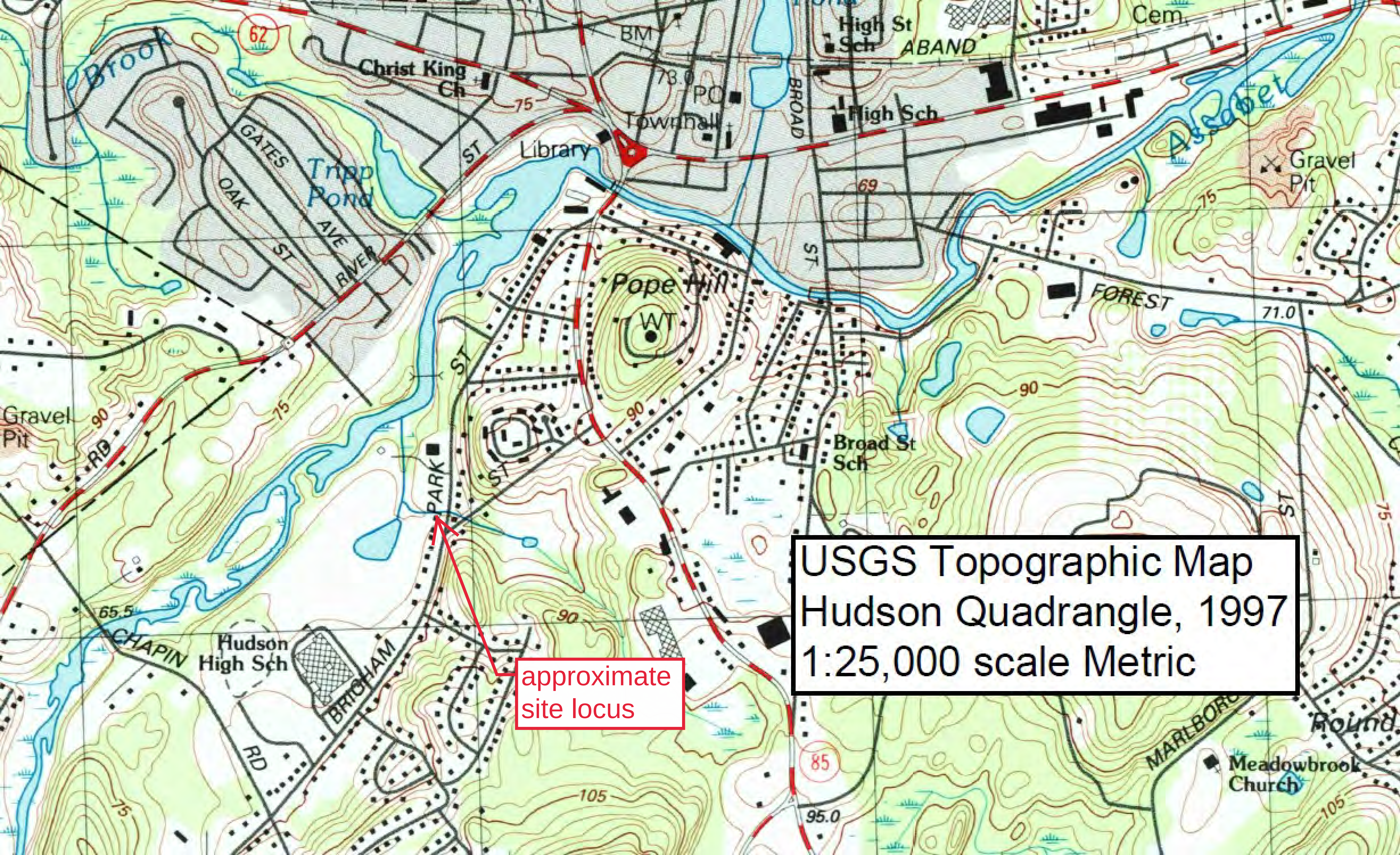
N

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

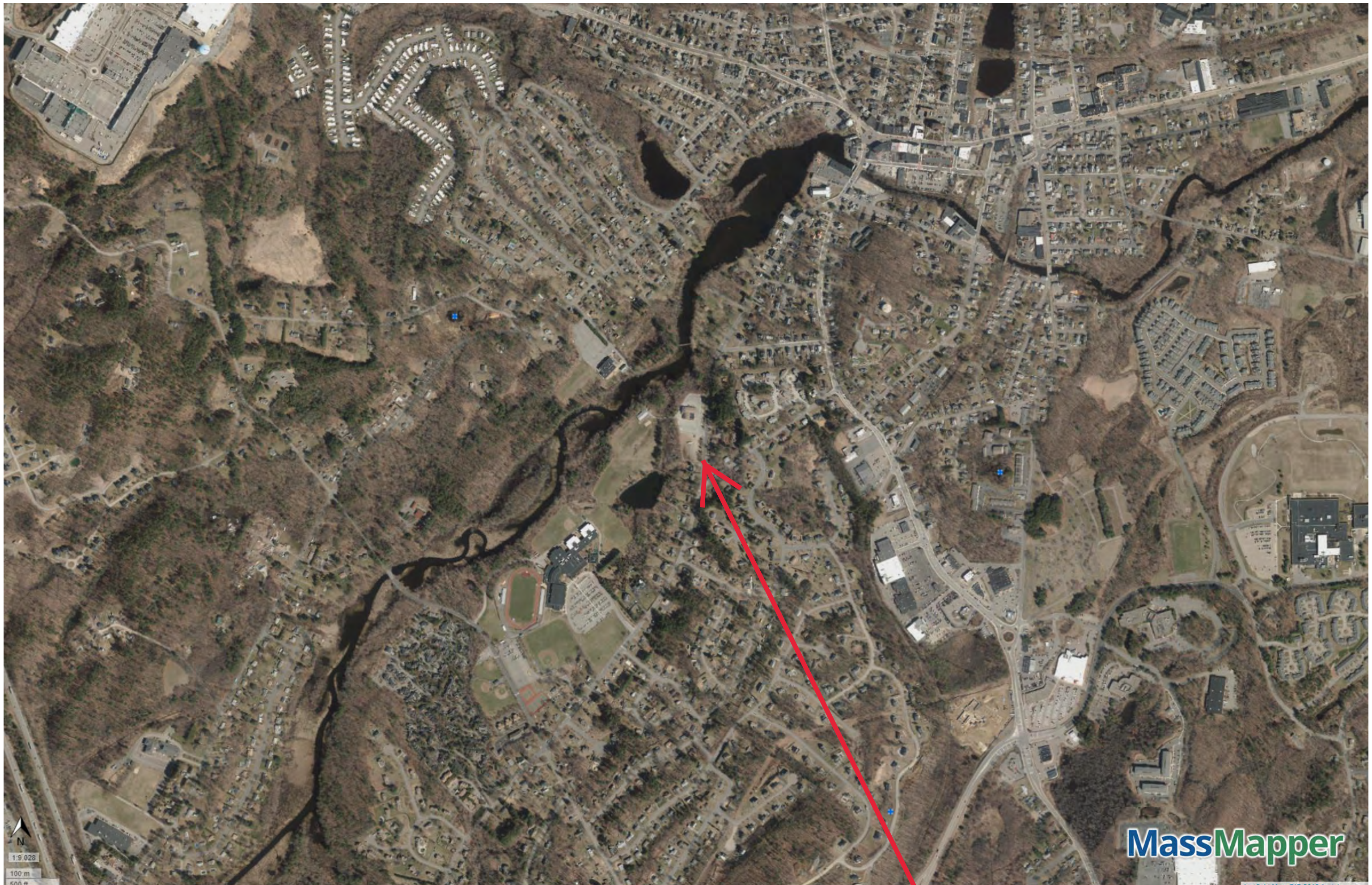
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 1/5/2023 at 10:11 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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


USGS Topographic Map
Hudson Quadrangle, 1997
1:25,000 scale Metric
approximate
site locus
Brook
Christ King
Ch
Library
Townhall
PO
High St
Sch
ABAND
High Sch
Cem
BROAD
ST
Assabet
Gravel
Pit
GATES
OAK
AVE
ST
RIVER
Tripp
Pond
Pope Hill
WT
FOREST
ST
71.0
69
73.0
BM
Gravel
Pit
RD
PARK
ST
Broad St
Sch
CHAPIN
Hudson
High Sch
BRIGHAM
RD
MARLBORO
Meadowbrook
Church
Round
65.5
95.0
85
62
90
75
105

Hudson Brigham St. Culvert, NHESP



NHESP Estimated Habitats of Rare Wildlife

NHESP Priority Habitats of Rare Species

NHESP Certified Vernal Pools

Natural Heritage Atlas Online Data Viewer, 15th edition, valid August 1, 2021
created: 1/5/2023
Brigham Street Culvert, Hudson

approximate site locus

EcoTec, Inc.

ENVIRONMENTAL CONSULTING SERVICES
102 Grove Street
Worcester, MA 01605-2629
508-752-9666 – Fax: 508-752-9494

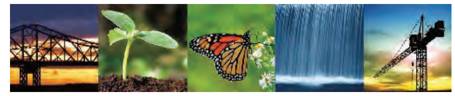
Scott Jordan
Senior Environmental Scientist

Scott Jordan is an Environmental Scientist with EcoTec, Inc. Since joining EcoTec in 2000, Mr. Jordan's duties have included wetland resource evaluation and delineation; erosion and sediment control planning and monitoring, environmental monitoring, including water quality analysis, sediment analysis and wildlife habitat impact analysis; environmental permitting at local, state, and federal level; pond and stream evaluation; wildlife habitat evaluation, vernal pool evaluation; and wetland restoration and replication design and oversight. He has served as an environmental consultant to the development community, engineering firms, municipalities, and conservation commissions. Prior to joining EcoTec, Mr. Jordan was the Senior Laboratory Technician for GeoComp Corporation where he performed numerous physical properties analysis of soils and geosynthetic materials in accordance with ASTM, and AASHTO specifications. His seven years experience evaluating New England soils includes soil analysis and classification of site-remediated soils with oil and hazardous material contamination. His educational background includes courses in organic and inorganic chemistry, biology, botany and comparative vertebrate physiology, with extensive coursework in ecology and wildlife biology; and he has completed several professional training seminars including erosion and sediment control, soil evaluation, wildlife habitat evaluation, wetland mitigation, vernal pool evaluation, water quality assessment using macro-invertebrates, and river morphology and functions. He has participated in several rare species and wildlife monitoring and inventory projects, including marsh bird surveys, marbled salamander (*Ambystoma opacum*) survey, great laurel (*Rhododendron maximum*) survey, wood turtle (*Glyptemys insculpta*) habitat assessments and sweeps, eastern box turtle (*Terrapene carolina*) habitat assessments, and greater black-backed gull (*Larus marinus*) inventory. His prior research experience includes behavioral and acoustic studies of the common loon (*Gavia immer*) in northwestern Maine.

Education: Bachelor of Science: Biology - Wildlife and Environmental, *Cum Laude*
Framingham State College, 2000
Biotechnology Certificate
Middlesex Community College, 1994

Professional Affiliations: Massachusetts Association of Conservation Commissioners
Association of Massachusetts Wetland Scientists
Society of Wetland Scientists
Society of Soil Scientists of Southern New England

APPENDIX D: GEOTECHNICAL REPORT



MEMORANDUM

To: Ms. Caitlin Glass
Woodard & Curran, Inc. (W&C)
41 Hutchins Drive,
Portland, Maine 04102

From: Andrew Fournier,
Jay L. Hodkinson, P.E.,
Bruce W. Fairless, P.E.
GZA GeoEnvironmental, Inc. (GZA)

Date: April 21, 2023

File No: 04.0191546.00

Re: Geotechnical Engineering Memorandum
Brigham Street Culvert and Park Street Culvert Headwall Replacement
Hudson, Massachusetts

This memorandum presents the results of the subsurface exploration program performed at the above-referenced site by GZA. The subsurface exploration program was completed in accordance with GZA's Proposal for Geotechnical Services dated February 17, 2023. GZA's objectives were to evaluate subsurface conditions and provide geotechnical recommendations for the proposed culvert replacement on Brigham Street and the proposed headwall replacement for a culvert on Park Street in Hudson, Massachusetts. The contents of this report are subject to the **Limitations** contained in **Appendix A** and the Terms and Conditions of our agreement. Note that elevations in this memorandum are in feet referenced to the North American Vertical Datum of 1988 (NAVD 88).

BACKGROUND/SITE DESCRIPTION

The Brigham Street culvert and the Park Street culvert are located relatively near each other and convey the same unnamed brook as shown in **Figure 1** below. The culvert on Brigham Street and the headwall on Park Street need to be replaced due to deterioration.

According to Woodard & Curran (W&C), the Brigham Street culvert is a three-sided reinforced concrete culvert with an approximate span of 36 inches and a height of 22 inches. The headwalls consist of stone abutments which support the embankment slope and roadway. A temporary repair was installed consisting of 12-inch and 15-inch-high density polyethylene (HDPE) corrugated pipes to provide conveyance after a section of the existing culvert failed. The culvert is approximately 70 feet long. Overhead utilities are located along the westbound travel lane of Brigham Street and the northbound travel lane of Park Street. Underground utilities at Brigham Street and Park Street consist of gas, sewer and water.

The proposed culvert replacement may consist of an aluminum multi-plate arch span or a 3- or 4-sided precast concrete box culvert. W&C indicated the proposed span of the replacement culvert at Brigham Street will likely be less than 10 feet and is

GZA
Known for excellence.
Built on trust.

