Stoney Bridge Road Culvert Replacement Alternatives Analysis

Stoney Bridge Road
Templeton, Massachusetts
June 5, 2019

Prepared for:
Town of Templeton
160 Patriots Road
East Templeton, Massachusetts 01438

MMI #6679-01

Prepared by:
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MILONE & MACBROOM
ENGINEERING | PLANNING | LANDSCAPE ARCHITECTURE | ENVIRONMENTAL SCIENCE

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1.0 INTRODUCTION

The Stoney Bridge Road culvert, known as Stone Bridge, conveys the Burnshirt River under Stoney Bridge Road in the town of Templeton, Massachusetts. The existing stone box culvert is deteriorated to the point where the town had to close the road to traffic. A partial collapse of the culvert and adjacent roadway embankment prompted the closure in August 2018. Milone & MacBroom, Inc. (MMI) was retained by the Town of Templeton to assess existing conditions and to investigate several crossing alternatives and to provide a recommended alternative for the existing structure.

Figure 1: Looking west down Stoney Bridge Road over the existing culvert crossing

2.0 SITE HISTORY

The Stoney Bridge Road culvert was constructed as part of a former industrial mill complex in the 1800s. A historic marker located at the east roadway approach signifies the former mill site that was dedicated to the town. Several of the alternatives as described herein include preservation and reuse of the existing culvert stones and the installation of interpretive signage to describe the history of the site.

Figure 2: Historic Stone Bridge Monument

3.0 SITE DESCRIPTION

3.1 Existing Conditions

The existing culvert is located on Stoney Bridge Road at Stone Bridge Pond, a location also known as Stone Bridge. The existing structure is an approximately 17-foot-long stone culvert that is approximately 2 feet high by 6 feet wide. Cut stone masonry form the walls of the culvert, and a granite slab over the culvert supports the roadway above. The culvert has a natural channel bottom and a short reach along the culvert that connects the upper and lower impoundment. A plume of sediment was observed at the inlet, and a scour hole exists at the culvert outlet, which is indicative of a constricted inlet and high-flow velocity through the culvert.

Earthen embankments with stone boulders along the roadway slopes form the approaches to the culvert. Stoney Bridge Road is a local road that begins at the intersection of Henshaw Road to the east then continues westerly over the culvert where it becomes Burnshirt Road at the Philipston town line.

Stoney Bridge Road crosses the northerly end of Stone Bridge Pond. An earthen dam at the southerly end of Stone Bridge Pond, located just south of the town line in Templeton, retains the impoundment of the pond. Stone Bridge Pond is a popular recreational resource including such activities as fishing, canoeing, and kayaking. Numerous hiking trails access Department of Conservation and Recreation (DCR) property to the west of the culvert site. The Ware River Rail Trail also crosses Stoney Bridge Road east of the culvert crossing.

The culvert replacement is prompted by a partial collapse of the culvert and surrounding roadway in early August 2018, which caused overtopping of the culvert and roadway. The road at the culvert is currently closed to through traffic. The site location is shown in the United States Geological Survey (USGS) Location Map (Figure 3).

3.2 Environmental Resource Areas

3.2.1 Protected and Recreational Open Space

According to the Protected and Recreational Open Space layer of the MassGIS data layers, there are three types of open space in the vicinity of the Stoney Bridge Road culvert. Stone Bridge Pond is located in the Ware River Watershed and is regulated by the DCR Division of Water Supply Protection. The land west of Stone Bridge Pond is a Wildlife Management Area (WMA) that is managed by the Department of Fish and Game. The Ware River Rail Trail, managed by the DCR's Division of State Parks and Recreation, is located east of the culvert and Stone Bridge Pond. Refer to the Environmental Resources Map, Figure 4, for the location of open space lands.

3.2.2 Federal Emergency Management Agency (FEMA) Flood Zone

The culvert is located within FEMA flood zone A. Refer to the FEMA Map (Figure 5).

Figure 3: USGS Site Location Map

Stoney Bridge Road Culvert Replacement
Templeton, Massachusetts

0 1,000 2,000
Feet
1 in = 2,000 feet
N

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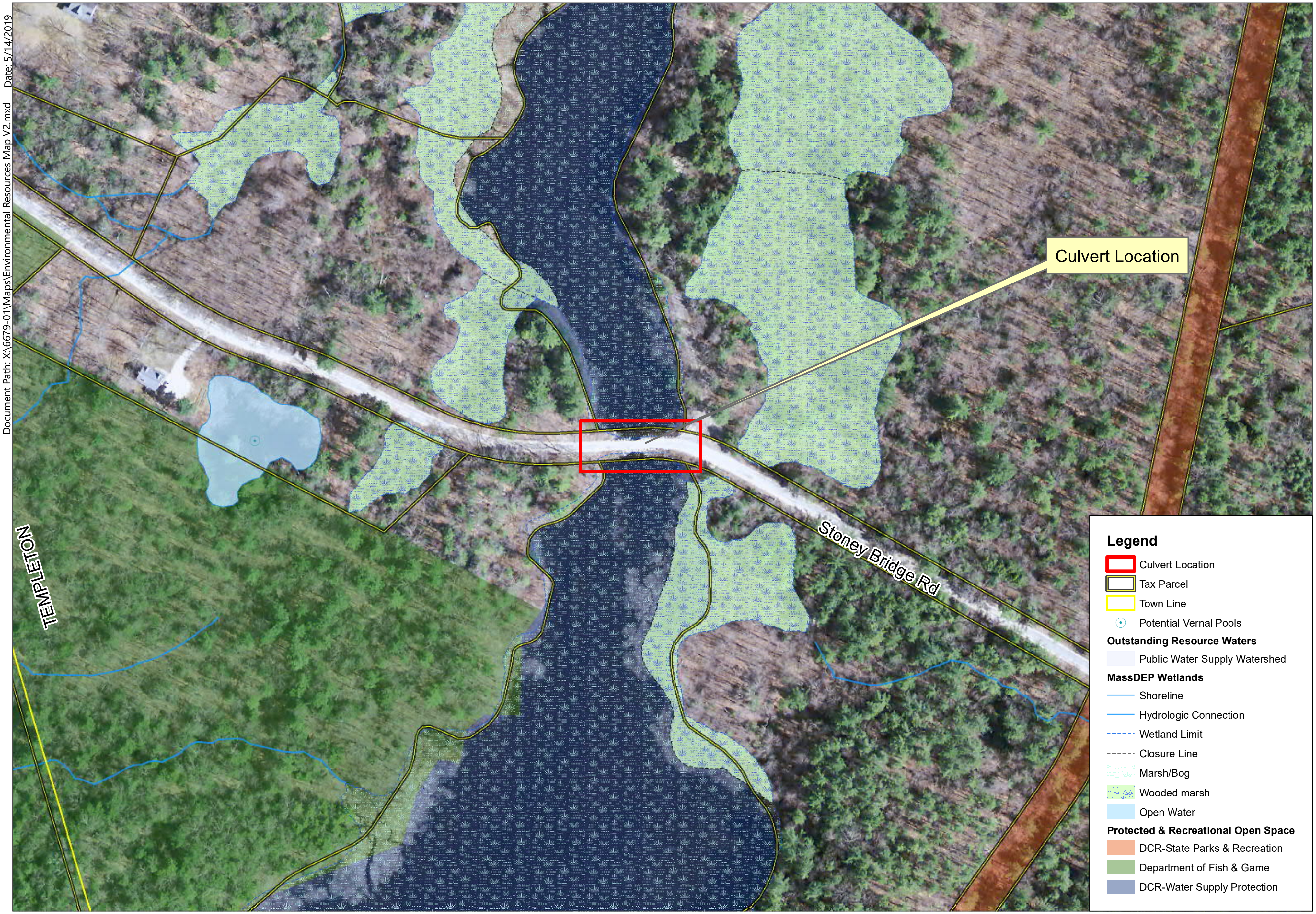

Figure 4: Environmental Resources Map

Stoney Bridge Rd Culvert Replacement

Templeton, MA

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0 100 200 Feet

N

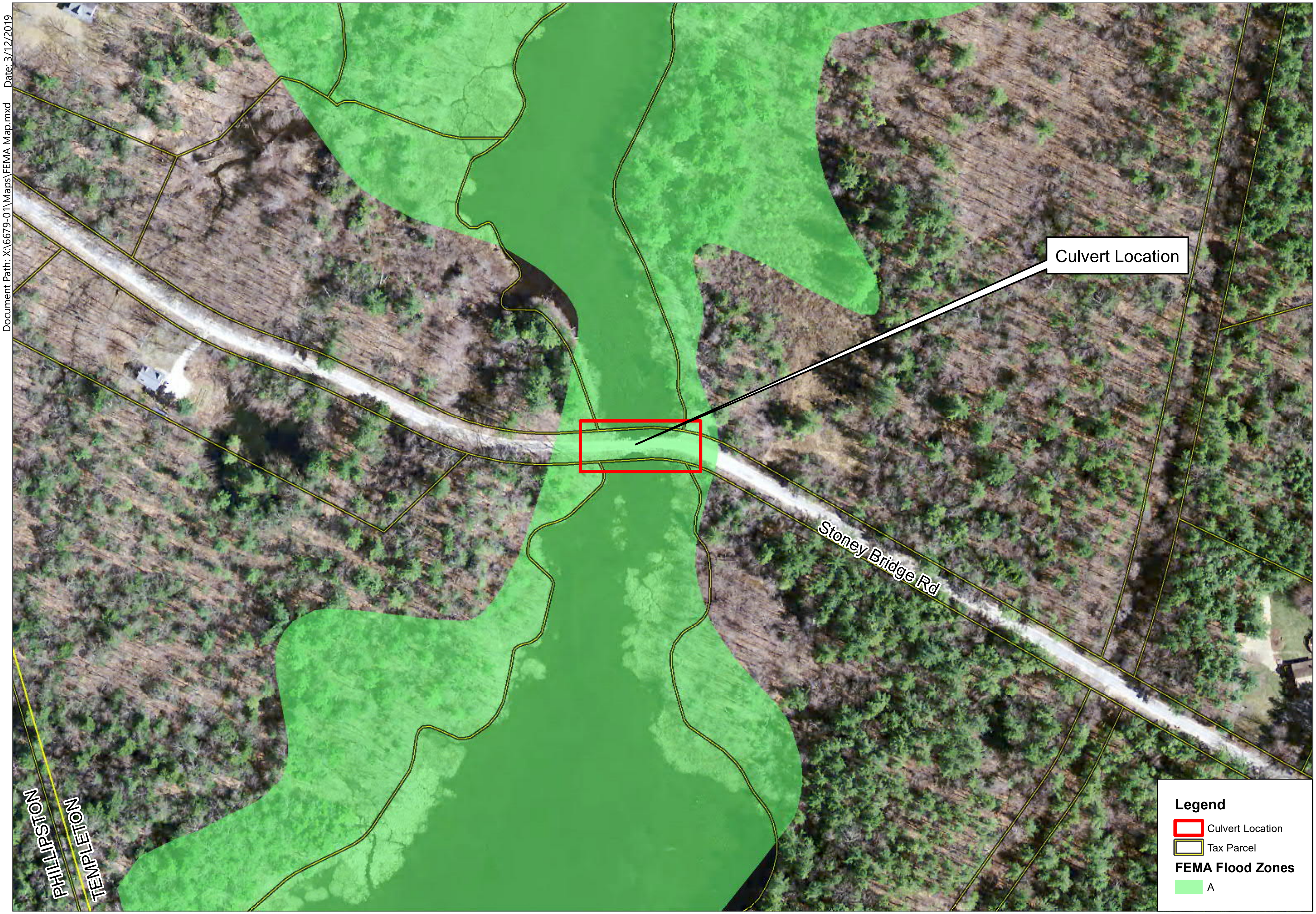

Figure 5: FEMA Map

Stoney Bridge Rd Culvert Replacement

Templeton, MA

MILONE & MACBROOM

0 100 200 Feet

N

4.0 SITE INVESTIGATIONS

4.1 Field Survey and Base Plan

MMI conducted a topographic field survey of the project site in January 2019. An existing conditions plan, included as an attachment to this report, was prepared based on the field survey and also depicts wetland resource area delineation as described herein. Property information and the Stoney Bridge Road right-of-way was obtained from Geographic Information System (GIS) assessor record information.

4.2 Wetland Delineation

On November 14, 2018, MMI wetland scientists completed a wetland delineation at the project site. Inland wetlands and watercourses were delineated in accordance with the Rules and Regulations of the Massachusetts Wetlands Protection Act and Section 404 of the Clean Water Act. Resource area boundaries and flags were surveyed using a hand-held Global Positioning System (GPS) and are shown on the project base mapping. The regulated area, as described in the report, include inland bank, land under water bodies, and riverfront area. MMI did observe bordering vegetated wetlands (BVWs) along the periphery of the pond (i.e., above the elevation of the ordinary high water mark), but these BVWs occur well outside the project area and thus were not delineated. Refer to the Wetland Delineation Report included as an attachment to this report for a more detailed description of the wetland resource areas.

4.3 Geotechnical Investigation

MMI conducted two geotechnical borings at each side of the culvert on December 26, 2018, to determine subsurface conditions. Geotechnical recommendations for proposed construction including foundation design, lateral earth pressures, seismic considerations, and temporary excavation and excavation support are specified in accordance with the requirements of the *Massachusetts Department of Transportation LRFD Bridge Manual*. As indicated in the report, the replacement culvert (four-sided structure or open-bottom culvert) can be supported by conventional shallow foundations or spread footings. Geotechnical findings and recommendations are provided in the Geotechnical Engineering Report included as an attachment to this report.

4.4 Coordination with Other Agencies

A project notification form was sent to the Massachusetts Historical Commission (MHC) to inquire of any significant historical or archeological resources within the project area. An online inquiry was also completed and sent with pertinent project information to the Templeton Community Preservation Committee for its input on the proposed alternatives.

A request for comment letter was submitted to both Templeton and Phillipston fire, police, and highway departments and the Narragansett Regional School District for input with respect to any impacts or delays that they foresee as a result of the proposed alternatives that permanently close the road to through traffic.

Response to correspondence as sent to these agencies will be included in the final draft of this report or provided to the town upon receipt.

5.0 HYDROLOGY

5.1 Watershed Description

The culvert tributary has a mapped watershed area of approximately 6.21 square miles. The tributary includes the most northerly portion of the Burnshirt River, originating northeast of the culvert, and the nearby Queen Lake as well as Wine Brook to the northwest of the culvert in addition to multiple unnamed streams. From the southerly end of Stone Bridge Pond, the Burnshirt River is a tributary to the Ware River and subsequently flows to the Chicopee and Connecticut Rivers.

5.2 Hydrologic Analysis

The peak-flow rates for the watershed were computed with the USGS *StreamStats* model. The program delineates the watershed, determines its drainage area and percent storage, and then applies regression equations for Massachusetts to predict the peak-flow rates. The base values of regional peak-flow rates predicted by the USGS *StreamStats* model are based upon regression analysis of existing gauging station data and do not account for the potential for climate change.

The following results were obtained from the *StreamStats* model:

TABLE 1
Peak Flood Flow Rates

Return Frequency, Years	Peak-Flow Rate (cfs)
2 Year	166
5 Year	281
10 Year	377
25 Year	518
50 Year	637
100 Year	766
500 Year	1110

6.0 HYDRAULIC MODELING

6.1 HY-8 Hydraulic Analysis

Preliminary hydraulic models were prepared to simulate peak flood flows from the *StreamStats* model for existing conditions and for the various crossing alternatives using the Federal Highway Administration (FHWA) *HY-8* computer program.

Under existing conditions, the culvert is clearly hydraulically inadequate where roadway overtopping of flood flows occurs during the 2-year event. Pursuant to Massachusetts Department of Transportation design guidance for a local rural road, a cross culvert should convey the 10-year design storm without roadway overtopping. Results of the *HY-8* analysis are summarized in the following tables under each alternative.

6.2 Stream Crossing Standards

The Massachusetts River and Stream Crossing Standards first released in 2004 outline standards for new culverts and, when feasible, for existing culvert replacements. These standards have been developed with the goals of providing passage for fish and wildlife and maintaining river continuity. Key criteria for the Massachusetts River and Stream Crossing Standard are listed below for the "General Standards" category:

1. Open-bottom structures are preferred.
2. Culverts should be embedded at least 2 feet and at least 25% for round pipe culverts.
3. Minimum crossing span of 1.2 times bankfull width
4. Match the existing natural bottom substrate
5. Match the water depth and velocity of the natural stream over a range of flows
6. Provide openness ratio of 0.82 feet or greater
7. Provide banks on both sides of the stream that match horizontal alignment and do not hinder use by riverine wildlife
8. Use bank slope of 1:1.5 vertical to horizontal
9. The internal banks should be stable during a 100-year event.

The standards further say that designs should avoid inlet and outlet drops, tailwater armoring, and scour pools.

6.3 Bankfull Width

The bankfull width of a channel is primarily a function of the bankfull discharge, which is approximately equal to the mean annual flood with an average return frequency of 1.5 to 2 years. It is also influenced by recent flood flow rates, channel slope, substrate size, and bank strength. The bankfull width in the vicinity of the Stoney Bridge Road culvert could not be accurately determined in the field due to the proximity of the impoundments at the inlet and outlet of the culvert. Consequently, the estimated bankfull width was determined to be 31 feet based on the results provided in *StreamStats,* which is based on *Equations for Estimating Bankfull Geometry and Discharge for Streams in Massachusetts* by Bardner C. Bent and Adrew M. Waite.

6.4 Aquatic Organism Passage (AOP) Analysis

The fish passage flows were estimated from regional methods (Bates and Kirn, 2009) for the AOP analysis. The high fish passage November flow is 28 cubic feet per second (cfs), which is applicable to brook and brown trout, while the high fish passage April flow is 102 cfs, which is applicable to rainbow trout. The low flow is 0.6 cfs and is applicable to brook, brown, and rainbow trout. Fish passage criteria for the hydraulic analysis were taken from the AOP guidelines (Bates and Kirn, 2009) for adult and juvenile brook, brown, and rainbow trout (Table 6-1).