Geotechnical
Environmental
Ecological
Water
Construction Management

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Suite 201
Bedford, NH 03110
T: 603.623.3600
F: 603.624.9463
www.gza.com

therefore not subject to Massachusetts Department of Transportation (MassDOT) Chapter 85 Permitting.

The Park Street culvert is an approximately 36-inch-wide corrugated metal pipe (CMP) that extends approximately 350 feet underground to the west of Park Street and drains into an unnamed brook. We understand the existing CMP will be relined, and the upstream headwall will be replaced with a precast concrete system.

SUBSURFACE EXPLORATIONS

GZA performed a subsurface exploration program to evaluate subsurface conditions in the vicinity of the proposed culvert and headwall replacements. Drilex Environmental of Auburn, Massachusetts coordinated utility clearance and drilled test borings GZ-1 through GZ-3 on March 13, 2023. Borings GZ-1 and GZ-2 were drilled in the roadway to the northeast and southwest, respectively, of the existing Brigham Street culvert in the east bound lane and extended to a depth of approximately 27 feet below ground surface (bgs). Boring GZ-3 was drilled in the roadway to the southwest of the existing Park Street culvert headwall in the southbound lane and extended to a depth of approximately 27 feet bgs. Boring B-3 was drilled approximately 34 feet away from the existing headwall due to conflicts with overhead and underground utilities. W&C surveyed the boring locations after the completion of the drilling program. The approximate locations of the test borings are shown on **Figure 2 – Exploration Location Plan.**

Borings were drilled using a truck-mounted drill rig with 4.25-inch-inside-diameter (ID) hollow stem augers (HSA). Standard Penetration Testing and split spoon sampling were performed semi-continuously through fill and generally at 5-foot intervals thereafter.

Samples were classified in accordance with the Modified Burmister System. The test borings were backfilled with drill cuttings upon the completion of the drilling and repaired at the surface with concrete-patch. GZA field personnel monitored the drilling and prepared the test boring logs which are included in **Appendix B**.

GEOTECHNICAL LABORATORY TESTING

Four soil samples obtained from the test borings were submitted to GZA's geotechnical laboratory subcontractor, Thielsch Engineering, for grain size distribution analyses. Laboratory test results for these samples are attached as **Appendix C** and are summarized in the table below.

Test Boring No.	Sample ID	Depth Below Grade (ft)	Stratum	Soil Description	Test Performed
GZ-1	S-3	5-7	Fill	Olive, GRAVEL, some Sand, trace Silt	Gradation
GZ-1	S-6	15-17	Sand and Gravel	Brown, fine to coarse SAND, some Gravel, little Silt	Gradation
GZ-2	S-5	15-17	Sand and Gravel	Brown, GRAVEL and fine to coarse Sand, little Silt	Gradation
GZ-3	S-5	10-12	Sand and Gravel	Brown, GRAVEL and fine to coarse Sand, little Silt	Gradation

GENERALIZED SUBSURFACE CONDITIONS

Based on the completed test borings, subsurface conditions at each culvert location were similar and consisted of loose to dense sand fill over loose to very dense natural sand and gravel. Descriptions of the geologic units encountered at each culvert location are as follows, in general order of occurrence below ground surface.

GENERALIZED SUBSURFACE CONDITIONS NEAR BRIGHAM STREET CULVERT (Boring GZ-1 and GZ-2)		
Soil Unit	**Approx. Depth Range (feet)**	**Generalized Description**
Asphalt	0.3	4 inches of bituminous asphalt pavement was encountered at the ground surface at both locations.
Fill	0.3 to 12	Approximately 11.7 and 9.5 feet of fill was encountered directly below the asphalt in borings GZ-1 and GZ-2, respectively. The material generally consisted of loose to dense, brown, fine to coarse SAND, with up to 50 percent Gravel and up to about 35 percent Silt.
Buried Topsoil	9.8 to 12.5	Buried topsoil was encountered directly below the Fill at a depth of 9.8 feet bgs in boring GZ-2. The buried topsoil consisted of fine to medium SAND, 20 to 35 percent Silt, and less than 10 percent each of Gravel and Organics. The bottom of the buried topsoil was not confirmed however, we estimate it could be approximately 1 to 3 feet thick.
Sand and Gravel	12 to 27	A natural deposit of Sand and Gravel was encountered at a depth of 12.5 feet bgs in boring GZ-2 and 12 feet bgs in boring GZ-1. The borings were terminated in the Sand and Gravel stratum. The Sand and Gravel generally consisted of loose to dense, gray to brown, fine to coarse SAND, with up to 50 percent Gravel and up to 35 percent Silt.

GENERALIZED SUBSURFACE CONDITIONS NEAR PARK STREET CULVERT HEADWALL (Borings GZ-3)		
Soil Unit	**Approx. Depth Range (feet)**	**Generalized Description**
Asphalt	0.3	4 inches of bituminous asphalt pavement was encountered at the ground surface in boring.
Fill	0.3 to 5.0	Fill was encountered directly below the asphalt in boring GZ-3. The Fill generally consisted of medium dense to dense, brown, fine to coarse SAND, with up to about 20 percent Silt and up to 20 percent Gravel.
Sand and Gravel	5.0 to 27	Natural Sand and Gravel was encountered below the Fill at a depth of 5 feet bgs in boring GZ-3. The Sand and Gravel generally consisted of medium dense to very dense, brown and gray, fine to medium SAND, with up to 50 percent Gravel and up to 20 percent of Silt.

Detailed descriptions of the materials encountered are presented on the boring logs in **Appendix B**.

<u>GROUNDWATER</u>

GZA measured groundwater depths during drilling in test borings GZ-1 and GZ-2 for the Brigham Street culvert. Groundwater was measured at approximately 21.4 (GZ-1) and 21.3 (GZ-2) feet bgs (corresponding to Elevations 210.7 and 211.4), respectively, as shown on the boring logs included in **Appendix B**. Based on GZA's visual observations during drilling, the stream was approximately 2-3 feet deep at the time the borings were completed which corresponds to approximately Elevation ±222 to 223 at the upstream side of the Brigham Street culvert.

At the Park Street culvert location, groundwater was measured in test boring GZ-3 at approximately 9.6 feet bgs (corresponding to Elevation 212.1) as shown on the boring logs included in **Appendix B**. There was approximately 2-3 feet of water in the stream at the time the borings were completed which corresponds to approximately Elevation ±215 to 216 at the upstream opening of the Park Street culvert.

Water level readings were made in the borings at the time and under conditions stated on the logs. Groundwater depths and elevations are approximate representations of the hydrostatic groundwater level. Therefore, the groundwater level observed in the test borings may not represent stabilized groundwater levels. Note that fluctuations in the level of the groundwater will occur due to variations in season, rainfall, temperature, construction, and other factors occurring since the time measurements were made.

BEDROCK

Bedrock was not encountered in test borings GZ-1 through GZ-3. Bedrock underlying each site area is mapped as sillimanite schist and gneiss, amphibolite, and biotite gneiss which are part of the Nashoba Formation.

IMPLICATIONS OF SUBSURFACE CONDITIONS

BRIGHAM STREET CULVERT

The subsurface conditions at the Brigham Street Culvert site, generally consist of loose to dense sand fill overlying a loose to dense natural sand and gravel stratum. Based on survey plans provided by W&C, and assuming that footings will bear approximately four feet below an invert of approximately Elevation ±219 feet down stream side and Elevation ±220 upstream side, the estimated elevation for the bottom of the proposed culvert footing at this site will be about Elevation ±215 to ±216 feet. Based on the test boring, soils at this elevation are likely to be loose to medium dense natural sand and gravel. Note, a layer of buried topsoil was encountered below the fill in test boring GZ-2 at about Elevation 222 feet. However, based on the anticipated footing depth, the topsoil will likely be removed during excavation for the proposed culvert footing and is therefore not considered a geotechnical issue. Should buried topsoil be encountered at the proposed footing elevation, it should be removed and replaced with compacted structural fill.

PARK STREET CULVERT HEADWALL

The subsurface conditions at the Park Street culvert headwall site generally consist of medium dense to dense sand fill overlying a medium dense to very dense natural sand and gravel stratum. Based on survey plans provided by W&C, and assuming that the precast headwall foundation will bear up to four feet below the existing invert of approximate Elevation ±213 feet, the estimated elevation for the bottom of the proposed precast headwall will be about Elevation ±209 feet. Based on the borings, soils at this elevation are likely to be dense natural sand and gravel.

RECOMMENDATIONS AND CONSTRUCTION CONSIDERATIONS

The following recommendations assume the buried topsoil stratum will be removed incidental to footing excavation. In addition, the footings for the proposed culvert replacement on Brigham Street and proposed headwall replacement on Park Street will be installed at approximately Elevation 215 feet and 209 feet, respectively.

FOUNDATION SUBGRADE PREPARATION

In order to densify the soils near the footing bearing elevation, the contractor should proof compact the subgrade soils. Following existing fill and buried topsoil removal, the excavated subgrade should be proof-compacted with at least 10 passes of a large, self-propelled vibratory double-drum trench roller capable of generating a minimum of 16,000 pounds of dynamic force. Areas exhibiting excessive weaving, or soft or unstable soils should be excavated and replaced with Structural Fill meeting the usage and compaction requirements discussed below. In confined areas, the final subgrade should be proof-compacted with a minimum of 10 passes of a heavy vibratory plate compactor.

When near the water table or behind retaining wall structures, the contractor should proof-compact using static (non-vibratory) equipment. To limit the impact of vibrations on the existing or newly constructed structures, the contractor should compact the subgrade using large plate compactors within 10 feet of a structure. For wet subgrades below groundwater level, crushed stone wrapped in geotextile fabric (Mirafi 140N or equivalent) may be used to stabilize the subgrade and allow for fill placement in-the-dry. A qualified geotechnical engineer should observe the foundation subgrade preparation.

BEARING CAPACITY

The proposed aluminum multi-plate arch span or 3- or 4-sided precast concrete box culvert on Brigham Street and the proposed precast headwall on Park Street can be supported on the undisturbed natural Sand and Gravel. Assuming the subgrade is prepared as discussed above, GZA recommends a maximum net allowable bearing pressure for the proposed culvert footings, headwall, abutments, and wingwalls of 2,000 pounds per square foot. The bearing pressures should assume total settlement to be less than 1 inch and differential settlement less than ½ inch over 20 feet.

DEWATERING

Based on the survey plans provided to GZA on April 11, 2023, the typical bottom of stream elevation at the upstream opening of the Brigham Street culvert is Elevation ±220 and the bottom of stream elevation at the upstream opening of the Park Street culvert is Elevation ±213 feet. Groundwater was encountered at Elevation ±210 feet for the Brigham Street culvert which is approximately 5 feet below the proposed bottom of footing elevation. However, groundwater was encountered at Elevation ±212 feet for the Park Street culvert which is approximately 3 feet above footing elevation and will require dewatering during construction. Please note that groundwater elevations measured during time of drilling were lower than stream elevations, however, groundwater elevations may be higher and closer to stream elevations during construction.

Temporary construction dewatering will be required to control groundwater seepage, precipitation, and surface inflow in excavations, to maintain the integrity of soil bearing surfaces, and allow construction in-the-dry. Temporary damming of the streams and open sump pumping may be sufficient to dewater the excavations; however, additional dewatering using well points and or steel sheeting to limit water infiltration may be required. Exposed sand and gravel subgrade can become unstable if exposed to high dewatering gradients.

FROST PROTECTION

Typical frost depth in the Commonwealth of Massachusetts is 4 feet bgs. We recommend that spread footings for abutments and wingwalls be supported a minimum of 4 feet below the lowest adjacent ground surface to provide frost protection.