TABLE 2
Fish Passage Hydraulic Criteria (Bates and Kirn, 2009)

FISH PASSAGE HYDRAULIC CRITERIA (BATES AND KIRN, 2009)			
Brook Trout			
Lifestage	**Adult**	**Juvenile**	**Notes**
Maximum velocity (fps)	2.40	0.80	Length 40 to 100 feet
Maximum outlet drop (ft)	0.67	0.33	
Target low-flow depth (ft)	0.35	0.18	
Brown Trout			
Lifestage	**Adult**	**Juvenile**	**Notes**
Maximum velocity (fps)	4.30	1.70	Length 40 to 100 feet
Maximum outlet drop (ft)	0.67	0.33	
Target low-flow depth (ft)	0.63	0.15	

The AOP hydraulic analysis was conducted using the *FishXing* modeling software (Furniss et al., 2009). Results indicate that velocity is a barrier for fish passage through the existing structure and that fish are unlikely to pass the structure over the range of low and high estimated fish passage flows.

TABLE 3
AOP Summary (Existing Culvert)

		Low Passage Flow		High Passage Flow		
Species	**Age**	**Q (cfs)**	**Barrier Type**	**Q (cfs)**	**Barrier Type**	**Passability (%)**
Brook Trout	Adult	0.9	None	107	Velocity	23.9%
Brook Trout	Juvenile	0.9	None	107	Velocity	7.4%
Brown Trout	Adult	0.9	None	107	Velocity	43.9%
Brown Trout	Juvenile	0.9	None	107	Velocity	16.7%

7.0 ALTERNATIVES ANALYSIS

A selection of alternatives was considered for the replacement of the Stoney Bridge Road culvert. These include a full culvert replacement with approach roadway reconstruction to restore two-way traffic, two pedestrian bridge crossing options, and to completely abandon the culvert with an open trapezoidal channel. The objective of the alternatives was to provide conveyance of the 10-year flood flows with underclearance, enhance fish passage through the crossing, and to explore recreational enhancements and accessibility to Stone Bridge Pond.

The alternatives presented hereafter also considered factors such as unique design challenges, cost, complexity of construction, permitting, duration of both design and construction, and available funding assistance programs. Several state and federal grants and funding sources should be considered by the town to assist with the cost of final engineering design and construction for this project such as Division of Ecological Restoration (DER) Culvert Replacement Municipal Assistance Grant Program, Community Preservation Act (CPA), Mass Municipal Vulnerability Preparedness (MVP) Program, FEMA Hazard Mitigation Grant Program (HMGP), FEMA Culvert Grants and Environmental and Historic Preservation (EHP), FHWA, and Surface Transportation Program (STP). Each alternative suggests funding opportunities based on the scope of work that best fits the requirements of the funding source.

Although the FEMA HMGP was also reviewed as a potential source for funding, the total cost of improvements based on concept design versus expected damages to other infrastructure as a result of the existing culvert is significantly below the 1.0 minimum benefit-cost ratio to qualify for funding under this program. Chapter 90 funds are also a popular source to fund local municipal roadway and bridge infrastructure maintenance and repair projects. However, Chapter 90 funds should be used with discretion as annual funding allocated to municipalities is limited, and other critical maintenance and repair projects often take precedence.

TABLE 4
Alternatives Matrix

Alternative	Description	Reduce Outlet Drop	Lower Velocity in Culvert	Increase Low Flow Depth	Retain Sediment in Structure	Improve Conveyance of Water & Sediment	Improve Flood Resiliency	Sustainability	Comparative Installation Cost	Brook Trout		Brown Trout		Permits[1]	Remarks
										Fish Passage Barrier(s)	% Fish Passability (AB, JB)	Fish Passage Barrier(s)	% Fish Passability (AB, JB)		
Existing Structure	5.5′ ± wide, 2.1′ high, 18′ long, open bottom structure, stone masonry abutments, granite slab top	-	-	-	-	-	-	O	Low	Velocity	23.9, 7.4	Velocity	43.9, 16.7	N/A	Sediment deposition at inlet, scour hole at outlet, roadway overtopping for 2-yr storm
Alt-1 Full Vehicle Crossing	20′ span concrete arch x 6′ high, wingwalls, 26′ wide	+	+	+	+	+	+	O	High	Velocity	80.5, 26.1	Velocity	100, 56.6	NOI, ENF, WQC, PCN	Structure supports full two-way vehicle roadway traffic
Alt-2 Pedestrian Crossing	16′ span concrete arch x 6′ high, headwalls, 12′ wide	+	+	+	+	+	+	+	Moderate	Velocity	64.4, 20.8	Velocity	100, 45.3	NOI, WQC, SV	Pedestrian crossing with capability for emergency vehicle crossing only
Alt-2A Pedestrian Crossing	16′ span concrete arch x 6′ high, headwalls, 6′ wide	+	+	+	+	+	+	+	Moderate	Velocity	64.8, 21.0	Velocity	100, 45.6	NOI, WQC, SV	Pedestrian crossing only
Alt-3 Permanently Abandon Structure	Increase channel width to 15′, remove stone abutments, grade 2:1 with riprap revetment	+	+	+	+	+	+	+	Low	N/A	N/A	N/A	N/A	NOI, SV	Alternative abandons existing crossing, with open channel, flood benches and boulder riparian enhancement

Key: **+** = good; **o** = none; **-** = poor

<u>Note 1: Permit Abbreviations</u>

NOI = Massachusetts Wetland Protection Act Notice of Intent
ENF = Massachusetts Environmental Policy Act Environmental Notification Form
WQC = MassDEP 401 Water Quality Certification
SV = United States Army Corps of Engineers Self-Verification Eligible
PCN = United States Army Corps of Engineers Pre-Construction Notification Required

7.1 Existing Culvert

The existing culvert is hydraulically inadequate where the roadway overtops during the 2-year storm event. A partial collapse of the stone masonry and roadway embankment that occurred in August 2018 prompted the closure of the roadway due to the questionable integrity of the masonry substructure. In addition, the existing structure restricts fish passage with high flow velocities through the culvert.

TABLE 5
Flood Capacity Summary – Existing Culvert

Event (Year)	Flow (cfs)	HW/D
2	166	3.17
10	377	3.46
25	518	3.61
100	766	3.83

7.2 Alternative 1 – Complete Culvert Replacement and Restore Two-Way Vehicle Traffic

Alternative 1 includes a three-sided open-bottom box culvert with a 20-foot span and a height of 6 feet. The length of the culvert is 28 feet long in order to construct a roadway to support two-way vehicle traffic. Flood conveyance capacity is vastly improved for the 10-year storm with ample underclearance to pass debris and ice. The check of the 100-year event also showed no overtopping of the roadway. Channel slope will be significantly reduced to approximately 0.7% by eliminating the sediment plumb at the inlet and filling the scour hole at the outlet with stone. Over time, the stone will naturally infill with sediment transport. The reduction in slope through the culvert also reduces flow velocity and thus enhances fish passage. This alternative includes substantial reconstruction of the roadway approaches and new highway guardrail to meet current design standards. However, this alternative does not incorporate some of the pedestrian or recreational access improvements included with the other alternatives as described herein. Wingwalls are provided along the roadway to accommodate roadway widening and minimize encroachment into the adjacent watercourse area. However, significant alteration of wetland resources is anticipated to accommodate widening of the roadway approaches and the construction of the culvert and retaining walls as shown on the concept plan in Appendix A. Lastly, this is the most expensive alternative with an estimated construction cost of $810,000.

TABLE 6
Flood Capacity Summary – Alternative 1

Event (Year)	Flow (cfs)	HW/D
2	166	0.45
10	377	0.64
25	518	0.79
100	766	1.02

Of all the alternatives, this alternative will involve significant engineering design for the preparation of construction documents associated with the widened roadway approaches and long retaining walls on each side of the culvert crossing along the causeway. Commonwealth of

Massachusetts Chapter 85 bridge review are required for spans equal to or greater than 10 feet and, as such, is required for this alternative. Wetland permits administered under the Massachusetts Wetland Protection Act (WPA) involve the filing of a Notice of Intent (NOI) for construction activities within the wetland resource areas. A Water Quality Certification (WQC) filing is required recognizing the work is within a designated Outstanding Resource Water (ORW), which consists of the DCR Water Supply protection area. Lastly, activities are regulated pursuant to the U.S. Army Corps of Engineers (USACE) General Permit for Massachusetts for activities subject to USACE's jurisdiction in waters of the United States. A Pre-Construction Notification (PCN) is expected for this alternative since the alteration of an inland bank is anticipated to exceed 100 feet but should be less than 500 feet. Duration of permitting and design through the bid process is approximately 9 to 12 months. Construction of this alternative is estimated at 12 to 15 months.

Since this alternative restores full vehicular access, eligible funding opportunities supported by the Commonwealth or federal agencies include subsidies by FHWA or Surface Transportation Program (STP). Another grant opportunity is by the Mass Municipal Vulnerability Preparedness (MVP) Program; however, this is a two-step process where the community must be initially certified as an MVP community to be eligible for MVP action grant funding.

7.3 Alternative 2 – Pedestrian Crossings with 12’ Bridge and Alternative 2A Pedestrian Crossing with 6’ Bridge

Alternative 2 is a 12-foot wide pedestrian bridge with a 16-foot span with a height of 6 feet as measured from the channel bottom to the low chord of the superstructure. The bridge will consist of a wood deck on wood or steel beams supported by concrete abutments and wingwalls. Existing roadway approach pavement will be removed and resurfaced with a stone dust or permeable pavers to reduce runoff and enhance infiltration. The 12-foot width of the approaches and bridge is provided for occasional access of maintenance or public safety vehicles, and removable bollards will prevent nonauthorized vehicle access. Granite slabs will be repurposed for steps down to improve accessibility to the watercourse, and parking spaces are provided for recreational users. As with Alternative 1, flood conveyance capacity is improved with conveyance of the 10-year storm with underclearance for passage of debris. The check of the 100-year event showed pressure flow through the opening with minimal overtopping of the bridge deck. Channel gradient is also reduced to enhance fish passage and to improve sediment transport through the bridge opening. Minimal alteration of wetland resource areas and the watercourse is anticipated with this alternative, with the approach improvements confined within the existing roadway. In addition, the existing culvert could be retained during construction of the new abutments or a temporary pipe could be installed with sandbag cofferdams to convey flow and enable dewatering of the work area. Alternative 2 construction cost is estimated at $320,000.

TABLE 7
Flood Capacity Summary – Alternative 2

Event (Year)	Flow (cfs)	HW/D
2	166	0.48
10	377	0.74
25	518	0.91
100	766	1.19

A variation of Alternative 2 (Alternative 2A) was considered, which includes a 6-foot wide bridge deck with the same span and height as the 12-foot-wide deck for Alternative 2. Similar channel enhancements as the previous alternative yield nearly similar results and benefits with respect to flood conveyance and fish passage. This alternative also includes similar recreational improvements for waterfront access. However, vehicle access is not possible with the reduced width of the bridge deck. The construction cost of Alternative 2A is estimated at $260,000.

Construction for the pedestrian crossings will involve engineering design of the substructure to support a prefabricated pedestrian bridge and final design associated with the access path and recreational improvements. As with Alternative 1, Chapter 85 bridge review is required. Also similar to Alternative 1, WPA wetlands permits will include filing of a NOI and WQC. The filing of a USACE Self-Verification Notification Form (SVNF) is anticipated given the limited alteration of inland bank, unlike Alternative 1 where a PCN is expected for the alteration of greater than 100 feet of inland bank. As depicted on the concept drawings, permanent easements will be required from adjacent abutters for the turnaround on the west side of the crossing and the access to the watercourse on the east approach. Temporary construction easements may also be necessary to construct the improvements as shown and will be determined during engineering design. Permitting, design, and bidding is estimated at 6 to 9 months, and construction is estimated at 6 months.

A notable advantage of Alternative 2 is that it can be constructed in phases, with initial construction of the concrete substructure followed by the installation of the prefabricated pedestrian bridge in a subsequent phase as funding allows.

With the waterfront access enhancements proposed for Alternative 2, a construction license and coordination with the Division of Fisheries & Wildlife is necessary for permanent fishing and boating access to Stone Bridge Pond.

Since this alternative is expected to comply with the Massachusetts Stream Crossing Standards, funding by the DER Culvert Replacement Municipal Assistance Grant Program would be an opportunity for this project. Recently, the town applied for DER funding under this program from DER for engineering and permitting fees associated with this project. Notification of awarded projects is anticipated in July 2019. Other favorable grant opportunities include the Community Preservation Act (CPA) and the FEMA Culvert Grants and EHP since these programs are for projects that enhance outdoor recreation, open space, and provide protection of environmental or historic resources.

7.4 Alternative 3 – Abandon Structure

Alternative 3 essentially involves the complete removal of the existing culvert and providing an open trapezoidal channel through the crossing. This alternative provides a natural condition with no structure or constrictions to impede flood flows. In addition to the channel enhancements described with the previous alternatives, other improvements include placement of boulders for riparian enhancement and fish passage. This alternative also includes various recreational improvements for access as shown on the concept plan in Appendix A. The construction cost of Alternative 3 is estimated at $170,000.

As with Alternatives 2 and 2A, this alternative permanently closes the road to through traffic and results in a detour of approximately 2.8 miles around the bridge site. The Town of Templeton public safety officials (police and fire) have indicated that the current closure has not significantly impacted response times to respective residences and businesses in proximity to the bridge site. The area west of the bridge is also primarily DCR property with minimal development up to the Phillipston town line, and thus, we would not expect a permanent closure to be a major inconvenience to town residents either.

Engineering design of Alternative 3 is limited to the removal of the existing structure and recreational improvements similar to Alternative 2. WPA wetlands permits will include filing of a NOI to remove the existing bridge. A WQC would only be required if alteration is required within the watercourse for the removal of the existing substructure. Like Alternative 2, a SVNF is expected with USACE. As with Alternative 2, permanent easements will be required for the west side parking spaces and easterly access to the watercourse. The need for temporary construction easements will be determined during engineering design. Permitting, design, and bidding is estimated at 3 to 6 months, and construction is estimated at 4 months.

As with Alternative 2, a construction license and coordination with the Division of Fisheries & Wildlife is necessary for permanent fishing and boating access to the watercourse area.

Similar to Alternative 2, CPA grants would be applicable to this opportunity with the enhancement of outdoor recreation and open space. This alternative could be phased over time with initial removal of the existing culvert followed by recreational improvements as funding allows.

7.5 Preferred Alternative

Each alternative provides improved hydraulics to pass the 10-year flood event through the crossing, with additional underclearance to pass debris, recognizing the known beaver activity in the area and the possibility of dens becoming dislodged during a significant storm event. In addition, all the open-bottom structures, increase of flood conveyance capacity, and the channel improvements also enhance fish passage for all the alternatives.

Alternative 2 is the preferred alternative as it is the most cost-effective solution that meets the project objectives and satisfies standard culvert design criteria. Although this alternative will result in permanent closure of the road to through traffic, the closure does not appear to be a major inconvenience to town residents or public safety agencies. The recreational enhancements and improved access to the watercourse area will provide long-term benefits to area residents and visitors while minimizing impacts to the adjacent environmental resource areas.

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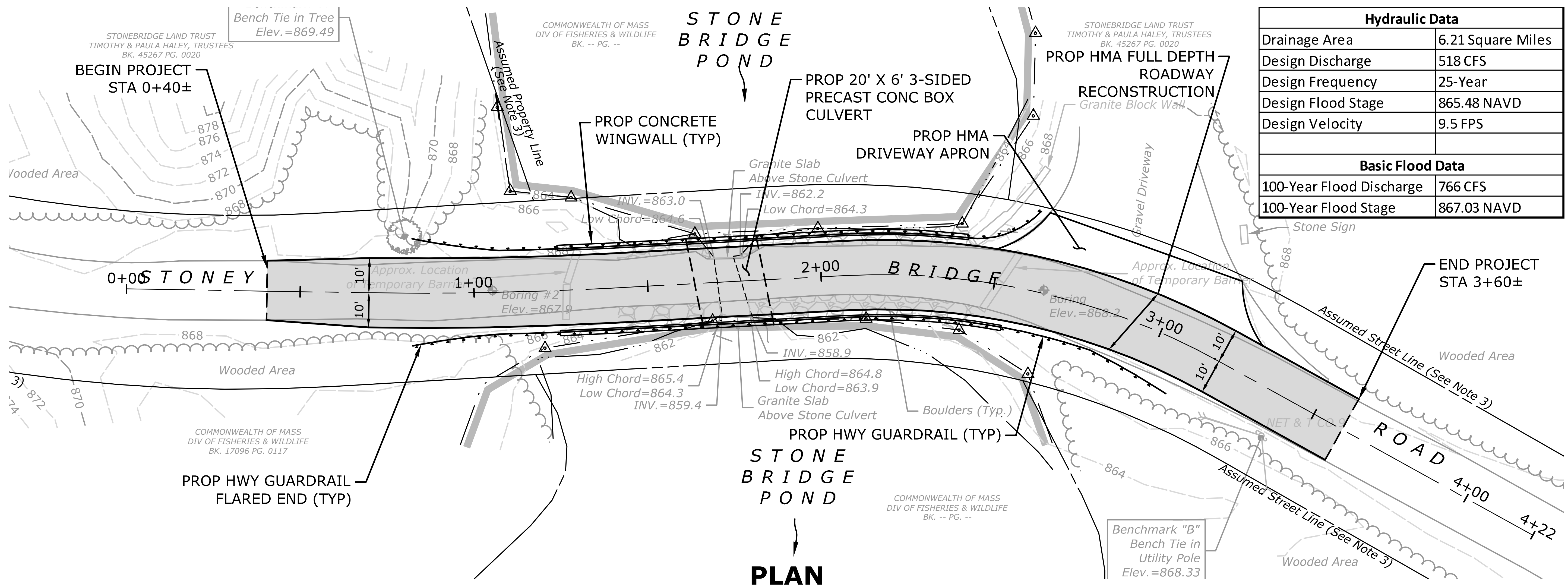
APPENDIX A

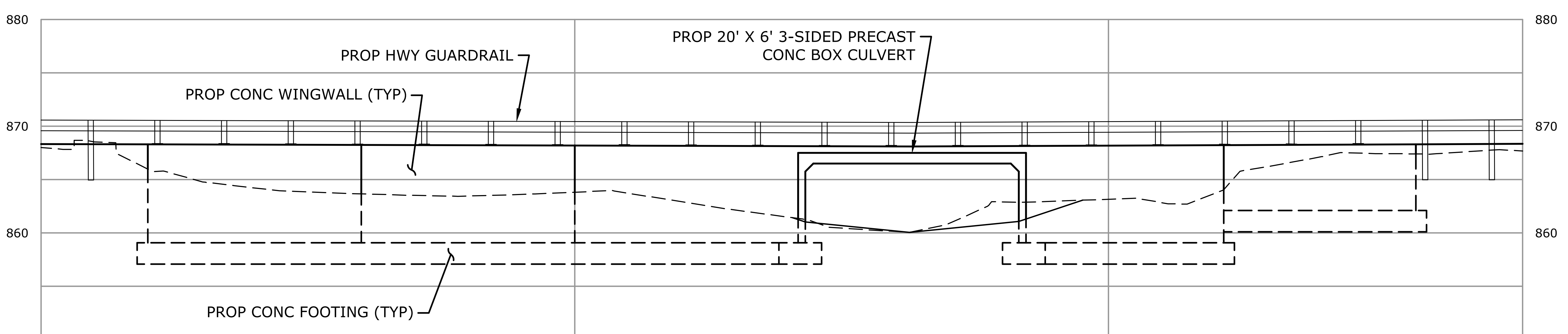
ALTERNATIVE CONCEPT DRAWINGS



Hydraulic Data	
Drainage Area	6.21 Square Miles
Design Discharge	518 CFS
Design Frequency	25-Year
Design Flood Stage	865.48 NAVD
Design Velocity	9.5 FPS
Basic Flood Data	
100-Year Flood Discharge	766 CFS
100-Year Flood Stage	867.03 NAVD

PLAN

SCALE: 1"=30'



CULVERT INLET ELEVATION

SCALE: 1"=10'

MILONE & MACBROOM
1350 MAIN STREET, SUITE 1012 SPRINGFIELD, MA 01103 413.241.6920 WWW.MMINC.COM

REVISIONS

ALTERNATIVE NO. 1 - ROADWAY OVER 3-SIDED BOX CULVERT

STONEY BRIDGE ROAD CULVERT CROSSING

TEMPLETON, MASSACHUSETTS

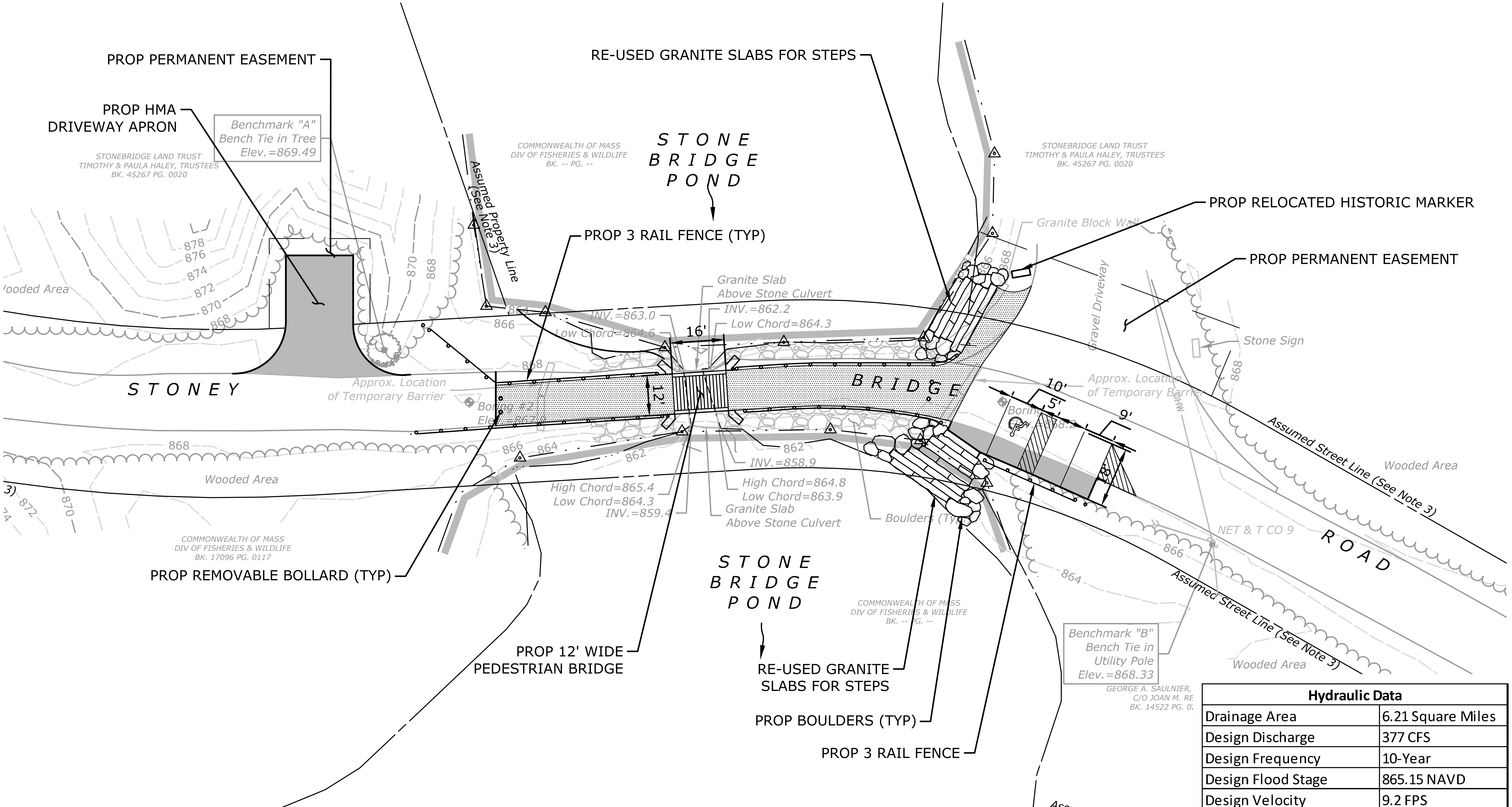
DESIGNED	DRAWN	CHECKED
MRG	HM	MRA

SCALE: AS NOTED

DATE: MAR 14, 2019

PROJECT NO.: 6679-01

SHEET NO.: ALT-1



Hydraulic Data	
Drainage Area	6.21 Square Miles
Design Discharge	377 CFS
Design Frequency	10-Year
Design Flood Stage	865.15 NAVD
Design Velocity	9.2 FPS
Basic Flood Data	
100-Year Flood Discharge	766 CFS
100-Year Flood Stage	868.19 NAVD

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REVISIONS

ALTERNATIVE NO. 2 - PEDESTRIAN CROSSING WITH 12 FT BRIDGE

STONEY BRIDGE ROAD
CULVERT CROSSING

TEMPLETON, MASSACHUSETTS

DESIGNED	DRAWN	CHECKED
MRA	HMM	MRG

SCALE 1"=30'

DATE MARCH 14, 2019

PROJECT NO. 6679-01

SHEET NO. ALT-2

Drawing: V:\DESIGN\6679-01-DE\CAD\NONPLANSET\PEDESTRIAN CROSSING ALTERNATIVE.DWG Layout Tab:ALT-2
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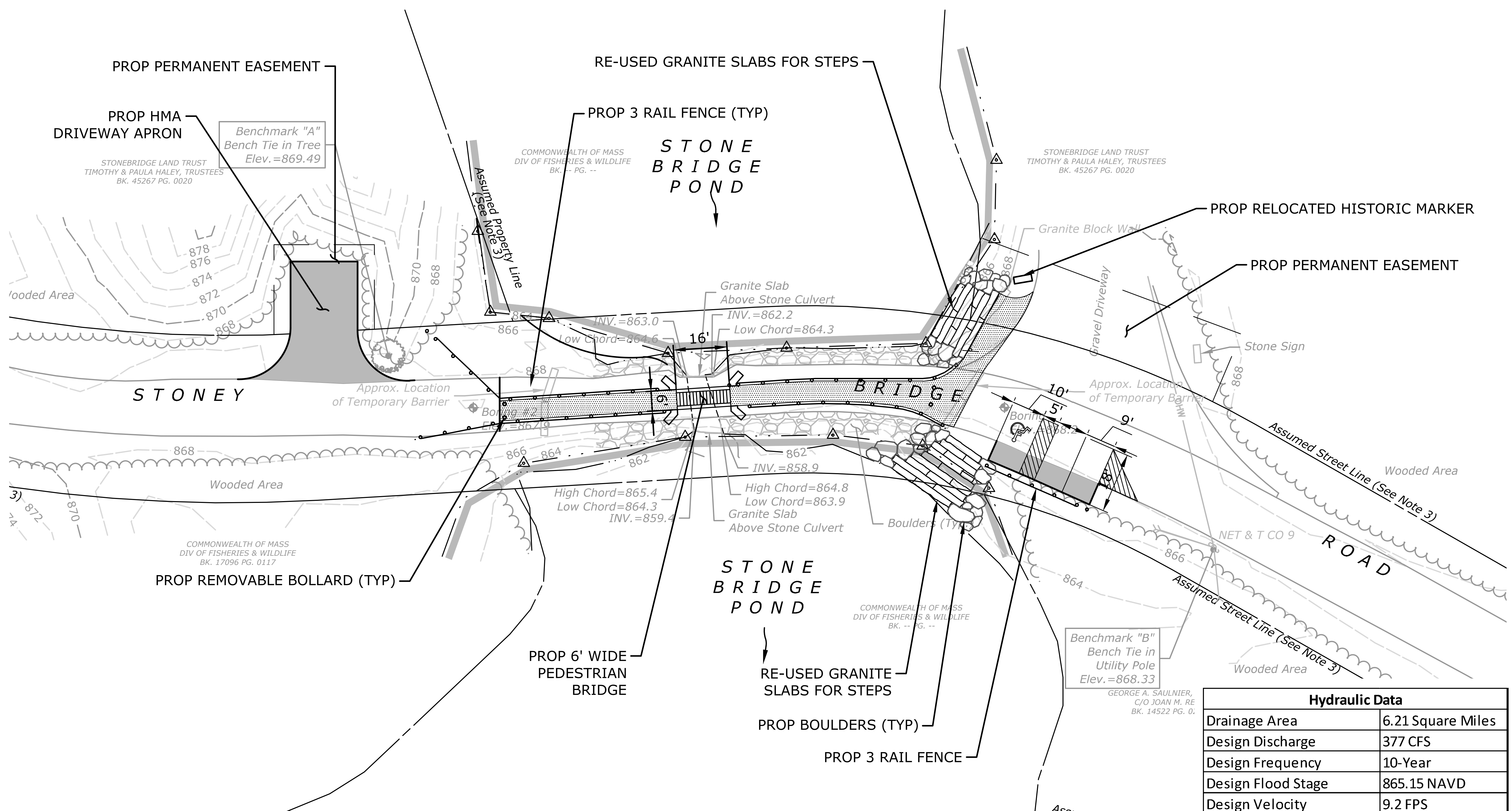

Hydraulic Data	
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Design Velocity	9.2 FPS
Basic Flood Data	
100-Year Flood Discharge	766 CFS
100-Year Flood Stage	868.19 NAVD

MILONE & MACBROOM
1350 MAIN STREET, SUITE 1012
SPRINGFIELD, MA 01103
413.241.6920
WWW.MMINC.COM

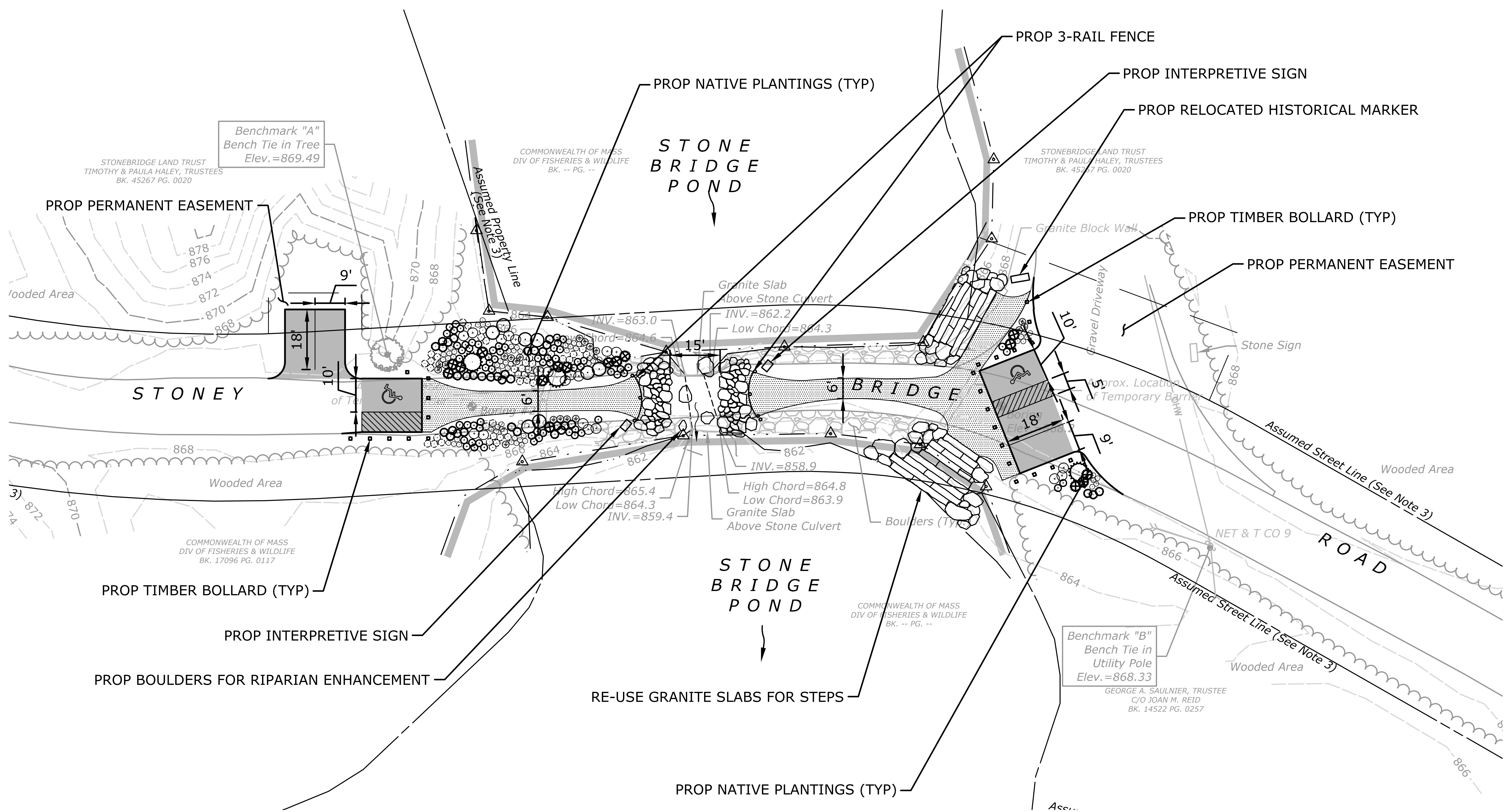
REVISIONS

ALTERNATIVE No. 2A - PEDESTRIAN CROSSING WITH 6 FT BRIDGE

STONEY BRIDGE ROAD
CULVERT CROSSING
TEMPLETON, MASSACHUSETTS

DESIGNED	DRAWN	CHECKED
MRA	HMM	MRG

SCALE 1"=30'
DATE MARCH 14, 2019
PROJECT NO. 6679-01
SHEET NO. ALT-2A



MILONE & MACBROOM

1350 MAIN STREET, SUITE 1012
SPRINGFIELD, MA 01103
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REVISIONS

ALTERNATIVE No. 3 - PERMANENT ABANDONED STRUCTURE

STONEY BRIDGE ROAD
CULVERT CROSSING

TEMPLETON, MASSACHUSETTS

DESIGNED	DRAWN	CHECKED
MRA	HMM	MRG

SCALE: 1"=30'

DATE: MARCH 14, 2019

PROJECT NO.: 6679-01

SHEET NO.: ALT-3

Drawing: V:\DESIGN\6679-01-DE\CAD\NONPLANSET\SB-REMOVAL-ALT-R1.DWG Layout Tab:ALT-3

Plotted by: HEATHERM On this date: Tue, 2019 June 4 - 12:46pm

APPENDIX B

ORDER OF MAGNITUDE CONSTRUCTION COST ESTIMATES

MILONE & MACBROOM	***ORDER OF MAGNITUDE***[1] ***CONSTRUCTION COST***	Project	6679-01
		Made By:	ECR
		Date:	03/13/19
Project: **Stoney Bridge Road Culvert Replacement** **Alternative 1 - Full Roadway Replacement** **Templeton, Massachusetts**		Chkd by:	MRG
		Date:	03/13/19

Item No.	Qty	Unit	Item Name	Unit Cost	Amount
120.1	160	CY	UNCLASSIFIED EXCAVATION	$30.00	$4,800.00
141.	605	CY	CLASS A TRENCH EXCAVATION	$35.00	$21,175.00
151.	270	CY	GRAVEL BORROW	$45.00	$12,150.00
170.	710	SY	FINE GRADING & COMPACTING	$3.25	$2,307.50
402.	80	CY	DENSE GRADED CRUSHED STONE FOR SUB-BASE	$72.00	$5,760.00
440.	705	LB	CALCIUM CHLORIDE FOR ROADWAY DUST CONTROL	$1.10	$775.50
450.23	70	TON	SUPERPAVE SURFACE COURSE - 12.5 (SSC - 12.5)	$80.00	$5,600.00
450.32	90	TON	SUPERPAVE INTERMEDIATE COURSE - 19.0 (SIC - 19.0)	$110.00	$9,900.00
450.42	160	TON	SUPERPAVE BASE COURSE - 37.5 (SBC - 37.5)	$100.00	$16,000.00
452.	36	GAL	ASPHALT EMULSION FOR TACK COAT	$7.00	$252.00
453.	325	FT	HMA JOINT SEALANT	$0.85	$276.25
620.12	350	FT	GUARDRAIL TL-2 (SINGLE FACED)	$29.00	$10,150.00
627.92	4	EA	GUARDRAIL FLARED END TREATMENT TL-2	$2,800.00	$11,200.00
748.	1	LS	MOBILIZATION	$20,000.00	$20,000.00
751.	20	CY	LOAM BORROW	$45.00	$900.00
904.	160	CY	4000 PSI, 3/4 INCH, 610 CEMENT CONCRETE	$1,500.00	$240,000.00
991.3	1	LS	HANDLING WATER	$80,000.00	$80,000.00
995.011	1	LS	CULVERT STRUCTURE (20 FT x 6 FT)	$180,000.00	$180,000.00

Subtotal	$621,246.25
10% Engineering & CDs	$62,124.63
20% Contingency	$124,249.25
Total (Rounded)	**$810,000.00**

Notes

[1] This is an order of magnitude cost estimate, as defined by the American Association of Cost Engineers, that is expected to be within -30 to +50 percent of the actual project cost. Milone & MacBroom, Inc. (MMI) has no control over the cost of labor, materials, equipment or services furnished by others or market conditions. MMI’s opinion of probable Total Project Costs and Construction Cost are made on the basis of MMI's experience and qualifications and represent MMI's best judgment as an experienced and qualified professional engineer, familiar with the construction industry. MMI cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by MMI.