CONCLUSION

We appreciate the opportunity to work with Woodard & Curran, Inc. on this project. If you have any questions regarding this memorandum, please contact Andrew Fournier at 603-316-8711 or Jay Hodkinson at 603-232-8742.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Andrew D. Fournier
Project Manager

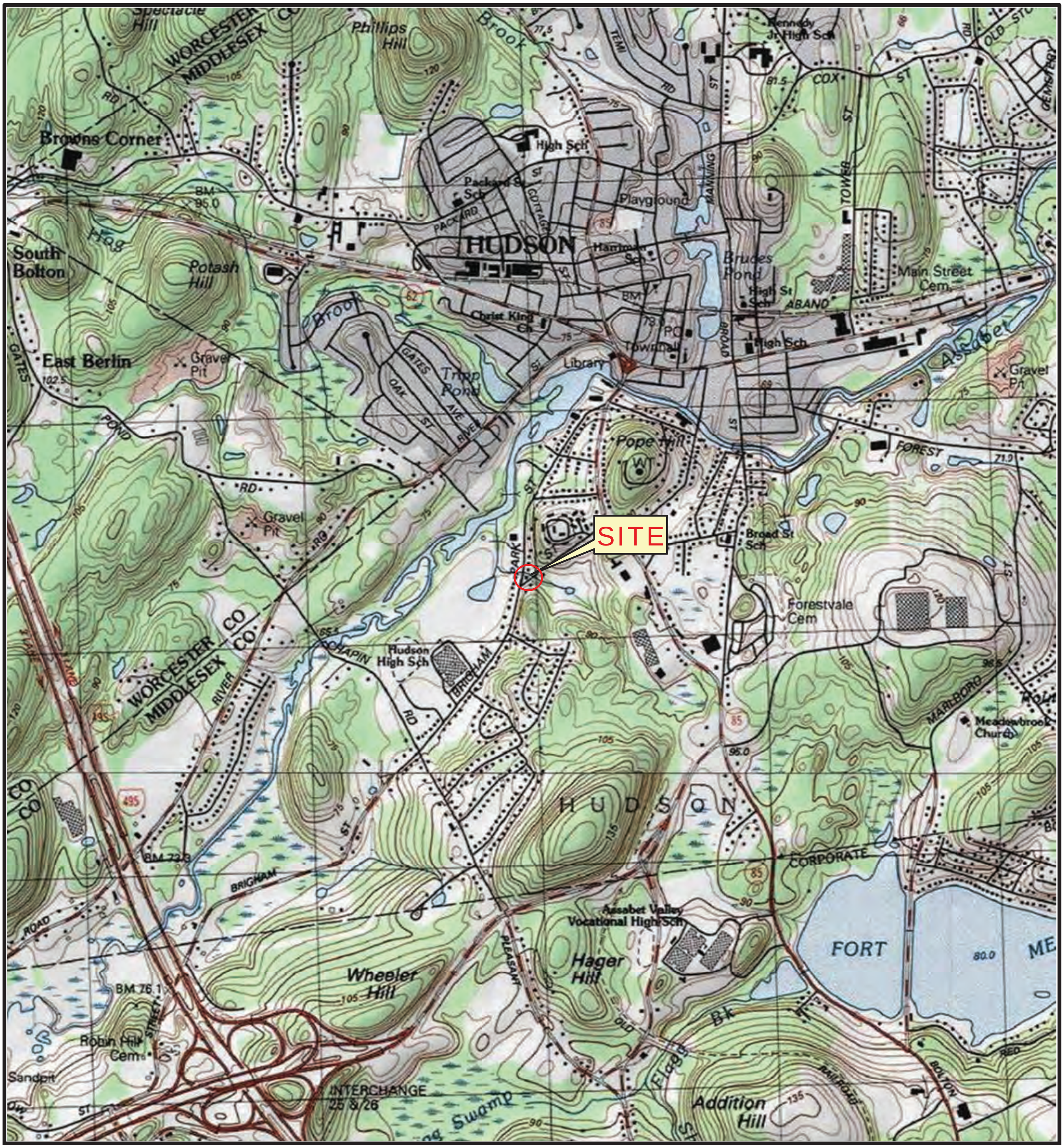
Bruce W. Fairless, P.E.
Consultant/Reviewer

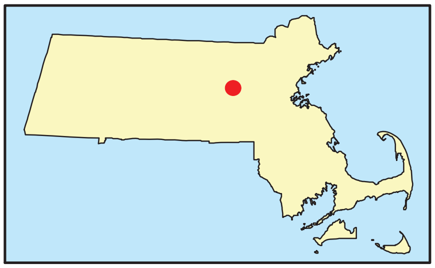
Jay L. Hodkinson, P.E.
Associate Principal

ADF/DGL/BWF:
p:\04jobs\0191500s\04.0191546.00 - hudson ma culvert\report\draft 04.0191546.00 hudson ma geotech report 04.21.2023.docx

Attachments: Figure 1 – Locus Plan
Figure 2 – Exploration Location Plan
Appendix A – Limitations
Appendix B – Boring Logs
Appendix C – Laboratory Test Results

Figure 1 – Locus Plan





SOURCE : USGS TOPOGRAPHIC QUADRANGLES SCANNED BY THE NATIONAL GEOGRAPHIC SOCIETY & I-CUBED, COPYRIGHT 2011

Data Supplied by : esri

0 1,000 2,000 4,000 6,000

SCALE IN FEET

N W E S

PROJ. MGR.: ADF
DESIGNED BY: IJC
REVIEWED BY: JLH
OPERATOR: IJC

DATE: 01-20-2023

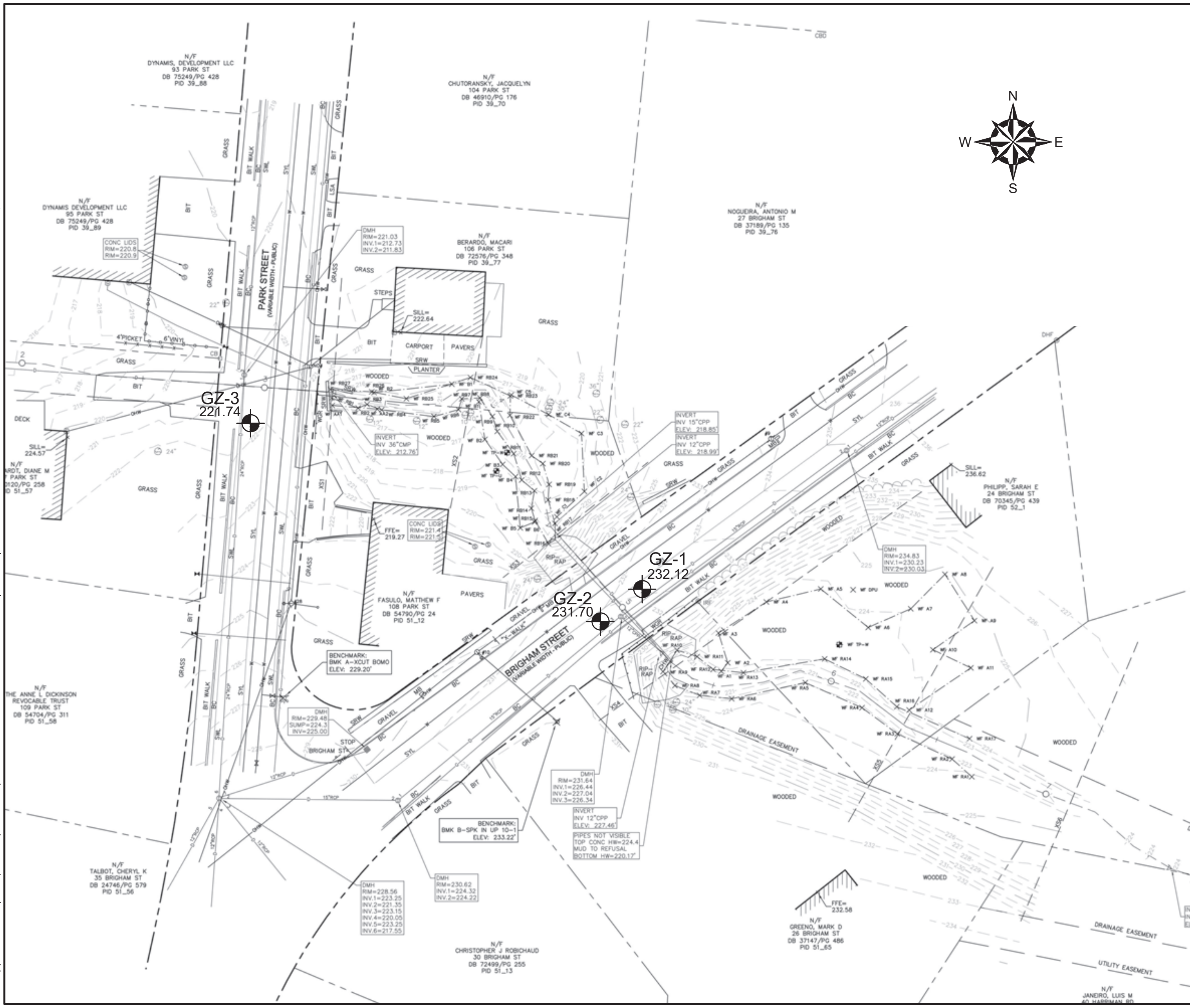
LOCUS MAP

BRIGHAM STREET AND PARK STREET CULVERTS
HUDSON, MASSACHUSETTS

JOB NO.
04.0191546.00

FIGURE NO.
1

Figure 2 – Sample Location Plan



GENERAL NOTES

1. BASE MAP DEVELOPED FROM ELECTRONIC DRAWING FILE "30902402-1-HUDSON-041123" PREPARED BY WSP USA INC. TRANSMITTED TO GZA ON APRIL 11, 2023.
2. GZA TEST BORINGS WERE PERFORMED BY DRILEX ENVIRONMENTAL INC. OF AUBURN, MASSACHUSETTS ON MARCH 13, 2023 AND WERE OBSERVED BY GZA PERSONNEL
3. THE LOCATIONS OF THE TEST BORINGS WERE DETERMINED IN THE FIELD USING RTK GPS SURVEY TECHNIQUES BY WSP USA INC.

LEGEND

GZ-1 232.12 — TEST BORING LOCATION, DESIGNATION, AND ELEVATION MEASURED IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

CULVERT REPLACEMENT
BRIGHAM AND PARK STREET
HUDSON, MASSACHUSETTS

EXPLORATION LOCATION PLAN

PREPARED BY:		PREPARED FOR:	
GZA GeoEnvironmental, Inc. www.gza.com		WOODARD & CURRAN	
PROJ MGR: ADF	REVIEWED BY: ADF	CHECKED BY: DGL	FIGURE 2
DESIGNED BY: DS	DRAWN BY: DS	SCALE: 1"=40'	
DATE: APRIL, 2023	PROJECT NO. 04.0191546.00	REVISION NO. -	

Appendix A – Limitations

USE OF REPORT

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

STANDARD OF CARE

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

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

4. In conducting our work, GZA relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the Report.

SUBSURFACE CONDITIONS

5. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then become evident, it will be necessary to reevaluate the conclusions and recommendations of this report.

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

7. Water level readings have been made in test holes (as described in this Report) and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.

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

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

COMPLIANCE WITH CODES AND REGULATIONS

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

COST ESTIMATES

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

12. Our interpretation of field screening and laboratory data is presented in the Report. Unless otherwise noted, we relied upon the laboratory's QA/QC program to validate these data.

13. Variations in the types and concentrations of contaminants observed at a given location or time may occur due to release mechanisms, disposal practices, changes in flow paths, and/or the influence of various physical, chemical, biological or radiological processes. Subsequently observed concentrations may be other than indicated in the Report.

ADDITIONAL SERVICES

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

Appendix B – Boring Logs

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Woodard & Curran
Brigham and Park St Culverts
Hudson, MA

EXPLORATION NO.: GZ-1
SHEET: 1 of 1
PROJECT NO: 04.0191546.00
REVIEWED BY: A. Fournier

Logged By: K. Ashe
Drilling Co.: Drilex Environmental
Foreman: E.Gravante

Type of Rig: Truck
Rig Model: Mobile B57
Drilling Method: HSA

Boring Location: See Plan
Ground Surface Elev. (ft.): 232.12
Final Boring Depth (ft.): 27
Date Start - Finish: 3/13/2023 - 3/13/2023

H. Datum: NAD83
V. Datum: NAVD88

Hammer Type: Automatic Hammer
Hammer Weight (lb.): 140
Hammer Fall (in.): 30
Auger or Casing O.D./I.D Dia (in.): 4.25

Sampler Type: SS
Sampler O.D. (in.): 2.0
Sampler Length (in.): 24
Rock Core Size: N/A

Groundwater Depth (ft.)

Date	Time	Stab. Time	Water	Casing
3/13/23	10:25	5 min	21.4	25

Depth (ft)	Casing Blows/ (Core Rate)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	Blows (RQD)	SPT Value	Sample Description (Modified Burmister Classification)	Remark	Stratum Depth (ft.)	Stratum Description	Elev. (ft.)
		S-1	0.3-2.3	24	16	16 13 8 6	21	S-1: Medium dense, brown and black, fine to coarse SAND, little Silt, dry.		0.3	ASPHALT	231.8
		S-2	3.0-5.0	24	9	6 6 13 23	19	S-2: Medium dense, brown, fine to coarse SAND, and Gravel, little Silt, dry.			FILL	
5		S-3	5.0-7.0	24	12	15 14 14 14	28	S-3: Medium dense, olive, GRAVEL, some medium Sand, trace Silt, dry.				
		S-4	8.0-10.0	24	8	16 10 7 5	17	S-4: Medium dense, brown, fine to coarse SAND, some Gravel, little Silt, dry.				
10		S-5	10.0-12.0	24	3	3 3 4 2	7	S-5: Loose, brown, fine to medium SAND, some Silt, some Gravel, dry.		12		220.1
									1. 2.			
15		S-6	15.0-17.0	24	10	20 4 4 6	8	S-6: Loose, brown, fine to coarse SAND, some Gravel, little Silt, moist.			SAND AND GRAVEL	
20		S-7	20.0-22.0	24	16	13 20 22 20	42	S-7: Dense, gray, fine to medium SAND, and Gravel, little Silt, wet.				
25		S-8	25.0-27.0	24	20	9 11 20 20	31	S-8: Dense, gray, fine SAND, some Silt, little Gravel, wet.		27		205.1
30								End of exploration at 27 feet	3.			

REMARKS

1. - Stratum change based on drill action.
2. - Gravel and cobbles observed in the drill cuttings from 12 to 15 ft. below ground surface.
3. - Hole backfilled with drill cuttings and 2 bags of sand and patched with quick-set concrete.

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

Exploration No.: GZ-1

TEST BORING LOG

GZA GeoEnvironmental, Inc. *Engineers and Scientists*	Woodard & Curran Brigham and Park St Culverts Hudson, MA	EXPLORATION NO.: GZ-2 SHEET: 1 of 1 PROJECT NO: 04.0191546.00 REVIEWED BY: A. Fournier

Logged By: K. Ashe **Drilling Co.:** Drilex Environmental **Foreman:** E.Gravante	**Type of Rig:** Truck **Rig Model:** Mobile B57 **Drilling Method:** HSA	**Boring Location:** See Plan **Ground Surface Elev. (ft.):** 231.7 **Final Boring Depth (ft.):** 27 **Date Start - Finish:** 3/13/2023 - 3/13/2023	**H. Datum:** NAD83 **V. Datum:** NAVD88

Hammer Type: Automatic Hammer
Hammer Weight (lb.): 140
Hammer Fall (in.): 30
Auger or Casing O.D./I.D Dia (in.): 4.25

Sampler Type: SS
Sampler O.D. (in.): 2.0
Sampler Length (in.): 24
Rock Core Size: N/A

Groundwater Depth (ft.)

Date	Time	Stab. Time	Water	Casing
3/13/23	8:48	5 min	21.3	25

Depth (ft)	Casing Blows/ (Core Rate)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	Blows (RQD)	SPT Value	Sample Description (Modified Burmister Classification)	Remark	Stratum Depth (ft.)	Stratum Description	Elev. (ft.)
										0.3	ASPHALT	231.4
		S-1	0.3-2.3	24	14	18 20 13 8	33	S-1: Dense, brown and black, fine to coarse SAND, little Silt, little Gravel, dry.				
		S-2	3.0-5.0	24	6	8 7 14 10	21	S-2: Medium dense, brown, fine to coarse SAND, some Gravel, little Silt, dry.				
5		S-3	5.0-7.0	24	1	7 8 5 3	13	S-3: Medium dense, brown and black, fine to medium SAND, some Gravel, little Silt, dry.			FILL	
		S-4A	8.0-9.8	22	6	3 6 9 6/4"	15	S-4A: Medium dense, brown, fine to coarse SAND, some Gravel, little Silt, dry.		9.8		221.9
10		S-4B	9.8-10.0	2	2			S-4B: Dark brown, fine to medium SAND, some Silt, trace Gravel, trace Organics, dry.			BURIED TOPSOIL	
										12.5		219.2
15		S-5	15.0-17.0	24	11	7 9 13 25	22	S-5: Medium dense, brown, GRAVEL and fine to coarse Sand, little Silt, moist.				
20		S-6	20.0-22.0	24	14	16 21 23 25	44	S-6: Dense, gray, fine to coarse SAND, some Silt, trace Gravel, wet.			SAND AND GRAVEL	
25		S-7	25.0-27.0	24	14	17 18 12 12	30	S-7: Dense, gray, fine to medium SAND, some Silt, trace Gravel, wet.		27		204.7
								End of exploration at 27 feet	1.			
30												

REMARKS

1. - Hole backfilled with drill cuttings and 2 bags of sand and patched with quick-set concrete.

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

Exploration No.: GZ-2

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Woodard & Curran
Brigham and Park St Culverts
Hudson, MA

EXPLORATION NO.: GZ-3
SHEET: 1 of 1
PROJECT NO: 04.0191546.00
REVIEWED BY: A. Fournier

Logged By: K. Ashe
Drilling Co.: Drilex Environmental
Foreman: E.Gravante

Type of Rig: Truck
Rig Model: Mobile B57
Drilling Method: HSA

Boring Location: See Plan
Ground Surface Elev. (ft.): 221.74
Final Boring Depth (ft.): 27
Date Start - Finish: 3/13/2023 - 3/13/2023

H. Datum: NAD83
V. Datum: NAVD88

Hammer Type: Automatic Hammer
Hammer Weight (lb.): 140
Hammer Fall (in.): 30
Auger or Casing O.D./I.D Dia (in.): 4.25

Sampler Type: SS
Sampler O.D. (in.): 2.0
Sampler Length (in.): 24
Rock Core Size: N/A

Groundwater Depth (ft.)

Date	Time	Stab. Time	Water	Casing
3/13/23	12:35	5 min	9.6	25

Depth (ft)	Casing Blows/ (Core Rate)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	Blows (RQD)	SPT Value	Sample Description (Modified Burmister Classification)	Remark	Stratum Depth (ft.)	Stratum Description	Elev. (ft.)
										0.3	ASPHALT	221.4
		S-1	0.3-2.3	24	11	26 20 16 12	36	S-1: Dense, brown, fine to coarse SAND, little Gravel, little Silt, dry.			FILL	
		S-2	3.0-5.0	24	8	15 14 10 13	29	S-2: Medium dense, brown, fine to coarse SAND, little Gravel, little Silt, dry.				
5										5		216.7
		S-3	5.0-7.0	24	10	11 9 10 15	19	S-3: Medium dense, brown, fine to medium SAND, little Silt, little Gravel, dry.			SAND AND GRAVEL	
		S-4	8.0-10.0	24	3	15 10 8 5	18	S-4: Medium dense, brown, fine to medium SAND, some Gravel, little Silt, moist.				
10		S-5	10.0-12.0	24	9	12 36 17 12	53	S-5: Very dense, brown, GRAVEL and fine to medium Sand, little Silt, wet.				
15		S-6	15.0-16.8	22	14	17 20 27 30/4"	47	S-6: Dense, brown and gray, GRAVEL, some fine to medium Sand, little Silt, wet.				
20		S-7	20.0-22.0	24	18	12 26 17 10	43	S-7: Dense, gray, fine to medium SAND, little Silt, trace Gravel, wet.				
25		S-8	25.0-27.0	24	24	10 10 13 14	23	S-8: Medium dense, gray, fine to coarse SAND, little Silt, little Gravel, wet.		27		194.7
								End of exploration at 27 feet	1.			
30												

REMARKS

1. - Hole backfilled with drill cuttings and 1 bag of sand and patched with quick-set concrete.

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

Exploration No.: GZ-3

LOG KEY

GZA
Geo Environmental, Inc.
Engineers and Scientists

BURMISTER SOIL CLASSIFICATION (INORGANIC)

COMPONENT	NAME	PROPORTIONAL TERM	PERCENT BY WEIGHT
MAJOR	GRAVEL, SAND, FINES*		>50
Minor	Gravel, Sand, Fines*	and	35 - 50
		some	20-35
		little	10-20
		trace	0-10

*See identification of fines table.

IDENTIFICATION OF FINES

Material	PI	Atterberg Thread Dia.
SILT	0	Cannot Roll
Clayey SILT	1-5	1/4"
SILT & CLAY	5-10	1/8"
CLAY & SILT	10-20	1/16"
Silty CLAY	20-40	1/32"
CLAY	>40	1/64"

GRADATION DESIGNATION	PROPORTION OF COMPONENT
Fine to coarse	All fractions > 10%
Medium to coarse	<10% fine
Fine to medium	<10% coarse
Coarse	<10% fine and medium
Medium	<10% coarse and fine
Fine	<10% coarse and medium

PLASTIC SOILS

Consistency	Blows/Ft. SPT N-Value
Very Soft	< 2
Soft	2 - 4
Medium Stiff	4 - 8
Stiff	8 - 15
Very Stiff	15 - 30
Hard	>30

GRAVEL & SAND

Density	Blows/Ft. SPT N-Value
Very Loose	< 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

BURMISTER SOIL CLASSIFICATION (ORGANIC)

Fibrous PEAT (Pt) - Lightweight, spongy, mostly visible organic matter, water squeezes readily from sample. Typically near top of deposit.
Fine Grained PEAT (Pt) - Lightweight, spongy, little visible organic matter, water squeezes reqdily from sample. Typically below fibrous peat.
Organic Silt (OL) - Typically gray to dark gray, often has strong H2S odor. Typically contains shells or shell fragments. Lightweight. Usually found near coastal regions. May contain wide range of sand fractions.
Organic Clay (OH) - Typically gray to dark gray, high plasticity. Usually found near coastal regions. May contain wide range of sand fractions. Need organic content test for final identification.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) (ASTM D 2487)

MAJOR DIVISIONS			Group Symbols
Coarse Grained Soils More than 50% of material larger than No. 200 sieve	Gravel More than 50% larger than No. 4 sieve	Clean Gravels (Little or no fines)	GW GP
		Gravels with Fines (Appreciable amount of fines)	GM GC
	Sand More than 50% smaller than No. 4 sieve	Clean Sands (Little or no fines)	SW SP
		Sands with Fines (Appreciable amount of fines)	SM SC
Fine Grained Soils More than 50% of material smaller than No. 200 sieve		Silts and Clays Liquid Limit <50	ML CL
		Silts and Clays Liquid Limit >50	OL MH CH OH
		Highly Organic Soils	Pt

ABBREVIATIONS

MR = Mud Rotary
HSA = Hollow Stem Auger
SSA = Solid Stem Auger
SS = Split Spoon Sampler
U = Undisturbed Sample (Shelby Tube)
MC = Modified California Sampler
V = Vibracore
M = Macrocore
R = Refusal
USCS = Unified Soil Classification System (ASTM D2487)
NYCBC = New York City Building Code
WOR = Weight of Rods
WOH= Weight of Hammer
SPT = Standard Penetration Test (ASTM D1586)
N-Value = Cumulative number of uncorrected blows for the middle two 6-inch intervals (blows/foot).

Tv = Field Vane Shear Test (Torvane)
PP = Pocket Penetrometer
PI = Plasticity Index
MC = Moisture Content
CO = Consolidation
UC = Unconfined Compression Test
SI = Sieve Analysis
DS = Direct Shear
PID = Photoionization Detector
ppm = Parts Per Million
REC = Recovery
RQD = Rock Quality Designation
▼ = Measured Water Level

Appendix C – Laboratory Test Results

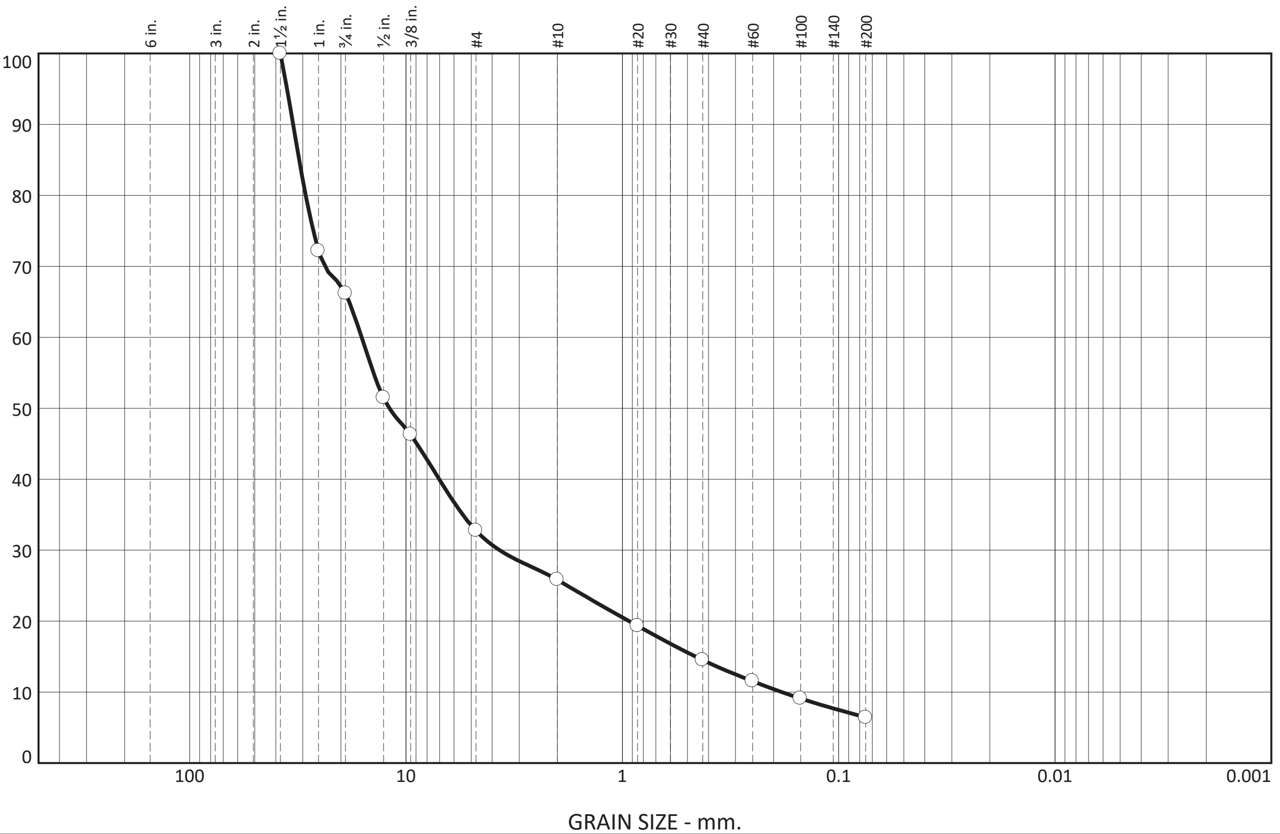
Thielsch DIVISION OF THE RISE GROUP	195 Frances Avenue Cranston RI, 02910 Phone: (401)-467-6454 Fax: (401)-467-2398 thielsch.com *Let's Build a Solid Foundation*	Client Information: GZA GeoEnvironmental, Inc. Bedford, NH 03110 Project Manager: Andrew Fournier Assigned By: Andrew Fournier Collected By: Kyle Ashe	Project Information: **Hudson, MA Culvert Relacement** **Bringham Street and Park Street** Project Number: 04.0191546.00 Summary Page: 1 of 1 Report Date: 03.23.23

LABORATORY TESTING DATA SHEET, Report No.: 7423-C-138

Boring No.	Sample No.	Depth (ft)	Laboratory No.	Identification Tests								Proctor / CBR / Permeability Tests								Laboratory Log and Soil Description
				As Rcvd Moisture Content %	LL %	PL %	Gravel %	Sand %	Fines %	Org. %	pH	γ_d MAX (pcf) W_{opt} (%)	γ_d MAX (pcf) W_{opt} (%) (Corr.)	Dry unit wt. (pcf)	Test Moisture Content %	Target Test Setup as % of Proctor	CBR @ 0.1"	CBR @ 0.2"	Permeability cm/sec	
				D2216	D4318		D6913			D2974	D4792	D1557								
GZ-1	S-3	5-7	23-S-1237				67.2	26.4	6.4											Olive, GRAVEL, some medium Sand, trace Silt.
GZ-1	S-6	15-17	23-S-1238				23.8	61.6	14.6											Brown, f-c SAND, some Gravel, little Silt.
GZ-2	S-5	15-17	12-S-1239				44.3	43.7	12.0											Brown, GRAVEL and f-c SAND, little Silt.
GZ-3	S-5	10-12	12-S-1240				53.0	36.2	10.8											Brown, GRAVEL and f-c SAND, little Silt.