MILONE & MACBROOM	ORDER OF MAGNITUDE [1] CONSTRUCTION COST	Project	6679-01
		Made By:	HMM
		Date:	03/14/19
Project: **Stoney Bridge Road Culvert Crossing Alternative 2 - Pedestrian Crossing with 12 ft Bridge Templeton, Massachusetts**		Chkd by:	MRG
		Date:	03/14/19

Item No.	Qty	Unit	Item Name	Unit Cost	Amount
120.1	27	CY	UNCLASSIFIED EXCAVATION	$30.00	$810.00
141.	110	CY	CLASS A TRENCH EXCAVATION	$35.00	$3,850.00
151.	105	CY	GRAVEL BORROW	$45.00	$4,725.00
402.	14	CY	DENSE GRADED CRUSHED STONE FOR SUB-BASE	$72.00	$1,008.00
450.23	12	TON	SUPERPAVE SURFACE COURSE - 12.5 (SSC - 12.5)	$80.00	$960.00
450.32	15	TON	SUPERPAVE INTERMEDIATE COURSE - 19.0 (SIC - 19.0)	$110.00	$1,650.00
450.42	28	TON	SUPERPAVE BASE COURSE - 37.5 (SBC - 37.5)	$100.00	$2,800.00
707.8	4	EA	STEEL BOLLARD	$1,000.00	$4,000.00
748.	1	LS	MOBILIZATION	$8,000.00	$8,000.00
904.	58	CY	4000 PSI, 3/4 INCH, 610 CEMENT CONCRETE	$1,500.00	$87,000.00
991.3	1	LS	HANDLING WATER	$40,000.00	$40,000.00
995.031	1	LS	PEDESTRIAN BRIDGE (12' WIDE)	$35,000.00	$35,000.00
655.	330	FT	CEDAR RAIL FENCE	$45.00	$14,850.00
	30	EA	BOULDERS	$300.00	$9,000.00
	25	EA	REMOVE, STACK & REPLACE GRANITE BLOCKS	$600.00	$15,000.00
	1	LS	PATH (HMA)	$10,300.00	$10,300.00

Subtotal	$238,953.00
10% Engineering & CDs	$23,895.30
20% Contingency	$47,790.60
Total (Rounded)	**$320,000.00**

Notes

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MILONE & MACBROOM	ORDER OF MAGNITUDE [1] CONSTRUCTION COST	Project	6679-01
		Made By:	HMM
		Date:	03/14/19
Project: **Stoney Bridge Road Culvert Crossing Alternative 2A - Pedestrian Crossing with 6 ft Bridge Templeton, Massachusetts**		Chkd by:	MRG
		Date:	03/14/19

Item No.	Qty	Unit	Item Name	Unit Cost	Amount
120.1	27	CY	UNCLASSIFIED EXCAVATION	$30.00	$810.00
141.	54	CY	CLASS A TRENCH EXCAVATION	$35.00	$1,890.00
151.	66	CY	GRAVEL BORROW	$45.00	$2,970.00
402.	14	CY	DENSE GRADED CRUSHED STONE FOR SUB-BASE	$72.00	$1,008.00
450.23	12	TON	SUPERPAVE SURFACE COURSE - 12.5 (SSC - 12.5)	$80.00	$960.00
450.32	15	TON	SUPERPAVE INTERMEDIATE COURSE - 19.0 (SIC - 19.0)	$110.00	$1,650.00
450.42	28	TON	SUPERPAVE BASE COURSE - 37.5 (SBC - 37.5)	$100.00	$2,800.00
707.8	4	EA	STEEL BOLLARD	$1,000.00	$4,000.00
748.	1	LS	MOBILIZATION	$7,000.00	$7,000.00
904.	43	CY	4000 PSI, 3/4 INCH, 610 CEMENT CONCRETE	$1,500.00	$64,500.00
991.3	1	LS	HANDLING WATER	$40,000.00	$40,000.00
995.031	1	LS	PEDESTRIAN BRIDGE (6' WIDE)	$25,000.00	$25,000.00
655.	330	FT	CEDAR RAIL FENCE	$45.00	$14,850.00
	30	EA	BOULDERS	$300.00	$9,000.00
	25	EA	REMOVE, STACK & REPLACE GRANITE BLOCKS	$600.00	$15,000.00
	1	LS	PATH (HMA)	$6,400.00	$6,400.00

Subtotal	$197,838.00
10% Engineering & CDs	$19,783.80
20% Contingency	$39,567.60
Total (Rounded)	**$260,000.00**

Notes

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MILONE & MACBROOM	*ORDER OF MAGNITUDE*[1] *CONSTRUCTION COST*	Project	6679-01
		Made By:	HMM
		Date:	03/14/19
Project: **Stoney Bridge Road Culvert Replacement**		Chkd by:	MRG
Alternative 3 - Permanent Abandoned Structure			
Templeton, Massachusetts		Date:	03/14/19

Item No.	Qty	Unit	Item Name	Unit Cost	Amount
120.1	31	CY	UNCLASSIFIED EXCAVATION	$30.00	$930.00
141.	125	CY	CLASS A TRENCH EXCAVATION	$35.00	$4,375.00
151.	31	CY	GRAVEL BORROW	$45.00	$1,395.00
402.	15	CY	DENSE GRADED CRUSHED STONE FOR SUB-BASE	$72.00	$1,080.00
450.23	14	TON	SUPERPAVE SURFACE COURSE - 12.5 (SSC - 12.5)	$80.00	$1,120.00
450.32	18	TON	SUPERPAVE INTERMEDIATE COURSE - 19.0 (SIC - 19.0)	$110.00	$1,980.00
450.42	31	TON	SUPERPAVE BASE COURSE - 37.5 (SBC - 37.5)	$100.00	$3,100.00
632.1	25	EA	GUARDRAIL POST - WOOD	$95.00	$2,375.00
655.	35	FT	CEDAR RAIL FENCE	$45.00	$1,575.00
748.	1	LS	MOBILIZATION	$8,000.00	$8,000.00
751.	30	CY	LOAM BORROW	$45.00	$1,350.00
991.3	1	LS	HANDLING WATER	$40,000.00	$40,000.00
	2	EA	INTERPRETIVE SIGN	$500.00	$1,000.00
	1	LS	PLANTINGS	$10,000.00	$10,000.00
	60	EA	BOULDERS	$300.00	$18,000.00
	25	EA	REMOVE & STACK GRANITE	$600.00	$15,000.00
	1	LS	HMA PATH SURFACE	$9,500.00	$9,500.00

Subtotal	$120,780.00
15% Engineering & CDs	$18,117.00
20% Contingency	$24,156.00
Total (Rounded)	**$170,000.00**

Notes

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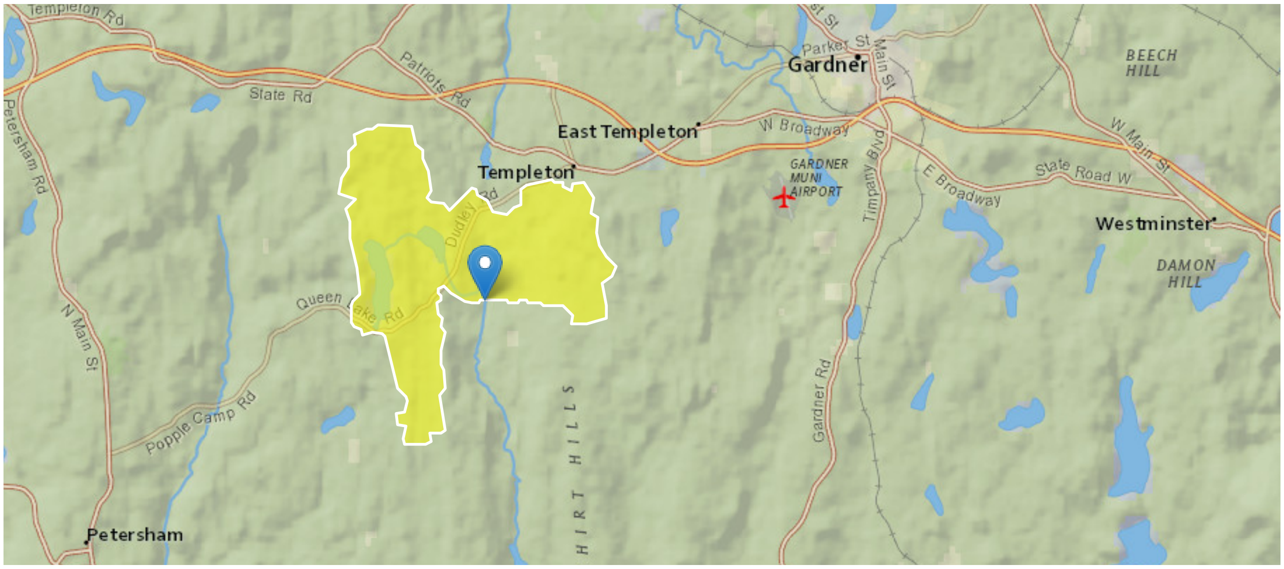
APPENDIX C

StreamStats ANALYSIS

StreamStats Report

Region ID: MA
Workspace ID: MA20190207211335963000
Clicked Point (Latitude, Longitude): 42.53114, -72.08943
Time: 2019-02-07 16:13:49 -0500



Stoney Bridge Road Culvert Replacement Templeton, MA

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	6.21	square miles
ELEV	Mean Basin Elevation	1070	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	20.9	percent

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	6.21	square miles	0.16	512
ELEV	Mean Basin Elevation	1070	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	20.9	percent	0	32.3

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

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp
2 Year Peak Flood	166	ft^3/s	82.6	335	42.3
5 Year Peak Flood	281	ft^3/s	138	575	43.4
10 Year Peak Flood	377	ft^3/s	180	789	44.7
25 Year Peak Flood	518	ft^3/s	239	1120	47.1
50 Year Peak Flood	637	ft^3/s	284	1430	49.4
100 Year Peak Flood	766	ft^3/s	330	1780	51.8

Statistic	Value	Unit	PIl	PIu	SEp
200 Year Peak Flood	906	ft^3/s	378	2170	54.1
500 Year Peak Flood	1110	ft^3/s	440	2800	57.6

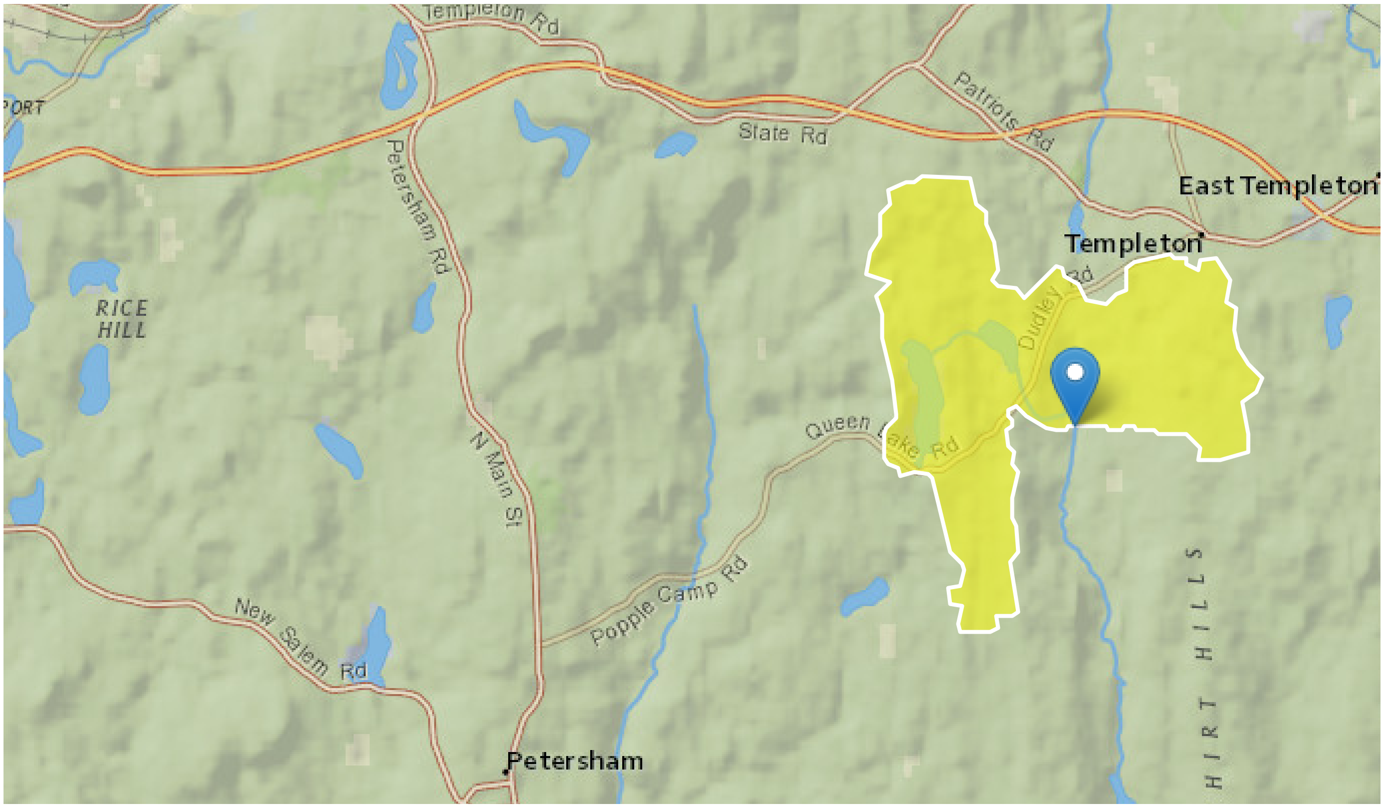
Peak-Flow Statistics Citations

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)

Application Version: 4.3.0

StreamStats Report

Region ID: MA
Workspace ID: MA20190311140909196000
Clicked Point (Latitude, Longitude): 42.53107, -72.08941
Time: 2019-03-11 10:09:23 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	6.21	square miles
BSLDEM10M	Mean basin slope computed from 10 m DEM	7.373	percent

Bankfull Statistics Parameters [Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	6.21	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	7.373	percent	2.2	23.9

Bankfull Statistics Flow Report [Bankfull Statewide SIR2013 5155]

PIl: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
Bankfull Width	31	ft	21.3
Bankfull Depth	1.62	ft	19.8
Bankfull Area	49.8	ft^2	29
Bankfull Streamflow	151	ft^3/s	55

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/)

Application Version: 4.3.0

APPENDIX D

HY-8 ANALYSIS

HY-8 Culvert Analysis Report

Site Data - Exist

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 862.20 ft

Outlet Station: 16.50 ft

Outlet Elevation: 858.90 ft

Number of Barrels: 1

Culvert Data Summary - Exist

Barrel Shape: User Defined

Barrel Span: 5.50 ft

Barrel Rise: 2.10 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0150 (top and sides)

Manning's n: 0.0350 (bottom)

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: None

Table 1 - Culvert Summary Table: Exist

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
2 year	166.00	105.22	868.55	6.348	4.498	5-S2n	0.977	1.847	1.144	3.500	16.296
10 year	377.00	110.76	869.12	6.921	4.905	5-S2n	1.008	1.869	1.185	3.500	16.556
25 year	518.00	113.51	869.42	7.216	5.115	5-S2n	1.023	1.882	1.205	3.500	16.690
100 year	766.00	117.56	869.86	7.663	5.432	5-S2n	1.045	1.896	1.232	3.500	16.899

****

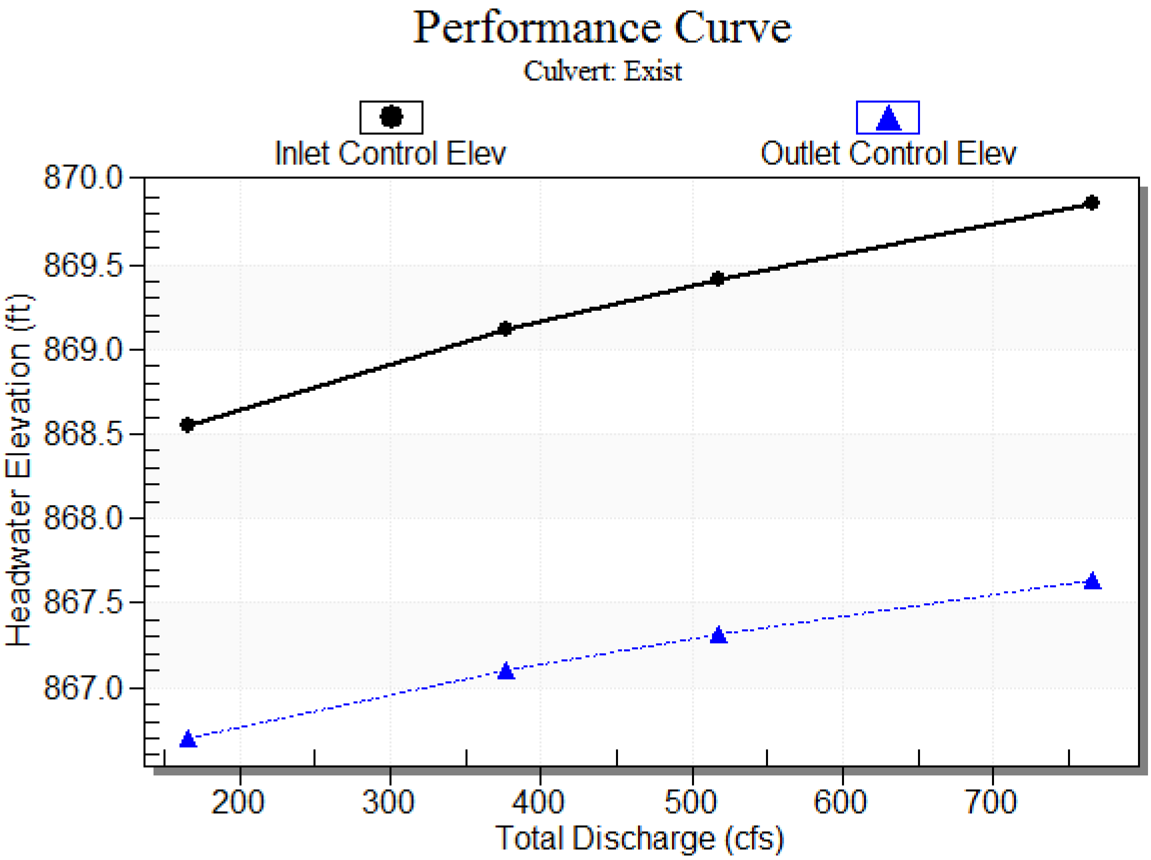
Straight Culvert

Inlet Elevation (invert): 862.20 ft,   Outlet Elevation (invert): 858.90 ft

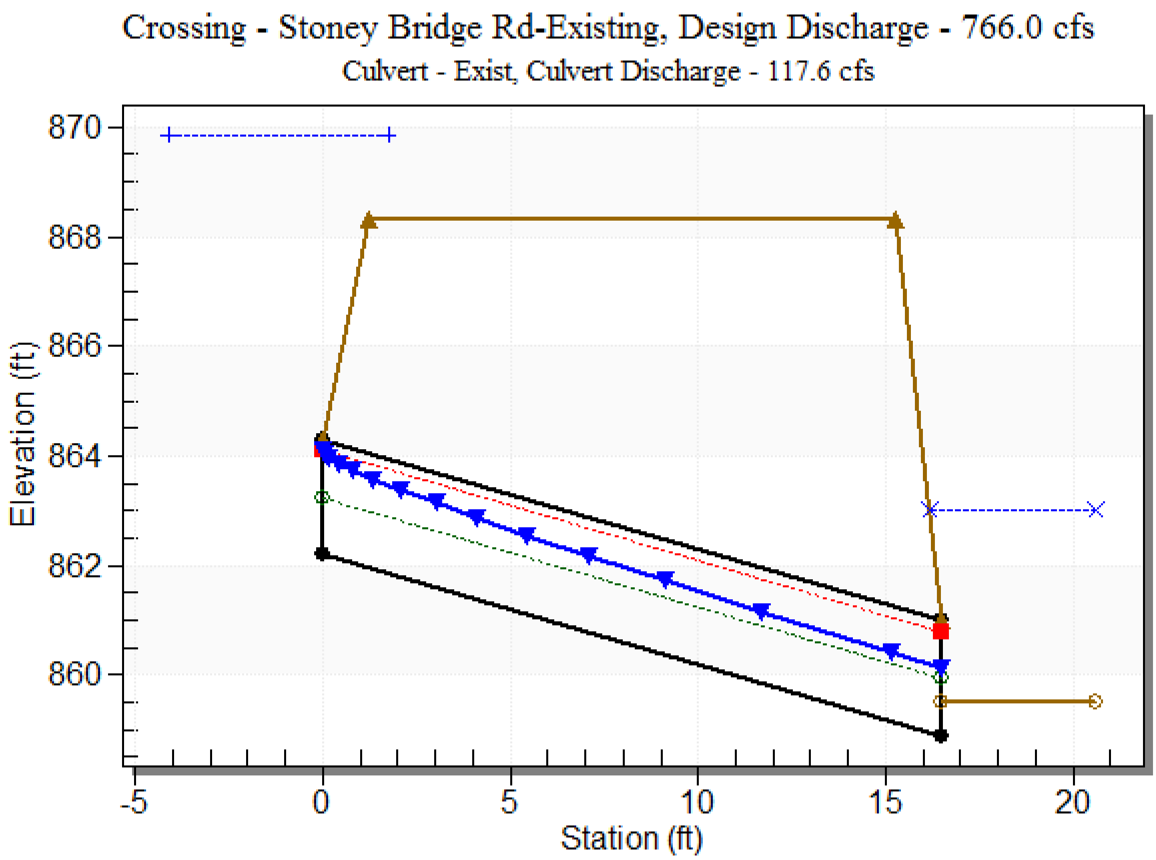
Culvert Length: 16.83 ft,   Culvert Slope: 0.2000

****

Culvert Performance Curve Plot: Exist



Water Surface Profile Plot for Culvert: Exist



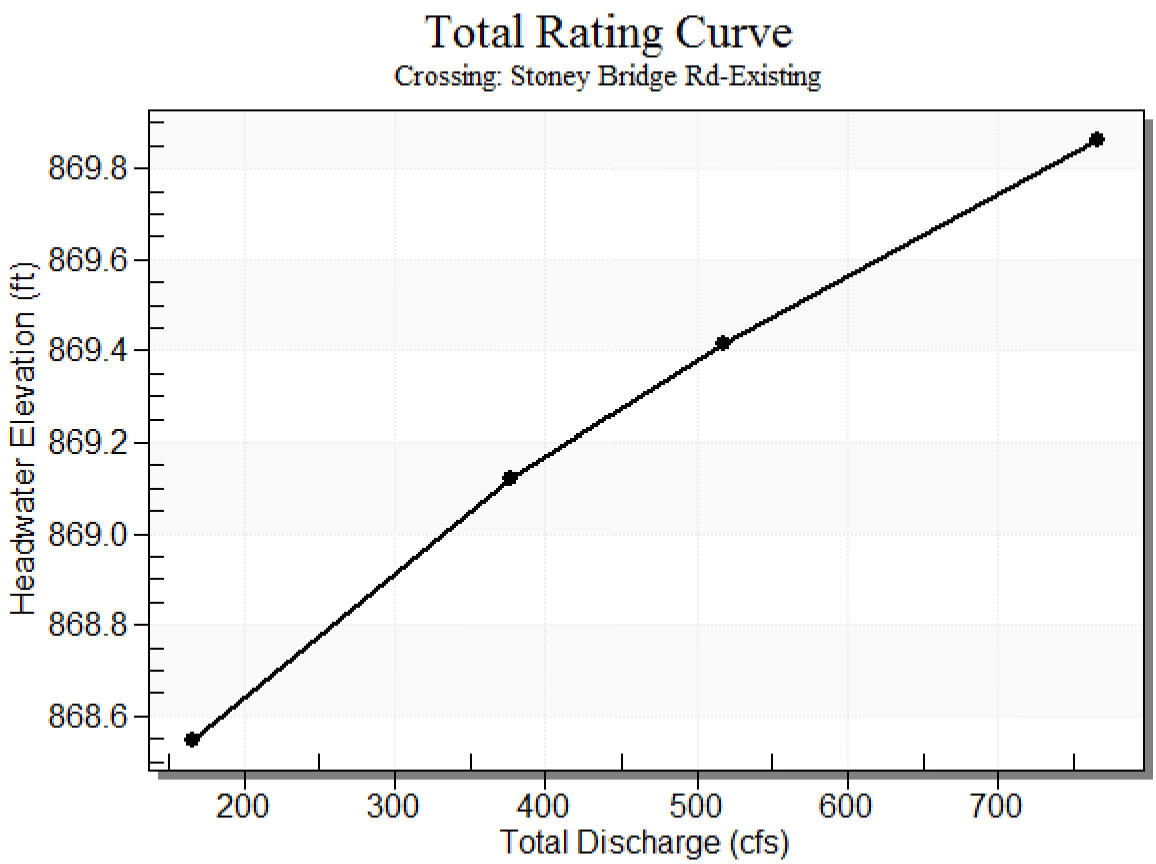
Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 2 - Summary of Culvert Flows at Crossing: Stoney Bridge Rd-Existing

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Exist Discharge (cfs)	Roadway Discharge (cfs)	Iterations
868.55	2 year	166.00	105.22	60.58	11
869.12	10 year	377.00	110.76	265.93	4
869.42	25 year	518.00	113.51	404.28	4
869.86	100 year	766.00	117.56	648.21	3
868.15	Overtopping	100.98	100.98	0.00	Overtopping

Rating Curve Plot for Crossing: Stoney Bridge Rd-Existing



Site Data - Conc 3-sided box 20 x 6

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 858.60 ft

Outlet Station: 28.00 ft

Outlet Elevation: 858.40 ft

Number of Barrels: 1

Culvert Data Summary - Conc 3-sided box 20 x 6

Barrel Shape: Concrete Box

Barrel Span: 20.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 24.00 in

Barrel Manning's n: 0.0120 (top and sides)

Manning's n: 0.0350 (bottom)

Culvert Type: Straight

Inlet Configuration: 1:1 Bevel Headwall

Inlet Depression: None

Table 3 - Culvert Summary Table: Conc 3-sided box 20 x 6

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
2 year	166.00	166.00	863.31	1.856	2.711	3-M1t	1.717	1.296	2.600	2.600	3.192
10 year	377.00	377.00	864.44	3.196	3.845	3-M2t	2.832	2.233	2.600	2.600	7.250
25 year	518.00	518.00	865.33	3.973	4.730	2-M2c	3.427	2.758	2.758	2.600	9.390
100 year	766.00	766.00	866.73	5.195	6.134	7-M2c	4.333	3.565	3.565	2.600	10.742

****

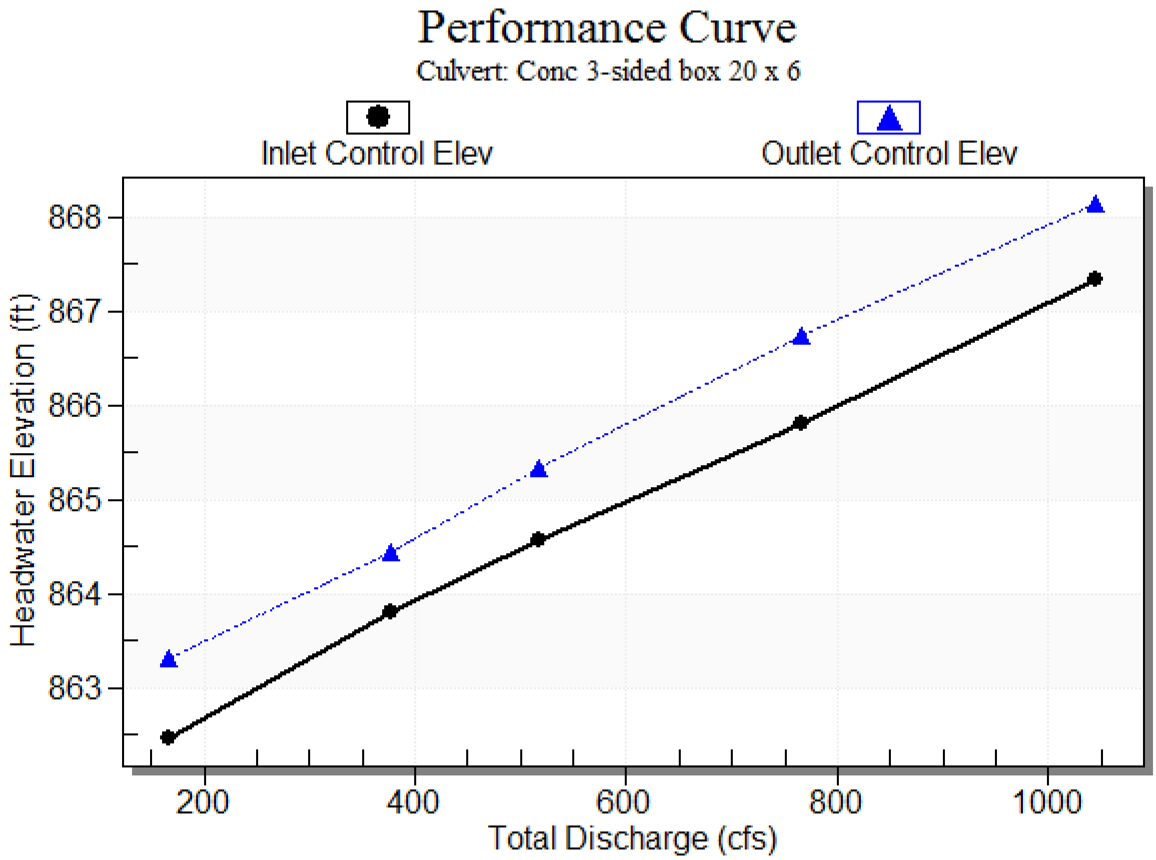
Straight Culvert

Inlet Elevation (invert): 860.60 ft,   Outlet Elevation (invert): 860.40 ft

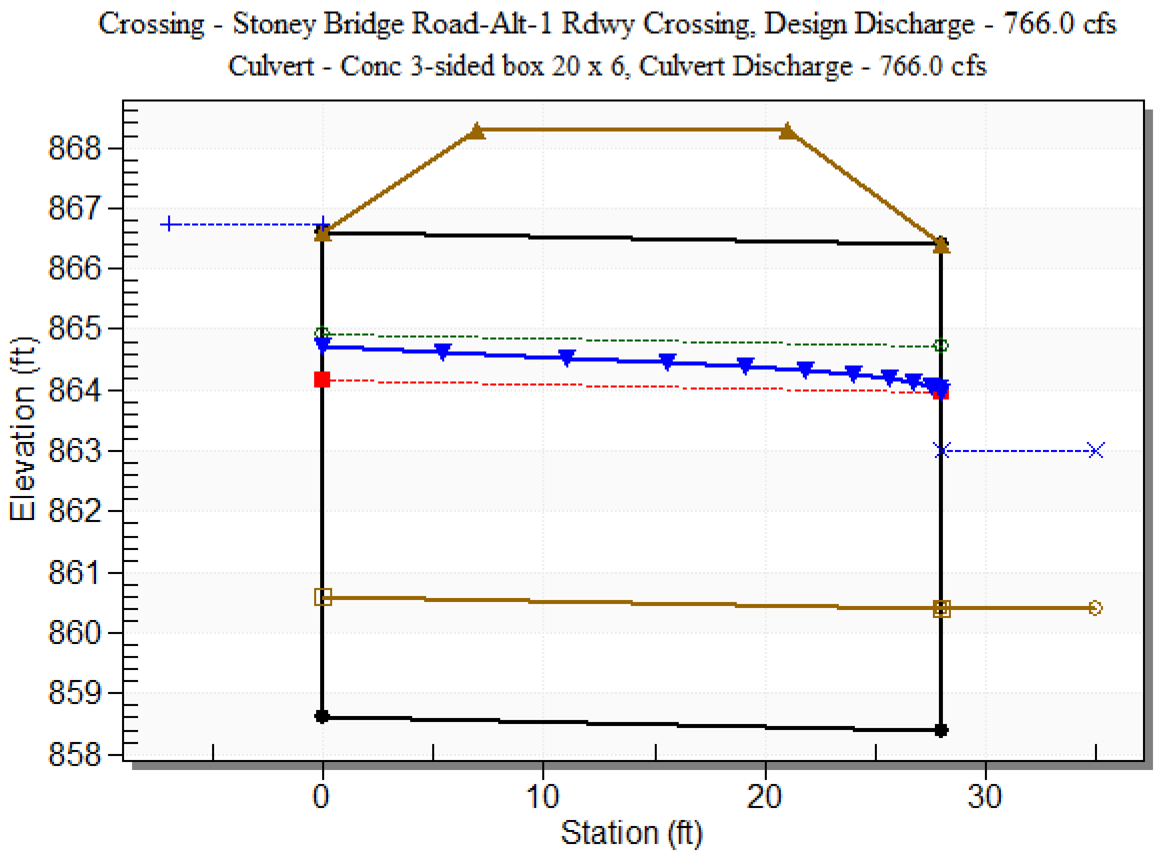
Culvert Length: 28.00 ft,   Culvert Slope: 0.0071

****

Culvert Performance Curve Plot: Conc 3-sided box 20 x 6



Water Surface Profile Plot for Culvert: Conc 3-sided box 20 x 6



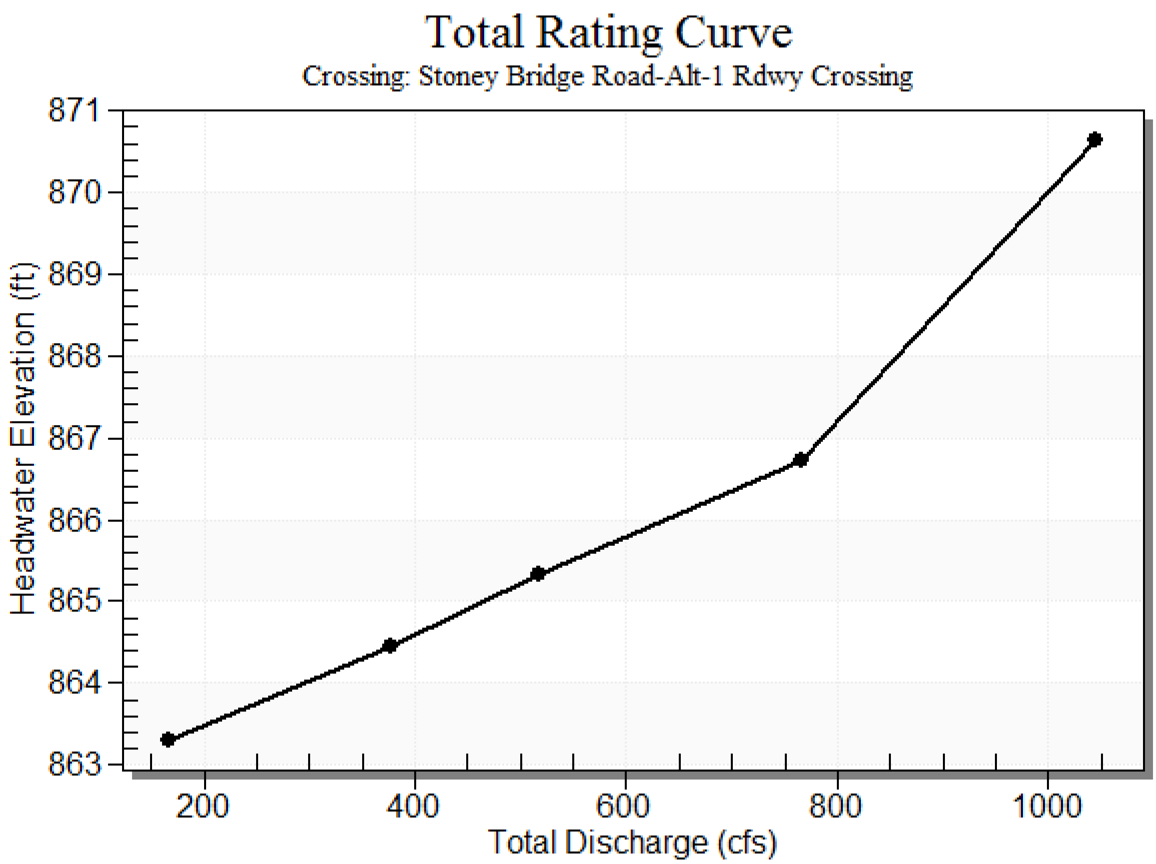
Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 4 - Summary of Culvert Flows at Crossing: Stoney Bridge Road-Alt-1 Rdwy