Date Received: *03.16.23*   Reviewed By: Date Reviewed: *03.23.23*

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	33.8	33.4	7.0	11.3	8.1	6.4	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 1/2"	100.0		
1"	72.2		
3/4"	66.2		
1/2"	51.5		
3/8"	46.3		
#4	32.8		
#10	25.8		
#20	19.3		
#40	14.5		
#60	11.5		
#100	9.1		
#200	6.4		

* (no specification provided)

Soil Description

Olive, GRAVEL, some medium Sand, trace Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 33.2792 D_{85}= 31.1585 D_{60}= 16.0359
D_{50}= 11.9297 D_{30}= 3.6929 D_{15}= 0.4592
D_{10}= 0.1834 C_u= 87.43 C_c= 4.64

Classification

USCS= GP-GM AASHTO= A-1-a

Remarks

Source of Sample: Boring **Depth:** 5-7'
Sample Number: GZ-1 / S-3

Date: 03.21.23

Thielsch Engineering Inc.

Cranston, RI

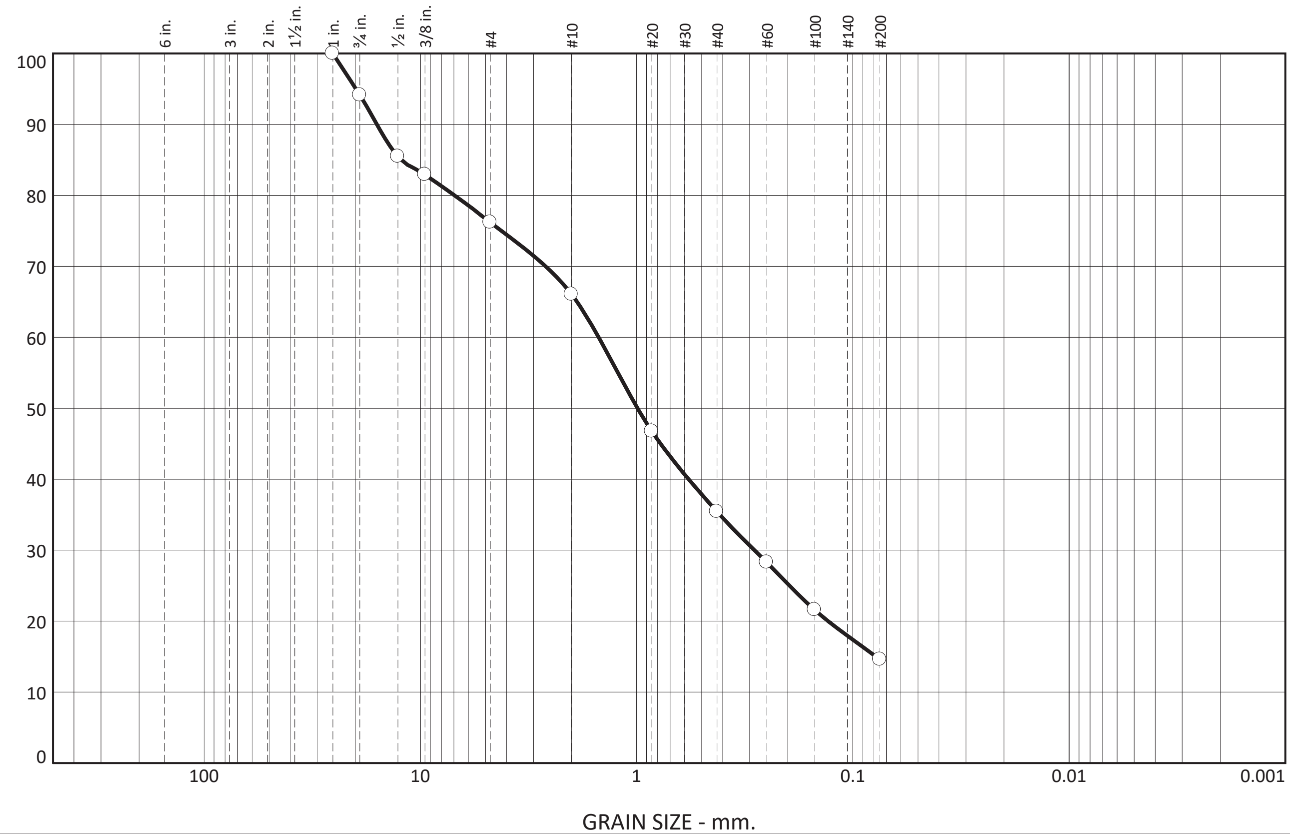
Client: GZA GeoEnvironmental
Project: Hudson, MA Culvert Replacements
Brigham Street and Park Street
Project No: 04.0191546.00 **Fig.** 23-S-1237

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

Tested By: RB / AF / JGW **Checked By:**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	5.9	17.9	10.2	30.6	20.8	14.6	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	94.1		
1/2"	85.5		
3/8"	82.9		
#4	76.2		
#10	66.0		
#20	46.8		
#40	35.4		
#60	28.3		
#100	21.6		
#200	14.6		

* (no specification provided)

Soil Description

Brown, f-c SAND, some Gravel, little Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 15.8904 D_{85}= 12.2784 D_{60}= 1.4982
D_{50}= 0.9905 D_{30}= 0.2853 D_{15}= 0.0783
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Remarks

Source of Sample: Boring **Depth:** 15-17'
Sample Number: GZ-1 / S-6 **Date:** 03.21.23

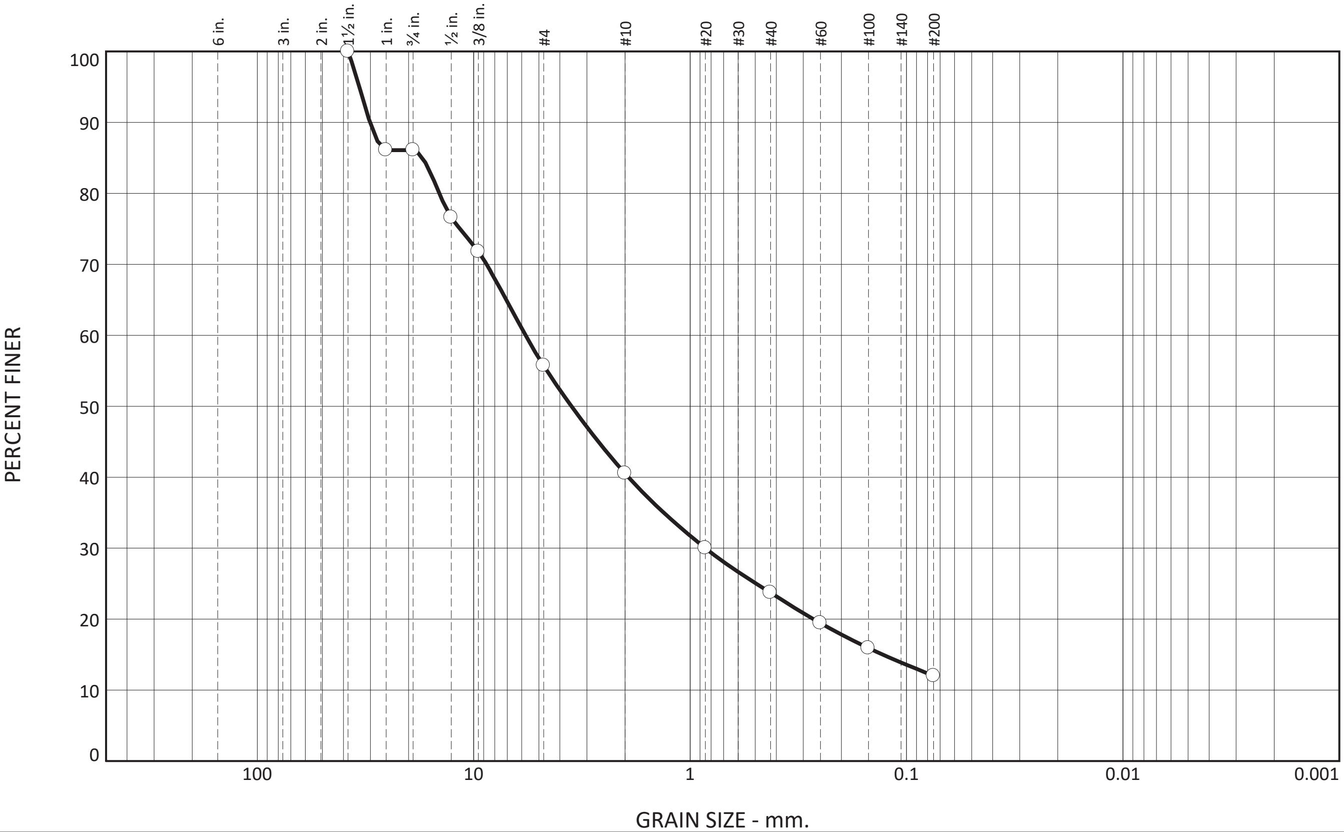
Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental
Project: Hudson, MA Culvert Replacements
Brigham Street and Park Street
Project No: 04.0191546.00 **Fig.** 23-S-1238

Tested By: RB / AF / JGW **Checked By:**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	13.9	30.4	15.2	16.8	11.7	12.0	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 1/2"	100.0		
1"	86.1		
3/4"	86.1		
1/2"	76.6		
3/8"	71.8		
#4	55.7		
#10	40.5		
#20	30.0		
#40	23.7		
#60	19.4		
#100	15.9		
#200	12.0		

* (no specification provided)

Soil Description

Brown, GRAVEL and f-c SAND, little Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 30.1390 D_{85}= 17.2217 D_{60}= 5.7580
D_{50}= 3.5344 D_{30}= 0.8508 D_{15}= 0.1289
D_{10}= C_u= C_c=

Classification

USCS= GP-GM AASHTO= A-1-a

Remarks

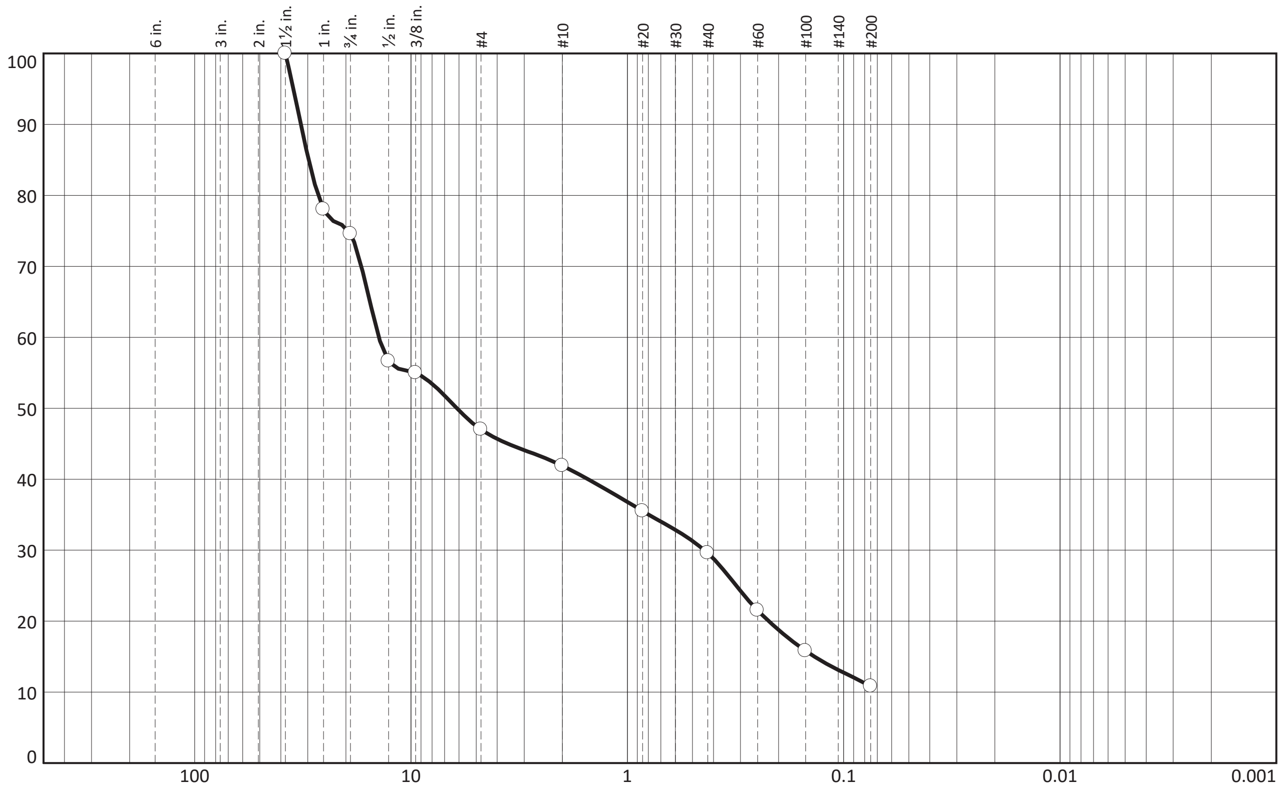
Source of Sample: Boring **Depth:** 15-17'
Sample Number: GZ-2 / S-5 **Date:** 03.21.23