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Conc 3-sided box 20 x 6 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
863.31	2 year	166.00	166.00	0.00	1
864.44	10 year	377.00	377.00	0.00	1
865.33	25 year	518.00	518.00	0.00	1
866.73	100 year	766.00	766.00	0.00	1
868.15	Overtopping	1045.44	1045.44	0.00	Overtopping

Rating Curve Plot for Crossing: Stoney Bridge Road-Alt-1 Rdwy Crossing



Site Data - Ped bridge 16x5

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 858.60 ft

Outlet Station: 16.00 ft

Outlet Elevation: 858.50 ft

Number of Barrels: 1

Culvert Data Summary - Ped bridge 16x5

Barrel Shape: Concrete Box

Barrel Span: 16.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 24.00 in

Barrel Manning's n: 0.0120 (top and sides)

Manning's n: 0.0350 (bottom)

Culvert Type: Straight

Inlet Configuration: 1:1 Bevel Headwall

Inlet Depression: None

Table 5 - Culvert Summary Table: Ped bridge 16x5

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
2 year	166.00	166.00	863.47	2.156	2.869	3-M1t	2.093	1.503	2.500	2.500	4.150
10 year	377.00	377.00	865.04	3.718	4.440	2-M2c	3.425	2.593	2.593	2.500	9.086
25 year	518.00	518.00	866.08	4.641	5.484	2-M2c	4.145	3.186	3.186	2.500	10.161
100 year	766.00	766.00	867.72	6.205	7.120	7-M2c	5.242	4.136	4.136	2.500	11.574

****

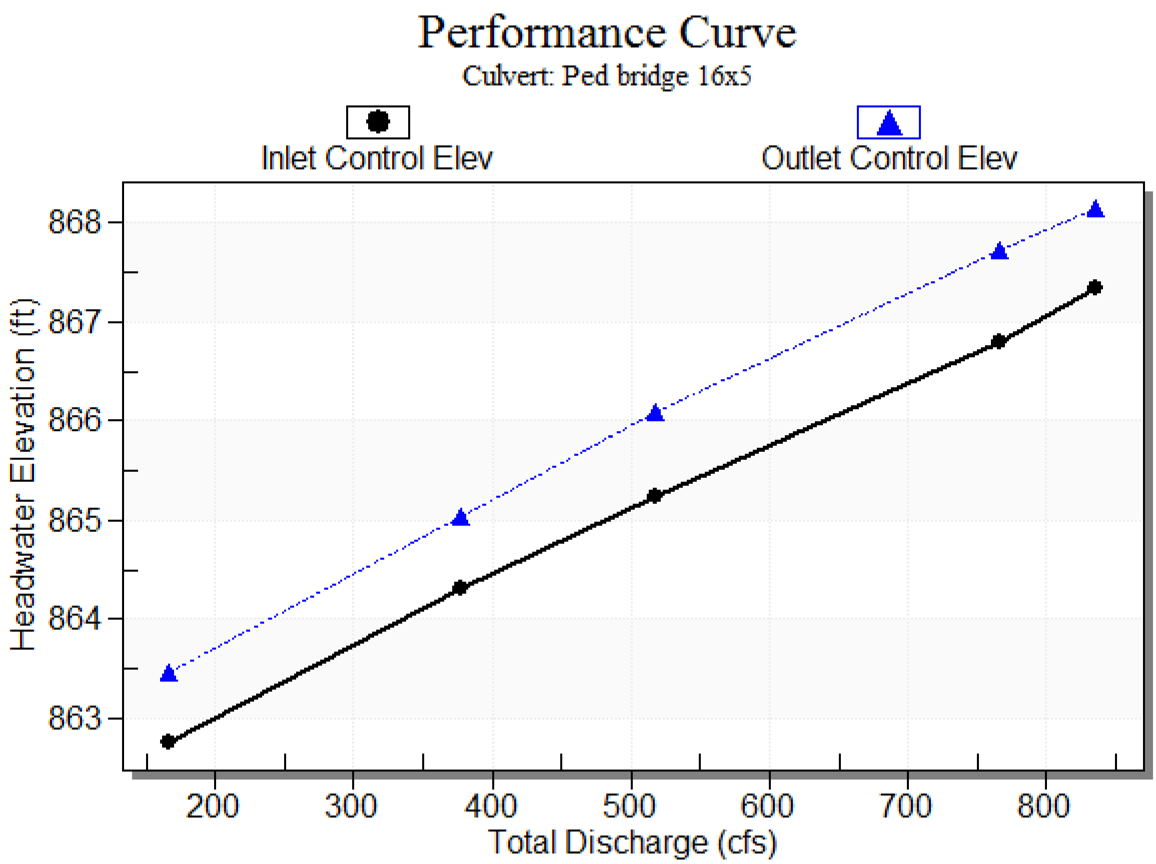
Straight Culvert

Inlet Elevation (invert): 860.60 ft,   Outlet Elevation (invert): 860.50 ft

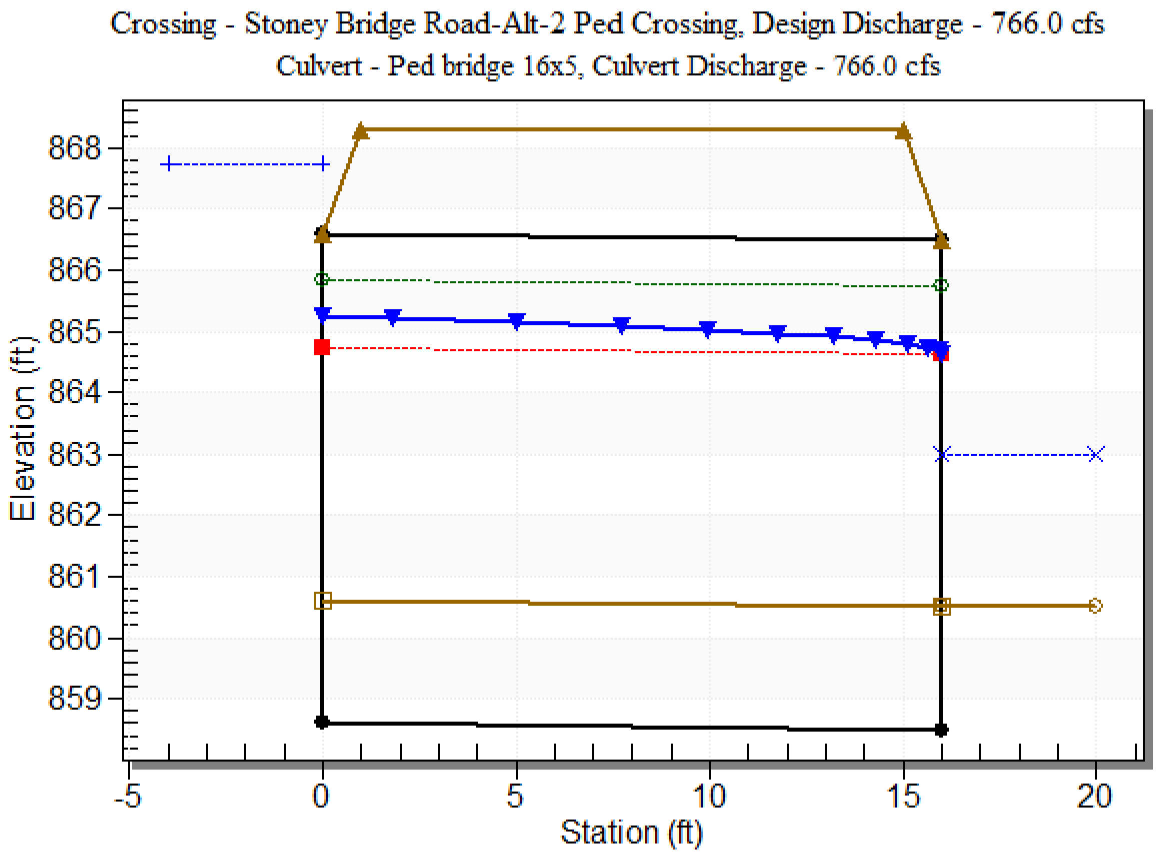
Culvert Length: 16.00 ft,   Culvert Slope: 0.0063

****

Culvert Performance Curve Plot: Ped bridge 16x5



Water Surface Profile Plot for Culvert: Ped bridge 16x5



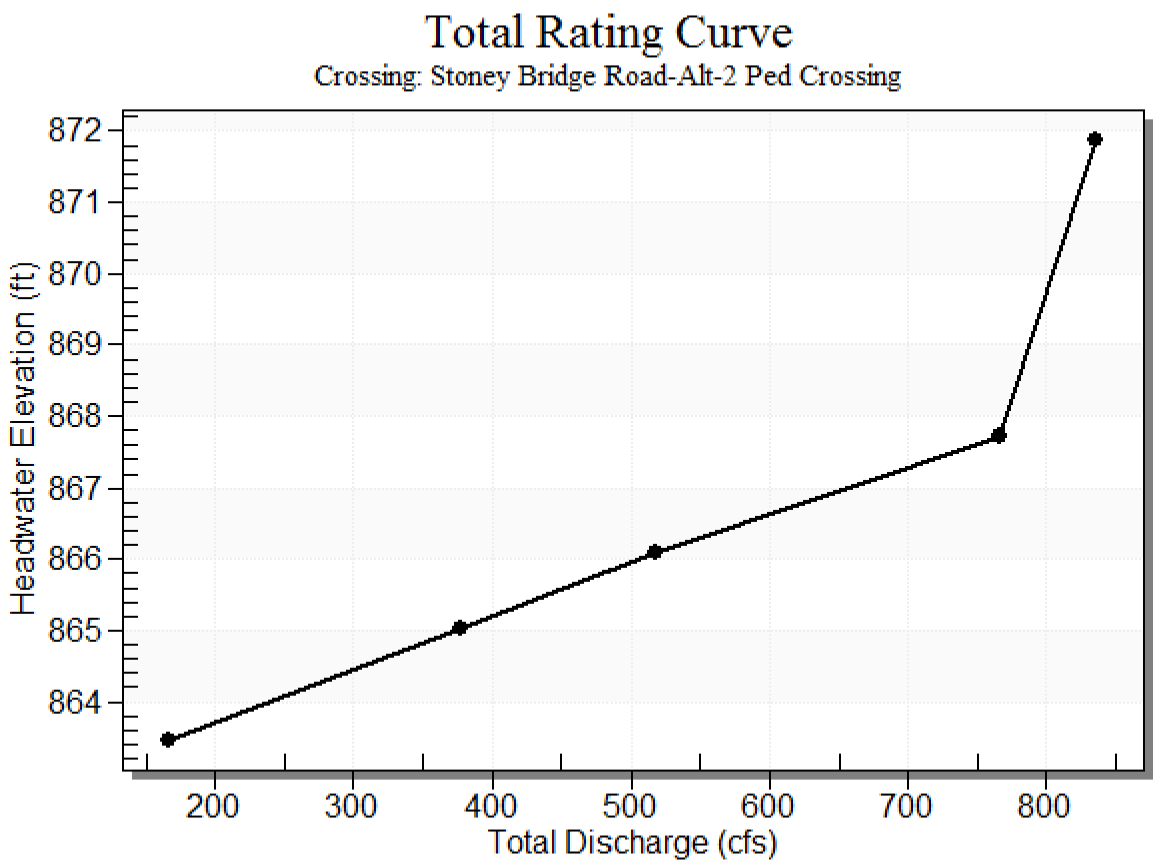
Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 6 - Summary of Culvert Flows at Crossing: Stoney Bridge Road-Alt-2 Ped

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Ped bridge 16x5 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
863.47	2 year	166.00	166.00	0.00	1
865.04	10 year	377.00	377.00	0.00	1
866.08	25 year	518.00	518.00	0.00	1
867.72	100 year	766.00	766.00	0.00	1
868.15	Overtopping	836.06	836.06	0.00	Overtopping

Rating Curve Plot for Crossing: Stoney Bridge Road-Alt-2 Ped Crossing



APPENDIX E

AOP ANALYSIS

APPENDIX E
Summary of Fish Passage Analysis
6/4/2019

Fish	Flow	Flow (cfs)	Existing		Alt 1 (Roadway)		Alt 2 (12' Pedestrian)		Alt 2A (6' Pedestrian)	
			Barriers	**Passage (%)**	**Barriers**	**Passage (%)**	**Barriers**	**Passage (%)**	**Barriers**	**Passage (%)**
Adult Brook Trout	LPF	0.9	None	23.9	None	80.5	None	64.4	None	64.8
	HPF	107	Velocity		Velocity		Velocity		Velocity	
Juvenile Brook Trout	LPF	0.9	None	7.4	None	26.1	None	20.8	None	21
	HPF	107	Velocity		Velocity		Velocity		Velocity	
Adult Brown Trout	LPF	0.9	None	43.9	None	100	None	100	None	100
	HPF	107	Velocity		None		None		None	
Juvenile Brown Trout	LPF	0.9	None	16.7	None	56.6	None	45.3	None	45.6
	HPF	107	Velocity		Velocity		Velocity		Velocity	

Wetland Delineation Report

Stoney Bridge Road
Templeton, Massachusetts
January 16, 2019

Prepared for:
Town of Templeton
160 Patriots Road
East Templeton, Massachusetts 01438

MMI #6679-01

Prepared by:
MILONE & MACBROOM, INC.
One Financial Plaza
1350 Main Street, Suite 1012
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MILONE & MACBROOM
ENGINEERING | PLANNING | LANDSCAPE ARCHITECTURE | ENVIRONMENTAL SCIENCE

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1.0 INTRODUCTION

On November 14, 2018, Peter Shea, a registered soil scientist with Milone & MacBroom, Inc. (MMI) conducted a site inspection of the project site as depicted on Figure 1. The purpose of the site investigation was to identify, characterize and demarcate resource areas subject to the provisions of the Massachusetts Wetland Protection Act at 310 CMR 10.00, Section 404 of the Clean Water Act, and Bylaws of the Town of Templeton, Massachusetts.

The project area is located at the Stoney Bridge Road cross culvert that bisects Stone Bridge Pond in Templeton, Massachusetts. The cross-culvert portion of the road is currently closed to thru traffic. The existing structure is a rectangular stone culvert that the Town is proposing to replace or repair to help restore the roadway. The culvert conveys flow of the Burnshirt River from the northern portion of Stone Bridge Pond to the southern portion of Stone Bridge Pond. Burnshirt river continues flowing south from the impoundment that forms the Stone Bridge Pond located approximately 0.46 miles south of the culvert.

Wetland resource areas were delineated using United States Army Corps of Engineers (USACE) methodology as provided in the Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region, the definitions provided in the Massachusetts Wetlands Protection Act at 310 CMR 10.00.

Weather conditions were clear and sunny with temperatures in the mid to high 40°s Fahrenheit. Site conditions were suitable for wetland delineation work. Geospatial data was accessed via the United States Department of Agriculture Natural Resources Conservation Service (NRCS) web soil survey, United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI), and the Massachusetts Geographic Information Systems online mapping tools. A copy of the NRCS web soil survey for the project area is provided in Appendix B.

2.0 FIELD INVESTIGATIONS

The wetland delineation was completed approximately 100 feet from the existing culvert (Figure 1). The land area upstream and downstream of the culvert consists of open water. The surrounding land area is rural undeveloped forested land.

The Burnshirt River is a perennial watercourse that flows through the Stoney Bridge Pond and is impounded by a dam structure located approximately 0.45 miles south of the culvert. The pond downstream of the culvert is approximately 23 acres of inundated land area and approximately 16 acres of inundated land area upstream of the culvert.

The soils mapped along the eastern and western shoreline of the pond are mapped as upland soils by NRCS. The soil survey mapping identifies the following soil mapping units with associated map number in the study area:

- Colton gravelly loamy sand, 8 to 15 percent slopes (282C)
- Searsport, loamy sand, 0 to 3 percent slopes (28A)

These soils are derived from loose sandy glaciofluvial parent material and thus generally well drained to excessively well drained soil comprised of loamy sand. Based on field observations the upland areas were consistent with the mapped soil types. Vegetation within the study area is dominated by white pine and eastern hemlock with red maple present along the shoreline. Vegetation along the immediate shoreline of the pond consisted of meadowsweet, European buckthorn, silky dogwood, golden rod, sedges rushes, and grasses.

Massachusetts Wetlands Protection Act

Resource areas within the project site were defined and delineated in accordance with the USACE methodologies, the definitions provided in the Massachusetts Wetlands Protection Act at 310 CMR 10.00. Resource areas that pertain to the study area are comprised of:

- 310 CMR 10.54 – Inland Bank
- 310 CMR 10.56 – Land Under Water Bodies and Waterways
- 310 CMR 10.58 – Riverfront Area

Inland Bank

Inland bank comprises the transition between Stone Bridge Pond/Burnshirt River and adjacent upland boundary. Per 310 CMR 10.54, inland bank commences at the mean annual low flow level and extends to the mean annual high flood level or the first observable break in slope, whichever is lower. Within the study area, the bank is a steep profile vegetated earthen feature that bounds the open water system.

Land Under Waterbodies and Waterways

The land below mean high water is considered land under waterbodies (LUW) per 310 CMR 10.56. This area would include the inundated are mapped as Stone Bridge Pond upstream and downstream of the culvert. Based on NWI mapping the northern pond is described as a "freshwater pond" and the southern wetland as a "lake".

Bordering Land Subject to Flooding

Bordering Land Subject to Flooding (BLSF) is comprised of areas within the 100-year floodplain upgradient of the BVW or the Inland Bank line. Areas of the site that are within the floodplain and upgradient inland bank are BLSF. Per FEMA mapping, the 100-year floodplain extends beyond the roadway and culvert approximately 126 feet to the east and west along Stoney Bridge Road.

Riverfront Area

Burnshirt River is a mapped perennial stream per United States Geological Survey (USGS) mapping and thus regulated as a river per 310 CMR 10.58. Based on USGS StreamStats mapping application the watershed of Burnshirt River is approximately 6.21 square miles.

Riverfront area occupies the land upgradient of the mean high-water line on the open water system and perennial watercourse north and south of the culvert for 200-feet.

3.0 WETLAND FUNCTIONAL EVALUATION

A functional evaluation of the open water system associated with the Burnshirt River based on MMI field observations, is summarized in Table 1. The first column lists the functions generally ascribed to wetlands; the second column summarizes the rationale used to determine whether these functions are being performed within the subject wetland and/or watercourse.

TABLE 1
Functions and Values Assessment- Open Water System (Stone Bridge Pond/Burnshirt River)

	Functions and Values	Comments
	Ground Water Recharge / Discharge	Yes – the open water system is likely supported by groundwater and a source of groundwater recharge.
	Flood flow Alteration (Storage & Desynchronization)	Yes – the wetland is mapped within the 100-year floodplain, has a large land area for flood storage, and is associated with a perennial watercourse.
	Fish & Shellfish Habitat	Yes – the ponds are large and deep enough to provide fish habitat.
	Sediment / Toxicant Retention	Yes – the pond has a dam and shorelines of bordering vegetated wetlands that allow for areas of sediment deposition and subsequent toxicant retention.
	Nutrient Removal / Retention / Transformation	Yes – the open water system and adjacent shoreline wetland communities provide high stem density which promotes filtering and absorption of nutrients from stormwater runoff.
	Production Export (Nutrient)	Yes – the open water system, perennial watercourse and vegetated shoreline provides a mechanism to export organic matter to downstream habitats.
	Sediment / Shoreline / Watercourse Bank Stabilization	Yes – the shoreline of the ponds is clearly defined and stabilized by vegetation.
	Wildlife Habitat	Yes – the large open waters system and associated wetlands provide for a diverse wetland dependent wildlife habitat for reptiles, amphibians, mammals, birds and insects.
	Recreation (Consumptive & Non-Consumptive)	Yes – the large open water system is likely utilized for recreational opportunities such as canoeing and fishing.
	Educational Scientific Value	Possible – the open water system is located in a rural area, is accessible, and has the potential for educational value based on diverse potential for wildlife habitats, variable wetland communities around the shoreline and aesthetics.
	Uniqueness / Heritage	Yes – the wetland system is relatively untouched with access available to the public for wildlife viewing, and two or more wetland classes visible from viewing locations.
	Visual Quality / Aesthetics	Yes – the wetland is diverse with vegetated areas along the shorelines of a large open water system with viewing available from the roadway.
ES	Endangered Species	No– the site is not located in a mapped Massachusetts Natural Heritage Area or as a Priority Habitats of Rare Species and Estimated Habitats of Rare Wildlife.

The principal functions and values of the wetland system at this location include the following:

- Groundwater recharge/discharge
- Sediment/toxicant retention
- Nutrient removal/retention/transformation
- Production export
- Wildlife habitat
- Fishery habitat

4.0 CONCLUSIONS

On November 14, 2018 MMI delineated wetlands and watercourses in the vicinity of the culvert under Stoney Bridge Road. Regulated resource areas include the inland bank, land under water bodies and waterways, riverfront area, and bordering land subject to flooding. In addition, bordering vegetated wetlands have been mapped along the eastern and western shorelines of the open water system, outside the project area, based upon mapping provided by Massachusetts Department of Environmental Protection. Based on field observations the Stoney Bridge Pond wetland system provides several important principal wetland functions and values within its watershed.

6679-01-j1619

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WETLAND DELINEATION

STONEY BRIDGE ROAD
SOILS REPORT

STONEY BRIDGE ROAD
TEMPLETON, MASSACHUSETTS

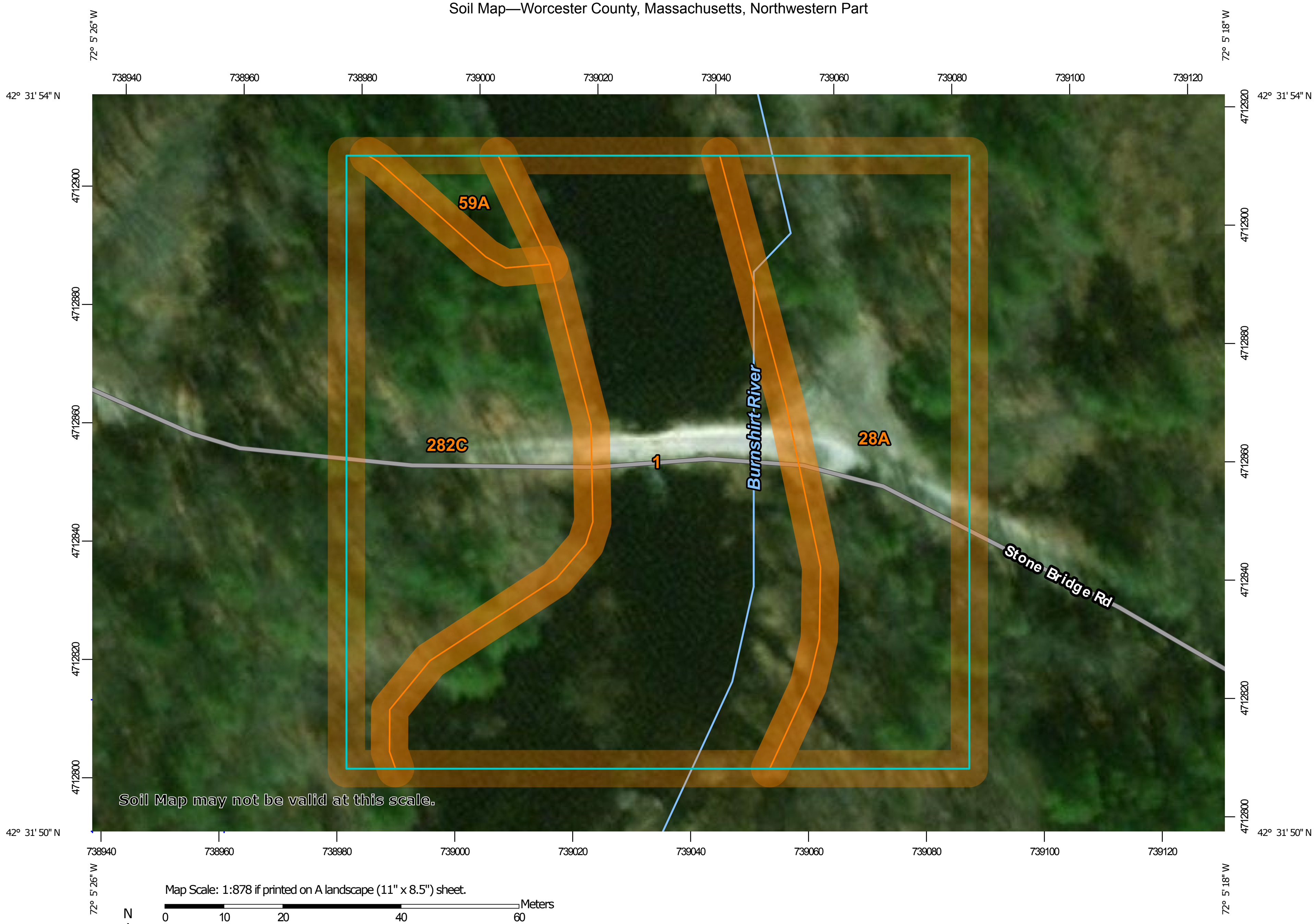
SOURCE: BING AERIAL, 2018, MASS DEP Wetlands, Oliver GIS, 2018

DATE: **JANUARY 18, 2019**		
SCALE: **1"=150'**		
PROJ. NO.: **6381-03**		
DESIGNED **PAS**	DRAWN **PAS**	CHECKED **MJS**
DRAWING NAME: FIG. 1		

APPENDIX A

NRCS Web Soil Survey

Soil Map—Worcester County, Massachusetts, Northwestern Part



Map Scale: 1:878 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 10, 20, 40, 60

Feet: 0, 40, 80, 160, 240

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

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

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Worcester County, Massachusetts, Northwestern Part
Survey Area Data: Version 12, Sep 11, 2018

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

Date(s) aerial images were photographed: Apr 14, 2011—Aug 27, 2016

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Water	1.1	41.4%
28A	Searsport loamy sand, 0 to 3 percent slopes	0.8	29.8%
59A	Bucksport and Wonsqueak mucks, 0 to 2 percent slopes	0.1	2.6%
282C	Colton gravelly loamy sand, 8 to 15 percent slopes	0.7	26.2%
Totals for Area of Interest		**2.7**	**100.0%**

APPENDIX B

Photo Log

Wetland Delineation Report
Stoney Bridge Road
East Templeton, Massachusetts

Photos taken November 14, 2018
MMI #6679-01

Facing West on Stoney Bridge Road, Upstream

Facing West on Stoney Bridge Road, Downstream

Facing West on Stoney Bridge Road

Facing North to Open Water System

Facing South to Open Water System

Upstream Shoreline

Downstream Eastern Shoreline

Downstream Western Shoreline

MILONE & MACBROOM

January 7, 2019

Mr. Carter Terenzini, Town Administrator
Town of Templeton
P.O. Box 620
160 Patriots Road
East Templeton, MA 01438

RE: Geotechnical Engineering Report
Proposed Stoney Bridge Road Culvert Replacement
Templeton, Massachusetts
MMI #6679-01-01

Dear Mr. Terenzini:

Milone & MacBroom, Inc. (MMI) is pleased to submit this geotechnical engineering report as part of the proposed Stoney Bridge Road Culvert Replacement project located in Templeton, Massachusetts. Refer to Figure 1 – Locus Plan in Appendix 1 for the general location of the project.

The design recommendations contained herein are based on American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications, 8th Edition, and the Massachusetts Department of Transportation LRFD *Bridge Manual*, 2013 Edition.

PURPOSE AND SCOPE

MMI performed subsurface explorations (e.g., borings) and a geotechnical engineering evaluation for the proposed culvert replacement. Our scope of services included characterizing the subsurface conditions at the site, performing geotechnical engineering analyses, and providing geotechnical design and construction recommendations for the project.

BACKGROUND

Site Description and Proposed Construction

The proposed culvert replacement is located in Templeton, Massachusetts, approximately ¼ mile east of 100 Stoney Bridge Road and ¼ mile west of 13 Stoney Bridge Road. The existing structure is a rectangular stone culvert with approximate dimensions of 6 feet high by 14 feet wide by 16 feet long. We understand the culvert and roadway overtopped in early August 2018 after a portion of the culvert and subsequently the roadway collapsed, restricting its hydraulic capacity. We understand the Town of Templeton seeks to replace or repair the existing culvert to eliminate flooding of the roadway, restore roadway access, and restore the hydraulic capacity and intended use of the structure.

REVIEW OF AVAILABLE INFORMATION

Regional Geology

According to published geologic data (1:125,000 scale, Surficial Geologic Map of the Mount Grace-Ashburnham-Monson-Webster 24-quadrangle area in central Massachusetts, J.R. Stone, 2013), the subsurface materials at the site are mapped as coarse deposits of sand and gravel.

SUBSURFACE EXPLORATIONS

MMI observed two borings (MM-1 and MM-2) that were performed by Seaboard Drilling, Inc. of Chicopee, Massachusetts, on December 26, 2018. The borings were performed to explore the subsurface conditions near the proposed culvert replacement. The borings were located by taping/pacing from existing site features, and approximate boring locations are shown on Figure 2 – Subsurface Exploration Location Plan contained in Appendix 1.

Hollow-stem auger drilling methods were used to advance the borings to depths ranging between approximately 19.0 and 39.0 feet below current site grades. Representative samples were obtained by split-barrel sampling procedures in general accordance with American Society for Testing and Materials (ASTM) Specification D-1586. Logs of the borings are included in Appendix 2.

The split-barrel sampling procedure utilizes a standard 2-inch-outside-diameter (O.D.) split-barrel sampler that is driven into the bottom of the boring with a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler the middle 12 inches of a normal 24-inch penetration is recorded as the Standard Penetration Resistance Value (N). The blows are indicated on the boring logs at their depth of occurrence and provide an indication of the relative consistency and density of the material. Groundwater levels were measured using a weighted tape in the open drill holes or inferred from the soil samples during drilling.

SUBSURFACE CONDITIONS

The generalized subsurface profile at the site as interpreted from the subsurface exploration data consists of asphalt, over fill, over natural deposits of silt, sand, and gravel. The encountered subsurface conditions are summarized as follows:

- Asphalt – ±0.1 feet thick, over
- Fill – ±3.0 to 5.0 feet thick, over
- Natural Deposits – ±18.9 to 36 feet thick (to the depths explored)

Bedrock was inferred by auger refusal in Boring MM-2 at a depth of approximately 19.0 feet below existing grade.

A more detailed description of the subsurface materials encountered is provided below:

Asphalt was encountered in both borings (MM-1 and MM-2) above the fill and was approximately 1.5 inches thick.

Fill was encountered in both borings (MM-1 and MM-2) and is generally described as medium dense to very dense, light to dark brown fine to coarse sand, some to and fine to coarse gravel, trace silt or silt, some fine to coarse sand, little fine to coarse gravel.

Natural deposits consisting of variable amounts of silt, sand, and gravel were encountered below the fill and are generally described as loose to medium dense in Boring MM-1 and dense to very dense in Boring MM-2. Boring MM-1 consisted predominately of gray-brown fine to medium sand, little to some silt with select split-spoon samples consisting of predominately silt, some to and fine to medium sand. Boring MM-2 consisted predominately of light brown to brown fine to coarse sand, little to and fine to coarse gravel, trace to and silt.

Groundwater was encountered in both borings (MM-1 and MM-2) at a depth of approximately 4.0 feet below existing grades. Groundwater levels will vary depending on factors such as temperature, season, precipitation, construction activity, and other conditions, which may be different from those at the time of these observations.

GEOTECHNICAL ANALYSES AND RECOMMENDATIONS

Foundations

Based on our understanding of the project and the encountered subsurface conditions summarized above, replacement of the existing culvert may consist of either a box culvert (four-sided structure) or open-bottom culvert supported by conventional shallow foundations (e.g., spread footings).

For an open-bottom culvert supported by spread footings, we recommend the following design parameters:

Description	Value
Strength Limit State – Nominal Bearing Resistance	9.5 ksf
Strength Limit State – Factored Bearing Resistance	4.3 ksf
Service Limit State – Bearing Resistance for Settlement of 1 inch	2.0 ksf
Bearing Resistance Factor (ϕ_b) – (AASHTO Table 10.5.5.2.2-1)	0.45
Coefficient of Friction for Sliding – (AASHTO Table 3.11.5.3-1)	0.55
Sliding Resistance Factor – (AASHTO Table 10.5.5.2.2-1)	0.80

Load factors should be selected from AASHTO LRFD (Table 3.4.1-2).
ksf = kips per square foot

For a box culvert, we recommend the following design parameters:

Description	Value
Strength Limit State – Nominal Bearing Resistance	11.1 ksf
Strength Limit State – Factored Bearing Resistance	5.0 ksf
Service Limit State – Bearing Resistance for Settlement of 1 inch	1.0 ksf
Bearing Resistance Factor (ϕ_b) – (AASHTO Table 10.5.5.2.2-1)	0.45
Coefficient of Friction for Sliding – (AASHTO Table 3.11.5.3-1)	0.55
Sliding Resistance Factor – (AASHTO Table 10.5.5.2.2-1)	0.90

Load factors should be selected from AASHTO LRFD (Table 3.4.1-2).
ksf = kips per square foot

We anticipate that the culvert will experience up to approximately 1 inch of total settlement and up to approximately ½ inch of differential settlement.

Regardless of the type of structure selected, its base should be constructed below the anticipated scour depth or a minimum depth of 48 inches below final grades, whichever is deeper. The minimum footing width should be 24 inches.

Structures should bear on a minimum 6-inch-thick crushed stone pad over undisturbed natural soils. The crushed stone pad should be placed 1 foot beyond the edges of the structure and at a one horizontal to one vertical (1H:1V) slope down and away to the top of the natural soil deposits.

Lateral Earth Pressures

Rigid (braced) walls should be designed to resist an equivalent static at-rest horizontal fluid pressure equal to 57 pounds per square foot (psf) (based on $\phi = 32°$, $c = 0$ psf, $K_o = 0.47$, and $Y = 120$ pounds per cubic foot). This assumes no unbalanced hydrostatic pressures (free-draining backfill), seismic forces, or traffic surcharge loads. We recommend using a traffic surcharge load of 250 psf.

Due to the limited expected wall movement and possible scour, we do not recommend the use of passive earth pressure against the base of walls.

Seismic Site Class and Liquefaction Potential

According to the Massachusetts Department of Transportation LRFD *Bridge Manual*, the proposed culvert is considered a conventional, noncritical/nonessential bridge and should follow the guidelines outlined for an AASHTO design seismic event for this locale. The site soils were analyzed for their potential to liquify during the design seismic event; based on their relative in-situ density and fines content, the saturated soils are not considered susceptible to liquification.

According to AASHTO Section 3.10.1, seismic effects for box culverts need not be considered except where they cross active faults. Additionally, according to AASHTO Section 11.5.4.2, since the site-adjusted peak ground acceleration, A_s, is less than or equal to 0.4g and other specified criteria are not applicable, a seismic design for the structure (i.e., box culvert and open-bottom structure) is not mandatory.

Should seismic effects be considered, we recommend a site class of "D" (stiff soil) per AASHTO 3.10.3.1-1, Site Class Definitions. We also recommend the following seismic design parameters for the site based on the AASHTO requirements for this locale and the above site class: $S_S = 0.14g$, $S_1 = 0.040g$, PGA = 0.065g, $S_{DS} = 0.224g$, $S_{D1} = 0.096g$, and $A_s = 0.104g$.

Temporary Excavations and Excavation Support

The on-site soils are classified as Class "C" soils as per the Occupational Safety and Health Administration (OSHA) and can be cut at a maximum 1V:1.5H slope up to a maximum excavation depth of 20 feet. These maximum slope and excavation depths assume no surcharge load (i.e., stockpiles, construction equipment, etc.) at the top of the excavations or seepage (e.g., cuts below the groundwater table).

In accordance with OSHA requirements, where the excavation cannot be sloped back, a temporary earth retaining system will be required. The temporary earth retaining system should be selected by the contractor and designed by a professional engineer registered in the State of Massachusetts.

Asphalt Pavement

Pavement sections should be constructed on a prepared subgrade of proof-compacted natural soils or compacted granular fill (CGF) over these materials. We recommended a finish course of 2 inches, over a binder course of 2 inches, over 8 inches of processed aggregate base.

MATERIALS AND COMPACTION REQUIREMENTS

On-Site Materials

Based on the information contained on the boring logs, the natural soils may be suitable for reuse as CGF. This material should be stockpiled and tested for conformance with the requirements herein for CGF.