Thielsch Engineering Inc. Cranston, RI	**Client:** GZA GeoEnvironmental **Project:** Hudson, MA Culvert Replacements Brigham Street and Park Street **Project No:** 04.0191546.00 **Fig.** 23-S-1239

Tested By: RB / AF / JGW **Checked By:**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	25.4	27.6	5.1	12.3	18.8	10.8	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 1/2"	100.0		
1"	78.0		
3/4"	74.6		
1/2"	56.6		
3/8"	55.0		
#4	47.0		
#10	41.9		
#20	35.5		
#40	29.6		
#60	21.5		
#100	15.8		
#200	10.8		

* (no specification provided)

Soil Description

Brown, GRAVEL and f-c SAND, little Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 32.3016 D_{85}= 29.7297 D_{60}= 14.0810
D_{50}= 6.1363 D_{30}= 0.4408 D_{15}= 0.1367
D_{10}= C_u= C_c=

Classification

USCS= GP-GM AASHTO= A-1-a

Remarks

Source of Sample: Boring **Depth:** 10-12'
Sample Number: GZ-3 / S-5

Date: 03.21.23

Thielsch Engineering Inc.

Cranston, RI

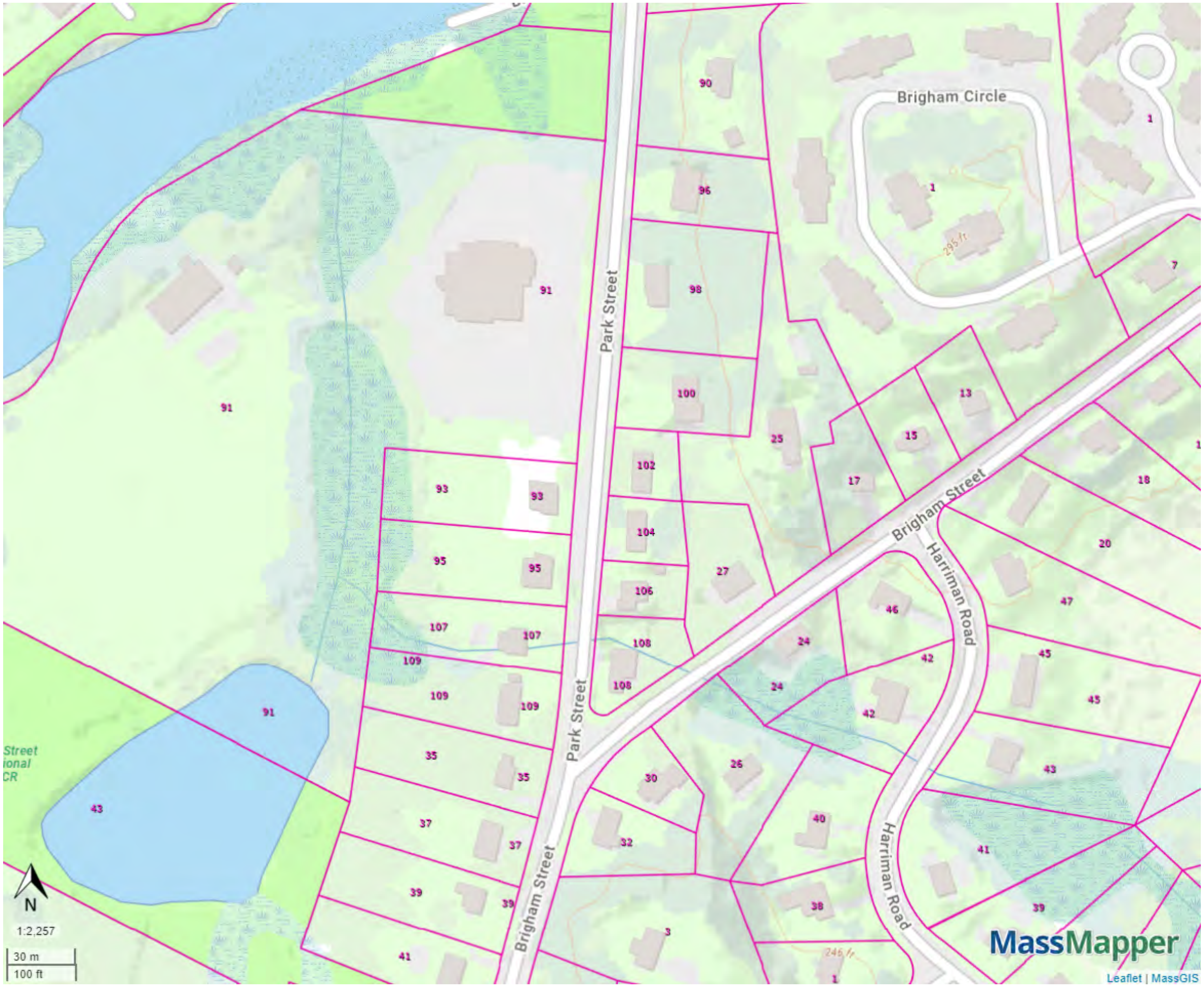
Client: GZA GeoEnvironmental
Project: Hudson, MA Culvert Replacements
Brigham Street and Park Street
Project No: 04.0191546.00 **Fig.** 23-S-1240

Tested By: RB / AF / JGW **Checked By:** [signature]

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicative of apparently identical samples.

APPENDIX E: ENVIRONMENTAL RESOURCE MAP

Brigham Street Culvert



Zone IIs

Potential Vernal Pools

IWPAs

Areas of Critical Environmental Concern ACECs

NHESP Priority Habitats of Rare Species

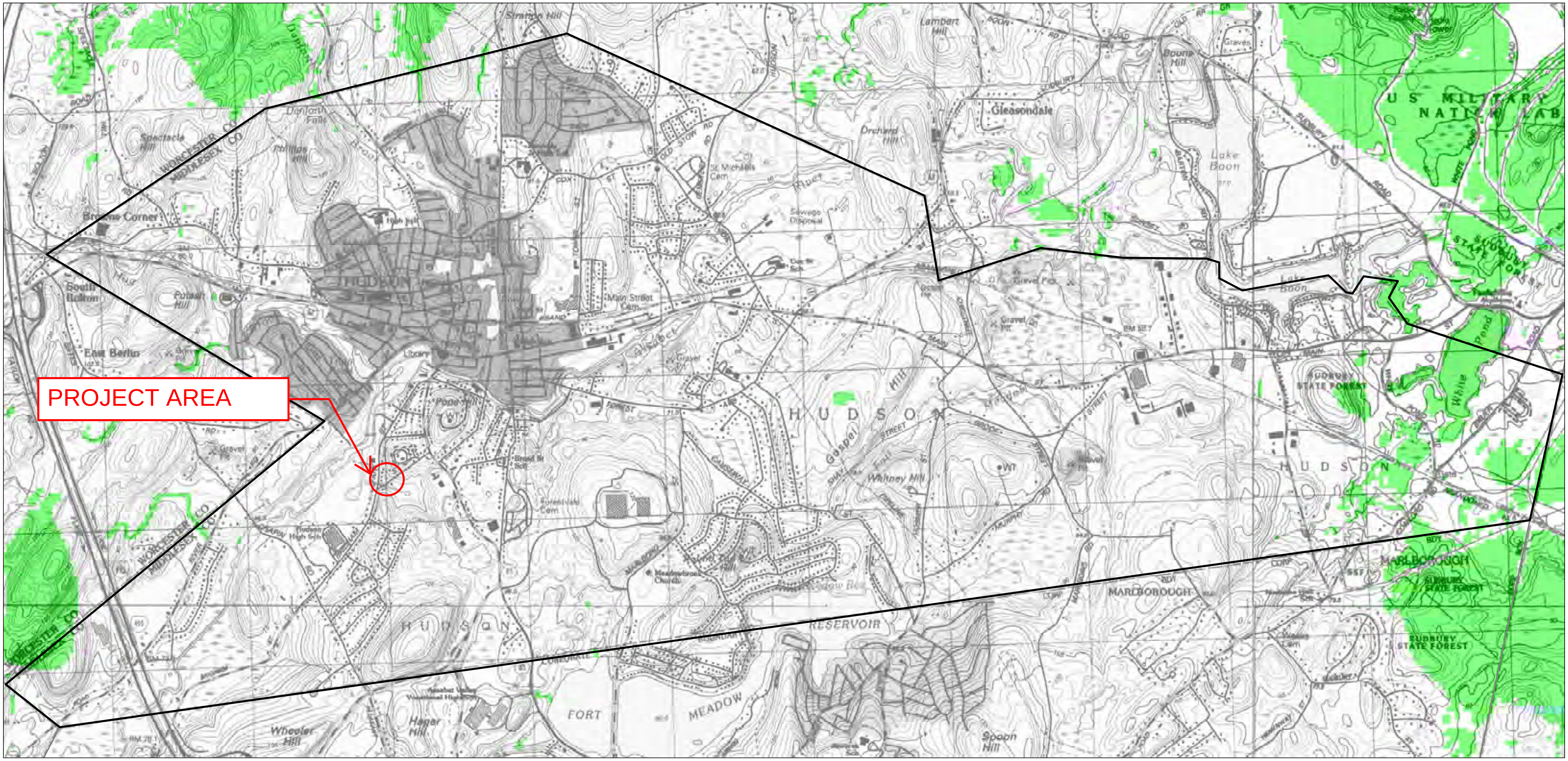
NHESP Estimated Habitats of Rare Wildlife

NHESP Certified Vernal Pools

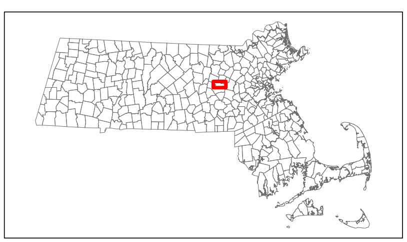
NHESP Ecoregions

Property Tax Parcels

Habitat of Potential Regional or Statewide Importance
Town of HUDSON, MA



Updated July 23, 2021



Habitat of Potential Regional or Statewide Importance

MassDEP's Massachusetts Wildlife Habitat Protection Guidance for Inland Wetlands (June 2006) adopted a new approach for assessing wildlife habitat impacts associated with work in wetlands. This approach utilizes maps developed at the University of Massachusetts Amherst using the Conservation Assessment and Prioritization System (CAPS). The maps depict Habitat of Potential Regional or Statewide Importance that may trigger more intensive review under the MA Wetlands Protection Act. For more information on how to assess wildlife habitat impacts, see Section III of the Guidance document: https://www.mass.gov/doc/massachusetts-wildlife-habitat-protection-guidance-for-inland-wetlands/download.

CAPS is an approach to prioritizing land for conservation/protection based on the assessment of ecological integrity for various ecological communities (e.g. forested wetland, shrub swamp, headwater stream) within an area. The CAPS model assesses ecological integrity of the Massachusetts landscape as influenced by environmental stressor metrics (e.g. pollution, fragmentation). It relies on data that are broadly available across Massachusetts. Ecological features which are not consistently surveyed or uniformly available, such as certified vernal pools, rare species habitat, and contamination sites are not included in the CAPS analysis. When available, this more specific ecological information may be used in conjunction with the CAPS outputs to better understand particular sites in Massachusetts and support informed conservation decision-making. For more information on the statewide maps produced by the CAPS model, see: http://www.umasscaps.org.

These maps were prepared by the University of Massachusetts Amherst, with funding from the Massachusetts Department of Environmental Protection.