Compacted Granular Fill

CGF for use as common fill (i.e., below pavement materials) shall consist of inorganic soil that is free of clay, loam, ice and snow, tree stumps, roots, and other organic matter and graded within the following limits:

Sieve Size	Percent Finer by Weight
3 inches	100
No. 4	50 – 85
No. 10	25 – 75
No. 40	10 – 50
No. 100	8 – 35
No. 200	0 – 10

Three-quarter-inch crushed stone consisting of sound, tough, durable rock meeting the following gradation can be used in areas below the water table:

Sieve Size	Percent Finer by Weight
3/4 inch	100
1/2 inch	85 – 100
3/8 inch	15 – 45
No. 4	0 – 15
No. 8	0 – 5

Pervious Structure Backfill

Pervious structure backfill for use as backfill behind walls should consist of hard, durable sand and gravel that is free of ice, clay, shale, roots, rubbish, and other organic matter and graded within the following limits:

Sieve Size	Percent Finer by Weight
5 inches	100
3.5 inches	90 – 100
1.5 inches	55 – 95
¼ inch	25 – 60
No. 10	15 – 45
No. 40	5 – 25
No. 100	0 – 10
No. 200	0 – 5

We recommend a minimum in-place dry density of 95 percent as per ASTM D1557 for material placed below structures. We recommend a minimum in-place dry density of 92 percent as per ASTM D1557 for material placed as backfill against structural walls. Materials should be placed within 2 percent of their optimum moisture content. We recommend a maximum loose lift thickness of 10 inches.

CONSTRUCTION CONSIDERATIONS

Subgrade Preparation

The existing asphalt and fill will be removed as a matter of course as the area is prepared for culvert replacement or before placement of the footings. The exposed subgrades should be proof compacted prior to any construction.

Footing Preparation

The base of excavations should be free of water, ice, frozen soil, and loose soils prior to placement of footings or culvert bottoms. We recommend the use of smooth-edged excavator buckets for final excavations to help protect the subgrade as proof compaction may not be feasible. The crushed stone below culvert bottoms or footings should be placed as soon as possible after subgrade preparation. The 6-inch crushed stone working pad shall be compacted with multiple orthogonal passes of a plate compactor.

Dewatering

If water levels remain low, we expect that temporary groundwater control can be accomplished by sumps and/or grading to low points. If water levels rise, temporary groundwater control may require the use of temporary cofferdams and/or bypass pumping as deemed necessary by the contractor.

CONSTRUCTION DOCUMENTS AND PLANS

Project plans should be provided to MMI to review for conformance with the geotechnical recommendations contained herein. If changes are made to the location or type of structure, the recommendations in this report will need to be reviewed.

CONSTRUCTION QUALITY CONTROL

We recommend that MMI make field observations of excavations and subgrade preparation to monitor actual conditions and compliance with our recommendations and the project specifications. Specifically, we recommend field observation of final excavations, subgrades, and fill placement and compaction. We can also assist in classifying material on site for segregation and/or mixing for reuse on site.

LIMITATIONS

This report is subject to the limitations included in Appendix 3. Thank you for the opportunity to be of service. Please feel free to call if you have any questions.

Very truly yours,

MILONE & MACBROOM, INC.

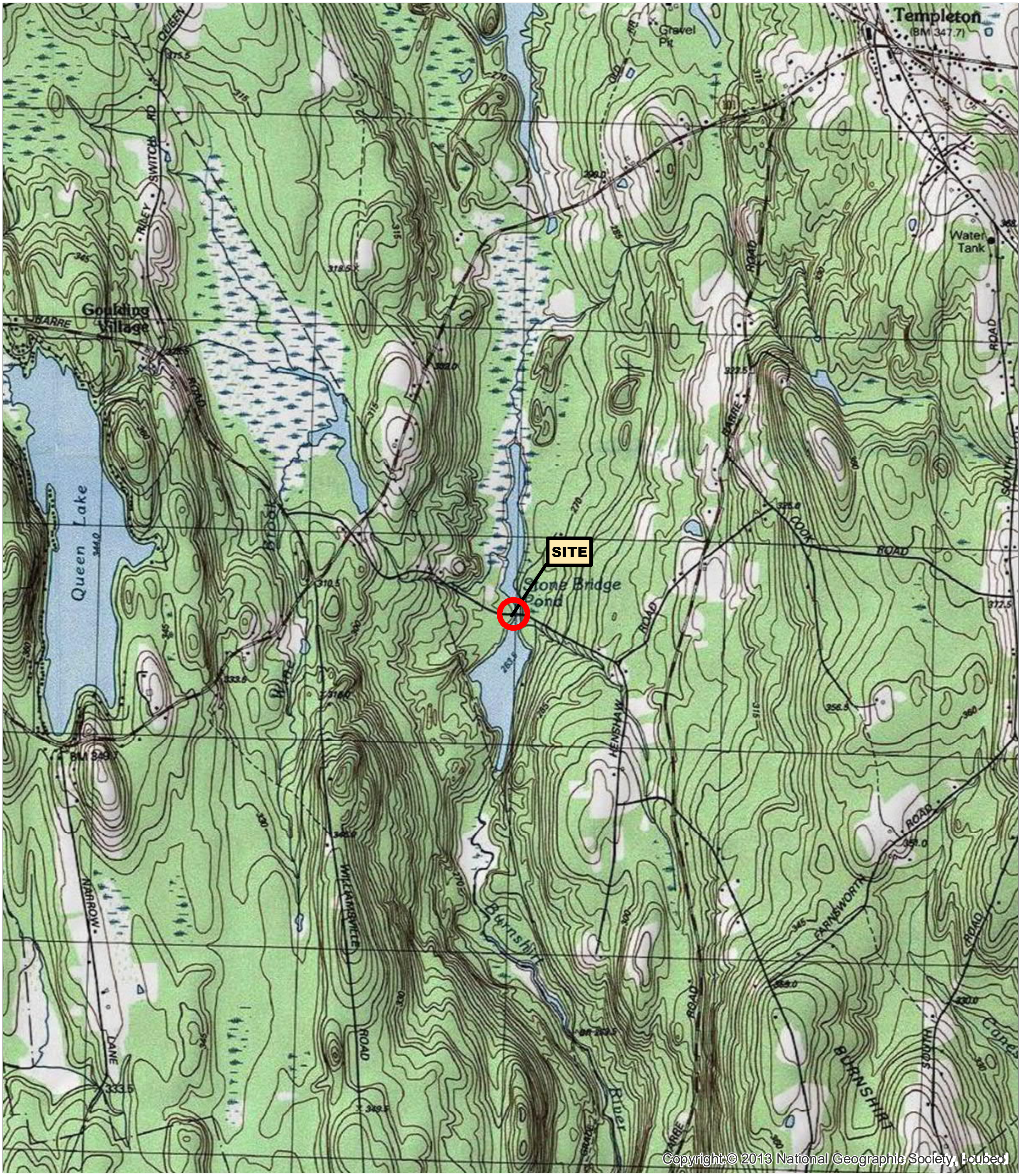
Ryan M. Henderson, EIT
Geotechnical Engineer

Joseph W. Kidd, PE
Senior Geotechnical Manager

Attachments: Appendix 1 – Figures
Appendix 2 – Boring Logs
Appendix 3 – Limitations

6679-01-01-j719-ltr.docx

APPENDIX 1
FIGURES



SOURCE(S):	FIGURE 1 - LOCUS PLAN	LOCATION:
2013, National Geographic Society, USA Topographic Map		STONEY BRIDGE ROAD TEMPLETON, MASSACHUSETTS
N	PROPOSED STONEY BRIDGE ROAD CULVERT REPLACEMENT MXD: W:\Geotech\6679-01-GT\Explorations\Locus Plan.mxd	Map By: J.M. CHECKED: J.K. MMI#: 6679-01 DATE: 12/28/2018 Scale: 1 inch = 2,000 feet

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(203) 271-1773
WWW.MMINC.COM

NOTES:

1. BASE MAP DEVELOPED FROM AN ELECTRONIC FILE BY MILONE & MACBROOM, INC. (MMI) TITLED "6679-01 SURVEY REQUEST MAP" AND DATED 12/18/18.
2. BORINGS BY MILONE & MACBROOM, INC. WERE PERFORMED BY SEABOARD DRILLING, INC. ON 12/26/18.
3. THE LOCATIONS OF THE BORINGS WERE DETERMINED BY TAPING/PACING FROM EXISTING SITE FEATURES. THESE LOCATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

LEGEND:

MM-1 — BORING BY MILONE & MACBROOM, INC.

0' 30' 60'

0 1/2" 1"

SCALE 1" = 60'

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SUBSURFACE EXPLORATION LOCATION PLAN

PROPOSED STONEY BRIDGE ROAD CULVERT REPLACEMENT

STONEY BRIDGE ROAD
TEMPLETON, MASSACHUSETTS

PROJECT PHASE: REV: ---

DATE	DECEMBER 28, 2018	
SCALE	1"=60'	
PROJ. NO.	6679-01	
DESIGNED JWK	DRAWN JGM	CHECKED JWK
DRAWING NAME:	FIG. 2	

Drawing: W:\GEOTECH\6679-01-GT\EXPLORATIONS\BORING LOCATION PLAN.DWG Layout Tab:8.5X11V

Plotted by: RYANMH On this date: Mon, 2019 January 7 - 9:50am

APPENDIX 2
BORING LOGS

TEST BORING LOG

MILONE & MACBROOM
99 Realty Drive
Cheshire, CT 06410
(203) 271-1773

PROJECT: CULVERT REPLACEMENT		BORING NO.: MM-1	SHEET: 1 of 2
LOCATION: STONEY BRIDGE ROAD, TEMPLETON, MA		CONTRACTOR: SEABOARD DRILLING, INC.	
PROJ. NO: 6679-01		FOREMAN: M. GLYNN	
CLIENT: TOWN OF TEMPLETON		INSPECTOR: J. MONTAGNO	
DATE: 2018-12-26		GROUND SURFACE ELEVATION: ±866.0'	

EQUIPMENT:	AUGER	CASING	SAMPLER	COREBRL.	GROUNDWATER DEPTH (FT.)			TYPE OF RIG:
TYPE	HSA	-	SS	-	DATE	TIME	WATER DEPTH	TRUCK W/ SAFETY HAMMER
SIZE ID (IN.)	4 1/4	-	1 3/8	-	2018-12-26	10:00 AM	±4.0'	RIG MODEL:
HMR. WT (LB.)	-	-	140	-				MOBILE B-53
HMR. FALL (IN.)	-	-	30	-				

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	DEPTH (FT.)	STRATUM DESCRIPTION	ELEV. (FT.)	Remark
				Top 1.5": ASPHALT. Bottom 10.5": Light brown, fine to coarse SAND and fine GRAVEL, trace Silt.	0.1'	ASPHALT	865.9'	
1								
2	S-1	15	32 38 44 25	S-1: Very dense, light brown, fine to coarse SAND and fine GRAVEL, trace Silt.		FILL		
3					3.0'		863.0'	
4	S-2	13	20 9 15 29	S-2: Medium dense, gray-brown, SILT, some fine Sand.	4.0'	G.W.T ▽	862.0'	
5								
6	S-3	20	9 11 11 11	S-3: Medium dense, gray-brown, fine to medium SAND, little Silt.				
7								
8								
9								
10								
11	S-4	21	3 2 5 5	S-4: Loose, gray, fine to medium SAND, little Silt.				
12								
13								
14						SILTY SAND		
15								
16	S-5	23	3 4 5 5	S-5: Loose, gray, fine SAND and SILT.				
17								
18								
19								
20								
21	S-6	20	3 5 9 8	S-6: Medium dense, gray-brown, fine to medium SAND, little Silt.				
22								

Remarks:

COHESIONLESS SOILS	COHESIVE SOILS	SAMPLE TYPE	PROPORTIONS
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = <10%
4-10 = LOOSE	2 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM DENSE	4 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	8 -15 = STIFF	UT = UNDISTURBED THINWALL	and = 35% - 50%
50+ = VERY DENSE	15-30 = VERY STIFF		
	30 + = HARD		

TEST BORING LOG

MILONE & MACBROOM
99 Realty Drive
Cheshire, CT 06410
(203) 271-1773

PROJECT:	CULVERT REPLACEMENT	BORING NO.: MM-1	SHEET: 2 of 2
LOCATION:	STONEY BRIDGE ROAD, TEMPLETON, MA	CONTRACTOR: SEABOARD DRILLING, INC.	
PROJ. NO:	6679-01	FOREMAN: M. GLYNN	
CLIENT:	TOWN OF TEMPLETON	INSPECTOR: J. MONTAGNO	
DATE:	2018-12-26	GROUND SURFACE ELEVATION: ±866.0'	

EQUIPMENT:	AUGER	CASING	SAMPLER	COREBRL.	GROUNDWATER DEPTH (FT.)			TYPE OF RIG:
TYPE	HSA	-	SS	-	DATE	TIME	WATER DEPTH	TRUCK W/ SAFETY HAMMER
SIZE ID (IN.)	4 1/4	-	1 3/8	-	2018-12-26	10:00 AM	±4.0'	RIG MODEL:
HMR. WT (LB.)	-	-	140	-				MOBILE B-53
HMR. FALL (IN.)	-	-	30	-				

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	DEPTH (FT.)	STRATUM DESCRIPTION	ELEV. (FT.)	Remark
24								
25	S-7	16	2 5 6 10	S-7: Medium dense, gray-brown, fine to medium SAND, little Silt.				
26								
27								
28								
29								
30	S-8	17	4 9 10 17	S-8: Medium dense, gray-brown, fine to medium SAND, some Silt.		SILTY SAND		
31								
32								
33								
34								
35	S-9	16	3 6 10 13	S-9: Medium dense, brown, fine to medium SAND, some Silt.				
36								
37								
38								
39				Bottom of Exploration ± 39.0'	39.0'		827.0'	1
40								
41								
42								
43								
44								
45								

Remarks: 1. Auger refusal at ± 39.0'.

COHESIONLESS SOILS	COHESIVE SOILS	SAMPLE TYPE	PROPORTIONS
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = <10%
4-10 = LOOSE	2 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM	4 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	8 -15 = STIFF	UT = UNDISTURBED THINWAL	and = 35% - 50%
50+ = VERY DENSE	15-30 = VERY STIFF		
	30 + = HARD		

TEST BORING LOG

MILONE & MACBROOM
99 Realty Drive
Cheshire, CT 06410
(203) 271-1773

PROJECT: CULVERT REPLACEMENT		BORING NO.: MM-2	SHEET: 1 of 1
LOCATION: STONEY BRIDGE ROAD, TEMPLETON, MA		CONTRACTOR: SEABOARD DRILLING, INC.	
PROJ. NO: 6679-01		FOREMAN: M. GLYNN	
CLIENT: TOWN OF TEMPLETON		INSPECTOR: J. MONTAGNO	
DATE: 2018-12-26		GROUND SURFACE ELEVATION: ±867.0'	

EQUIPMENT:	AUGER	CASING	SAMPLER	COREBRL.	GROUNDWATER DEPTH (FT.)			TYPE OF RIG:
TYPE	HSA	-	SS	-	DATE	TIME	WATER DEPTH	TRUCK W/ SAFETY HAMMER
SIZE ID (IN.)	4 1/4	-	1 3/8	-	2018-12-26	12:30 PM	±4.0'	RIG MODEL:
HMR. WT (LB.)	-	-	140	-				
HMR. FALL (IN.)	-	-	30	-				MOBILE B-53

Depth (FT)	SAMPLE NUMBER	RECOVERY (IN)	BLOWS PER 6"	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)	DEPTH (FT.)	STRATUM DESCRIPTION	ELEV. (FT.)	Remark
0-1				Top 1.5": ASPHALT. Bottom 10.5": Light brown, fine to coarse SAND, some fine to coarse Gravel, trace Silt.	0.1'	ASPHALT	866.9'	
1-3	S-1	11	22, 19, 22, 23	S-1: Dense, light brown, fine to coarse SAND, some fine to coarse Gravel, trace Silt.		FILL		
3-5	S-2	6	19, 11, 17, 18	S-2: Medium dense, Top 3": Dark brown, fine to coarse SAND, some fine to coarse Gravel, trace Silt. Bottom 3": Dark brown, SILT, some fine to coarse Sand, little fine to coarse Gravel.	4.0'	G.W.T	863.0'	
					5.0'		862.0'	
5-7	S-3	11	8, 16, 18, 20	S-3: Dense, brown, fine to coarse SAND, some Silt, little fine to coarse Gravel.		SILTY SAND WITH GRAVEL		
10-12	S-4	23	9, 28, 25, 31	S-4: Very dense, Top 11": Light brown, fine to coarse SAND and SILT, little fine to coarse Gravel. Middle 6": Brown, fine to coarse SAND, little fine Gravel, trace Silt. Bottom 6": Brown, fine to coarse GRAVEL, some fine to coarse Sand, trace Silt.				
15-17	S-5	24	28, 21, 18, 24	S-5: Dense, light brown, fine to coarse SAND and fine to coarse GRAVEL, little Silt.				
19					19.0'		348.0'	1
				Bottom of Exploration ± 19.0'				

Remarks: 1. Auger refusal at ± 19.0'.

COHESIONLESS SOILS	COHESIVE SOILS	SAMPLE TYPE	PROPORTIONS
N = 0 - 4 = VERY LOOSE	N = 0 -2 = VERY SOFT	C = ROCK CORE	trace = <10%
4-10 = LOOSE	2 - 4 = SOFT	S = SPLIT SPOON	little = 10% - 20%
10-30 = MEDIUM DENSE	4 - 8 = MEDIUM	UP = UNDISTURBED PISTON	some = 20% - 35%
30-50 = DENSE	8 -15 = STIFF	UT = UNDISTURBED THINWALL	and = 35% - 50%
50+ = VERY DENSE	15-30 = VERY STIFF		
	30 + = HARD		

APPENDIX 3
LIMITATIONS

GEOTECHNICAL LIMITATIONS

Explorations

1. The analyses and recommendations provided in this report are based in part on data contained on the subsurface exploration logs. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

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

3. Water level readings were reported on the logs referenced above. Please note that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, and other factors occurring since the time measurements were made.

Review

4. If any changes in the nature, design or location of the proposed project are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed, and the conclusions and recommendations of this report modified or verified in writing by Milone & MacBroom, Inc. It is recommended that this firm be provided the opportunity for a general review of final design and specifications in order that earthwork and foundation recommendations are properly interpreted and implemented in the design and specifications.

Use of Report

5. This report has been prepared for the exclusive use of the Town of Templeton, Massachusetts and their design team for specific application to the proposed Stoney Bridge Road Culvert Replacement project in Templeton, Massachusetts in accordance with generally accepted soil and foundation engineering practices. No other warranty, express or implied, is made.