UMass Amherst

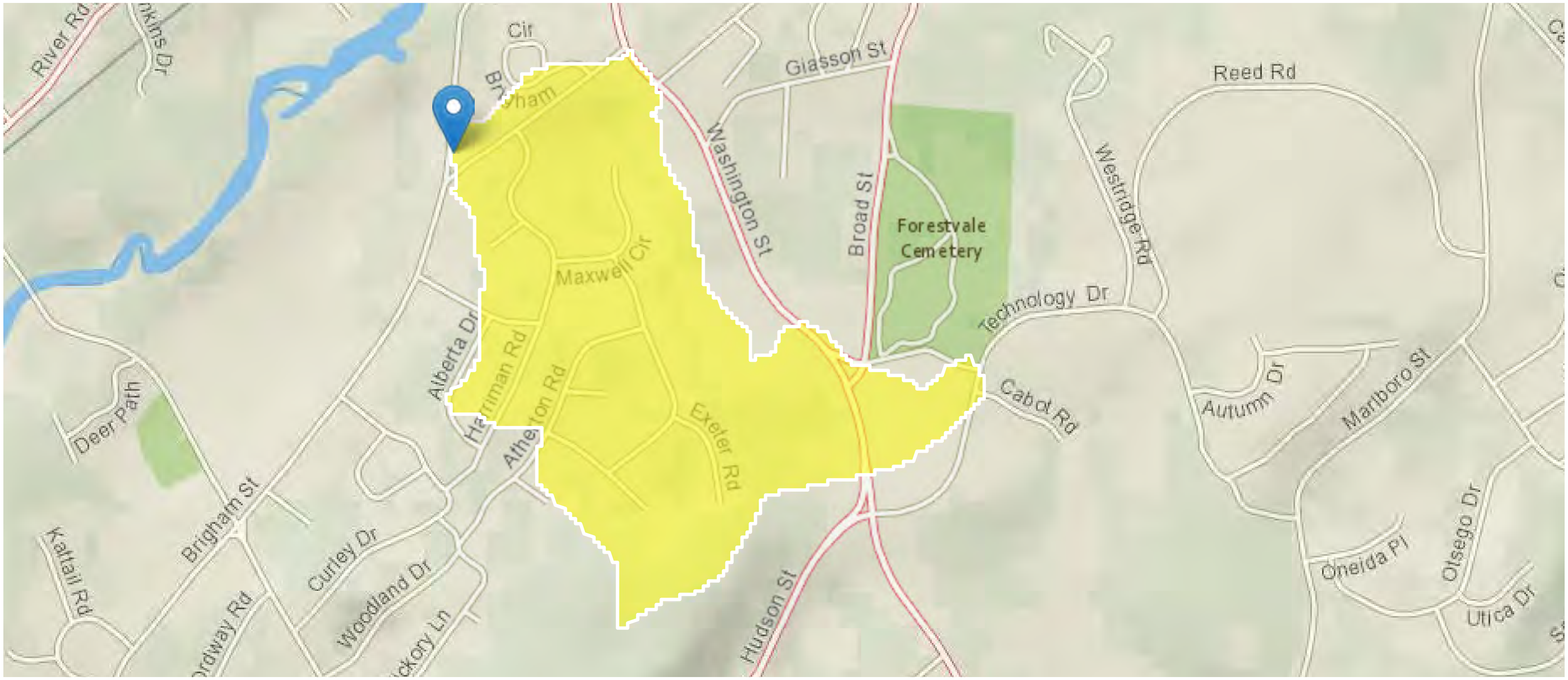
MassDEP

UMass Extension
CENTER FOR AGRICULTURE

APPENDIX F: STREAMSTATS REPORT

StreamStats Report

Region ID: MA
Workspace ID: MA20230623153807872000
Clicked Point (Latitude, Longitude): 42.38305, -71.57533
Time: 2023-06-23 11:38:30 -0400



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BSLDEM10M	Mean basin slope computed from 10 m DEM	6.946	percent
BSLDEM250	Mean basin slope computed from 1:250K DEM	4.305	percent
DRFTPERSTR	Area of stratified drift per unit of stream length	0.22	square mile per mile
DRNAREA	Area that drains to a point on a stream	0.23	square miles
ELEV	Mean Basin Elevation	299	feet
FOREST	Percentage of area covered by forest	38.22	percent
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	3.73	percent
MAREGION	Region of Massachusetts 0 for Eastern 1 for Western	0	dimensionless
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	59.97	percent

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.16	512
ELEV	Mean Basin Elevation	299	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	3.73	percent	0	32.3

Peak-Flow Statistics Flow Report [Peak Statewide 2016 5156]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	ASEp
50-percent AEP flood	13.5	ft^3/s	6.79	26.9	42.3
20-percent AEP flood	23.1	ft^3/s	11.4	46.7	43.4
10-percent AEP flood	30.9	ft^3/s	14.9	64.1	44.7
4-percent AEP flood	42.4	ft^3/s	19.7	91.2	47.1
2-percent AEP flood	52.1	ft^3/s	23.4	116	49.4
1-percent AEP flood	62.5	ft^3/s	27.2	144	51.8
0.5-percent AEP flood	73.9	ft^3/s	31.1	175	54.1
0.2-percent AEP flood	90.6	ft^3/s	36.4	226	57.6

Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Low-Flow Statistics

Low-Flow Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	4.305	percent	0.32	24.6

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRFTPERSTR	Stratified Drift per Stream Length	0.22	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

Low-Flow Statistics Disclaimers [Statewide Low Flow WRIR00 4135]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Low-Flow Statistics Flow Report [Statewide Low Flow WRIR00 4135]

Statistic	Value	Unit
7 Day 2 Year Low Flow	0.0184	ft^3/s
7 Day 10 Year Low Flow	0.00791	ft^3/s

Low-Flow Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Flow-Duration Statistics

Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	1.61	149
DRFTPERSTR	Stratified Drift per Stream Length	0.22	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1
BSLDEM250	Mean Basin Slope from 250K DEM	4.305	percent	0.32	24.6

Flow-Duration Statistics Disclaimers [Statewide Low Flow WRIR00 4135]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

Statistic	Value	Unit
50 Percent Duration	0.213	ft^3/s
60 Percent Duration	0.142	ft^3/s
70 Percent Duration	0.0839	ft^3/s
75 Percent Duration	0.0636	ft^3/s
80 Percent Duration	0.0641	ft^3/s
85 Percent Duration	0.0463	ft^3/s
90 Percent Duration	0.039	ft^3/s
95 Percent Duration	0.0206	ft^3/s
98 Percent Duration	0.0124	ft^3/s
99 Percent Duration	0.0084	ft^3/s

Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

August Flow-Duration Statistics

August Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	4.305	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.22	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

August Flow-Duration Statistics Disclaimers [Statewide Low Flow WRIR00 4135]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

August Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

Statistic	Value	Unit
August 50 Percent Duration	0.0472	ft^3/s

August Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Bankfull Statistics

Bankfull Statistics Parameters [Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	6.946	percent	2.2	23.9

Bankfull Statistics Parameters [Appalachian Highlands D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.07722	940.1535

Bankfull Statistics Parameters [New England P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	3.799224	138.999861

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.07722	59927.7393

Bankfull Statistics Disclaimers [Bankfull Statewide SIR2013 5155]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [Bankfull Statewide SIR2013 5155]

Statistic	Value	Unit
Bankfull Width	8.4	ft
Bankfull Depth	0.62	ft
Bankfull Area	5.12	ft^2
Bankfull Streamflow	12	ft^3/s

Bankfull Statistics Flow Report [Appalachian Highlands D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	8.26	ft
Bieger_D_channel_depth	0.735	ft
Bieger_D_channel_cross_sectional_area	6.13	ft^2

Bankfull Statistics Disclaimers [New England P Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [New England P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	16.7	ft
Bieger_P_channel_depth	0.995	ft
Bieger_P_channel_cross_sectional_area	16.4	ft^2

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	7.38	ft
Bieger_USA_channel_depth	0.881	ft
Bieger_USA_channel_cross_sectional_area	7.73	ft^2

Bankfull Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Bankfull Width	8.4	ft
Bankfull Depth	0.62	ft
Bankfull Area	5.12	ft^2
Bankfull Streamflow	12	ft^3/s
Bieger_D_channel_width	8.26	ft
Bieger_D_channel_depth	0.735	ft
Bieger_D_channel_cross_sectional_area	6.13	ft^2
Bieger_P_channel_width	16.7	ft
Bieger_P_channel_depth	0.995	ft
Bieger_P_channel_cross_sectional_area	16.4	ft^2
Bieger_USA_channel_width	7.38	ft
Bieger_USA_channel_depth	0.881	ft
Bieger_USA_channel_cross_sectional_area	7.73	ft^2

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_campaign=PDFCoverPages)

Probability Statistics

Probability Statistics Parameters [Perennial Flow Probability]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.01	1.99
PCTSNDGRV	Percent Underlain By Sand And Gravel	59.97	percent	0	100
FOREST	Percent Forest	38.22	percent	0	100
MAREGION	Massachusetts Region	0	dimensionless	0	1

Probability Statistics Flow Report [Perennial Flow Probability]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PC
Probability Stream Flowing Perennially	0.756	dim	71

Probability Statistics Citations

Bent, G.C., and Steeves, P.A.,2006, A revised logistic regression equation and an automated procedure for mapping the probability of a stream flowing perennially in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2006–5031, 107 p. (http://pubs.usgs.gov/sir/2006/5031/pdfs/SIR_2006-5031rev.pdf)

Maximum Probable Flood Statistics

Maximum Probable Flood Statistics Parameters [Crippen Bue Region 2]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.1	3000

Maximum Probable Flood Statistics Flow Report [Crippen Bue Region 2]

Statistic	Value	Unit
Maximum Flood Crippen Bue Regional	1960	ft^3/s

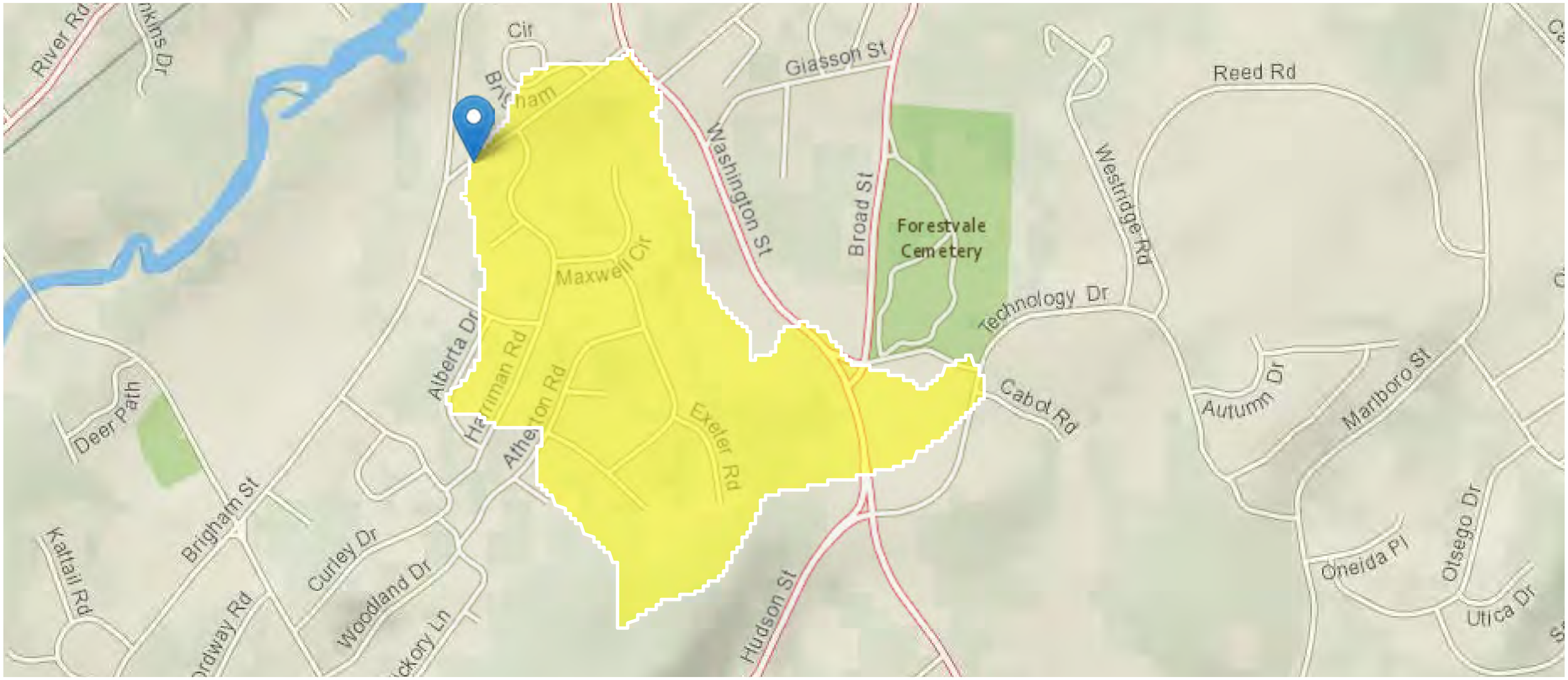
Maximum Probable Flood Statistics Citations

Crippen, J.R. and Bue, Conrad D.1977, Maximum Floodflows in the Conterminous United States, Geological Survey Water-Supply Paper 1887, 52p. (https://pubs.usgs.gov/wsp/1887/report.pdf)

Application Version: 4.15.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

StreamStats Report

Region ID: MA
Workspace ID: MA20230424004723650000
Clicked Point (Latitude, Longitude): 42.38291, -71.57485
Time: 2023-04-23 20:47:44 -0400



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
ACRSDFT	Area underlain by stratified drift	0.14	square miles
BSLDEM10M	Mean basin slope computed from 10 m DEM	6.878	percent
BSLDEM250	Mean basin slope computed from 1:250K DEM	4.325	percent
CAT1ROADS	Length of interstates lmtd access highways and ramps for lmtd access highways, includes cloverleaf interchanges (USGS Ntl Transp Dataset)	0	miles
CAT2ROADS	Length of sec hwy or maj connecting roads; main arteries & hwys not lmtd access, usually in the US Hwy or State Hwy systems (USGS Ntl Transp Dataset)	0	miles
CAT3ROADS	Length of local connecting roads; roads that collect traffic from local roads & connect towns, subdivisions & neighborhoods (USGS Nat Transp Dataset)	0.28	miles
CAT4ROADS	Length of local roads; generally paved street, road, or byway that usually have single lane of traffic in each direction (USGS Ntnl Transp Dataset)	2.99	miles
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	194215.9	meters
CENTROIDY	Basin centroid vertical (y) location in state plane units	903208.6	meters
CROSCOUNT1	Number of intersections between streams and roads, where the roads are interstate, limited access highway, or ramp (CAT1ROADS)	0	dimensionless
CROSCOUNT2	Number of intersections between streams and roads, where the roads are secondary highway or major connecting road (CAT2ROADS)	0	dimensionless
CROSCOUNT3	Number of intersections between streams and roads, where roads are local conecting roads (CAT3ROADS)	0	dimensionless
CROSCOUNT4	Number of intersections between streams and roads, where roads are local roads (CAT4ROADS)	4	dimensionless

Parameter Code	Parameter Description	Value	Unit
CRSDFT	Percentage of area of coarse-grained stratified drift	59.59	percent
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	121	feet per mi
DRFTPERSTR	Area of stratified drift per unit of stream length	0.22	square mile per mile
DRNAREA	Area that drains to a point on a stream	0.23	square miles
ELEV	Mean Basin Elevation	300	feet
FOREST	Percentage of area covered by forest	38.29	percent
LAKEAREA	Percentage of Lakes and Ponds	0	percent
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	3.79	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	78.6	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	40.4	percent
LFPLENGTH	Length of longest flow path	0.94	miles
MAREGION	Region of Massachusetts 0 for Eastern 1 for Western	0	dimensionless
MAXTEMPC	Mean annual maximum air temperature over basin area, in degrees Centigrade	14.9	degrees C
OUTLETX	Basin outlet horizontal (x) location in state plane coordinates	193835	feet
OUTLETY	Basin outlet vertical (y) location in state plane coordinates	903595	feet
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	59.59	percent
PRECPRIS00	Basin average mean annual precipitation for 1971 to 2000 from PRISM	47.9	inches
STRMTOT	total length of all mapped streams (1:24,000-scale) in the basin	0.61	miles
WETLAND	Percentage of Wetlands	6.76	percent

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.16	512
ELEV	Mean Basin Elevation	300	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	3.79	percent	0	32.3

Peak-Flow Statistics Flow Report [Peak Statewide 2016 5156]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	ASEp
50-percent AEP flood	13.5	ft^3/s	6.79	26.9	42.3
20-percent AEP flood	23.1	ft^3/s	11.4	46.7	43.4
10-percent AEP flood	30.9	ft^3/s	14.9	64.1	44.7
4-percent AEP flood	42.4	ft^3/s	19.7	91.2	47.1
2-percent AEP flood	52	ft^3/s	23.4	116	49.4
1-percent AEP flood	62.5	ft^3/s	27.2	144	51.8
0.5-percent AEP flood	73.9	ft^3/s	31.1	175	54.1
0.2-percent AEP flood	90.5	ft^3/s	36.3	225	57.6

Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Low-Flow Statistics

Low-Flow Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	4.325	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.22	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

Low-Flow Statistics Disclaimers [Statewide Low Flow WRIR00 4135]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Low-Flow Statistics Flow Report [Statewide Low Flow WRIR00 4135]

Statistic	Value	Unit
7 Day 2 Year Low Flow	0.0184	ft^3/s
7 Day 10 Year Low Flow	0.00793	ft^3/s

Low-Flow Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Flow-Duration Statistics

Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	1.61	149
DRFTPERSTR	Stratified Drift per Stream Length	0.22	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1
BSLDEM250	Mean Basin Slope from 250K DEM	4.325	percent	0.32	24.6

Flow-Duration Statistics Disclaimers [Statewide Low Flow WRIR00 4135]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

Statistic	Value	Unit
50 Percent Duration	0.213	ft^3/s
60 Percent Duration	0.142	ft^3/s
70 Percent Duration	0.0839	ft^3/s
75 Percent Duration	0.0636	ft^3/s
80 Percent Duration	0.0641	ft^3/s
85 Percent Duration	0.0463	ft^3/s
90 Percent Duration	0.0391	ft^3/s
95 Percent Duration	0.0206	ft^3/s
98 Percent Duration	0.0125	ft^3/s

Statistic	Value	Unit
99 Percent Duration	0.00842	ft^3/s

Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

August Flow-Duration Statistics

August Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	4.325	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.22	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

August Flow-Duration Statistics Disclaimers [Statewide Low Flow WRIR00 4135]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

August Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

Statistic	Value	Unit
August 50 Percent Duration	0.0473	ft^3/s

August Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Bankfull Statistics

Bankfull Statistics Parameters [Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	6.878	percent	2.2	23.9

Bankfull Statistics Parameters [Appalachian Highlands D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.07722	940.1535

Bankfull Statistics Parameters [New England P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	3.799224	138.999861

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.07722	59927.7393

Bankfull Statistics Disclaimers [Bankfull Statewide SIR2013 5155]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [Bankfull Statewide SIR2013 5155]

Statistic	Value	Unit
Bankfull Width	8.38	ft
Bankfull Depth	0.619	ft
Bankfull Area	5.11	ft^2
Bankfull Streamflow	11.9	ft^3/s

Bankfull Statistics Flow Report [Appalachian Highlands D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	8.26	ft
Bieger_D_channel_depth	0.735	ft
Bieger_D_channel_cross_sectional_area	6.13	ft^2

Bankfull Statistics Disclaimers [New England P Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [New England P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	16.7	ft
Bieger_P_channel_depth	0.995	ft

Statistic	Value	Unit
Bieger_P_channel_cross_sectional_area	16.4	ft^2

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	7.38	ft
Bieger_USA_channel_depth	0.881	ft
Bieger_USA_channel_cross_sectional_area	7.73	ft^2

Bankfull Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Bankfull Width	8.38	ft
Bankfull Depth	0.619	ft
Bankfull Area	5.11	ft^2
Bankfull Streamflow	11.9	ft^3/s
Bieger_D_channel_width	8.26	ft
Bieger_D_channel_depth	0.735	ft
Bieger_D_channel_cross_sectional_area	6.13	ft^2
Bieger_P_channel_width	16.7	ft
Bieger_P_channel_depth	0.995	ft
Bieger_P_channel_cross_sectional_area	16.4	ft^2
Bieger_USA_channel_width	7.38	ft
Bieger_USA_channel_depth	0.881	ft
Bieger_USA_channel_cross_sectional_area	7.73	ft^2

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_campaign=PDFCoverPages)

Probability Statistics

Probability Statistics Parameters [Perennial Flow Probability]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.01	1.99
PCTSNDGRV	Percent Underlain By Sand And Gravel	59.59	percent	0	100
FOREST	Percent Forest	38.29	percent	0	100
MAREGION	Massachusetts Region	0	dimensionless	0	1

Probability Statistics Flow Report [Perennial Flow Probability]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PC
Probability Stream Flowing Perennially	0.755	dim	71

Probability Statistics Citations

Bent, G.C., and Steeves, P.A.,2006, A revised logistic regression equation and an automated procedure for mapping the probability of a stream flowing perennially in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2006–5031, 107 p. (http://pubs.usgs.gov/sir/2006/5031/pdfs/SIR_2006-5031rev.pdf)

Maximum Probable Flood Statistics

Maximum Probable Flood Statistics Parameters [Crippen Bue Region 2]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.23	square miles	0.1	3000

Maximum Probable Flood Statistics Flow Report [Crippen Bue Region 2]

Statistic	Value	Unit
Maximum Flood Crippen Bue Regional	1960	ft^3/s

Maximum Probable Flood Statistics Citations

Crippen, J.R. and Bue, Conrad D.1977, Maximum Floodflows in the Conterminous United States, Geological Survey Water-Supply Paper 1887, 52p. (https://pubs.usgs.gov/wsp/1887/report.pdf)

Application Version: 4.14.0

StreamStats Services Version: 1.2.22

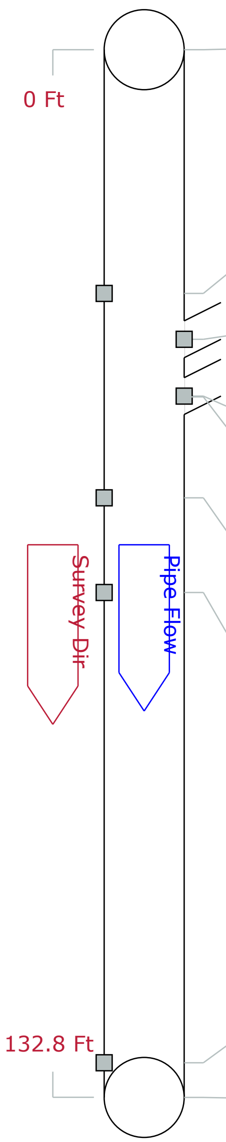
NSS Services Version: 2.2.1

APPENDIX G: CCTV REPORT

Pipe Graphic Report of PLR INLET PARK ST. X for Woodard&Curran

Setup	1	Surveyed By	TB	Certificate #	P0035658-012022	Owner	
Reviewed By		Reviewer #		Work Order			
Customer	Woodard&Curran			P/O #			
Media Label		Project	Hudson Sewer and Drain Investigations 2023				
Date	2023/03/06	Time	14:09	Weather		Pre-Cleaning	N
Date Cleaned							
Flow control		Survey Purpose		Direction	Downstream		
Street	Park St.	City	Hudson	Drainage area			
Location Code		Pipe Use	Stormwater Pipe				
Location details		Height	36	Width	ins		
Shape	Circular	Material	Corrugated Metal Pipe	Lining			
Coating		Pipe Joint length	Ft	Total length	Ft		
Length Surveyed	132.80 Ft	Year Constructed		Year Renewed			
Additional info							
Up	INLET PARK ST.	Rim to invert		Grade to invert		Rim to grade	Ft
Down	OUTFALL PARK ST.	Rim to invert		Grade to invert		Rim to grade	Ft

Structural | O & M | Miscellaneous | Constructional



0.0 Ft — End of Pipe [INLET PARK ST.]
Miscellaneous Water Level 10.000%

30.9 Ft — Surface Damage Corrosion 03 to 09 o'clock ST: 3 [S01]

36.7 Ft — Tap Break-in Activity 12.000 12 o'clock
Miscellaneous General Observation [CHANNEL TO MANHOLE]

43.9 Ft — Tap Break-in/Hammer 15.000 10 o'clock

44.0 Ft — Miscellaneous Water Level 25.000%

56.8 Ft — Deposits Settled Fine 06 o'clock 20.000% OM: 3

68.8 Ft — Surface Damage Corrosion 03 to 09 o'clock ST: 3 [F01]
Miscellaneous General Observation [NEWER CMP]

128.4 Ft — Deposits Settled Fine 06 o'clock 30.000% OM: 4

132.8 Ft — Miscellaneous Water Level 35.000%
Miscellaneous Survey Abandoned [PIPE NEEDS TO BE CLEANED...]

Tabular Report of PSR INLET PARK ST. for Woodard&Curran

Setup 1 Surveyed By TB Certificate # P0035658-012022 Owner
Reviewed By Reviewer # Work Order
Customer Woodard&Curran P/O #
Media Label Project Hudson Sewer and Drain Investigations 2023
Date 2023/03/06 Time 14:09 Weather Pre-Cleaning N Date Cleaned
Flow control Survey Purpose Direction Down
Inspection Status Complete Inspection Consequence Of Failure Pressure
Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street Park St. City Hudson Drainage area
Location Code Pipe Use Stormwater Pipe
Location details Height 36 Width ins
Shape Circular Material Corrugated Metal Pipe Lining
Coating Pipe Joint length Ft Total length Ft
Length Surveyed 132.8 Ft Year Constructed Year Renewed

Up INLET PARK ST. Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Down OUTFALL PARK ST. Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Coordinate System Vertical Datum
GPS Accuracy
Additional info

Structural O & M
Miscellaneous Constructional

Count	Video	CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0			AEP	End of Pipe								INLET PARK ST.
0.0			MWL	Miscellaneous Water Level			10.000					
30.9		S01	SCP	Surface Damage Corrosion					03	09		
36.7			TBA	Tap Break-in Activity	12.000				12			
36.7			MGO	Miscellaneous General Observation								CHANNEL TO MANHOLE
43.9			TB	Tap Break-in/Hammer	15.000				10			
44.0			MWL	Miscellaneous Water Level			25.000					
56.8			DSF	Deposits Settled Fine			20.000		06			
68.8		F01	SCP	Surface Damage Corrosion					03	09		
68.8			MGO	Miscellaneous General Observation								NEWER CMP
128.4			DSF	Deposits Settled Fine			30.000		06			
132.8			MWL	Miscellaneous Water Level			35.000					
132.8			MSA	Miscellaneous Survey Abandoned								PIPE NEEDS TO BE CLEANED...

132.8 Ft Total Length Surveyed

Scores

Structural:	Pipe Rating 24	Pipe Ratings Index 3	Quick Rating 3800
O&M:	Pipe Rating 7	Pipe Ratings Index 3.5	Quick Rating 4131
Overall	Pipe Rating 31	Pipe Ratings Index 6.5	Quick Rating 4139

Woodard & Curran

woodardcurran.com